ISSN 1306 - 696X

TURKISH JOURNAL of TRAUMA & EMERGENCY SURGERY

Ulusal Travma ve Acil Cerrahi Dergisi

Volume 32 | Number 8 | August 2026

www.tjtes.org

TURKISH JOURNAL of TRAUMA & EMERGENCY SURGERY

Ulusal Travma ve Acil Cerrahi Dergisi

ISSUED BY THE TURKISH ASSOCIATION OF TRAUMA AND EMERGENCY SURGERY

ULUSAL TRAVMA VE ACİL CERRAHİ DERNEĞİ YAYIN ORGANI

Owner *(Ulusal Travma ve Acil Cerrahi Derneği adına Sahibi)*	Mehmet Eryılmaz
Editorial Director *(Yazı İşleri Müdürü)*	Mehmet Eryılmaz
Publication Secretary *(Yayın Sekreteri)*	Kerem Ayar
Emblem *(Amblem)*	Metin Ertem
Correspondence address *(Yazışma adresi)*	Ulusal Travma ve Acil Cerrahi Dergisi Sekreterliği Şehremini Mah., Köprülü Mehmet Paşa Sok., Dadaşoğlu Apt., No: 23/1, 34104 Şehremini, İstanbul
Tel	+90 212 - 588 62 46
Fax *(Faks)*	+90 212 - 586 18 04

p-ISSN 1306-696x • **e-ISSN 1307-7945** • Included in Index Medicus, Medline; EMBASE, Excerpta Medica; Science Citation Index-Expanded (SCI-E), Scopus, DOAJ, EBSCO, ProQuest, CINAHL, Pubmed and Turkish Medical Index. *(Index Medicus, Medline; EMBASE, Excerpta Medica; Science Citation IndexExpanded (SCI-E), Scopus, DOAJ, EBSCO, ProQuest, CINAHL, Pubmed ve TÜBİTAK ULAKBİM Türk Tıp Dizini'nde yer almaktadır.)*

Publisher *(Yayımcı):* KARE Yayıncılık- KARE Medya (KARE Publishing) • www.kareyayincilik.com • Design *(Tasarım):* Ali Cangül • Graphics *(Grafikler):* Kare Publising • Linguistic Editor *(İngilizce Editörü):* Sinjore • Online Manuscript & Web Management *(Online Dergi & Web):* LookUs • Press *(Baskı):* Yıldırım Matbaacılık • Press date *(Basım tarihi):* August *(Ağustos)* 2026 • This publication is printed on paper that meets the international standard ISO 9706: 1994 *(Bu dergide kullanılan kağıt ISO 9706: 1994 standardına uygundur.)*

INFORMATION FOR THE AUTHORS

The Turkish Journal of Trauma and Emergency Surgery (TJTES) is an official publication of the Turkish Association of Trauma and Emergency Surgery. It is a peer-reviewed periodical that considers for publication clinical and experimental studies, case reports, technical contributions, and letters to the editor. Twelve issues are published annually.

Our journal is indexed in several prestigious databases, with the indexing history detailed below:

As of 2001, the journal has been indexed in Index Medicus / Medline and Scopus. Starting from 2005, it is included in Excerpta Medica and EMBASE. From 2007 onwards, it has been listed in the Science Citation Index Expanded (SCI-E) and the Journal Citation Reports / Science Edition. Since 2014, the journal is indexed in EBSCOhost and ProQuest. As of 2023, it has been added to PubMed Central.

The journal's impact factor in SCI-E indexed journals is 1.1 according to the 2023 Journal Citation Reports (JCR). In PubMed, the journal is cited as 'Ulus Travma Acil Cerrahi Derg'.

Submission of a manuscript by electronic means implies: that the work has not been published before (except in the form of an abstract or as part of a published lecture, review, or thesis); that it is not under consideration for publication elsewhere; and that its publication in the Turkish Journal of Trauma and Emergency Surgery is approved by all co-authors. The author(s) transfer(s) the copyright to the Turkish Association of Trauma and Emergency Surgery to be effective if and when the manuscript is accepted for publication. The author(s) guarantee(s) that the manuscript will not be published elsewhere in any other language without the consent of the Association. If the manuscript has been presented at a meeting, this should be stated together with the name of the meeting, date, and the place.

Manuscripts must be submitted in English. All submissions are initially reviewed by the editor, and then are sent to reviewers. All manuscripts are subject to editing and, if necessary, will be returned to the authors for answered responses to outstanding questions or for addition of any missing information to be added. For accuracy and clarity, a detailed manuscript editing is undertaken for all manuscripts accepted for publication. Final galley proofs are sent to the authors for approval.

Unless specifically indicated otherwise at the time of submission, rejected manuscripts will not be returned to the authors, including accompanying materials.

Priority of publications is given to original studies; therefore, selection criteria are more refined for reviews and case reports.

Manuscript submission: TJTES accepts only on-line submission via the official web site (please click, www.travma.org.tr/en) and refuses printed manuscript submissions by mail. All submissions are made by the on-line submission system called Journal Agent, by clicking the icon "Online manuscript submission" at the above mentioned web site homepage. The system includes directions at each step but for further information you may visit the web site (http://www.travma.org/en/journal/).

Manuscript preparation: Manuscripts should have double-line spacing, leaving sufficient margin on both sides. The font size (12 points) and style (Times New Roman) of the main text should be uniformly taken into account. All pages of the main text should be numbered consecutively. Cover letter, manuscript title, author names and institutions and correspondence address, abstract in Turkish (for Turkish authors only), and title and abstract in English are uploaded to the Journal Agent system in the relevant steps. The main text includes Introduction, Materials and Methods, Results, Discussion, Acknowledgments, References, Tables and Figure Legends.

The cover letter must contain a brief statement that the manuscript has been read and approved by all authors, that it has not been submitted to, or is not under consideration for publication in, another journal. It should contain the names and signatures of all authors. The cover letter is uploaded at the 10th step of the "Submit New Manuscript" section, called "Upload Your Files".

Abstract: The abstract should be structured and serve as an informative guide for the methods and results sections of the study. It must be prepared with the following subtitles: Background, Methods, Results and Conclusions. Abstracts should not exceed 200 words.

Figures, illustrations and tables: All figures and tables should be numbered in the order of appearance in the text. The desired position of figures and tables should be indicated in the text. Legends should be included in the relevant part of the main text and those for photomicrographs and slide preparations should indicate the magnification and the stain used. Color pictures and figures will be published if they are definitely required and with the understanding that the authors are prepared to bear the costs. Line drawings should be professionally prepared. For recognizable photographs, signed releases of the patient or of his/her legal representatives should be enclosed; otherwise, patient names or eyes must be blocked out to prevent identification.

References: All references should be numbered in the order of mention in the text. All reference figures in the text should be given in brackets without changing the font size. References should only include articles that have been published or accepted for publication. Reference format should conform to the "Uniform requirements for manuscripts submitted to biomedical journals" (http://www.icmje.org) and its updated versions (February 2006). Journal titles should be abbreviated according to Index Medicus. Journal references should provide inclusive page numbers. All authors, if six or fewer, should be listed; otherwise the first six should be listed, followed by "et al." should be written. The style and punctuation of the references should follow the formats below:

Journal article: Velmahos GC, Kamel E, Chan LS, Hanpeter D, Asensio JA, Murray JA, et al. Complex repair for the management of duodenal injuries. Am Surg 1999;65:972-5.

Chapter in book: Jurkovich GJ. Duodenum and pancreas. In: Mattox KL, Feliciano DV, Moore EE, editors. Trauma. 4th ed. New York: McGraw-Hill; 2000. p. 735-62.

Our journal has succeeded in being included in several indexes, in this context, we have included a search engine in our web site (www.travma.org.tr) so that you can access full-text articles of the previous issues and cite the published articles in your studies.

Review articles: Only reviews written by distinguished authors based on the editor's invitation will be considered and evaluated. Review articles must include the title, summary, text, and references sections. Any accompanying tables, graphics, and figures should be prepared as mentioned above.

Case reports: A limited number of case reports are published in each issue of the journal. The presented case(s) should be educative and of interest to the readers, and should reflect an exclusive rarity. Case reports should contain the title, summary, and the case, discussion, and references sections. These reports may consist of maximum five authors.

Letters to the Editor: "Letters to the Editor" are only published electronically and they do not appear in the printed version of TJTES and PubMed. The editors do not issue an acceptance document as an original article for the ''letters to the editor. The letters should not exceed 500 words. The letter must clearly list the title, authors, publication date, issue number, and inclusive page numbers of the publication for which opinions are released.

Informed consent - Ethics: Manuscripts reporting the results of experimental studies on human subjects must include a statement that informed consent was obtained after the nature of the procedure(s) had been fully explained. Manuscripts describing investigations in animals must clearly indicate the steps taken to eliminate pain and suffering. Authors are advised to comply with internationally accepted guidelines, stating such compliance in their manuscripts and to include the approval by the local institutional human research committee.

POLICIES

Open Access Policy: **The Turkish Journal of Trauma and Emergency Surgery - TJTES (Ulusal Travma ve Acil Cerrahi Dergisi)** supports the Budapest Open Access Initiative statement of principles that promotes free access to research literature. The declaration defines open access to academic literature as free availability on the internet, permitting users to read, record, copy, print, search, or link to the full text, examine them for indexing, use them as data for software or other lawful purposes without financial, legal, or technical barriers. Information sharing represents a public good, and is essential to the advancement of science. Therefore, articles published in this journal are available for use by researchers and other readers without permission from the author or the publisher provided that the author and the original source are cited. The articles in TJTES are accessible through search engines, websites, blogs, and other digital platforms.

Additional details on the Budapest Open Access Initiative and their guidelines are available at https://www.budapestopenaccessinitiative.org/, including a Turkish translation of the recommendations at http://www.budapestopenaccessinitiative.org/boai-10-translations/turkish-translation.

Creative Commons License: A Creative Commons license is a public copyright license that enables the free distribution of copyrighted work. TJTES articles are licensed under the Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC 4.0) version. The author grants the right to share and use original work with the condition that it be appropriately credited, it may

not be used for commercial purposes, and secondary products must also be made available under the same terms of use. Specific details can be found at https://creativecommons.org/licenses/by-nc/4.0/.

TJTES is committed to encouraging dissemination of academic work and interdisciplinary cooperation.

Ethics Policy: The observance of ethical principles throughout the research and publication process is fundamental to ensuring the integrity of the work and furthering the goal of contributing to and sharing high-quality, objective, reliable, and useful information.

TJTES has adopted ethical principles based on the guidelines prepared by the Committee on Publication Ethics (COPE) (https://publicationethics.org/). We implement these processes to ensure appropriate support for our authors and their institutions, as well as our readers. It is crucial that all of the stakeholders in the process (authors, readers and researchers, publishers, reviewers, and editors) comply with ethical principles.

Ethical Responsibilities of the Authors:

- Studies submitted for publication must be original work of the author. References to other studies must be cited and/or quoted completely and accurately;
- Only those who provide a substantial intellectual contribution to the content of the work may be cited as an author. Other contributors may be recognized with acknowledgements at the conclusion of the article;
- All competing interests or relationships that may be perceived to constitute a conflict of interest must be declared and explained;
- All studies involving human or animal subjects must comply with national and international laws and guidelines regarding privacy and ethical conduct (e.g., World Medical Association Declaration of Helsinki, US National Institutes of Health Policy on the Use of Laboratory Animals, EU Directive on the Use of Animals) and the details of approval and observance should be indicated in the Materials and Methods section of the manuscript;
- Authors must be able to provide documentation showing that they have the right to use the data analyzed, all necessary permission related to the research, and appropriate consent;
- Raw data and other material used in the article must be available and may be requested from the author(s) in order to verify the validity of the reporting;
- In the event the author(s) notice an error at any point in the publication process or after publication, they have the obligation to inform the journal editor or publisher and cooperate in appropriate corrective action;
- Authors may not submit their article for publication to more than one journal simultaneously. Each application must be initiated following the completion of any previous effort. Previously published articles, will not be accepted, including translations, without the proper acknowledgement of the original author;
- Changes in authorship designation (such as adding authors, changing the printed order of the authors, removing an author) once the evaluation process has begun will not be accepted in order to protect all parties involved.

Ethical Duties and Responsibilities of the Editors: The editor is responsible for everything published in the journal. In the context of this responsibility, editors have the following duties and obligations:

- Endeavor to meet the needs of readers and authors;
- Maintain continuous development to improve the journal;
- Consistently work to ensure quality and academic integrity. The editor is responsible for confirming that the publishing policies and standards are upheld;
- Support freedom of thought;
- Prevent business needs or other considerations from compromising intellectual and ethical standards, including acting in a balanced, objective, and fair manner in the course of their duties without any discrimination based on gender, religious or political beliefs, ethnic or geographical origin, sponsorship, renown, or other influence;
- Apply the publicly defined publication policies created and enforced to ensure a timely and impartial evaluation process for all submissions;
- Protect intellectual property and to defend the rights of the journal and author(s);
- Demonstrate clarity and transparency. The editor is expected to ensure that any errors, inconsistencies, or misleading statements are corrected quickly and appropriately acknowledged;
- Perform a thorough, timely, and objective investigation of any complaint or allegation of misconduct, including providing the opportunity for the author to present information refuting accusations, and to share the findings and conclusions and implement appropriate action, which may include, but is not limited to rejection of an article.

Reader Relationship: The editor is to make publication decisions based on expectations of suitable and desirable material. Studies accepted for publication must be original contributions that benefit the reader, researcher, practitioner, and the literature. In addition, editors are obliged to take into account feedback from readers, researchers, and practitioners, and to provide an informative response. Readers will also be informed of any funding provided to support published research.

Author Relationship:

- The decision to accept an article is to be based on the importance, original value, validity, and clarity of expression of the work, and the goals and objectives of the journal;
- Studies accepted for evaluation and publication will not be withdrawn unless serious problems are identified;
- The editor will not disregard positive reviewer comments unless there is a serious problem with the study;
- New editors will not change publishing decisions made by previous editor(s) unless there is a serious problem;
- A description of the submission and evaluation process is publicly available;
- Authors are provided with descriptive and informative feedback.

Reviewer Relationship:

- Reviewers are to be selected according to the subject of the study;
- Information and guidance for the evaluation phase is provided;
- Any conflicts of interest between authors and reviewers will be disclosed and managed appropriately;
- Reviewer identity is to be kept confidential to preserve a blind review process;
- Reviewers are to evaluate the study using unbiased, scientific, and constructive comments. Unkind or unscientific commentary will not be permitted;
- Reviewers will be evaluated using criteria such as timely response and quality of observations;
- The pool of reviewers is to be assessed and supplemented regularly to ensure a broad scope of expertise.

Editorial Board Relationship: The editor works with the members of the editorial board to ensure that they are familiar with journal policies and developments in regular meetings and announcements, and will provide training for new members and assistance to board members during their tenure in their role as a supporter of the journal.

- Editorial board members must be qualified and able to contribute to the journal;
- Members of the editorial board must evaluate studies impartially and independently;
- Editorial board members with the appropriate expertise will be given the opportunity to evaluate suitable articles;
- The editor will maintain regular contact with the editorial board and hold regular meetings regarding the development of editorial policies and other aspects of journal management.

Creativity and Openness:

- Constructive criticism is to be encouraged;
- Authors will be given the opportunity to reply to criticism or lodge complaints;
- Negative results will not be a reason for submission denial.

Ethical Responsibilities of the Reviewers: Peer review of research embodies the scientific method, subjecting the work to the exacting scrutiny of knowledgeable colleagues. The rigor of the review process directly affects the quality of the literature; it provides confidence in an objective and independent evaluation of the published work. TJTES uses a double-blind review process. All comments and the evaluation are transmitted through the journal management system. Reviewers should:

- Only agree to evaluate studies related to their specialty;
- Return reviews promptly and within the designated timeframe;
- Evaluate with impartiality. Nationality, gender, religious beliefs, political beliefs, commercial concerns, or other considerations must not influence the evaluation;
- Refuse to review any work with a potential conflict of interest and inform the journal editor;
- Maintain confidentiality of all information. Destroy manuscripts and related material following the review. Only the final published version may be used for any purpose;
- Report any suspicion of misconduct to the editor;
- Use thoughtful and constructive language intended to improve the quality of the article. Hostile or derogatory comments are not acceptable.

Ethical Responsibilities of the Publisher: The role of the publisher includes stewardship of the scholarly record. As such, the publisher should:

- Abide by ethical principles related to research integrity; the process of application, review, and selection; and publication;
- Collaborate with the editor and the editorial board to maintain and develop the journal in a relationship that recognizes editorial independence and is defined by written agreement;
- Publish content in a timely manner, including corrections, clarifications, and retractions;
- Preserve published work.

The publication processes of the journal are conducted in accordance with the guidelines of International Committee of Medical Journal Editors (ICMJE), the World Association of Medical Editors (WAME), the Council of Science Editors (CSE), the Committee of Publication Ethics (COPE), the European Association of Science Editors (EASE) and National Information Standards Organization (NISO).

Examples of some activities considered to be contrary to scientific research and publication ethics:

- Plagiarism: The representation of the ideas, methods, data, or other work of another, in whole or in part, as one's own. The original source must be appropriately acknowledged. Authors are encouraged to offer unique work that does not rely on substantial use of other sources, regardless of citation.
- Fraud: The use of fabricated or falsified data or other deceptive misrepresentation of fact.
- Distortion: Manipulation of the research records, data, images, or results, or presenting unused devices or materials as if they were used in the research, particularly in the interests of study sponsors.
- Republication: Duplicate submissions presented as unique publications.
- Slicing: The use of a portion of data or findings derived from a single research idea in multiple smaller units as separate publications.
- Inaccurate authorship: The inclusion of individuals as named authors who were not active contributors, the failure to include contributors, or the inappropriate ranking of authors.
- Lack of acknowledgement of individuals, institutions, or organizations that provided financial or other substantial support to the work.
- Use of a thesis or unpublished study without the permission of the owner.
- Failure to comply with ethical rules for human and animal research, including respect for patient rights and animal welfare, or obtaining the required approval.
- The misuse of resources, facilities, or devices provided for scientific research.
- The use of false or misleading statements.

On rare occasions it may be necessary for a journal to impose sanctions on researchers who have engaged in questionable research practices or publishing ethics malpractice: for example, a ban against publishing any further articles in the journal when doing so puts the journal's reputation demonstrably at risk, or not permitting a researcher to serve as a reviewer or editor. Bans of this nature may be implemented for a period of time and revoked or extended if necessary, upon review at the conclusion of the allotted time period. Sanctions may be appealed by writing to the journal editor.

Plagiarism Policy: Plagiarism is the theft of another's work and a violation of ethics, regardless of whether it is intentional or not. It is unacceptable conduct to submit or publish manuscripts using other sources without appropriately citing the reference. It is the policy of TJTES, to use plagiarism detection software for all submissions and to perform an editorial review when necessary. The editor or the editorial board may request revision or reject a manuscript that does not meet publication standards, including plagiarism, citation or other manipulation, or any fraudulent misrepresentation.

Copyright Transfer: Manuscripts submitted for publication in TJTES should be original, unpublished work. Upon submission, the authors are obliged to declare that the study, in whole or in part, has not been previously published or evaluated for publication on any other platform. Sanctions may be applied for failure to observe this policy.

Authors agree to transfer copyright privileges upon submission to the TJTES. This transfer takes effect upon acceptance for publication. No part of published material may be used for any other purpose without the written permission of the publisher.

Authors should obtain any necessary permission from the copyright holder when using content previously published in printed or electronic format, including pictures, tables, or other elements. The legal, financial, and criminal responsibility resides with the author.

Authors must return a completed copyright transfer form upon submission.

Conflict of Interest: The editor is required to ensure that any conflicts of interest between authors, reviewers, or other parties are disclosed and managed appropriately to provide an independent and impartial process.

Any potential perception of a financial or personal interest that may affect decision-making creates a conflict of interest. The presence of a conflict of interest is independent of the occurrence of inappropriateness. The reliability of the scientific process and published articles is directly related to the objective consideration of conflicts of interest during the planning, implementation, writing, evaluation, editing, and publication of scientific studies.

Financial relationships are the most easily identified conflicts of interest, and if undisclosed, they undermine the credibility of the journal, the authors, and the science. However, conflicts can also occur through individual relationships, academic competition, intellectual approach, and more. Authors should refrain as much as possible from any relationship that could restrict their ability to objectively access data or analyze, interpret, prepare, and publish their article. Authors must disclose any relationships related to study submissions.

Editors and peer reviewers should also be aware of potential conflicts of interest and refrain from engaging in any activity that could be questionable and report associations that could be perceived as presenting a conflict.

The publication team works diligently to ensure that the evaluation process is conducted in an impartial manner in order to protect the interests of all parties.

The conflict of interest form and more detailed information are available at: http://www.icmje.org/disclosure-of-interest/

Artificial Intelligence (Ai)–Assisted Technology

At submission, the journal should require authors to disclose whether they used artificial intelligence (AI)– assisted technologies (such as Large Language Models [LLMs], chatbots, or image creators) in the production of submitted work. Authors who use such technology should describe, in both the cover letter and the submitted work, how they used it. Use of AI for writing assistance should be reported in the acknowledgment section. Authors who used AI technology to conduct the study should describe its use in the methods section in sufficient detail to enable replication to the approach, including the tool used, version, and prompts where applicable. Chatbots (such as ChatGPT) should not be listed as authors because they cannot be responsible for the accuracy, integrity, and originality of the work, and these responsibilities are required for authorship. Therefore, humans are responsible for any submitted material that included the use of AI-assisted technologies. Authors should carefully review and edit the result because AI can generate authoritative-sounding output that can be incorrect, incomplete, or biased. Authors should not list AI and AIassisted technologies as an author or co-author, nor cite AI as an author. Authors should be able to assert that there is no plagiarism in their paper, including in text and images produced by the AI. Humans must ensure there is appropriate attribution of all quoted material, including full citations.

Publishing Fee: In order to further improve the quality and accessibility of the journal, a fee will be charged as a contribution to the cost of production. This fee will be charged during the process of application of submitted articles and will be charged regardless of eventual acceptance/rejection of the manuscript.

Foreign authors can complete the article submission process after depositing

USD 600.- to the USD account.

Turkish authors can complete the article submission process after depositing 5000.- TL to the account.

The article number released at the last stage of the article upload process must be written in the bank shipment description section.

Fast-track Publication Fee

The Turkish Journal of Trauma and Emergency Surgery, the scientific publication of the National Association of Trauma and Emergency Surgery, has now added the option of a Fast-track Publication Fee to meet the demand for an accelerated publication process. The charge for early publication is 10,000 TL for Turkish authors and 1000 USD for foreign authors.

Article Processing Charge

Starting with the first issue of 2024, the Turkish Journal of Trauma and Emergency Surgery will be introducing an Article Processing Charge (APC) of 200 USD for articles published in the journal. This charge is necessary to cover the costs associated with the publication services provided by the journal. These services include article management costs, the production of articles in PDF and other formats, and the distribution of published articles to various venues and other publishing functions.

TURKISH JOURNAL OF TRAUMA & EMERGENCY SURGERY
ULUSAL TRAVMA VE ACİL CERRAHİ DERGİSİ
Vol. - *Cilt* 32 Number - *Sayı* 8 August - *Ağustos* 2026

Contents - *İçindekiler*

Experimental Studies - *Deneysel Çalışma*

Original Articles - *Orijinal Çalışma*

TURKISH JOURNAL OF TRAUMA & EMERGENCY SURGERY
ULUSAL TRAVMA VE ACİL CERRAHİ DERGİSİ
Vol. - *Cilt* 32 Number - *Sayı* 8 August - *Ağustos* 2026

Contents - *İçindekiler*

Case Reports - *Olgu Sunumu*

EXPERIMENTAL STUDY

The effect of silibinin on liver healing following blunt trauma in rats

Alparslan Ertenlice,[1,2] Ersin Gürkan Dumlu,[1] Zeynep Ruken Hakkoymaz,[3] Bülent Baş,[4] Onur Karaca,[5] Şevket Barış Morkavuk,[6] İbrahim Kılınç,[2] Abdussamed Yalçın,[1] Ali Coşkun[1]

[1]Department of General Surgery, Ankara Yildirim Beyazit University Faculty of Medicine, Ankara-*Türkiye*
[2]Department of General Surgery, Ankara Bilkent City Hospital, Ankara-*Türkiye*
[3]Department of Medical Pathology, Ankara Bilkent City Hospital, Ankara-*Türkiye*
[4]Department of Microbiology, Ankara University Faculty of Veterinary Medicine, Ankara, Ankara-*Türkiye*
[5]Surgical Oncology Clinic, Gulhane Training and Research Hospital, University of Health Sciences, Ankara-*Türkiye*
[6]Department of General Surgery, Koç University Hospital, İstanbul-*Türkiye*

ABSTRACT

BACKGROUND: This study aimed to evaluate the effects of silibinin, a compound with demonstrated therapeutic effects in various liver diseases, on liver healing in a rat model of blunt liver trauma.

METHODS: Twenty-four Wistar albino rats weighing 250–300 g were randomly assigned to three equal groups. Group I served as the control group (CG) and received standard nutrition without trauma induction. Under general anesthesia, rats in Groups II and III underwent a blunt trauma procedure applied to the right upper abdominal quadrant. Group II, designated as the trauma group (TG), received standard nutrition only. Group III, designated as the trauma-silibinin group (T-SG), received silibinin at a dose of 100 mg/kg/day via gastric gavage for five days in addition to standard nutrition. Following the five-day observation period, blood samples were collected from inferior vena cava. Serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels were measured in the collected blood specimens. Histopathological examination of liver tissue was performed to assess the degree of inflammation.

RESULTS: Mean AST and ALT levels differed significantly among the groups ($p<0.001$). Although no statistically significant difference was observed in inflammation scores between the TG and T-SG groups ($p=0.115$), inflammation scores tended to be higher in the TG, with a moderate effect size ($r=0.41$). Furthermore, the risk of a high injury score was 11.7 times greater in the TG than in the T-SG.

CONCLUSION: To our knowledge, this is the priority study to evaluate the effects of silibinin in a rat model of blunt liver trauma. Silibinin may represent a promising therapeutic agent for reducing inflammation following liver trauma and promoting liver healing.

Keywords: Blunt trauma; healing; liver; silibinin; silybin.

INTRODUCTION

Trauma refers to cellular injury caused by exposure to excessive environmental energy, resulting in cell death through mechanisms such as ischemia–reperfusion injury. Trauma is the leading cause of death among individuals aged 1–44 years and the third leading cause of death across all age groups. Given its incidence, associated healthcare costs, and mortality rates, trauma remains a major public health challenge.[1-3] Liver injury is one of the most common abdominal organ injuries encountered in severe trauma. Until approximately three decades ago, diagnostic laparotomy was considered the standard approach for patients presenting with blunt abdominal trauma and suspected parenchymal organ injury. However, advances

Cite this article as: Ertenlice A, Dumlu EG, Hakkoymaz ZR, Baş B, Karaca O, Morkavuk ŞB, et al. The effect of silibinin on liver healing following blunt trauma in rats. Ulus Travma Acil Cerrahi Derg 2026;32:877-884.

Address for correspondence: Alparslan Ertenlice
Department of General Surgery, Ankara Yildirim Beyazit University Faculty of Medicine, Ankara, Türkiye
E-mail: ertenlice@gmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):877-884 DOI: 10.14744/tjtes.2026.28866
Submitted: 05.07.2025 Revised: 16.10.2025 Accepted: 02.03.2026 Published: 10.08.2026

in diagnostic imaging and therapeutic management have led to the widespread adoption of non-operative management in selected patients.[4] Currently, non-operative management is the standard treatment for hemodynamically stable patients with blunt liver trauma, with reported success rates of 80%–90%.[5] Nevertheless, mortality, morbidity, length of hospital stay, and treatment costs remain substantial. In a study by Tinkoff et al.[6] involving 21,532 patients with liver injuries, the mortality rate was 16.7%, the mean hospital stay was 10.1 days, and the average daily treatment cost was approximately $7,000. Therefore, identifying therapeutic agents that can improve outcomes and reduce healthcare burden remains an important area of research. Silibinin is a flavonoid compound and the antioxidant constituent of milk thistle (Silybum marianum). It has been used in the treatment of conditions such as Amanita phalloides poisoning, cirrhosis, alcoholic liver disease, and non-alcoholic liver disease.[7] Numerous in vitro and in vivo studies have demonstrated that silibinin possesses anti-apoptotic, anti-fibrotic, anti-inflammatory, antioxidant, anticancer, antifungal, neuroprotective, and cardioprotective properties.[8] In an experimental study published in 2019, Duran and Karaboğa[9] reported that hesperetin, another flavonoid compound, attenuated the systemic inflammatory response following traumatic injury and reduced secondary organ damage. The present study aimed to evaluate the effects of silibinin, which has demonstrated therapeutic benefits in various liver diseases, on liver healing in a rat model of blunt liver trauma.

MATERIALS AND METHODS

This study was conducted at the Experimental Animal Production and Research Laboratory of Ankara Training and Research Hospital following approval from the Ankara Training and Research Hospital Animal Experiments Local Ethics Committee for Animal Experiments (Approval No. 0069; January 20, 2022). The study was performed through collaboration among the Departments of General Surgery, Pathology, and Biochemistry. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Twenty-four Wistar albino rats weighing 250–300 g were included in the study. The animals were randomly assigned to three groups of eight rats each (n=8 per group). Group I served as the Control Group (CG), Group II as the Trauma Group (TG) and Group III as the Trauma–Silibinin Group (T-GS). Rats were fasted for 12 hours before the experimental procedures. All interventions were performed under appropriate anesthesia. Trauma was induced in the TG and T-SG groups by applying a standardized injury to the right upper abdominal quadrant using a custom-designed trauma platform (Fig. 1). Trauma was generated by dropping a fixed 200-g weight from a height of 40 cm, delivering 0.785 J of kinetic energy. The trauma model was based on previously published studies to ensure standardization and reproducibility of the injury response.[10] The CG received standard nutrition without trauma induction or additional intervention. Rats in the

Figure 1. Specially designed platform used for induction of the trauma model and positioning of the study subjects.

TG underwent blunt liver trauma and were monitored for five days while receiving standard nutrition only. Rats in the T-SG underwent the same trauma procedure and received silibinin at a dose of 100 mg/kg/day via gastric gavage in addition to standard nutrition for five days. The treatment dose was selected based on published bioavailability data and previous experimental studies.[11,12] At the end of the five-day ob-

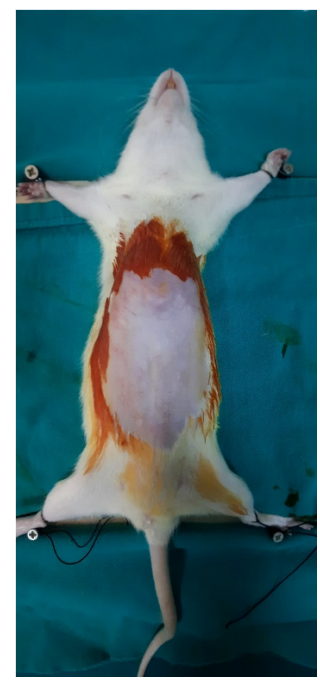

Figure 2. Subject prepared for laparotomy following the five-day observation period.

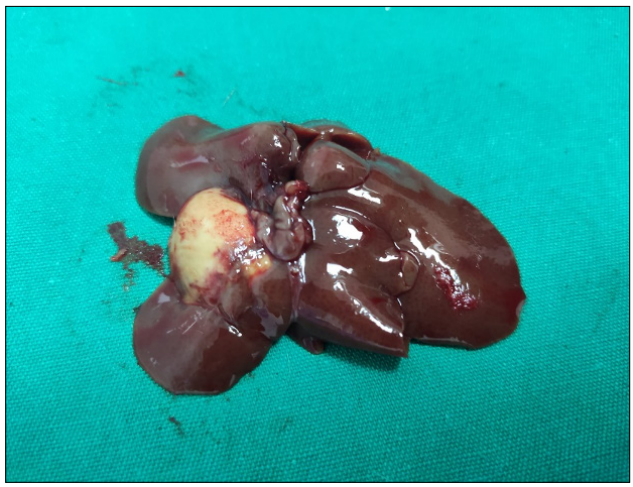

Figure 3. Representative image of a traumatized rat liver five days after injury.

Table 1. Inflammation grading system

0	No inflammation or minimal inflammatory changes
1	Mild injury characterized by cytoplasmic vacuolization and focal nuclear pyknosis
2	Moderate injury characterized by widespread nuclear condensation, increased cytoplasmic eosinophilia, and disruption of intercellular borders
3	Severe necrosis and neutrophil infiltration accompanied by disintegration of hepatic cords and bleeding

servation period, all animals were anesthetized. The animals were placed in the supine position and secured on the operating table (Fig. 2). After shaving and sterilization, a 2.5-cm midline incision was made. For biochemical analyses, blood samples (2 mL per rat) were collected from the vena cava into collection tubes. Subsequently, all rats were euthanized, and the livers were harvested (Fig. 3) and transferred to the pathology laboratory in specimen containers containing 10% formalin. Serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels were measured using validated laboratory kits.

Histopathological Evaluation

Histopathological assessment was performed by a pathologist blinded to the treatment groups. Following macroscopic examination, the specimens were individually labeled and embedded in paraffin blocks. Sections 5 µm thick were cut from the paraffin-embedded tissue samples and stained with hematoxylin and eosin (H&E). The degree of inflammation was evaluated according to the scoring system presented in Table 1.

Inflammation severity was graded on a scale from 0 to 3.[13] Representative histopathological findings are shown in Figure 4.

Statistical Analyses

Statistical analyses were performed using IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, USA). The Kolmogorov–Smirnov test was used to assess the distribution characteristics and homogeneity of continuous variables. Categorical variables were analyzed using Pearson's chi-square test or Fisher's exact test. For comparisons between two groups, the Student's t-test was used for normally distributed continuous variables, whereas the Mann–Whitney U test was applied to non-normally distributed variables. Comparisons among three groups were performed using one-way analysis of variance (ANOVA) with Bonferroni post hoc testing for normally distributed variables and the Kruskal–Wallis test for non-normally distributed variables. A p-value <0.05 was considered statistically significant. Odds ratios (ORs) were calculated for categorical outcomes to estimate the odds of elevated enzyme levels or high inflammation scores between groups. When zero counts were encountered, a continuity correction of 0.5 was applied.

RESULTS

The mean ALT level among all rats was 50.32±16.17 U/L (range: 19.3–75.8), while the mean AST level was 128.275±41.11 U/L (range: 65.1–209). Eight rats had an inflammation score of 0, whereas four rats had an inflammation score of 3 (Table 2).

ALT and AST values demonstrated a normal and homogeneous distribution across the study population (Fig. 5).

AST and ALT levels were first compared among the three study groups. Significant differences were observed in the mean AST and ALT values between the groups. The mean ALT level was 34.85 U/L in the CG, 66.23 U/L in the TG, and 49.85 U/L in the T-SG (p<0.001). Thus, the mean ALT level in the T-SG was higher than that in the CG but lower than

Table 2. Baseline characteristics of the study population

Study groups, n (%)	
CG	8 (33.3%)
TG	8 (33.3%)
T-SG	8 (33.3%)
Inflammation score, n (%)	
Score 0	8 (33.3%)
Score 1	6 (25%)
Score 2	5 (25%)
Score 3	4 (16.7%)
ALT, U/L, mean±SD	50.32±16.17 (19.3-75.8)
AST, U/L, mean±SD	128.275±41.11 (65.1-209)

CG: Control group; TG: Trauma group; T-SG: Trauma–silibinin group; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; SD: Standard deviation.

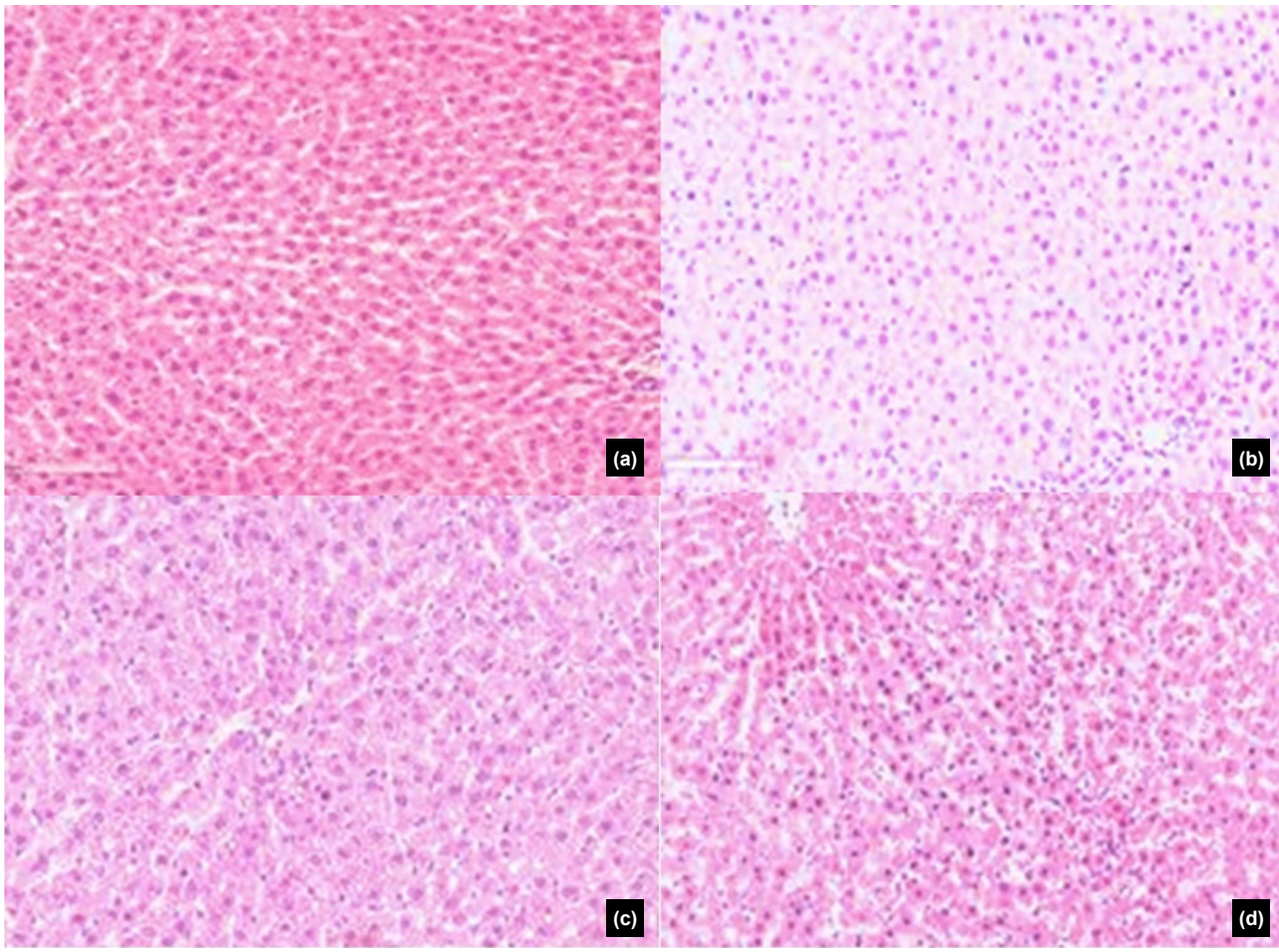

Figure 4. Inflammation scoring in rat liver tissue. **(a)** Score 0, **(b)** Score 1, **(c)** Score 2, and **(d)** Score 3 (H&E stain, ×200 magnification).

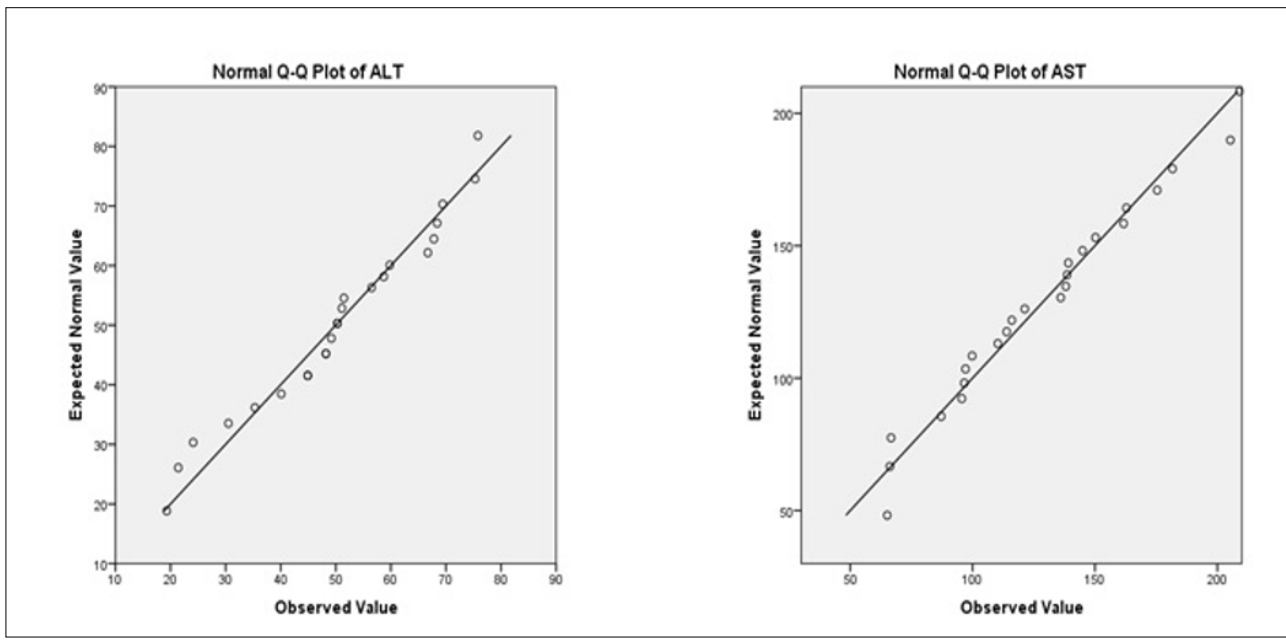

Figure 5. Scatter plot showing the distribution of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels.

Table 3. Comparison of AST and ALT levels among study groups

Parameter	Group			p value	p* (TG vs. T-SG)
	CG	TG	T-SG		
HALT, U/L, mean±SD	34.85±12.55	66.23±7.36	49.85±9.16	<0.001	0.001†
AST, U/L, mean±SD	84.28±15.57	173.87±23.77	126.66±12.46	<0.001	<0.001†

CG: Control group; TG: Trauma group; T-SG: Trauma–silibinin group; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; SD: Standard deviation. p value refers to the comparison among all study groups, whereas p* refers to the comparison between the TG and T-SG groups. †Student's t-test.

Table 4. Comparison of inflammation scores among study groups

Parameter	Group			p value	p* (TG vs. T-SG)	Effect size (r)
	CG	TG	T-SG			
Score 0	8	0	0			
Score 1	0	1	5	p<0.001	0.115χ^2	r=0.41
Score 2	0	4	2			
Score 3	0	3	1			

CG: Control group; TG: Trauma group; T-SG: Trauma–silibinin group. p-value refers to the comparison among all study groups, whereas p* refers to the comparison between the TG and T-SG groups. r=0.41 represents the effect size for the comparison between these two groups. χ^2: Chi-square test.

Table 5. Comparison of inflammation severity and odds ratios among study groups

Group	Low inflammation (Score 0–1)	High inflammation (Score 2–3)	Odds of high inflammation (high/low)	Odds Ratio (vs. T-SG)	p
CG	8	0	0.06*	0.05*	<0.001
TG	1	7	7.00	11.7	<0.001
T-SG	5	3	0.60	Reference	–

CG: Control group; TG: Trauma group; T-SG: Trauma–silibinin group. Inflammation scores were categorized as low (scores 0–1) and high (scores 2–3). Odds ratios (OR) represent the odds of developing high-grade inflammation relative to the T-SG (reference group). p-values were calculated using Fisher's exact test. *A continuity correction was applied because no cases were observed in the CG.

that in the TG. Post hoc Bonferroni analysis indicated that the observed differences were primarily attributable to comparisons between the T-SG and CG, although significant differences were also identified among all three groups. Similarly, the mean AST level was 84.28 U/L in the CG, 173.87 U/L in TG, and 126.66 U/L in the T-SG. The observed difference in AST levels was driven by significant differences among all three groups (Table 3).

The relationship between study groups and inflammation scores was also evaluated. All rats in the CG had an inflammation score of 0. In the TG, one rat had a score of 1, four rats had a score of 2, and three rats had a score of 3. In contrast, inflammation score 1 was the most common finding in the T-SG, occurring in five rats (p<0.001) (Table 4).

To further evaluate the effect of silibinin, the TG and T-SG were compared after excluding the CG. Significant differences were observed in both AST and ALT levels between these groups. The mean AST level was 173.87 U/L in the TG and 126.66 U/L in the T-SG, whereas the mean ALT level was 66.25 U/L and 49.85 U/L, respectively (p<0.001 and p=0.001, respectively).

No statistically significant difference was detected in inflammation score distributions among the groups (p=0.115). Nevertheless, inflammation scores tended to be higher in the TG, with a moderate effect size (r=0.41) (Table 4).

When inflammation scores were categorized as low (scores 0–1) or high (scores 2–3), the odds of developing high-grade inflammation were 11.7 times greater in the TG than in the T-SG. Because no rats in the CG exhibited high-grade inflammation, continuity correction yielded a very low odds value for this group (OR≈0.05) (Table 5).

DISCUSSION

Trauma remains a major public health problem because of its high mortality rates and substantial healthcare costs.[1] Liver injury is among the most common abdominal organ injuries encountered in severe trauma.[4] As the central organ responsible for numerous physiological functions, the liver plays a critical role in nutrient metabolism and immune regulation.[14] Following hepatic injury, hepatocyte proliferation is impaired, whereas inflammation, aging, and ductular reactions increase. Therefore, therapeutic strategies capable of restoring this balance at the cellular level may improve liver recovery.[15] Several experimental studies have explored this area. Mesenchymal stem cell transplantation, as well as supplementation with copper, zinc, multivitamin complexes, and resveratrol, has been reported to promote liver recovery in experimental models.[10,16,17] Milk thistle (Silybum marianum), a member of the Asteraceae family, contains silymarin as its principal compound.[18] Silibinin, the major active constituent of silymarin, is well known for its hepatoprotective properties.[19] In an experimental study published in 2013, Yao et al.[20] demonstrated that silibinin exerted significant therapeutic effects on insulin resistance in a model of non-alcoholic fatty liver disease. Furthermore, several experimental and in vitro studies have shown that silibinin protects against diazinon-induced hepatotoxicity in rats.[21-23] In an experimental study published in 2019, Akbari-Kordkheyli et al.[24] reported that preoperative and postoperative administration of silibinin protected the liver against ischemia–reperfusion injury. The authors suggested that silibinin improves liver circulation by reducing hepatic congestion, suppressing inflammation, and enhancing vasoregulatory gene expression. Serum aminotransferases are highly sensitive markers of hepatocellular injury, with ALT and AST among the most commonly assessed enzymes.[25] Bilgic et al.[26] reported that elevated ALT and AST levels were associated with increased mortality. Furthermore, several animal and clinical studies have demonstrated that higher serum ALT and AST levels after blunt liver trauma correlate with greater injury severity. In the present study, serum ALT and AST levels were measured to evaluate the effects of silibinin on liver recovery following blunt liver trauma. Mean ALT levels were highest in the TG, followed by the T-SG and the CG (ALT mean: TG > T-SG > CG). A similar pattern was observed for AST levels (AST mean: TG > T-SG > CG). Significant differences in both ALT and AST levels were detected among the three groups, and these differences remained significant when only the TG and T-SG were compared (Table 3). These findings suggest that oral administration of silibinin via gastric gavage may attenuate hepatocellular injury and support liver recovery following blunt liver trauma in rats.

Tissue injury caused by trauma, ischemia, infection, autoimmune processes, or toxic exposure primarily affects resident cells and triggers a complex response characterized by immune cell recruitment, cell migration, and cell death. Except during embryonic development, most forms of cell death induce inflammation, which may either exacerbate tissue damage or contribute to tissue repair and fibrosis.[27] In the present study, the degree of inflammation (ID) was assessed histopathologically to evaluate the potential effects of silibinin on liver healing and inflammation. A significant difference in the distribution of inflammation scores was observed among the study groups ($p<0.001$) (Table 4), largely reflecting differences between the control group and the trauma-exposed groups. In the categorical analysis, the odds of developing high-grade inflammation (score ≥2) were approximately 11.7-fold higher in the TG than in the T-SG. These findings suggest that silibinin may exert anti-inflammatory effects following blunt liver trauma, potentially by limiting hepatocellular injury and inflammation. Furthermore, silibinin administered via gastric gavage may support liver healing and reduce inflammation in this experimental rat model of blunt liver trauma. However, these findings should be confirmed in studies with larger sample sizes.

One limitation of this study is the absence of a second control group receiving silibinin without trauma, which could have provided additional information regarding the effects of silibinin on normal liver tissue. Furthermore, the inclusion of additional biochemical markers associated with liver regeneration and repair may have provided a more comprehensive assessment of the mechanisms underlying the observed effects.

CONCLUSION

This study suggests that silibinin may attenuate liver injury and support liver recovery in a rat model of blunt liver trauma. To the best of our knowledge, this is the priority study to investigate the effects of silibinin in an experimental model of blunt liver trauma. Silibinin may have a potential role in reducing inflammation and promoting liver repair following blunt liver injury; however, these findings are preliminary and require confirmation in further clinical investigations.

*This study is derived from the General Surgery specialty training thesis conducted by Alparslan Ertenlice at the Department of General Surgery, Ankara Yıldırım Beyazıt University.

Ethics Committee Approval: Ethical approval was obtained for the animal study. Ankara Training and Research Hospital Animal Experiments Local Ethics Committee (Date: 20.01.2022, Decision No: 0069).

Informed Consent: This study was conducted on animals. All necessary approvals have been obtained.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: A.E., E.G.D., A.C., Z.R.H.; Design: A.E., E.G.D., A.C.; Supervision: A.E., E.G.D., A.Y.; Resource: A.E., E.G.D., O.K., İ.K.; Materials: A.E., E.G.D., S.B.M., B.B.; Data collection and/or processing: A.E., E.G.D., Z.R.H., B.B.; Analysis and/or interpretation: A.E., E.G.D., S.B.M., Z.R.H., B.B.; Literature review: A.E., E.G.D., S.B.M.,

A.Y., O.K.; Writing: A.E., E.G.D., O.K., İ.K.; Critical review: A.E., E.G.D., A.Y., A.C., İ.K.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Brillantino A, Iacobellis F, Festa P, Mottola A, Acampora C, Corvino F, et al. Non-operative management of blunt liver trauma: safety, efficacy and complications of a standardized treatment protocol. Bull Emerg Trauma 2019;7:49–54. [CrossRef]
2. Kochanek KD, Murphy SL, Xu J, Tejada-Vera B. Deaths: Final Data for 2014. Natl Vital Stat Rep 2016;65:1–122.
3. Adıyaman E, Tokur ME, Mermi Bal Z, Gökmen AN, Koca U. Anestezi yoğun bakım ünitesinde takip ve tedavi edilen travma hastalarının retrospektif değerlendirilmesi. Turk J Intensive Care 2019;17:146–53. [CrossRef]
4. Coccolini F, Coimbra R, Ordonez C, Kluger Y, Vega F, Moore EE, et al. Liver trauma: WSES 2020 guidelines. World J Emerg Surg 2020;15:24. [CrossRef]
5. Fodor M, Primavesi F, Morell-Hofert D, Kranebitter V, Palaver A, Braunwarth E, et al. Non-operative management of blunt hepatic and splenic injury: a time-trend and outcome analysis over a period of 17 years. World J Emerg Surg 2019;14:29. [CrossRef]
6. Tinkoff G, Esposito TJ, Reed J, Kilgo P, Fildes J, Pasquale M, et al. American Association for the Surgery of Trauma Organ Injury Scale I: spleen, liver, and kidney, validation based on the National Trauma Data Bank. J Am Coll Surg. 2008;207:646–55. [CrossRef]
7. Federico A, Dallio M, Loguercio C. Silymarin/silybin and chronic liver disease: a marriage of many years. Molecules 2017;22:191. [CrossRef]
8. Tsaroucha AK, Korovesis GN, Valsami G, Lambropoulou M, Kollaras V, Anagnostopoulos C, et al. Silibinin-hydroxypropyl-β-cyclodextrin (SLB-HP-β-CD) complex prevents apoptosis in liver and kidney after hepatic ischemia-reperfusion injury. Food Chem Toxicol 2020;145:111731. [CrossRef]
9. Duran Y, Karaboğa İ. Effect of hesperetin on systemic inflammation and hepatic injury after blunt chest trauma in rats. Biotech Histochem. 2020;95:297–304. [CrossRef]
10. Ayten R, Aygen E, Cerrahoglu YZ, Camci C, Ilhan YS, Girgin M, et al. Effects of copper, zinc, and vitamin complex (Cernevit®) on hepatic healing in rats experimentally subjected to blunt hepatic trauma. Indian J Surg 2015;77(Suppl 3):1045–9. [CrossRef]
11. Zhao J, Agarwal R. Tissue distribution of silibinin, the major active constituent of silymarin, in mice and its association with enhancement of phase II enzymes: implications in cancer chemoprevention. Carcinogenesis 1999;20:2101–8. [CrossRef]
12. Wu JW, Lin LC, Hung SC, Chi CW, Tsai TH. Analysis of silibinin in rat plasma and bile for hepatobiliary excretion and oral bioavailability application. J Pharm Biomed Anal 2007;45:635–41. [CrossRef]
13. Cavalieri B, Perrelli MG, Aragno M, Mastrocola R, Corvetti G, Durazzo M, et al. Ischemic preconditioning attenuates the oxidant-dependent mechanisms of reperfusion cell damage and death in rat liver. Liver Transpl 2002;8:990–9. [CrossRef]
14. Trefts E, Gannon M, Wasserman DH. The liver. Curr Biol 2017;27:R1147-R51. [CrossRef]
15. Campana L, Esser H, Huch M, Forbes S. Liver regeneration and inflammation: from fundamental science to clinical applications. Nat Rev Mol Cell Biol 2021;22:608-24. [CrossRef]
16. Yilmaz N, Yilmaz A, Ilhan Y. Resveratrol ameliorates hepatic injury and modulates hepatic biomarkers of regeneration, apoptosis and survival in a rat model of blunt hepatic trauma. Bratisl Lek Listy 2020;121:512–5. [CrossRef]
17. Tanrıverdi AK, Polat O, Elçin AE, Ahlat O, Gürman G, Günalp M, et al. Mesenchymal stem cell transplantation in polytrauma: Evaluation of bone and liver healing response in an experimental rat model. Eur J Trauma Emerg Surg 2020;46:53–64. [CrossRef]
18. Yavuz A, Göbüt H, Büyükkasap Ç, Dikmen K, Bostancı H, Yalçınkaya A, Cingirt M, Gülbahar Ö, Taşkın Türkmenoğlu T, Dalgıç A. The effect of silymarin given before partial hepatectomy on liver regeneration in rats with ischemic preconditioning during liver resection. Arch Curr Med Res 2022;3:181–6. [CrossRef]
19. Soleimani V, Delghandi PS, Moallem SA, Karimi G. Safety and toxicity of silymarin, the major constituent of milk thistle extract: An updated review. Phytother Res 2019;33:1627–38. [CrossRef]
20. Yao J, Zhi M, Gao X, Hu P, Li C, Yang X. Effect and the probable mechanisms of silibinin in regulating insulin resistance in the liver of rats with non-alcoholic fatty liver. Braz J Med Biol Res 2013;46:270–7. [CrossRef]
21. Beydilli H, Yilmaz N, Cetin ES, Topal Y, Celik OI, Sahin C, Topal H, et al. Evaluation of the protective effect of silibinin against diazinon induced hepatotoxicity and free-radical damage in rat liver. Iran Red Crescent Med J 2015;17:e25310. [CrossRef]
22. Umetsu T, Inoue J, Kogure T, Kakazu E, Ninomiya M, Iwata T, et al. Inhibitory effect of silibinin on hepatitis B virus entry. Biochem Biophys Rep 2018;14:20–5. [CrossRef]
23. Miethe C, Nix H, Martin R, Hernandez AR, Price RS. Silibinin reduces the impact of obesity on invasive liver cancer. Nutr Cancer 2017;69:1272–80. [CrossRef]
24. Akbari-Kordkheyli V, Azizi S, Khonakdar-Tarsi A. Effects of silibinin on hepatic warm ischemia-reperfusion injury in the rat model. Iran J Basic Med Sci 2019;22:789–96.
25. Kobayashi A, Suzuki Y, Sugai S. Specificity of transaminase activities in the prediction of drug-induced hepatotoxicity. J Toxicol Sci 2020;45:515–37. [CrossRef]
26. Bilgic I, Gelecek S, Akgun AE, Ozmen MM. Predictive value of liver transaminases levels in abdominal trauma. Am J Emerg Med 2014;32:705–8. [CrossRef]
27. Mack M. Inflammation and fibrosis. Matrix Biol 2018;68:106–21. [CrossRef]

DENEYSEL ÇALIŞMA - *ÖZ*

Silibininin künt karaciğer travmalı sıçan modelinde karaciğer iyileşmesi üzerindeki etkisi

AMAÇ: Bu araştırma, çeşitli hastalıklarda karaciğer iyileşmesini destekleyen bir madde olan silibininin, künt karaciğer travması modeli kullanılarak karaciğer iyileşme süreci üzerindeki etkilerini değerlendirmeye odaklanmıştır.

GEREÇ VE YÖNTEM: Ortalama ağırlıkları 250-300 g arasında değişen yirmi dört Wistar Albino sıçan, rastgele ve eşit olarak üç gruba ayrıldı: Grup I, II ve III. Grup I, kontrol grubu (CG), travmaya maruz bırakılmadı ve standart beslenme uygulandı. Genel anestezi altında, Grup II ve III'teki sıçanlara sağ üst abdominal kadrana künt travma uygulandı. Grup II'ye, travma grubu (TG), standart beslenme verildi. Grup III, travma-silibinin grubu (T-SG), beş gün boyunca günde 100 mg/kg silibinin mide sondası (gavaj) yoluyla ve standart beslenme ile birlikte aldı. Beş günlük gözlem süresinin ardından, kan örnekleri vena kava inferior üzerinden alındı. Alınan kan örneklerinde serum alanin aminotransferaz (ALT) ve aspartat aminotransferaz (AST) düzeyleri analiz edildi. Karaciğer dokusundaki inflamasyon derecesini değerlendirmek amacıyla histopatolojik inceleme gerçekleştirildi.

BULGULAR: Gruplar arasındaki ortalama AST ve ALT değerlerinin karşılaştırılmasında istatistiksel olarak anlamlı bir fark saptandı ($p<0.001$). Travmatik gruplar (TG ve T-SG) karşılaştırıldığında inflamasyon skorları açısından istatistiksel olarak anlamlı bir farklılık gözlenmedi ($p=0.115$). Ancak, travma grubunda daha yüksek skor eğilimi saptandı ve bu orta düzeyde bir etki büyüklüğüne sahipti ($r=0.41$). Ayrıca, yüksek hasar skoru görülme riski, T-SG grubuna kıyasla travma grubunda 11.7 kat daha fazlaydı.

SONUÇ: Bildiğimiz kadarıyla bu çalışma, silibininin künt karaciğer travmalı sıçan modelindeki etkilerini değerlendiren öncelikli bir araştırmadır. Silibininin, karaciğer travmasında inflamasyonu azaltma ve iyileşmeyi destekleme açısından potansiyel olarak faydalı bir ajan olabileceği düşünülmektedir.

Anahtar sözcükler: Künt travma; iyileşme; karaciğer; silibin; silibinin.

Ulus Travma Acil Cerrahi Derg 2026;32(8):877-884 DOI: 10.14744/tjtes.2026.28866

EXPERIMENTAL STUDY

Comprehensive evaluation of the antioxidant, anti-inflammatory, and anti-apoptotic effects of hydroxytyrosol in skeletal muscle ischemia–reperfusion injury

Tayfun Özdem,[1] Şahin Kaymak,[2] Hakan Kartal,[3] Ertan Demirdaş,[3] Gökhan Erol,[3] Elif Ertaş,[4] Başak Yavuz,[5] Faruk Metin Çomu,[6] Tuna Demirkıran,[1] Muharrem Emre Özdaş,[7] Işıl Taşöz Özdaş,[1] Rahman Şenocak[2]

[1]Department of Cardiovascular Surgery, Gulhane Education and Research Hospital, Ministry of Health, Ankara-*Türkiye*
[2]Department of General Surgery, Gulhane Education and Research Hospital, University of Health Sciences, Ankara-*Türkiye*
[3]Department of Cardiovascular Surgery, Gulhane Education and Research Hospital, University of Health Sciences, Ankara-*Türkiye*
[4]Department of Biostatistics, Selçuk University, Konya-*Türkiye*
[5]Department of Histology and Embryology, Izmir Democracy University Faculty of Medicine, Izmir-*Türkiye*
[6]Department of Physiology, Kirikkale University Faculty of Medicine, Kirikkale-*Türkiye*
[7]Department of Pediatric Cardiovascular Surgery, Etlik City Hospital, Ankara-*Türkiye*

ABSTRACT

BACKGROUND: Skeletal muscle ischemia–reperfusion (I/R) injury is a complex pathological process characterized by excessive reactive oxygen species production, activation of inflammatory cascades, and apoptosis, ultimately resulting in substantial structural and functional tissue damage. Hydroxytyrosol (HT), a naturally occurring phenolic compound predominantly in olive-derived products, exhibits potent antioxidant and anti-inflammatory properties. This study aimed to comprehensively evaluate the potential protective effects of HT against lower-extremity skeletal muscle I/R injury in an experimental rat model.

METHODS: Twenty-four adult Wistar albino rats were randomly assigned to four experimental groups: Sham, HT-Control, I/R, and HT+I/R. Hind-limb ischemia was induced for two hours, followed by two hours of reperfusion. In the treatment group, HT (10 mg/kg, intraperitoneally) was administered 30 minutes before ischemia induction. Serum oxidative stress parameters, including total antioxidant status (TAS), total oxidant status (TOS), and oxidative stress index (OSI), were measured. Skeletal muscle tissues were evaluated histopathologically, and interleukin-1β (IL-1β) levels, caspase-3 expression, and terminal deoxynucleotidyl transferase-mediated dUTP nick-end labeling (TUNEL)-positive apoptotic cells were assessed.

RESULTS: Compared with the Sham group, the untreated I/R group exhibited significantly higher TOS and OSI levels, increased histopathological injury scores, marked inflammatory cell infiltration, and enhanced apoptotic activity ($p<0.05$). HT administration significantly attenuated oxidative stress, reduced inflammatory responses, decreased tissue injury severity, and lowered apoptotic indices compared with the I/R group ($p<0.05$).

CONCLUSION: Hydroxytyrosol exerted significant protective effects against skeletal muscle I/R injury by attenuating oxidative stress, suppressing inflammatory mediators, and reducing apoptosis. These findings highlight the therapeutic potential of HT as a promising adjunctive strategy in the prevention and management of ischemia–reperfusion-induced tissue damage.

Keywords: Apoptosis; hydroxytyrosol; ischemia–reperfusion; oxidative stress; skeletal muscle.

Cite this article as: Özdem T, Kaymak Ş, Kartal H, Demirdaş E, Erol G, Ertaş E, et al. Comprehensive evaluation of the antioxidant, anti-inflammatory, and anti-apoptotic effects of hydroxytyrosol in skeletal muscle ischemia–reperfusion injury. Ulus Travma Acil Cerrahi Derg 2026;32:885-894.

Address for correspondence: Tayfun Özdem
Department of Cardiovascular Surgery, Gulhane Education and Research Hospital, Ministry of Health, Ankara, Türkiye
E-mail: tayfunozdem@yahoo.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):885-864 DOI: 10.14744/tjtes.2025.49540
Submitted: 17.02.2026 Revised: 26.02.2026 Accepted: 14.05.2026 Published: 10.08.2026

INTRODUCTION

Skeletal muscle ischemia–reperfusion (I/R) injury is a major pathological condition encountered in a variety of clinical settings, including vascular surgery, trauma, organ transplantation, and tourniquet application. It may result in substantial tissue damage and functional impairment.[1] During ischemia, interruption of blood flow causes cellular hypoxia. Paradoxically, restoration of blood flow during reperfusion exacerbates tissue injury and contributes to impaired microvascular perfusion.[2]

Reperfusion is associated with excessive production of reactive oxygen species (ROS), leading to disruption of cellular redox homeostasis and activation of inflammatory pathways. Together with intracellular calcium overload and mitochondrial dysfunction, these processes play a central role in the pathogenesis of tissue injury, ultimately leading to cell death through apoptosis and necrosis.[3] Therefore, agents capable of attenuating oxidative stress and inflammation while inhibiting apoptotic pathways have attracted considerable interest as potential therapeutic strategies for skeletal muscle I/R injury.[4]

Hydroxytyrosol (HT) is a major bioactive phenolic compound derived from olive oil and olive leaves and is recognized for its potent free radical–scavenging activity and its ability to modulate inflammatory and apoptotic pathways.[3,5] In skeletal muscle, HT has been reported to ameliorate mitochondrial dysfunction and protect against muscle degeneration.[6] However, studies evaluating the effects of HT on oxidative balance, inflammation, and apoptosis in skeletal muscle I/R injury remain limited.

The present experimental study investigated the protective effects of hydroxytyrosol against ischemia–reperfusion–induced injury in rat hindlimb skeletal muscle. Systemic redox status was assessed by measuring serum total antioxidant status (TAS), total oxidant status (TOS), and oxidative stress index (OSI). Histopathological alterations were evaluated using hematoxylin–eosin staining, inflammatory responses were assessed through interleukin-1β (IL-1β) expression, and apoptotic activity in skeletal muscle tissue was examined by terminal deoxynucleotidyl transferase-mediated dUTP nick-end labeling (TUNEL) staining and caspase-3 activity.

MATERIALS AND METHODS

Ethical Approval and Experimental Animals

Ethical approval for this study was obtained from the Local Ethics Committee of Kobay DHL Inc., Ankara, Türkiye (Approval No. 693; December 8, 2023). All experimental procedures were conducted in accordance with institutional guidelines and current regulations governing the care and use of laboratory animals.

The experimental study was performed at the Experimental Animal Research Facility and completed within a one-week period in December 2023.

Adult male Wistar albino rats weighing 250–300 g were included in the study. Animals were housed under standardized environmental conditions at a temperature of 22±2°C, relative humidity of 50±5%, and a 12-hour light/dark cycle. Standard laboratory chow and water were provided ad libitum. Food was withheld for 12 hour before the experimental procedures.

Surgical Procedure and Ischemia–Reperfusion Model

All experimental procedures were performed in accordance with the Guide for the Care and Use of Laboratory Animals.[7]

Prior to surgical intervention, general anesthesia was induced using ketamine (50–100 mg/kg) and xylazine (10 mg/kg), administered either intramuscularly or intraperitoneally. Body temperature was maintained throughout the procedure using a thermostatically controlled heating pad and an external warming source.

After shaving and sterile preparation of the surgical field, the animals were placed in the supine position. A right inguinal incision was made to expose the femoral vessels, and the femoral artery and vein were carefully dissected free from surrounding connective tissue. To minimize thrombus formation, heparin (100 U/kg) was administered intravenously through the femoral vein in all animals.

Ischemia was induced by applying an atraumatic microvascular clamp to the femoral artery. Successful ischemia was confirmed by limb pallor, cooling, and loss of distal pulse, and absence of pulsation in the distal artery. In the hydroxytyrosol-treated groups, HT (10 mg/kg, intraperitoneally) was administered 30 minutes before ischemia induction.[8]

Following 2 hours of ischemia, the vascular clamp was removed to initiate reperfusion. Restoration of blood flow was confirmed by normalization of limb color and temperature. The incision was closed using 4-0 silk sutures, and the animals were observed for an additional two hours during the reperfusion period.

Experimental Groups and Drug Administration

Animals were randomly assigned to four groups (n=6 per group):

Sham Group: Animals underwent anesthesia and vascular isolation to control for the effects of surgical manipulation; however, no ischemia was induced and no treatment was administered.

HT-Control Group: To assess the potential effects of HT in the absence of ischemia, animals underwent anesthesia and vascular isolation, followed by intraperitoneal administration of HT. No ischemia was induced.

Ischemia–Reperfusion (I/R) Group: Animals were subjected to 120 minutes of hindlimb ischemia followed by 120 minutes of reperfusion without pharmacological treatment.

I/R + Hydroxytyrosol (HT) Group: HT (10 mg/kg, intraperitoneally) was administered 30 minutes before ischemia induction as a prophylactic treatment, followed by the ischemia–reperfusion protocol.

At the end of the reperfusion period, animals were euthanized under deep anesthesia. Blood samples were collected by cardiac puncture for biochemical analyses, including TAS, TOS, and OSI. Plasma was separated by centrifugation and stored at −80°C until analysis.

Gastrocnemius muscle specimens were harvested from the affected hindlimb for histopathological (hematoxylin–eosin staining), immunohistochemical (TUNEL, caspase-3), and biochemical (IL-1β, tissue homogenization) analyses. Tissue samples designated for histopathological and immunohistochemical evaluation were fixed in 10% formalin for subsequent processing and analysis.

Histological Evaluation by Hematoxylin–Eosin Staining

At the end of the experimental period, gastrocnemius muscle specimens were collected and immersed in 10% neutral-buffered formalin for 48 hours to ensure adequate preservation of tissue morphology.

Subsequently, the samples underwent routine histological processing, including stepwise dehydration in ascending concentrations of alcohol followed by xylene clearing. The processed tissues were then embedded in paraffin, and serial sections (5 μm thick) were cut using a microtome (Leica RM 2125RT).

After deparaffinization and rehydration, the tissue sections were stained using a hematoxylin–eosin (H&E) staining kit (ab245880). Microscopic evaluation was performed using a light microscope equipped with a digital camera system (Olympus CX43).

Structural alterations in the muscle tissue were assessed using a semi-quantitative scoring system based on the presence of edema, inflammatory cell infiltration, and necrosis. Each parameter was scored as follows: 0=none, 1=mild, 2=moderate, and 3=severe (Fig. 1).

Caspase-3 Immunohistochemical Analysis

Caspase-3 expression was evaluated immunohistochemically to assess apoptosis in skeletal muscle tissue.

Paraffin-embedded tissue sections (4–5 μm) previously fixed in formalin were cleared in xylene and subsequently rehydrated through graded alcohol concentrations. Heat-induced antigen retrieval was performed in citrate buffer (pH 6.0) using a microwave oven for 15 minutes, after which the slides were allowed to cool to room temperature.

To block endogenous peroxidase activity, sections were treated with 3% hydrogen peroxide (H_2O_2) for 10 minutes. After blocking nonspecific background staining, the slides were incubated overnight at +4°C with an anti-caspase-3 primary antibody (Anti-Caspase-3 [EPR18297], ab184787).

Following rinsing with phosphate-buffered saline (PBS), sections were incubated with a biotinylated secondary antibody and subsequently treated with a streptavidin–peroxidase complex. The antigen–antibody reaction was visualized using 3,3′-diaminobenzidine (DAB) chromogen (UltraView Universal DAB Detection Kit, 5269806001). Finally, the slides were counterstained with Mayer's hematoxylin and coverslipped.

Cells exhibiting brown cytoplasmic and/or nuclear immunoreactivity were considered positive. The apoptotic index was graded semi-quantitatively according to staining intensity and distribution as follows: 0, none; 1, mild; 2, moderate; and 3, severe/diffuse (Fig. 2).[4,9]

IL-1β Immunohistochemical Analysis

IL-1β expression was evaluated as a tissue-level marker of the inflammatory response associated with ischemia–reperfusion injury.

Paraffin sections underwent the same deparaffinization, rehydration, and antigen retrieval procedures described for caspase-3 analysis. After blocking endogenous peroxidase activity, sections were incubated overnight at +4°C with an anti-IL-1β primary antibody (Anti-IL-1 beta [RM1009], ab283818).

Following incubation with the secondary antibody and strep-

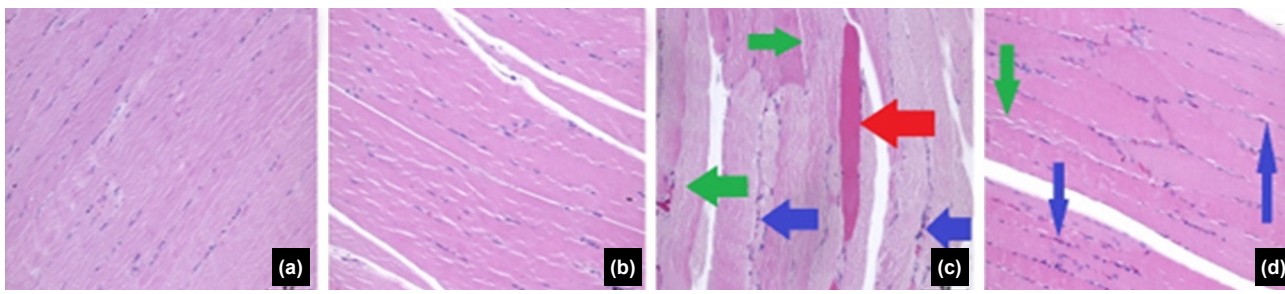

Figure 1. Hematoxylin–eosin histological evaluation of skeletal muscle. Light microscopic images of skeletal muscle sections stained with hematoxylin–eosin (H&E) obtained from the experimental groups. Panels a, b, c, and d correspond to the Sham, HT-Control, I/R, and HT+I/R groups, respectively. Red arrows indicate areas of necrosis, green arrows indicate edema, and blue arrows indicate inflammatory cell infiltration (magnification ×200). HT: Hydroxytyrosol.

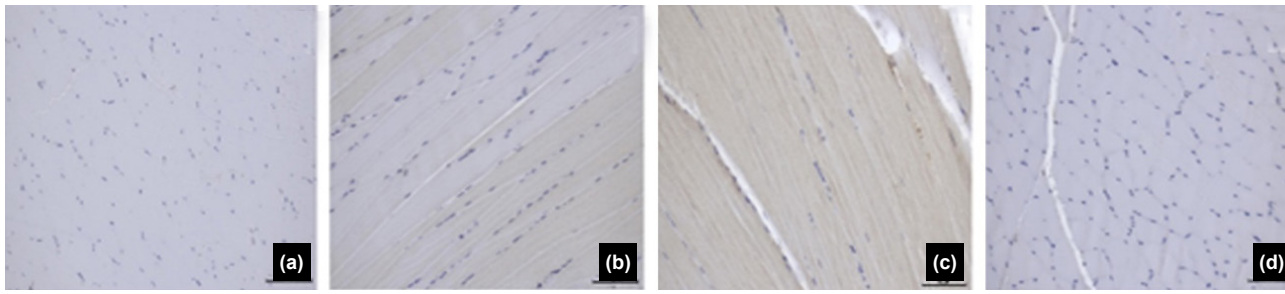

Figure 2. Caspase-3 immunohistochemical evaluation of skeletal muscle. Light microscopic images of skeletal muscle sections immunostained with a primary anti-caspase-3 antibody. Panels a, b, c, and d correspond to the Sham, HT-Control, I/R, and HT+I/R groups, respectively (magnification ×200). HT: Hydroxytyrosol.

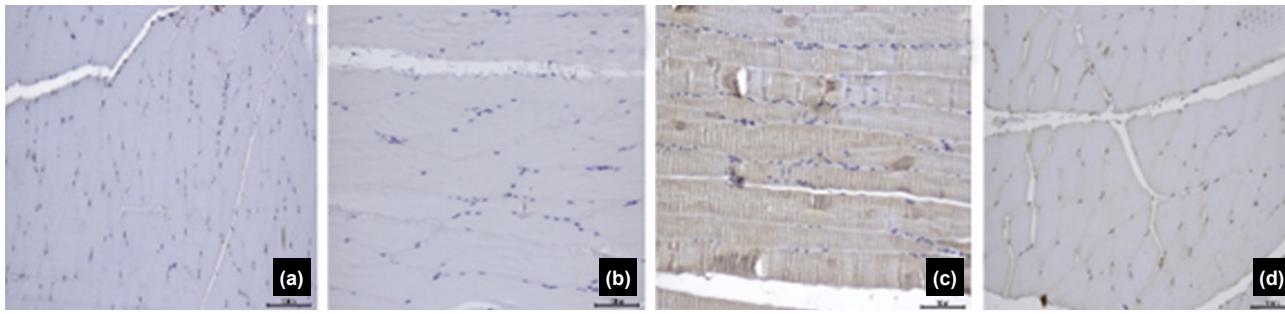

Figure 3. Interleukin-1β immunohistochemical evaluation of skeletal muscle. Light microscopic images of skeletal muscle sections immunostained with a primary anti-interleukin-1β (anti–IL-1β) antibody. Panels a, b, c, and d correspond to the Sham, HT-Control, I/R, and HT+I/R groups, respectively (magnification ×200). HT: Hydroxytyrosol.

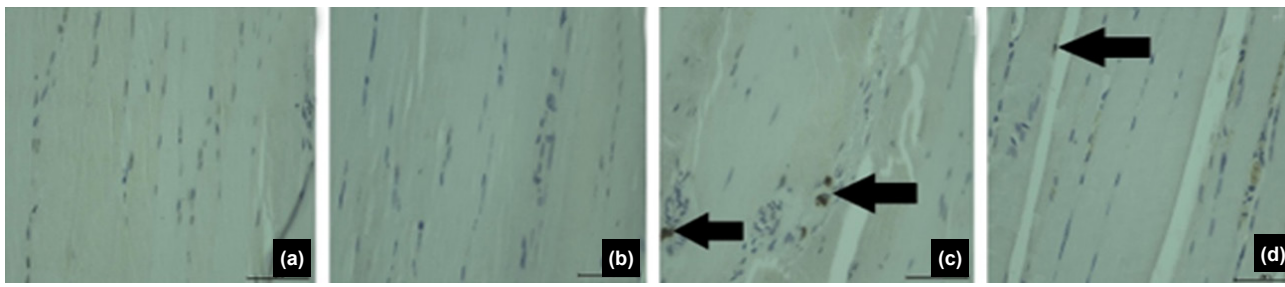

Figure 4. TUNEL immunohistochemical evaluation of skeletal muscle. Light microscopic images of skeletal muscle sections stained using the TUNEL method. Panels A, B, C, and D correspond to the Sham, HT-Control, I/R, and HT+I/R groups, respectively. Black arrows indicate TUNEL-positive apoptotic cells (magnification ×400). HT: Hydroxytyrosol.

tavidin–horseradish peroxidase (HRP), IL-1β immunoreactivity was visualized using DAB chromogen. The slides were counterstained with hematoxylin and evaluated in a blinded manner.

Immunopositive staining observed in inflammatory cells and interstitial regions surrounding muscle fibers was scored as follows: 0, negative; 1, weak; 2, moderate; and 3, strong. Scores were compared among the study groups (Fig. 3).[10]

TUNEL Immunohistochemical Analysis

Apoptotic cell death in skeletal muscle tissue was detected in situ using the TUNEL method.

DNA fragmentation was detected using a commercially available assay kit (ApopTag® Plus Peroxidase In Situ Apoptosis Kit, S7101). Tissue sections were deparaffinized and rehydrated, followed by incubation with proteinase K to enhance membrane permeability and facilitate reagent penetration.

Subsequently, sections were incubated with the TUNEL reaction mixture containing terminal deoxynucleotidyl transferase (TdT) enzyme and labeling solution at 37°C for 60 minutes in a humidified chamber. After washing, a peroxidase-conjugated reagent was applied. Signal development was achieved using DAB chromogen (UltraView Universal DAB Detection Kit, 5269806001).

Cells exhibiting brown nuclear staining were considered TUNEL-positive. For quantitative analysis, five randomly selected microscopic fields from each specimen were evaluated. The apoptotic index (AI) was calculated as the percentage of positively stained cells relative to the total number of cells counted (Fig. 4).[4,9]

Total Antioxidant Status, Total Oxidant Status, and Oxidative Stress Index Analysis

At the end of the experimental protocol, blood samples were collected into plain tubes without a clot activator. Following clot formation, samples were centrifuged at 3,000 g for 10 minutes at +4°C. The separated serum was aliquoted and stored at −80°C until biochemical analysis.

Serum TAS and TOS were measured spectrophotometrically using commercially available automated colorimetric assay kits (TAS: MBS2567994; TOS: MBS2567995).

TAS was determined based on the ability of serum antioxidants to reduce the blue-green 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical cation to its colorless form, with absorbance measured at 660 nm. Results were expressed as mmol Trolox equivalent/L.

For TOS measurement, oxidant molecules in the serum converted the ferrous ion complex to ferric ions under acidic conditions. The resulting color formation was measured at 530 nm and expressed as μmol H_2O_2 equivalent/L.

The OSI, representing the overall oxidant–antioxidant balance, was calculated after conversion of TAS values from mmol to μmol (×1000) to ensure unit compatibility. OSI values were expressed as arbitrary units (AU), calculated using the TOS/TAS ratio.[1]

Statistical Analysis

Sample size was determined using the Mead method, which indicated that six rats per group were sufficient for the Sham, HT-Control, I/R, and HT+I/R groups, yielding a total sample size of 24 animals.

Continuous variables are presented as mean ± standard deviation, whereas categorical variables are expressed as frequencies and percentages.

Differences in TAS, TOS, OSI, and TUNEL values among groups were analyzed using one-way analysis of variance (ANOVA). When overall statistical significance was detected, intergroup comparisons were performed using Tukey's post hoc multiple-comparison test.

Associations between experimental groups and histopathological parameters, including edema, necrosis, inflammatory cell infiltration (ICI), caspase, and IL-1β expression, were evaluated using the chi-square exact test.

A p value <0.05 was considered statistically significant. All analyses were performed using IBM SPSS Statistics version 25.

RESULTS

Biochemical Evaluation

Biochemical findings according to the treatment group are summarized in Table 1.

Mean TOS values were 0.12±0.01 in the Sham group, 0.16±0.02 in the HT-Control group, 0.28±0.03 in the I/R group, and 0.14±0.03 in the HT+I/R group. Overall comparison revealed a significant difference among the groups (p<0.001).

Post hoc analysis demonstrated that TOS levels were significantly higher in the I/R group than in the Sham, HT-Control, and HT+I/R groups (all p<0.05). Furthermore, TOS levels were significantly lower in the Sham group than in the HT-Control and I/R groups (p<0.05). HT treatment significantly reduced TOS levels in the HT+I/R group compared with the untreated I/R group (p<0.05).

Total Antioxidant Status

Mean TAS values were 0.24±0.05 in the Sham group, 0.30±0.03 in the HT-Control group, 0.25±0.03 in the I/R group, and 0.26±0.05 in the HT+I/R group. No statistically significant differences were observed among the groups (p=0.11).

Oxidative Stress Index

Mean OSI values were 0.05±0.01 in the Sham group, 0.06±0.01

Table 1. Comparison of biochemical parameters among experimental groups

Treatment group	TOS (Mean±SD)	TAS (Mean±SD)	OSI (Mean±SD)
Sham (a)	0.12±0.0^{b,c}	0.24±0.05	0.05±0.01^{c}
HT-Control (b)	0.16±0.02^{a,c}	0.30±0.03	0.06±0.01^{c}
I/R (c)	0.28±0.03^{a,b,d}	0.25±0.03	0.11±0.01^{a,b,d}
HT+I/R (d)	0.14±0.03^{c}	0.26±0.05	0.06±0.01^{c}
p	<0.001	0.11	<0.001

SD: Standard deviation; TAS: Total Antioxidant Status. Comparisons among groups were performed using one-way analysis of variance (ANOVA). Different superscript letters (a, b, c, d) indicate statistically significant differences between groups (p<0.05).

in the HT-Control group, 0.11±0.01 in the I/R group, and 0.06±0.01 in the HT+I/R group. Overall comparison demonstrated a significant difference among the groups (p<0.001).

Post hoc analysis showed that OSI levels were significantly higher in the I/R group than in the Sham, HT-Control, and HT+I/R groups (p<0.05). No significant differences were observed among the Sham, HT-Control, and HT+I/R groups (p>0.05).

Histopathological Examination Using Hematoxylin–Eosin Staining

Histopathological findings are presented in Table 2.

Edema

No edema was observed in the Sham and HT-Control groups, with all specimens classified as grade 0. In the I/R group, 83.3% of specimens exhibited grade 2 edema and 16.7% exhibited grade 3 edema. In the HT+I/R group, 83.3% of specimens showed grade 1 edema and 16.7% showed grade 2 edema. Edema severity differed significantly among the groups (p<0.001).

Necrosis

No necrotic changes were observed in the Sham or HT-Control groups, and all specimens were classified as grade 0. In the I/R group, necrosis was graded as 1 in 50% of specimens, 2 in 33.3%, and 3 in 16.7%. The HT+I/R group exhibited the same grading distribution. Overall, necrosis scores differed significantly among the groups (p=0.002).

Inflammatory Cell Infiltration

All animals in the Sham and HT-Control groups were classified as grade 0. In the I/R group, severe infiltration (grade 3) was observed in all animals (100%). In the HT+I/R group, inflammatory cell infiltration was graded as 1 in 33.3% of animals and 2 in 66.7%. A significant association was observed between treatment group and ICI severity (p<0.001).

Immunohistochemical Evaluation

Immunohistochemical findings are summarized in Table 3.

Mean TUNEL-positive cell counts were 1±0 in both the Sham and HT-Control groups, 4.33±2.1 in the I/R group, and 1.33±0.75 in the HT+I/R group. Intergroup comparison demonstrated a significant difference (p<0.001). Post hoc analysis revealed significantly higher TUNEL values in the I/R group than in all other groups (p<0.05).

Caspase-3 Expression

All animals in the Sham and HT-Control groups were classified as grade 0. In the I/R group, all animals (100%) exhibited grade 2 caspase-3 immunoreactivity. In the HT+I/R group, 83.3% of animals were classified as grade 0 and 16.7% as grade 1. Caspase-3 expression differed significantly among the groups (p<0.001).

IL-1β Expression

No IL-1β immunoreactivity was observed in the Sham and HT-Control groups, with all specimens classified as grade 0. In the I/R group, 66.7% of animals exhibited grade 3 staining and 33.3% exhibited grade 2 staining. In the HT+I/R group, 66.7% of animals exhibited grade 1 staining and 33.3% exhibited grade 2 staining. IL-1β expression differed significantly among the groups (p<0.001).

DISCUSSION

The beneficial health effects of olive oil and adherence to the

Table 2. Comparison of histopathological scores among experimental groups

Parameter	Grade	Sham n (%)	HT-Control n (%)	I/R n (%)	HT+I/R n (%)	p
Edema	0	6 (100)	6 (100)	0 (0)	0 (0)	<0.001
	1	0 (0)	0 (0)	0 (0)	5 (83.3)	
	2	0 (0)	0 (0)	5 (83.3)	1 (16.7)	
	3	0 (0)	0 (0)	1 (16.7)	0 (0)	
Necrosis	0	6 (100)	6 (100)	0 (0)	0 (0)	0.002
	1	0 (0)	0 (0)	3 (50)	3 (50)	
	2	0 (0)	0 (0)	2 (33.3)	2 (33.3)	
	3	0 (0)	0 (0)	1 (16.7)	1 (16.7)	
Inflammatory cell infiltration (ICI)	0	6 (100)	6 (100)	0 (0)	0 (0)	<0.001
	1	0 (0)	0 (0)	0 (0)	2 (33.3)	
	2	0 (0)	0 (0)	0 (0)	4 (66.7)	
	3	0 (0)	0 (0)	6 (100)	0 (0)	

Comparisons among groups were performed using the chi-square exact test. A p value <0.05was considered statistically significant.HT: Hydroxytyrosol.

Table 3. Comparison of immunohistochemical findings among experimental groups

Parameter	Sham[a]	HT-Control[b]	I/R[c]	HT+I/R[d]	p
TUNEL-positive cells (Mean±SD)	1±0[c]	1±0[c]	4.33±2.1[a,b,d]	1.33±0.75[c]	<0.001*
Grade 0	6 (100)	6 (100)	0 (0)	5 (83.3)	<0.001†
Grade 1	0 (0)	0 (0)	0 (0)	1 (16.7)	
Grade 2	0 (0)	0 (0)	6 (100)	0 (0)	
Grade 0	6 (100)	6 (100)	0 (0)	0 (0)	<0.001†
Grade 1	0 (0)	0 (0)	0 (0)	4 (66.7)	
Grade 2	0 (0)	0 (0)	2 (33.3)	2 (33.3)	
Grade 3	0 (0)	0 (0)	4 (66.7)	0 (0)	

SD: Standard deviation, HT: Hydroxytyrosol. *Data were analyzed using one-way analysis of variance (ANOVA). †Variables were analyzed using the Chi-square exact test. Different superscript letters (a, b, c, d) indicate statistically significant differences between groups (p<0.05).

Mediterranean diet have been demonstrated in numerous epidemiological studies. Hydroxytyrosol, one of the principal bioactive compounds found in olive products, is characterized by high bioavailability and a favorable safety profile in humans.[11] The European Food Safety Authority (EFSA) has approved a health claim indicating that olive oil polyphenols contribute to the protection of blood lipids from oxidative damage.[5]

In the present study, the protective effects of hydroxytyrosol on oxidative stress, edema, inflammation, necrosis, and apoptosis were evaluated in a rat hindlimb I/R model using histopathological, biochemical, and immunohistochemical analyses. As expected, I/R injury significantly increased OSI, TOS, pro-inflammatory cytokine IL-1β expression, and apoptotic markers, including caspase-3 and TUNEL positivity. Pre-ischemic administration of HT significantly attenuated these pathological alterations, preserved tissue architecture histologically, and reduced the overall oxidative burden.

Ischemia–Reperfusion Pathophysiology and Oxidative Stress

The pathophysiology of I/R injury is characterized by depletion of energy stores during ischemia and paradoxical exacerbation of tissue damage following reperfusion due to excessive generation of reactive oxygen species. During ischemia, intracellular adenosine triphosphate (ATP) levels decline, anaerobic glycolysis increases, and intracellular calcium accumulates. Upon reperfusion, reoxygenation promotes electron leakage from the mitochondrial respiratory chain and activates enzymatic systems such as xanthine oxidase, resulting in a surge of cytotoxic ROS, including superoxide anion, hydrogen peroxide, and hydroxyl radicals.[7,4]

In the present study, significantly elevated TOS and OSI levels in the I/R group compared with the Sham group confirm the oxidative stress induced by reperfusion. Oxidative stress promotes membrane damage through peroxidation of polyunsaturated fatty acids within phospholipid bilayers, thereby compromising cellular integrity. Previous studies have consistently reported increased levels of lipid peroxidation by-products, such as malondialdehyde (MDA), in experimental I/R models.[12]

The significantly lower TOS and OSI levels observed in the HT+I/R group compared with the untreated I/R group, approaching those of the Sham group, demonstrate the potent antioxidant effects of HT.

Although TAS values did not differ significantly among the groups (p=0.11), this finding is consistent with previous observations. During the early phase of I/R injury, antioxidant reserves may be rapidly consumed as part of the cellular defense response to oxidative stress. The reduction in TOS without a corresponding increase in TAS suggests that HT may not primarily enhance systemic antioxidant capacity. Rather, HT appears to suppress excessive ROS production at its source or directly scavenge free radicals, thereby reducing the overall oxidant burden. Previous studies have demonstrated that HT decreases mitochondrial ROS generation and preserves mitochondrial membrane potential, thereby limiting oxidative damage.[8,13] This mechanism may explain the reduced OSI values observed in the present study. Because OSI reflects the balance between oxidants and antioxidants, the reduction in OSI is likely attributable to the ability of HT to decrease the oxidant component of this ratio.

Modulation of the Inflammatory Response and IL-1β Expression

Oxidative imbalance associated with skeletal muscle I/R injury triggers a non-infectious inflammatory response. Excessive ROS generation activates transcriptional regulators that promote the expression of pro-inflammatory cytokines.[14,15] In the present study, marked IL-1β immunoreactivity in the I/R group indicated activation of this inflammatory pathway. As a key mediator of the early inflammatory response, IL-1β promotes leukocyte recruitment and amplifies tissue injury. Consistent with these findings, the substantial inflammatory cell infiltration and edema observed histologically in the I/R

group likely represent local tissue manifestations of cytokine-mediated inflammation.

Previous studies have suggested that the anti-inflammatory effects of HT are mediated, at least in part, through inhibition of the nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB) signaling pathway. Activated by oxidative stress and cytokines, NF-κB induces the transcription of pro-inflammatory mediators, including tumor necrosis factor-alpha (TNF-α), IL-1β, IL-6, inducible nitric oxide synthase (iNOS), and cyclooxygenase-2 (COX-2).[16,17] In the present study, the significant reductions in IL-1β immunostaining scores and histopathological indicators of inflammation, including ICI and edema, in the HT-treated group support the anti-inflammatory effects of HT.

Prevention of Apoptosis and Cell Death

Cell death following I/R injury occurs primarily through necrosis and apoptosis. Whereas necrosis is typically associated with severe ischemic damage, apoptosis is a regulated process that is predominantly activated during reperfusion and contributes to the loss of potentially viable tissue.[3,18]

In the present study, the I/R group exhibited marked increases in both TUNEL positivity, indicative of DNA fragmentation, and caspase-3 expression, a key executor of apoptosis. These findings demonstrate that reperfusion injury induces a substantial apoptotic response in skeletal muscle tissue.

During I/R injury, opening of the mitochondrial permeability transition pore (mPTP) facilitates the release of cytochrome c into the cytoplasm, leading to the sequential activation of caspase-9 and caspase-3. Previous studies have demonstrated that HT modulates the mitochondrial apoptotic pathway.[19] In the present study, HT treatment reduced both TUNEL-positive cell counts and caspase-3 immunostaining intensity to levels comparable to those observed in the Sham group. These findings suggest that HT exerts not only antioxidant but also potent anti-apoptotic effects.

Skeletal Muscle Integrity and Mitochondrial Function

Studies investigating the effects of HT on exercise physiology have demonstrated its role in regulating muscle metabolism and enhancing resistance to fatigue. Skeletal muscle is a highly energy-dependent tissue whose function is closely linked to mitochondrial capacity. I/R injury leads to structural disorganization of muscle fibers, sarcomere damage, and ultimately necrosis.[20]

The histopathological improvement and reduction in necrosis observed in the present study may be attributable to the preservation of mitochondrial integrity and attenuation of the cellular energy deficit induced by injury. These findings suggest that HT acts not only as a local antioxidant but also as a bioactive molecule capable of modulating cellular metabolism and energy balance.

Systemic Implications

The findings of the present study are consistent with previously reported protective effects of HT in I/R injury affecting other organ systems. In myocardial I/R models, HT has been shown to reduce infarct size.[8,21] In hepatic I/R injury, HT exerts hepatoprotective effects by enhancing antioxidant enzyme activity and suppressing inflammation.[22] Similarly, in renal I/R injury, HT has been reported to attenuate acute kidney injury and preserve renal function.[23]

The consistency between the findings of the present study and those reported in other organ systems suggests that the protective effects of HT are not tissue-specific but rather result from modulation of fundamental cellular pathological mechanisms, including oxidative stress, inflammation, and mitochondrial dysfunction.

CONCLUSION

Hydroxytyrosol demonstrated significant protective effects against lower-extremity ischemia–reperfusion injury in rats. Biochemical analyses revealed that HT treatment significantly reduced oxidative stress, as evidenced by lower TOS and OSI values. Histopathological and immunohistochemical evaluations further demonstrated reductions in tissue necrosis, edema, inflammatory cell infiltration, IL-1β expression, and apoptotic markers, including caspase-3 and TUNEL positivity, in the HT+I/R group compared with the untreated I/R group.

These findings indicate that HT protects skeletal muscle tissue from reperfusion-induced injury through redox-modulating, anti-inflammatory, and anti-apoptotic mechanisms. HT may therefore represent a promising adjunctive therapeutic strategy in clinical settings associated with I/R injury, including vascular surgery, trauma, and organ transplantation. Nevertheless, further studies investigating different dosing regimens, administration timing (during ischemia or at the onset of reperfusion), and long-term outcomes are needed before these findings can be translated into clinical practice.

Limitations

This study has several limitations. First, only a single dose of HT (10 mg/kg) and a single administration time point were evaluated; therefore, dose–response relationships and the efficacy of post-reperfusion administration could not be assessed. Second, although the effects of HT on oxidative stress and inflammation were demonstrated, the underlying molecular signaling pathways were not investigated in detail. Finally, because this study was conducted in an experimental animal model, additional well-designed clinical studies are required to determine the translational relevance of these findings in humans.

Ethics Committee Approval: Ethical approval for this study was obtained from the Local Ethics Committee of Kobay DHL Inc., Ankara, Türkiye (Date: 08.12.2023, Decision No: 693).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: T.Ö., S.K., H.T.Ö.; Design: T.Ö., S.K., H.K.; Supervision: H.K., T.B.; Resource: T.Ö.; Materials: M.E.Ö., H.T.Ö., E.D., G.Ü., H.K.; Data collection and/or processing: E.E., B.K., F.M.G., R.S.; Analysis and/or interpretation: E.E., B.K., F.M.G.; Literature review: E.D., H.K., T.B.; Writing: T.Ö., H.K., G.Ü., R.S.; Critical review: G.Ü., E.D., H.T.Ö., M.E.Ö.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Demirdaş E, Arslan G, Kartal H, Erol G, Özdem T, Yavuz BB, et al. Melatonin as a shield against skeletal muscle damage: A study on ischemia-reperfusion injury. Ulus Travma Acil Cerrahi Derg 2025;31:103–11. [CrossRef]
2. Kartal H, Kaymak Ş, Şenocak R, Demirdaş E, Demirkıran T, Özdem T, et al. Investigation of the protective effects of hydroxytyrosol on erythrocyte deformability during hind limb ischemia-reperfusion injury in rats. Ulus Travma Acil Cerrahi Derg 2026;32:118–27. [CrossRef]
3. Batarfi WA, Yunus MHM, Hamid AA, Lee YT, Maarof M. Hydroxytyrosol: a promising therapeutic agent for mitigating inflammation and apoptosis. Pharmaceutics 2024;16:1504. [CrossRef]
4. Fang Q, Zhang Y, Jiang DS, Chen Y. Hydroxytyrosol inhibits apoptosis in ischemia/reperfusion-induced acute kidney injury via activating Sonic Hedgehog signaling pathway. Eur Rev Med Pharmacol Sci 2020;24:12380–8.
5. Velotti F, Bernini R. Hydroxytyrosol interference with inflammaging via modulation of inflammation and autophagy. Nutrients 2023;15:1774. [CrossRef]
6. Wang X, Li H, Zheng A, Yang L, Liu J, Chen C, et al. Mitochondrial dysfunction-associated OPA1 cleavage contributes to muscle degeneration: preventative effect of hydroxytyrosol acetate. Cell Death Dis 2014;5:e1521. [CrossRef]
7. Miao J, Huang Z, Liu S, Li X, Jia P, Guo Y, et al. Hydroxytyrosol protects against myocardial ischemia reperfusion injury by inhibiting mitochondrial permeability transition pore opening. Exp Ther Med 2019;17:671–8. [CrossRef]
8. Bermudez-Oria A, Godoy E, Perez V, Musci Ferrari C, Donato M, Fernandez-Bolanos J, et al. Unveiling the cardioprotective potential of hydroxytyrosol: Insights from an acute myocardial infarction model. Antioxidants (Basel) 2025;14:803. [CrossRef]
9. Pei YH, Chen J, Xie L, Cai XM, Yang RH, Wang X, et al. Hydroxytyrosol protects against myocardial ischemia/reperfusion injury through a PI3K/Akt-dependent mechanism. Mediators Inflamm 2016;2016:1232103. [CrossRef]
10. Fusco R, Cordaro M, Siracusa R, D'Amico R, Genovese T, Gugliandolo E, et al. Biochemical evaluation of the antioxidant effects of hydroxytyrosol on pancreatitis-associated gut injury. Antioxidants (Basel) 2020;9:781. [CrossRef]
11. Ditano-Vázquez P, Torres-Peña JD, Galeano-Valle F, Pérez-Caballero AI, Demelo-Rodríguez P, Lopez-Miranda J, et al. The fluid aspect of the mediterranean diet in the prevention and management of cardiovascular disease and diabetes: the role of polyphenol content in moderate consumption of wine and olive oil. Nutrients 2019;11:2833. [CrossRef]
12. Colica C, Di Renzo L, Trombetta D, Smeriglio A, Bernardini S, Ciocoloni G, et al. Antioxidant effects of a hydroxytyrosol-based pharmaceutical formulation on body composition, metabolic state, and gene expression: a randomized double-blinded, placebo-controlled crossover trial. Oxid Med Cell Longev 2017;2017:2473495. [CrossRef]
13. Kitsati N, Mantzaris MD, Galaris D. Hydroxytyrosol inhibits hydrogen peroxide-induced apoptotic signaling via labile iron chelation. Redox Biol 2016;10:233–42. [CrossRef]
14. Wen X, Wan F, Zhong R, Chen L, Zhang H. Hydroxytyrosol alleviates intestinal oxidative stress by regulating bile acid metabolism in a piglet model. Int J Mol Sci 2024;25:5590. [CrossRef]
15. Echeverría F, Ortiz M, Valenzuela R, Videla LA. Hydroxytyrosol and cytoprotection: a projection for clinical interventions. Int J Mol Sci 2017;18:930. [CrossRef]
16. Morvaridzadeh M, Alami M, Berrougui H, Boumezough K, Sidibé H, Salih I, et al. Polyphenol-microbiota interactions in atherosclerosis: the role of hydroxytyrosol and tyrosol in modulating inflammation and oxidative stress. Nutrients 2025;17:3784. [CrossRef]
17. Zubair H, Bhardwaj A, Ahmad A, Srivastava SK, Khan MA, Patel GK, et al. Hydroxytyrosol induces apoptosis and cell cycle arrest and suppresses multiple oncogenic signaling pathways in prostate cancer cells. Nutr Cancer 2017;69:932–42. [CrossRef]
18. Reyes-Corral M, Gil-González L, González-Díaz Á, Tovar-Luzón J, Ayuso MI, Lao-Pérez M, et al. Pretreatment with oleuropein protects the neonatal brain from hypoxia-ischemia by inhibiting apoptosis and neuroinflammation. J Cereb Blood Flow Metab 2025;45:717–34. [CrossRef]
19. Sirangelo I, Liccardo M, Iannuzzi C. Hydroxytyrosol prevents doxorubicin-induced oxidative stress and apoptosis in cardiomyocytes. Antioxidants (Basel) 2022;11:1087. [CrossRef]
20. Casuso RA, Al Fazazi S, Plaza-Díaz J, Ruiz-Ojeda FJ, Rueda-Robles A, Aragón-Vela J, et al. Physiological doses of hydroxytyrosol modulate gene expression in skeletal muscle of exercised rats. Life (Basel) 2021;11:1393. [CrossRef]
21. Wu LX, Xu YY, Yang ZJ, Feng Q. Hydroxytyrosol and olive leaf extract exert cardioprotective effects by inhibiting GRP78 and CHOP expression. J Biomed Res 2018;32:371–9. [CrossRef]
22. Silva AFR, Resende D, Monteiro M, Coimbra MA, Silva AMS, Cardoso SM. Application of hydroxytyrosol in the functional foods field: from ingredient to dietary supplements. Antioxidants (Basel) 2020;9:1246. [CrossRef]
23. Pastor R, Bouzas C, Tur JA. Beneficial effects of dietary supplementation with olive oil, oleic acid, or hydroxytyrosol in metabolic syndrome: Systematic review and meta-analysis. Free Radic Biol Med 2021;172:372–85. [CrossRef]

DENEYSEL ÇALIŞMA - *ÖZ*

İskelet kası iskemi–reperfüzyon hasarında hidroksitirozolün antioksidan, anti-enflamatuvar ve anti-apoptotik etkilerinin kapsamlı değerlendirilmesi

AMAÇ: İskelet kası iskemi-reperfüzyon (I/R) hasarı; reaktif oksijen türlerinin aşırı üretimi, enflamatuvar yanıtın aktivasyonu ve apoptoz ile karakterize, sonuçta belirgin yapısal ve fonksiyonel doku hasarına yol açan karmaşık bir patolojik süreçtir. Zeytin ve zeytin ürünlerinde doğal olarak bulunan fenolik bir bileşik olan hidroksitirozol (HT), güçlü antioksidan ve antienflamatuvar özelliklere sahiptir. Bu çalışmada, alt ekstremite iskelet kası I/R hasarı oluşturulan deneysel sıçan modelinde HT'nin olası koruyucu etkilerinin kapsamlı olarak değerlendirilmesi amaçlandı.

GEREÇ VE YÖNTEM: Yirmi dört erişkin Wistar albino sıçan rastgele dört gruba ayrıldı: Sham, HT-kontrol, I/R ve HT+I/R. Arka ekstremitede 2 saat iskemi ve ardından 2 saat reperfüzyon uygulandı. Tedavi grubunda, iskemi indüksiyonundan 30 dakika önce HT (10 mg/kg, intraperitoneal) uygulandı. Serum total antioksidan kapasite (TAS), total oksidan durum (TOS) ve oksidatif stres indeksi (OSI) ölçüldü. İskelet kası dokuları histopatolojik olarak incelendi; ayrıca interlökin-1β (IL-1β), kaspaz-3 ekspresyonu ve TUNEL-pozitif apoptotik hücreler değerlendirildi.

BULGULAR: Tedavi uygulanmayan I/R grubunda, Sham grubuna kıyasla TOS ve OSI düzeyleri, histopatolojik hasar skorları, enflamatuvar hücre infiltrasyonu ve apoptotik aktivite anlamlı derecede artmıştı ($p<0.05$). HT uygulaması, I/R grubuna göre oksidatif stres belirteçlerini, enflamatuvar yanıtı, doku hasarının şiddetini ve apoptotik indeksleri anlamlı olarak azalttı ($p<0.05$).

SONUÇ: Hidroksitirozol, oksidatif stresi azaltarak, enflamasyonu baskılayarak ve apoptozu inhibe ederek iskelet kası I/R hasarına karşı belirgin koruyucu etki göstermiştir. Bu bulgular, HT'nin iskemi-reperfüzyona bağlı doku hasarının önlenmesi ve tedavisinde umut verici bir yardımcı tedavi stratejisi olabileceğini düşündürmektedir.

Anahtar sözcükler: Apoptozis; hidroksitirozol; iskemi-reperfüzyon; iskelet kası; oksidatif stres.

Ulus Travma Acil Cerrahi Derg 2026;32(8):885-894 DOI: 10.14744/tjtes.2025.49540

EXPERIMENTAL STUDY

Effects of topical Turkish propolis on burn wound healing in an experimental burn model

Esra Ardahan Akgül,[1] Figen Yardımcı,[2] Derya Demir,[3] Fahri Emrah Soylu[4]

[1]Department of Nursing, İzmir Katip Çelebi University, Faculty of Health Sciences, İzmir-*Türkiye*
[2]Department of Pediatric Nursing, Ege University Faculty of Nursing, İzmir-*Türkiye*
[3]Department of Medical Pathology, Ege University Faculty of Medicine, İzmir-*Türkiye*
[4]Ege University, Laboratory Animals Application and Research Center İzmir-*Türkiye*

ABSTRACT

BACKGROUND: Burns are a leading cause of accident-related mortality, following motor vehicle accidents and drowning. Burn wound healing is influenced by several factors, including the degree, depth, and cause of the burn. This study aimed to compare and evaluate the effects of 1% silver sulfadiazine, 0.2% nitrofurazone, propolis vehicle, 10% water-soluble propolis, and 15% water-soluble propolis on partial-thickness burn wound healing using histopathological assessment.

METHODS: In this randomized controlled experimental study, rats were randomly assigned to six groups: control, silver sulfadiazine, nitrofurazone, propolis vehicle, 10% water-soluble propolis, and 15% water-soluble propolis. The animals were anesthetized before burn induction. Four contact burns were created on each rat, and wound areas were measured and recorded. Tissue samples were collected from the wound sites for histopathological examination.

RESULTS: Rats treated with 15% water-soluble propolis had significantly smaller wound areas on days 7 (p=0.019 and p=0.047), 14 (p=0.01 and p=0.033), and 21 (p=0.00 and p=0.040) compared with the control and propolis vehicle groups, respectively. Histopathological evaluation on day 14 revealed differences favoring the propolis-treated groups in terms of fibroblast proliferation, collagen deposition, fibrosis, and mononuclear cell infiltration (p=0.017).

CONCLUSION: The application of water-soluble propolis to burn wounds in rats appears to promote wound healing.

Keywords: Apitherapy; burns; dressing; nursing; propolis; wound healing.

INTRODUCTION

Burn injury is one of the leading causes of accident-related mortality worldwide, following motor vehicle accidents and drowning incidents.[1] Hospitalization due to burns can significantly impair patients' quality of life.[2,3] Burn wound healing is a complex biological process consisting of four sequential phases: hemostasis, inflammation, proliferation, and maturation.[4] Several factors influence burn wound healing, including the degree, depth, and cause of the burn injury.[5] Burn dressings are applied for three primary purposes: to absorb wound exudate, control pain, and prevent infection.[6] In addition, appropriate dressings accelerate epithelialization, facilitate the removal of necrotic tissue, protect newly regenerated skin,[7] and help prevent biofilm formation.[8] Silver sulfadiazine and nitrofurazone are among the most commonly used topical agents in the conventional treatment of burn wounds.[9,10]

However, concerns regarding the adverse effects associated with silver sulfadiazine and nitrofurazone have increased interest in biogenic products with antimicrobial, regenerative, and analgesic properties for burn wound management.[11] One

Cite this article as: Ardahan Akgül E, Yardımcı F, Demir D, Soylu FE. Effects of topical Turkish propolis on burn wound healing in an experimental burn model. Ulus Travma Acil Cerrahi Derg 2026;32:895-907.

Address for correspondence: Esra Ardahan Akgül
Department of Nursing, İzmir Katip Çelebi University, Faculty of Health Sciences, İzmir, Türkiye
E-mail: esra.ardahan@ikcu.edu.tr

Ulus Travma Acil Cerrahi Derg 2026;32(8):895-907 DOI: 10.14744/tjtes.2026.17258
Submitted: 23.07.2025 Revised: 09.01.2026 Accepted: 12.02.2026 Published: 10.08.2026

such product is propolis, a substance collected and processed by honey bees.[12-16]

The beneficial effects of propolis on burn wound healing were first reported by Khachaturov and Gudkov.[17] Since then, several studies have investigated the effects of topical propolis on skin burn wounds.[18-20] Olczyk et al.[21] reported that propolis promotes wound healing and may serve as a promising apitherapeutic agent for topical burn treatment. Almeida et al.[22] evaluated two different types of propolis (green and red) and observed reduced inflammation and accelerated epithelialization in the propolis-treated groups. Jastrzębska-Stojko et al.[11] demonstrated that a 1% and 3% honey–propolis mixture increased hydroxyproline and collagen levels compared with silver sulfadiazine and normal saline. Furthermore, propolis dressings have been shown to enhance epithelialization, collagen deposition, and angiogenesis.[23,24] In corneal injury models, rabbits treated with propolis exhibited smaller corneal epithelial defects.[25,26] Similar beneficial effects have been reported in burn wounds. Nevertheless, evidence regarding the optimal dosage and clinical effectiveness of propolis remains limited, highlighting the need for further research to establish its therapeutic value.[27]

The distinguishing feature of the present study is the evaluation of water-soluble propolis at different concentrations in an experimental burn model.

Therefore, the aim of this randomized controlled experimental study was to compare the effects of propolis vehicle (water and glycol), 1% silver sulfadiazine, 0.2% nitrofurazone, 10% water-soluble propolis, and 15% water-soluble propolis on the healing of partial-thickness burn wounds in an experimental rat model.

MATERIALS AND METHODS

Hypotheses

H1: In the experimental burn model, wound area measurements differ among wounds treated with propolis vehicle, 1% silver sulfadiazine, 0.2% nitrofurazone, and water-soluble propolis.

H2: In the experimental burn model, histological scores differ among wounds treated with propolis vehicle, 1% silver sulfadiazine, 0.2% nitrofurazone, and water-soluble propolis.

Study Design

This randomized clinical trial was conducted at the Laboratory Animals Application and Research Center using a rat burn model (Fig. 1).

The primary outcome measures were wound area measurements and histological scores. Independent variables included body weight, age, and dressing material applied to the rats.[28] The study was conducted in accordance with the Animal Research: Reporting of In Vivo Experiments (ARRIVE) guidelines and was registered at the U.S. National Library of Medicine Clinical Trials (Identifier: NCT04277182).

Sample

The inclusion criteria for the rats were as follows:

- Certified as healthy by the attending veterinarian;
- Body weight between 200 and 400 g;
- Age between 8 and 9 weeks;
- Wistar albino rats (Rattus norvegicus);
- Fed a standard diet with free access to water and food (ad libitum);
- Housed in a controlled environment at 28°C under a 12-hour light/dark cycle;
- Individually housed to prevent damage to each other's burn wounds.

The minimum sample size was calculated as five rats per group (total n=30) using a significance level of α=0.05, statistical power of 80%, and an effect size of 0.65 (G*Power version 3.1.9.4.).[29] To compensate for potential attrition during the study, one additional rat was included in each group, resulting in a total sample of 36 rats (18 females and 18 males). Three rats died from burn shock on the first day of the study, and three additional rats died due to anesthesia-related complications on day 3. Consequently, the study was completed with 30 rats.

Burn Wound Induction

The study commenced after the rats had been acclimatized to the laboratory environment and the researcher for one week.

Randomization was performed using the Random Sequence Generator available at www.random.org. No stratification was used.

Prior to burn induction and subsequent procedures (days 0, 3, 7, 14, and 21), rats were anesthetized intraperitoneally with ketamine (75 mg/kg) and xylazine (15 mg/kg). Following anesthesia, the dorsal area of each rat was shaved using a sterile disposable razor and disinfected with povidone-iodine solution. Partial-thickness burn wounds were induced using a brass block with a circular diameter of 7 mm. Contact burns produced by a brass block have been reported to provide greater consistency than scald burns.[30] The brass block was immersed in boiling water for 3 minutes and then applied to the dorsal skin for 10 seconds using only its own weight, without additional pressure.[30] To avoid altering the wound-healing process through repeated biopsies from a single wound site, four burn wounds were created on the dorsum of each rat, with approximately 1 cm between wound sites. The brass block was reheated in boiling water for 3 minutes before each burn induction (Fig. 2).

Following the procedures, analgesia was provided via intra-

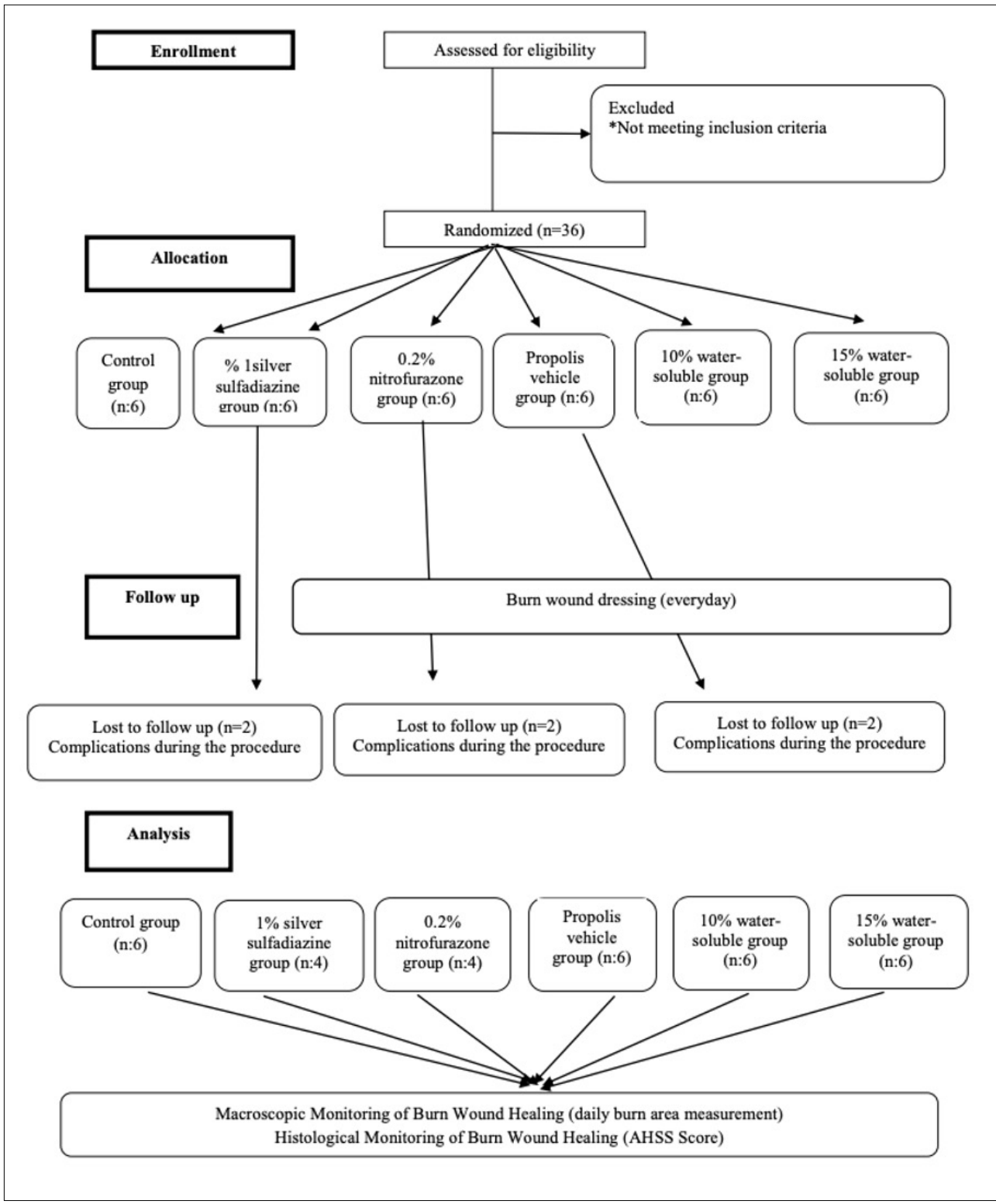

Figure 1. Flowchart of the study design and research procedures.

peritoneal administration of paracetamol (25 mg/kg) on days 0, 1, 2, 3, 7, and 14.[31] The anesthesia and analgesia protocols were determined by the attending veterinarian at the Laboratory Animals Research Center.

Burn Wound Dressing

The designated dressing material was applied daily to the burn wounds of rats in the intervention groups and covered with sterile gauze.

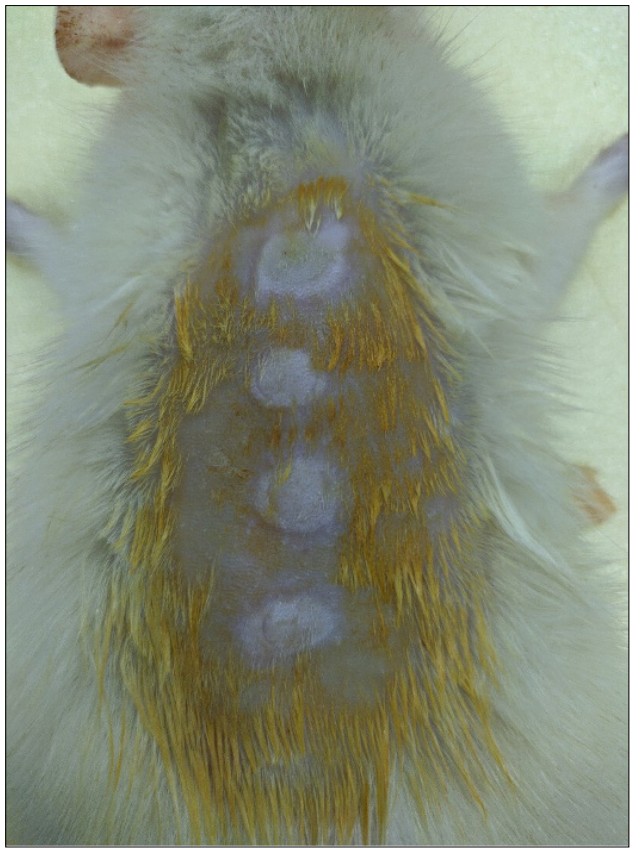

Figure 2. Image of a rat with experimentally induced burn wounds.

Burn Wound Dressing Materials

1% Silver Sulfadiazine: A white, opaque antibacterial cream containing 10 mg of silver sulfadiazine per gram of cream.

0.2% Nitrofurazone: A semi-transparent, lemon-yellow antibacterial cream containing 0.2% nitrofurazone.

Propolis Vehicle: The vehicle used in the 10% and 15% water-soluble propolis formulations consisted of a water–glycol mixture. A BEEO® product (SBS Bilimsel Bio Çözümler Company, Istanbul Technical University, Türkiye) was used as the vehicle.

10% Water-Soluble Propolis: This formulation contains a total phenolic content of 42.0 mg/mL, a total flavonoid content of 52.0 mg/mL, and an antioxidant capacity of 111.4 mg/mL. Each milliliter contains 100 mg of pure propolis (SBS Bilimsel Bio Çözümler Company, Istanbul Technical University, Türkiye).

15% Water-Soluble Propolis: This formulation contains a total phenolic content of 61.6 mg/mL, a total flavonoid content of 69.3 mg/mL, and an antioxidant capacity of 150.6 mg/mL. Each milliliter contains 150 mg of pure propolis. Information regarding antioxidant capacity was obtained directly from the manufacturer. No financial support was received from BEEO for the provision of study products (SBS Bilimsel Bio Çözümler Company, Istanbul Technical University, Türkiye).

Monitoring of Burn Wound Healing

Macroscopic wound healing was evaluated by daily measurement of wound areas using the ImitoWound mobile application.

Histological Evaluation of Burn Wound Healing

For histological assessment, tissue samples were collected from the burn wounds on days 3, 7, 14, and 21 using a sterile disposable 8-mm punch biopsy device (Acu Punch®, Acuderm Inc., USA). Samples were fixed in 10% formalin. Burn wound healing was evaluated using Abramov's Histological Scoring System (AHSS). Histological sections were examined under light microscopy, and scores were assigned based on mononuclear cell infiltration, neutrophil density, collagen deposition, angiogenesis, and fibroblast proliferation. The overall histological score was calculated as the sum of these individual parameters.[32] Although epithelialization and granulation tissue formation are included in the original scoring system, these parameters were excluded because they were not observed during wound healing in the rat model. Instead, fibroblast proliferation, which plays a crucial role in wound contraction and healing in rats, was included in the assessment.[33] A single-blind design was used for histopathological assessment. The pathologist evaluating the biopsy specimens was blinded to group assignment.

Sacrifice of the Animals

At the end of the study, all rats were euthanized by administration of ketamine (200 mg/kg).

Data Analysis

Data were analyzed using IBM SPSS Statistics version 22. Descriptive variables were presented as frequencies and percentages. The distribution of burn wound area measurements and histological scores was evaluated using the Kolmogorov–Smirnov test for normality. The Kruskal–Wallis test was used to compare quantitative variables among the groups. When significant differences were identified, pairwise comparisons were performed using the Bonferroni test. A p value ≤0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the principles of animal welfare and the 5R framework for animal experimentation proposed by William Russell and Rex Burch.[34] The research protocol was approved by the Ege University Animal Experiments Local Ethics Committee (Approval No. 2019-048; Date: 05/22/2019).

RESULTS

Baseline Data

The mean body weight of the rats was 289.17±46.79 grams, and the mean baseline wound area was 0.47±0.037 cm². There were no statistically significant differences among the groups in terms of body weight before burn induction. Similarly, no significant differences were observed in wound area measurements obtained immediately after burn induction and before the first dressing application (X2=3.001, p=0.700) (Table 1). These findings indicate that all groups were comparable at baseline and that the study was initiated under equivalent conditions.

Burn Wound Area Measurements

On day 3 after burn induction, no statistically significant difference in wound area was observed among the groups (X2=5.246, p=0.387).

On day 7, the largest mean wound area was observed in the control group (0.58±0.15 cm2), whereas the smallest mean wound area was observed in the 15% water-soluble propolis group (0.34±0.04 cm2). A statistically significant difference was found among the groups (X2=15.986, p=0.007). Dunn–Bonferroni pairwise comparisons showed that the mean wound area in the 15% water-soluble propolis group was 0.270 cm² smaller than that in the control group (p=0.019) and 0.271 cm² smaller than that in the propolis vehicle group (p=0.047) (Fig. 3).

On day 14, the largest mean wound area was observed in the propolis vehicle group (0.54±0.15 cm2), while the smallest was observed in the 15% water-soluble propolis group (0.20±0.05 cm2). Significant differences were detected among

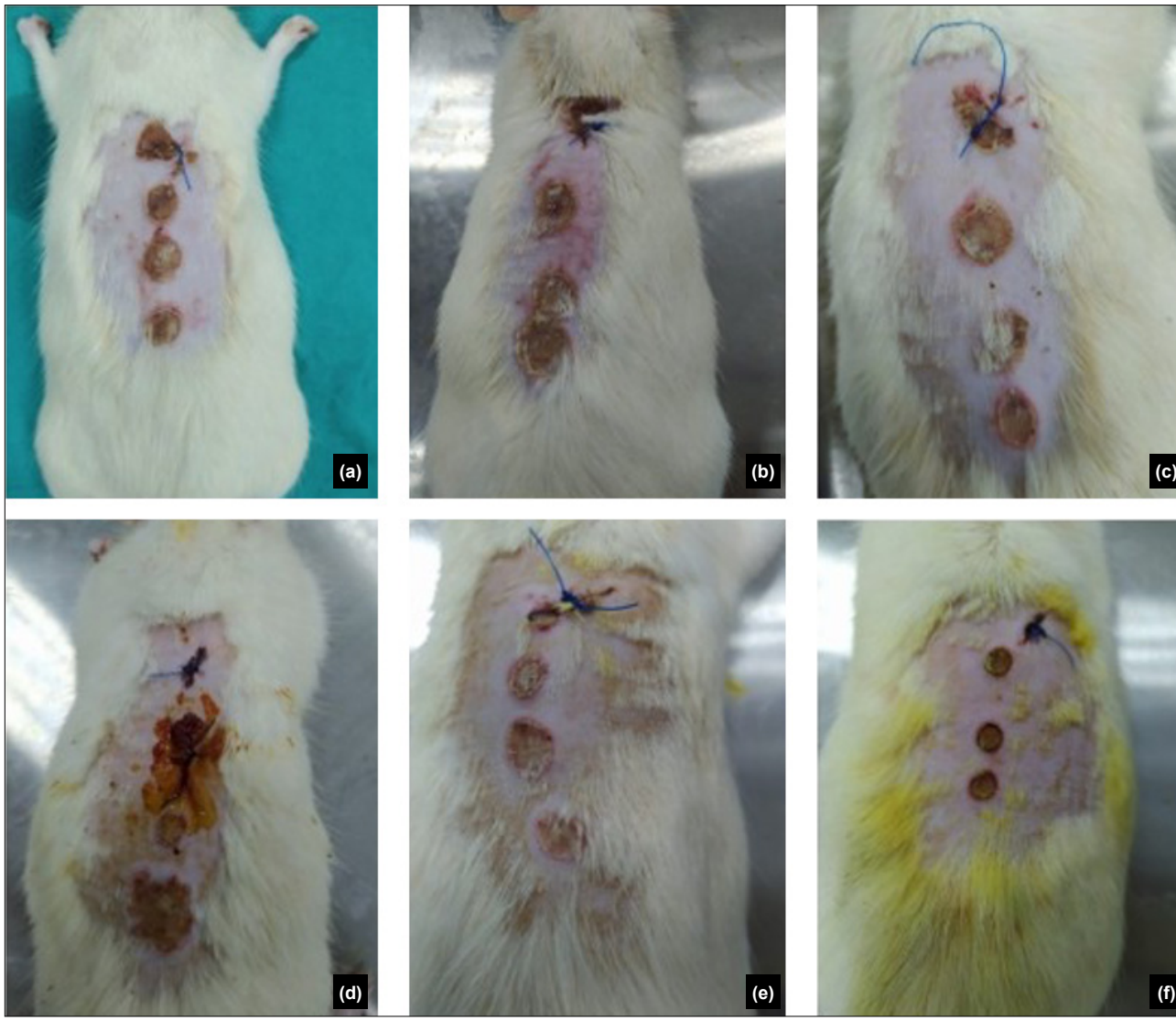

Figure 3. Burn wound images on Day 7 after burn induction. **(a)** Control group; **(b)** 1% silver sulfadiazine group; **(c)** 0.2% nitrofurazone group; **(d)** propolis vehicle group; **(e)** 10% water-soluble propolis group; and **(f)** 15% water-soluble propolis group.

Table 1. Mean wound area measurements by treatment group during the study period (cm^2)

Treatment group	Day 0 (X±SD)	Day 3 (X±SD)	Day 7 (X±SD)	Day 14 (X±SD)	Day 21 (X±SD)
Control group	0.48±0.03	0.49±0.17	0.58±0.15	0.53±0.17	0.49±0.20
1% silver sulfadiazine group	0.46±0.01	0.42±0.14	0.38±0.11	0.33±0.13	0.24±0.08
0.2% nitrofurazone group	0.46±0.03	0.49±0.28	0.42±0.09	0.38±0.07	0.29±0.05
Propolis vehicle group	0.48±0.05	0.53±0.31	0.58±0.14	0.54±0.15	0.39±0.10
10% water-soluble propolis group	0.49±0.04	0.32±0.11	0.37±0.12	0.26±0.12	0.20±0.14
15% water-soluble propolis group	0.46±0.02	0.33±0.11	0.31±0.03	0.20±0.05	0.11±0.06
Statistical analysis	p=0.700	p=0.387	p=0.007	p=0.004	p=0.001
	X^2=3.001	X^2=5.246	X^2=15.986	X^2=17.319	X^2=19.797

X^2: Kruskal–Wallis test; X: Mean; SD: Standard deviation.

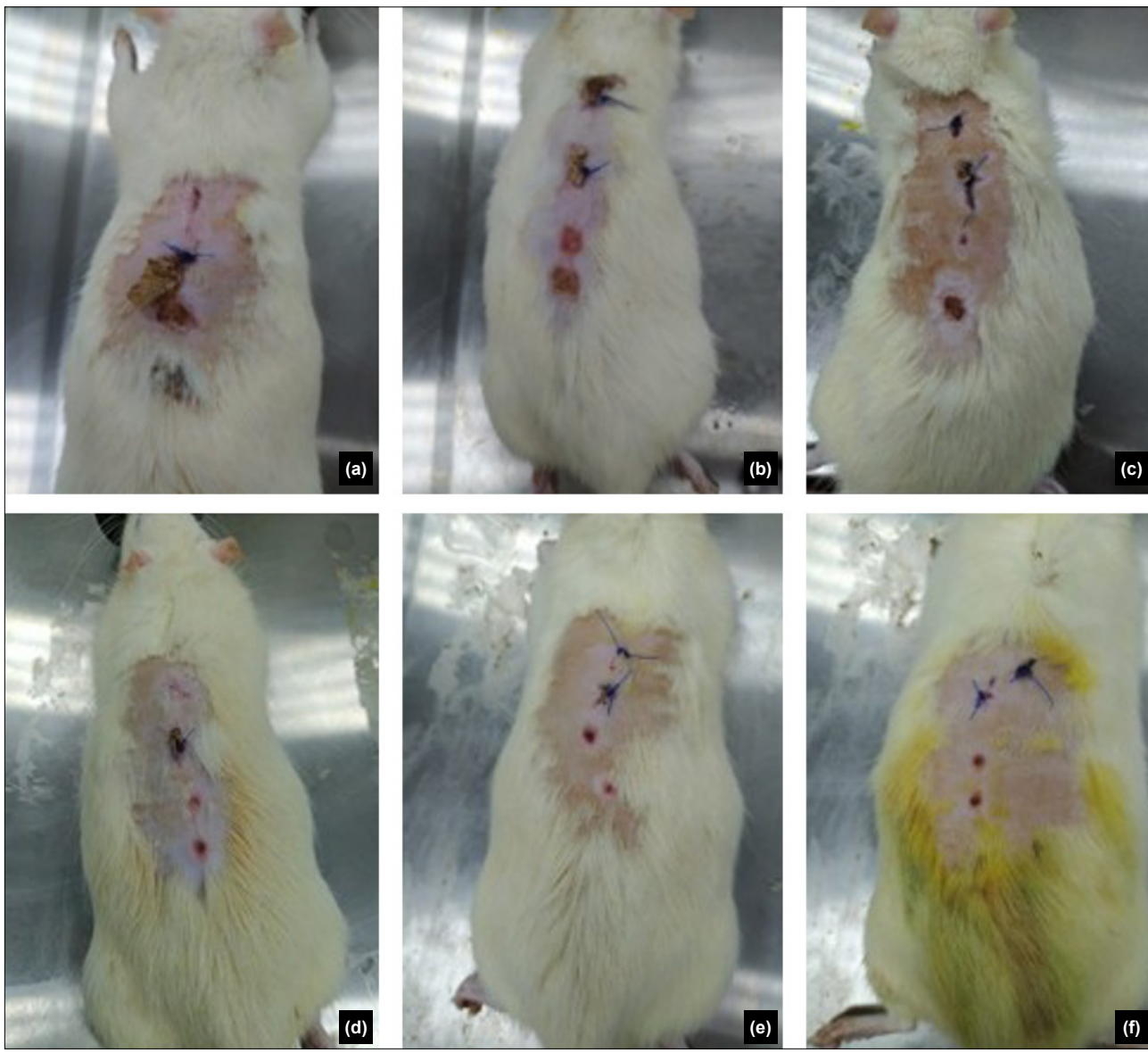

Figure 4. Burn wound images on Day 14 after burn induction. **(a)** Control group; **(b)** 1% silver sulfadiazine group; **(c)** 0.2% nitrofurazone group; **(d)** propolis vehicle group; **(e)** 10% water-soluble propolis group; and **(f)** 15% water-soluble propolis group.

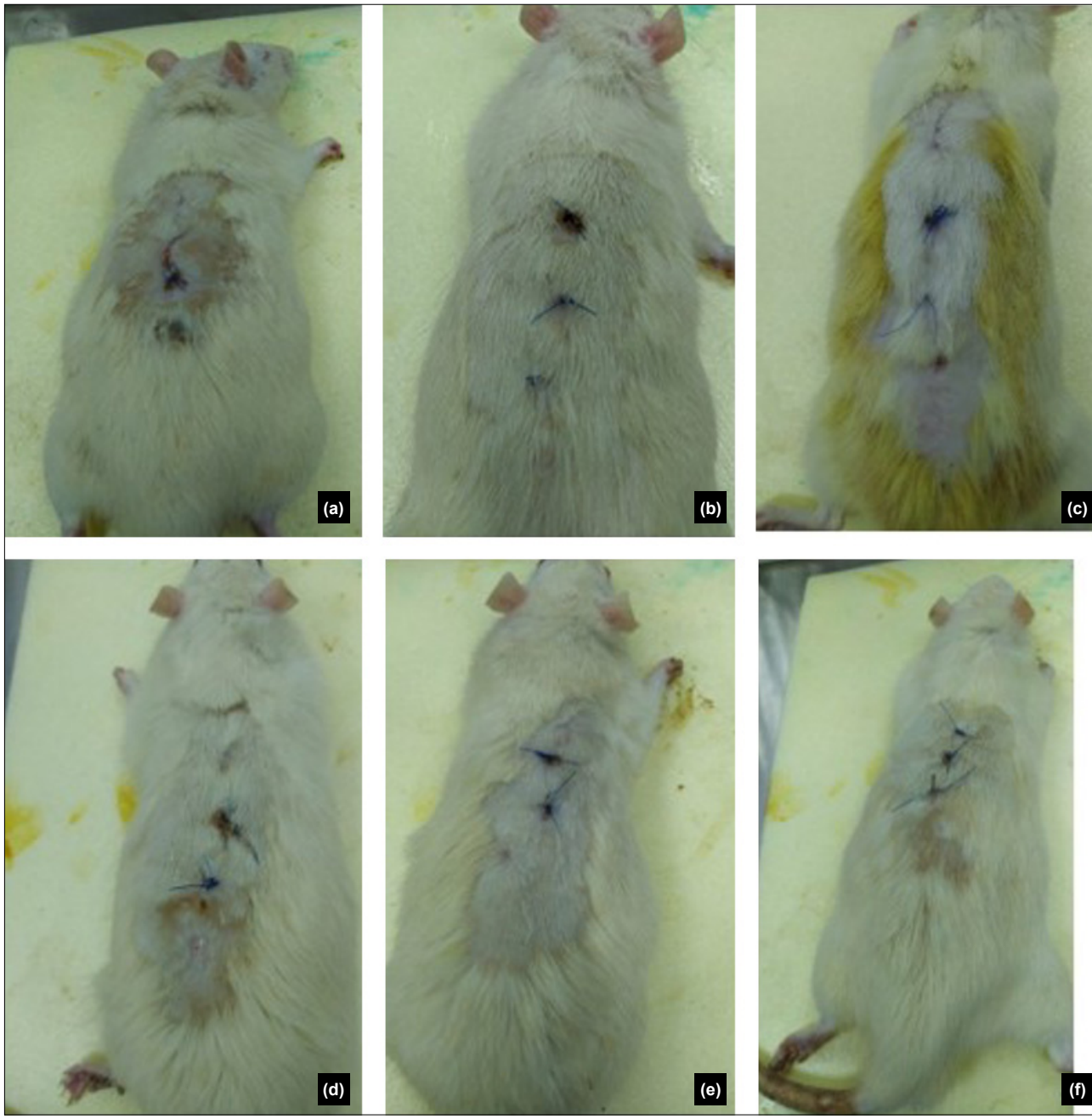

Figure 5. Burn wound images on Day 21 after burn induction. **(a)** Control group; **(b)** 1% silver sulfadiazine group; **(c)** 0.2% nitrofurazone group; **(d)** propolis vehicle group; **(e)** 10% water-soluble propolis group; and **(f)** 15% water-soluble propolis group.

the groups (X2=17.319, p=0.004). Dunn–Bonferroni pairwise comparisons demonstrated that the wound area in the 15% water-soluble propolis group was significantly smaller than that in the control group by an average of 0.335 cm2 (p=0.01) and smaller than that in the propolis vehicle group by an average of 0.290 cm2 (p=0.033) (Fig. 4).

On day 21, the largest mean wound area was observed in the control group (0.49±0.2 cm2), whereas the smallest was observed in the 15% water-soluble propolis group (0.11±0.06 cm2). Significant differences were identified among the groups (X2=19.797, p=0.001). Dunn–Bonferroni analysis revealed that the wound area in the 15% water-soluble propolis group was smaller than that in the control group by an average of 0.388 cm2 (p=0.01) and smaller than that in the propolis vehicle group by an average of 0.290 cm2 (p=0.04) (Table 2, Fig. 5).

Analysis demonstrated that wound areas in the propolis-treated groups were 1.157-fold smaller on day 7, 0.230-fold smaller on day 14, and 0.221-fold smaller on day 21 compared with those in the non-propolis groups. The model explained

Table 2. Pairwise comparisons of burn wound area among treatment groups

Day	Pairwise comparison	Mean difference	p*
Day 7	15% water-soluble propolis vs. control	-0.27000	0.019
	15% water-soluble propolis vs. 1% silver sulfadiazine	-0.06833	1.000
	15% water-soluble propolis - 0.2% nitrofurazone	-0.11083	1.000
	15% water-soluble propolis vs. propolis vehicle	-0.27083	0.047
	15% water-soluble propolis vs. 10% water-soluble propolis	-0.06500	1.000
	1% silver sulfadiazine vs. control	-0.20167	0.443
	1% silver sulfadiazine vs. 0.2% nitrofurazone	-0.04250	1.000
	1% silver sulfadiazine vs. propolis vehicle	-0.20250	0.600
	1% silver sulfadiazine vs.10% water-soluble propolis	0.00333	1.000
	10% water-soluble propolis vs. control	-0.20500	0.365
	10% water-soluble propolis vs. 0.2% nitrofurazone	-0.04583	1.000
	10% water-soluble propolis vs. propolis vehicle	-0.20583	0.552
	0.2% nitrofurazone vs. control	-0.15917	1.000
	0.2% nitrofurazone vs. propolis vehicle	-0.16000	1.000
	Control vs. propolis vehicle	0.20500	1.000
Day 14	15% water-soluble propolis vs. control	-0.33500	0.010
	15% water-soluble propolis vs. 1% silver sulfadiazine	-0.13500	1.000
	15% water-soluble propolis vs. 0.2% nitrofurazone	-0.18000	0.746
	15% water-soluble propolis vs. propolis vehicle	-0.29000	0.033
	15% water-soluble propolis vs. 10% water-soluble propolis	-0.06500	1.000
	1% silver sulfadiazine vs. control	-0.20000	1.000
	1% silver sulfadiazine vs. 0.2% nitrofurazone	-0.04500	1.000
	1% silver sulfadiazine vs. propolis vehicle	-0.15500	1.000
	1% silver sulfadiazine vs.10% water-soluble propolis	0.07000	1.000
	10% water-soluble propolis vs. control	-0.27000	0.141
	10% water-soluble propolis vs. 0.2% nitrofurazone	-0.11500	1.000
	10% water-soluble propolis vs. propolis vehicle	-0.22500	0.286
	0.2% nitrofurazone vs. control	-0.15500	1.000
	0.2% nitrofurazone vs. propolis vehicle	-0.11000	1.000
	Control vs. propolis vehicle	0.04500	1.000
Day 21	15% water-soluble propolis vs. control	-0.38833	0.002
	15% water-soluble propolis vs. 1% silver sulfadiazine	-0.13500	0.861
	15% water-soluble propolis vs. 0.2% nitrofurazone	-0.18500	0.365
	15% water-soluble propolis vs. propolis vehicle	-0.28250	0.040
	15% water-soluble propolis vs. 10% water-soluble propolis	-0.09167	1.000
	1% silver sulfadiazine vs. control	-0.25333	1.000
	1% silver sulfadiazine vs. 0.2% nitrofurazone	-0.05000	1.000
	1% silver sulfadiazine vs. propolis vehicle	-0.14750	1.000
	1% silver sulfadiazine vs. 10% water-soluble propolis	0.04333	1.000
	10% water-soluble propolis vs. control	-0.29667	0.065
	10% water-soluble propolis vs. 0.2% nitrofurazone	-0.09333	1.000
	10% water-soluble propolis vs. propolis vehicle	-0.19083	0.568
	0.2% nitrofurazone vs. control	-0.20333	1.000
	0.2% nitrofurazone vs. propolis vehicle	0.09333	1.000
	Control vs. propolis vehicle	0.10583	1.000

*Dunn–Bonferroni post hoc test. *Adjusted p value.

Table 3. Mean AHSS scores by treatment group during the study period

	Day 3 (X±SD)	Day 7 (X±SD)	Day 14 (X±SD)	Day 21 (X±SD)
Control group	4.00±1.89	4.83±1.32	5.50±1.76	4.00±0.63
1% silver sulfadiazine group	4.00±2.16	4.25±1.25	7.25±1.25	3.75±1.50
0.2% nitrofurazone group	5.00±1.41	7.50±1.00	6.25±0.95	5.75±1.50
Propolis vehicle group	4.25±0.50	5.00±0.81	6.25±1.25	3.50±1.00
10% water-soluble propolis group	3.36±1.50	6.00±1.09	8.83±0.98	3.16±2.04
15% water-soluble propolis group	3.36±1.21	5.16±1.16	8.00±1.41	2.66±2.16
Statistical analysis	p=0.697	p=0.273	p=0.010	p=0.179
	X^2=3.020	X^2=6.356	X^2=15.204	X^2=7.609

X^2: Kruskal–Wallis test; X: Mean; SD: Standard deviation; AHSS: Abramov Histological Scoring System.

Table 4. Pairwise comparisons of AHSS scores among treatment groups

Day	Pairwise comparison	Mean difference	p*
Day 14	15% water-soluble propolis vs. control	2.50000	0.265
	15% water-soluble propolis vs. 1% silver sulfadiazine	0.75000	1.000
	15% water-soluble propolis vs. 0.2% nitrofurazone	1.75000	1.000
	15% water-soluble propolis vs. propolis vehicle	1.75000	1.000
	15% water-soluble propolis vs. 10% water-soluble propolis	-0.83333	1.000
	1% silver sulfadiazine vs. control	1.75000	1.000
	1% silver sulfadiazine vs. 0.2% nitrofurazone	1.00000	1.000
	1% silver sulfadiazine vs. propolis vehicle	1.00000	1.000
	1% silver sulfadiazine vs.10% water-soluble propolis	-1.58333	1.000
	10% water-soluble propolis vs. control	3.33333	0.017
	10% water-soluble propolis vs. 0.2% nitrofurazone	2.58333	0.180
	10% water-soluble propolis vs. propolis vehicle	2.58333	0.169
	0.2% nitrofurazone vs. control	0.75000	1.000
	0.2% nitrofurazone vs. propolis vehicle	0.00000	1.000
	Control vs. propolis vehicle	-0.75000	1.000

*Dunn–Bonferroni post hoc test. * Adjusted p value; AHSS: Abramov Histological Scoring System.

26.6%, 42.3%, and 37.4% of the variance in wound area on days 7, 14, and 21, respectively.

Histological Scores of Burn Wounds

No statistically significant differences in histological scores were observed among the groups on days 3 (X2=3.020, p=0.697), 7 (X2=6.356, p=0.273), or 21 (X2=7.609, p=0.179) following burn induction (Table 3).

On day 14, the highest mean Abramov Histological Scoring System (AHSS) score was observed in the 10% water-soluble propolis group (8.83±0.98), whereas the lowest score was observed in the control group (5.50±1.76). A statistically significant difference was found among the groups (X2=15.204, p=0.010). Dunn–Bonferroni analysis demonstrated that AHSS scores in the 10% water-soluble propolis group were higher than those in the control group by an average of 3.33 points (p=0.017) (Table 4). This improvement is likely associated with enhanced epithelialization, collagen deposition, fibroblast proliferation, and angiogenesis, parameters that typically peak around the 14th day of burn wound healing (Figs. 6, 7, and 8).

Necrosis was observed only on day 3 and only in the 0.2% nitrofurazone group. No evidence of necrosis was observed

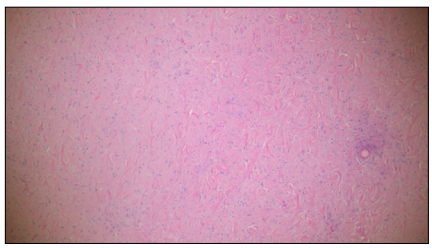

Figure 6. Histopathological evaluation of collagen deposition.

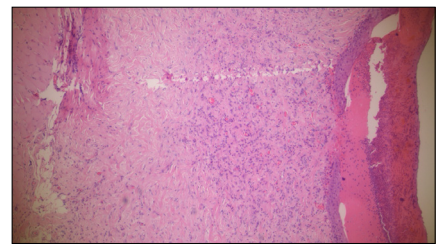

Figure 7. Histopathological evaluation of epithelialization.

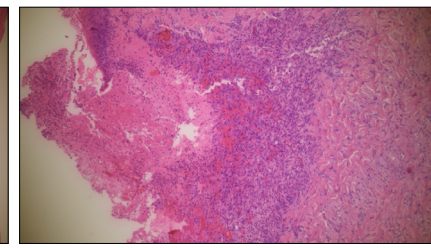

Figure 8. Histopathological evaluation of fibroblast proliferation.

Table 5. Analysis of factors associated with burn wound area and AHSS scores

	Regression coefficient						
	β	SE	Statistic	p	Exp(β)	95% CI for Exp(β)	
						Lower	Upper
Burn wound area (Day 7)							
Treatment group							
*Non-propolis treatment	Reference						
Propolis treat-ment	-1.157	0.049	-3.183	0.004	0.515	-0.259	-0.056
Body weight	-1.616	0.001	-0.030	0.976	-0.005	-0.001	0.001
Burn wound area (Day 14)							
Treatment group							
*Non-propolis treatment	Reference						
Propolis treat-ment	-0.230	0.051	-4.369	<0.001	0.637	-0.330	-0.119
Body weight	-0.001	0.001	-0.917	0.367	0.135	-0.002	0.001
Burn wound area (Day 21)							
Treatment group							
*Non-propolis treatment	Reference						
Propolis treat-ment	-0.217	0.054	-4.005	<0.001	0.603	-0.329	-0.106
Body weight	0.000	0.001	-0.653	0.530	-0.100	-0.002	0.001
AHS score (Day 14)							
Treatment group							
*Non-propolis treatment	Reference						
Propolis treat-ment	2.194	0.508	4.320	<0.001	0.632	1.154	3.235
Body weight	0.000	0.005	-0.058	0.954	-0.009	-0.012	0.011

*Control, 1% silver sulfadiazine, 0.2% nitrofurazone, and propolis vehicle; AHSS: Abramov Histological Scoring System.

in any other group. Similarly, pathogen growth was detected only on day 3 and only in the 0.2% nitrofurazone group. The absence of pathogen growth in all other groups represents an important finding of the study.

The enter method was used to identify factors affecting burn wound area and AHSS scores. The final model indicated that wound dressing material significantly influenced wound area measurements on days 7, 14, and 21, as well as AHSS scores on day 14.

According to the model, AHSS scores in the propolis-treated groups were 2.191 times higher on day 14 than those in the non-propolis groups. The model explained approximately 40% of the variance in AHSS scores. Body weight was not found to have a significant effect on wound area measurements or AHSS scores (Table 5).

Clinical Significance

A post hoc power analysis was performed using G*Power

version 3.1.9.4. The observed effect size was 1.08, and the achieved statistical power (1-ß) was 0.99. Because both the observed effect size and statistical power exceeded the values specified during sample size calculation (effect size=0.65, power=0.80), the findings were considered clinically meaningful.[35]

DISCUSSION

Burn wound healing is a process involving three overlapping phases: inflammation, proliferation, and remodeling. Effective healing requires regulation of inflammation, activation of fibroblasts, angiogenesis, and collagen synthesis. Due to its high content of flavonoids and phenolic compounds, propolis may support these processes by reducing oxidative stress, modulating inflammatory responses, promoting fibroblast proliferation, and stimulating collagen deposition.[4]

Biogenic materials with antimicrobial, regenerative, and analgesic properties are receiving increasing attention in burn wound management.[11] Propolis is one such natural product, characterized by strong antioxidant activity that may reduce oxidative stress and contribute to tissue repair.[15,36] Furthermore, there remains a need for cost-effective, easy-to-apply wound care products with minimal adverse effects for the treatment of burn injuries.[37]

In the present study, wound areas treated with 15% water-soluble propolis were smaller than those of the control and propolis vehicle groups on days 7, 14, and 21. These findings are consistent with those reported by Marquele-Oliveira et al.,[38] Krupp et al.,[24] and Jastrzębska-Stojko,[11] who reported smaller wound areas on day 14 in rats treated with propolis-containing formulations compared with the control group. Jastrzębska-Stojko et al.[11] also compared the effects of different concentrations of propolis and found that wound areas were smaller on days 14 and 21 in rats treated with 3% propolis than in rats treated with 1% propolis. In contrast to the findings of Jastrzębska-Stojko et al.,[11] no significant differences in wound area measurements were observed between the 10% and 15% propolis groups in the present study.

In this study, angiogenesis scores were higher in the propolis-treated groups on days 7, 14, and 21 compared to other groups. Similar findings have been reported by Berretta et al.[39] and Krupp et al.,[24] who found higher levels of angiogenesis in wounds treated with propolis than in the control group. This finding suggests that propolis may promote angiogenesis through the upregulation of vascular endothelial growth factor (VEGF) and nitric oxide synthesis, thereby enhancing granulation tissue formation and oxygen delivery to regenerating tissue.

Inflammation is one of the processes that occurs following a burn injury. Mononuclear cell density is an important indicator of chronic inflammation.[32] In the present study, mononuclear cell density was lower in the 15% water-soluble propolis group than in the other groups on day 7. On day 14, mononuclear cell density was highest in the propolis vehicle group. Consistent with our findings, de Almeida et al.[22] reported reduced inflammation in the propolis-treated group compared with the control group. In the present study, neutrophil density, an indicator of inflammation, was lower in the propolis-treated groups on days 3, 7, and 14. Similarly, de Moura et al.[40] reported fewer inflammatory cells on day 3 in the propolis-treated group than in the control group. This result may be associated with the anti-inflammatory effects of propolis, including inhibition of cyclooxygenase and lipoxygenase pathways and subsequent reduction of prostaglandin and leukotriene production.

In the present study, fibroblast proliferation was higher in the propolis-treated groups on days 7 and 14. Similarly, de Almeida et al.[22] and Berretta et al.[39] reported higher levels of fibroblast proliferation in propolis-treated wounds than in control wounds on day 14. Fibroblast proliferation is essential for granulation tissue formation. This effect may be related to phenolic compounds in propolis, including caffeic acid phenethyl ester (CAPE), which has been reported to promote extracellular matrix synthesis.

In the present study, collagen deposition increased on day 14 in all groups, and no evidence of earlier collagen deposition was observed in any group. Collagen deposition was higher in the propolis-treated groups than in the other groups. Consistent with our findings, Pessolato[41] and Krup[24] reported higher levels of collagen deposition in propolis-treated wounds than in control wounds. These findings suggest that propolis may support fibroblast-mediated collagen synthesis and maturation, thereby contributing to wound remodeling.

According to the Abramov Histological Scoring System scores, angiogenesis, collagen deposition, and fibroblast proliferation, which are indicators of wound healing, were higher in the 10% and 15% propolis groups on day 14. Increased levels of these parameters are expected during the proliferative phase of wound healing, which typically occurs between days 4 and 21. Consistent with the present study, Doğan et al.[42] reported increased angiogenesis, collagen deposition, and fibroblast proliferation on day 14, with higher levels observed in the propolis-treated group than in the control group. Together, these findings suggest that propolis may enhance the proliferative phase of wound healing, which is associated with tissue regeneration.

In this study, wound healing was evaluated using a partial-thickness burn model. However, necrosis was observed in one rat on day 3, suggesting that a full-thickness burn may have been induced in that animal. This should be considered a limitation of the study.

Overall, the findings of this study indicate that propolis contributes to burn wound healing through its effects on inflammation, angiogenesis, fibroblast proliferation, and collagen deposition, all of which are important components of the tissue repair process.

CONCLUSION

Many in vivo studies using various wound models have demonstrated the beneficial effects of propolis on wound healing. However, evidence regarding the optimal dose and clinical effectiveness of propolis remains limited. Further studies are needed to determine its clinical value.

Ethics Committee Approval: This study was approved by the Ege University Animal Experiments Local Ethics Committee (Date: 22.05.2019, Decision No: 2019-048).

Clinical Registration: This study was registered at the U.S. National Library of Medicine Clinical Trials (Identifier: NCT04277182; https://clinicaltrials.gov/ct2/show/NCT04277182).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: E.A.A.; Design: E.A.A., F.Y., D.D., F.E.S.; Supervision: F.Y., D.D., F.E.S.; Resource: E.A.A.; Materials: E.A.A.; Data collection and/or processing: E.A.A., F.Y., D.D.; Analysis and/or interpretation: E.A.A., D.D.; Literature review: E.A.A.; Writing: E.A.A.; Critical review: E.A.A., F.Y.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Granger J, Estrada C, Abramo T, Grant V, Tothy A. An evidence-based approach to pediatric burns. Pediatric Emergency Medicine Practice 2009;6:1-17.
2. Xie B, Xiao SC, Zhu SH, Xia ZF. Evaluation of long term health-related quality of life in extensive burns: a 12-year experience in a burn center. Burns 2012;38:348–55. [CrossRef]
3. Gunning A, van Heijl M, van Wessem K, Leenen L. The association of patient and trauma characteristics with the health-related quality of life in a Dutch trauma population. Scand J Trauma Resusc Emerg Med 2017;25:41. [CrossRef]
4. Li Z, Yuan B, Dong X, Duan L, Tian H, He C, et al. Injectable polysaccharide hybrid hydrogels as scaffolds for burn wound healing. RSC Advances 2015;5:94248–56. [CrossRef]
5. Jiji S, Udhayakumar S, Rose C, Muralidharan C, Kadirvelu K. Thymol enriched bacterial cellulose hydrogel as effective material for third degree burn wound repair. International Journal of Biological Macromolecules 2019;122:452–60. [CrossRef]
6. Zor F, Ersöz N, Külahçı Y, Kapı E, Bozkurt M. Birinci basamak yanık tedavisinde altın standartlar. diclemedj 2009;36:219–25.
7. Harma B. Çocuklarda ikinci derece yanıkların tedavisinde beş farklı yara örtüsünün etkinliklerinin histopatolojik olarak değerlendirilmesi [uzmanlık tezi]. Malatya: İnönü Üniversitesi Tıp Fakültesi; 2011.
8. Metcalf DG, Parsons D, Bowler PG. Clinical safety and effectiveness evaluation of a new antimicrobial wound dressing designed to manage exudate, infection and biofilm. Int Wound J 2017;14:203–13. [CrossRef]
9. Ozlu NGO, Vural F. Recommendations of the current guidelines for burn care. HEAD 2020;17:187-94.
10. Özok G. Çocuk yanıkları. Turkish Pediatrics Archive 2010;45:17–9. [CrossRef]
11. Jastrzębska-Stojko Z, Stojko R, Rzepecka-Stojko A, Kabała-Dzik A, Stojko J. Biological activity of propolis-honey balm in the treatment of experimentally-evoked burn wounds. Molecules 2013;18:14397–413. [CrossRef]
12. Possamai MM, Honorio-França AC, Reinaque AP, França EL, Souto PC. Brazilian propolis: a natural product that improved the fungicidal activity by blood phagocytes. Biomed Res Int 2013;2013:541018. [CrossRef]
13. Silva AJ, Silva JR, de Souza NC, Souto PCS. Membranes from latex with propolis for biomedical applications. Materials Letters 2014;116:235–8. [CrossRef]
14. Sforcin JM. Biological properties and therapeutic applications of propolis. Phytother Res 2016;30:894–905. [CrossRef]
15. Pasupuleti VR, Sammugam L, Ramesh N, Gan SH. Honey, propolis, and royal jelly: a comprehensive review of their biological actions and health benefits. Oxid Med Cell Longev 2017;2017:1259510. [CrossRef]
16. Zabaiou N, Fouache A, Trousson A, Baron S, Zellagui A, Lahouel M, et al. Biological properties of propolis extracts: Something new from an ancient product. Chem Phys Lipids 2017;207:214–22. [CrossRef]
17. Khachaturov A, Gudkov A. Propolis therapy of certain dermatoses and burns in the far north. J Vestnik Dermatologii i Venerologii 1969;43:63–5.
18. Nímia HH, Carvalho VF, Isaac C, Souza FÁ, Gemperli R, Paggiaro AO. Comparative study of Silver Sulfadiazine with other materials for healing and infection prevention in burns: A systematic review and meta-analysis. Burns 2019;45:282–92. [CrossRef]
19. Ait Abderrahim L, Taïbi K, Ait Abderrahim N, Boussaid M, Rios-Navarro C, Ruiz-Saurí A. Euphorbia honey and garlic: Biological activity and burn wound recovery. Burns 2019;45:1695–706. [CrossRef]
20. Staniczek J, Jastrzębska-Stojko Ż, Stojko R. Biological activity of propolis ointment with the addition of 1% nanosilver in the treatment of experimentally-evoked burn wounds. Polymers (Basel) 2021;13:2312. [CrossRef]
21. Olczyk P, Komosińska-Vassev K, Winsz-Szczotka K, Koźma EM, Wisowski G, Stojko J, et al. Propolis modulates vitronectin, laminin, and heparan sulfate/heparin expression during experimental burn healing. J Zhejiang Univ Sci B 2012;13:932–41. [CrossRef]
22. de Almeida EB, Cordeiro Cardoso J, Karla de Lima A, de Oliveira NL, de Pontes-Filho NT, Oliveira Lima S, et al. The incorporation of Brazilian propolis into collagen-based dressing films improves dermal burn healing. J Ethnopharmacol 2013;147:419–25. [CrossRef]
23. Durmuş AS, Han MC, Sağlıyan A, Özkaraca M, Kandemir FM. Effects of propolis and hypericum perforatum cream on burn wound healing. FU Vet J Health Sci 2018; 32:173–7.
24. Krupp T, Dos Santos BD, Gama LA, Silva JR, Arrais-Silva WW, de Souza NC, et al. Natural rubber - propolis membrane improves wound healing in second-degree burning model. Int J Biol Macromol 2019;131:980–8. [CrossRef]
25. Bozkan Z, Belge A, Sarierler M, Tunca R, Yayıngül R, İpek E. Comparison of the efficacy of amniotic membrane transplantation, topical water-based propolis extract, corticosteroid and antibiotic use in different combinations on subacute corneal alkali burns in rabbits. Kafkas Univ Vet Fak Derg 2019;25:825–33.
26. Martin LF, Rocha EM, Garcia SB, Paula JS. Topical Brazilian propolis improves corneal wound healing and inflammation in rats following alkali burns. BMC Complement Altern Med 2013;13:337. [CrossRef]
27. Oryan A, Alemzadeh E, Moshiri A. Potential role of propolis in wound healing: Biological properties and therapeutic activities. Biomed Pharmacother 2018;98:469–83. [CrossRef]
28. Percie du Sert N, Hurst V, Ahluwalia A, Alam S, Avey MT, Baker M, et al. The ARRIVE guidelines 2.0: Updated guidelines for reporting animal research. PLoS Biol 2020;18:e3000410. [CrossRef]
29. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed.

Hillsdale (NJ): Lawrence Erlbaum Associates; 1988.
30. Nergiz S. Ratlarda yüzeysel ve derin yanık modellerinin karşılaştırılması [uzmanlık tezi]. Sivas: Sivas Cumhuriyet Üniversitesi Tıp Fakültesi, Plastik, Rekonstrüktif ve Estetik Cerrahi Anabilim Dalı; 2014.[Article in Turkish]
31. Çalışkan D, Koca T, Doğuç DK, Özgöçmen M, Akçam M. The protective effect of pomegranate juice in paracetamol-induced acute hepatotoxicity in rats. Turk Pediatri Ars 2016;51:72–8. [CrossRef]
32. Abramov Y, Golden B, Sullivan M, Botros SM, Miller JJ, Alshahrour A, et al. Histologic characterization of vaginal vs. abdominal surgical wound healing in a rabbit model. Wound Repair Regen 2007;15:80–6. [CrossRef]
33. Grada A, Mervis J, Falanga V. Research techniques made simple: animal models of wound healing. J Invest Dermatol 2018;138:2095–105.e1. [CrossRef]
34. Russell WMS, Burch RL. The principles of humane experimental technique. London: Methuen & Co; 1959.
35. Sainani KL. Clinical versus statistical significance. PM R 2012;4:442–5. [CrossRef]
36. Barrientos S, Stojadinovic O, Golinko MS, Brem H, Tomic-Canic M. Growth factors and cytokines in wound healing. Wound Repair Regen 2008;16:585–601. [CrossRef]
37. Hazar E, İnce AR, Çam S, Karagöz N. Hizmet işletmelerinde maliyet analizi: Sivas Numune Hastanesi yanık ünitesinde yatan hastaların maliyet analizi. Bus Manag Stud Int J 2013;1:156–67. [CrossRef]
38. Marquele-Oliveira F, da Silva Barud H, Torres EC, Machado RTA, Caetano GF, Leite MN, et al. Development, characterization and pre-clinical trials of an innovative wound healing dressing based on propolis (EPP-AF®)-containing self-microemulsifying formulation incorporated in biocellulose membranes. Int J Biol Macromol 2019;136:570–8. [CrossRef]
39. Berretta AA, Nascimento AP, Bueno PC, Vaz MM, Marchetti JM. Propolis standardized extract (EPP-AF®), an innovative chemically and biologically reproducible pharmaceutical compound for treating wounds. Int J Biol Sci 2012;8:512–21. [CrossRef]
40. de Moura SA, Negri G, Salatino A, Lima LD, Dourado LP, Mendes JB, et al. Aqueous extract of brazilian green propolis: primary components, evaluation of inflammation and wound healing by using subcutaneous implanted sponges. Evid Based Complement Alternat Med 2011;2011:748283. [CrossRef]
41. Pessolato AG, Martins Ddos S, Ambrósio CE, Mançanares CA, de Carvalho AF. Propolis and amnion reepithelialise second-degree burns in rats. Burns 2011;37:1192–201. [CrossRef]
42. Doğan E, Karademir G, Gedikli S, Okur S. Effects of oral and topical Momordica charantia-Propolis premix on wound healing. Harran Univ Vet Fak Derg 2020;9:53–8. [CrossRef]

DENEYSEL ÇALIŞMA - *ÖZ*

Deneysel yanık modelinde topikal propolis uygulamasının yanık iyileşmesine etkisi

AMAÇ: Yanık, motorlu taşıt kazaları ve boğulmalardan sonra kazaya bağlı ölümlerin en yaygın nedenidir. Yanık yarası iyileşmesinde yanığın derecesi, derinliği ve etkeni gibi göz önünde bulundurulması gereken birçok faktör vardır. Bu çalışmanın amacı, kısmi kalınlıktaki yanık yarasında %1 gümüş sülfadiazin, %0.2 nitrofurazon, propolis aracı ve %10 suda çözünen ve %15 suda çözünen propolisin yara iyileşmesi üzerindeki etkilerini histopatolojik olarak karşılaştırmak ve değerlendirmektir.
GEREÇ VE YÖNTEM: Bu randomize kontrollü deneysel çalışmada, sıçanlar altı gruba ayrılmıştır (kontrol-gümüş sülfadiazin-nitrofurazon-propolis çözücüsü-%10 suda çözünür propolis-%15 suda çözünür propolis). Yanık indüksiyonundan önce sıçanlara anestezi uygulanmış, sırtları traş edilmiş ve sırtlarında dört adet temas yanığı oluşturulmuştur. Yanık alanı ölçülmüş ve yara alanından doku örneği alınarak histopatolojik inceleme yapılmıştır.
BULGULAR: Çalışmada, %15 suda çözünür propolis ile tedavi edilen sıçanların yara alanlarının genişliği, kontrol ve propolis araç grubuna kıyasla 7. (p=0.019; p=.047), 14. (p=0.01; p=0.033), ve 21. (p=0.00; p=0.040) 21. günlerde önemli ölçüde daha küçük bulunmuştur. Histopatolojik incelemelerde, çalışmanın 14. gününde fibroblast proliferasyonu, kolajenizasyon, fibrozis ve mononükleer hücreler açısından gruplar arasında propolis lehine bir fark tespit edilmiştir (p=0.017).
SONUÇ: Suda çözünebilen propolisin sıçanların yanık yarasına uygulanmasının yara iyileşmesi üzerinde olumlu bir etkisi olduğu görülmektedir.

Anahtar sözcükler: Apiterapi; hemşirelik; pansuman; propolis; yanık; yara iyileşmesi.

Ulus Travma Acil Cerrahi Derg 2026;32(8):895-907 DOI: 10.14744/tjtes.2026.17258

ORIGINAL ARTICLE

Predicting intestinal ischemia in mechanical intestinal obstruction: the role of the C-reactive protein–albumin–lymphocyte index

Sinan Aslan, Vural Soyer

Department of General Surgery, Mersin City Training and Research Hospital, Mersin-*Türkiye*

ABSTRACT

BACKGROUND: Intestinal ischemia requiring bowel resection is a serious complication of mechanical intestinal obstruction, and early identification of patients with irreversible ischemic injury remains challenging. Albumin-based immunonutritional indices, including the C-reactive protein–albumin–lymphocyte (CALLY) index, Prognostic Nutritional Index (PNI), and modified Glasgow Prognostic Score (mGPS), may reflect systemic inflammation, nutritional reserve, and immune status. This study aimed to evaluate the prognostic value of these indices for predicting bowel resection due to irreversible ischemic injury in patients undergoing surgery for non-malignant mechanical intestinal obstruction.

METHODS: We retrospectively analyzed data from 680 adult patients admitted with mechanical intestinal obstruction between January 2017 and July 2025. After excluding patients with malignancy-related obstruction, 464 patients with non-malignant mechanical intestinal obstruction were included in the final analysis. Patients were categorized according to bowel resection status. Demographic characteristics, laboratory parameters, inflammatory and immunonutritional indices, and clinical outcomes were recorded. Separate preoperative multivariate logistic regression models were constructed to avoid mathematical overlap and multicollinearity among related indices. Diagnostic performance was assessed using receiver operating characteristic curve analysis.

RESULTS: The final cohort comprised 300 patients who did not undergo bowel resection and 164 who required bowel resection. Patients in the resection group exhibited higher inflammatory marker levels and lower nutritional and immune-related indices. In the conventional preoperative model, C-reactive protein (CRP) was positively associated with bowel resection, whereas albumin level and lymphocyte count were inversely associated with this outcome. In separate index-based models, a CALLY index ≤2.77, lower PNI values, and an mGPS of 2 were independently associated with bowel resection. The CALLY index demonstrated moderate discriminatory performance with an area under the curve (AUC) of 0.744. However, pairwise AUC comparisons revealed no significant discriminatory advantage of the CALLY index over PNI or the C-reactive protein–albumin ratio (CAR).

CONCLUSION: Preoperative inflammatory and immunonutritional markers were associated with bowel resection due to irreversible ischemic injury in patients with non-malignant mechanical intestinal obstruction. The CALLY index was independently associated with bowel resection and demonstrated moderate discriminatory performance; however, it was not superior to PNI or CAR. These indices may serve as adjunctive tools within a broader preoperative risk assessment framework rather than as standalone decision-making tools. Prospective multicenter studies are needed to externally validate the proposed cutoff values and the performance of these markers.

Keywords: Bowel resection; C-reactive protein–albumin–lymphocyte (CALLY) index; Mechanical intestinal obstruction; modified Glasgow Prognostic Score (mGPS); Prognostic Nutritional Index (PNI).

Cite this article as: Aslan S, Soyer HV. Predicting intestinal ischemia in mechanical intestinal obstruction: the role of the C-reactive protein–albumin–lymphocyte (CALLY) index. Ulus Travma Acil Cerrahi Derg 2026;32:908-919.

Address for correspondence: Sinan Aslan

Department of General Surgery, Mersin City Training and Research Hospital, Mersin, Türkiye

E-mail: drsinanaslan84@gmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):908-920 DOI: 10.14744/tjtes.2026.67362

Submitted: 10.12.2025 Revised: 26.04.2026 Accepted: 14.05.2026 Published: 10.08.2026

INTRODUCTION

Mechanical intestinal obstruction remains one of the most common causes of emergency surgical admission and continues to pose substantial diagnostic and therapeutic challenges in clinical practice. It results from a physical interruption of intestinal transit, most commonly due to postoperative adhesions, hernias, or neoplasms.[1,2] Despite advances in diagnostic imaging and perioperative management, intestinal ischemia and subsequent bowel necrosis remain among the most serious complications of mechanical intestinal obstruction. Delayed recognition of ischemia may rapidly lead to sepsis, multiorgan failure, and death, underscoring the need for early and reliable predictors of irreversible bowel injury.[3,4]

Traditional diagnostic approaches for mechanical intestinal obstruction rely primarily on clinical assessment and radiologic imaging, particularly computed tomography (CT) and contrast-enhanced studies.[4,5] However, these modalities often fail to reliably distinguish reversible ischemia from irreversible bowel necrosis, especially in older patients or those with significant comorbidities, in whom clinical manifestations may be nonspecific or atypical.[2,3,6] Consequently, there is increasing interest in simple, objective, and reproducible biomarkers that reflect the systemic inflammatory response, nutritional status, and immune competence, all of which are closely associated with intestinal perfusion and tissue viability.[7,8] In this context, composite immunonutritional indices, particularly the C-reactive protein–albumin–lymphocyte (CALLY) index, may provide clinically useful information for the early identification of patients at increased risk of intestinal ischemia.

Over the past decade, albumin-based immunonutritional indices have gained attention as prognostic markers across a wide range of clinical settings. The modified Glasgow Prognostic Score (mGPS), derived from serum C-reactive protein (CRP) and albumin levels, is widely used in oncology as a measure of the interaction between systemic inflammation and nutritional status.[8] Another established marker, the Prognostic Nutritional Index (PNI), incorporates albumin concentration and lymphocyte count and provides a practical assessment of both nutritional and immune status; it has been associated with postoperative and long-term outcomes in various patient populations.[9] More recently, the CALLY index has emerged as a comprehensive biomarker integrating inflammatory, nutritional, and immune parameters into a single formula and has demonstrated promising prognostic value in several surgical and oncologic settings.[10,11]

Although these indices have been extensively validated in malignant and chronic inflammatory diseases,[12,13] their diagnostic and prognostic utility in acute surgical conditions, such as mechanical intestinal obstruction, remains poorly defined. Recent studies of acute intestinal obstruction have suggested that immunonutritional markers may serve as early warning indicators.[14] Identifying whether albumin-based immunonutritional indices can predict intestinal ischemia or the need for bowel resection may facilitate more timely and accurate preoperative decision-making in emergency surgical practice.

To date, evidence regarding the role of the CALLY index in a broad and heterogeneous population of patients with mechanical intestinal obstruction remains limited. This distinction is clinically relevant because mechanical intestinal obstruction encompasses diverse etiologies, including adhesive obstruction, incarcerated hernia, volvulus, intussusception, and malignancy-related obstruction, which may differ in their inflammatory response, rate of ischemic progression, and likelihood of requiring bowel resection.[1,2,4,6] Although the CALLY index has previously been evaluated in a cohort of patients with strangulated abdominal wall hernias,[15] to our knowledge, the present study is among the first to investigate its role in a broader cohort of patients with non-malignant mechanical intestinal obstruction.

This study aimed to evaluate the prognostic value of the mGPS, PNI, and CALLY index for predicting bowel resection due to irreversible ischemic injury in patients undergoing surgery for non-malignant mechanical intestinal obstruction and to compare the discriminatory performances of these indices.

MATERIALS AND METHODS

Study Design and Setting

This retrospective observational cohort study was conducted in the Department of General Surgery at Mersin City Training and Research Hospital, a tertiary referral center with a high volume of gastrointestinal emergency surgeries. The study protocol was approved by the Non-Interventional Clinical Research Ethics Committee of Mersin City Training and Research Hospital (approval date: November 20, 2025; approval no. 2025/30). The requirement for informed consent was waived because of the retrospective design and use of anonymized patient data. The study was conducted in accordance with the Declaration of Helsinki, and the manuscript was prepared following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Patient Selection

Between January 2017 and July 2025, a total of 680 adult patients admitted with mechanical intestinal obstruction were screened. Mechanical intestinal obstruction was diagnosed based on clinical findings, including abdominal pain, abdominal distension, vomiting, and cessation of stool or flatus, with radiological confirmation by computed tomography. After application of the initial exclusion criteria, 540 surgically treated patients remained eligible for inclusion. Of the initially screened population, 82 patients were excluded because of paralytic ileus, primary mesenteric ischemia, or pseudo-obstruction; 36 were excluded because of missing laboratory data required for the calculation of immunonutritional indices; and 22 were excluded because they were successfully managed conservatively without surgery. Because malignan-

cy-related obstruction may independently influence systemic inflammation, nutritional status, albumin concentration, and lymphocyte count, 76 patients with malignancy-related mechanical intestinal obstruction were excluded from the primary analysis. The final analytic cohort consisted of 464 patients with non-malignant mechanical intestinal obstruction, including 300 patients who did not undergo bowel resection and 164 patients who underwent bowel resection (Fig. 1).

Inclusion and Exclusion Criteria

Patients were eligible for inclusion if they were aged ≥18 years, had a diagnosis of mechanical intestinal obstruction confirmed by clinical and radiological findings, and underwent surgical intervention because of suspected strangulation, intestinal ischemia, or failure of conservative management. Patients were excluded if they had paralytic ileus, primary mesenteric ischemia, pseudo-obstruction, successful non-operative management, missing essential laboratory data (including CRP, albumin, or lymphocyte count), incomplete operative records, or incomplete pathology records in cases requiring bowel resection. Patients with malignancy-related mechanical intestinal obstruction were excluded from the revised primary analytic cohort. Failure of conservative management was defined as persistent or worsening obstructive symptoms, absence of clinical improvement, or radiological progression despite initial non-operative treatment.

Study Groups and Outcome Definitions

Patients were divided into two groups according to intraoperative findings and bowel resection status. The non-resection group comprised patients in whom bowel viability was preserved or recovered after intraoperative reassessment and resection was not required. The resection group comprised patients who underwent bowel resection because of irreversible ischemia, necrosis, or gangrene. The primary outcome was bowel resection for surgically confirmed irreversible intestinal ischemia or bowel necrosis. Accordingly, the primary outcome represented irreversible ischemic injury requiring resection rather than all grades of reversible intestinal ischemia. Secondary outcomes included intensive care unit admission, length of hospital stay, and 30-day mortality.

Data Collection and Variables

Patient data were retrospectively extracted from the institutional electronic database, laboratory records, operative reports, and pathology reports, as applicable. The following variables were recorded: age, sex, American Society of Anesthesiologists classification, etiology of obstruction, symptom duration, hemoglobin level, white blood cell count, neutrophil count, lymphocyte count, platelet count, CRP level, albumin level, neutrophil-to-lymphocyte ratio (NLR), C-reactive protein-to-albumin ratio (CAR), Prognostic Nutritional Index, CALLY index, Modified Glasgow Prognostic Score, intraoperative findings, bowel resection status, intensive care unit (ICU) admission, length of hospital stay, and 30-day mortality. Symptom duration was defined as the interval between the patient-reported onset of obstructive symptoms and hospital admission and was recorded in hours. In the revised non-malignant analytic cohort, the etiology of obstruction was categorized as adhesive, hernia-related, or volvulus/intussusception. Adhesive obstruction served as the reference category in the logistic regression analyses.

Calculation of Immunonutritional Indices

Inflammatory and immunonutritional indices were calculated using preoperative laboratory values obtained at admission or immediately before surgery. When multiple preoperative laboratory measurements were available, the value obtained closest to the time of the operative decision was used. The indices were calculated using the following formulas:

PNI=10 × serum albumin (g/dL) + 0.005 × total lymphocyte count (10^3/μL)

CAR=CRP (mg/L) / serum albumin (g/dL)

NLR=neutrophil count / lymphocyte count

CALLY index=[serum albumin (g/dL) × lymphocyte count (10^3/μL)] / CRP (mg/L)

For PNI calculation, lymphocyte counts were converted to cells/mm^3. In contrast, the CALLY index was calculated using lymphocyte counts expressed as 10^3/μL, consistent with the institutional laboratory reporting format.

The Modified Glasgow Prognostic Score was defined as follows: mGPS=2 for CRP >10 mg/L and albumin <3.5 g/dL; mGPS=1 for CRP >10 mg/L and albumin ≥3.5 g/dL; and mGPS=0 for CRP ≤10 mg/L, regardless of albumin concentration.

Surgical Management and Intraoperative Assessment

The decision to perform surgery was made by the attending senior surgeon based on clinical findings, laboratory parameters, and radiological evidence of obstruction, strangulation, ischemia, or failure of conservative treatment. Open surgery was generally preferred in patients with suspected ischemia or advanced obstruction, whereas laparoscopy was attempted in selected patients when considered technically feasible. Bowel viability was assessed intraoperatively based on bowel color, peristaltic activity, mesenteric pulsation, response to decompression, and the effect of warm saline irrigation. Bowel resection was performed when ischemic or necrotic bowel segments failed to recover after reassessment of bowel viability. The method of reconstruction was determined according to intraoperative findings and patient condition. All resected specimens underwent pathological examination, and operative and pathological findings were recorded in the institutional database.

Statistical Analysis

Primary statistical analyses were performed using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). Receiver operating characteristic (ROC) curve

plotting, bootstrap confidence interval estimation, and pairwise area under the curve (AUC) comparisons were performed using Python and standard scientific libraries. The distribution of continuous variables was assessed visually and using the Kolmogorov–Smirnov test. Continuous variables are presented as median and interquartile range (IQR), whereas categorical variables are presented as counts and percentages. Comparisons between patients who underwent bowel resection and those who did not were performed using the Mann–Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables, as appropriate. Because malignancy-related obstruction may independently influence systemic inflammation, nutritional status, albumin levels, and lymphocyte count, patients with malignancy-related mechanical intestinal obstruction were excluded from the primary analysis. The final analytic cohort therefore consisted of patients with non-malignant mechanical intestinal obstruction. Patients were compared according to bowel resection status. In addition, the baseline and laboratory characteristics of the revised analytic cohort were compared with those of patients excluded because of malignancy-related obstruction. Missing data for variables required in the relevant analyses were handled using complete-case analysis, and no imputation was performed. Univariate logistic regression analysis was used to identify factors associated with bowel resection. Only variables available before or at the time of preoperative assessment were considered candidate predictors. Postoperative outcomes, including ICU admission, length of hospital stay, and 30-day mortality, were not included in the regression models. American Society of Anesthesiologists (ASA) classification was dichotomized as ASA ≥III versus ASA II, and adhesive obstruction served as the reference category for etiology. The Modified Glasgow Prognostic Score was evaluated as mGPS=2 versus mGPS 0–1. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). Adjusted multivariate logistic regression models were constructed using separate preoperative model structures to minimize mathematical overlap and multicollinearity among inflammatory and immunonutritional markers. Model 1 represented a conventional preoperative model that included CRP, albumin, and lymphocyte count in addition to adjustment variables. Model 2 evaluated the CALLY index as a dichotomous variable using the ROC-derived cutoff value of ≤2.77 and excluded CRP, albumin, lymphocyte count, and CAR because these variables are mathematically incorporated into the CALLY index. Model 3A evaluated PNI and excluded albumin and lymphocyte count because they are components of the PNI formula. Model 3B evaluated mGPS and excluded CRP and albumin because these variables are incorporated into the mGPS definition. Index-based markers were analyzed in separate models rather than simultaneously to reduce collinearity and preserve model interpretability. All adjusted models included age, sex, ASA classification ≥III, etiology, and symptom duration as covariates. Model performance was assessed using the Akaike information criterion (AIC) and McFadden's pseudo-R^2. ROC curve analysis was performed to evaluate the discriminatory performance of the CALLY index, PNI, mGPS, CAR, and NLR for predicting bowel resection. The AUC and corresponding 95% CIs were calculated, and optimal cutoff values were determined using Youden's J statistic. Cutoff values derived from Youden's J statistic were considered exploratory and were not externally validated. For the CALLY index and PNI, lower values were considered indicative of higher risk, whereas higher values of mGPS, CAR, and NLR were considered indicative of higher risk. AUC confidence intervals and pairwise AUC comparisons were estimated using bootstrap resampling with 1,000 iterations. Pairwise comparisons were performed using the CALLY index as the reference marker. A two-sided p value of <0.05 was considered statistically significant.

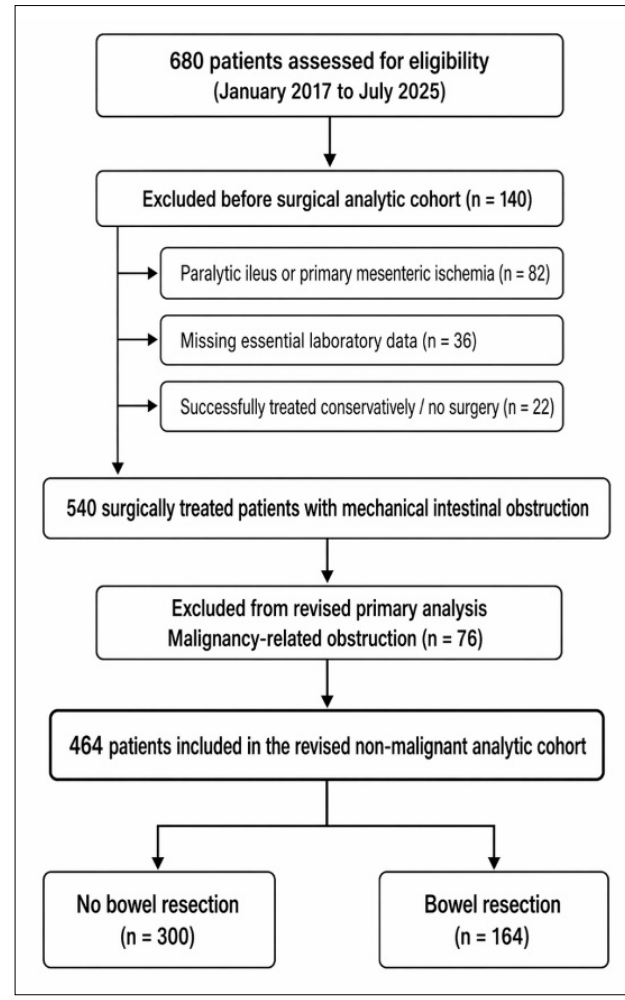

Figure 1. Flow diagram of patient selection. Of the 680 patients assessed between January 2017 and July 2025, 540 surgically treated patients met the initial eligibility criteria. After excluding 76 patients with malignancy-related obstruction, 464 patients were included in the revised non-malignant analytic cohort, comprising 300 patients who did not undergo bowel resection and 164 patients who underwent bowel resection.

RESULTS

Patient Selection

A total of 680 patients admitted with mechanical intestinal obstruction between January 2017 and July 2025 were assessed for eligibility. After exclusion of 140 patients according to the predefined eligibility criteria, 540 surgically treated patients remained. Subsequently, 76 patients with malignancy-related obstruction were excluded from the revised primary analysis. The final analytic cohort included 464 patients, comprising 300 patients who did not undergo bowel resection and 164 patients who underwent bowel resection (Fig. 1).

Baseline Demographic and Clinical Characteristics

Baseline demographic and clinical characteristics are presented in Table 1. Patients in the resection group were older than those in the no-resection group (69 [59–78] [22] vs. 63 [54–73] [17] years; p<0.001). Sex distribution and ASA classification did not differ significantly between the groups. The etiology of obstruction differed significantly between the groups (p<0.001). Adhesive obstruction was less frequent in the resection group, whereas hernia-related obstruction was more common. Symptom duration was significantly longer in the resection group than in the no-resection group (33.5 [20.0–71.2] vs. 21.0 [11.0–41.2] hours; p<0.001).

Preoperative Laboratory Parameters and Immunonutritional Indices

Preoperative laboratory findings and immunonutritional indices are summarized in Table 2. The resection group had significantly lower hemoglobin, albumin, lymphocyte count, PNI, and CALLY index values and significantly higher white blood cell count, neutrophil count, CRP, NLR, and CAR values than the no-resection group. Platelet counts did not differ significantly between the groups. A CALLY index ≤2.77 was more frequent in the resection group than in the no-resection group (79.9% vs. 31.7%; p<0.001). The frequency of mGPS=2 was also higher in the resection group (35.4% vs. 11.0%; p<0.001).

Clinical Outcomes

Clinical outcomes are presented in Table 3. ICU admission was more frequent in the resection group than in the non-resection group (28.7% vs. 8.7%; p<0.001). Hospital stay was significantly longer in the resection group (10 [8–14] vs. 6 [4–9] days; p<0.001). Thirty-day mortality was also higher in the resection group (9.1% vs. 2.3%; p=0.002).

Univariable Logistic Regression Analysis

Univariable logistic regression analysis is presented in Table 4. Age, ASA classification ≥III, hernia-related obstruction, symptom duration, CRP, white blood cell count, neutrophil count, NLR, CAR, CALLY index ≤2.77, and mGPS=2 were associated with increased odds of bowel resection. Higher albumin, lymphocyte count, hemoglobin, and PNI values were associated with lower odds of bowel resection. Female sex, volvulus/intussusception, and platelet count were not significantly associated with bowel resection.

Multivariable Logistic Regression Models

The adjusted multivariable logistic regression models are

Table 1. Baseline demographic and clinical characteristics of patients with mechanical intestinal obstruction

Variable	No bowel resection (n=300)	Bowel resection (n=164)	p
Age, years	63 (54–73)	69 (59–78)	<0.001*
Sex, n (%)			0.326
Female	154 (51.3)	92 (56.1)	
Male	146 (48.7)	72 (43.9)	
ASA classification, n (%)			0.125
II	43 (14.3)	13 (7.9)	
III	219 (73.0)	130 (79.3)	
IV	38 (12.7)	21 (12.8)	
Etiology, n (%)			<0.001*
Adhesive	188 (62.7)	74 (45.1)	
Hernia-related	64 (21.3)	62 (37.8)	
Volvulus/intussusception	48 (16.0)	28 (17.1)	
Symptom duration, hours	21.0 (11.0–41.2)	33.5 (20.0–71.2)	<0.001*

Data are presented as median (interquartile range) or n (%), as appropriate. Patients with malignancy-related obstructions were excluded from the revised analytic cohort. Continuous variables were compared using the Mann–Whitney U test, and categorical variables were compared using the chi-square test. ASA: American Society of Anesthesiologists; IQR: Interquartile range. *p<0.05.

Table 2. Preoperative laboratory parameters and immunonutritional indices according to bowel resection

Variable	No bowel resection (n=300)	Bowel resection (n=164)	p
Hemoglobin, g/dL	12.7 (11.8–13.7)	12.2 (10.9–13.4)	<0.001*
White blood cell count, $10^3/\mu L$	11.1 (9.2–14.8)	12.6 (10.3–17.6)	<0.001*
Neutrophil count, $10^3/\mu L$	6.1 (3.4–11.1)	8.4 (4.0–14.7)	0.006*
Platelet count, $10^3/\mu L$	248 (208–307)	245 (196–294)	0.332
CRP, mg/L	49.7 (23.8–101.3)	125.9 (67.4–185.0)	<0.001*
Albumin, g/dL	4.1 (3.8–4.4)	3.7 (3.3–3.9)	<0.001*
Lymphocyte count, $10^3/\mu L$	1.50 (1.07–2.01)	1.15 (0.75–1.72)	<0.001*
NLR	4.1 (2.5–6.4)	6.9 (4.2–12.2)	<0.001*
CAR	11.9 (5.9–27.3)	35.9 (19.1–54.0)	<0.001*
PNI	49.1 (44.8–52.5)	42.2 (39.0–46.4)	<0.001*
CALLY index	3.09 (1.76–4.82)	2.01 (1.09–2.59)	<0.001*
CALLY index ≤2.77, n (%)	95 (31.7)	131 (79.9)	<0.001*
mGPS, n (%)			<0.001*
0	30 (10.0)	0 (0.0)	
1	237 (79.0)	106 (64.6)	
2	33 (11.0)	58 (35.4)	

Data are presented as median (interquartile range) or n (%), as appropriate. Patients with malignancy-related obstruction were excluded from the revised analytic cohort. Continuous variables were compared using the Mann–Whitney U test, and categorical variables were compared using the chi-square test. CRP: C-reactive protein; NLR: Neutrophil-to-lymphocyte ratio; CAR: C-reactive protein-to-albumin ratio; PNI: Prognostic Nutritional Index; CALLY: C-reactive protein–albumin–lymphocyte index; mGPS: Modified Glasgow Prognostic Score. *p<0.05.

Table 3. Clinical outcomes according to bowel resection status

Variable	No bowel resection (n=300)	Bowel resection (n=164)	p
ICU admission, n (%)	26 (8.7)	47 (28.7)	<0.001*
Length of hospital stay, days	6 (4–9)	10 (8–14)	<0.001*
30-day mortality, n (%)	7 (2.3)	15 (9.1)	0.002*

Data are presented as median (interquartile range) or n (%), as appropriate. Patients with malignancy-related obstruction were excluded from the revised analytic cohort. Continuous variables were compared using the Mann–Whitney U test, whereas categorical variables were compared using the chi-square test with continuity correction or Fisher's exact test, as appropriate. ICU: Intensive care unit. *p<0.05.

shown in Table 5. In the conventional preoperative model, CRP level was independently associated with increased odds of bowel resection (adjusted OR: 1.010; 95% CI: 1.007–1.014; p<0.001), whereas albumin level (adjusted OR: 0.121; 95% CI: 0.066–0.221; p<0.001) and lymphocyte count (adjusted OR: 0.640; 95% CI: 0.467–0.877; p=0.005) were independently associated with lower odds of bowel resection.

In the CALLY-based model, a CALLY index ≤2.77 was independently associated with bowel resection (adjusted OR: 9.024; 95% CI: 5.578–14.598; p<0.001). In the alternative index-based models, lower PNI remained independently associated with bowel resection (adjusted OR: 0.833; 95% CI: 0.797–0.871; p<0.001), whereas mGPS=2 was associated with increased odds of bowel resection (adjusted OR: 4.454; 95% CI: 2.662–7.451; p<0.001).

The conventional preoperative model showed the most favorable apparent model fit, with the lowest AIC and highest McFadden pseudo-R^2 values among all evaluated models. Among the index-based models, the CALLY-based model showed more favorable apparent fit indices than the PNI- and mGPS-based models.

Diagnostic Performance

Diagnostic performance results are shown in Table 6 and Fig-

Table 4. Univariable logistic regression analysis for predicting bowel resection

Variable	OR	95% CI	p
Age, per year	1.031	1.016–1.047	<0.001
Female sex	1.211	0.826–1.776	0.326
ASA classification ≥III	1.943	1.012–3.731	0.046
Hernia-related obstruction	2.461	1.584–3.825	<0.001
Volvulus/intussusception	1.482	0.865–2.538	0.152
Symptom duration, per hour	1.014	1.008–1.020	<0.001
CRP, per mg/L	1.012	1.009–1.015	<0.001
Albumin, per g/dL	0.085	0.049–0.147	<0.001
Lymphocyte count, per 10^3/μL	0.595	0.456–0.777	<0.001
Hemoglobin, per g/dL	0.802	0.710–0.906	<0.001
White blood cell count, per 10^3/μL	1.038	1.015–1.061	<0.001
Neutrophil count, per 10^3/μL	1.034	1.013–1.055	0.001
Platelet count, per 10^3/μL	0.999	0.996–1.001	0.344
NLR	1.158	1.108–1.210	<0.001
CAR	1.052	1.040–1.064	<0.001
PNI, per unit	0.83	0.796–0.865	<0.001
CALLY index ≤2.77	8.566	5.447–13.470	<0.001
mGPS=2	4.427	2.731–7.176	<0.001

Values are presented as odds ratios with 95% confidence intervals. Adhesive obstruction was used as the reference category for the etiology. Patients with malignancy-related obstruction were excluded from the revised analytic cohort. ASA: American Society of Anesthesiologists; CAR: C-reactive protein-to-albumin ratio; CALLY: C-reactive protein–albumin–lymphocyte index; CI: Confidence interval; CRP: C-reactive protein; mGPS: Modified Glasgow Prognostic Score; NLR: Neutrophil-to-lymphocyte ratio; OR: Odds ratio; PNI: Prognostic Nutritional Index.

Table 5. Adjusted multivariable logistic regression models for predicting bowel resection

Model	Main predictor	Adjusted OR (95% CI)	p	AIC	McFadden pseudo-R^2
Model 1: Conventional preoperative model	CRP, per mg/L	1.010 (1.007–1.014)	<0.001	428.4	0.322
	Albumin, per g/dL	0.121 (0.066–0.221)	<0.001		
	Lymphocyte count, per 10^3/μL	0.640 (0.467–0.877)	0.005		
Model 2: CALLY-based model	CALLY Index ≤2.77	9.024 (5.578–14.598)	<0.001	465.7	0.254
Model 3A: PNI-based model	PNI, per unit	0.833 (0.797–0.871)	<0.001	474.4	0.24
Model 3B: mGPS-based model	mGPS=2	4.454 (2.662–7.451)	<0.001	527.6	0.151

Values are presented as adjusted odds ratios with 95% confidence intervals. All models were adjusted for age, sex, ASA classification ≥III, etiology, and symptom duration. Postoperative outcomes were not included in the regression models. To minimize multicollinearity, the CALLY-based model excluded overlapping laboratory components incorporated into the CALLY index. AIC: Akaike information criterion; ASA: American Society of Anesthesiologists; CALLY: C-reactive protein–albumin–lymphocyte index; CI: Confidence interval; CRP: C-reactive protein; mGPS: Modified Glasgow Prognostic Score; OR: Odds ratio; PNI: Prognostic Nutritional Index.

ure 2. The CALLY index yielded an AUC of 0.744 (95% CI: 0.699–0.788; p<0.001), with an optimal cutoff value of ≤2.77. At this cutoff, sensitivity was 79.9%, specificity was 68.3%, positive predictive value (PPV) was 58.0%, and negative predictive value (NPV) was 86.1%.

PNI showed an AUC of 0.775 (95% CI: 0.727–0.821), CAR an

Table 6. Diagnostic performance of preoperative inflammatory and immunonutritional markers for predicting bowel resection

Panel A. Diagnostic performance of individual markers

Marker	Risk-defining cutoff	AUC (95% CI)	Sensitivity/ Specificity (%)	PPV/NPV (%)	p
CALLY index	≤2.77	0.744 (0.699–0.788)	79.9/68.3	58.0/86.1	<0.001
PNI	≤44.15	0.775 (0.727–0.821)	65.2/79.7	63.7/80.7	<0.001
mGPS	=2	0.654 (0.615–0.693)	35.4/89.0	63.7/71.6	<0.001
CAR	≥18.97	0.768 (0.722–0.813)	76.2/65.3	54.6/83.4	<0.001
NLR	≥6.34	0.693 (0.642–0.742)	54.9/74.7	54.2/75.2	<0.001

Panel B. Pairwise bootstrap comparisons of AUC using the CALLY index as the reference marker

Comparison	p value
CALLY index vs. PNI	0.378
CALLY index vs. mGPS	0.014
CALLY index vs. CAR	0.482
CALLY index vs. NLR	0.116

Cutoffs were determined using Youden's J statistic. Lower values of the CALLY index and PNI and higher values of mGPS, CAR, and NLR indicate greater risk. Confidence intervals for AUC estimates were generated using bootstrap resampling. The CALLY index did not demonstrate statistically superior discriminatory performance compared with PNI or CAR. AUC: Area under the curve; CI: Confidence interval; PPV: Positive predictive value; NPV: Negative predictive value; CALLY: C-reactive protein–albumin–lymphocyte index; PNI: Prognostic Nutritional Index; mGPS: Modified Glasgow Prognostic Score; CAR: C-reactive protein-to-albumin ratio; NLR: Neutrophil-to-lymphocyte ratio.

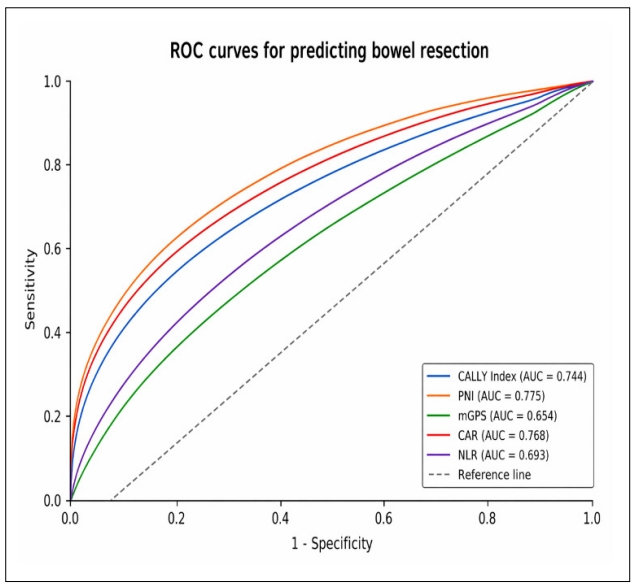

Figure 2. Receiver operating characteristic (ROC) curves for predicting bowel resection. Receiver operating characteristic curves comparing the C-reactive protein–albumin–lymphocyte (CALLY) index, Prognostic Nutritional Index (PNI), Modified Glasgow Prognostic Score (mGPS), C-reactive protein-to-albumin ratio (CAR), and neutrophil-to-lymphocyte ratio (NLR) for predicting bowel resection after exclusion of malignancy-related obstruction. Area under the curve (AUC) values are presented in the legend.

AUC of 0.768 (95% CI: 0.722–0.813), NLR an AUC of 0.693 (95% CI: 0.642–0.742), and mGPS an AUC of 0.654 (95% CI: 0.615–0.693). Although PNI and CAR had numerically higher AUC values than the CALLY index, pairwise bootstrap comparisons showed no statistically significant differences between the CALLY index and PNI (p=0.378) or between the CALLY index and CAR (p=0.482). The CALLY index demonstrated a significantly higher AUC than mGPS (p=0.014), whereas the difference between the CALLY index and NLR was not statistically significant (p=0.116).

Comparison With Malignancy-Related Obstruction Cases

The revised analytic cohort and patients excluded because of malignancy-related obstruction are compared in Supplementary Table 1. No significant differences were observed between the groups in terms of age, sex, ASA classification III–IV, symptom duration, CRP level, albumin level, lymphocyte count, NLR, CAR, PNI, CALLY index, frequency of mGPS=2, or bowel resection rate.

DISCUSSION

Intestinal ischemia requiring bowel resection is a serious complication of mechanical intestinal obstruction. Delayed recognition of ischemia may lead to irreversible bowel necrosis, sepsis, postoperative morbidity, and death. Therefore, identifying simple preoperative markers that may help stratify the risk of irreversible ischemia requiring bowel resection is clinically relevant in emergency surgical practice.[1,4–6,16] In the non-malignant analytic cohort, patients who underwent bowel resection had higher inflammatory marker levels and lower nutritional and immune-related indices. In the conventional preoperative model, CRP was positively associated with

bowel resection, whereas albumin and lymphocyte counts were inversely associated with this outcome. In separate index-based models, a CALLY index value of ≤2.77, lower PNI values, and an mGPS of 2 remained independently associated with bowel resection.

Separate preoperative model structures were used to preserve temporal validity and model interpretability. ICU admission, length of hospital stay, and 30-day mortality were not included in the regression models because they represented postoperative or post-decision outcomes rather than true preoperative predictors. In addition, inflammatory and immunonutritional markers with shared mathematical components were not entered simultaneously into a single model, given the overlap among CRP, albumin, lymphocyte count, CAR, PNI, mGPS, and the CALLY index. This strategy reduced the risk of multicollinearity and allowed clearer interpretation of the association between each marker construct and bowel resection.

The CALLY index, evaluated using an ROC-derived cutoff value of ≤2.77, was independently associated with bowel resection and demonstrated moderate discriminatory performance, with an AUC of 0.744. However, pairwise AUC comparisons showed that the CALLY index did not have a statistically significant discriminatory advantage over PNI or CAR. Therefore, the present findings should not be interpreted as evidence that the CALLY index is superior to other inflammatory or immunonutritional markers. Rather, the CALLY index appears to provide an integrated inflammatory, nutritional, and immune signal that is broadly comparable to PNI and CAR, while demonstrating significantly higher discriminatory performance than mGPS in this cohort.

The biological plausibility of the CALLY index in this context is related to its combined inflammatory, nutritional, and immune components.[8,15,17] CRP reflects systemic inflammatory activation, which may increase in response to strangulation, ischemia, bacterial translocation, and necrosis.[1,4,6,16] Albumin levels decrease during systemic inflammation and may also reflect reduced nutritional reserves, whereas lymphocyte count provides information on immune competence and physiological stress.[9,11,17] By integrating these parameters, the CALLY index may reflect the systemic burden associated with irreversible ischemic injury more comprehensively than any single laboratory marker.[8,15,16] Interest in the CALLY index has recently extended beyond oncologic prognosis to acute or inflammatory surgical conditions.[7,15] Compared with a previously reported cohort of patients with strangulated abdominal wall hernias,[15] the present study evaluated a more heterogeneous population with non-malignant mechanical intestinal obstruction, including adhesive, hernia-related, volvulus, and intussusception-related obstruction. This broader case mix may extend the potential applicability of immunonutritional risk assessment to a wider range of emergency surgical settings in the future.

The findings regarding PNI also merit specific consideration. In the present analysis, lower PNI was independently associated with bowel resection and showed the highest numerical AUC among the evaluated markers. This finding suggests that impaired nutritional reserve and lymphocyte-mediated immune status may be closely related to the development of irreversible ischemic injury in mechanical intestinal obstruction. PNI has been extensively investigated as a prognostic marker in surgical and oncologic populations, largely because it integrates serum albumin, which reflects nutritional and inflammatory status, with lymphocyte count, which reflects immune competence and physiological stress.[9,15,18–21] However, PNI does not directly incorporate CRP and therefore may not fully capture the acute inflammatory component of obstruction-related ischemia. In contrast, the CALLY index integrates CRP, albumin, and lymphocyte count into a single index. The numerically comparable performance of PNI and the CALLY index in this cohort suggests that these indices may provide complementary rather than hierarchical risk information.

The association between mGPS and bowel resection also deserves consideration. In the adjusted model, an mGPS of 2 was associated with increased odds of bowel resection, suggesting that the coexistence of systemic inflammation and hypoalbuminemia may reflect greater physiological vulnerability in patients with mechanical intestinal obstruction. Nevertheless, its discriminatory performance was lower than that of the CALLY index, PNI, and CAR. This lower discriminatory performance may be partly explained by the structure of mGPS. Unlike continuous or ratio-based indices, mGPS categorizes CRP and albumin values into three broad categories, which may limit its ability to distinguish subtle differences in risk. Nevertheless, mGPS remains a simple, reproducible, and clinically accessible marker of inflammation-related risk, with prognostic value reported across several malignant and inflammatory conditions.[22,23–26]

The novelty of the present study should be interpreted in the context of its broader and more heterogeneous clinical population. A previous study evaluated albumin-based nutritional indices, including the CALLY index, in patients with strangulated abdominal wall hernias.[15] Therefore, the present study should not be considered the first investigation of the CALLY index in obstruction-related ischemia. Rather, its contribution lies in evaluating the CALLY index and related immunonutritional indices in a broader population of patients with non-malignant mechanical intestinal obstruction, including adhesive, hernia-related, volvulus, or intussusception-related obstructions. This distinction is clinically relevant because these etiologies may differ in underlying pathophysiology, timing of ischemic progression, inflammatory response, and operative decision-making. By extending the assessment beyond an isolated strangulated hernia cohort, this study provides a more generalizable framework for exploring immunonutritional risk markers in emergency mechanical obstruction.

The exclusion of malignancy-related obstruction was intended to minimize clinically relevant confounding. Malignancy may affect CRP, albumin, and lymphocyte counts through chronic inflammation, cachexia, malnutrition, and treatment-related immune changes.[9,12,13] Including such cases in the primary analysis could have biased the evaluation of albumin-based immunonutritional indices. Therefore, malignancy-related cases were excluded from the primary analytic cohort, and the excluded group was compared with the final non-malignant cohort. This comparison did not identify significant differences in the CALLY index, PNI, CAR, mGPS, or bowel resection rates, suggesting that exclusion of malignancy-related cases did not materially alter the overall distribution of these markers. Nevertheless, residual confounding related to the retrospective design and unmeasured disease-related factors cannot be excluded.

From a clinical standpoint, the evaluated markers should be interpreted as adjunctive risk-stratification tools rather than standalone decision rules. Mechanical intestinal obstruction is a dynamic emergency condition in which decision-making requires integration of clinical examination, radiological findings, serial laboratory trends, comorbidity status, and intraoperative assessment.[1,4–6] In this context, a low CALLY index, low PNI, high CAR, or mGPS of 2 may help identify patients with greater systemic inflammatory burden and reduced physiological reserve. However, these markers should not be used in isolation to mandate, defer, or prioritize surgery. Their potential clinical value lies in supporting early risk recognition, closer monitoring, and more individualized perioperative planning in patients with suspected ischemic progression.

This study has several limitations. First, its retrospective, single-center design introduces the possibility of selection bias, information bias, and confounding factors that were not measured. In addition, the use of complete-case analysis may have introduced bias related to missing data. Second, the primary endpoint was bowel resection due to irreversible ischemia or necrosis, rather than all grades of reversible intestinal ischemia; therefore, the findings apply mainly to advanced ischemic injury requiring bowel resection. Third, the ROC-derived cutoff values and observed discriminatory performance of the evaluated markers were exploratory and require external validation in independent cohorts. Fourth, although separate models were used to reduce multicollinearity, the evaluated indices shared overlapping biological components, and causal interpretations should be avoided. Finally, surgical decision-making and intraoperative bowel viability assessment may vary among surgeons and over time.

In conclusion, preoperative inflammatory and immunonutritional markers were associated with bowel resection due to irreversible ischemic injury in patients with non-malignant mechanical intestinal obstruction. The CALLY index was independently associated with bowel resection and demonstrated moderate discriminatory performance; however, it was not statistically superior to PNI or CAR. These findings suggest that the CALLY index may serve as an adjunctive marker within a broader preoperative risk assessment framework rather than as a standalone predictor or decision rule. Prospective multicenter studies are needed to externally validate the proposed cutoff values and marker performance and to determine whether integrating immunonutritional indices with clinical and radiological findings improves decision-making in patients with mechanical intestinal obstruction.

CONCLUSION

Preoperative inflammatory and immunonutritional markers were associated with bowel resection due to irreversible ischemic injury in patients with non-malignant mechanical intestinal obstruction. The CALLY index was independently associated with bowel resection and demonstrated moderate discriminatory performance; however, it did not show a statistically significant advantage over PNI or CAR. These findings suggest that the CALLY index may serve as an adjunctive marker within a broader preoperative risk assessment framework rather than as a standalone predictor or decision rule. Given the comparable performance of several inflammatory and immunonutritional indices, these markers should be interpreted in conjunction with clinical examination, radiological findings, serial laboratory trends, and surgical judgment. Prospective multicenter studies are needed to externally validate the proposed cutoff values and marker performance and to determine whether integrating immunonutritional indices into clinical risk assessment improves decision-making in patients with intestinal obstruction.

Acknowledgments: The authors thank the surgical team and medical records unit of Mersin City Training and Research Hospital for their support during data collection.

Ethics Committee Approval: This study was approved by the Non-Interventional Clinical Research Ethics Committee of Mersin City Training and Research Hospital (Date: 20.11.2025, Decision No: 2025/30).

Informed Consent: The requirement for informed consent was waived because of the retrospective design and use of anonymized patient data.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: S.A., H.V.S.; Design: S.A., H.V.S.; Supervision: S.A.; Resource: S.A.; Materials: S.A.; Data collection and/or processing: S.A., H.V.S.; Analysis and/or interpretation: S.A., H.V.S.; Literature review: S.A., H.V.S.; Writing: S.A.; Critical review: S.A.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Ten Broek RPG, Krielen P, Di Saverio S, Coccolini F, Biffl WL, Ansaloni L, et al. Bologna guidelines for diagnosis and management of adhesive

small bowel obstruction (ASBO): 2017 update of the evidence-based guidelines from the world society of emergency surgery ASBO working group. World J Emerg Surg 2018;13:24. [CrossRef]
2. Eren T, Boluk S, Bayraktar B, Ozemir IA, Yildirim Boluk S, Tombalak E, et al. Surgical indicators for the operative treatment of acute mechanical intestinal obstruction due to adhesions. Ann Surg Treat Res 2015;88:325–33. [CrossRef]
3. Uprak TK, Akin MI, Coskun M, Yegen C. Factors predicting surgical treatment in patients with adhesive small bowel obstruction: retrospective single-centre study. J Coll Physicians Surg Pak 2022;32:1127–31. [CrossRef]
4. Bower KL, Lollar DI, Williams SL, Adkins FC, Luyimbazi DT, Bower CE. Small bowel obstruction. Surg Clin North Am 2018;98:945–71. [CrossRef]
5. Millet I, Boutot D, Faget C, Pages-Bouic E, Molinari N, Zins M, et al. Assessment of strangulation in adhesive small bowel obstruction on the basis of combined CT findings: implications for clinical care. Radiology 2017;285:798–808. [CrossRef]
6. Pan S, Yang J, Liu Z, Nai R, Chen Z. A prediction model to differentiate transient ischemia from irreversible transmural necrosis in closed-loop small bowel obstruction. Front Med (Lausanne) 2024;11:1466754. [CrossRef]
7. Gungor F, Kılavuz H, Arslan MF, Demir M, Korkmaz YY, Bekraki A, et al. Predictive value of the cally score in determining surgical strategy for complicated left-sided colonic diverticulitis: a retrospective cohort study. Medicina (Kaunas) 2025;61:1455. [CrossRef]
8. Takeda Y, Sugano H, Okamoto A, Nakano T, Shimoyama Y, Takada N, et al. Prognostic usefulness of the C-reactive protein-albumin-lymphocyte (CALLY) index as a novel biomarker in patients undergoing colorectal cancer surgery. Asian J Surg 2024;47:3492–8. [CrossRef]
9. Sun G, Li Y, Peng Y, Lu D, Zhang F, Cui X, et al. Impact of the preoperative prognostic nutritional index on postoperative and survival outcomes in colorectal cancer patients who underwent primary tumor resection: a systematic review and meta-analysis. Int J Colorectal Dis 2019;34:681–9. [CrossRef]
10. Wu B, Liu J, Shao C, Yu D, Liao J. Integrating inflammation, nutrition, and immunity: the CALLY index as a prognostic tool in digestive system cancers - a systematic review and meta-analysis. BMC Cancer 2025;25:672. [CrossRef]
11. Sakurai K, Kubo N, Hasegawa T, Nishimura J, Iseki Y, Nishii T, et al. Clinical significance of the CALLY index in patients with gastric cancer undergoing gastrectomy. World J Surg 2024;48:2749–59. [CrossRef]
12. Pang HY, Chen XF, Yan MH, Chen LH, Chen ZX, Zhang SR, et al. Clinical significance of the advanced lung cancer inflammation index in gastrointestinal cancer patients: a systematic review and meta-analysis. Front Oncol 2023;13:1021672. [CrossRef]
13. Kılıç Ö, Tecer D, Canbaş M, Kaya MN, Çınar M, Yılmaz S. Immune nutrition indices are associated with disease activity in rheumatoid arthritis: a cross-sectional study. Biomark Med 2024;18:1093–102. [CrossRef]
14. Akbas A, Koyuncu S, Hacım NA, Dasiran MF, Kasap ZA, Okan I. Can HALP (Hemoglobin, Albumin, Lymphocytes, and Platelets) score differentiate between malignant and benign causes of acute mechanic intestinal obstruction? Cancer Biother Radiopharm 2022;37:199–204. [CrossRef]
15. Angın YS, Şendil AM, Zengin A, Ceylan C, Kılıç M, Ulaş M. The predictive value of albumin-based nutritional indices for intestinal ischemia in strangulated abdominal wall hernias: an insight into the novel CALLY Index. Hernia 2025;29:168. [CrossRef]
16. Li X, Tian M, Liu Y, Zhang Y, Chen J. Predictive factors of intestinal ischaemia in adhesive small bowel obstruction. Journal of the College of Physicians and Surgeons-Pakistan: JCPSP2024;34:146–50. [CrossRef]
17. Yang M, Lin SQ, Liu XY, Tang M, Hu CL, Wang ZW, et al. Association between C-reactive protein-albumin-lymphocyte (CALLY) index and overall survival in patients with colorectal cancer: From the investigation on nutrition status and clinical outcome of common cancers study. Front Immunol 2023;14:1131496. [CrossRef]
18. Tanaka Y, Inoue D, Tsuyoshi H, Nakamura Y, Kato M, Kato M, et al. Usefulness of nutritional assessment indicators in predicting treatment discontinuation due to adverse events from parp inhibitors in ovarian cancer patients. Cancers (Basel) 2024;16:3602. [CrossRef]
19. Maehira H, Mori H, Nitta N, Maekawa T, Nishina Y, Ishikawa H, et al. Clinical impact of the prognostic nutritional index and skeletal muscle index for the incompletion of adjuvant chemotherapy for pancreatic cancer. Asian J Surg 2024:S1015-9584(24)02484-9.
20. Wang L, Long X, Zhu Y, Luo A, Yang M. Association of prognostic nutritional index with long-term survival in lung cancer receiving immune checkpoint inhibitors: A meta-analysis. Medicine (Baltimore) 2024;103:e41087. [CrossRef]
21. Sun K, Chen S, Xu J, Li G, He Y. The prognostic significance of the prognostic nutritional index in cancer: a systematic review and meta-analysis. J Cancer Res Clin Oncol 2014;140:1537–49. [CrossRef]
22. Demirelli B, Babacan NA, Ercelep Ö, Öztürk MA, Kaya S, Tanrıkulu E, et al. Modified Glasgow Prognostic Score, Prognostic Nutritional Index and ECOG Performance Score Predicts Survival Better than Sarcopenia, Cachexia and Some Inflammatory Indices in Metastatic Gastric Cancer. Nutr Cancer 2021;73:230–8. [CrossRef]
23. Nie D, Zhang L, Wang C, Guo Q, Mao X. A high Glasgow prognostic score (GPS) or modified Glasgow prognostic score (mGPS) predicts poor prognosis in gynecologic cancers: a systematic review and meta-analysis. Arch Gynecol Obstet 2020;301:1543–51. [CrossRef]
24. Wu D, Wang X, Shi G, Sun H, Ge G. Prognostic and clinical significance of modified glasgow prognostic score in pancreatic cancer: a meta-analysis of 4,629 patients. Aging (Albany NY) 2021;13:1410-21. [CrossRef]
25. Shimada A, Matsuda T, Sawada R, Hasegawa H, Yamashita K, Harada H, et al. The modified Glasgow prognostic score is a reliable predictor of oncological outcomes in patients with rectal cancer undergoing neoadjuvant chemoradiotherapy. Sci Rep 2023;13:17111. [CrossRef]
26. Wu J, Wang H, Yang R, Liu D, Li W. Prognostic significance of the modified Glasgow Prognostic Score in NSCLC patients undergoing immune checkpoint inhibitor therapy: a meta-analysis. Front Oncol 2024;14:1449853. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Mekanik intestinal obstrüksiyonda intestinal iskemi prediksiyonu: C-reaktif protein–albümin–lenfosit indeksinin rolü

AMAÇ: Barsak rezeksiyonu gerektiren intestinal iskemi, mekanik intestinal obstrüksiyonun ciddi komplikasyonlarından biridir ve geri dönüşümsüz iskemik hasarı olan hastaların erken dönemde belirlenmesi güçtür. C-reaktif protein–albümin–lenfosit (CALLY) İndeksi, Prognostik Nutrisyonel İndeks (PNI) ve modifiye Glasgow Prognostik Skoru (mGPS) gibi albümin temelli immünonutrisyonel indeksler; sistemik enflamasyon, nutrisyonel rezerv ve immün durumu yansıtabilir. Bu çalışmada, non-malign mekanik intestinal obstrüksiyon nedeniyle opere edilen hastalarda bu indekslerin geri dönüşümsüz iskemik hasara bağlı barsak rezeksiyonunu öngörmedeki prognostik değerinin değerlendirilmesi amaçlandı.

GEREÇ VE YÖNTEM: Bu retrospektif gözlemsel kohort çalışmada, Ocak 2017 ile Temmuz 2025 tarihleri arasında mekanik intestinal obstrüksiyon nedeniyle başvuran 680 yetişkin hasta tarandı. Önceden tanımlanmış dışlama kriterleri ve malignite ilişkili obstrüksiyonun dışlanması sonrasında, non-malign mekanik intestinal obstrüksiyonu olan 464 hasta final analize dahil edildi. Hastalar barsak rezeksiyonu durumuna göre gruplandırıldı. Demografik özellikler, laboratuvar parametreleri, enflamatuvar ve immünonutrisyonel indeksler ile klinik sonuçlar kaydedildi. İlişkili indeksler arasındaki matematiksel örtüşme ve çoklu doğrusal bağlantı riskini azaltmak amacıyla ayrı preoperatif çok değişkenli lojistik regresyon modelleri oluşturuldu. Tanısal performans ROC eğrisi analizi ile değerlendirildi.

BULGULAR: Final kohort, barsak rezeksiyonu uygulanmayan 300 hasta ve barsak rezeksiyonu uygulanan 164 hastadan oluştu. Rezeksiyon grubunda enflamatuvar belirteçler daha yüksek, nutrisyonel ve immün ilişkili indeksler daha düşük bulundu. Konvansiyonel preoperatif modelde CRP barsak rezeksiyonu ile pozitif ilişkili iken, albümin ve lenfosit sayısı bu sonuçla ters ilişkiliydi. Ayrı indeks temelli modellerde, CALLY İndeksi değerinin ≤2.77 olması, düşük PNI değerleri ve mGPS skorunun 2 olması barsak rezeksiyonu ile bağımsız olarak ilişkili bulundu. CALLY indeksi orta düzeyde ayırt edici performans gösterdi (AUC=0.744). Ancak ikili AUC karşılaştırmalarında CALLY'nin PNI veya CAR'a göre istatistiksel olarak anlamlı bir ayırt edici üstünlüğü saptanmadı.

SONUÇ: Preoperatif enflamatuvar ve immünonutrisyonel belirteçler, non-malign mekanik intestinal obstrüksiyonu olan hastalarda geri dönüşümsüz iskemik hasara bağlı barsak rezeksiyonu ile ilişkili bulundu. CALLY İndeksi barsak rezeksiyonu ile bağımsız olarak ilişkiliydi ve orta düzeyde ayırt edici performans gösterdi; ancak PNI veya CAR'a istatistiksel olarak üstün değildi. Bu indeksler, tek başına karar verdirici araçlar olmaktan ziyade, daha geniş bir preoperatif risk değerlendirme çerçevesinde yardımcı belirteçler olarak kullanılabilir. Önerilen cutoff değerlerinin ve belirteç performansının doğrulanması için prospektif çok merkezli çalışmalara ihtiyaç vardır.

Anahtar sözcükler: Barsak rezeksiyonu; CALLY indeksi; mekanik intestinal obstrüksiyon; mGPS; PNI.

Ulus Travma Acil Cerrahi Derg 2026;32(8):908-919 DOI: 10.14744/tjtes.2026.67362

Supplementary Table 1. Comparison of the final analytic cohort and patients excluded because of malignancy-related obstruction

Variable	Final analytic cohort (n=464)	Malignancy-related obstruction excluded (n=76)	p
Age, years	65 (56–75)	65 (57–75)	0.922
Female sex, n (%)	246 (53.0)	40 (52.6)	1.000
ASA classification III–IV, n (%)	408 (87.9)	62 (81.6)	0.179
Symptom duration, hours	26 (14–51)	26 (14–58)	0.807
CRP, mg/L	71.0 (31.3–141.1)	78.8 (51.2–129.5)	0.193
Albumin, g/dL	3.9 (3.6–4.2)	3.9 (3.5–4.1)	0.290
Lymphocyte count, $10^3/\mu L$	1.38 (0.96–1.98)	1.31 (0.94–1.83)	0.599
NLR	5.0 (2.9–8.5)	4.4 (2.8–8.3)	0.712
CAR	18.4 (7.7–39.4)	20.8 (12.5–35.2)	0.168
PNI	47.0 (42.4–51.1)	45.7 (42.5–48.5)	0.139
CALLY index	2.81 (1.56–4.16)	2.79 (1.65–4.29)	0.827
mGPS=2, n (%)	91 (19.6)	19 (25.0)	0.354
Bowel resection, n (%)	164 (35.3)	28 (36.8)	0.902

Data are presented as median (interquartile range) or n (%). Continuous variables were compared using the Mann–Whitney U test, whereas categorical variables were compared using the chi-square test with continuity correction or Fisher's exact test, as appropriate. ASA: American Society of Anesthesiologists; CRP: C-reactive protein; NLR: Neutrophil-to-lymphocyte ratio; CAR: C-reactive protein-to-albumin ratio; PNI: Prognostic Nutritional Index; CALLY: C-reactive protein–albumin–lymphocyte index; mGPS: Modified Glasgow Prognostic Score.

ORIGINAL ARTICLE

Comparative performance among inflammatory biomarkers for pre-operative prediction of gangrenous cholecystitis

Alp Omer Canturk,[1] Merve Yesilsancak,[1] Elif Tutar,[1] Emre Sabuncu,[2] Erhan Eroz,[2] Necattin Firat,[1] Fatih Altintoprak,[1]

[1]Department of General Surgery, Sakarya University Faculty of Medicine, Sakarya-*Türkiye*
[2]Department of General Surgery, Sakarya Training and Research Hospital, Sakarya-*Türkiye*

ABSTRACT

BACKGROUND: This study aimed to compare the diagnostic performance of inflammatory biomarkers derived from routine blood parameters in patients with acute cholecystitis, based on the hypothesis that these biomarkers can predict gangrenous cholecystitis independently of imaging before surgery.

METHODS: Data from 187 consecutive adult patients who underwent laparoscopic cholecystectomy for acute cholecystitis during the same hospitalization were retrospectively analyzed in an observational cohort. After the exclusion of 7 cases, 180 patients constituted the analytic cohort. Gangrenous cholecystitis was defined as intraoperative or pathological verification. C-reactive protein (CRP) and six prespecified haemogram-derived indices – the neutrophil-, platelet- and monocyte-to-lymphocyte ratios (neutrophil-to-lymphocyte ratio [NLR], platelet-to-lymphocyte ratio [PLR], monocyte-to-lymphocyte ratio [MLR]) and three composite indices (systemic immune-inflammation index, systemic inflammation response index [SIRI], aggregate index of systemic inflammation) – were evaluated; diagnostic accuracy was assessed using receiver operating characteristic-area under the curve (ROC-AUC), cutoff points were determined using the Youden index, and an age- and sex-adjusted logistic regression model was established.

RESULTS: Gangrenous cholecystitis was confirmed in 33 of the 180 analyzed patients (18.3%). CRP was 163.00 mg/L (interquartile range [IQR] 39.00–224.00) in the gangrenous group and 15.00 mg/L (IQR 4.02–55.89) in the non-gangrenous group. Among hemogram-derived indices, SIRI (7.10 [4.09–10.03] vs. 2.48 [1.03–4.89]) and MLR (0.62 [0.40–0.79] vs. 0.31 [0.19–0.50]) were significantly higher in gangrenous cases (both $p<0.001$); NLR was 8.00 (5.32–12.90) vs. 4.00 (2.35–6.66) ($p<0.001$). In the ROC analysis, CRP showed the highest discriminatory power (AUC 0.81; 95% confidence interval 0.71–0.89); at a cutoff point of 61.0 mg/L, the sensitivity and specificity were 0.73 and 0.78, respectively. Among the derived indices, the highest AUCs were observed for SIRI and AISI. In the model including CRP and SIRI adjusted for age and sex, only CRP remained an independent predictor; each 10 mg/L increase in CRP was associated with a 14% increase in the odds of gangrenous cholecystitis.

CONCLUSION: CRP provides the highest discrimination for pre-operative prediction of gangrenous cholecystitis and was the only independent predictor in multivariable analysis. The hemogram-derived indices showed moderate univariable discrimination, but their additional value beyond CRP remains uncertain and requires further evaluation in larger, prospective cohorts.

Keywords: Acute cholecystitis; C-reactive protein; Gangrenous cholecystitis; inflammatory biomarkers; laparoscopic cholecystectomy.

Cite this article as: Canturk AO, Yesilsancak M, Tutar E, Sabuncu E, Eroz E, Firat N, et al. Comparative performance among inflammatory biomarkers for pre-operative prediction of gangrenous cholecystitis. Ulus Travma Acil Cerrahi Derg 2026;32:920-929.

Address for correspondence: Alp Ömer Cantürk
Department of General Surgery, Sakarya University Faculty of Medicine, Sakarya, Türkiye
E-mail: dr.omercanturk@gmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):920-929 DOI: 10.14744/tjtes.2026.63043
Submitted: 17.01.2026 Revised: 06.07.2026 Accepted: 08.07.2026 Published: 10.08.2026

INTRODUCTION

Acute cholecystitis is one of the most common complications of gallstone disease and increases morbidity and mortality if surgery is not performed in a timely manner.[1] Current guidelines recommend early laparoscopic cholecystectomy, but the difficulty level of acute cholecystitis surgery can vary significantly, and there are no clearly defined criteria in the literature for predicting gangrenous cholecystitis preoperatively.[2] Gangrenous cholecystitis is one of these severe clinical presentations, with an incidence of 10–40% and morbidity of 15–50% among acute cholecystitis cases.[3] Deciding on the timing of surgery and the balance between risks and benefits is a challenging process that requires clinical experience. This is particularly true for severe variants such as gangrenous cholecystitis, where objective pre-operative risk stratification is still poorly defined. Various clinical and sonographic scoring systems have been developed to predict difficult cholecystectomy and conversion to open surgery, but these scores alone are often insufficient to provide a generalizable prediction of gangrene.[4-6]

Radiological imaging is the primary tool for diagnosing acute cholecystitis. However, it is less reliable in predicting gangrenous cholecystitis. The sensitivity of computed tomography (CT) in predicting gangrenous cholecystitis has been reported to be 29%. This necessitates the development of new strategies for predicting gangrenous cholecystitis independent of radiological imaging. There has been a shift toward clinical studies focusing on accessible, imaging-independent, inexpensive, and generalizable biomarkers in this field.[7,8] Hematological and biochemical markers have been extensively researched for this purpose. Numerous studies have been conducted on inflammation biomarkers, such as the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), monocyte-to-lymphocyte ratio (MLR), and C-reactive protein (CRP). However, fewer studies have addressed newer composite biomarkers, such as the systemic immune-ınflammation ındex (SII), systemic inflammation response index (SIRI), and aggregate index of systemic ınflammation (AISI).[9-12] The current literature predominantly consists of studies that focus on individual markers and are conducted across different cohorts with heterogeneous outcomes. Studies reporting head-to-head comparisons of multiple inflammatory biomarkers within the same cohort, along with calibration and clinical benefit analyses, are limited.

The primary aim of this study was to compare the performance of seven prespecified inflammatory biomarkers derived from routine pre-operative blood parameters, independent of imaging, in predicting gangrenous cholecystitis. The selection of biomarkers was hypothesis-driven. CRP was included as the canonical hepatic acute-phase reactant of established clinical relevance, whereas the six hemogram-derived indices were prespecified to represent biologically complementary axes of systemic inflammation – neutrophil-, platelet-, and monocyte-based ratios against lymphocyte balance, together with the multi-component composites that combine them. These specific indices have been the most extensively investigated hemogram-derived inflammatory ratios in acute surgical and inflammatory conditions, supporting their selection over less-studied alternatives.[13]

MATERIALS AND METHODS

Study Design and Ethical Approval

This study was designed as a single-center, retrospective, observational cohort analysis of consecutive patients who underwent surgery at a tertiary center for acute cholecystitis between July 2023 and December 2024. The reporting was structured according to the STROBE guidelines for observational studies. Ethical approval for the study was obtained from the Scientific Research Ethics Committee of Sakarya University (E-43012747-050.04–450863-86). This study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Selection and Data Collection

All consecutive patients aged >18 years who presented to the hospital due to acute cholecystitis and underwent cholecystectomy during the same admission, with accessible pre-operative laboratory records obtained at the time of emergency presentation, surgical operation videos, and pathology slide records, were included in the study population. Patients were excluded at the screening stage if they had a history of medical treatment or percutaneous cholecystostomy during admission for acute cholecystitis, concurrent choledocholithiasis or pancreatitis, or incomplete study records. The final analytic cohort, therefore, comprised 180 patients (Fig. 1).

After identifying suitable patients, demographic characteristics, presenting complaints, vital signs, abdominal ultrasound and computed tomography reports, surgical notes, intraoperative video recordings, and final pathology reports were retrospectively extracted from the hospital information management system and transferred to an anonymized electronic database.

Definition of Gangrenous Cholecystitis

Gangrenous cholecystitis was defined a priori as the presence of histopathological evidence of necrosis or gangrene in the resected specimen and/or intraoperative macroscopic findings indicative of gangrene – such as ischemic, greenish-black discoloration of the gallbladder wall, pericholecystic necrosis, or a necrotic odor (Fig. 2). All resected gallbladders underwent routine histopathological examination, and intraoperative video recordings were available for all patients; surgical video recordings were reviewed by two surgeons blinded to the clinical information, with consensus reached in cases of disagreement.

Laboratory Analyses and Inflammatory Biomarkers

Pre-operative blood samples were collected as part of rou-

tine care during the initial emergency department visit. Analyses were performed using the institution's standard hematology and biochemistry infrastructure. All measurements were based on clinical routine units: CRP: mg/L; complete blood count and differential: $\times 10^9$/L; red cell distribution width (RDW): %. CRP, white blood cell count (WBC), NEU, LYM, MONO, PLT, and RDW were used as raw data for basic variables. Measurements taken at the same sampling time were used for all indices derived from these variables.

Six prespecified hemogram-derived indices were calculated and analyzed alongside CRP, with each index selected a priori for a distinct mechanistic role in systemic inflammation. To minimize statistical and biological redundancy, reciprocal indices and exploratory derivatives were not included in the final univariable, receiver operating characteristic (ROC), or multivariable analyses (see discussion).

• SIRI = (NEU×MONO)/LYM. Rationale: Integrates the combined neutrophil and monocyte response with lymphopenia, reflecting cellular innate immune activation.

• SII = (PLT×NEU)/LYM. Rationale: Combines neutrophilia and lymphopenia with the platelet component to capture immunothrombotic activity.

• AISI ≃ PIV = (NEU×MONO×PLT)/LYM. Rationale: A four-component composite aggregating neutrophil, monocyte, and platelet contributions against lymphocyte count.

• NLR = NEU/LYM. Rationale: The most extensively validated inflammatory ratio has established prognostic value across surgical and infectious conditions.

• PLR = PLT/LYM. Rationale: Highlights the platelet contribution to systemic inflammation and reflects the inflammation–thrombosis axis.

• MLR = MONO/LYM. Rationale: Emphasizes the monocyte–macrophage axis, which is mechanistically relevant to local tissue ischemia and necrosis.

Statistical Analysis

Statistical analyses of the data obtained from the study were performed using Python 3.11 and the Statistical Package for the Social Sciences version 25.0 software (IBM Corp., Armonk, NY, USA). For continuous variables, the mean±standard deviation (SD) or median (interquartile range, [IQR]) was used, whereas for categorical variables, the number and percentage (n [%]) were used. The assumption of normal distribution was assessed using the Shapiro–Wilk test.

Binary comparisons for variables meeting the assumption of normal distribution, the Welch t-test was used; for those not meeting this assumption, the Mann–Whitney U test was used. For categorical variables, the Chi-square test or, in cases where the expected cell value was <5, Fisher's exact Chi-square test was used. The effect size was reported as the rank-biserial correlation (r) for non-parametric comparisons. In analyses where multiple biomarkers were tested simultaneously, p-values were adjusted using the Benjamini–Hochberg false-discovery-rate (FDR) procedure across the seven prespecified markers (k=7). All statistical tests were two-sided; the conventional threshold of $p<0.05$ (or Benjamini–Hochberg FDR-adjusted $q<0.05$ for multi-marker analyses) was used to define statistical significance, and confidence intervals

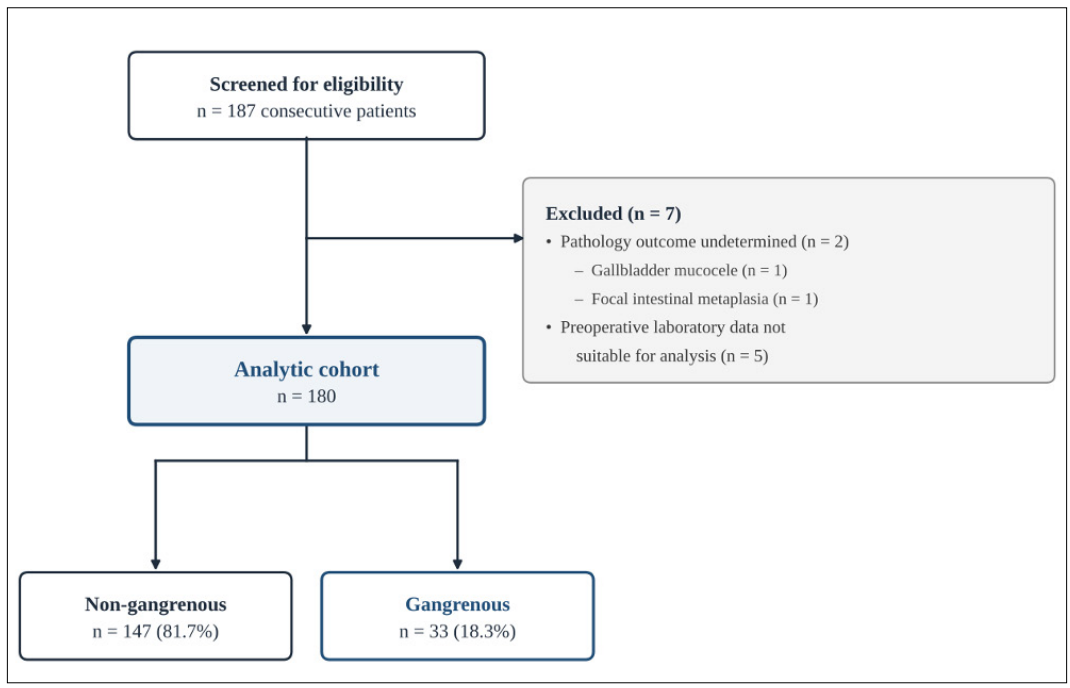

Figure 1. Patient flow through the study. Cohort flow diagram structured according to the STROBE statement.

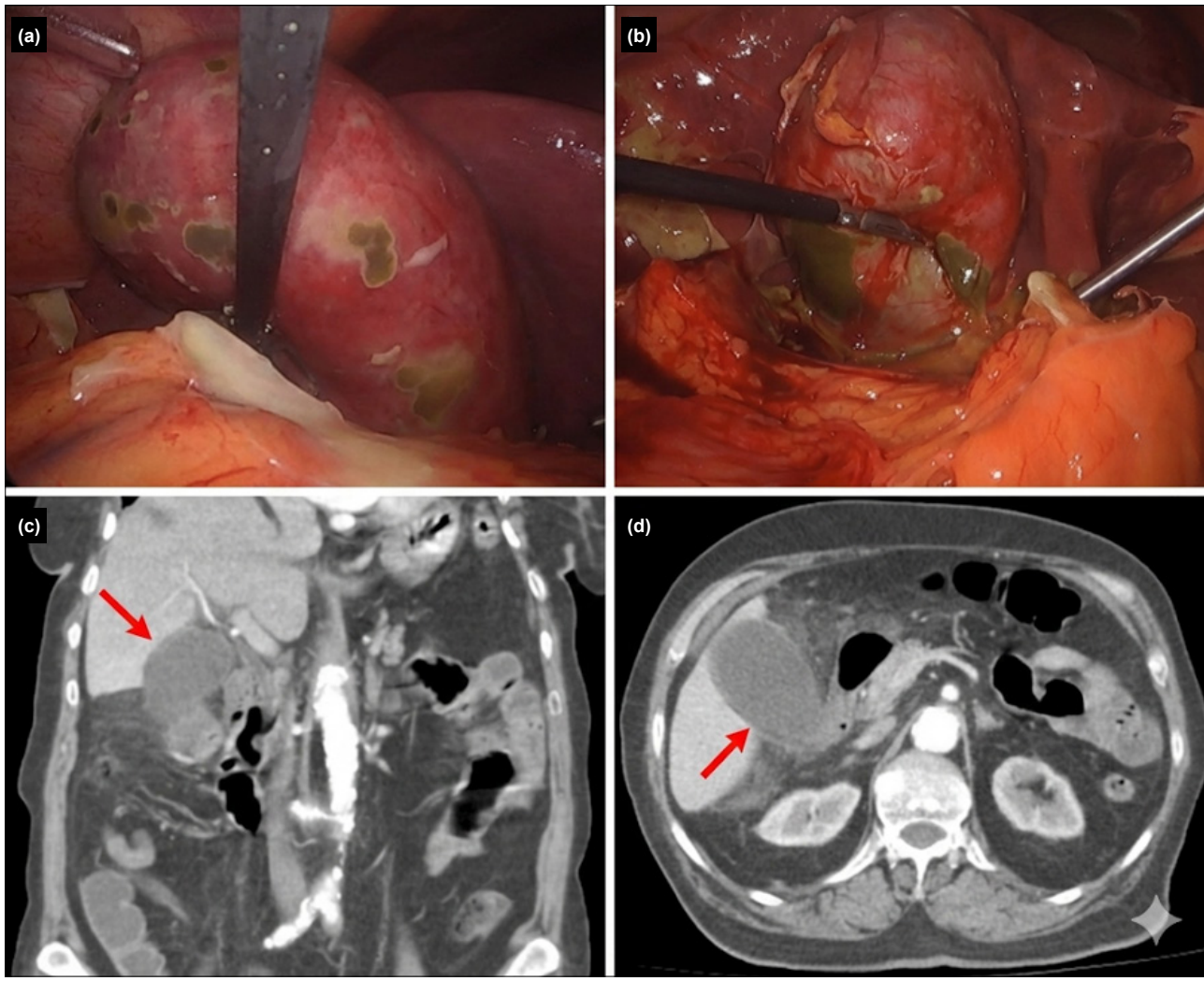

Figure 2. Representative intraoperative and cross-sectional imaging findings of gangrenous cholecystitis. **(a and b)** Intraoperative laparoscopic views. **(c)** Coronal and **(d)** axial preoperative contrast-enhanced computed tomography images (arrows indicate the gallbladder).

(CI) are reported at the 95% level.

ROC analyses and Youden-optimal cutoff determination were restricted a priori to the seven prespecified inflammatory biomarkers (CRP, NLR, PLR, MLR, SII, SIRI, and AISI). Raw hematological components (WBC, neutrophil, lymphocyte, monocyte, and platelet counts, and RDW) were reported as baseline descriptors in Table 1 only and were not subjected to ROC, FDR, or multivariable testing. For each prespecified marker, the cohort-specific optimal cutoff was identified using the highest Youden index (J), and the corresponding sensitivity and specificity were reported.

The multivariable model was prespecified before any data inspection and deliberately parsimonious. CRP was included as the canonical hepatic acute-phase reactant, biologically distinct from cellular indices. SIRI was selected on biological grounds as the most comprehensive cellular composite, integrating neutrophil, monocyte, and lymphocyte components in a single ratio and structurally encompassing the simpler indices NLR (NEU/LYM) and MLR (MONO/LYM). The other hemogram-derived indices (NLR, PLR, MLR, SII, and AISI) were not entered together with SIRI because they share components and would have introduced severe collinearity with limited additional information. The robustness of the model to this choice was assessed in a sensitivity analysis in which SIRI was substituted by each of the other five indices in turn (Supplementary Table S1). Logistic regression was therefore performed with CRP and SIRI as inflammatory predictors, adjusted for age and sex. Robust (HC3) standard errors were used in coefficient estimates; results are presented as odds ratios (OR) and 95% CI. To improve clinical interpretability, the CRP OR is additionally reported per 10 mg/L increment, in addition to the standard per/mg/L estimate.

The discriminatory power of the logistic model was assessed using the area under the curve (AUC), mean Brier score, and average precision.

Table 1. Baseline demographic and pre-operative laboratory characteristics by gangrenous cholecystitis status

Characteristic	Overall (n=180)	Non-gangrenous (n=147)	Gangrenous (n=33)	p
Sex, n (%)				0.156
Female	107 (59.4)	91 (61.9)	16 (48.5)	
Male	73 (40.6)	56 (38.1)	17 (51.5)	
Age, years (mean±SD)	50.7±14.1	49.5±14.1	56.3±13.0	0.010
CRP, mg/L	21.80 (5.94–81.22)	15.00 (4.02–55.89)	163.00 (39.00–224.00)	<0.001
WBC, ×10⁹/L	11.47 (8.70–14.30)	11.00 (8.38–13.88)	13.71 (11.22–17.26)	0.001
Neutrophils, ×10⁹/L	8.85 (5.67–11.80)	8.10 (5.02–11.04)	11.66 (8.80–13.31)	<0.001
Lymphocytes, ×10⁹/L	1.90 (1.27–2.60)	1.94 (1.45–2.61)	1.35 (0.90–2.10)	0.002
Monocytes, ×10⁹/L	0.63 (0.45–0.90)	0.60 (0.43–0.80)	0.81 (0.60–1.08)	0.001
Platelets, ×10⁹/L	260 (225–305)	266 (222–307)	239 (232–293)	0.782
RDW, %	13.60 (13.00–14.33)	13.60 (13.00–14.35)	13.70 (13.00–14.30)	0.796

Values are expressed as mean±SD for age and median (IQR) for laboratory variables. p-values reflect univariable comparisons between non-gangrenous and gangrenous groups. CRP: C-reactive protein; IQR: Interquartile range; RDW: Red cell distribution width; SD: Standard deviation; WBC: White blood cell count.

RESULTS

Study Population and Baseline Characteristics

A total of 187 consecutive patients underwent laparoscopic cholecystectomy for acute cholecystitis during the study period and were screened for inclusion. Seven patients (3.7%) were excluded. The final analytic cohort comprised 180 patients, of whom 33 (18.3%) had gangrenous cholecystitis confirmed by intraoperative and pathological assessment [non-gangrenous, n=147; gangrenous, n=33; (Table 1)]. The gangrenous group was older (mean age, 56.3±13.0 years vs. 49.5±14.1 years; Welch t-test p=0.010), consistent with the mean±SD presentation in Table 1. Sex distribution did not differ significantly between groups (male: 51.5% vs. 38.1%; p=0.156). At presentation, CRP, WBC, neutrophil, lymphocyte, and monocyte counts differed between groups, whereas platelet count and RDW did not (Table 1). Regarding outcome ascertainment, all 33 patients classified as gangrenous (100%) had histopathological confirmation of necrosis or gangrene in the resected specimen, and intraoperative macroscopic findings reviewed on surgical video were concordant with the pathological diagnosis in every case; no patient was classified solely on the basis of one modality.

Biomarker Distributions and Univariable Comparisons

In univariate analyses, CRP was the strongest discriminator between groups, with markedly higher values in gangrenous cases (median 163.00 mg/L [IQR 39.00–224.00] vs. 15.00 mg/L [IQR 4.02–55.89]; p<0.001; rank-biserial r=+0.611). All six prespecified hemogram-derived indices (NLR, PLR, MLR, SII, SIRI, and AISI) were also significantly elevated in gangrenous cases (all p<0.001; FDR-adjusted q<0.001 with k=7; effect sizes r=+0.40 to +0.56), though with consistently smaller effect sizes than CRP. Full distributional summaries are provided in Table 2; selected boxplots are shown in Figure

Table 2. Univariable comparisons of inflammatory biomarkers between gangrenous and non-gangrenous groups

Biomarker	Non-gangrenous, median (IQR)	Gangrenous, median (IQR)	p-value	FDR q value	Rank-biserial r
CRP	15.00 (4.02–55.89)	163.00 (39.00–224.00)	<0.001	<0.001	+0.611
SIRI	2.48 (1.03–4.89)	7.10 (4.09–10.03)	<0.001	<0.001	+0.556
AISI	605 (294–1274)	1765 (1022–2741)	<0.001	<0.001	+0.551
MLR	0.31 (0.19–0.50)	0.62 (0.40–0.79)	<0.001	<0.001	+0.548
SII	1030 (567–1788)	2236 (1601–3057)	<0.001	<0.001	+0.518
NLR	4.00 (2.35–6.66)	8.00 (5.32–12.90)	<0.001	<0.001	+0.503
PLR	132.5 (100.0–181.1)	202.5 (127.3–276.5)	<0.001	<0.001	+0.401

Effect size is presented as the rank-biserial correlation (r). Analytic n=180; lymphocyte-dependent indices were computed on n=178. AISI: Aggregate index of systemic inflammation, CRP: C-reactive protein; FDR: False discovery rate; IQR: Interquartile range; MLR: Monocyte-to-lymphocyte ratio; NLR: Neutrophil-to-lymphocyte ratio; PLR: Platelet-to-lymphocyte ratio; SII: Systemic immune-inflammation index; SIRI: Systemic inflammation response index.

Table 3. Diagnostic accuracy of biomarkers for gangrenous cholecystitis

Marker	AUC (95% CI)	Optimal cut-off (Youden)	Sensitivity	Specificity
CRP	0.81 (0.71–0.89)	>61.0	0.73	0.78
SIRI	0.78 (0.69–0.85)	>3.86	0.79	0.68
AISI	0.78 (0.69–0.85)	>1022	0.76	0.70
MLR	0.77 (0.69–0.85)	>0.356	0.85	0.62
SII	0.76 (0.67–0.84)	>1410	0.82	0.66
NLR	0.75 (0.67–0.83)	>4.59	0.85	0.57
PLR	0.70 (0.60–0.81)	>195	0.58	0.81

AUC 95% CIs were estimated via bootstrap resampling (2000 iterations). AISI: Aggregate index of systemic inflammation, AUC: Area under the curve; CI: Confidence interval; CRP: C-reactive protein; MLR: Monocyte-to-lymphocyte ratio; NLR: Neutrophil-to-lymphocyte ratio; PLR: Platelet-to-lymphocyte ratio; ROC: Receiver operating characteristic; SII: Systemic immune-inflammation index; SIRI: Systemic inflammation response index.

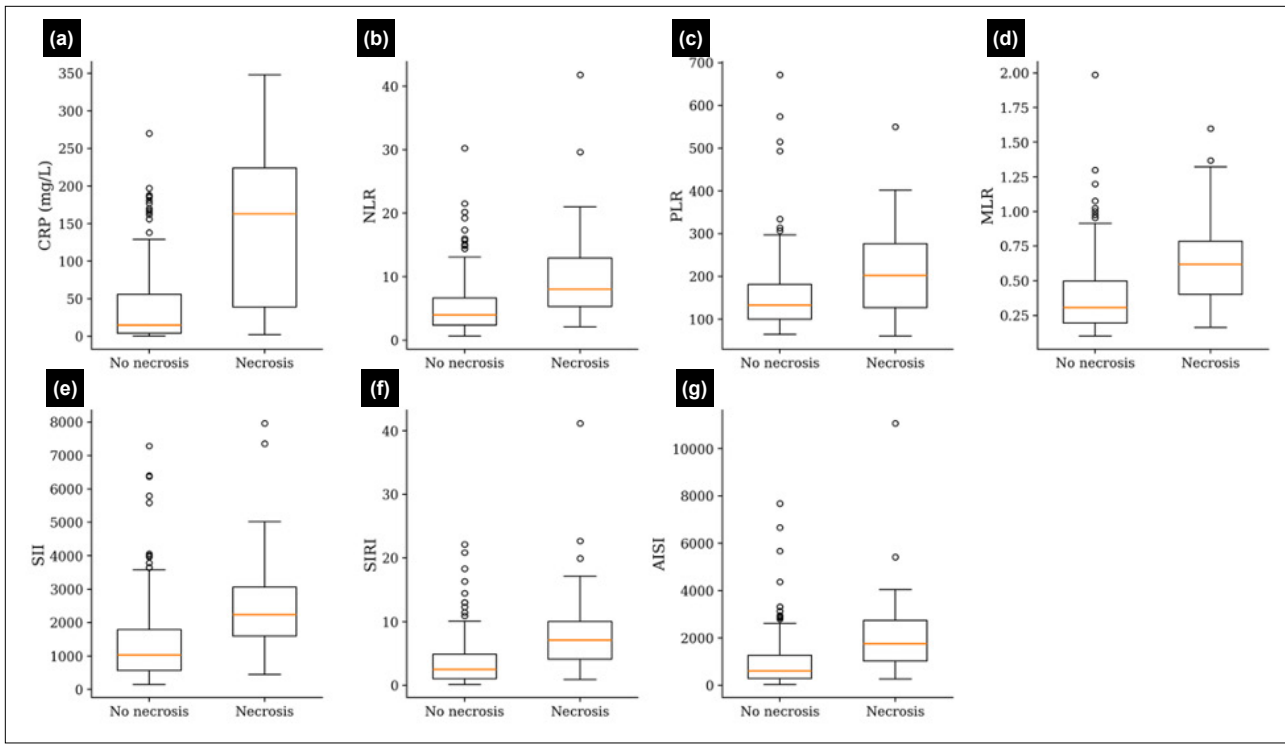

Figure 3. Distribution of CRP and haemogram-derived inflammatory indices by gangrenous cholecystitis status. Box-and-whisker plots for (a) CRP, (b) NLR, (c) PLR, (d) MLR, (e) SII, (f) SIRI, and (g) AISI. Boxes denote the interquartile range, the central horizontal line represents the median, and whiskers extend to ×1.5 the interquartile range; open circles indicate outlier values. Lymphocyte-dependent indices were computed on n=178. AISI: Aggregate index of systemic inflammation; CRP: C-reactive protein; FDR: False discovery rate; MLR: Monocyte-to-lymphocyte ratio; NLR: Neutrophil-to-lymphocyte ratio; PLR: Platelet-to-lymphocyte ratio; SII: Systemic immune-inflammation index; SIRI: Systemic inflammation response index.

3. Platelet count and RDW did not differ between groups [platelets: p=0.782; RDW: p=0.796; Table 1].

Diagnostic Accuracy and Biomarker Performance

In ROC analysis, CRP demonstrated the highest discriminatory power for gangrenous cholecystitis (AUC 0.81, 95% CI 0.71–0.89), with a Youden-optimal cutoff of 61.0 mg/L yielding sensitivity 0.73 and specificity 0.78. The six hemogram-derived indices showed moderate, broadly comparable discrimination (AUC range 0.70–0.78), without any single index outperforming CRP. Full ROC metrics are summarized in Table 3, and curves are shown in Figure 4.

Multivariate Logistic Regression and Model Performance

In the prespecified multivariate logistic regression model (CRP+SIRI+age+sex), CRP was the only independent predic-

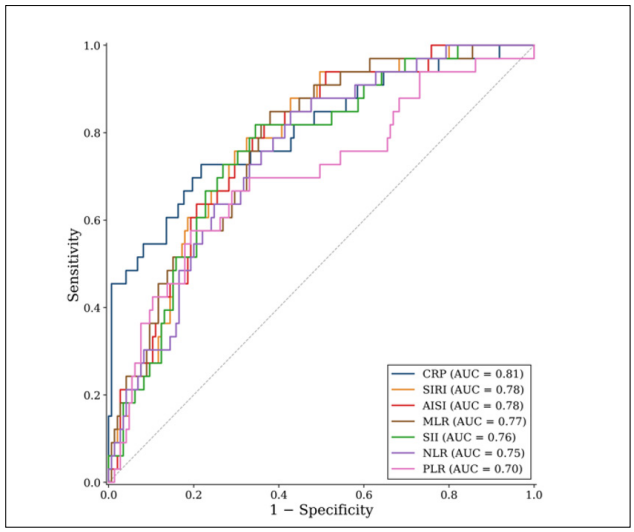

Figure 4. Receiver operating characteristic (ROC) curves of inflammatory biomarkers for gangrenous cholecystitis. The dashed diagonal represents the line of no discrimination. AISI: Aggregate index of systemic inflammation; AUC: Area under the curve; CRP: C-reactive protein; MLR: Monocyte-to-lymphocyte ratio; NLR: Neutrophil-to-lymphocyte ratio; PLR: Platelet-to-lymphocyte ratio; ROC: Receiver operating characteristic; SII: Systemic immune-inflammation index; SIRI: Systemic inflammation response index.

Table 4. Multivariable logistic regression for gangrenous cholecystitis

Predictor	OR (95% CI)	p
CRP (per 10 mg/L)	1.14 (1.09–1.20)	<0.001
SIRI (per 1 unit)	1.07 (1.00–1.16)	0.057
Age (per 1 year)	1.01 (0.97–1.04)	0.718
Male sex (vs. female)	1.85 (0.73–4.66)	0.192

Complete-case analysis (n=178). The CRP odds ratio is reported per 10 mg/L increment. SIRI and age are reported per one unit increase. Sex is reported as male versus female. Model performance metrics: AUC=0.83; Brier score=0.103; average precision=0.641. AUC: Area under the curve; CI: Confidence interval; CRP: C-reactive protein; HC3: Heteroscedasticity-consistent (type 3) standard errors; OR: Odds ratio; SIRI: Systemic inflammation response index.

tor of gangrenous cholecystitis (Table 4). Each 10 mg/L increase in CRP was associated with a 14% increase in the odds of gangrenous cholecystitis (OR 1.14, 95% CI 1.09 to 1.20).

SIRI did not reach the conventional significance threshold (p=0.057) and should therefore not be interpreted as an independent predictor in this cohort. Age and male sex did not reach statistical significance, and no significant multicollinearity was detected. In a sensitivity analysis, SIRI was replaced in turn by each of the other five prespecified hemogram-derived indices (Supplementary Table S1). The CRP estimate was stable in every specification (odds ratio 1.013 to 1.015 per 1 mg/L, all p<0.001), and model performance was essentially unchanged (AUC 0.82 to 0.83; Brier score 0.101 to 0.104). The cellular index reached nominal significance when SIRI was replaced by NLR (p=0.041), PLR (p=0.016), SII (p=0.014) or AISI (p=0.041). These p values were not adjusted for multiplicity and the corresponding effect sizes were very small (odds ratios 1.000 to 1.07 per unit increase). Model discrimination and the CRP estimate were therefore stable across substitutions, although the statistical significance of the cellular index varied. (Supplementary Table S1.)

DISCUSSION

In this single-center retrospective cohort study, we evaluated the comparative performance of multiple inflammatory biomarkers in predicting the presence of gangrenous cholecystitis in patients who underwent surgery for acute cholecystitis. In our study, CRP alone demonstrated the highest discriminatory power. Hemogram-derived composite indices exhibited moderate discriminatory power. Furthermore, in the predefined model, CRP was verified as an independent predictor, and overall model performance in this cohort was acceptable, although the model was not externally validated. The most important contribution of this study to the literature is that it directly compared hemogram-derived composite indices (particularly SIRI/SII/AISI) within the same cohort and under the same endpoint definition, thereby establishing a quantitative basis for determining which indicator may provide more meaningful risk stratification in practice.

The fact that CRP alone demonstrated the strongest discriminatory performance is consistent with the findings of studies on the spectrum of complicated acute cholecystitis. Bouassida et al.[14] reported that CRP is a strong predictor of clinically significant outcomes, such as advanced acute cholecystitis and conversion to open surgery, in a large prospective cohort study. In our study, focusing on the direct presence of gangrene, necrosis as an outcome and reinforcing the definition through pathological and operative assessment supports a close relationship between CRP, an acute-phase reactant reflecting the systemic inflammatory burden and severe tissue damage.

Our findings regarding inflammatory biomarkers are generally consistent with those of previous studies, indicating an association between NLR and the severity and complicated course of acute cholecystitis. Micić et al.[12] reported that NLR could predict severe acute cholecystitis; similarly, studies conducted in different subgroups have shown that preoperative NLR may be parallel to an increased inflammatory burden.[15,16] However, the heterogeneity of evidence regarding NLR has also been emphasized at the meta-analysis level. Kler et al.[17] reported in a meta-analysis that NLR may be a diagnostic/prognostic indicator for acute cholecystitis; however, they noted that results should be interpreted with caution due to differences in study designs, endpoint definitions, and cutoff values.[17] In our study, the moderate discrimina-

tory power of NLR and the prominence of CRP can be considered a possible reflection of this heterogeneity.

Chen et al.[18] demonstrated that these indices can contribute to clinically meaningful scenarios, such as distinguishing between acute and chronic cholecystitis; however, there is a gap in the literature regarding gangrenous cholecystitis. Our study found that inflammatory biomarkers alone can provide more consistent guidance in predicting gangrenous cholecystitis than cell counts. However, it also provides evidence supporting the notion that, as most of these indices are derived from the same hematological components, the claim of a "best" marker cannot currently be definitively established for the derived inflammatory biomarkers. The biological basis of these findings is consistent with the acute-phase response and natural immune activation. In acute inflammation, hepatic acute-phase proteins rise rapidly; the severity of this response may parallel tissue damage and infection load.[19,20] Hemogram-derived indices, on the other hand, combine different dimensions of systemic inflammation on the same scale by reflecting cellular components such as neutrophilia, relative lymphopenia, and monocyte response.[21] Indices that include the platelet component can indirectly capture the inflammation–thrombosis interaction and the concept of immunothrombosis; the ability of severe inflammatory conditions to increase the thrombotic tendency at the microvascular level can be explained by these relationships.[22] These mechanisms account for the univariable elevation of biomarkers such as SIRI/SII/AISI in gangrenous cases observed in our study, but this elevation did not translate into independent predictive value beyond CRP in the multivariable analysis.

The Tokyo Guidelines provide a fundamental reference for severity classification and treatment strategies in the clinical management of acute cholecystitis.[1,23] However, in practice, the degree of tissue gangrene and necrosis encountered in the operating theater may vary among patients who may fall within the same clinical severity category, which may create difficulties in surgical timing and strategy selection. In this context, markers that can be generated independently of imaging and routine blood tests may provide additional predictive value to clinical assessment alongside the Tokyo Guidelines. Similarly, the existence of biomarker studies aimed at predicting the need for percutaneous cholecystostomy indicates that laboratory-based risk classification can be integrated into decision-making processes.[23] Our study may enable earlier detection of risk and individualization of treatment management, particularly in cases with suspected severe inflammation or necrosis, rather than serving as an alternative to existing scoring systems.

From a practical surgical-strategy perspective, the present findings suggest several operational implications that warrant prospective evaluation. In patients presenting with markedly elevated CRP at admission – and therefore a higher prior probability of underlying gangrene – clinicians may consider prioritising the case on the emergency operative list, ensuring senior surgical involvement given the recognised increase in operative difficulty in gangrenous disease, and preparing for technically demanding scenarios including subtotal cholecystectomy or early conversion when a safe dissection plane cannot be established, in line with current emergency-surgery consensus guidelines.[24] The cohort-specific CRP cutoff identified here (61 mg/L) is not yet validated for clinical decision-making, but it may inform prospective protocols linking biomarker thresholds to perioperative checklists such as broader-spectrum antibiotic coverage, intraoperative drain placement, and a more vigilant post-operative monitoring strategy. The hemogram-derived indices, given their lack of independent predictive value beyond CRP, are not recommended as standalone decision aids; however, when integrated into structured laboratory panels alongside CRP and the Tokyo Guidelines-based assessment, they may help to standardize risk communication with patients and surgical teams. These implications remain hypotheses generated by a single-center cohort and require prospective multicenter validation before clinical adoption.

Study Strengths and Limitations

The strengths of this study include its sequential case series design, definition of outcome by pathology and intraoperative assessment, and head-to-head comparison of multiple biomarkers within the same cohort. Several limitations should be acknowledged. First, the single-center retrospective design limits generalizability and exposes the analysis to residual selection bias inherent to retrospective cohorts. Second, the analytic cohort was restricted by design to patients who underwent same-admission laparoscopic cholecystectomy; patients managed conservatively or with percutaneous cholecystostomy were not eligible, because gangrenous cholecystitis could not be ascertained in those settings by the present intraoperative/pathological outcome definition. This introduces a spectrum bias: the findings apply to surgically managed acute cholecystitis and may not generalize to the highest-risk patients diverted to non-operative or interventional pathways. Third, the cutoff values are cohort-specific, and the absence of external validation means that the diagnostic thresholds reported here require confirmation in independent, multicenter cohorts before clinical adoption. Finally, because the hemogram-derived indices share overlapping cellular components, claims of superiority among the retained markers – even within the prespecified seven-marker design (see Methods) – remain provisional in this cohort, and the borderline performance of SIRI in the multivariable model underscores that the additional value of any cellular index beyond CRP remains uncertain.

CONCLUSION

This study evaluated inflammatory markers obtained from routine blood tests for the pre-operative prediction of gangrenous cholecystitis. CRP emerged as the most powerful single discriminating marker and the only independent predictor

in multivariable analysis. The hemogram-derived composite indices showed moderate univariable discrimination, but their additional value beyond CRP remains uncertain in the present cohort. CRP, which is rapidly available during emergency presentation, may therefore offer useful pre-operative information when imaging is inadequate. However, the cohort-specific cutoff values reported here are not yet ready for clinical use and require validation in independent multicenter populations before being adopted as decision thresholds. Any potential complementary role of hemogram-derived indices similarly requires further evaluation in larger, prospective cohorts.

Ethics Committee Approval: Ethical approval for the study was obtained from the Scientific Research Ethics Committee of Sakarya University (Date: 20.02.2025, Decision No: E-43012747-050.04–450863-86).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: A.Ö.C., N.F.; Design: A.Ö.C.; Supervision: F.A.; Resource: E.E:; Materials: E.S.; Data collection and/or processing: E.T., M.Y.; Analysis and/or interpretation: A.Ö.C.; Literature review: A.Ö.C.; Writing: A.Ö.C.; Critical review: F.A., N.F.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

Use of AI for Writing Assistance: Disclosure on the use of Artificial Intelligence Generated Content (AIGC). During the preparation of this manuscript, the authors used an artificial intelligence based tool to improve the readability and grammar of the text, and to assist with the plotting code used to generate the figures from the raw dataset. All figures were produced directly from the study data, and all output was reviewed and edited by the authors, who take full responsibility for the content of the publication.

REFERENCES

1. Yokoe M, Hata J, Takada T, Strasberg SM, Asbun HJ, Wakabayashi G, et al. Tokyo Guidelines 2018: diagnostic criteria and severity grading of acute cholecystitis (with videos). J Hepatobiliary Pancreat Sci. 2018;25:41–54. [CrossRef]
2. Sureka B, Rastogi A, Mukund A, Thapar S, Bhadoria AS, Chattopadhyay TK. Gangrenous cholecystitis: Analysis of imaging findings in histopathologically confirmed cases. Indian J Radiol Imaging. 2018;28:49–54. [CrossRef]
3. Önder A, Kapan M, Ülger BV, Oğuz A, Türkoğlu A, Uslukaya Ö. Gangrenous cholecystitis: mortality and risk factors. Int Surg. 2015;100:254–60. [CrossRef]
4. Randhawa JS, Pujahari AK. Preoperative prediction of difficult lap chole: a scoring method. Indian J Surg. 2009;71:198-201. [CrossRef]
5. Gupta N, Ranjan G, Arora MP, Goswami B, Chaudhary P, Kapur A, et al. Validation of a scoring system to predict difficult laparoscopic cholecystectomy. Int J Surg. 2013;11:1002–6. [CrossRef]
6. Magnano San Lio R, Barchitta M, Maugeri A, Quartarone S, Basile G, Agodi A. Preoperative risk factors for conversion from laparoscopic to open cholecystectomy: a systematic review and meta-analysis. Int J Environ Res Public Health. 2022;20:408. [CrossRef]
7. Okuda Y, Saida T, Morinaga K, Ohara A, Hara A, Hashimoto S, et al. Diagnosing gangrenous cholecystitis on computed tomography using deep learning: A preliminary study. Acute Med Surg. 2022;9:e783. [CrossRef]
8. Bennett GL, Rusinek H, Lisi V, Israel GM, Krinsky GA, Slywotzky CM, et al. CT findings in acute gangrenous cholecystitis. AJR Am J Roentgenol. 2002;178:275–81. [CrossRef]
9. Serban D, Stoica PL, Dascalu AM, Bratu DG, Cristea BM, Alius C, et al. The significance of preoperative neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and systemic inflammatory index (SII) in predicting severity and adverse outcomes in acute calculous cholecystitis. J Clin Med. 2023;12:6946. [CrossRef]
10. Mok KW, Reddy R, Wood F, Turner P, Ward JB, Pursnani KG, et al. Is C-reactive protein a useful adjunct in selecting patients for emergency cholecystectomy by predicting severe/gangrenous cholecystitis? Int J Surg. 2014;12:649-53. [CrossRef]
11. Turhan VB, Gök HF, Ünsal A, Akpınar M, Güler Şimşek G, Buluş H. Pre-operative neutrophil/lymphocyte and platelet/lymphocyte ratios are effective in predicting complicated acute cholecystitis. Ulus Travma Acil Cerrahi Derg. 2022;28:471–6. [CrossRef]
12. Micić D, Stanković S, Lalić N, Đukić V, Polovina S. Prognostic value of preoperative neutrophil-to-lymphocyte ratio for prediction of severe cholecystitis. J Med Biochem. 2018;37:121–7. [CrossRef]
13. Islam MM, Satici MO, Eroglu SE. Unraveling the clinical significance and prognostic value of the neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, systemic immune-inflammation index, systemic inflammation response index, and delta neutrophil index: An extensive literature review. Turk J Emerg Med. 2024;24:8–19. [CrossRef]
14. Bouassida M, Zribi S, Krimi B, Laamiri G, Mroua B, Slama H, et al. C-reactive protein is the best biomarker to predict advanced acute cholecystitis and conversion to open surgery. A prospective cohort study of 556 cases. J Gastrointest Surg 2020;24:2766–72. [CrossRef]
15. Korayem IM, Bessa SS. Preoperative predictors of difficult early laparoscopic cholecystectomy among patients with acute calculous cholecystitis in Egypt. BMC Surg. 2024;24:329. [CrossRef]
16. Xia Z, Liu Y, Sun S, Shan E, Liu Y. The value of preoperative neutrophil/lymphocyte ratio in predicting the severity of cholecystolithiasis with cholecystitis in elderly patients. BMC Surg. 2024;23:360. [CrossRef]
17. Kler A, Taib A, Hajibandeh S, Hajibandeh S, Asaad P. The predictive significance of neutrophil-to-lymphocyte ratio in cholecystitis: a systematic review and meta-analysis. Langenbeck's Archives of Surgery 2022;407:927–35.
18. Chen L, Chen X. The role of different systemic inflammatory indexes derived from complete blood count in differentiating acute from chronic calculus cholecystitis and predicting its severity. J Inflamm Res. 2024;17:2051–62. [CrossRef]
19. Mantovani A, Garlanda C. Humoral innate immunity and acute-phase proteins. N Engl J Med. 2023;388:439–52. [CrossRef]
20. Rizo-Téllez SA, Sekheri M, Filep JG. C-reactive protein: a target for therapy to reduce inflammation. Front Immunol. 2023;14:1237729. [CrossRef]
21. Buonacera A, Stancanelli B, Colaci M, Malatino L. Neutrophil to lymphocyte ratio: an emerging marker of the relationships between the immune system and diseases. Int J Mol Sci. 2022;23:3636. [CrossRef]
22. Stark K, Massberg S. Interplay between inflammation and thrombosis in cardiovascular pathology. Nat Rev Cardiol. 2021;18:666–72. [CrossRef]
23. Takada T. Tokyo Guidelines 2018: updated Tokyo Guidelines for the management of acute cholangitis/acute cholecystitis. J Hepatobiliary Pancreat Sci. 2018;25:1-2. [CrossRef]
24. Pisano M, Allievi N, Gurusamy K, Borzellino G, Cimbanassi S, Boerna D, et al. 2020 World Society of Emergency Surgery updated guidelines for the diagnosis and treatment of acute calculus cholecystitis. World J Emerg Surg. 2020;15:61. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Gangrenöz kolesistit tanısında enflamatuvar biyobelirteçlerin performansı

AMAÇ: Akut kolesistitli hastalarda rutin kan parametrelerinden türetilen enflamatuvar biyobelirteçlerin gangrenöz kolesistiti görüntülemeden bağımsız olarak ameliyat öncesi öngörebileceği hipoteziyle, bu biyobelirteçlerin tanısal performanslarının karşılaştırılması amaçlandı.

GEREÇ VE YÖNTEM: Bu çalışmada akut kolesistit nedeniyle aynı yatışta laparoskopik kolesistektomi uygulanan 187 ardışık erişkin hasta retrospektif gözlemsel kohort olarak tarandı. Yedi olgu dışlandıktan sonra 180 hasta analitik kohortu oluşturdu. Gangrenöz kolesistit tanısı peroperatif veya patolojik verifikasyon ile konuldu. Acil başvuruda alınan preoperatif kan örneklerinden CRP ile altı önceden belirlenmiş hemogram türevi indeks — nötrofil-, trombosit- ve monosit-lenfosit oranları (NLR, PLR, MLR) ile üç kompozit indeks (SII, SIRI, AISI) — hesaplandı; tanısal doğruluk ROC-AUC ile değerlendirildi, Youden indeksi ile kesim noktaları belirlendi ve yaş ile cinsiyete göre düzeltilmiş lojistik regresyon modeli kuruldu.

BULGULAR: Gangrenöz kolesistit, analiz edilen 180 hastanın 33'ünde (%18.3) doğrulandı. CRP gangrenöz olgularda 163.00 mg/L (IQR 39.00–224.00) iken gangrenöz olmayan grupta 15.00 mg/L (IQR 4.02–55.89) bulundu. Hemogram türevli indekslerden SIRI 7.10 (4.09–10.03) versus 2.48 (1.03–4.89) ($p<0.001$) ve MLR 0.62 (0.40–0.79) vs 0.31 (0.19–0.50) ($p<0.001$) daha yüksek saptandı; NLR 8.00 (5.32–12.90) versus 4.00 (2.35–6.66) bulundu ($p<0.001$). ROC analizinde CRP en yüksek ayırt ediciliği gösterdi (AUC 0.81; %95 GA 0.71–0.89); 61.0 mg/L kesim noktasında duyarlılık 0.73 ve özgüllük 0.78 hesaplandı. Türetilmiş indekslerde en yüksek AUC SIRI ve AISI'da gözlendi. CRP ve SIRI'yi içeren, yaş ve cinsiyete göre düzeltilmiş modelde yalnızca CRP bağımsız öngördürücü olarak kaldı; CRP'de her 10 mg/L artışın gangrenöz kolesistit olasılık oranında (odds) %14 artışla ilişkili olduğu saptandı.

SONUÇ: Akut kolesistit cerrahisi öncesinde CRP gangrenöz kolesistiti öngörmede en yüksek ayırt ediciliği sağlamakta ve çok değişkenli analizde tek bağımsız öngördürücü olarak öne çıkmaktadır. Hemogram türevli indeksler tek değişkenli analizde orta düzeyde ayırt edicilik göstermiş, ancak CRP'nin ötesinde ek öngörü değeri bu kohort temelinde belirsizliğini korumaktadır. Olası tamamlayıcı rolleri daha büyük, ileriye dönük kohortlarda doğrulanmalıdır.

Anahtar sözcükler: Akut kolesistit; biyobelirteçler; C-reaktif protein; Gangrenöz kolesistit; laparoskopik kolesistektomi.

Ulus Travma Acil Cerrahi Derg 2026;32(8):920-929 DOI: 10.14744/tjtes.2026.63043

Supplementary Table S1. Sensitivity analysis of the multivariable logistic regression model: substitution of the cellular index

Inflammatory index	n	CRP OR (95% CI)	CRP p	Index OR (95% CI)	Index p	Model AUC (95% CI); Bri-er; AP
SIRI (prespeci-fied)	178	1.014 (1.008–1.019)	<0.001	1.07 (1.00–1.16)	0.057	0.83 (0.74–0.90); 0.103; 0.641
NLR	178	1.014 (1.009–1.019)	<0.001	1.07 (1.00–1.15)	0.041	0.83 (0.75–0.90); 0.103; 0.647
PLR	178	1.015 (1.010–1.020)	<0.001	1.004 (1.00–1.01)	0.016	0.83 (0.74–0.90); 0.101; 0.671
MLR	178	1.013 (1.008–1.019)	<0.001	3.12 (0.98–9.89)	0.054	0.83 (0.74–0.90); 0.104; 0.640
SII	178	1.014 (1.009–1.019)	<0.001	1.000 (1.00–1.00)	0.014	0.83 (0.74–0.91); 0.102; 0.672
AISI	178	1.014 (1.009–1.019)	<0.001	1.000 (1.00–1.00)	0.041	0.82 (0.73–0.90); 0.103; 0.663

Each row represents a separate logistic regression model replacing the cellular inflammatory index in the original specification (CRP+cellular index+age+sex). Complete-case analysis (n=178). AISI: Aggregate index of systemic inflammation; AP: Average precision; AUC: Area under the curve; CI: Confidence interval; CRP: C-reactive protein; HC3: Heteroscedasticity-consistent (type 3) standard errors; MLR: Monocyte-to-lymphocyte ratio; NLR: Neutrophil-to-lymphocyte ratio; OR: Odds ratio; PLR: Platelet-to-lymphocyte ratio; SII: Systemic immune-inflammation index; SIRI: Systemic inflammation response index.

ORIGINAL ARTICLE

Association between systemic immune-inflammation index and mortality in patients admitted to the intensive care unit after urgent or elective major abdominal surgery*

Fatma İrem Yeşiler, Gamze Haras, Helin Şahintürk, Pınar Zeyneloğlu

Department of Anesthesiology and Critical Care Unit, Başkent University Faculty of Medicine, Ankara-*Türkiye*

ABSTRACT

BACKGROUND: Major abdominal surgery is associated with a high incidence of postoperative complications, morbidity, and mortality. The Systemic Immune-Inflammation Index (SII), calculated from neutrophil, platelet, and lymphocyte counts, reflects both inflammatory and immune status and has been shown to predict outcomes in various diseases. This study aimed to retrospectively evaluate the outcomes of patients admitted to the intensive care unit (ICU) after urgent or elective major abdominal surgery and to investigate the association between postoperative SII and ICU mortality.

METHODS: We retrospectively analyzed patients admitted to the surgical ICU after major abdominal surgery between November 2022 and November 2023. Patients who died within the first 24 hours of ICU admission, were admitted to the ICU for less than 48 hours, and were younger than 18 years were excluded.

RESULTS: During the study period, 360 patients were admitted to the surgical ICU, of whom 102 underwent major abdominal surgery. One patient was excluded because of death within the first 24 hours of ICU admission, leaving 101 patients for analysis. Fifty-nine patients (58.4%) were women, and the mean age was 70.1±15.2 years. Urgent abdominal surgery was performed in 42 patients (41.6%). ICU mortality was higher among patients who underwent urgent surgery (23.8%) than among those who underwent elective surgery (5.1%) (p=0.013). Receiver operating characteristic (ROC) curve analysis identified a postoperative SII cutoff value of 998.26. A low postoperative SII was independently associated with mortality after major abdominal surgery, with a sensitivity of 82.9% and a specificity of 69.2% (95% confidence interval: 0.0579–0.913, p=0.004).

CONCLUSION: Postoperative SII may be a useful prognostic marker for predicting clinical outcomes and mortality in patients undergoing major abdominal surgery.

Keywords: Abdominal surgery; emergency; intensive care unit; systemic immune-inflammation index.

INTRODUCTION

Major abdominal surgery is associated with a high risk of postoperative complications, morbidity, and mortality. The number of patients requiring intensive care unit (ICU) admission following major abdominal surgery has increased in recent years. Advanced age, multiple comorbidities, and complex surgical procedures contribute to an increased need for ICU care and prolonged ICU stays.[1]

Major abdominal surgery may lead to numerous postoperative complications because of the gastrointestinal tract's flora and prolonged fasting during the perioperative period. Whether surgery is performed on an urgent or elective basis may also

Cite this article as: Yeşiler Fİ, Haras G, Şahintürk H, Zeyneloğlu P. Association between systemic immune-inflammation index and mortality in patients admitted to the intensive care unit after urgent or elective major abdominal surgery. Ulus Travma Acil Cerrahi Derg 2025;31:930-939.

Address for correspondence: Fatma İrem Yeşiler

Department of Anesthesiology and Critical Care Unit, Başkent University Faculty of Medicine, Ankara, Türkiye

E-mail: fatmairem84@hotmail.com

*This research was presented at the 22th National Intensive Care Congress by Turkish Society of Intensive Care at Antalya-Turkey as an oral presentation (Feb 22-25,2024).

Ulus Travma Acil Cerrahi Derg 2026;32(8):930-939 DOI: 10.14744/tjtes.2026.80149

Submitted: 15.08.2025 Revised: 12.01.2026 Accepted: 04.02.2026 Published: 10.08.2026

influence postoperative complications, morbidity, and mortality. Although many patients are admitted to the ICU after abdominal surgery, several hematological and biochemical indices have recently been investigated as predictors of postoperative outcomes and survival after major abdominal surgery.[2,3]

The Systemic Immune-Inflammation Index (SII) was first described in 2014. Calculated using neutrophil, platelet, and lymphocyte counts, SII reflects the inflammatory and immunological status of patients. It has been widely studied as a marker of systemic inflammation and a predictor of prognosis in a variety of clinical conditions. Neutrophils, lymphocytes, and platelets play essential roles in immune regulation, infection, and inflammation. Elevated SII is associated with increased systemic inflammation and may serve as a prognostic marker in various diseases. Previous studies have demonstrated associations between SII and cancer, cardiovascular disease, aging, postoperative complications, and other inflammatory conditions.[3-7] Because inflammatory and immune responses substantially influence postoperative recovery, SII may serve as a useful predictor of morbidity and mortality after abdominal surgery.[8]

The aim of this study was to retrospectively evaluate the outcomes of patients admitted to the ICU following urgent and elective major abdominal surgery and to investigate the association between postoperative SII and ICU mortality.

MATERIALS AND METHODS

We reviewed patients admitted to the surgical ICU after major abdominal surgery between November 2022 and November 2023. Patients who died within the first 24 hours after ICU admission, remained in the ICU for less than 48 hours, were younger than 18 years of age, or had incomplete medical records were excluded from the study.

The primary objective of this study was to investigate the association between postoperative SII and ICU mortality following major abdominal surgery. The secondary objective was to evaluate the clinical outcomes and mortality of patients admitted to the ICU after urgent and elective major abdominal surgery.

As described in previous studies, SII was calculated using the following formula:

SII = Platelet count × Neutrophil count / Lymphocyte count. [2-8]

The SII was calculated using the first laboratory results obtained at ICU admission during the early postoperative period. Patients were categorized into two groups according to the type of surgery (urgent or elective). Additionally, patients were stratified according to the SII cutoff value: high-SII group (≥998.26) and low-SII group (<998.26).

The study was approved by the Başkent University Institutional Review Board (Project No. KA24/74; Date: February 27, 2024) and was supported by the Başkent University Research Fund. All study procedures were conducted in accordance with the principles of the Declaration of Helsinki.

Data Collection

Patient data were obtained from electronic medical and nursing records. The following variables were recorded: age, sex, smoking history, body mass index (BMI), history of previous abdominal surgery, solid organ transplantation, trauma, and comorbidities, including diabetes mellitus (DM), hypertension, chronic cardiovascular disease, chronic pulmonary disease, chronic liver failure, and chronic kidney disease. Surgical variables included the type and urgency of surgery, American Society of Anesthesiologists (ASA) classification, duration of surgery, type and volume of blood and blood product transfusions, and serum lactate levels. Clinical data collected at ICU admission included the indication for ICU admission, Acute Physiology and Chronic Health Evaluation II (APACHE II) score, Sequential Organ Failure Assessment (SOFA) score, Glasgow Coma Scale (GCS) score, vital signs, and the ratio of arterial partial pressure of oxygen to fraction of inspired oxygen (PaO_2/FiO_2). Postoperative complications were also recorded, including acute respiratory distress syndrome (ARDS), respiratory support modality, need for intubation and invasive or noninvasive mechanical ventilation, tracheotomy, pneumonia, pleural effusion, infection, sepsis, septic shock, vasopressor and inotropic therapy (e.g., noradrenaline, adrenaline, etc.), acute kidney injury (AKI), and renal replacement therapy (RRT). Laboratory parameters measured at ICU admission included hemoglobin (Hb), leukocyte, neutrophil, and platelet counts; alanine aminotransferase (ALT); aspartate aminotransferase (AST); albumin; blood urea nitrogen (BUN); serum creatinine; C-reactive protein (CRP); procalcitonin; arterial blood gas (ABG) parameters; lactate; and the international normalized ratio (INR). Inflammatory and prognostic indices, including the Glasgow Prognostic Score, CRP-to-albumin ratio, platelet-to-lymphocyte ratio (PLR), neutrophil-to-lymphocyte ratio (NLR), and Systemic Immune-Inflammation Index (SII), were calculated. The SII was calculated as platelet count × neutrophil count / lymphocyte count using laboratory values obtained at ICU admission during the early postoperative period. Length of ICU stay, length of hospital stay, 28-day ICU mortality, and 28-day hospital mortality were also recorded.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 25.0 (released 2017; IBM Corp., Armonk, NY, United States). Variables are presented as mean values ± standard deviation. Frequencies are expressed as numbers (n) and percentages (%). The chi-square test was used to compare categorical variables between the two groups. Qualitative data were compared using the chi-square

test or Fisher's exact test, as appropriate. Quantitative data were compared using the independent-samples t-test or the Mann–Whitney U test, depending on data distribution. A p value <0.05 was considered statistically significant. Receiver operating characteristic (ROC) curve analysis was performed to determine the optimal SII cutoff value and to calculate the area under the curve (AUC). Sensitivity and specificity values were calculated, and patients were subsequently categorized into high- and low-SII groups according to the identified threshold. Univariate and multivariate linear regression analyses were performed to evaluate the association between mortality and SII.

According to the Youden index, the optimal cutoff value for SII was 998.26. This threshold yielded a sensitivity of 82.95% and a specificity of 69.23%.

RESULTS

During the study period, 360 patients were admitted to the surgical ICU. Of these, 102 underwent major abdominal surgery. One patient was excluded because of death within the first 24 hours after ICU admission, leaving 101 patients for analysis. Fifty-nine patients (58.4%) were women, and the mean age was 70.1±15.2 years. Urgent abdominal surgery was performed in 42 patients (41.6%). Hypertension was the most common comorbidity (68.3%). Malignancy was more prevalent in the urgent surgery group than in the elective surgery group (45.2% vs.11.9%, p<0.001) (Table 1). Patients who underwent urgent surgery were more frequently admitted to the ICU from the emergency department (57.1% vs. 0.0%, p<0.001), whereas all patients in the elective surgery group were admitted from hospital wards (100% vs. 38.1%, p<0.001) (Table 2).

APACHE II and SOFA scores, as well as heart rate were higher in the urgent surgery group than in the elective surgery group (p<0.05) (Table 2).

Patients who underwent urgent surgery had a shorter duration of surgery (3.1±1.5 vs. 4.9±1.7 hours, p<0.001) and higher lactate levels (3.8±4.7 vs. 1.5±0.8 mmol/L, p<0.001)

Table 1. Demographic and clinical characteristics of patients undergoing urgent and elective major abdominal surgery

Variable	Number (n)/Percent (%)			
	Total (n=101)	Urgent surgery (n=42)	Elective surgery (n=59)	p
Age, years, mean±SD	70.1±15.2	67.9±18.2	71.6±12.6	0.52
Sex			0.5	
Male	42 (41.6)	19 (45.2)	23 (39)	
Female	59 (58.4)	2,3 (54.8)	36 (61)	
Smoking history	41 (30.7)	10 (23.8)	21 (35.6)	0.23
Comorbidities				
Hypertension	69 (68.3)	26 (61.9)	43 (72.9)	0.28
Diabetes mellitus	30 (29.7)	9 (21.4)	21 (35.6)	0.19
Coronary artery disease	40 (39.6)	18 (42.9)	22 (37.3)	0.69
Chronic respiratory disease	31 (30.7)	11 (26.2)	20 (33.9)	0.51
Chronic liver disease	15 (14.9)	2 (4.8)	13 (22)	0.02
Chronic renal disease	22 (21.8)	9 (21.4)	13 (22)	1.000
Malignancy	26 (25.7)	19 (45.2)	7 (11.9)	<0.001
Previous abdominal surgery	56 (55.4)	27 (64.3)	29 (49.2)	0.16
Previous organ transplantation	2 (2.0)	2 (4.8)	0 (0.0)	0.17
Acute trauma	2 (2.0)	2 (4.8)	0 (0.0)	0.17
ASA Classification				0.08
I	1 (1.0)	0 (0.0)	1 (1.7)	
II	15 (14.9)	4 (9.5)	11 (18.6)	
III	73 (72.3)	30 (71.4)	43 (72.9)	
IV	9 (8.9)	5 (11.9)	4 (6.8)	
V	3 (3.0)	3 (7.1)	0 (0.0)	

SD: Standard deviation; ICU: Intensive care unit; ASA: American Society of Anesthesiologists. p<0.05 was considered statistically significant.

Table 2. Severity scores, vital signs, and ICU admission characteristics of patients undergoing urgent and elective major abdominal surgery

	Mean±SD			
	Total (n=101)	**Urgent surgery (n=42)**	**Elective surgery (n=59)**	**p**
APACHE II score	14.8±6.4	18.1±6.4	12.4±5.1	0.000
SOFA score	4.3±3.2	5.6±4.0	3.3±2.0	0.002
Temperature (oC)	35.5±1.2	35.4±1.7	35.5±0.6	0.26
Heart rate, beats per min	88.2±19.9	94.8±19.7	83.6±18.7	0.003
Mean arterial pressure, mmHg	86.7±17.6	83.7±16.8	88.9±18.0	0.18
Oxygen saturation (%)	97.3±3.1	97.5±3.4	97.1±2.9	0.2
Lactate at ICU admission (mmol/L)	3.0±3.4	3.9±4.8	2.3±1.5	0.19
Source of ICU admission				<0.001
Emergency department	24 (23.8)	24 (57.1)	0 (0.0)	
Hospital ward	75 (74.3)	16 (38.1)	59 (100)	
Endoscopy unit	1 (1.0)	1 (2.4)	0 (0.0)	
Another ICU	1 (1.0)	1 (2.4)	0 (0.0)	

SD: Standard deviation; ICU: Intensive care unit; APACHE: Acute Physiology and Chronic Health Evaluation II; SOFA: Sequential Organ Failure Assessment. p<0.05 was considered statistically significant.

Table 3. Intraoperative characteristics of patients

	Mean±SD			
	Total (n=101)	**Urgent surgery (n=42)**	**Elective surgery (n=59)**	**p**
Duration of surgery (hours)	4.2±1.8	3.1±1.5	4.9±1.7	<0.001
RBC transfusion (units)	1.2±1.5	1.2±1.2	1.2±1.7	0.47
FFP transfusion (units)	1.2±1.5	1.4±1.3	1.0±1.6	0.07
Final lactate level (mmol/L)	2.4±3.3	3.8±4.7	1.5±0.8	<0.001

SD: Standard deviation; RBC: Red blood cells; FFP: Fresh frozen plasma. p<0.05 was considered statistically significant.

Table 4. Respiratory support characteristics of patients admitted to the intensive care unit

	n (%)			
	Total (n=101)	**Urgent surgery (n=42)**	**Elective surgery (n=59)**	**p**
PaO_2/FiO_2 ratio at ICU admission				0.54
300–400	42 (42)	17 (40.5)	25 (42.3)	
200–300	45 (45)	18 (42.9)	27 (45.8)	
100–200	12 (12)	6 (14.3)	6 (10.2)	
<100	1 (1)	1 (2.4)	0 (0.0)	
Respiratory support modalities				
Low-flow oxygen therapy	95 (94.1)	36 (85.7)	59 (100)	0.004
High-flow oxygen therapy	3 (3)	1 (2.4)	2 (3.4)	1.000
NIMV	7 (6.9)	4 (9.5)	3 (5.1)	0.44
IMV	34 (33.7)	27 (64.3)	7 (11.9)	<0.001
Intubation during ICU stay	6 (5.9)	4 (9.5)	2 (3.4)	0.23

PaO_2/FiO_2: Ratio of arterial oxygen partial pressure to fraction of inspired oxygen; NIMV: Noninvasive mechanical ventilation; IMV: Invasive mechanical ventilation; ICU: Intensive care unit. p<0.05 was considered statistically significant.

than those who underwent elective surgery (Table 3).

The need for mechanical ventilation was greater in the urgent surgery group than in the elective surgery group (64.3% vs. 11.9%, p<0.001) (Table 4).

The use of steroids and norepinephrine was significantly higher among patients who underwent urgent surgery than among those who underwent elective surgery (p<0.001 and p=0.012, respectively). The incidence of sepsis, septic shock, and AKI was also higher in the urgent surgery group (p<0.001, p<0.001 and p=0.021, respectively) (Table 5).

Postoperative leukocyte, neutrophil, platelet, albumin, and glucose levels were lower, whereas BUN, CRP, AST, and INR values were higher in the urgent surgery group than in the elective surgery group (p<0.05) (Table 6).

The duration of mechanical ventilation and ICU length of stay were longer among patients who underwent urgent surgery. In addition, ICU mortality was higher in the urgent surgery group than in the elective surgery group (p<0.05) (Table 7).

APACHE II and SOFA scores and heart rate at ICU admission were higher in the low-SII group than in the high-SII group (p<0.05). Conversely, GCS scores and mean arterial pressure

Table 5. Treatments and clinical outcomes of patients admitted to the intensive care unit

Treatment modalities	n (%)			p
	Total (n=101)	Urgent surgery (n=42)	Elective surgery (n=59)	
Steroid therapy	34 (33.7)	23 (54.7)	11 (18.6)	<0.001
Methylprednisolone	29 (28.7)	19 (45.2)	10 (16.9)	
Hydrocortisone	4 (4)	4 (9.5)	0 (0.0)	
Dexamethasone	1 (1)	0 (0.0)	1 (1.7)	
Inotropic therapy	12 (11.9)	8 (19)	4 (6.8)	0.07
Norepinephrine therapy	27 (26.7)	17 (40.5)	10 (16.9)	0.012
Adrenalin therapy	6 (5.9)	5 (11.9)	1 (1.7)	0.079
Glypressin therapy	4 (4)	4 (9.5)	0 (0.0)	0.027
Sepsis	28 (27.7)	20 (47.6)	8 (13.6)	<0.001
Septic shock	7 (6.9)	4 (9.5)	3 (5.1)	<0.001
Requirement for blood or blood product transfusion	53 (53)	26 (61.9)	27 (46.6)	0.10
Pleural effusion	25 (24.8)	11 (26.2)	14 (23.7)	0.82
Pneumonia	10 (9.9)	6 (14.3)	4 (6.8)	0.31
ARDS	37 (36.6)	18 (42.9)	19 (32.2)	0.44
Mild	28 (27.7)	13 (31)	15 (25.4)	
Moderate	8 (7.9)	4 (9.5)	4 (6.8)	
Severe	1 (1.0)	1 (2.4)	0 (0.0)	
AKI	22 (21.9)	12 (28.6)	10 (16.9)	0.021
Stage 1	5 (5)	3 (7.1)	2 (3.4)	
Stage 2	7 (6.9)	1 (2.4)	6 (10.2)	
Stage 3	10 (9.9)	8 (19)	2 (3.4)	
Renal replacement therapy				0.006
IHD	5 (5)	3 (7.1)	2 (3.4)	
CRRT	5 (5)	5 (11.9)	0 (0.0)	
Cardiac arrest	9 (8.9)	8 (19)	1 (1.7)	0.007
Reoperation	15 (14.9)	10 (23.8)	5 (8.5)	0.076
Reoperation for bleeding control	7 (6.9)	4 (9.5)	3 (5.1)	0.44
Delirium	3 (3)	2 (4.8)	1 (1.7)	0.57

ARDS: Acute respiratory distress syndrome; AKI: Acute kidney injury; IHD: Intermittent hemodialysis; CRRT: Continuous renal replacement therapy. p<0.05 was considered statistically significant.

Table 6. Postoperative laboratory parameters of patients admitted to the intensive care unit

Postoperative parameter	n (%)			p
	Total (n=101)	Urgent surgery (n=42)	Elective surgery (n=59)	
Hemoglobin (g/dL)	11.0±1.6	10.7±1.7	11.3±1.5	0.09
Hematocrit (%)	32.2±4.7	31.2±5.1	32.8±4.2	0.09
Platelet count (10^3/μL)	224.5±127.2	190.8±130.1	248.6±120.5	0.004
Leukocyte count (10^3/μL)	12.2±7.3	10.5±8.9	13.4±5.7	0.001
Neutrophil count (10^3/μL)	10.5±7.3	9.6±9.6	11.2±5.1	0.005
Blood urea nitrogen (mg/dL)	20.7±14.3	28.8±15.2	15.0±10.6	<0.001
Creatinine (mg/dL)	1.3±0.5	1.4±0.6	1.2±0.4	0.05
Albumin (g/dL)	2.7±0.5	2.5±0.5	2.8±0.5	0.001
Total bilirubin (mg/dL)	1.5±2.1	1.6±2.3	1.3±2.1	0.3
Aspartate aminotransferase (U/L)	152.8±385.4	194.0±571.1	122.7±145.8	0.04
Alanine aminotransferase (U/L)	90.7±340.7	129.9±524.0	64.1±98.3	0.06
C-reactive protein (mg/L)	62.2±83.8	115.3±105.5	24.4±27.1	<0.001
Glucose (mg/dL)	152.7±43.1	140.4±47.1	161.5±38.2	0.01
Lactate (mmol/L)	3.0±3.4	3.9±4.8	2.3±1.5	0.2
INR	1.3±0.3	1.4±0.4	1.2±0.2	<0.001
SII	3016.2±3759.8	3330.6±4708.6	2792.3±2928.7	0.71

SD: Standard deviation; INR: International normalized ratio; SII: Systemic Immune-Inflammation Index. p<0.05 was considered statistically significant.

Table 7. Length of stay and mortality outcomes

Postoperative parameter	n (%)			p
	Total (n=101)	Urgent surgery (n=42)	Elective surgery (n=59)	
Length of stay (days)		Mean±SD (min-max)		
Duration of IMV	0.9±1.9 (0-13)	1.6±2.5 (0-13)	0.3±1.2 (0-8)	<0.001
ICU stay	3.3±2.9 (2-18)	4.2±3.4 (2-18)	2.7±2.2 (2-15)	<0.001
Hospital stay	20.7±17.3 (2-90)	25.5±20.3 (2-90)	17.3±14.1 (4-90)	0.09
Mortality outcomes		Number (n)/Percent (%)		
ICU mortality	13 (12.9)	10 (23.8)	3 (5.1)	0.013
28-day mortality	21 (20.8)	14 (33.3)	7 (11.9)	0.012

SD: Standard deviation; IMV: Invasive mechanical ventilation; ICU: Intensive care unit; min: Minimum; max: Maximum. p<0.05 was considered statistically significant.

were lower in the low-SII group (p<0.05) (Table 8).

The need for invasive mechanical ventilation and renal replacement therapy was greater in the low-SII group than in the high-SII group. Likewise, sepsis, septic shock, and AKI occurred more frequently in patients with low SII. Mortality rates were also higher in the low-SII group (Table 9).

ROC curve analysis identified a postoperative SII cutoff value of 998.26. A low postoperative SII was independently associated with ICU mortality in patients undergoing major abdominal surgery, with a sensitivity of 82.9% and a specificity of 69.2% (95% confidence interval [CI]: 0.0579–0.913, p=0.004). The predictive performance of postoperative SII for ICU mortality was statistically significant, with an area under the curve of 0.746±0.085 (p=0.004) (Fig. 1).

Table 8. Severity scores and physiological parameters at ICU admission according to postoperative SII group

	SII<998.3 (n=23)	SII≥998.3 (n=78)	p
APACHE II score	17.4±6.7	14.0±6.1	0.03
SOFA score	6.2±3.8	3.7±2.7	0.001
GCS score	6.9±6.3	11.1±5.9	0.002
Heart rate, beats per min	97.5±22.9	85.6±18.1	0.013
Mean arterial pressure, mmHg	78.4±13.3	89.2±17.9	0.011
Lactate at ICU admission (mmol/L)	4.7±6.1	2.5±1.9	0.08

SD: Standard deviation; ICU: Intensive care unit; APACHE: Acute Physiology and Chronic Health Evaluation II; SOFA: Sequential Organ Failure Assessment; GCS: Glasgow Coma Scale. p<0.05 was considered statistically significant.

Table 9. Comparison of treatments and outcomes between low- and high-SII groups

	SII<998.3 (n=23)	SII≥998.3 (n=78)	p
Invasive mechanical ventilation	14 (60.9)	20 (25.6)	0.002
Vasopressor therapy	13 (56.5)	14 (17.9)	0.001
Inotropic therapy	6 (26.1)	6 (7.7)	0.027
Sepsis	9 (39.1)	19 (24.4)	0.004
Septic shock	4 (17.4)	3 (3.8)	0.004
Blood and blood product transfusion	16 (69.6)	37 (48.1)	0.014
AKI	11 (47.8)	11 (14.1)	0.001
Stage 1	2 (8.7)	3 (3.8)	
Stage 2	4 (17.4)	3 (3.8)	
Stage 3	5 (21.7)	5 (6.4)	
Renal replacement therapy	5 (21.7)	5 (6.4)	0.005
IHD	1 (4.3)	4 (5.1)	
CRRT	4 (17.4)	1 (1.3)	
ICU mortality	8 (34.8)	5 (6.4)	0.001
28-day mortality	9 (39.1)	12 (15.4)	0.018

AKI: Acute kidney injury; IHD: Intermittent hemodialysis; CRRT: Continuous renal replacement therapy; ICU: Intensive care unit. p<0.05 was considered statistically significant.

DISCUSSION

In this cohort study, a low postoperative SII was independently associated with ICU mortality among patients who underwent major abdominal surgery, with a sensitivity of 82.9% and a specificity of 69.2%. Severity ICU scores and mortality rates were higher in the low-SII group than in the high-SII group. Similarly, adverse clinical outcomes were more common among patients with low SII values. APACHE II and SOFA scores, heart rate, and lactate levels were higher in the urgent surgery group than in the elective surgery group. Patients who underwent urgent surgery had a higher incidence of sepsis, septic shock, AKI, as well as greater requirements for steroids, norepinephrine, RRT, and invasive mechanical ventilation. Furthermore, ICU length of stay and duration of mechanical ventilation were longer among patients who underwent urgent surgery, and mortality rates were higher in this group.

The SII has emerged as a reliable prognostic biomarker in medical, surgical, and critically ill populations. It reflects the interplay among inflammation (neutrophils), immune competence (lymphocytes), and thrombocytic activity (platelets). In our cohort, adverse outcomes were more common in the

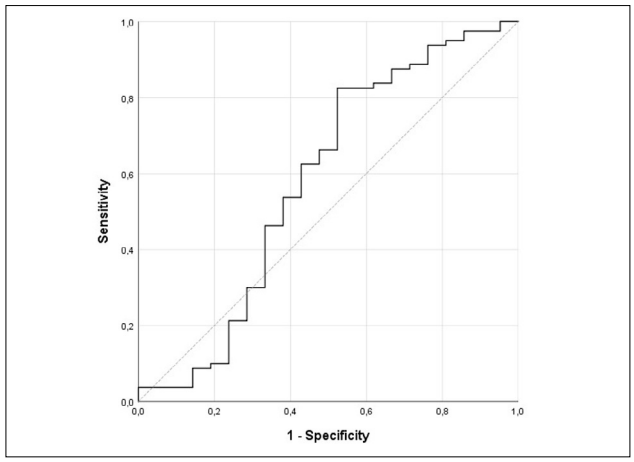

Figure 1. The predictive performance of postoperative Systemic Immune-Inflammation Index (SII) measured at intensive care unit (ICU) admission for ICU mortality following abdominal surgery.

low-SII group than in the high-SII group. This finding may reflect immune suppression or immune exhaustion, both of which are commonly observed in critically ill patients. A low postoperative SII, particularly below established thresholds, may indicate immune dysregulation, lymphocyte depletion, or bone marrow suppression. Zhang et al.[9] reported that both extremely high and extremely low SII values were associated with increased ICU mortality, with low postoperative SII values (<1000) being linked to impaired immune recovery and sepsis-related mortality. Severe infection or surgical trauma may induce a state of immunoparalysis characterized by lymphocyte depletion, impaired immune function, and increased susceptibility to secondary infections and death.[3,8,9] These findings support the incorporation of SII into routine perioperative risk assessment, particularly in critically ill surgical patients, as dynamic changes in SII may influence postoperative recovery and survival.

In the present study, a low postoperative SII was independently associated with ICU mortality in patients undergoing major abdominal surgery, with a sensitivity of 82.9% and a specificity of 69.2% at a cutoff value of 998.26. In contrast, most previous studies have reported that elevated SII values are associated with increased systemic inflammation, adverse outcomes, morbidity, and mortality. High SII has been identified as an important biomarker in various clinical settings, including cardiovascular disease, neurological disorders, malignancy, and sepsis.[4-6] However, the prognostic significance of low SII values in critically ill surgical patients may reflect immune exhaustion, lymphopenia, and reduced thrombopoietic activity, all of which are associated with impaired host defense mechanisms and increased vulnerability to sepsis, organ failure, and death.[3,9]

APACHE II and SOFA scores are widely used severity assessment tools for predicting morbidity and mortality in critically ill patients and are commonly applied in both medical and surgical ICUs.[10] It is well established that patients undergoing urgent or emergency surgery are at greater risk of postoperative morbidity and mortality than those undergoing elective procedures. Consistent with previous studies, patients in the urgent surgery group in our cohort had significantly higher APACHE II and SOFA scores, reflecting greater disease severity at ICU admission.[11,12]

Hyperlactatemia is a well-recognized marker of cellular injury and has been associated with increased morbidity and mortality, particularly among critically ill patients.[12,13] Multiple factors during major surgery can contribute to elevated lactate levels. One of the most important clinical applications of lactate measurement is its ability to serve as an indirect marker of tissue perfusion. In our study, lactate levels were higher in the urgent surgery group than in the elective surgery group. Several factors, including hypotension and hypoxia, may contribute to elevated lactate levels in patients undergoing urgent surgery. In contrast, lactate levels may be lower in patients undergoing elective surgery because their preoperative condition is generally more stable and physiological abnormalities can be optimized before surgery.[12,14]

Compared with the elective surgery group, patients who underwent urgent surgery had higher rates of sepsis, septic shock, and AKI, as well as greater requirements for steroids, norepinephrine, invasive mechanical ventilation, and renal replacement therapy. These findings are consistent with previous studies demonstrating higher postoperative complication rates among patients undergoing urgent surgery.[12,15-17] Our results are consistent with those of previous studies showing that sepsis-related complications are associated with adverse postoperative outcomes and increased mortality.[12,15] This finding may be explained by the fact that urgent surgical interventions are often performed in critically ill patients who present with greater physiological derangement and a higher burden of comorbid conditions.

We also observed that postoperative leukocyte, neutrophil, platelet, and glucose levels were lower in the urgent surgery group than in the elective surgery group. Although leukocytosis is commonly observed in surgical patients, particularly in the presence of sepsis or systemic inflammation, the relative postoperative leukopenia and neutropenia observed in patients undergoing urgent surgery may reflect immune exhaustion or an overwhelming systemic inflammatory response.[18] Similarly, thrombocytopenia is frequently encountered in critically ill surgical patients and may result from sepsis, disseminated intravascular coagulation (DIC), or massive transfusion. Reduced platelet counts have consistently been associated with increased risks of bleeding and mortality in ICU populations.[18] Lower postoperative glucose levels in the urgent surgery group may be attributable to inadequate nutritional intake, stress-related hyperinsulinemia, or hypoglycemia associated with advanced sepsis.[19] The postoperative laboratory differences observed between the urgent and elective surgery groups likely reflect the underlying physiological disturbances associated with acute presentation, limited

preoperative optimization, and increased perioperative risk. These parameters may be useful not only for assessing patients' clinical status but also for postoperative risk stratification and guiding ICU monitoring and management.

It is noteworthy that although severity scores, complication rates, and mortality were significantly higher among patients undergoing urgent surgery, postoperative SII values did not differ significantly between the urgent and elective surgery groups. This finding may be explained by the fact that, as reported in previous studies, the systemic inflammatory response during the early postoperative period is largely driven by surgical trauma. Consequently, SII measured shortly after surgery may primarily reflect the acute surgical stress response rather than differences in preoperative clinical status. Furthermore, previous studies have suggested that SII is a patient-specific and time-dependent prognostic biomarker rather than a marker intended solely for comparisons between patient groups.[3,20]

ICU length of stay and duration of mechanical ventilation were longer among patients who underwent urgent surgery. These patients are often critically ill at baseline and have limited opportunities for physiological optimization before surgery. This clinical condition is associated with an increased risk of postoperative complications and adverse outcomes, including prolonged mechanical ventilation and extended ICU stays, as observed in our patients undergoing urgent surgery. Prolonged invasive mechanical ventilation in this population may result from several factors, including perioperative hemodynamic instability, acute respiratory failure, sepsis, preexisting organ dysfunction, and perioperative complications.[21-23] Extended durations of mechanical ventilation and ICU stay are associated with higher rates of ventilator-associated pneumonia, ICU-acquired weakness, mortality, and healthcare costs.[22,23] Therefore, early identification of high-risk patients, appropriate preoperative triage, and aggressive perioperative management are essential to improve clinical outcomes and optimize resource utilization.[24]

Limitations of the study include its retrospective design, the use of data obtained from electronic medical records, the single-center setting, and the relatively small sample size. Therefore, generalizability of the findings may be limited.

CONCLUSION

In our cohort, a low postoperative SII was independently associated with ICU mortality among patients admitted to the ICU after urgent or elective major abdominal surgery. Postoperative complications following major abdominal surgery may adversely affect quality of life, prolong ICU and hospital length of stay, and increase mortality risk. A low SII may reflect lymphocyte depletion associated with sepsis-induced immunosuppression, platelet consumption due to coagulopathy or massive transfusion, or an impaired neutrophilic response to severe infection. Routine assessment of postoperative SII at ICU admission may help clinicians identify patients at increased risk of mortality, facilitate early risk stratification, and support decisions regarding closer monitoring and targeted therapeutic interventions.

Ethics Committee Approval: This study was approved by The Başkent University Institutional Review Board (Date: 27.02.2024, Decision No: KA24/74).

Peer-review: Externally peer-reviewed.

Informed Consent: Written informed consent was obtained.

Authorship Contributions: Concept: F.İ.Y., H.Ş., P.Z.; Design: F.İ.Y., H.Ş., P.Z.; Supervision: H.Ş., P.Z.; Resource: F.İ.Y., G.H.; Materials: F.İ.Y., G.H.; Data collection and/or processing: F.İ.Y., G.H.; Analysis and/or interpretation: F.İ.Y., H.Ş.; Literature review: F.İ.Y., G.H.; Writing: F.İ.Y., H.Ş., P.Z.; Critical review: H.Ş., P.Z.

Conflict of Interest: None declared.

Financial Disclosure: The authors declare that no financial support was received for this study.

Use of AI for Writing Assistance: The author declared that this study did not use the artificial intelligence.

REFERENCES

1. Martini V, Lederer AK, Laessle C, Makowiec F, Utzolino S, Fichtner-Feigl S, et al. Clinical characteristics and outcomes of surgical patients with intensive care unit lengths of stay of 90 days and greater. Crit Care Res Pract 2017;2017:9852017. [CrossRef]
2. Sim YS, Lee JH, Cjang JH, Ryu YJ. Clinical outcome and prognosis of patients admitted to the surgical ICU after abdomen surgery. Korean Journal of Critical Care Medicine 2015;30:1–7. [CrossRef]
3. Hu B, Yang XR, Xu Y, Sun YF, Sun C, Guo W, et al. Systemic immune-inflammation index predicts prognosis of patients after curative resection for hepatocellular carcinoma. Clin Cancer Res 2014;20:6212–22. [CrossRef]
4. Ye C, Yuan L, Wu K, Shen B, Zhu C. Association between systemic immune-inflammation index and chronic obstructive pulmonary disease: a population-based study. BMC Pulm Med 2023;23:295. [CrossRef]
5. RA Rosalia, M Klincheva, M Klimkarov, R Zimoski, N Hristov, P Milojevik, et al. The systemic immune-inflammation index is associated with early postoperative morbidity and mortality following cardiac surgery. European Heart Journal 2020;41:ehaa946.3151 [CrossRef]
6. Fest J, Ruiter R, Mulder M, Groot Koerkamp B, Ikram MA, Stricker BH, et al. The systemic immune-inflammation index is associated with an increased risk of incident cancer-A population-based cohort study. Int J Cancer 2020;146:692–8. [CrossRef]
7. Wang ZC, Jiang W, Chen X, Yang L, Wang H, Liu YH. Systemic immune-inflammation index independently predicts poor survival of older adults with hip fracture: a prospective cohort study. BMC Geriatr 2021;21:155. [CrossRef]
8. Jiao Y, Zhang X, Liu M, Sun Y, Ma Z, Gu X, et al. Systemic immune-inflammation index within the first postoperative hour as a predictor of severe postoperative complications in upper abdominal surgery: a retrospective single-center study. BMC Gastroenterol 2022;22:403. [CrossRef]
9. Zhang L, Liu L, Yan G, Ma X, Zhu G, Dong X, et al. Predictive Value of the Systemic Immune-Inflammation Index in the 28-Day Mortality for Patients with Sepsis-Associated Acute Kidney Injury and Construction

of a Prediction Model. J Inflamm Res 2024;17:8727–39. [CrossRef]
10. Nag DS. Assessing the risk: Scoring systems for outcome prediction in emergency laparotomies. Biomedicine (Taipei) 2015;5:20. [CrossRef]
11. Hansted AK, Møller MH, Møller AM, Vester-Andersen M. APACHE II score validation in emergency abdominal surgery. A post hoc analysis of the InCare trial. Acta Anaesthesiol Scand 2020;64:180–7. [CrossRef]
12. Kassahun WT, Babel J, Mehdorn M. Assessing differences in surgical outcomes following emergency abdominal exploration for complications of elective surgery and high-risk primary emergencies. Sci Rep 2022;12:1349. [CrossRef]
13. Henry K, Merab K, Leonard M, Ronald KL, Nasser K, Moses G. Elevated serum lactate as a predictor of outcomes in patients following major abdominal surgery at a tertiary hospital in Uganda. BMC Surg 2021;21:319. [CrossRef]
14. Riaz S, Mir AW, Sidiq S, Gurcoo SA, Shah MA, Ara F, et al. Perioperative serum lactate as a predictor of post-operative length of hospital stay and in-hospital mortality in patients undergoing major emergency abdominal surgeries. Asian J Med Sci 2024;15:16–21. [CrossRef]
15. Barrow E, Anderson ID, Varley S, Pichel AC, Peden CJ, Saunders DI, et al. Current UK practice in emergency laparotomy. Ann R Coll Surg Engl 2013;95:599–603. [CrossRef]
16. Okidi R, Sambo VDC, Okello I, Ekwem DA, Ekwang S, Obalim F, et al. Associated factors of mortality and morbidity in emergency and elective abdominal surgery: a two-year prospective cohort study at lacor hospital, Uganda. BMC Surg 2024;24:144. [CrossRef]
17. Tefera GM, Feyisa BB, Umeta GT, Kebede TM. Predictors of prolonged length of hospital stay and in-hospital mortality among adult patients admitted at the surgical ward of Jimma University medical center, Ethiopia: prospective observational study. J Pharm Policy Pract 2020;13:24. [CrossRef]
18. Hotchkiss RS, Monneret G, Payen D. Immunosuppression in sepsis: a novel understanding of the disorder and a new therapeutic approach. Lancet Infect Dis 2013;13:260–8. [CrossRef]
19. Yeh HF, Chao WC, Wu CL, Chan MC. Hypoglycemia and hospital mortality in critically ill patients. Sci Rep 2025;15:2642. [CrossRef]
20. Shevchenko I, Grigorescu CC, Serban D, Cristea BM, Simion L, Gherghiceanu F, et al. The value of systemic inflammatory indices for predicting early postoperative complications in colorectal cancer. Medicina (Kaunas) 2024;60:1481. [CrossRef]
21. Braga M, Pecorelli N, Ariotti R, Capretti G, Greco M, Balzano G, Castoldi R, Beretta L. Enhanced recovery after surgery pathway in patients undergoing pancreaticoduodenectomy. World J Surg 2014;38:2960-6. [CrossRef]
22. Saunders DI, Murray D, Pichel AC, Varley S, Peden CJ; UK Emergency Laparotomy Network. Variations in mortality after emergency laparotomy: the first report of the UK Emergency Laparotomy Network. Br J Anaesth 2012;109:368–75. [CrossRef]
23. Fehlmann CA, Taljaard M, McIsaac DI, Suppan L, Andereggen E, Dupuis A, et al. Incidence and outcomes of emergency department patients requiring emergency general surgery: a 5-year retrospective cohort study. Swiss Med Wkly 2024;154:3729. [CrossRef]
24. Degu S, Kejela S, Zeleke HT. Perioperative mortality of emergency and elective surgical patients in a low-income country: a single institution experience. Perioper Med (Lond) 2023;12:49. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Acil ve elektif majör abdominal cerrahi sonrası yoğun bakıma kabul edilen hastalarda sistemik immün enflamasyon indeksinin mortalite ile ilişkisi

AMAÇ: Majör abdominal cerrahiler, postoperatif komplikasyonların, morbidite ve mortalitenin yüksek olduğu ameliyatlardır. Nötrofil, trombosit ve lenfosit sayılarını kullanarak hastaların inflamatuar ve immünolojik durumunu değerlendiren Sistemik İmmün İnflamasyon İndeksinin (SII), çeşitli hastalıkların prognozunu tahmin etmekte etkili olduğu yönünde yayınlar bulunmaktadır. Bu çalışmada, acil ve elektif majör abdominal cerrahi sonrası yoğun bakım ünitesine (YBÜ) yatırılan hastaların sonuçlarını retrospektif olarak analiz etmeyi ve postoperatif SII ile postoperatif YBÜ mortalitesi arasındaki ilişkiyi araştırmayı amaçladık.

GEREÇ VE YÖNTEM: Kasım 2022-2023 tarihleri arasında cerrahi yoğun bakım ünitesine majör abdominal cerrahi sonrası kabul edilen hastalar retrospektif olarak değerlendirildi. İlk 24 saat içinde ölen, 48 saatten kısa süre yoğun bakım ünitesinde takip edilen ve18 yaş altındaki hastalar çalışma dışı bırakıldı.

BULGULAR: Çalışma periyodu içinde cerrahi yoğun bakım ünitesine 360 hasta kabul edildi. Majör abdominal cerrahi geçiren hasta sayısı 102 idi. İlk 24 saatte ölen 1 hasta çalışma dışı bırakıldıktan sonra 101 hasta çalışmaya dahil edildi. Hastaların 59' u (%58.4) kadın ve yaş ortalaması 70.1±15.2 idi. Acil abdominal cerrahi yapılan hasta sayısı 42 (%41.6) idi. Acil cerrahi geçirenlerde YBÜ mortalite oranı (%23.8) elektif cerrahiye (%5.1) göre yüksekti (p=0.013). ROC eğrisi analizi sonrası postoperatif SII düzeyinin kesim noktası değeri 998.26 olarak belirlendi. Düşük postoperatif SII düzeyinin %82.9 sensitivite ve %69.2 spesifite ile majör abdominal cerrahi geçiren hastalarda mortalite için bağımsız bir risk faktörü olduğu bulundu (%95 CI: 0.0579-0.913, p=0.004).

SONUÇ: Bulgularımız, majör abdominal cerrahi sonrası postoperatif SII'nin prognozu belirlemede ve mortaliteyi öngörmede etkili bir parametre olabildiğini göstermektedir.

Anahtar sözcükler: Abdominal cerrahi; acil; sistemik immün inflamasyon indeksi; yoğun bakım ünitesi.

Ulus Travma Acil Cerrahi Derg 2026;32(8):930-939 DOI: 10.14744/tjtes.2026.80149

ORIGINAL ARTICLE

Emergency surgical management of nontraumatic pathologic spinal pain diagnosed in the emergency department

Emel Altıntaş,[1] Derya Karaoğlu Gündoğdu,[2] Yunus Kaçar[3]

[1]Department of Emergency Medicine, Ufuk University Faculty of Medicine, Ankara-*Türkiye*
[2]Department of Neurosurgery, Selçuk University Faculty of Medicine, Konya-*Türkiye*
[3]Department of Neurosurgery, Koru Hospital, Ankara-*Türkiye*

ABSTRACT

BACKGROUND: This study aimed to evaluate patients who presented to the emergency department with non-traumatic back or lumbar pain, without new-onset neurological deficits or cauda equina syndrome. Because of inadequate response to medical treatment, patients underwent imaging of the affected region and subsequently required emergency neurosurgical intervention.

METHODS: We included patients aged ≥18 years who presented to the emergency department with back or lumbar pain, experienced no pain relief despite analgesic treatment, underwent imaging of the affected region, and were referred for emergency surgical treatment by the neurosurgery department based on imaging findings. Patients presenting with trauma, new-onset neurological deficits, or a history of prior spinal surgery were excluded.

RESULTS: The study included 35 patients with a mean age of 65.51 years (range: 42–82). Among them, 11.4% (n=4) had chronic kidney disease, 37.14% (n=13) had diabetes mellitus, 22.8% (n=8) had a history of cancer, and 22.8% (n=8) had a family history of cancer. No red flag findings other than cancer-related risk factors were identified. The primary clinical indicator of underlying pathology was persistent pain despite analgesic treatment. Advanced diagnostic evaluation revealed pathological fractures in 77.1% of patients (n=27), spinal abscesses in 14.2% (n=5), and spondylodiscitis in 8.5% (n=3); all patients underwent emergency surgical treatment. Among patients with pathological fractures, histopathological examination demonstrated osteoporotic fractures in 59.2% (n=16) and metastatic fractures in 40.8% (n=11). Notably, all spinal metastases led to the initial diagnosis of cancer, and only two of these patients presented with red flag symptoms.

CONCLUSION: Patients without spinal emergencies or red flag symptoms may still require emergency surgical intervention. Therefore, diagnostic and evaluation algorithms should be developed for this patient population. We believe that pain severity scores may play an important role in such algorithms.

Keywords: Abscess; pathological fracture; spinal emergencies; spinal pain; spondylodiscitis.

INTRODUCTION

Acute low back and/or back pain (LBBP) is defined as pain lasting up to six weeks after symptom onset.[1] A substantial proportion of the population experiences LBBP during their lifetime. The reported etiologies include compression fractures (4%), spondylolisthesis (3%), tumors/metastases (0.7%), and infections (0.01%), whereas more than 90% of cases are classified as nonspecific LBBP.[2]

Current guidelines emphasize the importance of identifying

Cite this article as: Altıntaş E, Karaoğlu Gündoğdu D, Kaçar Y. Emergency surgical management of nontraumatic pathologic spinal pain diagnosed in the emergency department. Ulus Travma Acil Cerrahi Derg 2026;32:940-946.

Address for correspondence: Emel Altıntaş
Department of Emergency Medicine, Ufuk University Faculty of Medicine, Ankara, Türkiye
E-mail: emelaltintas61@gmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):940-946 DOI: 10.14744/tjtes.2026.43589
Submitted: 20.04.2025 Revised: 26.01.2026 Accepted: 18.02.2026 Published: 10.08.2026

red flags through patient history and physical examination to guide diagnostic triage.[1-3] Red flag conditions include a history of cancer, unexplained weight loss, immunosuppression, intravenous (IV) drug use, recurrent urinary tract infections, fever, trauma, urinary retention, bladder or bowel incontinence, loss of anal sphincter tone, saddle anesthesia, lower-extremity motor weakness, and neurological deficits that persist or worsen for more than one month.[1-3]

Emergency referral and magnetic resonance imaging (MRI) are recommended when cauda equina syndrome (CES) is suspected, particularly in the presence of urinary retention, multilevel motor weakness, fecal incontinence, or saddle anesthesia. Early imaging in patients with non-emergent LBBP is generally considered to provide limited clinical benefit.[4] However, the most appropriate imaging modality in the absence of red flags, and the sequence of cost-effective imaging approaches remain unclear.[1] Currently, insufficient evidence exists to support specific imaging pathways, and decisions regarding imaging are generally left to the discretion of the treating specialist.[4] Given these uncertainties, we investigated patients who presented to the emergency department with non-traumatic LBBP, without new-onset neurological deficits or CES, who underwent imaging because of persistent pain despite medical treatment and ultimately required surgical intervention. We also aimed to highlight potential limitations of current red flag criteria.

MATERIALS AND METHODS

This study was conducted in accordance with the principles of the Declaration of Helsinki. The study protocol received an exemption from the Koru Hospital Non-Interventional Ethics Committee (Approval Number: 2023/4033).

Patients aged ≥18 years who presented to the emergency department with spinal pain and underwent imaging of the affected region between January 2022 and January 2023 were included. Patients presenting with trauma, those with new-onset neurological deficits, and those with a history of prior spinal surgery were excluded. Demographic and clinical characteristics, including age, sex, comorbidities, body mass index (BMI), pain location, and pain severity measured using the Visual Analog Scale (VAS), were recorded. Patients initially received intramuscular nonsteroidal anti-inflammatory drug (NSAID) therapy and were observed for one hour. Intravenous tramadol hydrochloride was administered as a slow infusion over 30 minutes, followed by a two-hour observation period. Persistent pain was defined as the absence of any reduction in VAS score after both intramuscular NSAID administration and intravenous tramadol treatment.

The imaging modalities used (plain radiography [X-ray], computed tomography [CT], and MRI) as well as final diagnoses were documented. Patients with persistent pain underwent initial X-ray evaluation. Those with findings suggestive of compression fractures or disc-space abnormalities were referred for neurosurgical consultation. CT and MRI were performed when the acuity of a compression fracture was uncertain, intracanal pathology was suspected, or abnormalities identified on X-ray could not be adequately characterized. When pathology was clearly demonstrated on X-ray, further diagnostic and therapeutic decisions were made by the neurosurgical team. Postoperative VAS scores were assessed within the first 48 hours.

Statistical Analysis

Data were analyzed using SPSS Statistics for Windows, version 23 (IBM, Armonk, NY, USA). Descriptive statistics were used to summarize the data and are presented as frequencies and percentages.

RESULTS

Of the 387 patient records reviewed, 185 patients were excluded because they presented with trauma, eight because of newly developed neurological deficits, three because they had previously undergone spinal surgery, and 156 because their pain improved with analgesic treatment and imaging was therefore not performed. Patients whose pain responded to analgesia were provisionally diagnosed with degenerative spinal disorders.

The remaining 35 patients were included in the study. The mean age was 65.51 years (range: 42–82), and 48.5% (n=17) were male. The mean BMI was 26.54 (range: 17–49). Pain and spinal tenderness were reported in the thoracic region in 48.5% of patients (n=17), the lumbar region in 42.9% (n=15), and the thoracolumbar region in 8.6% (n=3). Regarding comorbidities, 11.4% (n=4) of patients had chronic kidney disease (CKD), 31.4% (n=13) had diabetes mellitus (DM), and 22.8% (n=8) had a history of cancer. Additionally, 22.8% (n=8) reported a family history of cancer. No other red flag findings were identified. At presentation, VAS pain scores ranged from 6 to 10, whereas post-treatment scores ranged from 5 to 9. Seven patients (20%) reported the maximum VAS score of 10 at the time of emergency department admission (Table 1).

The imaging modalities performed in the emergency department were as follows: direct radiography along in 25.7% of patients (n=9), spinal CT alone in 57.1% (n=20), both direct radiography and CT in 5.7% (n=2), CT and MRI in 8.5% (n=3), and direct radiography, CT, and MRI in 2.8% (n=1) (Figs. 1 and 2).

Final diagnoses included osteoporotic fractures in 45.7% of patients (n=16), spinal abscesses in 14.2% (n=5), spondylodiscitis in 8.5% (n=3), and spinal metastases (SM) in 28.5% (n=10). Among patients with spinal metastases, 70% (n=7) originated from lung cancer, 20% (n=2) from renal cell carcinoma (RCC), and 10% (n=1) from breast cancer (Table 1). The mean interval between diagnosis and surgery was 21.91±15.56 hours (min–max: 5–48).

Table 1. Demographic characteristics of the patients

No.	Sex	Age	Pain location	Red flag history	Comorbidities	Family history	BMI	VAS1	VAS2	X-ray	CT	MRI	Diagnosis
1	Male	50	Lumbar	History of cancer		Prostate cancer	20	10	9	+			Renal cell carcinoma metastasis
2	Female	42	Lumbar				20	10	8		+		Renal cell carcinoma metastasis
3	Male	76	Thoracic				21	7	5		+		Lung cancer metastasis
4	Female	55	Lumbar				28	9	8	+	+	+	Lung cancer metastasis
5	Female	65	Lumbar	History of cancer	DM	Lung cancer	41	8	7	+			Lung cancer metastasis
6	Male	52	Thoracolumbar	History of cancer		Lung cancer	25	10	9		+		Lung cancer metastasis
7	Male	74	Thoracic	Cancer	Lung cancer	Lung cancer	18	9	8		+		Lung cancer metastasis
8	Male	68	Thoracic	Cancer	Lung cancer		20	8	6	+	+		Lung cancer metastasis
9	Male	75	Thoracic				17	10	8		+	+	Lung cancer metastasis
10	Female	68	Lumbar	History of cancer		Breast cancer	28	9	8		+		Breast cancer metastasis
11	Female	46	Thoracic				24	9	6		+	+	Breast cancer metastasis
12	Female	56	Lumbar		DM		23	9	7	+			Spondy-lodiscitis
13	Female	42	Lumbar		CKD	DM	22	9	7	+			Spondy-lodiscitis
14	Male	71	Thoracic		DM	DM	30	9	7	+			Spondy-lodiscitis
15	Male	82	Thoracic		DM, CKD	DM	32	10	9		+		Spinal epidural abscess
16	Female	80	Lumbar		DM		42	10	9		+		Spinal epidural abscess
17	Female	74	Thoracic		DM	DM	49	10	9		+		Spinal epidural abscess
18	Female	58	Lumbar		DM, CKD		21	10	9	+			Spinal epidural abscess
19	Female	58	Lumbar		DM	DM	33	9	8		+	+	Spinal epidural abscess
20	Male	68	Thoracic				19	9	7		+		Osteoporotic fracture
21	Male	73	Thoracic				19	8	6	+			Osteoporotic fracture
22	Male	63	Lumbar	Cancer	DM, stom-ach cancer		22	8	6	+			Osteoporotic fracture
23	Male	67	Thoracic	Cancer	Rectal cancer		21	6	5		+		Osteoporotic fracture
24	Male	73	Lumbar	Cancer	Prostate cancer		26	8	7	+			Osteoporotic fracture
25	Female	67	Lumbar		DM	DM	42	8	6	+	+		Osteoporotic fracture
26	Female	61	Thoracic			DM	33	7	6		+		Osteoporotic fracture
27	Female	64	Lumbar	History of can-cer	DM	Lung cancer	36	8	6		+		Osteoporotic fracture
28	Male	78	Thoracic				19	9	7		+		Osteoporotic fracture
29	Male	73	Thoracic		DM, CKD		24	8	6		+		Osteoporotic fracture
30	Female	62	Thoracolumbar	Cancer	Breast cancer	Breast cancer	35	6	6		+		Osteoporotic fracture
31	Female	72	Thoracic				28	8	6		+		Osteoporotic fracture
32	Female	54	Lumbar				28	8	7		+		Osteoporotic fracture
33	Female	68	Thoracic		DM		23	9	6		+		Osteoporotic fracture
34	Male	76	Thoracic	Cancer	Lung cancer	Lung cancer	18	9	8		+		Osteoporotic fracture
35	Male	82	Thoracolumbar	Cancer	Prostate can-cer		22	9	8		+		Osteoporotic fracture

DM: Diabetes mellitus; CKD: Chronic kidney disease; VAS1: Visual Analog Scale pain score at emergency department presentation; VAS2: Visual Analog Scale pain score after analgesic treatment; X-ray: Plain radiography; CT: Computed tomography; MRI: Magnetic resonance imaging.

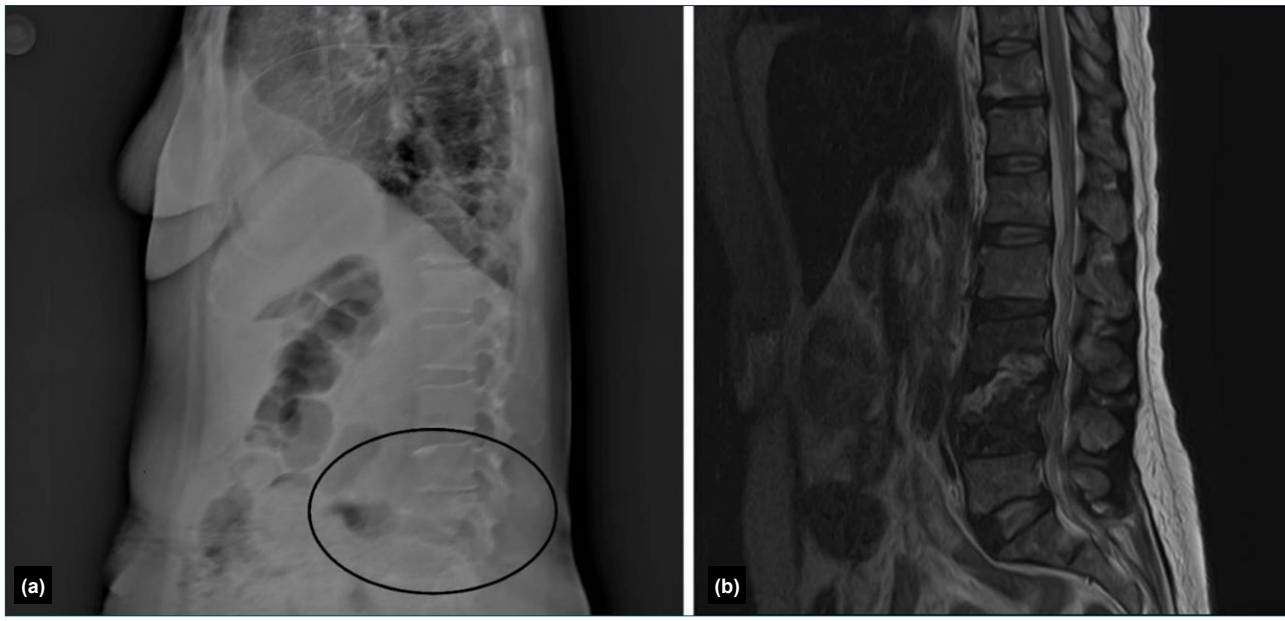

Figure 1. (a) X-ray demonstrated vertebral body collapse at L4, irregularity of the L3–L4 disc space, and disruption of lumbar spinal alignment (outlined area in the figure). Based on these findings, the patient was referred to the relevant specialists with a differential diagnosis of spondylodiscitis. **(b)** Lumbar spine magnetic resonance imaging (MRI), performed after hospital admission, supported a preliminary diagnosis of spinal abscess. The patient subsequently underwent surgical intervention by the neurosurgery team. The preoperative C-reactive protein (CRP) level was 140 and decreased to 34 after two weeks of antibiotic therapy.

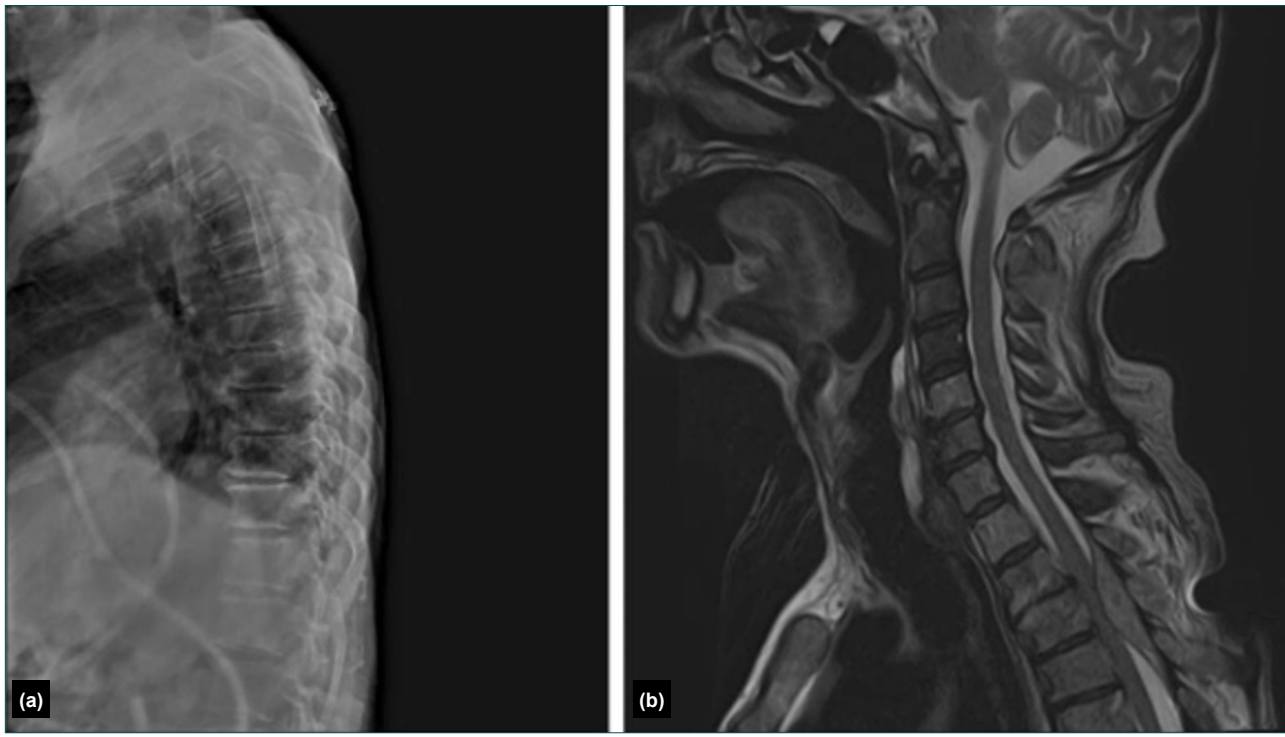

Figure 2. (a) Plain radiography and spinal computed tomography (CT) of the region corresponding to spinal tenderness revealed no identifiable pathology. **(b)** Spinal magnetic resonance imaging (MRI) demonstrated an extradural lesion at the T3 level, suspicious for a metastatic mass. Following consultation with the relevant specialties, the patient underwent surgery 10 hours after presentation to the emergency department.

DISCUSSION

The evaluation of patients presenting with low back and/or back pain should include assessment of pain duration, intensity, characteristics, aggravating and relieving factors, and associated symptoms such as fever, night sweats, weight loss, substance use, and depression. Physical examination should assess spinal asymmetry, localized tenderness, and neurological function, including motor strength, reflexes, and sensation. The straight leg-raise test and assessment of Waddell's signs are also recommended.[4] The straight leg-raise test is performed with the patient in the supine position and involves passive flexion of the hip while the knee is kept fully extended. The test is considered positive when pain is elicited at less than 45° of hip flexion and radiates along the appropriate dermatomal distribution. Waddell's non-organic signs include tenderness, simulation, distraction, regional disturbances, and overreaction. Examples include discordant findings during distraction testing or pain elicited within the first 30° of rotation.[4]

Routine imaging is not recommended for patients with new-onset symptoms unless findings suggest an emergency condition requiring urgent evaluation.[4] Red flags include new neurological deficits, bowel and/or bladder dysfunction, and a history of trauma or malignancy. Imaging is generally not recommended when symptoms have been present for less than six weeks and no red flags are identified. However, imaging may be required when it is likely to alter diagnosis or management.[3] Patients whose diagnosis and subsequent treatment were guided by imaging findings obtained in the emergency department were included in the study. Unfortunately, no standardized imaging protocol existed during the study period. Decisions regarding additional imaging were largely influenced by the emergency physician's clinical judgment and the persistence of pain despite initial treatment. In our country, however, MRI is routinely preferred when CES is suspected.

Review of symptom duration and neurological examination findings revealed that none of the patients met conventional criteria for immediate imaging according to standard guidelines. Osteoporotic fractures, pathological fractures secondary to bone metastases, and vertebral destruction caused by spondylodiscitis could be diagnosed using plain radiography alone. The patients were subsequently admitted to the neurosurgery department and underwent emergency surgical intervention after appropriate preoperative preparation. In patients with obesity, for whom plain radiography was considered insufficient, spinal CT was selected as the initial imaging modality for evaluation of the painful region. When plain radiographic findings were inconclusive, spinal CT was used as a secondary imaging modality. In one patient, persistent severe pain despite unremarkable radiographic and CT findings prompted MRI evaluation, which revealed a metastatic lesion causing epidural spinal cord compression.

Most cases of spondylodiscitis occur secondary to infections originating in the genitourinary tract, skin and soft tissues, respiratory tract, gastrointestinal tract, or oral cavity. Established risk factors include age, DM, immunosuppression, IV drug use, alcoholism, liver cirrhosis, malignancy, and renal failure. MRI is the imaging modality of choice for diagnosis.[5] Spinal epidural abscess develops in approximately 4%–38% of patients with spondylodiscitis. Two of our patients had DM, one of whom also had renal failure. Because these conditions are known risk factors for spondylodiscitis, early diagnosis is essential to prevent progression to spinal epidural abscess formation. Although spondylodiscitis is primarily treated with antibiotic therapy, surgical intervention may be necessary when spinal alignment is compromised or when intraspinal pathology is present.[6] In our cohort, the initial suspicion of spondylodiscitis arose from vertebral alignment abnormalities identified on plain radiographs. Following admission to the neurosurgery service and completion of further diagnostic evaluation, all patients underwent surgical treatment.

Spinal epidural abscess is associated with substantial morbidity and mortality.[7] Clinical manifestations are often nonspecific, including back pain, fever, leukocytosis, and elevated erythrocyte sedimentation rate (ESR) or C-reactive protein levels.[8] Generally, most cases are initially misdiagnosed. [8-10] Consequently, the diagnosis is frequently missed, with delays reported in up to 75% of cases.[10] The classic triad of back pain, fever, and neurological deficits is present in only 13% of patients. Reported risk factors include IV drug use, immunosuppression, alcoholism, previous spinal surgery, DM, indwelling catheter use, chronic renal failure (CRF), spinal fracture, and malignancy, with at least one risk factor present in 98% of affected patients.[9,10] Additional predictors for obtaining MRI include fever and/or chills, antibiotic use within the previous 30 days, back and/or neck pain, IV substance use, and advanced age.[7] In patients without progressive deficits, ESR measurement is recommended when fever, risk factors, radicular pain, or static neurological deficits are present; MRI is advised if ESR is elevated.[11] Irreversible paralysis is the most severe complication of spinal epidural abscesses, occurring in 4%–22% of patients.[8] Five patients in our cohort were diagnosed with spinal epidural abscesses. Two had both DM and CKF, whereas the remaining three had DM alone. None exhibited the classic triad. Four patients presented with a VAS score of 10 that decreased only to 9 following analgesic treatment, while the fifth patient's score decreased from 9 to 8. Among the patients who underwent surgery for spinal epidural abscess, four were successfully managed with prolonged antibiotic therapy following surgery, whereas one patient died of septic shock one week postoperatively. Given the risk of irreversible neurological injury and the substantial morbidity and mortality associated with spinal epidural abscess, this diagnosis should be considered in patients with risk factors whose pain remains severe despite treatment.

Spinal metastasis should be considered in patients with malignancies.[12] Breast, prostate, and lung cancers are the most

common malignancies associated with SM. Other important causes include non-Hodgkin lymphoma, RCC, and multiple myeloma. Emergency surgery may be required in the presence of spinal instability or spinal cord compression, as treatment delays can result in permanent neurological deficits.[12] A history of malignancy is considered a red flag.[13] However, 64% of patients with spinal malignancies do not require emergency surgery.[14] In our cohort, seven patients had lung cancer metastases, two had RCC metastases, and one had breast cancer metastasis. Nine patients had no prior history of malignancy and received their initial cancer diagnosis following pathological evaluation of tissue obtained during surgery for SM. Five of these patients reported a family history of cancer. Early diagnosis not only prevented neurological deterioration but also enabled timely initiation of oncological treatment. Imaging was performed because pain severity failed to improve after treatment. We therefore believe that a family history of cancer should be carefully assessed in patients whose pain remains refractory to treatment.

Advanced age, trauma, corticosteroid use, and the presence of contusions or abrasions have been reported as predictors of osteoporotic fractures.[15] However, many of these factors are not included among traditional red flags. Studies have demonstrated that combinations of risk indicators identify more clinically significant pathology than reliance on red flags alone.[16] In our study, seven osteoporotic fractures occurred in women with BMIs ranging from 28 to 42. Advanced age and female sex may therefore be useful indicators when considering osteoporotic fractures.[15,16] Although all affected patients were older than 54 years, none had a history of trauma, corticosteroid use, or evidence of contusions or abrasions. Their diagnoses were established through imaging prompted by persistent pain.

Although low back pain is highly prevalent and most patients respond to analgesic treatment, routine imaging for all patients with red flag symptoms is not cost-effective. Nevertheless, early diagnosis and treatment of SM, spinal epidural abscesses, spondylodiscitis, and osteoporotic fractures before the development of neurological deficits can substantially reduce morbidity and mortality. To our knowledge, no previous study has specifically identified persistent pain despite treatment as a predictor of pathology requiring emergency surgery. However, our findings suggest that failure of VAS pain scores to decrease following treatment with NSAIDs and tramadol may represent an important warning sign and should be investigated further as a potential red flag criterion.

We believe that the imaging studies obtained because of persistent pain severity were clinically beneficial and that the development of a standardized diagnostic algorithm for such patients would be valuable.

Limitations

This study has limitations, including its retrospective design and relatively short study period of 12 months. Prospective, multicenter studies with longer follow-up periods are needed to provide more robust and generalizable evidence. Furthermore, imaging decisions were based primarily on physician judgment and patient response to treatment rather than a standardized protocol. However, as part of routine clinical practice in our country, MRI is the preferred imaging modality in the emergency department when CES is suspected. Finally, because patients whose pain improved after analgesic treatment were excluded, information regarding underlying pathologies in this population remains limited.

CONCLUSION

Patients without CES or red flag symptoms may nevertheless require emergency surgical intervention. Therefore, diagnostic and evaluation algorithms should be developed for this patient population. We believe that pain severity scores may play an important role in such algorithms.

Ethics Committee Approval: This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Koru Hospital Non-Interventional Ethics Committee (Date: 02.11.2023, Decision No: 4033).

Peer-review: Externally peer-reviewed.

Informed Consent: All participants provided informed consent.

Authorship Contributions: Concept: E.A., D.K.G., Y.K.; Design: E.A., D.K.G., Y.K.; Data collection and/or processing: E.A., D.K.G., Y.K.; Analysis and/or interpretation: E.A., D.K.G., Y.K.; Writing: E.A., D.K.G., Y.K.; Critical review: E.A., D.K.G., Y.K.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Kreiner DS, Matz P, Bono CM, Cho CH, Easa JE, Ghiselli G, et al. Guideline summary review: an evidence-based clinical guideline for the diagnosis and treatment of low back pain. Spine J 2020;20:998–1024. [CrossRef]
2. Koes BW, van Tulder MW, Thomas S. Diagnosis and treatment of low back pain. BMJ 2006;332:1430–4. [CrossRef]
3. Oliveira CB, Maher CG, Pinto RZ, Traeger AC, Lin CC, Chenot JF, et al. Clinical practice guidelines for the management of non-specific low back pain in primary care: an updated overview. Eur Spine J 2018;27:2791–803. [CrossRef]
4. David Gibbs, BS Ben G McGahan, Alexander E. Ropper, David S. Xu. Back pain: differential diagnosis and management. Neurol Clin 2023;41:61-76. [CrossRef]
5. Cottle L, Riordan T. Infectious spondylodiscitis. J Infect. 2008;56:401-12. [CrossRef]
6. Gentile L, Benazzo F, De Rosa F, Boriani S, Dallagiacoma G, Franceschetti Get al. A systematic review: characteristics, complications and treatment of spondylodiscitis. Eur Rev Med Pharmacol Sci 2019;23:117–28.
7. Artenstein AW, Friderici J, Visintainer P. A Predictive model facilitates

early recognition of spinal epidural abscess in adults. West J Emerg Med 2018;19:276–81. [CrossRef]
8. Darouiche RO. Spinal epidural abscess. N Engl J Med 2006;355:2012–20. [CrossRef]
9. Tang HJ, Lin HJ, Liu YC, Li CM. Spinal epidural abscess--experience with 46 patients and evaluation of prognostic factors. J Infect 2002;45:76–81. [CrossRef]
10. Davis DP, Wold RM, Patel RJ, Tran AJ, Tokhi RN, Chan TC, et al. The clinical presentation and impact of diagnostic delays on emergency department patients with spinal epidural abscess. J Emerg Med 2004;26:285–91. [CrossRef]
11. Alerhand S, Wood S, Long B, Koyfman A. The time-sensitive challenge of diagnosing spinal epidural abscess in the emergency department. Intern Emerg Med 2017;12:1179–83. [CrossRef]
12. Ropper AE, Ropper AH. Acute spinal cord compression. N Engl J Med 2017;376:1358–69. [CrossRef]
13. Downie A, Williams CM, Henschke N, Hancock MJ, Ostelo RW, de Vet HC, et al. Red flags to screen for malignancy and fracture in patients with low back pain: systematic review. BMJ 2013;347:f7095. [CrossRef]
14. Premkumar A, Godfrey W, Gottschalk MB, Boden SD. Red flags for low back pain are not always really red: a prospective evaluation of the clinical utility of commonly used screening questions for low back pain. J Bone Joint Surg Am 2018;100:368–74. [CrossRef]
15. Han CS, Hancock MJ, Downie A, Jarvik JG, Koes BW, Machado GC, et al. Red flags to screen for vertebral fracture in people presenting with low back pain. Cochrane Database Syst Rev 2023;8:CD014461. [CrossRef]
16. Williams CM, Henschke N, Maher CG, van Tulder MW, Koes BW, Macaskill P, et al. Red flags to screen for vertebral fracture in patients presenting with low-back pain. Cochrane Database Syst Rev 2023;11:CD008643. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Acil servise başvuran ve acil cerrahi ile tedavi edilen travma dışı patolojik omurga ağrısı

AMAÇ: Bu çalışmanın amacı, acil servise travmatik olmayan sırt veya bel ağrısı şikayetiyle başvuran, yeni başlangıçlı nörolojik defisit veya kauda equina sendromu bulunmayan ve medikal tedavinin yetersiz kalması üzerine ilgili bölgeye görüntüleme yapılan, sonrasında nöroşirürji kliniği tarafından acil cerrahi müdahale gereken hastaların değerlendirilmesidir.
GEREÇ VE YÖNTEM: Çalışmaya, acil servise sırt veya bel ağrısı şikayetiyle başvuran, analjezik tedaviye rağmen ağrısı geçmeyen, ağrılı bölgeye görüntüleme yapılan ve görüntüleme sonucuna göre nöroşirürji tarafından acil cerrahi tedavi önerilen 18 yaş ve üzeri hastalar dahil edilmiştir. Travma öyküsü olan, yeni nörolojik defisit gelişen veya daha önce cerrahi tedavi geçirmiş hastalar çalışma dışı bırakılmıştır.
BULGULAR: Çalışmaya dahil edilen 35 hastanın ortalama yaşı 65.51 (aralık: 42–82) idi. Hastaların %11.4'ünde (n=4) kronik böbrek yetmezliği, %37.14'ünde (n=13) diabetes mellitus, %22.8'inde (n=8) kanser tanısı mevcuttu. Hastaların %22.8'inin (n=8) ailesinde kanser öyküsü vardı. Kanser şüphesi dışında başka kırmızı bayrak semptomu saptanmadı. Patolojiyi işaret eden temel bulgu, analjezik tedaviye yanıt alınamamasıydı. Gelişmiş görüntüleme tetkikleri sonucunda hastaların %77.1'ine (n=27) patolojik kırık, %14.2'sine (n=5) spinal apse, %8.5'ine (n=3) spondilodiskit tanısı konuldu ve bu hastaların tamamına acil cerrahi tedavi uygulandı. Patolojik kırık tanısıyla opere edilen hastaların patoloji sonuçlarına göre %59.2'sinde (n=16) osteoporotik kırık, %40.8'inde (n=11) metastatik kırık saptandı. Dikkat çekici olarak, spinal metastaz tanısı alan hastaların tamamı kanserin ilk tanısı olup, yalnızca iki hastada kırmızı bayrak semptomları mevcuttu.
SONUÇ: Spinal acil durumu veya kırmızı bayrak semptomu olmayan hastalar da acil cerrahi tedavi gerektirebilir. Bu nedenle, bu hasta grubuna yönelik tanı ve değerlendirme algoritmaları geliştirilmelidir. Bu algoritmalarda ağrı şiddet skorlarının önemli bir yer tutacağına inanmaktayız.

Anahtar sözcükler: Apse; omurga ağrısı; patolojik kırık; spinal aciller; spondilodiskit.

Ulus Travma Acil Cerrahi Derg 2026;32(8):940-946 DOI: 10.14744/tjtes.2026.43589

ORIGINAL ARTICLE

Gallstone ileus: a single-center experience

Fatih Feratoğlu,[1,2] Cemal Hacıalioğlu,[2] Tarık Emre Yılmaz,[2,3] Selçuk Kaya[2]

[1]Department of General Surgery, Medical Park Göztepe Hospital, İstanbul-*Türkiye*
[2]Department of General Surgery, Kartal Dr. Lütfi Kirdar City Hospital, University of Health Sciences, İstanbul-*Türkiye*
[3]Department of Gastrointestinal System Surgery, Ankara Bilkent City Hospital, University of Health Sciences, Ankara-*Türkiye*

ABSTRACT

BACKGROUND: Gallstone ileus (GSI) is a rare surgical emergency. Its diagnosis is challenging and frequently delayed. Moreover, there is no consensus regarding the optimal surgical approach. The primary point of debate is whether cholecystectomy and fistula repair should be performed and, if so, when. Several studies have suggested that omitting cholecystectomy and fistula repair may increase the risk of cholangitis, gallbladder cancer, and recurrent gallstone ileus. However, most of these data originate from studies conducted in the previous century and have not been supported by contemporary evidence. This study aimed to present our clinical experience with gallstone ileus, discuss diagnostic and therapeutic strategies, and review the relevant literature.

METHODS: Medical records of 13 patients who underwent surgery for GSI between 2017 and 2022 at the Department of General Surgery, Kartal Dr. Lütfi Kirdar City Hospital, were retrospectively reviewed.

RESULTS: Of the patients, 69% were diagnosed with gallstone ileus at the time of admission, whereas 30.7% experienced a delayed diagnosis. The median time to surgery was 6 hours, and the median length of hospital stay was 6.5 days among patients diagnosed at admission. In contrast, patients with a delayed diagnosis had a median time to surgery of 126 hours and a median hospital stay of 14.5 days. Failure to establish the diagnosis at admission was associated with preoperative delays and prolonged hospitalization ($p<0.05$). Eleven patients underwent surgery aimed solely at relieving bowel obstruction, with fistula repair omitted. Two patients underwent additional cholecystectomy and fistula repair. During a mean follow-up period of 39.7 months, no cases of recurrent gallstone ileus, gallbladder cancer, or cholangitis were observed, despite omission of fistula repair in most patients.

CONCLUSION: GSI is a rare surgical emergency that is frequently associated with delayed diagnosis. Accurate diagnosis at presentation reduces preoperative delay and shortens hospital stay. Current evidence is insufficient to support routine cholecystectomy and fistula repair in all patients with GSI. The relationship between GSI and malignancy remains unclear. Surgical management should be individualized, and cholecystectomy with fistula repair should be considered when additional gallstones are present in the gallbladder.

Keywords: Bowel obstruction; cholecystoenteric fistula; fistula repair; gallstone ileus.

INTRODUCTION

Gallstone ileus (GSI) is a rare surgical emergency that predominantly affects elderly patients. It is caused by a large gallstone within the gallbladder that chronically erodes the gallbladder wall and an adjacent segment of the gastrointestinal tract, eventually resulting in the formation of a biliary-enteric fistula. The stone subsequently migrates into the intestinal lumen, becomes impacted, and causes mechanical bowel obstruction.

Because of its rarity, diagnosis is challenging and frequently delayed.[1,2] This occurs despite the presence of characteristic radiological findings, including pneumobilia, air within the gallbladder, and an ectopic gallstone in the bowel at the site of obstruction. Management of the bowel obstruction includes enterotomy with stone extraction, bowel resection when in-

Cite this article as: Feratoğlu F, Hacıalioğlu C, Yılmaz TE, Kaya S. Gallstone ileus: a single-center experience. Ulus Travma Acil Cerrahi Derg 2026;32:947-953.

Address for correspondence: Fatih Feratoğlu
Department of General Surgery, Medical Park Göztepe Hospital, İstanbul, Türkiye
E-mail: fferatoglu@gmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):947-953 DOI: 10.14744/tjtes.2026.24485
Submitted: 25.09.2025 Revised: 23.02.2026 Accepted: 24.02.2026 Published: 10.08.2026

dicated, or, in selected cases, manual fragmentation and advancement of the stone into the colon without enterotomy. However, the principal area of controversy remains whether cholecystectomy and fistula repair should be performed during the initial operation (one-stage approach), electively as part of a two-stage strategy, or omitted altogether. The one-stage approach has been associated with higher morbidity and mortality.[3,4] Most authors agree that it should be reserved for relatively younger patients with fewer comorbidities. Several studies have reported that omission of cholecystectomy and fistula repair is associated with increased risks of cholangitis, gallbladder cancer, and recurrent gallstone ileus.[5-7] However, most of these reports originate from the previous century, when imaging modalities that facilitate early diagnosis and preoperative planning were not as widely available as they are today.

The present study aimed to evaluate our institutional experience with GSI, with a particular focus on diagnostic delays, surgical strategies, and postoperative outcomes. As a secondary objective, we assessed the impact of an accurate diagnosis at initial presentation on time to surgery and overall hospital stay. We hypothesized that relief of bowel obstruction alone, without routine cholecystectomy and fistula repair, does not increase the risk of recurrence or biliary complications.

MATERIALS AND METHODS

The medical records of 13 patients who underwent surgery for GSI between January 2017 and July 2022 in the Department of General Surgery at Kartal Dr. Lütfi Kirdar City Hospital were retrospectively reviewed. Statistical analyses were performed using the Statistical Package for the Social Sciences software (SPSS, version 24.0, IBM Co., Armonk, NY, USA). The normality of quantitative variables was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Variables that were not normally distributed were compared using the Mann–Whitney U test. A p-value <0.05 was considered statistically significant.

The study was approved by the Ethics Committee of Kartal Dr. Lütfi Kirdar City Hospital (Date: 22.02.2022, Decision no: 2022/514/220/19) and was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its subsequent amendments or comparable ethical standards.

RESULTS

Thirteen patients were diagnosed with gallstone ileus. The median age was 67 years (interquartile range [IQR]: 64–82). Eight patients were male and five were female. Five patients (38.4%) had a known history of gallstones before presentation. One patient had a history of acute cholecystitis, while another had a history of acute cholecystitis, acute pancreatitis, and two previous endoscopic retrograde cholangiopancreatography (ERCP) procedures (Table 1).

All 13 patients underwent both plain abdominal radiography (AXR) and abdominal computed tomography (CT) during the initial evaluation. On AXR, 12 patients (92.3%) demonstrated air–fluid levels consistent with small bowel obstruction. The remaining patient, who did not exhibit air–fluid levels, was subsequently found to have a proximal bowel obstruction located just distal to the ligament of Treitz. Pneumobilia was identified in four patients (30.76%), an ectopic gallstone in three (23.07%), and Rigler's triad (pneumobilia, small bowel obstruction, and an ectopic gallstone) in two (15.3%). Air within the gallbladder was observed in seven patients (53.84%). On CT imaging, all patients demonstrated air–fluid levels consistent with bowel obstruction. Seven patients (53.84%) had pneumobilia and Rigler's triad, 12 (92.3%) had air within the gallbladder, and three (23.07%) had a visible biliary-enteric fistula tract (Table 2).

The mean diameter of the obstructing gallstones on CT was 30 mm (range: 21–43mm). Four stones (30.76%) were completely calcified, five (38.46%) had a calcified rim, and four (30.76%) were radiolucent. One patient had a large calcified gallstone remaining in the gallbladder, while another had multiple gallstones within the gallbladder and biliary tree.

Nine of the 13 patients (69.23%) were correctly diagnosed with GSI at hospital admission (Group 1), whereas four patients (30.76%) experienced a delayed diagnosis (Group 2).

Table 1. Patient history, stone, operative findings and diagnosis data

Variable	n=13 (%)
Median age [range]	67 [42–83]
History of cholelithiasis	5 (38.4%)
Biliary emergency history	2 (15.38%)
Cholecystitis	1 (7.6%)
Cholecystitis, pancreatitis and ERCP	1 (7.6%)
Obstructing stone mean diameter (mm)	30 (21–43)
Calcified	4 (30.76%)
Calcified rim	5 (38.4%)
Radiolucent	4 (30.76%)
Type of fistula	
Cholecystoduodenal	13 (100%)
Site of obstruction	
Terminal ileum	8 (61.5%)
Proximal ileum	4 (30.7%)
Proximal jejunum	1 (7.6%)
Admitted with gallstone ileus diagnosis	9 (69.23%)
Delayed diagnosis	4 (30.76%)
Delayed preoperative	3 (23%)
Peroperative diagnosis	1 (7.6%)
Total preoperative diagnosis	12 (92.3%)

Table 2. Radiological signs present in the initial plain abdominal radiographs and CT scans

Radiological sign	Plain abdominal radiograph	CT
Bowel obstruction	92.3%	100%
Pneumobilia	30.76%	53.84%
Ectopic gallstone	23.07%	100%
Rigler's triad	15.38%	53.84%
Air in gallbladder	53.84%	92.3%
Biliary-enteric fistula tract		23.07%

CT: Computed tomography.

Table 4. Type of surgery preferred in gallstone ileus cases

Type of surgery	n (%)
Bowel surgery only	11 (84.6%)
Enterotomy and stone extraction only	7 (53.8%)
Small bowel resection	2 (15.3%)
Manual propulsion	2 (15.3%)
Obstruction and fistula surgery	2 (15.3%)
Enterotomy, stone extraction, cholecystectomy and fistula repair	1 (7.6%)
Enterotomy, stone extraction, cholecystectomy and fistula repair, common bile duct exploration	1 (7.6%)

Table 3. Time to surgery since admission, length of total hospital stay and postoperative stay data

Variable	Total (n=13)	Group 1 (n=9)	Group 2 (n=4)	p
Time to surgery (hours)	12 (3–192)	6 (3–15)	126 (102–192)	0.003
Length of total hospital stay (days)	6.5 (4.5–37.5)	6 (4.5–13.25)	14.5 (10–37.5)	0.011
Postoperative stay (days)	6 (3–32)	6.25 (3–13)	7.5 (6–32)	0.148

Values represent medians, with ranges given in parentheses.

Among the latter, three were initially admitted with a diagnosis of nonspecific small bowel obstruction and one with gastric outlet obstruction. In the delayed-diagnosis group, GSI was identified preoperatively in three patients (23%) and intraoperatively in one patient (7.69%). Overall, 12 patients (93.3%) were diagnosed preoperatively.

The median time from hospital admission to surgery was 6 hours (range: 3–15 hours) in Group 1 and 126 hours (range: 102–192 hours) in Group 2, with an overall median of 12 hours (range: 3–192 hours). The median total hospital stay and postoperative hospital stay were 6.5 days (range: 4.5–13.25 days) and 6.25 days (range: 3–13 days), respectively, in Group 1, compared with 14.5 days (range: 10–37.5 days) and 7.5 days (range: 6–32 days), respectively, in Group 2. Overall, the median total hospital stay was 6.5 days (range: 4.5–37.5 days), and the median postoperative hospital stay was 6 days (range: 3–32 days). Time to surgery and total hospital stay differed significantly between the two groups ($p<0.05$) (Table 3).

All 13 patients had a cholecystoduodenal fistula. The site of obstruction was the terminal ileum in eight patients, the proximal ileum in four patients, and the proximal jejunum in one patient.

Seven patients (53.8%) underwent enterotomy with stone extraction alone; two underwent small bowel resection; two underwent manual fragmentation and propulsion of the stone without enterotomy; one underwent enterotomy with stone extraction, cholecystectomy, and fistula repair; and one underwent enterotomy with stone extraction, cholecystectomy, fistula repair, common bile duct (CBD) exploration, and drainage (Table 4).

One patient who underwent enterotomy and stone extraction died of acute respiratory distress syndrome secondary to coronavirus pneumonia on postoperative day 12. Apart from this case, there was no postoperative mortality. The mean follow-up period was 39.7 months (range: 18–76 months).

None of the patients who did not undergo cholecystectomy during the operation subsequently underwent elective cholecystectomy and fistula repair. Ten patients who did not undergo cholecystectomy and fistula repair had a mean follow-up period of 37.7 months (range: 18–76 months), corresponding to a cumulative follow-up duration of 377 patient-months. During this follow-up period, none of the patients who did not undergo cholecystectomy and fistula repair developed cholecystitis, cholangitis, recurrent gallstone ileus, or gallbladder cancer.

Four patients who did not undergo cholecystectomy and fistula repair underwent abdominal CT scans 6–48 months after surgery for reasons unrelated to biliary disease. These scans were retrospectively compared with the preoperative CT studies. Three of these patients had preoperative pneumobilia, which had resolved in all cases. In one patient, the gallbladder had become atrophic and was no longer visible on CT four years after surgery. In the remaining three patients, the gallbladder had decreased in size. Furthermore, air within the

gallbladder had resolved in two of the three patients whose gallbladders remained visible.

DISCUSSION

Gallstone ileus is a relatively rare cause of bowel obstruction. By 1994, only 1,001 cases had been reported in the literature,[1] and only a limited number of case series have been published since then, rarely including more than 30 patients from a single center.[2] Historically, GSI was reported to account for 1–5% of all intestinal obstructions,[5] whereas more recent studies estimate its incidence at approximately 0.095% of all bowel obstructions.[4] This difference likely reflects changes in diagnostic and therapeutic practices, including the widespread adoption of ultrasonography and laparoscopic cholecystectomy.[8,9]

The diagnosis of GSI is widely regarded as challenging and is frequently delayed.[10,11] Patients typically present 3–8 days after symptom onset.[2,12] Furthermore, surgery is often delayed for an additional 3–4.5 days following hospital admission.[2,10,13] The principal reason for this delay is that, despite the presence of characteristic radiological findings, AXR has limited sensitivity and the findings are often subtle or nonspecific. Although CT has excellent sensitivity and specificity for GSI, not all patients with bowel obstruction undergo CT evaluation.[2,10,14]

In our series, the median time from admission to surgery was considerably shorter than that reported in the literature (12 hours versus 3–4.5 days). We believe that this favorable outcome is attributable to our institutional approach to bowel obstruction, whereby all patients undergo abdominal CT scanning as part of the initial evaluation. We demonstrated that establishing the correct diagnosis during the initial assessment significantly reduced both time to surgery (6 vs. 126 hours, p=0.003) and total hospital stay (6 vs. 14.5 days, p=0.011). Although all patients exhibited CT findings consistent with GSI, the diagnosis was established at admission in only 69.23% of cases, highlighting the potential for further improvements in diagnostic accuracy, time to surgery, and overall hospital stay.

In our series, plain abdominal radiography demonstrated limited diagnostic utility, consistent with previous reports.[10,15,16] Although classic radiological signs were present in some cases, most findings were subtle and became apparent only upon retrospective review and comparison with CT imaging. Air within the gallbladder was observed more frequently in our cohort than previously reported (53% vs. up to 24%); however, this finding was also recognized only retrospectively. Overall, our results suggest that although AXR remains a useful initial imaging modality, it is insufficiently reliable for establishing the diagnosis of GSI.

In contrast, abdominal CT has excellent sensitivity and specificity for the diagnosis of GSI.[17,18] Beyond confirming the diagnosis, CT provides valuable information regarding the site of obstruction and the presence of additional gallstones within the gallbladder, biliary tree, or intestinal tract, thereby facilitating operative planning. In one patient, abdominal identified a second calcified gallstone measuring 22×28 mm within the gallbladder (Fig. 1). To prevent recurrent GSI, cholecystectomy and fistula repair were planned and performed. In another patient, abdominal CT demonstrated multiple gallstones within both the gallbladder and common bile duct, with marked dilation of the common bile duct to 32 mm (Fig. 2). To address choledocholithiasis and reduce the risk of recurrent GSI, cholecystectomy, CBD exploration, and drainage were incorporated into the operative plan. Thus, preoperative CT directly influenced surgical decision-making in these two patients. Routine cholecystectomy and fistula repair were not performed in our series. Instead, a patient-tailored strategy was adopted, with cholecystectomy and fistula repair reserved for patients in whom additional gallstones were identified within the biliary system.

Cholecystectomy and cholecystoenteric fistula repair have been advocated by some authors because of concerns that persistent biliary-enteric fistulas may increase the risk of recurrent gallstone ileus (RGSI), ascending cholangitis, and gallbladder cancer.

Fistula closure during emergency surgery has been associated with higher mortality, increased complication rates, longer hospital stays, and greater hospital costs compared with enterotomy and stone extraction alone.[3,4]

Mir et al.,[19] in a systematic review of 113 patients with RGSI, reported that 85% of recurrences occurred within the first 6 months after the initial operation. Similarly, Alzerwi et al.,[20] in a meta-analysis, found that the median time to recurrence was 20.5 days (range: 8.5–95.5 days) following initial surgery. Recent case reports have demonstrated that recurrent gallstone ileus may occur even within days of the index operation, underscoring the importance of thoroughly evaluating patients for additional stones during the perioperative period.

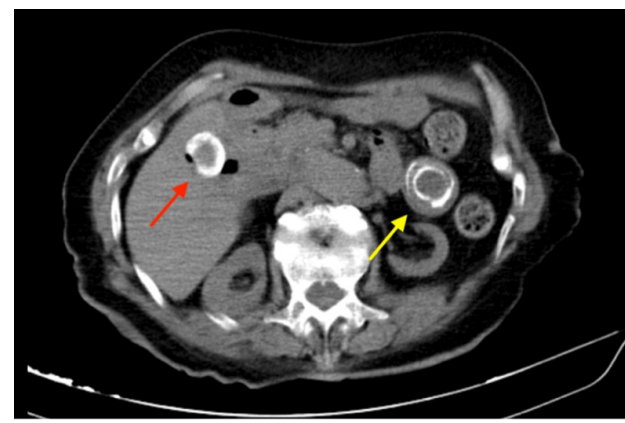

Figure 1. Image of an 82-year-old female patient with gallstone ileus. A second gallstone was identified within the gallbladder (red arrow), prompting cholecystectomy and fistula repair. The obstructing intestinal gallstone is also visible (yellow arrow).

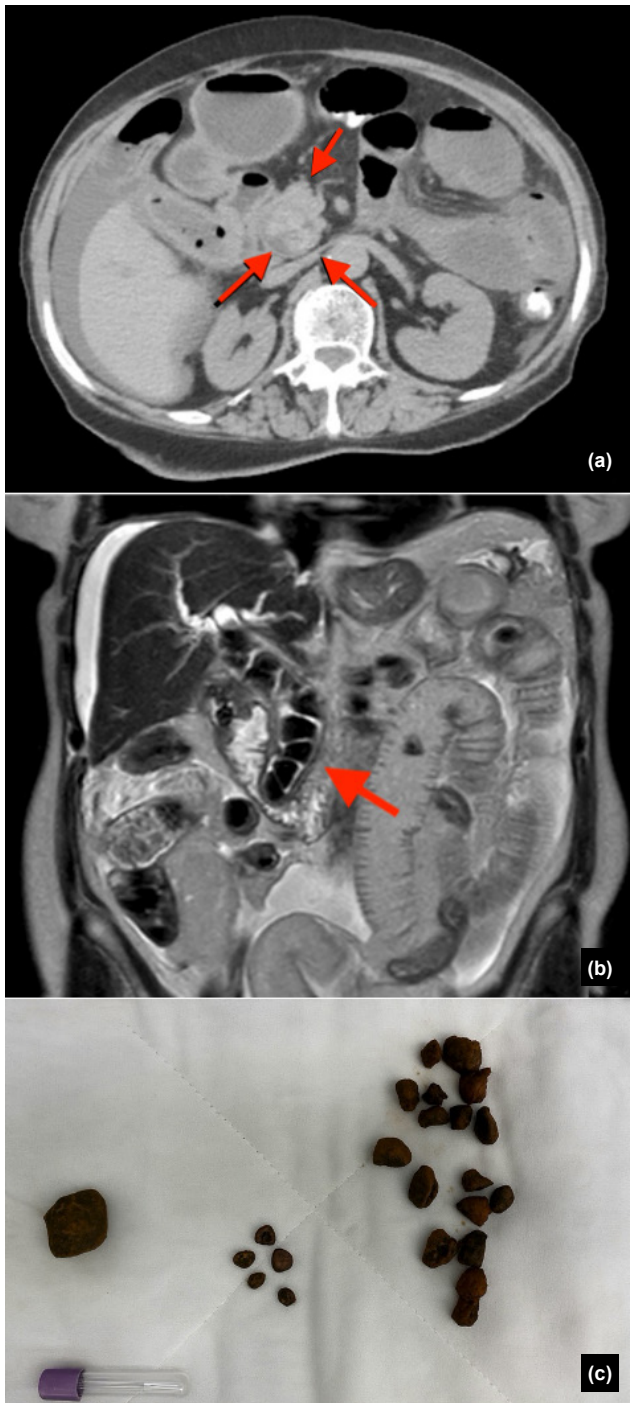

Figure 2. (a-c) Computed tomography **(a)** and magnetic resonance imaging (MRI) **(b)** images of a 67-year-old female patient with gallstone ileus. In addition to the obstructing gallstone within the bowel, multiple gallstones were identified in the common bile duct (CBD) (arrows). Therefore, cholecystectomy, fistula repair, and CBD exploration were performed. Gallstones extracted from the bowel, gallbladder, and CBD, shown from left to right, respectively **(c)**.

[21] These observations suggest that RGSI is more likely the result of missed stones than de novo stone formation, as it is improbable that a new stone measuring at least 2 cm in diameter would form within a few months in a gallbladder that drains freely through a fistula large enough to permit passage of such a stone. Therefore, the risk of recurrence may be minimized by assessing patients for additional stones in both the gallbladder and bowel through preoperative CT imaging and perioperative manual examination of the intestinal tract.

Evidence linking persistent cholecystoduodenal fistulas to cholangitis originates primarily from Wakefield's 1939 study, which reported an 11% incidence of cholangitis in affected patients.[6] Subsequently, Clavien et al.[5] reported in 1990 that one of 23 patients treated with enterotomy and stone extraction alone required rehospitalization for cholangitis. However, contemporary data regarding the incidence of cholangitis after enterotomy and stone extraction alone for GSI are lacking. Furthermore, some episodes of cholangitis may have been attributable to residual gallstones in the gallbladder or CBD, which were more likely to be missed in earlier decades when advanced preoperative imaging was not routinely available. Finally, even when cholangitis occurs, it can often be managed nonoperatively. It should also be noted that cholecystocolonic fistulas, which have been associated with cholangitis rates as high as 60%, represent a distinct clinical entity and should be evaluated separately.[5]

In 1965, Berliner and Burson[22] reported that 15% of 57 patients with gallstone ileus and biliary-enteric fistulas developed gallbladder carcinoma during long-term follow-up. These findings have not been reproduced in subsequent studies, although several case reports have described the development of gallbladder carcinoma in patients who previously underwent enterotomy and stone extraction alone for GSI.[23,24] Conversely, there are also reports of biliary-enteric fistulas caused by underlying malignancies presenting as gallstone ileus.[25,26] Therefore, some cases of GSI associated with malignancy may represent fistulas secondary to cancer rather than malignancies arising as a consequence of a persistent fistula. Furthermore, numerous case series, including our own, have not demonstrated an increased incidence of malignancy following enterotomy and stone extraction alone.[2,10] In our view, the relationship between persistent fistulas and subsequent malignancy remains uncertain.

CONCLUSION

Gallstone ileus is a rare surgical emergency characterized by distinctive but often subtle radiological findings, frequently leading to delayed diagnosis. We believe that routine CT evaluation of patients presenting with bowel obstruction improves the diagnostic accuracy of GSI. Accurate diagnosis at presentation is associated with reduced preoperative delay and shorter hospital stay. Further improvements in diagnostic accuracy may be achieved by refining the evaluation of CT scans performed at presentation.

At present, there is insufficient evidence to support routine cholecystectomy and fistula repair in all patients with GSI.

The association between GSI and malignancy remains unclear, and additional studies are needed to clarify this relationship. Surgical management should be individualized. Cholecystectomy and fistula repair should be considered in patients with additional gallstones identified within the gallbladder.

Ethics Committee Approval: This study was approved by the Kartal Dr. Lütfi Kirdar City Hospital (Date: 22.02.2022, Decision No: 2022/514/220/19).

Informed Consent: Written informed consent was obtained.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: F.F., C.H., T.E.Y., S.K.; Design: F.F., C.H., T.E.Y., S.K.; Supervision: F.F., C.H., T.E.Y., S.K.; Resource: F.F., C.H., T.E.Y., S.K.; Materials: F.F., C.H., T.E.Y., S.K.; Data collection and/or processing: F.F., C.H., T.E.Y.; Analysis and/or interpretation: F.F., S.K.; Literature review: F.F.; Writing: F.F.; Critical review: F.F., S.K.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Reisner RM, Cohen JR. Gallstone ileus: a review of 1001 reported cases. Am Surg 1994;60:441–6.
2. Muthukumarasamy G, Venkata SP, Shaikh IA, Somani BK, Ravindran R. Gallstone ileus: surgical strategies and clinical outcome. J Dig Dis 2008;9:156–61. [CrossRef]
3. Doko M, Zovak M, Kopljar M, Glavan E, Ljubicic N, Hochstädter H. Comparison of surgical treatments of gallstone ileus: preliminary report. World J Surg 2003;27:400–4. [CrossRef]
4. Halabi WJ, Kang CY, Ketana N, Lafaro KJ, Nguyen VQ, Stamos MJ, et al. Surgery for gallstone ileus: a nationwide comparison of trends and outcomes. Ann Surg 2014;259:329–35. [CrossRef]
5. Clavien PA, Richon J, Burgan S, Rohner A. Gallstone ileus. Br J Surg 1990;77:737–42. [CrossRef]
6. Wakefield E, Vickers P, Walters W. Intestinal obstruction caused by gallstones. Surgery 1939;5:670.
7. Bossart PA, Patterson AH, Zintel HA. Carcinoma of the gallbladder. A report of seventy-six cases. Am J Surg 1962;103:366–9. [CrossRef]
8. Csikesz NG, Tseng JF, Shah SA. Trends in surgical management for acute cholecystitis. Surgery 2008;144:283–9. [CrossRef]
9. Shaffer EA. Epidemiology and risk factors for gallstone disease: has the paradigm changed in the 21st century? Curr Gastroenterol Rep 2005;7:132–40. [CrossRef]
10. Vera-Mansilla C, Sanchez-Gollarte A, Matias B, Mendoza-Moreno F, Díez-Alonso M, Garcia-Moreno Nisa F. Surgical Treatment of Gallstone Ileus: Less Is More. Visc Med 2022;38:72–7. [CrossRef]
11. Tan YM, Wong WK, Ooi LL. A comparison of two surgical strategies for the emergency treatment of gallstone ileus. Singapore Med J 2004;45:69–72.
12. Vasilescu AM, Tarcoveanu E, Bradea C, Lupascu C, Stagnitti F. Gallstone Ileus. What therapeutic options are there? Ann Ital Chir 2022;92:300–6.
13. Ayantunde AA, Agrawal A. Gallstone ileus: diagnosis and management. World J Surg 2007;31:1292–7. [CrossRef]
14. Kurtz RJ, Heimann TM, Kurtz AB. Gallstone ileus: a diagnostic problem. Am J Surg 1983;146:314–7. [CrossRef]
15. Yu CY, Lin CC, Shyu RY, Hsieh CB, Wu HS, Tyan YS, et al. Value of CT in the diagnosis and management of gallstone ileus. World J Gastroenterol 2005;11:2142–7. [CrossRef]
16. Fancellu A, Niolu P, Scanu AM, Feo CF, Ginesu GC, Barmina ML. A rare variant of gallstone ileus: Bouveret's syndrome. J Gastrointest Surg 2010;14:753–5. [CrossRef]
17. Abdullah S, Özkaya G, Gündoğdu A, Turgut BC, Ergün S. Surgical management of gallstone ileus: laparoscopic and open approaches in a single-center experience. Medicina 2025;61:2174. [CrossRef]
18. Augustin G, Bruketa T, Kunjko K, Romić I, Mikuš M, Vrbanić A, et al. Colonic gallstone ileus: a systematic literature review with a diagnostic-therapeutic algorithm. Updates Surg 2023;75:1071–82. [CrossRef]
19. Mir SA, Hussain Z, Davey CA, Miller GV, Chintapatla S. Management and outcome of recurrent gallstone ileus: A systematic review. World J Gastrointest Surg 2015;7:152–9. [CrossRef]
20. Alzerwi NAN, Idrees B, Alsareii S, Aldebasi Y, Alsultan A. The regularity of the site of impaction in recurrent gallstone ileus: a systematic review and meta-analysis of reported cases. Can J Gastroenterol Hepatol 2021;2021:5539789. [CrossRef]
21. Samee A, Shete R, Rana S, Samee M, Zubair Y, Samee A. Gall stone ileus and recurrence: management dilemma for the operating surgeon. Cureus 2024;16:e75577. [CrossRef]
22. Berliner SD, Burson LC. One-stage repair for cholecyst-duodenal fistula and gallstone ileus. Arch Surg 1965;90:313–6. [CrossRef]
23. Castro CM, Morales HL, Baeza MS. Gallbladder cancer as incidental finding in two stage resolution of gallstone ileus. Arq Bras Cir Dig 2015;28:219–20. [CrossRef]
24. Sanada T, Baba H, Ohba A, Wakabayashi M, Ebana H, Nakamura H, et al. Gallbladder carcinoma, progressed along cholecystoduodenal fistula--a case report. Gan To Kagaku Ryoho 2010;37:2717–9. [Article in Japanese]
25. Heemskerk J, Nienhuijs SW "Gallstone ileus as first presentation of a gallbladder carcinoma. JGLD 2009;18:251–9.
26. Day EA, Marks C. Gallstone ileus. Review of the literature and presentation of thirty-four new cases. Am J Surg 1975;129:552–8. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Safra taşı ileusu: Tek merkez tecrübemiz

AMAÇ: Safra taşı ileusu yaşlı popülasyonu etkileyen, nadir bir cerrahi acildir. Nadir görülmesi sebebiyle, preoperatif doğru tanı koyulma oranı düşüktür ve tedavisi gecikmeli olmaktadır. Optimum tedavi stratejisi konusunda ise fikir birliği yoktur. Asıl tartışma konusu ise kolesistektomi ve fistül onarımı acil veya elektif mi yapılmalı veya hiç yapılmamalı mı sorularıdır. Kolesistektomi ve fistül onarımının morbidite ve mortaliteyi arttırdığı birçok yazar tarafından gösterilmiştir, yapılmamasının ise nüks safra taşı ileusu, safra kesesi kanseri ve asendan kolanjit ile ilişkili olduğuna dair yayınlar vardır. Ancak bu verilerin neredeyse tamamı önceki yüzyıla ait yayınlardan köken almakta olup güncel verilerle desteklenmemektedir. Bu çalışmanın amacı kliniğimizin safra taşı ileusu tecrübesini paylaşarak, safra taşı ileusu tanısı ve tedavi stratejilerini literatür eşliğinde tartışmaktır.

GEREÇ VE YÖNTEM: Kartal Dr. Lütfi Kirdar Hastanesi, Genel Cerrahi Kliniğinde 2017-2022 yılları arasında safra taşı ileusu sebebiyle ameliyat olmuş 13 hastanın verileri retrospektif olarak incelendi.

BULGULAR: Hastaların %69'u safra taşı ileusu tanısı ile interne edildi, %30.7'si geç tanı aldı. Yatışta doğru tanı alanların median ameliyata alınma süresi 6 saat, median yatış süresi 6.5 gün idi. Geç tanı alanların ise median ameliyata alınma süresi, 126 saat, yatış süresi 14.5 gün idi. Yatışta safra taşı ileusu tanısı koyulmaması preoperatif gecikme ve daha uzun hastanesi yatışı ile ilişkilendirildi ($p<0.05$). Retrospektif olarak incelendiğinde tüm hastaların, yatışta, birden fazla safra taşı ileusu radyolojik bulgusu olduğu görüldü. 11 hasta sadece barsak obstrüksiyonuna yönelik opere edildi, iki hastada safra kesesi veya koledokta taş izlenmesi sebebiyle kolesistektomi ve fistül onarımı da yapıldı. Ortalama 39.7 aylık takip süresince, 11 hastada kolesistoenterik fistül onarımı yapılmamasına rağmen, hiçbir hastada nüks, safra kesesi kanseri veya kolanjit izlenmedi.

SONUÇ: Safra taşı ileusu, nadir olması sebebiyle tanı ve tedavisinde gecikme olan bir hastalıktır. İlk değerlendirmede doğru tanı, preoperatif gecikme ve hastane yatışını kısaltmaktadır. Rutin kolesistoenterik fistül onarımını savunan çalışmaların sonuçları tartışmalı olup cerrahi yaklaşımda hasta bazlı karar vermek gerekme gerekir. Safra kesesinde bakiye safra taşı bulunan safra taşı ileusu hastalarında, kolesistektomi ve filstül onarımı da düşünülmelidir. Optimum tedavi stratejisinin oluşturulabilmesi için daha çok tecrübe paylaşımı ve ileri çalışmalar gerekmektedir.

Anahtar sözcükler: Barsak obstrüksiyonu; fistül onarımı; kolesistoenterik fistül; safra taşı ileusu.

Ulus Travma Acil Cerrahi Derg 2026;32(8):947-953 DOI: 10.14744/tjtes.2026.24485

ORIGINAL ARTICLE

Violence against the elderly: a retrospective analysis from a forensic medicine perspective

Çağdaş Savaş,[1] Nazlıcan Aras,[2] Mehmet Hakan Özdemir[3]

[1]Council of Forensic Medicine, Izmir Forensic Medicine Group Presidency, İzmir-*Türkiye*
[2]Council of Forensic Medicine 3rd Specialization Board, İstanbul-*Türkiye*
[3]Department of Forensic Medicine, Dokuz Eylul University Faculty of Medicine, İzmir-*Türkiye*

ABSTRACT

BACKGROUND: In many contemporary studies, individuals aged 65 years and older are defined as older adults. Owing to population aging, the number of older adults worldwide is steadily increasing. Age-related physical and cognitive decline, together with social changes, may increase vulnerability to violence in this population. This study aimed to present and discuss data on older adults aged 65 years and over who were victims of violence and underwent medicolegal evaluation, to draw attention to measures that may help prevent violence against older adults, and to propose potential strategies for prevention and intervention.

METHODS: A total of 275 case files and forensic reports pertaining to individuals aged 65 years and older who underwent medicolegal assessment at the Department of Forensic Medicine, Dokuz Eylul University Faculty of Medicine, between January 1, 2016 and January 1, 2025, were retrospectively reviewed. Sociodemographic characteristics, location of the violent incident, perpetrator characteristics, type of violence, injury site, wound type, presence of a psychiatric diagnosis related to the incident, type of psychiatric diagnosis, and the forensic medical severity of injuries were evaluated. Statistical analyses were performed using IBM SPSS version 29.0.

RESULTS: Among the 275 cases of violence, 97 (35.3%) involved women and 178 (64.7%) involved men. The mean age was 71.53±6.2 years. The most common perpetrators were unknown or unrelated individuals (n=105, 38.2%), followed by friends or neighbors (n=90, 32.7%). Violence most frequently occurred in the home or its immediate surroundings (n=143, 52%), followed by streets, parks, and other public outdoor areas (n=69, 25.1%). Domestic violence accounted for 21.5% of cases. Neglect was identified in 19 cases (6.9%). Isolated physical violence was the most common form of violence (n=238, 86.5%). The injuries were life-threatening in 21 cases (7.6%), while bone fractures were documented in 78 cases (28.4%).

CONCLUSION: Specific legal regulations should be implemented to better protect older adults and support their participation in social life. Additionally, comprehensive strategies should be developed to address violence against older adults both within and outside the family setting. A multilevel, integrated approach is needed to improve prevention and intervention efforts through the identification of individuals at risk of perpetrating or experiencing violence.

Keywords: Domestic violence; elder abuse; forensic medicine; home and surroundings; unknown/unrelated individuals; violence against older adults.

INTRODUCTION

In many developed countries, individuals aged 65 years and older are generally classified as older adults. Old age is commonly divided into three stages: early old age (65–74 years), middle old age (75–84 years), and advanced old age (≥85 years).[1-3]

Declining fertility rates and increasing life expectancy have led to a rapid rise in the global older adult population. The

Cite this article as: Savaş Ç, Aras N, Özdemir MH. Violence against the elderly: a retrospective analysis from a forensic medicine perspective. Ulus Travma Acil Cerrahi Derg 2026;32:954-961.

Address for correspondence: Çağdaş Savaş
Council of Forensic Medicine, Izmir Forensic Medicine Group Presidency, İzmir, Türkiye
E-mail: cagsavas@gmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):954-961 DOI: 10.14744/tjtes.2026.24452
Submitted: 18.10.2025 Revised: 31.12.2025 Accepted: 18.02.2026 Published: 10.08.2026

worldwide population aged 65 years and older was estimated to increase from approximately 550 million in 2000 to 973 million by 2030. Similarly, the number of individuals aged 80 years and older, estimated at approximately 9.3 million in 2000, is expected to reach 19.5 million by 2030. According to United Nations projections, the proportion of older adults in the global population is expected to increase from 10% to 17% between 2021 and 2050.[3,4] According to data from the Turkish Statistical Institute (TURKSTAT), the number of older adults in Türkiye reached 8,722,806 in 2023, and the proportion of individuals aged 65 years and older increased from 7.1% in 2007 to 10.6% in 2024. Population projections indicate that this proportion will rise to 13.5% in 2030, 17.9% in 2040, 27% in 2060, 33.4% in 2080, and 33.6% in 2100.[5,6]

Aging is associated with various physiological and functional changes, including slower cognitive processing, impaired attention and perception, declines in sensory functions such as hearing and vision, reduced muscle strength, and delayed reflex responses. In addition to these age-related changes, socioeconomic challenges and social transformations may increase vulnerability to violence among older adults. Insufficient social support further exacerbates this vulnerability and may contribute to the occurrence of violence against older individuals.[7-16]

Available evidence indicates that violence against older adults is increasing both globally and in Türkiye.[14-17] Consequently, violence against older adults remains an important public health concern. Therefore, the dissemination of current data on this issue may contribute to raising awareness and informing the development of evidence-based strategies and interventions aimed at its prevention and management.

This study aimed to present and discuss data on individuals aged 65 years and older who were victims of violence and underwent forensic evaluation, to highlight measures that may help prevent violence against older adults, and to propose potential solutions for addressing this problem.

MATERIALS AND METHODS

This study examined the sociodemographic characteristics of individuals aged 65 years and older who were victims of violence and underwent medicolegal evaluation at the Department of Forensic Medicine, Dokuz Eylul University Faculty of Medicine. The variables evaluated included the location where the violent incident occurred, perpetrator characteristics, type of violence, injury site, wound type, presence of a psychiatric diagnosis related to the incident, psychiatric diagnoses established, and the forensic medical severity of the injuries. For this purpose, a total of 275 case files and forensic reports belonging to individuals aged 65 years and older who were subjected to violence and underwent medicolegal assessment between January 1, 2016 and January 1, 2025, were retrospectively reviewed. This study was approved by the Dokuz Eylul University Faculty of Medicine Ethics Committee (Date: 12.03.2025, Decision No: 2025/09-18) and was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical Analysis

Statistical analyses were performed using IBM SPSS version 29.0 (IBM; International Business Machines, New York, USA). Continuous variables were summarized as mean ± standard deviation, whereas categorical variables were expressed as percentages. Associations between categorical variables were analyzed using Pearson's chi-square test or the Fisher–Freeman–Halton exact test. A p value <0.05 was considered statistically significant.

RESULTS

Among the 275 cases of violence included in the study, 97 (35.3%) involved women and 178 (64.7%) involved men. The mean age of the victims was 71.53±6.2 years (range, 65–90). According to age-group analysis, 202 cases (73.5%) were aged 65–74 years, 61 (22.2%) were aged 75–84 years, and 12 (4.4%) were aged 85 years and older (Fig. 1).

The most common perpetrators of violence were unknown or unrelated individuals (n=105, 38.2%), followed by friends or neighbors (n=90, 32.7%) (Table 1). Among all perpetrators, 232 (84.4%) were male and 43 (15.6%) were female. Violence was perpetrated by a single individual in 240 cases (87.3%) and by multiple individuals in 35 cases (12.7%).

The most common location where violence occurred was the home and its immediate surroundings (n=143, 52%), followed by streets, parks, and other open public areas (n=69, 25.1%). In addition, 22 cases (8%) occurred in traffic-related settings, whereas 12 cases (4.4%) occurred in nursing homes. Among incidents occurring in the home and surrounding environment, the perpetrator was most frequently a friend or neighbor (n=59, 41.3%), followed by a child (n=29, 20.3%), another relative (n=21, 14.7%), and a spouse (n=17, 11.9%). Nearly half of the incidents involving unknown or unrelated perpetrators (n = 51, 48.6%) occurred in open public areas, whereas 21 cases (20%) occurred in traffic-related settings (Table 1).

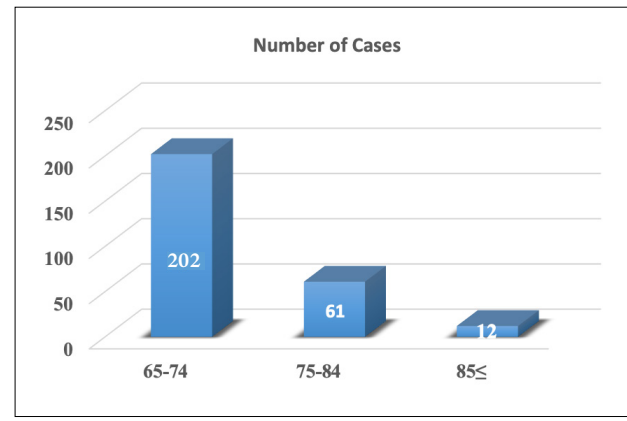

Figure 1. Distribution of cases according to age group.

Table 1. Distribution of perpetrators of violence according to location of the incident

Perpetrator	Home and surroundings	Nursing home	Traffic	Open area	Workplace and surroundings	Other	Total
Spouse	17 (11.9%)	-	-	1 (1.4%)	-	-	18 (6.5%)
Child	29 (20.3%)	-	-	-	-	-	29 (10.5%)
Other relative	21 (14.7%)	-	-	3 (4.3%)	-	1 (9.1%)	25 (9.1%)
Friend/neighbor	59 (41.3%)	5 (41.7%)	1 (4.5%)	13 (18.8%)	8 (44.4%)	4 (36.4%)	90 (32.7%)
Caregiver	1 (0.7%)	6 (50%)	-	-	-	-	7 (2.5%)
Unknown/unrelated person	16 (11.2%)	1 (8.3%)	21 (95.5%)	51 (73.9%)	10 (55.6%)	6 (54.5%)	105 (38.2%)
Other	-	-	-	1 (1.4%)	-	-	1 (0.4%)
Total	143 (100%)	12 (100%)	22 (100%)	69 (100%)	18 (100%)	11 (100%)	275 (100%)

*Percentages are calculated within each column.

Table 2. Distribution of domestic violence according to type of violence

Domestic violence status	Physical	Physical/ sexual	Physical/ psychological	Physical/ economic	Physical/ economic/ psychological	Total
Absent	210 (97.2%)	2 (0.9%)	4 (1.9%)	-	-	216 (100%)
Present	28 (47.5%)	1 (1.7%)	15 (25.4%)	5 (8.5%)	10 (16.9%)	59 (100%)
Total	238 (100%)	3 (100%)	19 (100%)	5 (100%)	10 (100%)	275 (100%)

*Percentages are calculated within each row.

Domestic violence was identified in 59 cases (21.5%), whereas 216 cases (78.5%) did not involve domestic violence. Elder neglect was not identified in the majority of cases (n=256, 93.1%). Neglect was documented in only 19 cases (6.9%).

The most common form of violence was isolated physical violence (n=238, 86.5%), followed by combined physical and psychological violence (n=19, 6.9%). Among the three cases involving sexual violence, one involved anal penetration and two involved unwanted touching. With regard to the mechanism of injury, blunt-force trauma was the most common cause (n=251, 91.3%), followed by injuries caused by sharp or penetrating objects (n=15, 5.5%), and firearm-related injuries (n=9, 3.3%).

Among cases of domestic violence, isolated physical violence was the most common form (n=28, 47.5%), followed by combined physical and psychological violence (n=15, 25.4%), and combined physical, economic, and psychological violence (n=10, 16.9%) (Table 2).

Most victims were injured by kicks, punches, or similar forms of physical assault (n = 204, 74.2%), whereas 24 cases (8.7%) involved objects such as sticks or iron rods. Injuries most commonly involved the head, neck, and face region (n=114, 41.5%), followed by injuries affecting multiple body regions (n=70, 25.5%). Upper-extremity injuries were observed in 52 cases (18.9%). Regarding wound characteristics, ecchymosis and edema were the most common findings (n=118, 42.9%), followed by multiple wound types (n=82, 29.8%). Bone fractures were not identified in the majority of cases (n=197, 71.6%). No medical treatment was required in 115 cases (41.8%), whereas wound care or other medical treatment was provided in 75 cases (27.3%). A summary of the characteristics of elder abuse cases is presented in Table 3.

Psychiatric evaluation following exposure to violence was not performed in most cases (n=247, 89.8%). Among the 28 cases that underwent psychiatric assessment, 20 (7.3%) received a psychiatric diagnosis and eight (2.9%) did not. The most common psychiatric diagnoses were post-traumatic stress disorder (n=9, 45%), adjustment disorder (n=7, 35%), and acute stress disorder (n=4, 20%) (Table 4).

Among the 20 individuals diagnosed with a psychiatric disorder following violence exposure, 10 (50.0%) were male and 10 (50.0%) were female. No statistically significant association was found between victim sex and the presence of a psychiatric diagnosis following exposure to violence (p=0.227).

From a forensic medical perspective, injuries in 151 cases (54.9%) were considered manageable with simple medical

Table 3. Summary of violence-related characteristics among older adult victims

Instrument used in the assault	
Blunt object (stick, iron bar, etc.)	n=24, 8.7%
Sharp object (knife, glass, etc.)	n=17, 6.2%
Firearm	n=9, 3.3%
Other	n=21, 7.6%
No instrument used	n=204, 74.2%
Injury site	
Head, neck, and face	n=114, 41.5%
Abdomen, chest, and back	n=29, 10.5%
Upper extremity	n=52, 18.9%
Lower extremity	n=10, 3.6%
Multiple body regions	n=70, 25.5%
Wound type	
Ecchymosis/edema	n=118, 42.9%
Abrasion	n=33, 12%
Laceration/incision	n=23, 8.4%
Sharp penetrating injury	n=8, 2.9%
Gunshot wound	n=7, 2.5%
Multiple wound types	n=82, 29.8%
Other	n=4, 1.5%
Bone fracture	
Present	n=78, 28.4%
Absent	n=197, 71.6%
Treatment administered	
Medical treatment/wound dressing	n=75, 27.3%
Minimal intervention	n=47, 17.1%
Surgical treatment	n=27, 9.8%
Other	n=11, 4%
No treatment required	n=115, 41.8%

Table 4. Psychiatric and forensic medical findings among older adult victims of violence

Psychiatric evaluation	
Psychiatric diagnosis established	n=20, 7.3%
No psychiatric diagnosis established	n=8, 2.9%
Not evaluated	n=247, 89.8%
Psychiatric diagnosis	
Post-traumatic stress disorder	n=9, 45%
Adjustment disorder	n=7, 35%
Acute stress disorder	n=4, 20%
Forensic medical assessment	
Injury manageable with simple medical intervention	n=151, 54.9%
Injury not manageable with simple medical intervention	n=124, 45.1%
Life-threatening condition	
Present	n=21, 7.6%
Absent	n=254, 92.4%

intervention, whereas injuries in 124 cases (45.1%) were considered not manageable with simple medical intervention. The injuries were life-threatening in 21 cases (7.6%) and non-life-threatening in 254 cases (92.4%) (Table 4).

Among the 232 cases involving male perpetrators, 115 (49.6%) resulted in injuries that were not manageable with simple medical intervention. In contrast, among the 43 cases involving female perpetrators, 34 (79.1%) resulted in injuries that were manageable with simple medical intervention. A statistically significant association was identified between perpetrator sex and injury severity as assessed by the need for simple medical intervention ($p<0.05$).

DISCUSSION

Preventing violence against older adults is essential not only for protecting individual health and well-being but also for promoting a healthy social structure. Available data indicate that violence against older adults is increasing in parallel with the growing proportion of the older adult population. Although growing awareness of the issue has led to an increase in the number of studies conducted in this field, the available literature remains limited. Therefore, the dissemination and discussion of data from different institutions and regions are crucial for raising awareness and developing effective prevention and intervention strategies.

In the present study, men constituted the majority of victims of violence (n=178, 64.7%). In this regard, our findings are consistent with previous studies reporting that exposure to violence is more common among men.[1,18,19] This pattern may be explained by men's greater participation in occupational and social activities, as well as gender-related behavioral differences. However, some studies have reported that women are more frequently victims of violence in older age groups.[20-22]

Most victims in our study were aged 65–74 years (n=202, 73.5%), corresponding to the early stage of old age. This finding is consistent with previous studies demonstrating that violence is more frequently reported among individuals in the younger segment of the older adult population.[18,23,24]

Violence against older adults may be perpetrated by both strangers and individuals known to the victim. Previous studies have indicated that approximately half of all victims experience abuse perpetrated by family members or acquaintances.[25,26] Santos et al.[24] reported that spouses or partners were

the most common perpetrators, followed by children and grandchildren. Similarly, Paiva and Tavares found that partners (29.1%) and caregivers (25%) were the most common perpetrators of violence against older adults.[27] In contrast, the most common perpetrators in our study were unknown or unrelated individuals (38.2%), followed by friends and neighbors (32.7%).

Regarding perpetrator sex, 84.4% were male and 15.6% were female. This finding is in agreement with previous studies reporting similar results.[21,22,28]

Violence against older adults may occur in a variety of settings, including nursing homes, and assisted living facilities; however, previous studies have reported that most incidents occur in the home environment.[29] Consistent with these findings, the most common location of violence in our study was the home and its immediate surroundings (n=143, 52%), followed by streets, parks, and other public outdoor areas (n=69, 25.1%). Sivarajasingam et al.[30] reported that most older adults presenting to emergency departments after violent incidents had been assaulted in their homes.Likewise, a report from the Canadian Centre for Justice and Public Safety Statistics indicated that 71% of older adults who experienced violence were victimized in residential settings, including private residences (83%) and shared accommodations such as nursing homes or care facilities (15%).[31]

The same report noted that violence occurring in shared residential settings was most frequently perpetrated by acquaintances (40%), neighbors (19%), strangers (11%), roommates (9%), or authority figures (7%).[31] In the present study, friends or neighbors were the most common perpetrators of violence occurring in the home environment (41.3%), followed by children (20.3%). Nearly half of the incidents involving unknown or unrelated perpetrators occurred in public outdoor areas (48.6%), whereas one-fifth occurred in traffic-related settings (20%).

Violence against older adults may take many forms, including physical, psychological, sexual, and economic abuse. In addition, neglect refers to the failure to meet an older adult's basic needs, such as adequate nutrition, shelter, personal care, or medical treatment. Previous studies have reported substantial variation in the prevalence and types of violence experienced by older adults.

In a study of 729 cases, Paiva and Tavares reported that psychological violence was the most common form of abuse (20.9%), followed by physical violence.[27] In a study conducted in the United States involving 5,777 older adults, 11.4% of participants reported experiencing violence, including psychological violence (4.6%) and physical violence (1.6%).[25] Other studies have similarly reported that psychological violence is the most prevalent form of abuse among older adults, with rates ranging from 11.6% to 33.4%.[32,33] In contrast, another large-scale study conducted across 524 cities found that 67.7% of older adults who experienced violence were victims of physical violence, whereas 29.1% were victims of psychological violence.[34] Santos et al.[24] reported that physical violence was the most common form of abuse among older adults (84.7%), followed by psychological violence manifested as verbal aggression, insults, and humiliation (62%).Likewise, according to the Canadian Centre for Justice and Public Safety Statistics, physical force was used in more than half (60%) of police-reported cases of violence against older adults, and weapons were involved in 19% of these incidents.[31] Consistent with these findings, isolated physical violence was the most common form of violence observed in our study (86.5%), followed by combined physical and psychological violence (6.9%). Among physical assaults, blunt-force trauma was the predominant injury mechanism (91.3%), followed by injuries caused by sharp or penetrating objects (5.5%) and firearm-related injuries (3.3%).

In our study, 21.5% of cases (n=59) were classified as domestic violence. Among these cases, isolated physical violence was the most common form of abuse (47.5%), followed by combined physical and psychological violence (25.4%). Barros et al.[35] reported a domestic violence prevalence of 78.7% among 169 older adults receiving primary healthcare services. Duque et al.[36] and Aleissa et al.[37] reported corresponding rates of 20.8% and 54.7%, respectively. Frazão et al.[22] found that isolated physical violence was the most common form of domestic violence among older adults with disabilities (86%). Barros et al.[35] reported that 21.5% of older adults exposed to domestic violence experienced psychological abuse, whereas 3% experienced physical abuse. Similarly, Apratto Júnior reported prevalence rates of 10% for physical violence and 43.2% for psychological violence among older adults exposed to domestic violence.[38]

Neglect was identified in 19 cases (6.9%) in our series. prevalence was lower than those reported in previous studies, in which rates of elder neglect ranged from 13.8% to 58.5%.[35,37,39]

Among the 28 individuals who underwent psychiatric evaluation following exposure to violence, 20 (7.3%) received a psychiatric diagnosis, whereas eight (2.9%) did not. The most common diagnosis was post-traumatic stress disorder (45%), followed by adjustment disorder (35%). Choi et al.[40] reported that post-traumatic stress disorder was identified in 62.2% of individuals exposed to violence. Similarly, Fadeeva et al.,[41] in a study examining the relationship between violence against older adults and mental health in the United Kingdom, reported that 26.4% of victims had common mental disorders, including anxiety and depressive disorders.

In our study, psychiatric diagnoses following exposure to violence were equally distributed between men and women, with each sex accounting for 50% of diagnosed cases. No statistically significant association was found between victim sex and the presence of a psychiatric diagnosis following exposure to violence (p=0.227).

De Sousa et al.[42] reported that, among elderly victims of physical violence evaluated at a forensic medicine unit in Brazil, 56.7% sustained injuries without the use of a weapon or instrument, and 42.9% of injuries involved the jaw and facial region. Similarly, Yıldız reported that 54.5% of older victims sustained injuries without the use of any instrument and that the head and neck region was the most frequently injured anatomical site (55.8%).[43] Consistent with these findings, our study showed that 74.2% of victims sustained injuries without the use of a weapon, most commonly as a result of kicking or punching, and that the head, neck, and face region was the most frequently affected anatomical site (41.5%).

Karbeyaz and Çelikel reported that 68.4% of injuries among older victims of violence were manageable with simple medical intervention.[44] de Sousa et al.[42] found that 90.1% of injuries were limited to soft-tissue damage. Similarly, Yıldız reported that most injuries (71.2%) were manageable with simple medical intervention, whereas 28.8% resulted in serious outcomes such as life-threatening conditions, permanent disability, loss of function, or permanent facial scarring.[43] In our study, 54.9% of injuries were considered manageable with simple medical intervention, and the vast majority (92.4%) were not life-threatening. Among incidents perpetrated by men, 49.6% resulted in injuries that were not manageable with simple medical intervention, whereas 79.1% of incidents perpetrated by women resulted in injuries that were manageable with simple medical intervention. A statistically significant association was identified between perpetrator sex and injury severity, as assessed by the need for simple medical intervention ($p<0.05$).

CONCLUSION

This study demonstrated that older adults are most frequently subjected to isolated physical violence perpetrated by unknown or unrelated individuals and by friends or neighbors. These incidents most commonly occur in the home and its immediate surroundings, as well as in public areas such as streets and parks. Although domestic violence accounted for 21.5% of all cases, this proportion remains substantial and should not be overlooked. Furthermore, injuries resulting from violence perpetrated by men were significantly more severe than those resulting from violence perpetrated by women. In light of these findings, legal measures aimed at protecting older adults should be strengthened to promote their safety and active participation in society. In addition, aggravating legal provisions should be considered for offenses involving violence against older adults. Because violence against older adults occurs in diverse forms and contexts, a single, generalized approach is unlikely to address the complexity of the problem. Therefore, tailored strategies should be developed to prevent and combat violence against older adults both within and outside the family setting. A coordinated, multilevel approach is needed to improve prevention and intervention strategies by identifying individuals at risk of either perpetrating or being subjected to violence.

Ethics Committee Approval: This study was approved by the Dokuz Eylul University Faculty of Medicine Ethics Committee (Date: 12.03.2025, Decision No: 2025/09-18).

Informed Consent: Retrospective study

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: Ç.S., N.A., M.H.Ö.; Design: Ç.S., M.H.Ö.; Supervision: M.H.Ö., Ç.S.; Resource: N.A., Ç.S.; Materials: Ç.S., N.A., M.H.Ö.; Data collection and/or processing: Ç.S., M.H.Ö., N.A.; Analysis and/or interpretation: Ç.S., M.H.Ö.; Literature review: Ç.S., N.A., M.H.Ö.; Writing: Ç.S., N.A., M.H.Ö.; Critical review: M.H.Ö., Ç.S.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Güler H, Kaya A, Şenol E, Belpınar MS, Aktaş EÖ. 65 yaş ve üzeri olgular için düzenlenen adli raporların retrospektif incelenmesi. EJM 2020;59:196–201. [CrossRef]
2. Sabharwal S, Wilson H, Reilly P, Gupte CM. Heterogeneity of the definition of elderly age in current orthopaedic research. Springerplus 2015;4:516. [CrossRef]
3. World Health Organization. International day of older persons 2024: "Ageing with Dignity: The Importance of Strengthening Care and Support Systems for Older Persons Worldwide". Available at: https://www.who.int/srilanka/news/detail/01-10-2024-ageing-with-dignity--the-importance-of-strengthening-care-and-support-systems-for-older-persons-worldwide. Accessed July 07, 2025.
4. Hunsaker JC III, Shields LBE. Violence against the elderly. In: Madea B, editor. Handbook of forensic medicine. 2nd ed. Hoboken (NJ): John Wiley & Sons; 2022. p. 1005–20. [CrossRef]
5. Türkiye İstatistik Kurumu. İstatistiklerle Yaşlılar, 2023. Available at: https://data.tuik.gov.tr/Bulten/Index?p=Istatistiklerle-Yaslilar-2023-53710#:~:text=TÜİK%20Kurumsal&text=Yaşlı%20nüfus%20olarak%20kabul%20edilen,10%2C2'ye%20yükseldi. Accessed July 07, 2025.
6. Türkiye İstatistik Kurumu. İstatistiklerle Yaşlılar, 2024. Available at: https://data.tuik.gov.tr/Bulten/Index?p=Istatistiklerle-Yaslilar-2024-54079. Accessed July 07, 2025.
7. Kandiş H, Karakuş A, Katırcı Y, Karapolat S, Kara İH. Geriatrik yaş grubu ve adli travmalar. Turkish Journal of Geriatrics 2011;14:193–8. [Article in Turkish]
8. Gündüz T, Karbeyaz K, Yüksel F, Balcı Y. Yeni Türk Ceza Kanunu çerçevesinde geriatrik olgulara düzenlenen adli raporların değerlendirilmesi. Turkish Journal of Geriatrics 2010;13(1):8-12. [Article in Turkish]
9. Gamsız Bilgin N, Mert E. Geriatrik yaş grubu adli olguların özellikleri. Türk Geriatri Dergisi 2005;8:13–6. [Article in Turkish]
10. Aktürk A, Avci A, Gülen M, Ay MO, İçme F, Satar S. Acil anabilim dalına travma sonrası kabul edilen geriatrik hastaların ileriye dönük analizi. Cukurova Med J 2013;38:687–95.
11. Jacobs DG. Special considerations in geriatric injury. Curr Opin Crit Care 2003;9:535–9. [CrossRef]
12. Akköse Aydın Ş, Bulut M, Fedakar R, Özgürer A, Özdemir F. Bursa'daki travmalı yaşlı hastalar. Ulus Travma Acil Cerrahi Derg 2006;12:230–4. [Article in Turkish]
13. Şen Tanrıkulu C, Tanrıkulu Y. Geriatrik popülasyonda travma analizi: Kesitsel çalışma. Yeni Tıp Dergisi 2013;30:100–4.

14. Kıssal A, Beşer A. Yaşlı istismar ve ihmalinin değerlendirilmesi. TAF Prev Med Bull 2009;8:357–64. [Article in Turkish]
15. Koştu N. Yaşlı istismarı ve ihmalinin önlenmesinde halk sağlığı hemşiresinin rolü. Özveri Dergisi 2005;2:527–34. [Article in Turkish]
16. Uysal A. Dünyada yaygın bir sorun: Yaşlı istismarı ve ihmali. Aile ve Toplum Eğitim Kültür ve Araştırma Dergisi 2002;5:43–9. [Article in Turkish]
17. McGann E, Moynihan BA. Elder abuse. In: Lynch VA, editor. Forensic nursing. 6th ed. New York (NY): Elsevier Mosby; 2006. p. 271–277.
18. Subedi J, Yadav DK, Pokharel PK, Uprety S, Yadav BK, K C A, et al. Abuse and its associated factors among elderly population of Kamalamai Municipality of Sindhuli District, Nepal. PLoS One 2025;20:e0316078.
19. Aliustaoğlu S, Yazıcı Y, İnce N, İnce H, All. A. İstanbul'da adli tip bakişi ile yaşli ölümleri ve özellikleri. İst Tıp Fak Derg 2011;70:34–8.
20. Şahin H, erkal S, Demirel B. Yazılı basında aile içi şiddet mağduru yaşlılar. Journal of International Social Research 2017;10:635–40. [CrossRef]
21. Joosten M, Vrantsidis F. Understanding elder abuse: a scoping study. Melbourne: University of Melbourne and National Ageing Research Institute; 2017.
22. Frazão SL, Silva MS, Norton P, Magalhães T. Domestic violence against elderly with disability. J Forensic Leg Med 2014;28:19–24. [CrossRef]
23. Kalaycı I, Yazıcı SÖ, Özkul M, Küpeli A. Perceptıons of the elderly on elderly abuse. Turkish Journal of Geriatrics 2016;19:232–7.
24. Santos AJ, Nunes B, Kislaya I, Gil AP, Ribeiro O. Elder abuse victimization patterns: latent class analysis using perpetrators and abusive behaviours. BMC Geriatr 2019;19:117. [CrossRef]
25. Acierno R, Hernandez MA, Amstadter AB, Resnick HS, Steve K, Muzzy W, et al. Prevalence and correlates of emotional, physical, sexual, and financial abuse and potential neglect in the United States: the National Elder Mistreatment Study. Am J Public Health 2010;100:292–7. [CrossRef]
26. Rosen T, Makaroun LK, Conwell Y, Betz M. Violence in older adults: scope, impact, challenges, and strategies for prevention. Health Aff (Millwood) 2019;38:1630–7. [CrossRef]
27. de Paiva MM, Tavares DM. Physical and psychological violence against the elderly: prevalence and associated factors. Rev Bras Enferm 2015;68:1035–41. [CrossRef]
28. Biermann T, Dippel O, Bergner M, Keller J, Coffey C, Sperling W, et al. Assaults in the elderly--a population-based study with victim and perpetrator characteristics. J Forensic Sci 2011;56:669–73. [CrossRef]
29. Rape, Abuse & Incest National Network (RAINN). Elder Abuse. Available at: https://rainn.org/articles/elder-abuse. Accessed August 10, 2025.
30. Sivarajasingam V, Shepherd J, Matthews K, Jones S. Trends in violence in England and Wales 1995-2000: an accident and emergency perspective. J Public Health Med 2002;24:219–26. [CrossRef]
31. Canadian Centre for Justice and Public Safety Statistics. Violence against seniors and their perceptions of safety in Canada. Available at: https://www150.statcan.gc.ca/n1/en/pub/85-002-x/2022001/article/00011-eng.pdf?st=MRb5bnkv. Accessed August 10, 2025.
32. Yon Y, Mikton CR, Gassoumis ZD, Wilber KH. Elder abuse prevalence in community settings: a systematic review and meta-analysis. Lancet Glob Health 2017;5:e147–56. [CrossRef]
33. Yon Y, Ramiro-Gonzalez M, Mikton CR, Huber M, Sethi D. The prevalence of elder abuse in institutional settings: a systematic review and meta-analysis. Eur J Public Health 2019;29:58–67. [CrossRef]
34. Mascarenhas MD, Andrade SS, das Neves AC, Pedrosa AA, da Silva MM, Malta Dde C. Violência contra a pessoa idosa: análise das notificações realizadas no setor saúde - Brasil, 2010 [Violence against the elderly: analysis of the reports made in the health sector--Brazil, 2010]. Cien Saude Colet 2012;17:2331–41. [Article in Portuguese] [CrossRef]
35. Barros RLDM, Leal MCC, Marques APDO, Lins MEM. Domestic violence against elderly people assisted in primary care. Saúde em Debate 2019;43:793–804. [Article in Portuguese]
36. Duque AM, Leal MC, Marques AP, Eskinazi FM, Duque AM. Violência contra idosos no ambiente doméstico: prevalência e fatores associados (Recife/PE) [Violence against the elderly in the home environment: prevalence and associated factors (Recife, State of Pernambuco)]. Cien Saude Colet 2012;17:2199–208. [Article in Portuguese] [CrossRef]
37. Aleissa M, Abusaris R, Alaqeel M, Mylani R, Balubaid HH, Alnjeidi Z, et al. Determining patterns and types of violence against the elderly in the Kingdom of Saudi Arabia. J Elder Abuse Negl 2024;36:251–64. [CrossRef]
38. Apratto Júnior PC. A violência doméstica contra idosos nas áreas de abrangência do Programa Saúde da Família de Niterói (RJ, Brasil) [The domestic violence against the elderly within the Family Health Program of Niterói (RJ, Brazil)]. Cien Saude Colet 2010;15:2983–95. [Article in Portuguese] [CrossRef]
39. Neuberg M, Pudmej Ešegović V, Križaj M, Cikač T, Meštrović T. Abuse and neglect of older people in health facilities from the perspective of nursing professionals: A cross-sectional study from Croatia. Int J Older People Nurs 2022;17:e12484. [CrossRef]
40. Choi YJ, O'Donnell M, Choi HB, Jung HS, Cowlishaw S. Associations among elder abuse, depression and PTSD in South Korean older adults. Int J Environ Res Public Health 2018;15:1948. [CrossRef]
41. Fadeeva A, Hashemi L, Cooper C, Stewart R, McManus S. Violence against older people and associations with mental health: A national probability sample survey of the general population in England. J Affect Disord 2024;363:1–7. [CrossRef]
42. de Sousa RIM, de Macedo Bernardino Í, de Castro RD, Cavalcanti AL, Bento PM, d'Ávila S. Maxillofacial trauma resulting from physical violence Against older adults: A 4-year study in a Brazilian forensic service. Pesqui Bras Odontopediatria Clín Integr 2016;16;1:313–22. [CrossRef]
43. Yıldız A. Physical Violence Against Older Adults: A 7-year retrospective evaluation from a university hospital's department of forensic medicine. Senex: Yaşlılık Çalışmaları Dergisi 2022;5:48–59. [CrossRef]
44. Karbeyaz K, Çelikel A. The elder physical abuse reflected in judicial authorities in Eskisehir. Arch Gerontol Geriatr 2017;73:284–7. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Adli tıp bakış açısıyla yaşlılara yönelik şiddet; Retrospektif analiz

AMAÇ: Günümüzde yapılan pek çok çalışmada kronolojik olarak 65 yaş ve üzeri bireyler "yaşlı" olarak tanımlanmaktadır. İstatistiklere göre dünyada yaşlı nüfusun sayısı gün geçtikçe artmaktadır. Zihinsel, fiziksel faaliyetlerdeki gerileme ve sosyal değişimlerin bir sonucu olarak yaşlılar şiddete karşı daha savunmasızdırlar. Bu çalışmada adli raporları düzenlenen şiddet mağduru 65 yaş ve üzeri yaşlı olguların verilerinin paylaşılıp tartışılması ile yaşlılara yönelik şiddet eylemlerinin önlenmesi için alınacak tedbirlere dikkat çekilmesi ve buna yönelik çözüm önerilerinin sunulması amaçlanmıştır.
GEREÇ VE YÖNTEM: 01.01.2016-01.01.2025 tarihleri arasında Dokuz Eylül Üniversitesi Tıp Fakültesi Adli Tıp Anabilim Dalımızca medikolegal değerlendirmesi yapılan 65 yaş ve üzeri yaşlı olgulara ait toplam 275 dosya ve rapor geriye dönük olarak incelenmiştir. Sosyodemografik özellikler, şiddetin uygulandığı yer, şiddeti uygulayan kişi, şiddetin türü, yaralanma bölgesi, yara tipi, olayla ilgili psikiyatrik tanı konulup konulmadığı, konulan psikiyatrik tanı, adli tıbbi açıdan yaralanmanın niteliği vb. değerlendirilmiştir. Verilerin istatistiksel analizi SPSS 29.0 paket programı kullanılarak yapılmıştır.
BULGULAR: Şiddete uğrayan toplam 275 olgunun 97'si (%35.3) kadın, 178'i (%64.7) erkekti. Yaş ortalaması 71.53 ± 6,2 yıl olarak saptandı. Olguların en sık tanımadığı/diğer 2. kişiler (n=105, %38.2), ikinci sıklıkta ise arkadaş/komşuları (n=90, %32.7) tarafından şiddete uğradığı saptandı. Şiddetin uygulandığı en sık yerin ev ve çevresi (n=143, %52), ikinci sıklıkta sokak, park vb. açık alanlar (n=69, %25.1) olduğu saptandı. Olguların %21.5'i aile içi şiddet kapsamında değerlendirildi. 19 (%6.9) olguda ihmal tespit edildi. En sık izole fiziksel şiddet (n=238, %86,5) görülürken, şiddete maruz kalan olguların 21'inde (%7.6) yaralanmanın yaşamsal tehlikeye neden olduğu, 78'inde (%28,4) kemik kırığı meydana geldiği belirlendi.
SONUÇ: Yaşlının günlük hayata sosyal katılımının sağlanmasında yaşlıları koruyucu özel yasal düzenlemeler yapılmalı, aile içinde ve dışında yaşlılara yönelik şiddetle mücadelede farklı yaklaşımlar geliştirilmelidir. Şiddet uygulaması veya şiddet mağduru olması muhtemel kişiler arasında tanımlama yapılarak bu kapsamda müdahale ve önlemeyi iyileştirici çok düzeyli entegre bir yaklaşım sergilenmelidir.

Anahtar sözcükler: Adli tıp; aile içi şiddet; ev ve çevresi; tanımadık/diğer 2. kişi; yaşlı şiddeti.

Ulus Travma Acil Cerrahi Derg 2026;32(8):954-961 DOI: 10.14744/tjtes.2026.24452

ORIGINAL ARTICLE

Effect of extubation timing on prognosis in patients with acute stroke undergoing mechanical thrombectomy under general anesthesia: A retrospective study

Öznur Demiroluk, Elif Acar Değer, Büşra Şimşek Ersöz, Cansu Ofluoğlu, Arzu Yıldırım Ar

Department of Anesthesiology and Reanimation, University of Health Sciences Fatih Sultan Mehmet Health Research and Application Center, Istanbul-*Türkiye*

ABSTRACT

BACKGROUND: The timing of extubation after general anesthesia (GA) in patients with acute ischemic stroke treated with mechanical thrombectomy (MT) is a significant issue. Prolonged duration of mechanical ventilation is considered to be an independent risk factor that negatively affects functional survival in patients receiving neurocritical care. This study evaluated the effect of time to extubation and the development of pneumonia on clinical prognosis after MT performed under GA.

METHODS: This retrospective, single-center, observational study included patients ≥18 years of age who underwent MT under GA for acute ischemic stroke between January 2023 and May 2025. Patient data were retrospectively obtained from hospital records and supplemented, when necessary, with information from patients' relatives. Demographic data, lengths of intensive care unit and hospital stay, additional complications, neurological functional status (modified Rankin Scale [mRS]) at discharge, and mortality were examined. Patients were evaluated according to extubation timing, pneumonia, discharge mRS score (0–2, favorable; 3–6, unfavorable), and 30-day mortality using multivariate logistic regression analysis.

RESULTS: Data from 119 patients (mean age, 70.3±13.6 years) were analyzed. Patients in whom time to extubation was >24 h were older (p=0.003), exhibited a lower pre-procedural Glasgow Coma Scale (GCS) score (p<0.001), and higher pneumonia and mortality rates (p<0.001). Logistic regression analyses revealed that time to extubation >24 h significantly increased the likelihood of an unfavorable mRS score and mortality (p<0.001). Lower pre-procedural GCS (odds ratio [OR] 0.64; p<0.001) and higher American Society of Anesthesiologists Physical Status (ASA-PS) classification (OR 27.966; p<0.002) scores significantly affected time to extubation. A high ASA-PS score was found to increase the probability of pneumonia by tenfold (95% confidence interval 1.1–100.9). Patients with pneumonia exhibited significantly higher mRS scores (p<0.001).

CONCLUSION: Although the time to extubation had a significant impact on poor neurological prognosis and mortality in patients undergoing MT for acute stroke, the development of pneumonia appeared to be associated with unfavorable early neurological functional outcomes.

Keywords: Acute ischemic stroke; general anesthesia; pneumonia; prognosis; thrombectomy.

INTRODUCTION

Endovascular mechanical thrombectomy (MT) is a recommended treatment for acute ischemic stroke caused by the occlusion of large cerebral vessels. In clinical practice, MT is performed with patients under general anesthesia (GA), conscious sedation, or local anesthesia.[1,2] During GA, intubation and complete immobilization provide advantages, such as bet-

Cite this article as: Demiroluk O, Değer EA, Ersoz BS, Ofluoglu C, Yıldırım Ar A. Effect of extubation timing on prognosis in patients with acute stroke undergoing mechanical thrombectomy under general anesthesia: A retrospective study. Ulus Travma Acil Cerrahi Derg 2026;32:962-970.

Address for correspondence: Öznur Demiroluk

Department of Anesthesiology and Reanimation, University of Health Sciences Fatih Sultan Mehmet Health Research and Application Center, Istanbul, Türkiye

E-mail: onrdemiroluk@hotmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):962-970 DOI: 10.14744/tjtes.2026.70514

Submitted: 08.01.2026 Revised: 27.05.2026 Accepted: 01.07.2026 Published: 10.08.2026

ter angiographic imaging and shorter procedure time. However, due to the anesthetic drugs used during GA, there is a risk for hypotension, blood pressure fluctuations, and secondary changes in cerebral perfusion, as well as complications, including airway difficulties during intubation or aspiration.[3]

The effect of anesthetic techniques used during MT for acute ischemic stroke on clinical outcomes remains controversial. Some studies have reported that GA is associated with unfavorable neurological outcomes and an increased risk for complications.[4-6] In contrast, some randomized studies reported no difference between anesthetic techniques and suggested that GA may be associated with better functional outcomes than sedation.[7,8] These differences suggest that both the anesthesia technique and post-anesthesia care may be decisive factors affecting clinical prognosis.

The timing of extubation is an important clinical issue after intubation under GA. Prolonged mechanical ventilation is associated with adverse outcomes, such as ventilator-associated pneumonia and longer intensive care unit (ICU) and hospital lengths of stay, and is considered to be an independent risk factor that negatively affects functional survival in patients receiving neurocritical care.[9] Although there are no clear guidelines regarding optimal extubation timing in patients intubated and mechanically ventilated for acute ischemic stroke, mechanical ventilation lasting >24 h has been reported to be associated with worse neurological recovery and functional outcomes.[10,11]

As such, this retrospective study aimed to evaluate the impact of extubation timing and development of secondary pneumonia on mortality and neurological clinical prognosis (according to the modified Rankin Scale [mRS]) in patients undergoing MT under GA for acute ischemic stroke.

MATERIALS AND METHODS

The present investigation was a retrospective, single-center, observational study approved by the ethics committee. Data from patients ≥18 years of age with American Society of Anesthesiologists Physical Status (ASA-PS) classifications 1–4, who underwent MT under GA between January 2023 and May 2025, were retrospectively reviewed. These patients either presented to the authors' hospital with acute ischemic stroke or were referred to the authors' stroke unit from other centers.

Patients diagnosed with large-vessel occlusion in the anterior cerebral circulation (middle cerebral artery M1–M2 segments and/or internal carotid artery) or posterior cerebral circulation (basilar artery, vertebral artery, and/or posterior cerebral artery) detected using computed tomography (CT) angiography were included. Patients who developed aspiration before the procedure or during intubation, those with severe pre-procedural neurological sequelae (mRS score 3–6), radiologically confirmed intracranial hemorrhage before the procedure, pregnant women, pre-procedural ICU admission or need for mechanical ventilation, cases of intracranial hemorrhage during the procedure, and patients for whom data could not be accessed were excluded.

The medical records of 1012 patients, who underwent endovascular MT for acute ischemic stroke at the authors' center, were retrospectively reviewed. After excluding 837 patients treated under local anesthesia or conscious sedation, data from 175 patients who underwent MT under GA with endotracheal intubation were evaluated. Of these, 52 were excluded due to missing data and refusal of the patient/relative to provide information for participation, 2 due to aspiration before the procedure, and 2 due to hemorrhagic transformation during the procedure. Ultimately, therefore, data from 119 patients who underwent MT under GA were analyzed.

In all patients, GA was administered under standard monitoring, including electrocardiography, heart rate, non-invasive blood pressure, peripheral oxygen saturation, and end-tidal carbon dioxide, using inhalational anesthesia and remifentanil infusion.

Data were obtained through the hospital's electronic records system and telephone interviews with patients/relatives. Recorded demographic and clinical variables included age, sex, pre-procedural Glasgow Coma Scale (GCS), comorbidities, ASA-PS score, occlusion location, time of procedure, time from hospital admission to procedure (≤6 h or >6 h), time to extubation (≤24 h or >24 h), ICU admission and length of stay, total hospital length of stay, post-procedural pneumonia, intracranial hemorrhage, and severe cerebral ischemia/cerebral edema. The procedure time was categorized as daytime (regular working hours) and off-hours (nighttime, weekends, or holidays).

To evaluate prognosis, neurological status at discharge was determined using the mRS, and 30-day mortality was examined. mRS scores of 0–2 and 3–6 were considered to be favorable and unfavorable neurological functional outcomes, respectively. Pneumonia was defined as the presence of a new or progressive lung infiltration on chest radiography or thoracic CT within the first 7 days after the procedure, accompanied by ≥2 clinical findings, such as fever (>38°C), leukocytosis or leukopenia (leukocyte count >12 x 10^3/mL or <4 x 10^3/mL), purulent respiratory secretions, or increased oxygen requirement(s).[10] Due to the retrospective design of this study, it was not possible to differentiate between consistent microbiological culture results and ventilator-associated pneumonia; as such, pneumonia was evaluated based on clinical and radiological findings and considered within the context of pneumonia associated with early stroke.

Standardized stroke severity scores, such as the National Institutes of Health Stroke Scale (NIHSS), were not consistently available in the retrospective records; therefore, the GCS was used as a neurological assessment parameter.

The primary endpoints included discharge mRS score and 30-

day mortality; the secondary endpoint was the development of pneumonia. Patients were grouped and compared according to time to extubation, presence of pneumonia, mRS outcomes, and mortality status.

The present study was approved by the Kartal Koşuyolu Specialized Training and Research Hospital Ethics Committee (Decision No: Koşuyolu-YİEAH-BAEK-2025/07/1118-1295). This study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical Analyses

Descriptive statistics are expressed as numbers and percentages for categorical variables, mean±standard deviation for normally distributed numerical variables, and median (interquartile range [IQR], i.e., 25th percentile–75th percentile) for non-normally distributed numerical variables. Differences in the distributions of time to extubation, pneumonia, mRS group, and survival status according to categorical variables were assessed using the chi-squared test. Differences between continuous variables were assessed using Student's t-test for normally distributed parameters and the Mann–Whitney U test for non-normally distributed parameters. Factors affecting dependent variables were identified using binary logistic regression analysis. Analyses were performed using the Statistical Package for the Social Sciences version 26.0 (IBM Corporation, Armonk, NY, USA). Differences with $p<0.05$ were considered to be statistically significant.

Table 1. Descriptive characteristics of patients, comorbidities, ICU admission, hospital and ICU length of stay, complications, mRS, and mortality rates

Variable	n=119 (100.0)
Age (mean±SD)	70.3±13.6
Gender: Female/Male n (%)	50 (42.0)/69 (58.0)
ASA 2/ASA 3/ASA 4 n (%)	2 (1.7)/34 (28.6)/83 (69.7)
Time of procedure: Daytime/Off-hours n (%)	41 (34.5)/78 (65.5)
Pre-procedural GCS (mean±SD)	11.2±3.8
Occlusion site n (%)	
Posterior circulation	50 (42.0)
Anterior circulation	69 (58.0)
Time to intervention n (%)	
≤6 h	74 (62.2)
>6 h	45 (37.8)
Procedure duration (min) (mean±SD)	53.8±28.0
Anesthesia duration (min) (mean±SD)	70.2±30.2
Extubation time n (%)	
≤24 h	53 (44.5)
>24 h	66 (55.5)
Presence of ICU admission n (%), days	94 (79.0)
Length of ICU stay median (IQR), days	4 (1–12.5)
Length of hospital stay median (IQR), days	8 (2–23)
Complications	
Post-procedural pneumonia n (%)	36 (30.3)
Post-procedural intracranial hemorrhage n (%)	15 (12.6)
Severe cerebral ischemia/cerebral edema n (%)	12 (10.1)
mRS median (IQR)	5 (1–6)
mRS ≤2 (favorable) n (%)	46 (38.65)
mRS 3–6 (unfavorable) n (%)	73 (61.34)
Mortality (30 days) n (%)	37 (31.1)

SD: Standard deviation; IQR: Indicates interquartile range; ASA: American Society of Anesthesiologists physical status classification system; GCS: Glasgow Coma Scale; ICU: Intensive care unit; mRS: Modified Rankin Score.

Table 2. Patients' comorbid diseases

Comorbid diseases	n (%)
DM	40 (33.6)
Hypertension	88 (73.9)
CAD	36 (30.3)
Arrhythmia	10 (8.4)
Congestive heart failure	17 (14.3)
Asthma -COPD	11 (9.2)
Previous cerebrovascular disease	28 (23.5)
Hypothyroidism	8 (6.7)
CKD	4 (3.4)
Malignancy	9 (7.6)

DM: Diabetes mellitus; CAD: Coronary artery disease; COPD: Chronic obstructive pulmonary disease; CKD: Chronic kidney disease.

RESULTS

This study included data from 119 patients (mean age, 70.3±13.6 years; 58% male) who underwent MT under GA. ASA-PS class 4 accounted for 69.7% of the patients, and 65.5% of the procedures were performed off-hours, whereas the remaining procedures were performed during the daytime.

The pre-procedural GCS score was >8 in 64.7% and ≤8 in 35.3% of patients. The time to extubation was >24 h in 55.5% of patients (n=66). The ICU admission rate was 79%, the median ICU length of stay was 4 days (IQR 1–12.5 days), and the median total hospital stay was 8 days (IQR 2–23 days). Post-procedural pneumonia occurred in 30.3% of patients, intracranial hemorrhage in 12.6%, and severe cerebral ischemia/cerebral edema in 10.1%. The median discharge mRS score was 5 (IQR 1–6); 38.7% (n=46) had favorable (i.e., mRS score 0–2) outcomes and 61.3% (n=73) had unfavorable (i.e., mRS score 3–6) outcomes. The 30-day mortality rate was 31.1% (Table 1).

The most common comorbidities were hypertension (73.9%), diabetes mellitus (33.6%), coronary artery disease (30.3%), and cerebrovascular disease (23.5%) (Table 2).

Comparisons according to time to extubation

Patients with extubation time >24 h were older than those extubated ≤24 h (p=0.003). In this group, female sex, ASA-PS class 4, procedures performed during off-hours, lower pre-procedural GCS score, and anterior circulation occlusion were significantly more prevalent (all p<0.05).

The prevalence of pneumonia was markedly higher in patients with an extubation time >24 h (86.1% vs. 13.9%; p<0.001). In the same group, the rates of intracranial hemorrhage and severe cerebral ischemia/cerebral edema were significantly higher (p<0.05).

ICU and hospital lengths of stay were significantly longer in patients with extubation times >24 h (p<0.001). In addition, the 30-day mortality rate was significantly higher in this group (p<0.001). There was no significant difference in the distribution of comorbid diseases between the groups (p>0.05) (Table 3).

Comparison according to the development of pneumonia

Patients who developed pneumonia were older than those who did not (81.5 [IQR 67–87]) versus 68 [61–77] years; p=0.002). There were no significant differences in sex distribution (p>0.05). Pneumonia occurred significantly more frequently in patients with ASA class 4 and in those who underwent procedures during off-hours (P<0.001). The median pre-procedural GCS score was significantly higher in patients without pneumonia (15 [8–15] vs. 8 [6–10.75]); p<0.001).

The frequency of pneumonia was markedly higher in patients with an extubation time >24 h (47% vs. 9.4%; p<0.001). ICU and hospital stays were significantly longer in patients who developed pneumonia (p<0.001). These patients also exhibited higher mRS scores (p<0.001). However, there was no significant relationship between the development of pneumonia and 30-day mortality (p=0.226).

Functional outcome and mortality

An unfavorable mRS score was significantly more frequent in older patients, those with ASA class 4, procedures performed during off-hours, anterior circulation occlusion, and intervention time ≤6 h (all p≤0.001). An unfavorable mRS score was markedly higher in patients with an extubation time >24 h (p<0.001). In these patients, the ICU admission rate, ICU and hospital lengths of stay, and frequencies of pneumonia, intracranial hemorrhage, and severe cerebral ischemia/cerebral edema were significantly higher (Table 4).

Thirty-day mortality was significantly higher among females, those with ASA class 4, procedures performed off-hours, lower pre-procedural GCS scores, and prolonged time to extubation (all p<0.001). Anterior circulation location, intracranial hemorrhage, and severe cerebral ischemia/cerebral edema were also associated with mortality. While pneumonia was not associated with mortality, the hospital stay was longer among survivors (Table 4).

Logistic regression analyses

Logistic regression analyses revealed that patients with extubation time >24 h had a 41-fold higher likelihood of an unfavorable mRS score (odds ratio [OR] 41.6; 95% confidence interval [CI]: 13.7–127.2) and a 26-fold higher likelihood of 30-day mortality (OR 26.8; 95% CI: 5.9–123.2).

Prolonged time to extubation was independently associated with a low pre-procedural GCS score (OR 0.68; p<0.001) and high ASA-PS score (OR 27.96; p=0.002). Each 1-point increase in pre-procedural GCS score reduced the likelihood of extubation time >24 h by approximately 31% (95% CI:

Table 3. Patient comparisons according to time to extubation

Variable	Extubation time		p
	≤24 h (n=53)	>24 h (n=66)	
Age med (IQR)	66 (61–74.5)	76 (65–85)	0.003[1]
Gender F/M n (%)	16 (32.0)/37 (53.6)	34 (68.0)/32 (46.4)	0.019[2]
ASA score n (%)			<0.001[2]
ASA 2–3	35 (97.2)	1 (2.8)	
ASA 4	18 (21.7)	65 (78.3)	
Time of procedure n (%)			<0.001[2]
Daytime	34 (82.9)	7 (17.1)	
Off-hours	19 (24.4)	59 (75.6)	
Pre-procedural GCS med (IQR)	15 (15–15)	8 (6–11)	<0.001[2]
Occlusion site n (%)			0.032[2]
Posterior circulation	28 (56.0)	22 (44.0)	
Anterior circulation	25 (36.2)	44 (63.8)	
Intervention time n (%)			<0.001[2]
≤6 h	18 (24.3)	56 (75.7)	
>6 h	35 (77.8)	10 (22.2)	
Procedure duration (min) (IQR)	50 (35–67.5)	50 (30–70)	0.976[1]
Anesthesia duration (min) (IQR)	70 (55–90)	67.5 (45–80)	0.474[1]
ICU admission n (%)	28 (29.8)	66 (70.2)	<0.001[2]
ICU length of stay med (IQR)	1 (0–1.5)	9 (4–36.5)	<0.001[1]
Hospital length of stay med (IQR)	4 (2–9.5)	15 (5–40)	<0.001[1]
Complications n (%)			
Post-procedural pneumonia	5 (13.9)	31 (86.1)	<0.001[2]
Post-procedural intracranial hemorrhage	3 (20.0)	12 (80.0)	0.041[2]
Post-procedural severe cerebral ischemia/edema	2 (16.7)	10 (83.3)	0.040[2]
mRS med (IQR)	1 (0–2)	6 (5–6)	<0.001[1]
Mortality (30 days) n (%)	2 (5.4)	35 (94.6)	<0.001[2]

[1]Mann-Whitney U test, [2]Chi-square test. SD: Standard deviation; IQR: Indicates interquartile range; F: Female, M: Male; ASA: American Society of Anesthesiologists physical status classification system; GCS: Glasgow Coma Scale; ICU: Intensive care unit; mRS: Modified Rankin Score.

0.571–0.828). In patients with ASA-PS class 4, the likelihood of extubation >24 h increased by approximately 28-fold (95% CI: 3.3–240.5), and the likelihood of pneumonia increased 10-fold (95% CI: 1.1–100.9) (Table 5).

The goodness-of-fit of the logistic regression model was assessed using the Hosmer–Lemeshow test, which revealed no evidence of poor model fit (p>0.05).

DISCUSSION

Results of this retrospective study revealed that a time to extubation exceeding 24 h was an independent risk factor for unfavorable neurological functional outcomes and 30-day mortality in patients undergoing MT under GA for acute stroke. In addition, the development of pneumonia was associated with prolonged time to extubation and poor functional outcomes but did not affect mortality. These findings indicate that the timing of post-procedural extubation is an important determinant of neurological prognosis, mortality, and respiratory complications.

However, patients with delayed extubation (>24 h) also had lower pre-procedural GCS scores, higher ASA-PS classifications, and a higher incidence of pneumonia, suggesting that extubation timing may reflect baseline clinical status and overall disease severity. Although these variables were included in the multivariate model, the relatively small sample size and predominance of unfavorable outcomes in the delayed extubation group may have contributed to the overestimation of effect size and wide CIs observed. Time to extubation may also be a surrogate marker of neurological severity rath-

Table 4. Patient comparisons according to mRS score and 30-day mortality rate

Variable	mRS		p	Mortality		p
	Favorable (n=46)	Unfavorable (n=73)		Alive (n=82)	Deceased (n=37)	
Age med (IQR) (mean±SD)	66 (60.75–74.25)	76 (64.5–85)	0.001[1]	68.7±13.2	74.0±13.7	0.051[3]
Sex (n)%			0.042[2]			<0.001[2]
Female	14 (28.0)	36 (72.0)	25(50.0)	25(50.0)		
Male	32 (46.4)	37 (53.6)	57(82.6)	12(17.4)		
ASA class (n) %			<0.001[2]			<0.001[2]
ASA 2–3	29 (80.6)	7 (19.4)		34 (94.4)	2 (5.6)	
ASA 4	17 (20.5)	66 (79.5)		48 (57.8)	35 (42.2)	
Time of procedure n (%)			<0.001[2]			<0.001[2]
Daytime	30 (73.2)	11 (26.8)		37 (90.2)	4 (9.8)	
Off-hours	16 (20.5)	62 (79.5)	45 (57.7)	33 (42.3)		
Pre-procedural GCS med (IQR)	15 (15–15)	8 (6.5–11)	<0.001[2]	15 (8–15)	8 (7–11)	<0.001[2]
Occlusion site (n)%			0.011[2]			0.009[2]
Posterior Circ	26 (52.0)	24 (48.0)		41 (82.0)	9 (18.0)	
Anterior Circ	20 (29.0)	49 (71.0)		41 (59.4)	28 (40.6)	
Intervention time (n) %			<0.001[2]			<0.001[2]
≤6 h	15 (20.3)	59 (79.7)		42 (56.8)	32 (43.2)	
>6 h	31 (68.9)	14 (31.1)		40 (88.9)	5 (11.1)	
Procedure duration (min) med (IQR)	45 (30–60)	55 (30–70)	0.346[1]	50 (30–70)	50 (30–65)	0.899[1]
Anesthesia duration (min) med (IQR)	62.5 (48.75–81.25)	70 (45–87.5)	0.820[1]	70 (45–90)	70 (45–80)	0.542[1]
Extubation time (n)%			<0.001[2]			<0.001[2]
≤24 h	41 (77.4)	12 (22.6)		51 (96.2)	2 (3.8)	
>24 h	5 (7.6)	61 (92.4)		31 (47.0)	35 (53.0)	
ICU admission (n) %	23 (24.5)	71 (75.5)	<0.001[2]	58 (61.7) [2]	36 (38.3)	0.001[2]
ICU length of stay med (IQR)	0.5 (0–2)	7.5 (3–35.75)	<0.001[1]	3 (0–21.5)	5 (2–8.75)	0.178[1]
Hospital length of stay med (IQR)	3.5 (2–12)	12 (5–37)	<0.001[1]	12 (3–32.25)	5 (2–8.75)	0.005[1]
Complications n (%)						
Post-procedural pneumonia	6 (16.7)	30 (83.3)	0.001[2]	22 (61.1)	14 (38.9)	0.226[2]
Post-procedural intracranial hemorrhage	1 (6.7)	14 (93.3)	0.006[2]	5 (33.3)	10 (66.7)	0.003*[2]
Post-procedural severe cerebral ischemia/edema	0 (0.0)	12 (100.0)	0.003*[2]	2 (16.7)	10 (83.3)	<0.001*[2]

*Fisher's exact test was used. [1]Mann–Whitney U test, [2]Chi-square test; [3]Student's t-test.

er than a directly modifiable causal determinant. Therefore, these findings should be interpreted as associations rather than causal relationships.

Adverse effects of prolonged time to extubation on clinical prognosis have also been demonstrated in previous studies. Fandler-Höfler et al.[11] reported that the time to extubation >24 h was associated with higher 90-day mRS scores in patients with anterior circulation acute stroke undergoing MT under GA, and that early extubation (≤6 h) was strongly associated with better functional outcomes. Similarly, Nikoubashman et al.[10] showed that prolonged mechanical ventilation (>24 h) was associated with unfavorable functional outcomes and 90-day mortality, but reported no additional difference in clinical outcomes between early (≤6 h) and delayed (6–24 h) extubation. Raming et al.[12] reported that late extubation reduced the likelihood of 90-day functional independence and survival after stroke, and demonstrated that extubation as soon as possible after the procedure was associated with more favorable prognostic outcomes. These reports support the findings of the present study. However, our study pre-

Table 5. Results of multivariable logistic regression analyses

a. Factors affecting the mRS

Variable	B coefficient	S.E.	Wald	p	OR	%95 CI
Constant	0.636	0.285	4.998	0.025	1.890	
Time to extubation (ref: ≤24 h)	3.730	0.569	42.928	<0.001	41.683	13.657–127.222

Age, sex, ASA score, pneumonia, pre-procedural GCS, occlusion site, and time of procedure were included in the model but were not statistically significant.

b. Factors affecting mortality

Variable	B coefficient	S.E.	Wald	p	OR	%95 CI
Constant	−1.532	0.388	15.568	<0.001	0.216	
Sex (ref: male)	1.448	0.496	8.513	0.004	4.254	1.608–11.250
Time to extubation (ref: ≤ 24 h)	3.291	0.777	17.957	<0.001	26.883	5.866–123.209

Age, sex, ASA score, pneumonia, pre-procedural GCS, occlusion site, and time of procedure were included in the model but did not reach statistical significance.

c. Factors affecting pneumonia development

Variable	B coefficient	S.E.	Wald	p	OR	%95 CI
Constant	−1.853	0.521	12.651	<0.001	0.157	
ASA group (ref: ASA 2–3)	2.381	1.139	4.367	0.037	10.817	1.159–100.924
Time to extubation (ref: ≤24 h)	1.131	0.608	3.461	0.063	3.098	0.941–10.199

Age, sex, pneumonia, pre-procedural GCS, occlusion site, and time of procedure were included in the model but did not reach statistical significance.

d. Factors affecting extubation timing

Variable	B coefficient	S.E.	Wald	p	OR	%95 CI
Constant	2.000	1.728	1.339	0.247	7.388	
Pre-procedural GCS	−0.375	0.095	15.649	<0.001	0.687	0.571–0.828
ASA group (ref: ASA 2–3)	3.331	1.098	9.207	0.002	27.966	3.252–240.472

Age, sex, pneumonia, occlusion site, and time of procedure were included in the model but did not reach statistical significance. S.E: Standard error; OR: Odds ratio; CI: Confidence interval; ASA: American Society of Anesthesiologists; GCS: Glasgow Coma Scale.

cludes commentary regarding the effects of different extubation timing within the first 24 h. Unlike previous studies, this study evaluated anterior and posterior circulation stroke cases together to enable the assessment of a broader patient group.

In our study, advanced age, high ASA-PS class, low pre-procedural GCS scores, procedures performed during off-hours, post-procedural hemorrhage, and progressive ischemia were significantly associated with unfavorable neurological outcomes and mortality. Beuker et al.[13] demonstrated a strong association between advanced age and prolonged mechanical ventilation and prognosis in their study evaluating long-term outcomes after thrombectomy. Nikoubashman et al.[10] showed that clinical factors, such as age, infarct size, and pneumonia, were associated with ventilation duration and had the greatest impact on functional outcome. Popat et al.[14] reported that the strongest predictors of mortality in patients with acute stroke were age and stroke volume calculated from radiographic imaging.

In our study, limiting mortality to 30 days and the relatively small sample size may explain why the association between age and mortality was not statistically evident. In addition, due to data limitations potentially related to the frequent performance of procedures during off-hours, pre-procedural neurological status was assessed only using the GCS, which may have limited the evaluation of the relationship between stroke severity and prognosis. However, in multivariate regression analyses, time to extubation emerged as the strongest determinant of both poor functional outcomes and mortality, independent of these factors.

In addition to time to extubation, female sex was a significant factor associated with mortality. This finding is consistent with those of previous studies. Appelros et al.[15] reported that, although stroke is more common among men worldwide, it

tends to be more severe in women, and higher 30-day mortality rates have been observed among females (24.7% in women vs. 19.7% in men). Similarly, Reeves et al.[16] reported that women experience worse functional outcomes and a lower quality of life than men after stroke. Previous studies have also suggested that stroke occurs at an older age in women and is associated with a higher burden of age-related comorbidities, which may contribute to worse outcomes. Although our study did not include sex-based subgroup analyses, the number of males was higher. Mortality and adverse functional outcomes were more frequently associated with female sex.

We found that the frequency of pneumonia was significantly higher in patients with time to extubation >24 h. However, in the multivariate analyses, the time to extubation was not identified as an independent risk factor for pneumonia. Although advanced age, high ASA-PS score, and low pre-procedural GCS score were associated with the development of pneumonia, only high ASA score was an independent risk factor. This suggests that the development of pneumonia may be more closely related to underlying patient characteristics than to extubation timing.

Lin et al.[17] reported that a high stroke score was an important risk factor for early pneumonia (<7 days) in patients with acute stroke. Several studies have reported that pneumonia is strongly related to stroke severity and overall clinical condition.[18,19] Teh et al.[20] reported that stroke-associated pneumonia was associated with prolonged hospital stay, poor functional outcomes at discharge, and increased mortality for up to 1 year. In contrast, we observed longer ICU and hospital stays and more frequent unfavorable neurological functional outcomes (mRS score ≥3) in patients who developed pneumonia; however, pneumonia was not directly associated with 30-day mortality. Nevertheless, these findings should be interpreted with caution. The relatively short follow-up period and the limited sample size may have reduced the ability to detect an association between pneumonia and short-term mortality. In addition, early mortality in this patient population may be more strongly influenced by factors, such as stroke severity, lower GCS scores, hemorrhagic complications, cerebral edema, and prolonged mechanical ventilation, rather than pneumonia itself. Therefore, the absence of a statistically significant association between pneumonia and 30-day mortality should not be interpreted as evidence of lack of prognostic significance.

When factors affecting extubation timing were evaluated, low pre-procedural GCS and high ASA-PS scores were independent determinants of late extubation. This indicates that delayed extubation may be an expected outcome in patients with substantial systemic comorbidities and severe neurological status. Similarly, Lioutas et al.[21] reported significantly higher rates of extubation failure in patients with severe stroke. These results suggest that extubation decisions in patients with acute stroke should consider neurological status, systemic conditions, and respiratory parameters.

The present study had several limitations, the first of which was its retrospective design, which limits causal inferences. Second, the relatively small sample size may have reduced the statistical power. In addition, patients with missing baseline clinical or outcome data were excluded, which may have introduced selection bias and reduced statistical power because the missing data may not have been randomly distributed. Third, neurological assessment was limited to the GCS because standardized stroke severity scores, such as the NIHSS, were not consistently available in the retrospective records, likely due to the urgent nature of stroke management and frequent off-hour presentations with limited staffing. Therefore, GCS, which is the most consistently documented neurological assessment parameter, was used.

Finally, due to the difficulty in obtaining long-term follow-up data in this retrospective study, prognosis was assessed using the mRS at discharge; as such, our findings should be interpreted with caution. However, the results suggest that the timing of extubation in patients with acute stroke undergoing MT under GA may be associated with early clinical outcomes.

CONCLUSION

Prolonged time to extubation was associated with unfavorable neurological outcomes and increased mortality in patients with acute stroke who underwent MT under GA. However, this relationship should be interpreted with caution due to potential residual confounding factors related to stroke severity and overall clinical condition. Nevertheless, further prospective studies are required to confirm this association.

Ethics Committee Approval: The present study was approved by the Kartal Koşuyolu Specialized Training and Research Hospital Ethics Committee (Date: 06.05.2025, Decision No: Koşuyolu-YİEAH-BAEK-2025/07/1118-1295).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: Ö.D., C.O., E.A.D, B.Ş.E.; Design: Ö.D., A.Y.A., B.Ş.E., C.O.; Supervision: Ö.D., A.Y.A.; Resource: Ö.D., A.Y.A., B.Ş.E.; Materials: E.A.D., Ö.D., A.Y.A., B.Ş.E.; Data collection and/or processing: Ö.D., E.A.D., B.Ş.E.; Analysis and/or interpretation: Ö.D., A.Y.A.; Literature review: Ö.D., E.A.D., A.Y.A.; Writing: Ö.D., A.Y.A.; Critical review: Ö.D., A.Y.A.

Informed Consent: Retrospective study.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Goyal M, Menon BK, van Zwam WH, Dippel DW, Mitchell PJ, Demchuk AM, et al. Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. Lancet 2016;387:1723–31. [CrossRef]

2. Zhang Y, Jia L, Fang F, Ma L, Cai B, Faramand A. General anesthesia versus conscious sedation for intracranial mechanical thrombectomy: a systematic review and meta-analysis of randomized clinical trials. J Am Heart Assoc 2019;8:e011754. [CrossRef]
3. Wagner B, Lorscheider J, Wiencierz A, Blackham K, Psychogios M, Bolliger D, et al. Endovascular treatment for acute ischemic stroke with or without general anesthesia: a matched comparison. Stroke 2022;53:1520–9. [CrossRef]
4. Schönenberger S, Hendén PL, Simonsen CZ, Uhlmann L, Klose C, Pfaff JAR, et al. Association of general anesthesia vs procedural sedation with functional outcome among patients with acute ischemic stroke undergoing thrombectomy: a systematic review and meta-analysis. JAMA 2019;322:1283–93. [CrossRef]
5. van den Berg LA, Koelman DL, Berkhemer OA, Rozeman AD, Fransen PS, Beumer D, et al. Type of anesthesia and differences in clinical outcome after intra-arterial treatment for ischemic stroke. Stroke 2015;46:1257–62. [CrossRef]
6. Campbell D, Diprose WK, Deng C, Barber PA. General anesthesia versus conscious sedation in endovascular thrombectomy for stroke: a meta-analysis of 4 randomized controlled trials. J Neurosurg Anesthesiol 2021;33:21–27. [CrossRef]
7. Brekenfeld C, Mattle HP, Schroth G. General is better than local anesthesia during endovascular procedures. Stroke 2010;41:2716–7. [CrossRef]
8. Ilyas A, Chen CJ, Ding D, Foreman PM, Buell TJ, Ironside N, et al. Endovascular mechanical thrombectomy for acute ischemic stroke under general anesthesia versus conscious sedation: a systematic review and meta-analysis. World Neurosurg 2018;112:e355–67. [CrossRef]
9. Asehnoune K, Roquilly A, Cinotti R. Respiratory management in patients with severe brain injury. Crit Care 2018;22:76. [CrossRef]
10. Nikoubashman O, Schürmann K, Probst T, Müller M, Alt JP, Othman AE, et al. Clinical impact of ventilation duration in patients with stroke undergoing interventional treatment under general anesthesia: the shorter the better? AJNR Am J Neuroradiol 2016;37:1074–9. [CrossRef]
11. Fandler-Höfler S, Heschl S, Kneihsl M, Argüelles-Delgado P, Niederkorn K, Pichler A, et al. Ventilation time and prognosis after stroke thrombectomy: the shorter, the better! Eur J Neurol 2020;27:849–55. [CrossRef]
12. Raming L, Moustafa H, Prakapenia A, Barlinn J, Gerber J, Theilen H, et al. Association of anesthetic exposure time with clinical outcomes after endovascular therapy for acute ischemic stroke. Front Neurol 2019;10:679. [CrossRef]
13. Beuker C, Köppe J, Feld J, Meyer CL, Dröge P, Ruhnke T, et al. Association of age with 1-year outcome in patients with acute ischaemic stroke treated with thrombectomy: real-world analysis in 18 506 patients. J Neurol Neurosurg Psychiatry 2023;94:631–7. [CrossRef]
14. Popat C, Ruthirago D, Shehabeldin M, Yang S, Nugent K. Outcomes in patients with acute stroke requiring mechanical ventilation: predictors of mortality and successful extubation. Am J Med Sci 2018;356:3–9. [CrossRef]
15. Appelros P, Stegmayr B, Terént A. Sex differences in stroke epidemiology: a systematic review. Stroke 2009;40:1082–90. [CrossRef]
16. Reeves MJ, Bushnell CD, Howard G, Gargano JW, Duncan PW, Lynch G, et al. Sex differences in stroke: epidemiology, clinical presentation, medical care, and outcomes. Lancet Neurol 2008;7:915–26. [CrossRef]
17. Lin K, Deng X, Xiao Y, Yang Z, He Z, Li X, et al. Risk factors of stroke-associated pneumonia in patients with acute ischemic stroke treated by endovascular thrombectomy. BMC Neurol 2025;25:165. [CrossRef]
18. Zhu Y, Gao J, Lv Q, Yin Q, Yang D. Risk factors and outcomes of stroke-associated pneumonia in patients with stroke and acute large artery occlusion treated with endovascular thrombectomy. J Stroke Cerebrovasc Dis 2020;29:105223. [CrossRef]
19. Zheng F, Gao W, Xiao Y, Guo X, Xiong Y, Chen C, et al. Systemic inflammatory response index as a predictor of stroke-associated pneumonia in patients with acute ischemic stroke treated by thrombectomy: a retrospective study. BMC Neurol 2024;24:287. [CrossRef]
20. Teh WH, Smith CJ, Barlas RS, Wood AD, Bettencourt-Silva JH, Clark AB, et al Impact of stroke-associated pneumonia on mortality, length of hospitalization, and functional outcome. Acta Neurol Scand 2018;138:293–300. [CrossRef]
21. Lioutas VA, Hanafy KA, Kumar S. Predictors of extubation success in acute ischemic stroke patients. J Neurol Sci 2016;368:191–4. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Genel anestezi altında mekanik trombektomi uygulanan akut inme hastalarında ekstübasyon zamanlamasının prognoz üzerindeki etkisi: Retrospektif çalışma

AMAÇ: Akut iskemik inme geçiren ve mekanik trombektomi (MT) ile tedavi edilen hastalarda genel anestezi (GA) sonrası ekstübasyon zamanlaması önemli bir konudur. Mekanik ventilasyonun uzun süresi, nörokritik bakım alan hastalarda fonksiyonel sağkalımı olumsuz etkileyen bağımsız bir risk faktörü olarak kabul edilmektedir. Bu çalışma, GA altında yapılan MT sonrası ekstübasyon zamanının ve pnömoni gelişiminin klinik prognoz üzerindeki etkisini değerlendirmiştir.

GEREÇ VE YÖNTEM: Bu retrospektif, tek merkezli, gözlemsel çalışma, Ocak 2023 ile Mayıs 2025 tarihleri arasında akut iskemik inme nedeniyle GA altında MT uygulanan ≥18 yaş hastaları içermiştir. Hasta verileri, hastane kayıtlarından retrospek-tif olarak elde edilmiş ve gerektiğinde hastaların yakınlarından alınan bilgilerle desteklenmiştir. Demografik ver-iler, yoğun bakım ünitesi ve hastane yatış süreleri, ek komplikasyonlar, taburculukta nörolojik fonksiyonel du-rum (modifiye Rankin Ölçeği [mRS]) ve mortalite incelenmiştir. Hastalar, ekstübasyon zamanlaması, pnömoni, taburculuk mRS skoru (0–2, olumlu; 3–6, olumsuz) ve 30 günlük mortaliteye göre çok değişkenli lojistik re-gresyon analizi kullanılarak değerlendirilmiştir.

BULGULAR: Yüz on dokuz hastadan (ortalama yaş, 70.3±13.6 yıl) elde edilen veriler analiz edildi. Ekstübasyon süresi >24 saat olan hastalar daha yaşlıydı (p=0.003), işlem öncesi Glasgow Koma Ölçeği (GCS) skorları daha düşüktü (p<0.001) ve pnömoni ve ölüm oranları daha yüksekti (p<0.001). Lojistik regresyon analizleri, ekstübasyon sü-resinin >24 saat olmasının, olumsuz mRS skoru ve ölüm olasılığını önemli ölçüde artırdığını ortaya koydu (p<0.001). İşlem öncesi daha düşük GCS (OR 0.64; p<0.001) ve daha yüksek Amerikan Anesteziyologlar Derneği Fiziksel Durum (ASA-PS) sınıflandırması (OR 27.966; p<0.002) skorları, ekstübasyon süresini önemli ölçüde etkiledi. Yüksek ASA-PS skorunun pnömoni olasılığını on kat artırdığı bulundu (95% CI 1.1–100.9). Pnömonili hastalarda anlamlı derecede daha yüksek mRS skorları gözlendi (p<0.001).

SONUÇ: Akut inme nedeniyle mekanik trombektomi uygulanan hastalarda ekstübasyon süresinin nörolojik prognozun bozulması ve mortalite üzerinde önemli bir etkisi olmasına rağmen, pnömoni gelişimi de olumsuz erken nörolojik fonksiyonel sonuçlarla ilişkili görünmektedir.

Anahtar sözcükler: Akut iskemik inme; trombektomi; pnömoni; genel anestezi; prognoz.

Ulus Travma Acil Cerrahi Derg 2026;32(8):962-970 DOI: 10.14744/tjtes.2026.70514

ORIGINAL ARTICLE

Predictors of prolonged hospitalization and inflammation severity in acute appendicitis: a retrospective cohort study

Uğur Duman, Ulaş Karabay, Ahmed Taha

Department of General Surgery, University of Health Sciences, Bursa Yuksek Ihtisas Training and Research Hospital, Bursa-*Türkiye*

ABSTRACT

BACKGROUND: Acute appendicitis remains one of the most common causes of acute abdomen and the leading indication for emergency abdominal surgery worldwide. Despite advances in imaging and clinical scoring systems, predicting disease severity and postoperative outcomes at the time of admission remains challenging. Early identification of patients at risk for complicated appendicitis or prolonged hospitalization may improve treatment planning and optimize resource utilization. This study evaluated the predictive value of routinely available inflammatory markers for complicated appendicitis and prolonged hospital length of stay.

METHODS: This retrospective study included adult patients who underwent emergency appendectomy for acute appendicitis between May 2024 and April 2025. Demographic characteristics, hospital length of stay, surgical and pathological findings, and admission laboratory parameters were analyzed. Total white blood cell count (WBC-T), C-reactive protein (CRP), neutrophil-to-lymphocyte ratio (NLR), and left shift (LS) were assessed. Disease severity was classified according to the American Association for the Surgery of Trauma (AAST) grading system and categorized as uncomplicated or complicated. Hospital stay was classified as regular (≤2 days) or prolonged (>2 days). Independent predictors were identified using univariate and multivariate logistic regression analyses. Receiver operating characteristic (ROC) analysis and the Youden index were used to determine optimal cut-off values.

RESULTS: A total of 387 patients were included; 24.8% experienced a prolonged hospital stay, and 15.0% had complicated appendicitis. CRP, NLR, and LS were significantly higher in patients with prolonged hospitalization, whereas WBC-T was not. Multivariate analysis identified elevated CRP as the only independent predictor of prolonged hospital stay (odds ratio [OR]: 1.014, 95% confidence interval [CI]: 1.010–1.019; p<0.001). A CRP cut-off value of 43.05 mg/L predicted prolonged hospitalization with 59.4% sensitivity and 79.4% specificity (area under the curve [AUC]: 0.728). For complicated appendicitis, elevated CRP (OR: 1.008, 95% CI: 1.005–1.012; p<0.001) and increased LS (OR: 1.049, 95% CI: 1.012–1.087; p=0.008) were independent predictors. A CRP cut-off of 27.46 mg/L predicted complicated appendicitis with 69% sensitivity and 67% specificity (AUC: 0.74), whereas an LS cut-off of 77.61% demonstrated high sensitivity but limited specificity.

CONCLUSION: Admission CRP is a practical and reliable biomarker for predicting both prolonged hospitalization and complicated appendicitis. Combined assessment of CRP and left shift may further improve preoperative risk stratification and support clinical decision-making.

Keywords: Acute appendicitis; appendectomy; C-reactive protein; inflammation; length of stay.

INTRODUCTION

Acute appendicitis is one of the most common causes of acute abdomen and remains the leading indication for emergency abdominal surgery worldwide. Consequently, appendectomy is among the most frequently performed emergency surgical procedures. Acute appendicitis represents a substantial public health burden at both the global and national levels. In 2021, the global incidence of acute appendicitis was estimated at 214 (174–274) cases per 100,000 population,[1] corresponding

Cite this article as: Duman U, Karabay U, Taha A. Predictors of prolonged hospitalization and inflammation severity in acute appendicitis: a retrospective cohort study. Ulus Travma Acil Cerrahi Derg 2026;32:971-979.

Address for correspondence: Uğur Duman

Department of General Surgery, University of Health Sciences, Bursa Yuksek Ihtisas Training and Research Hospital, Bursa, Türkiye

E-mail: drugurduman@yahoo.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):971-979 DOI: 10.14744/tjtes.2026.73623

Submitted: 25.01.2026 Revised: 29.01.2026 Accepted: 11.06.2026 Published: 10.08.2026

to 17 million new cases worldwide. In Türkiye, the cumulative incidence has been reported as 123 per 100,000 population in Istanbul, the country's most populous city, reflecting the considerable national disease burden.[2]

Despite its high prevalence, the diagnosis of acute appendicitis remains challenging. In particular, the variability and atypical presentation of symptoms and clinical findings across different age groups and patient populations make the decision to perform an appendectomy challenging.[3,4] These diagnostic challenges contribute to negative appendectomy rates.[5] Although several clinical and laboratory-based scoring systems have been developed to aid diagnosis, their overall accuracy remains suboptimal.[6] Although numerous diagnostic scoring systems remain in use, incorporating objective laboratory parameters has improved their diagnostic performance.[7,8] Advances in imaging have substantially improved the diagnosis of acute appendicitis, and computed tomography is now considered the reference standard for most patients, except in selected patient populations.[9]

An equally important clinical challenge is distinguishing complicated from uncomplicated appendicitis.[10] Accurate prediction of disease severity at the time of hospital admission based on clinical findings and imaging can guide treatment planning and optimize resource utilization. This has become increasingly relevant with the growing adoption of outpatient and same-day discharge protocols for patients with uncomplicated appendicitis undergoing appendectomy.[11,12]

This study aimed to evaluate the predictive value of routinely measured inflammatory markers at hospital admission for complicated appendicitis and prolonged hospital stay.

MATERIALS AND METHODS

This study was approved by the Medical Sciences Ethics Committee of Bursa Yuksek Ihtisas Training and Research Hospital (Approval Date: 21/05/2025; Approval No. 2024 – TBEK 2025/05-05) and was conducted in accordance with the principles of the Declaration of Helsinki.

Medical records of patients who presented to the emergency department of Bursa Yuksek Ihtisas Training and Research Hospital with abdominal pain and underwent surgery for acute appendicitis between May 1, 2024 and April 30, 2025 were retrospectively reviewed. Patients aged ≥18 years who underwent appendectomy on the day of admission following diagnostic evaluation were included. Patients who were immunocompromised, had concomitant infectious conditions other than appendicitis, or had incomplete medical records were excluded (Fig. 1).

Demographic characteristics, length of hospital stay, operative findings, pathological findings, admission complete blood count results, and serum C-reactive protein (CRP) levels were collected. The total white blood cell count (WBC), neutrophil-to-lymphocyte ratio (NLR), and left shift (LS) were calculated from the admission complete blood count.

Hospital stays of ≤2 days were defined as regular, whereas stays of >2 days were considered prolonged. Disease severity was classified according to the American Association for the Surgery of Trauma (AAST) grading system (Table 1).[13] Negative appendectomies and AAST grades I–II were categorized as uncomplicated appendicitis, whereas AAST grades III–V were classified as complicated appendicitis. Admission

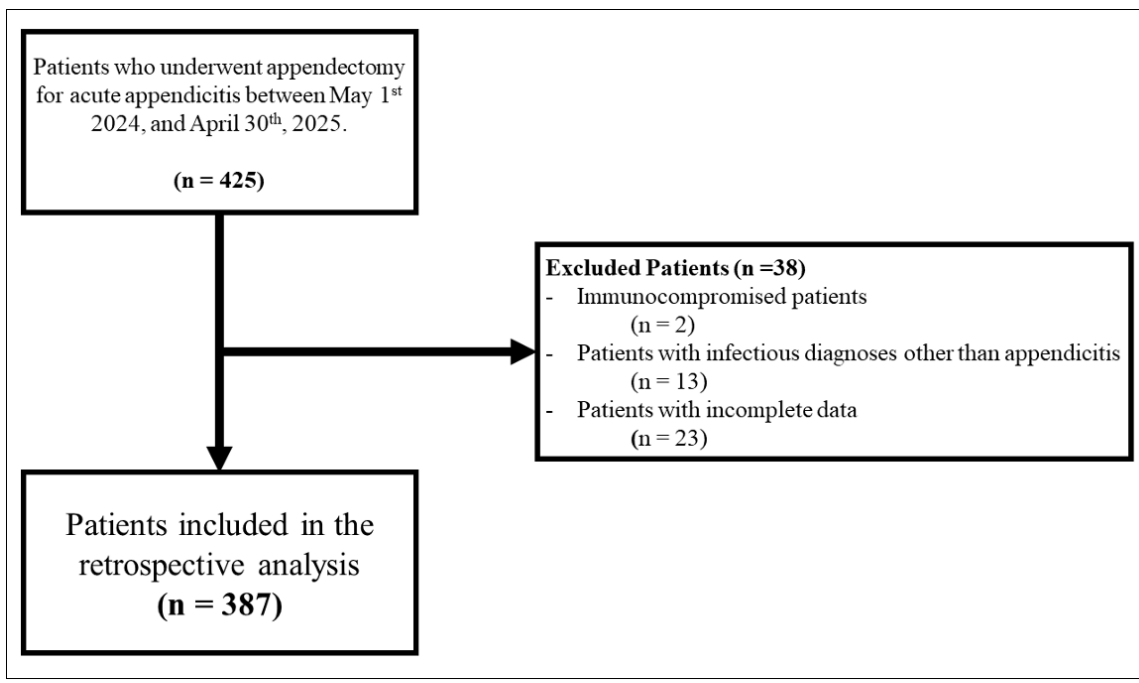

Figure 1. Flowchart illustrating patient recruitment.

Table 1. American Association for the Surgery of Trauma (AAST) grading system for acute appendicitis (source: https://www.aast.org/trauma-acs-resources/trauma-tools/emergency-general-surgery-anatomic-severity-tables.html)

AAST grade	Description	Operative findings	Histopathological findings
I	Acutely inflamed appendix, intact	Acutely inflamed appendix, intact	Neutrophilic infiltration at the base of the crypts and submucosa, with or without extension into the muscular wall
II	Gangrenous appendix, intact	Gangrenous appendix, intact	Mucosal and muscular wall necrosis; tissue architecture is not identifiable on hematoxylin and eosin (H&E) staining
III	Perforated appendix with localized contamination	Perforated appendix with localized contamination	Gross perforation or focal disruption of the muscular wall
IV	Perforated appendix with periappendiceal phlegmon or abscess	Perforated appendix with periappendiceal abscess or phlegmon	Gross perforation
V	Perforated appendix with generalized peritonitis	Perforated appendix with generalized purulent contamination beyond the periappendiceal region	Gross perforation

WBC-T, CRP, NLR, and LS values were compared according to hospital stay (regular vs. prolonged) and disease severity (uncomplicated vs. complicated). Variables identified in the univariate analyses were subsequently included in the multivariable analysis. Independent predictors of prolonged hospital stay and complicated appendicitis were identified using logistic regression analysis. Optimal cut-off values for the independent predictors were determined using receiver operating characteristic (ROC) curve analysis.

Statistical Analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 26 (IBM, Chicago, IL, USA). The normality of continuous variables was assessed using the Kolmogorov–Smirnov test. Normally distributed variables are presented as mean ± standard deviation. Normally distributed continuous variables were compared using the independent-samples t-test. Non-normally distributed variables were presented as median (minimum–maximum). Between-group comparisons of non-normally distributed variables were performed using the Mann–Whitney U test. Categorical variables were summarized using cross-tabulations. Fisher's exact test was used to calculate p values when expected cell counts were small. Variables identified in the univariate analyses were subsequently included in the multivariable logistic regression models. Results of the logistic regression analyses are reported as odds ratios (ORs) with 95% confidence intervals (CIs). A p value <0.05 was considered statistically significant. Optimal cut-off values were determined using ROC curve analysis and the Youden index.

RESULTS

A total of 425 patients underwent emergency appendectomy for acute appendicitis at the Department of General Surgery, Bursa Yuksek Ihtisas Training and Research Hospital, between May 1, 2024 and April 30, 2025. Thirty-eight patients were excluded because of immunocompromising conditions (n=2), concomitant infections other than appendicitis (n=13), or incomplete medical records (n=23). The remaining 387 patients were included in the analysis (Fig. 1).

Of the study population, 150 patients (38.76%) were female and 237 (61.24%) were male. Age distribution did not differ significantly between the sexes (p=0.282). The length of hospital stay after appendectomy differed between females (2 [1–12] days) and males (2 [1–14] days), although the median length of stay was the same in both groups (p=0.023) (Table 2). To further investigate this finding, cross-tabulation and chi-square analyses were performed to evaluate potential sex-related differences in hospital stay and appendicitis severity. No significant association was observed between sex and hospital stay duration (p=0.07). Likewise, appendicitis severity did not differ significantly between females and males (p=0.77) (Table 3).

Patients were categorized according to hospital stay as either regular (≤2 days) or prolonged (>2 days). The regular-stay group included 291 patients (75.19%), whereas 96 patients (24.81%) had prolonged hospital stays. WBC-T counts did not differ significantly between the two groups (p=0.303) (Table 3). However, CRP levels (p<0.001), NLR (p=0.003), and LS (p=0.006) were significantly higher in patients with prolonged hospital stays (Table 4).

Table 2. Patient age and postoperative hospital stay according to gender

	n (%)	Age (years)	p	Hospital stay (days)	p
Female	150 (38.76)	33 (18-80)	0.282	2 (1-12)	0.02
Male	237 (61.24)	30 (18-81)		2 (1-14)	

Age (years) and hospital stay (days) are presented as median (minimum–maximum). Statistical significance was defined as p<0.05.

Table 3. Association of gender with hospital stay duration and appendicitis severity

	Hospital stay		p	Appendicitis severity		p
	Regular (≤2 days)	Prolonged (>2 days)		Uncomplicated	Complicated	
Female						
n	105	45	0.07	129	21	0.77
%	70%	30%		86%	14%	
Male						
n	186	51		200	37	
%	78.50%	21.50%		84.40%	15.60%	

Chi-square test.

Table 4. Inflammatory markers according to postoperative hospital stay

	Hospital stay		
	Regular (≤ 2 days)	Prolonged (>2 days)	p
WBC-T (/mm^3)	13,930 (4,270-24,970)	13,855 (3,990-29,380)	0.303
CRP (mg/L)	11.7 (0.11-323)	67.55 (3.13-541)	<0.001
NLR	5.38 (1.34-30.53)	7.39 (0.84-34.79)	0.003
LS (%)	79.1 (50.69-96.1)	82.68 (41.47-94.62)	0.006

WBC-T: Total white blood cell count; CRP: C-reactive protein; NLR: Neutrophil-to-lymphocyte ratio; LS: Left shift. Data are presented as median (minimum-maximum). Statistical significance was defined as p<0.05.

Based on pathology reports and appendicitis severity grading, 13 patients (3.4%) underwent negative appendectomy. Following review of operative findings and pathology reports, 179 patients (46.3%) were classified as AAST Grade I, 137 (35.4%) as Grade II, 52 (13.4%) as Grade III, five (1.3%) as Grade IV, and one (0.3%) as Grade V. The uncomplicated appendicitis group consisted of 329 patients (85.01%) including those with negative appendectomy and AAST Grades I and II. The complicated appendicitis group comprised 58 patients (14.99%) with AAST Grades II, IV, and V (Table 5).

Patients with complicated appendicitis had significantly higher WBC-T counts than those with uncomplicated appendicitis (15341±4402 vs. 13878±4126/mm3, respectively; p=0.014). Similarly, CRP (71.55 [3.13–408.97] vs. 12 [0.11–541] mg/L), NLR (8.56 [1.48–23.61] vs. 5.56 [0.84–34.79]), and LS (84.4% [56%–92.2%] vs. 79.5% [41.47%–96.1%]) were all significantly higher in the complicated appendicitis group (p<0.001) (Table 6).

Elevated CRP was identified as an independent predictor of prolonged hospital stay (OR: 1.014, 95% CI: 1.010–1.019; p<0.001). The predictive performance of CRP for prolonged hospital stay was evaluated using ROC curve analysis. The area under the curve (AUC) was 0.728 (p<0.001). Based on the Youden index, the optimal cutoff value was 43.05 mg/L, yielding a sensitivity of 59.4% and a specificity of 79.4% (Fig. 2).

Table 5. Distribution of patients according to the AAST grading system for acute appendicitis (source: https://www.aast.org/trauma-acs-resources/trauma-tools/emergency-general-surgery-anatomic-severity-tables.html)

Pathology	n (%)	n (%)	
Negative appendectomy	13 (3.4)	329 (85.01)	Uncomplicated
AAST Grade I	179 (46.3)		
AAST Grade II	137 (35.4)		
AAST Grade III	52 (13.4)	58 (14.99)	Complicated
AAST Grade IV	5 (1.3)		
AAST Grade V	1 (0.3)		

Negative appendectomies and AAST Grades I–II were classified as uncomplicated appendicitis, whereas AAST Grades III–V were classified as complicated appendicitis.

Table 6. Association of inflammatory markers with appendicitis severity

	Severity		
	Uncomplicated	Complicated	p
WBC-T (/mm^3)	13.878±4.126*	15.341±4402*	0.014
CRP (mg/L)	12 (0.11-541)	71.55 (3.13-408.97)	<0.001
NLR	5.56 (0.84-34.79)	8.56 (1.48-23.61)	<0.001
LS (%)	79.5 (41.47-96.1)	84.4 (56-92.2)	<0.001

WBC-T: Total white blood cell count; CRP: C-reactive protein; NLR: Neutrophil-to-lymphocyte ratio; LS: Left shift. Data are presented as median (range) or *mean±standard deviation (SD), as appropriate according to the data distribution. Statistical significance was defined as p<0.05.

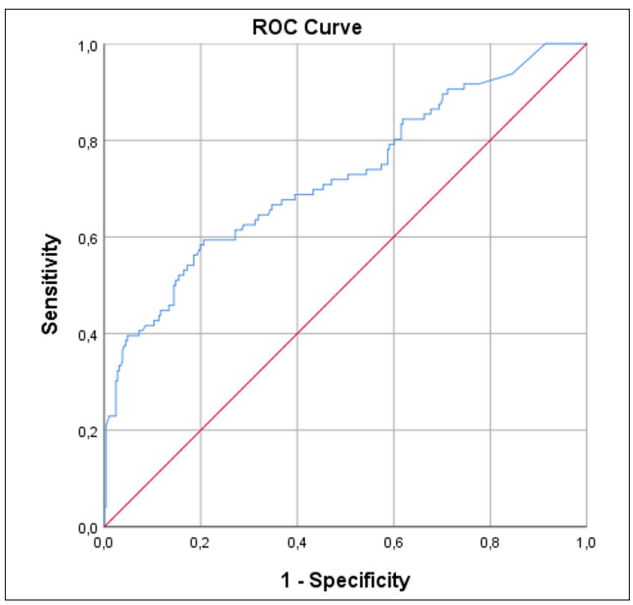

Figure 2. Receiver operating characteristic (ROC) curve for predicting prolonged hospital stay using C-reactive protein (CRP) levels (AUC: 0.724). The optimal CRP cut-off value for predicting prolonged hospital stay was 43.05 mg/L, with a sensitivity of 59.4% and a specificity of 79.4%, as determined by the Youden index (J: 0.388). CRP was identified as an independent predictor of prolonged hospital stay after appendectomy (OR: 1.014, 95% CI: 1.010–1.019; p<0.001).

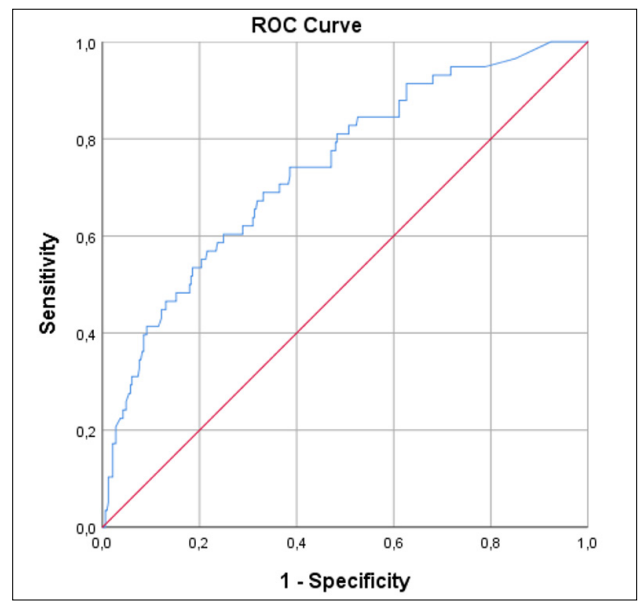

Figure 3. Receiver operating characteristic (ROC) curve for predicting complicated appendicitis using C-reactive protein (CRP) levels. (AUC: 0.740). The optimal CRP cut-off value for predicting complicated appendicitis was 27.46 mg/L, with a sensitivity of 69% and a specificity of 67%, as determined by the Youden index (J: 0.358). CRP was identified as an independent predictor of complicated appendicitis (OR: 1.008, 95% CI: 1.005–1.012; p<0.001).

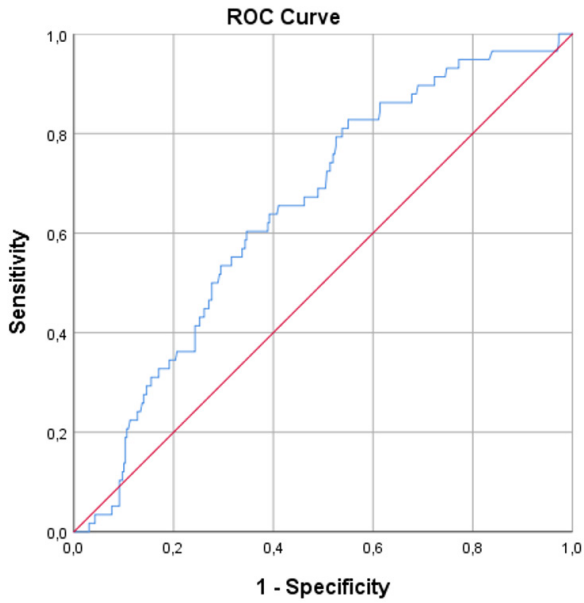

Figure 4. Receiver operating characteristic (ROC) curve for predicting complicated appendicitis using the left shift (LS) ratio. (AUC: 0.649). The optimal LS cut-off value for predicting complicated appendicitis was 77.61%, with a sensitivity of 82.8% and a specificity of 45%, as determined by the Youden index (J: 0.277). Left shift ratio was identified as an independent predictor of complicated appendicitis (OR: 1.049, 95% CI: 1.012–1.087; p=0.008).

Elevated CRP (OR: 1.008, 95% CI: 1.005–1.012; p<0.001) and increased LS (OR: 1.049, 95% CI: 1.012–1.087; p=0.008) were identified as independent predictors of complicated appendicitis. ROC analysis showed that CRP predicted complicated appendicitis with an AUC of 0.74 (p<0.001). The optimal cut-off value was 27.46 mg/L, with a sensitivity of 69% and a specificity of 67% (Fig. 3). The predictive performance of LS was also evaluated by ROC analysis, yielding an AUC of 0.649 (p<0.001). The optimal cut-off value was 77.61%, corresponding to a sensitivity of 82.8% and a specificity of 45% (Fig. 4).

DISCUSSION

Acute appendicitis remains one of the most common surgical emergencies and the leading indication for emergency abdominal surgery.[14] In particular, challenges in preoperative diagnosis[15] and the unpredictability of the clinical course remain important clinical concerns.[16] Therefore, this study aimed to determine whether simple laboratory parameters available at hospital admission could predict disease severity and postoperative outcomes in patients with acute appendicitis.

In our cohort, males accounted for 61.24% of patients, consistent with previous epidemiological studies reporting a higher incidence of acute appendicitis in men.[17,18] This sex difference has been shown to be particularly pronounced among young adults.[19] Our findings are therefore consistent with the existing literature Diagnosis of appendicitis in women may be more challenging because gynecologic conditions often mimic appendicitis, increasing diagnostic complexity and potentially delaying diagnosis.[20]

When hospital stay was analyzed as a continuous variable, the distributions differed between females and males despite identical median values. When hospital stay was analyzed as a categorical variable, no significant difference was observed between females and males. A possible explanation for this finding is that a portion of the sample clustered in the tail of the distribution, resulting in outliers. Therefore, the observed difference in hospital stay duration between sexes should be interpreted with caution. Overall, the results suggest that there is no meaningful difference in the length of hospital stay between the two sexes.[21] It has been hypothesized that biological differences between sexes may influence the course of appendicitis and contribute to prolonged hospital stays.[22] Similarly, we found no difference in the severity of appendicitis between sexes. Previous studies have suggested that anatomical and physiological differences, overlapping gynecologic conditions, and delayed diagnosis may contribute to more severe appendicitis in women.[22,23] However, our findings are consistent with reports demonstrating no association between sex and appendicitis severity.[24]

Comparison of postoperative hospital stay revealed no significant difference in WBC-T counts between patients with regular and prolonged hospitalization. Current evidence regarding the predictive value of leukocytosis, a well-established marker of the immune response to infection, is heterogeneous. While some studies suggest that leukocytosis is not a reliable predictor of hospital stay duration, others have identified it as an independent risk factor for prolonged hospitalization.[25,26] These conflicting findings may be explained by the rapid fluctuations in leukocyte counts[27] and their susceptibility to various influences, including medication use.[28] In contrast, CRP levels (p<0.001), NLR (p=0.003), and LS (p=0.006) were significantly higher in patients with prolonged hospital stays, consistent with previous reports. Acute-phase reactants such as CRP and inflammatory indices such as NLR are more consistent, albeit non-specific, markers of the inflammatory response.[29] Similarly, complete blood count–derived indices, including the left shift[30] and NLR,[31] provide more stable and objective measures of inflammation than leukocytosis alone. Elevated levels of these markers likely reflect greater inflammatory severity, which may contribute to prolonged hospital stay.[32]

Analysis of inflammatory markers for predicting complicated appendicitis showed that WBC-T, CRP, NLR, and LS were significantly higher in patients with complicated appendicitis. Although WBC-T was not a significant predictor of prolonged hospital stay, its higher levels in complicated appendicitis suggest that it may indirectly influence hospitalization duration. However, as discussed previously, the current evidence regarding its prognostic value remains conflicting, indicating

that WBC-T is not a sufficiently reliable predictor when used alone.[33] Given the greater inflammatory burden associated with complicated appendicitis, elevated levels of CRP, NLR, and LS are expected despite their non-specific nature. Although some studies have reported conflicting findings,[34] the current evidence largely supports an association between complicated appendicitis and increased WBC-T,[35] CRP,[36] NLR,[37] and LS.[38]

One of the primary aims of this retrospective study was to identify predictors of prolonged hospital stay. Although several inflammatory markers were associated with prolonged hospitalization, statistical analysis identified only CRP as an independent predictor (OR: 1.014, 95% CI: 1.010–1.019; p<0.001). While some studies have suggested that CRP alone is insufficient to predict hospital stay duration,[39] the majority of available evidence supports a positive association between elevated CRP levels and prolonged hospitalization.[26,32] Therefore, we consider CRP to be an important prognostic marker. We subsequently evaluated its ability to predict prolonged hospital stay and identified an optimal cut-off value of 43.05 mg/L, with a sensitivity of 59.4% and a specificity of 79.4%. A CRP level above this threshold at hospital admission may therefore predict prolonged hospitalization, consistent with previous reports. Similar cut-off values and odds ratios have been reported across different studies and patient populations.[40,41]

The second aim of this study was to evaluate the association between inflammatory markers and complicated appendicitis. Statistical analysis identified elevated CRP (OR: 1.008, 95% CI: 1.005–1.012; p<0.001) and increased LS (OR: 1.049, 95% CI: 1.012–1.087; p=0.008) as independent predictors of complicated appendicitis. The diagnostic value of CRP has been consistently reported in previous studies,[42,43] in agreement with our findings. For CRP, the optimal cut-off value was 27.46 mg/L, with a sensitivity of 69% and a specificity of 67%. Although higher CRP cut-off values have been reported,[44,45] this variability may reflect differences in patient populations and in the classification criteria used to define complicated appendicitis. In our study, complicated appendicitis was classified according to the AAST clinicopathological criteria. Although the identified cut-off value does not provide definitive diagnostic certainty, it demonstrated moderate diagnostic accuracy for predicting complicated appendicitis. These findings further support the clinical value of preoperative CRP measurement at presentation. Similarly, the diagnostic performance of LS in our study was comparable to that reported previously, although the available evidence remains less extensive than for CRP.[46] The optimal LS cut-off value for predicting complicated appendicitis was 77.61%, with a sensitivity of 82.8% and a specificity of 45%, indicating moderate diagnostic performance. Although LS has limited predictive value when used alone, combining it with CRP may improve diagnostic accuracy.

CONCLUSION

Our findings demonstrate that simple inflammatory markers obtained from routine blood tests at hospital admission, particularly CRP, provide valuable prognostic information in patients with acute appendicitis. Elevated CRP was the only independent predictor of prolonged hospital stay and, together with LS, independently predicted complicated appendicitis. The identification of clinically relevant CRP cut-off values for prolonged hospitalization and complicated appendicitis further supports its role in preoperative risk stratification. Although NLR and LS provide additional information, their predictive value appears limited when used in isolation. Incorporating preoperative CRP assessment into routine clinical evaluation may facilitate early identification of patients at increased risk of complications, optimize perioperative management, and improve clinical outcomes. Prospective multicenter studies are needed to validate these findings and refine predictive models.

Ethics Committee Approval: This study was approved by the Medical Sciences Ethics Committee of Bursa Yuksek Ihtisas Training and Research Hospital (Date: 21.05.2025, Decision No: 2024 – TBEK 2025/05-05).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: U.D., U.K., A.T.; Design: U.D., U.K., A.T.; Supervision: U.D., U.K., A.T.; Resource: U.D.; Materials: U.D.; Data collection and/or processing: U.D.; Analysis and/or interpretation: U.D.; Literature review: U.D.; Writing: U.D.; Critical review: U.D.

Informed Consent: Retrospective study.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. GBD 2021 Appendicitis Collaborator Group. Trends and levels of the global, regional, and national burden of appendicitis between 1990 and 2021: findings from the Global Burden of Disease Study 2021. Lancet Gastroenterol Hepatol 2024;9:825–58.
2. Kırman ÜN, Keser BN, Akten H, Çolapkulu N, Sürek A, Erçetin C, et al. Acute appendicitis in Istanbul: An 8-year retrospective cohort study. Med J Bakırköy 2022;18:22–4. [CrossRef]
3. Hashim T, AlTahan YA, Elgassim MA, Zaki HA, Elgassim M, Abdelrahman A. Atypical presentation and diagnostic challenges of appendicitis in an 85-year-old male: a case report. Cureus 2024;16:e65622. [CrossRef]
4. Benabbas R, Hanna M, Shah J, Sinert R. Diagnostic accuracy of history, physical examination, laboratory tests, and point-of-care ultrasound for pediatric acute appendicitis in the emergency department: a systematic review and meta-analysis. Acad Emerg Med 2017;24:523–51. [CrossRef]
5. Chaochankit W, Boocha A, Samphao S. Negative appendectomy rate in patients diagnosed with acute appendicitis. BMC Surg 2022;22:404. [CrossRef]
6. Kularatna M, Lauti M, Haran C, MacFater W, Sheikh L, Huang Y, et al. Clinical prediction rules for appendicitis in adults: which is best? World J

Surg 2017;41:1769–81. [CrossRef]
7. de Castro SM, Ünlü C, Steller EP, van Wagensveld BA, Vrouenraets BC. Evaluation of the appendicitis inflammatory response score for patients with acute appendicitis. World J Surg 2012;36:1540–5. [CrossRef]
8. Shuaib A, Shuaib A, Fakhra Z, Marafi B, Alsharaf K, Behbehani A. Evaluation of modified Alvarado scoring system and RIPASA scoring system as diagnostic tools of acute appendicitis. World J Emerg Med 2017;8:276–80. [CrossRef]
9. Expert Panel on Gastrointestinal Imaging; Garcia EM, Camacho MA, Karolyi DR, Kim DH, Cash BD, et al. ACR Appropriateness criteria® right lower quadrant pain-suspected appendicitis. J Am Coll Radiol 2018;15:S373–87. [CrossRef]
10. Di Saverio S, Podda M, De Simone B, Ceresoli M, Augustin G, Gori A, et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. World J Emerg Surg 2020;15:27. [CrossRef]
11. de Wijkerslooth EML, Bakas JM, van Rosmalen J, van den Boom AL, Wijnhoven BPL. Same-day discharge after appendectomy for acute appendicitis: a systematic review and meta-analysis. Int J Colorectal Dis 2021;36:1297–309. [CrossRef]
12. Clasie KA, Ng SG, Adams S, Karpelowsky J, James R, Iemma JL, et al. Same-Day Discharge for Paediatric Uncomplicated Appendicitis in Australia. ANZ J Surg 2025;95:2543–9. [CrossRef]
13. American Association for the Surgery of Trauma. Emergency General Surgery Anatomic Severity Tables. Available at: https://www.aast.org/resources/trauma-tools/emergency-general-surgery-anatomic-severity-tables.html. Accessed July 2, 2026
14. Moris D, Paulson EK, Pappas TN. Diagnosis and management of acute appendicitis in adults: a review. JAMA 2021;326:2299–311. [CrossRef]
15. Issaiy M, Zarei D, Saghazadeh A. Artificial intelligence and acute appendicitis: a systematic review of diagnostic and prognostic models. World J Emerg Surg 2023;18:59. [CrossRef]
16. Casas MA, Angeramo CA, Monrabal Lezama M, Rotholtz NA, Schlottmann F. C-reactive protein, white blood cells, and neutrophil/lymphocyte ratio for predicting complicated appendicitis: which is more reliable? J Gastrointest Surg 2024;28:1704–5. [CrossRef]
17. Kollias TF, Gallagher CP, Albaashiki A, Burle VS, Slouha E. Sex differences in appendicitis: a systematic review. Cureus 2024;16:e60055. [CrossRef]
18. Zampieri N, Mottadelli G, Camoglio FS. Gender specific data in patients with acute appendicitis: a single center perspective. Minerva Pediatr (Torino) 2024;76:79–85. [CrossRef]
19. Golz RA, Flum DR, Sanchez SE, Liu X, Donovan C, Drake FT. Geographic association between incidence of acute appendicitis and socioeconomic status. JAMA Surg 2020;155:330–8. [CrossRef]
20. Hatipoglu S, Hatipoglu F, Abdullayev R. Acute right lower abdominal pain in women of reproductive age: clinical clues. World J Gastroenterol 2014;20:4043–9. [CrossRef]
21. Walędziak M, Lasek A, Wysocki M, Su M, Bobowicz M, Myśliwiec P, et al. Risk factors for serious morbidity, prolonged length of stay and hospital readmission after laparoscopic appendectomy - results from Pol-LA (Polish Laparoscopic Appendectomy) multicenter large cohort study. Sci Rep 2019;9:14793. [CrossRef]
22. Arda Y, Brackin RB, Nzenwa IC, Holtrop TET, Paranjape CN, Luckhurst CM, et al. Sex-based disparities in acute appendicitis: a nationwide analysis. J Surg Res 2025;316:240–7. [CrossRef]
23. Webster DP, Schneider CN, Cheche S, Daar AA, Miller G. Differentiating acute appendicitis from pelvic inflammatory disease in women of childbearing age. Am J Emerg Med 1993;11:569–72. [CrossRef]
24. Miller G, Gall LS, Macdonald A, Khan KS. Gender disparities in adult patients undergoing emergency appendicectomy: A comparative analysis. Scott Med J 2025;70:4–9. [CrossRef]
25. Crandall M, Shapiro MB, Worley M, West MA. Acute uncomplicated appendicitis: case time of day influences hospital length of stay. Surg Infect (Larchmt) 2009;10:65–9. [CrossRef]
26. Zhang P, Zhang Q, Zhao H, Li Y. Factors affecting the length of hospital stay after laparoscopic appendectomy: A single center study. PLoS One 2020;15:e0243575. [CrossRef]
27. Katoh N, Nishino J, Nishimura K, Kawabata C, Hotta Y, Matsui T, et al. Normal sequential changes in neutrophil CD64 expression after total joint arthroplasty. J Orthop Sci 2013;18:949–54. [CrossRef]
28. Pasternak Y, Yarden-Bilavsky H, Kodman Y, Zoldan M, Tamary H, Ashkenazi S. Inhaled corticosteroids increase blood neutrophil count by decreasing the expression of neutrophil adhesion molecules Mac-1 and L-selectin. Am J Emerg Med 2016;34:1977–81. [CrossRef]
29. Sengul S, Guler Y, Calis H, Karabulut Z. The role of serum laboratory biomarkers for complicated and uncomplicated appendicitis in adolescents. J Coll Physicians Surg Pak 2020;30:420–4. [CrossRef]
30. Tehrani HY, Petros JG, Kumar RR, Chu Q. Markers of severe appendicitis. Am Surg 1999;65:453–5. [CrossRef]
31. Kelly ME, Khan A, Riaz M, Bolger JC, Bennani F, Khan W, et al. The utility of neutrophil-to-lymphocyte ratio as a severity predictor of acute appendicitis, length of hospital stay and postoperative complication rates. Dig Surg 2015;32:459–63. [CrossRef]
32. Bancke Laverde BL, Maak M, Langheinrich M, Kersting S, Denz A, Krautz C, et al. Risk factors for postoperative morbidity, prolonged length of stay and hospital readmission after appendectomy for acute appendicitis. Eur J Trauma Emerg Surg 2023;49:1355–66. [CrossRef]
33. Shrestha B, Koju R , Makaju Shrestha S, Shrestha K, Hada G, Shakya YR, et al . Predicting complicated appendicitis based on neutrophil to lymphocyte ratio, a study in University Hospital of Nepal. Kathmandu Univ Med J (KUMJ) 2023;21:270–4.
34. Yesilalioglu S, Az A, Sogut O, Ergenc H, Demirel I. Systemic inflammatory markers for distinguishing uncomplicated and complicated acute appendicitis in adult patients. North Clin Istanb 2023;10:507–13. [CrossRef]
35. Mei Y, Huang Z, Huang ZY, Shen YB, Liu ZH, Wei QN, et al. Development and validation of a nomogram for predicting perforation in the early 24 h of acute appendicitis. SAGE Open Med 2025;13:20503121251391271. [CrossRef]
36. Basukala S, Gurung S, Tamang A, Shrestha O, Devkota M, Thapa N, et al. Diagnostic value of biochemical markers in prediction of perforation in acute appendicitis: a cross-sectional study. Ann Med Surg (Lond) 2024;86:6495–501. [CrossRef]
37. Hamid F, Ayaz SB, Asif M, Imran MN, Mehraj A, Akhtar N. Peroperative findings in acute appendicitis: relationship with neutrophil-to-lymphocyte and platelet-to-lymphocyte ratios. J Coll Physicians Surg Pak 2025;35:1325–30. [CrossRef]
38. Yazla M, Kadıoğlu B, Demirdelen H, Aksoy FM, Özkan E, Katipoğlu B. Predictive efficacy of immature granulocytes in acute complicated appendicitis. Rev Assoc Med Bras (1992) 2024;70:e20241178. [CrossRef]
39. Shin J, Ihn MH, Kim KS, Kim SH, Lee J, Yun S, et al. Risk factors for prolonged hospitalization and delayed treatment completion after laparoscopic appendectomy in patients with uncomplicated acute appendicitis. Ann Coloproctol 2023;39:50–8. [CrossRef]
40. Dölling M, Klös M, Pachmann J, Stockheim J, Rahimli M, Al-Madhi S, et al. Complicated appendicitis: value of inflammatory markers based on EAES 2015 guidelines. Surg Endosc 2025;39:6586–96. [CrossRef]
41. Liu M, Yang P, Gou Y. Non-linear association between C-reactive protein levels and length of stay in pediatric appendicitis patients undergoing laparoscopic appendectomy. Front Pediatr 2024;12:1464193. [CrossRef]
42. Yu CW, Juan LI, Wu MH, Shen CJ, Wu JY, Lee CC. Systematic review and meta-analysis of the diagnostic accuracy of procalcitonin, C-reactive protein and white blood cell count for suspected acute appendicitis. Br J Surg 2013;100:322–9. [CrossRef]

43. Birben B, Sönmez BM, Er S, Özden S, Kösa MT, Tez M. External validation of the AppendistatTM score and comparison with CRP levels for the prediction of complicated appendicitis. Ulus Travma Acil Cerrahi Derg 2021;27:187–91. [CrossRef]
44. Brombacher M, Moolla H, Nair V, Clarke D. The use of C-reactive protein to predict uncomplicated appendicitis and increase uptake of laparoscopy in low resource hospitals-A retrospective cohort study. World J Surg 2024;48:1515–20. [CrossRef]
45. Díaz López MI, Crespo Álvarez E, Martínez Manzano Á, Urrechaga E, Orgaz Morales MT, González Morales M, et al. Usefulness of extended inflammatory parameters related to neutrophil activation reported by Sysmex XN-1000 hematology analyzer for predicting complicated acute appendicitis. Comparison with canonical inflammatory laboratory tests. Cir Esp (Engl Ed) 2024;102:300–6. [CrossRef]
46. Üstüner MA, Ay OF, Özen AV, Aydın MC. The role of immature granulocytes in predicting complicated appendicitis: a retrospective observational study. Ann Ital Chir 2025;96:1349–56. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Akut appendisitte uzamış hastane yatışı ve inflamasyon şiddetinin göstergeleri: Retrospektif bir kohort çalışması

AMAÇ: Akut appendisit, akut karın durumunun en yaygın nedenlerinden birisidir ve dünya çapında acil abdominal cerrahi girişimler için önde gelen endikasyon olmaya devam etmektedir. Görüntüleme ve klinik skorlama sistemlerindeki ilerlemelere rağmen, hastaneye yatış sırasında hastalık şid-detini ve ameliyat sonrası sonuçları tahmin etmek zor olmaya devam etmektedir. Komplike appendisit veya uzun hastane yatış süresi riski taşıyan hastaların erken tanınması, tedavi planlamasını ve kaynak kullanımını iyileştirebilir. Bu çalışma, kolay ulaşılabilen çeşitli enflamatuvar belirteçlerin komplike appendisit ve uzun hastane yatış süresi için prediktif değerini değerlendirmeyi amaçlamıştır.
GEREÇ VE YÖNTEM: Bu retrospektif çalışma, Mayıs 2024 ile Nisan 2025 tarihleri arasında akut appendisit nedeniyle acil appendektomi geçiren yetişkin hastaları verilerini değerlendirmektedir. Demografik veriler, hastanede kalış süresi, cerrahi ve patolojik bulgular ve yatış sırasındaki laboratuvar parametreleri analize dahil edilmiştir. Toplam lökosit sayısı (WBC-T), C-reaktif protein (CRP), nötrofil-lenfosit oranı (NLR) ve sola kayma (LS) değerlendirilmiştir. Appendisit şiddeti, American Association for the Surgery of Trauma (AAST) derecelendirme sistemi kullanılarak sınıflandırılmış ve komplike olmayan veya komplike olarak gruplandırılmıştır. Hastanede kalış süresi normal (≤2 gün) veya uzun süreli (>2 gün) olarak kategorize edilmiştir. Tek değişkenli ve çok değişkenli lojistik regresyon analizleri ile bağımsız prediktörleri belirlenmiştir. Optimal kestirim değerlerini belirlemek için ROC analizi ve Youden indeksi kullanılmıştır.
BULGULAR: Analize toplam 387 hasta dahil edildi; %24.8'inde hastanede kalış süresi uzadı ve %15.0'inde komplike appendisit görüldü. CRP, NLR ve LS değerleri, hastanede kalış süresi uzamış hastalarda anlamlı derecede daha yüksekti, WBC-T'de anlamlı bir farklılık yoktu. Çok değişkenli analiz, yüksek CRP'yi hastanede kalış süresinin uzamasının tek bağımsız belirleyicisi olarak tanımladı (OR 1.014, %95 CI 1.010–1.019; p<0.001). 43.05 mg/L'lik bir CRP eşik değeri, hastanede kalış süresinin uzamasını %59.4 duyarlılık ve %79.4 özgüllükle tahmin etti (AUC 0.728). Komplike appendisit için, yüksek CRP (OR 1.008, %95 CI 1.005–1.012; p<0.001) ve artmış LS (OR 1.049, %95 CI 1.012–1.087; p=0.008) bağımsız prediktörlerdi. CRP ≥27.46 mg/L, %69 duyarlılık ve %67 özgüllükle (AUC 0.74) komplike appendisiti tahmin ederken, LS ≥%77.61 yüksek duyarlılık ancak sınırlı özgüllük gösterdi.
SONUÇ: Hastaneye yatış sırasında ölçülen CRP değeri, hem uzun hastane yatış süresini hem de komplike appendisit olgularını öngörmede değerli ve pratik bir biyobelirteçtir. CRP ve sola kayma değerlerinin birlikte değerlendirilmesi, ameliyat öncesi risk sınıflandırmasını iyileştirebilir ve klinik karar verme süreçlerine rehberlik edebilir.

Anahtar sözcükler: Akut appendisit; appendektomi; C-reaktif protein; enflamasyon; hastanede kalış süresi.

Ulus Travma Acil Cerrahi Derg 2026;32(8):971-979 DOI: 10.14744/tjtes.2026.73623

ORIGINAL ARTICLE

Evaluation of cases admitted to the Pediatric Surgery Department of the Karadeniz Technical University Faculty of Medicine Hospital due to abdominal trauma between 2019 and 2022 in terms of child abuse

Hacı Seyit Bölükbaşı,[1] Güven Seçkin Kırcı,[2] Erdal Özer[2]

[1]Tunceli Provincial Health Directorate, Tunceli-*Türkiye*

[2]Department of Forensic Medicine, Karadeniz Technical University Faculty of Medicine, Trabzon-*Türkiye*

ABSTRACT

BACKGROUND: Trauma poses a high risk of mortality and morbidity in the pediatric age group. The preventable nature of a considerable portion of trauma cases in this age group highlights a significant issue. In our study, we aimed to raise awareness about abdominal injuries resulting from trauma, focusing on the period from 2019 to 2022 and the cases admitted to the Pediatric Surgery Department at Karadeniz University. We examined cases based on various factors, such as gender, age, origin, injured organ, presence of multiple traumas, duration of hospital admission, month and year of occurrence, length of hospital stay, physical abuse indicators, presence of genital injuries, psychiatric history, whether the incident was an accident or a preventable situation, the presumed responsible party, case type, indicators suggesting neglect, trauma history, vital threat, the presence of bone fractures, and whether simple medical interventions could address the injuries. Across this examination, we aimed to shed light on the extent and forensic aspects of abdominal injuries resulting from trauma, fostering awareness regarding child abuse issues.

METHODS: The research has a cross-sectional descriptive study design and was conducted by retrospectively examining the files of cases that presented with abdominal trauma to the Pediatric Surgery Department of Karadeniz Technical University Faculty of Medicine Hospital between 2019 and 2022. The examination involved both electronic and physical records.

RESULTS: Out of the 64 cases presenting with abdominal trauma, 47 (73.4%) were male, and 17 (26.6%) were female. When examining the origin distribution, falls from a height were the most common cause, accounting for 25 cases (39.1%); followed by 18 cases (28.1%) involving bicycle falls. Regarding the distribution of injured organs, it was found that 15 cases (23.4%) had injuries to multiple abdominal organs, 15 cases (23.4%) had liver injuries, and 12 cases (18.8%) had intra-abdominal free fluid. It was found that 35 cases (54.7%) were forensic cases. Neglect-indicating signs were identified in 41 cases (64%).

CONCLUSION: Pediatric trauma, including the mechanisms of trauma occurrence and child abuse, is a subject that needs to be addressed from a forensic medical perspective. Preventive measures for trauma in the pediatric age group should be organized and reviewed, and healthcare professionals should not forget their legal reporting obligations in cases of forensic traumatic injuries.

Keywords: Child abuse; forensic medicine; traumatic injury.

INTRODUCTION

A significant proportion of trauma cases across all age groups consists of childhood trauma. Trauma, which poses a major threat to child health, continues to be an important problem despite advances in preventive measures and emergency and intensive care services. Childhood trauma remains a critical public health issue, particularly because it is largely preventable.

Cite this article as: Bölükbaşı HS, Kırcı GS, Özer E. Evaluation of cases admitted to the pediatric surgery Department of Faculty of Medicine hospital due to abdominal trauma between 2019 and 2022 in terms of child abuse. Ulus Travma Acil Cerrahi Derg 2026;32:980-986.

Address for correspondence: Hacı Seyit Bölükbaşı

Tunceli Provincial Health Directorate, Tunceli, Türkiye

E-mail: hseyitbolukbasi166@gmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):980-986 DOI: 10.14744/tjtes.2026.17339

Submitted: 16.02.2026 Revised: 12.04.2026 Accepted: 27.06.2026 Published: 10.08.2026

Pediatric trauma is currently the leading cause of mortality among children. Each year, more than 1.5 million children are injured, and approximately 500,000 of them require hospitalization. These injuries result in severe trauma in nearly 25% of patients under 18 years of age, and an estimated 15,000–20,000 children die annually due to trauma.[1]

In cases of severe pediatric trauma, multisystem injuries occur in approximately half of the patients, resulting in multi-organ injury. Blunt trauma in pediatric patients frequently leads to intra-abdominal organ injuries. Approximately 10% of trauma-related deaths in children are attributed to abdominal trauma. Following head and thoracic injuries, abdominal trauma ranks third among the causes of trauma-related mortality.[1] Childhood trauma, being largely preventable, constitutes a major public health concern. A 2008 study conducted by United Nations International Children's Emergency Fund and the Social Services and Child Protection Agency revealed that among children aged 7–18 years in Türkiye, 45% were exposed to physical abuse, 51% to emotional abuse, and 25% to neglect within the family environment.[2]

In our study, we aimed to raise awareness regarding child abuse by examining the cases admitted with abdominal trauma to the Pediatric Surgery Department of Karadeniz Technical University Faculty of Medicine Hospital , between 2019 and 2022.

MATERIALS AND METHODS

The study is a retrospective, cross-sectional, descriptive research. The electronic medical records of 64 patients who were admitted to the Pediatric Surgery Department of Karadeniz Technical University Faculty of Medicine Hospital due to abdominal trauma between 2019 and 2022 (January 01, 2019–December 31, 2022) were reviewed. These 64 cases constituted the study population.

From the patient records, the following variables were extracted and entered into the data collection form designed for the study: Sex, age, origin, injured organ, presence of multitrauma, time from injury to hospital admission, month and year of the incident, length of hospital stay, findings suggestive of physical abuse, presence of genital injury, psychiatric history, whether the event was accidental or preventable, the person believed to be responsible, case type, indicators of possible neglect, trauma history, presence of life-threatening injury, bone fractures, and whether the condition could be managed with simple medical intervention. Descriptive statistics for the age variable were presented using frequency (n) and percentage (%). Chi-square analysis was used to compare variables, such as origin with age, sex, multitrauma, and findings indicative of neglect. Statistical analyses and calculations were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics 26.0 (IBM Corp. Released 2019. The IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.). Ethical approval for the study was obtained from the Scientific Research Ethics Committee of Karadeniz Technical University Faculty of Medicine on 24 February 2023, with decision number 24237859-139. Permission for physical and electronic archive review was obtained from the Chief Physician's Office of Karadeniz Technical University Faculty of Medicine Hospital.

RESULTS

Of the individuals included in the study, 73.4% were male and 26.6% were female; 14.1% were aged 0–3 years, 17.1% were 4–6 years, 39.1% were 7–11 years, and 29.7% were 12–18 years. Evaluation of the causes of the incidents revealed that 10.9% were due to in-vehicle traffic accidents, 7.8% to non-vehicle traffic accidents, 39.1% to falls from height, 4.7% to assault, 4.7% to firearm injuries, 28.1% to bicycle falls, 1.6% to being trapped under an object, and 3.1% to animal-related injuries; no cases involved injuries caused by sharp, penetrating, or crushing instruments. Regarding organ involvement, 23.4% of the injuries affected the liver, 14.1% the spleen, 4.7% the kidney, 1.6% the jejunum, 1.6% the bladder, and 23.4% constituted multiple-organ injuries. Free intraperitoneal fluid was detected in 18.8% of cases, and 3.1% presented with laboratory abnormalities; additionally, 9.4% had no identifiable organ injury. No isolated colon, pancreas, stomach, duodenum, ileum, or retroperitoneal hematoma injuries were identified. All cases were assessed for findings suggestive of physical abuse – including bruises of varying ages, oral injury findings (frenulum and upper-lip lacerations due to facial trauma, dental avulsions, pulp necrosis, and fractures of teeth, jaw, and facial bones), burns and fractures suspicious for abuse – and none of the individuals (n=64, 100%) exhibited any signs of physical abuse or genital injury. Of the cases, 15.6% were classified as accidental, 67.2% as preventable, and 17.2% lacked sufficient information. In the assessment of unsafe in-vehicle travel, the evaluation focused on whether age-appropriate safety measures were taken, including child-seat use and the child's seating position. Unsafe out-of-vehicle travel considered whether necessary precautions were taken during pedestrian movement. Situations involving unsecured household items were evaluated based on the presence of objects that could fall due to child interaction and lead to trauma. Unsafe play environments included settings, such as balconies, stair gaps, and large vehicle beds that could cause fall-related injuries. Failure to restrict access to sharp instruments or firearms was noted in cases where preventive measures were lacking. Insufficient supervision during peer interactions was assessed in situations where the child was in environments or with individuals that could pose a risk for trauma.

In the category of medical neglect, situations, such as failure to comply with healthcare professionals' recommendations and delays by parents in seeking timely medical care for their children were taken into consideration. When examining the distribution of findings suggestive of neglect, 7.8% were related to unsafe in-vehicle travel, 6.3% to unsafe out-of-vehicle

Table 1. Distribution of findings suggestive of neglect

	n	%
Unsafe in-vehicle travel	5	7.8
Unsafe travel outside the vehicle	4	6.3
Failure to secure household items	1	1.6
Unsafe play environment	26	40.6
Lack of restriction to access sharp objects and firearms	2	3.1
Inadequate supervision in peer interactions	2	3.1
Medical neglect	1	1.6
None	12	18.8
Unknown	11	17.2
Total	64	100.0

travel, and 40.6% to unsafe play environments. In 18.8% of the cases, no findings suggestive of neglect were identified, while data were unavailable for 17.2% of cases (Table 1).

According to Table 2, a statistically significant association was identified between the origin of the incident and findings suggestive of neglect (p<0.001). Among individuals involved in in-vehicle traffic accidents, 71.4% had findings indicative of unsafe in-vehicle travel; 80.0% of those involved in out-of-vehicle traffic accidents had findings consistent with unsafe pedestrian travel; 76.0% of individuals who sustained injuries due to falls from height had findings suggestive of unsafe play environments; 66.7% of assault victims had no findings indicative of neglect; and 66.7% of firearm-related injury cases demonstrated failure to restrict access to sharp instruments or firearms.

Table 3 presents the distribution between age groups and findings suggestive of neglect. Among individuals aged 0–3 years, 22.2% were involved in unsafe in-vehicle travel, while 44.4% of those aged 0–3 years, 63.6% of those aged 4–6 years, and 52.0% of those aged 7–11 years were found to be in unsafe play environments. Among individuals aged 12–18 years, 42.1% had no findings suggestive of neglect. A statistically significant association was found between age and findings indicative of neglect (p=0.009).

A statistically significant relationship was also identified between the origin of the incident and the individual considered responsible or at fault (p=0.003). In in-vehicle (71.4%) and out-of-vehicle (80.0%) traffic accidents, as well as in cases of firearm injury (66.7%), bicycle-related falls (38.9%), entrapment under an object (100.0%), and animal-related injuries (50.0%), the person suspected or considered responsible was predominantly a parent. In all assault cases (100.0%), the suspected or responsible individual was determined to be a peer (Table 4).

Table 2. Comparison of origin and indicators suggestive of neglect

Findings suggestive of neglect	Unsafe in vehicle travel n (%)	Unsafe travel outside the vehicle n (%)	Unsecured household items n (%)	Unsafe play environment n (%)	Failure to prevent access to sharp objects and firearms n (%)	Insufficient supervision in peer relationships n (%)	Medical neglect n (%)	None n(%)	Unknown n (%)	χ^2	p
Origin											
In-vehicle traf-fic accident	5 (71.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (28.6)		
Out-of-vehicle traffic accident	0 (0.0)	4 (80.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (20.0)		
Fall from height	0 (0.0)	0 (0.0)	0 (0.0)	19 (76.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (12.0)	3 (12.0)		
Assault	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	2 (66.7)	0 (0.0)		
Firearm injury	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (66.7)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	113.176	<0.001*
Fall from bicy-cle	0 (0.0)	0 (0.0)	0 (0.0)	6 (33.3)	0 (0.0)	0 (0.0)	1 (5.6)	6 (33.3)	5 (27.8)		
Being trapped under an object	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		
Animal-related injury	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	0 (0.0)		

*Likelihood ratio test.

Table 3. Comparison of age and indicators suggestive of neglect

Indicators suggestive of neglect	Unsafe in vehicle travel n (%)	Unsafe travel outside the vehicle n (%)	Unsecured household items n (%)	Unsafe play environment n (%)	Failure to prevent access to sharp objects and firearms n (%)	Insufficient supervision in peer relationships n (%)	Medical neglect n (%)	None n(%)	Unknown n (%)	χ^2	p
Age											
0–3	2 (22.2)	0 (0.0)	1 (11.1)	4 (44.4)	0 (0.0)	0 (0.0)	1 (11.1)	0 (0.0)	1 (11.1)		
4–6	1 (9.1)	1 (9.1)	0 (0.0)	7 (63.6)	0 (0.0)	0 (0.0)	0 (0.0)	1 (9.1)	1 (9.1)	33.628	0.009*
7–11	1 (4.0)	3 (12.0)	0 (0.0)	13 (52.0)	1 (4.0)	0 (0.0)	0 (0.0)	3 (12.0)	4 (16.0)		
12–18	1 (5.3)	0 (0.0)	0 (0.0)	2 (10.5)	1 (5.3)	2 (10.5)	0 (0.0)	8 (42.1)	5 (26.3)		

*Likelihood ratio test.

DISCUSSION

Trauma constitutes a major concern in the pediatric age group due to its high associated mortality and morbidity. In the United States, traumatic injuries in children older than 1 year result in over 20,000 deaths annually. Following head trauma, abdominal injury represents the leading cause of mortality.[3] The fact that a substantial proportion of trauma cases in this population is an important issue that warrants attention. Due to the insufficient development of awareness, increased vulnerability to injury, and inadequate parental supervision and attentiveness, children in this age group are placed at heightened risk for traumatic events.

In our study, among the cases (n=64), 14.1% were between 0 and 3 years of age, 17.1% between 4 and 6 years, 39.1% between 7 and 11 years, and 29.7% between 12 and 18 years. A thesis conducted in Ankara that evaluated abdominal trauma in children, 9.4% of the cases were between 0 and 2 years, 18.3% between 3 and 6 years, 24.9% between 7 and 11 years, and 47.3% between 12 and 18 years.[4] In the study by Yasak et al.,[5] which examined children who developed solid organ injury following abdominal trauma and presented to the emergency department, among 70 cases, 44.3% were aged 0–6 years, 41.4% were aged 7–12 years, and 14.3% were aged 13–18 years.In the study by Ameh et al.[6] assessing blunt abdominal trauma in children, among 56 cases, 5 (8.9%) were younger than 5 years, 28 (50%) were between 5 and 9 years, and 23 (41.1%) were between 10 and 15 years. In a thesis study conducted in Erzurum evaluating pediatric trauma cases undergoing forensic assessment, among 1,663 cases, 4.4% (n=74) were in the infancy period (0–2 years), 7.3% (n=121) in the play age group (3–6 years), 13.4% (n=223) in the school-age group (7–11 years), and 74.9% (n=1,245) in the adolescence period (12–18 years).[7] When the age distribution of our cases is compared with those in the literature, several differences become apparent. These disparities may be attributed to factors, such as the evaluation of abdominal trauma based on specific mechanisms of injury, the classification of individuals older than 15 years as adults in many international studies, and the formation of age groups according to treatment-oriented rather than medicolegal perspectives. Consequently, these methodological variations contribute to the differences observed between the age distribution in our study and those reported in the literature.

In our study, 73.4% of the evaluated cases (n=64) were male and 26.6% were female, indicating that male patients were admitted to the Pediatric Surgery ward for abdominal trauma at a rate three times higher than females. In a thesis conducted in Ankara evaluating abdominal trauma in children (n=2413), 66.7% of the cases were male and 33.3% were female, with male patients being twice as numerous as female patients.[8] In the study by Durak et al.,[9] which examined 58 pediatric patients who presented to the Pediatric Surgery Department with blunt abdominal trauma and had corresponding medicolegal files, 67% of the cases were male and 33% were female.

Table 4. Comparison of origin and the accused or allegedly responsible person

Accused or allegedly responsible person	Parent n (%)	Friend n (%)	None n (%)	Unknown n (%)	χ^2	p
Origin						
In-vehicle traffic accident	5 (71.4)	0 (0.0)	0 (0.0)	2 (28.6)		
Out-of-vehicle traffic accident	4 (80.0)	0 (0.0)	0 (0.0)	1 (20.0)		
Fall from height	19 (76.0)	0 (0.0)	3 (12.0)	3 (12.0)		
Assault	0 (0.0)	3 (100.0)	0 (0.0)	0 (0.0)		
Firearm injury	2 (66.7)	1 (33.3)	0 (0.0)	0 (0.0)	33.857	0.003*
Fall from bicycle	7 (38.9)	0 (0.0)	6 (33.3)	5 (27.8)		
Being trapped un-der an object	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)		
Animal-related in-jury	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)		

*Fisher-Freeman Halton test

Similarly, in Günal's[10] study of 304 pediatric patients admitted for blunt trauma, 62% were male and 38% were female. Akay et al.[11] also reported in their assessment of 328 pediatric trauma cases that 73% were male and 27% were female, demonstrating a threefold predominance of males.Overall, research conducted in our country consistently shows that males in the pediatric age group are more frequently exposed to trauma. When evaluated in the context of similar studies in the literature, our findings regarding sex distribution are consistent and support this predominance of male involvement in traumatic injuries.

When the etiological causes of the cases in our study were evaluated, it was determined that among the 64 patients, 25 (39.1%) sustained injuries due to falls from height, 18 (28.1%) due to bicycle falls, 12 (18.7%) due to traffic accidents, and 3 (4.7%) as a result of assault; moreover, 95% of all cases involved blunt trauma as the underlying mechanism. In a thesis study conducted in Ankara evaluating abdominal trauma in children, the mechanism of trauma in 2,413 cases was reported as follows: 51.9% traffic accidents, 22.5% assault, 14% falls, and 1.5% bicycle-related falls. It was also found that 93.7% of the cases resulted from blunt trauma.[4] In another thesis study conducted in Erzurum at the Department of Forensic Medicine, which evaluated pediatric trauma cases subjected to medicolegal assessment, 1,663 cases were analyzed in terms of origin, revealing that 52.8% were due to assault, 18.4% were traffic accidents, and 3.5% were falls. Regarding the mechanism of injury, 75.5% of the cases were caused by blunt trauma.[7] In the study by Yasak et al.,[5] which examined 70 pediatric patients who developed solid organ injury following blunt abdominal trauma, the mechanisms were reported as 41.4% falls from height, 35.7% traffic accidents, and 8.5% bicycle accidents. According to the literature, 90–91% of pediatric trauma cases are attributed to blunt mechanisms, whereas only 9–10% result from penetrating trauma,[12] demonstrating that the trauma mechanisms in our study are consistent with previously published data. Studies conducted on medicolegal case archives have shown that the most common types of forensic cases are assault and traffic accidents.[7,13] In contrast, in our study, falls from height and bicycle accidents were identified as the most frequent etiological factors.

In our study, the distribution of injured organs revealed that 23.4% of injuries involved the liver, 14.1% the spleen, 4.7% the kidney, 1.6% the jejunum, 1.6% the bladder, and 23.4% constituted multiple organ injuries. In addition, 18.8% of the cases demonstrated free intra-abdominal fluid, and 3.1% showed abnormalities in hematologic parameters, while 9.4% of the patients exhibited no identifiable organ injury. According to the literature, approximately 95% of abdominal traumas in children are blunt in nature, most commonly involving the liver, spleen, kidneys, and small intestine, whereas only about 5% are penetrating injuries, in which the small intestine, liver, major vessels, and kidneys are most frequently affected.[13] In a thesis study conducted in Diyarbakır evaluating childhood physical trauma cases with medicolegal reports, among 51 patients with intra-abdominal organ injuries, 37.3% had splenic injuries and 19.6% had hepatic injuries, indicating that the spleen and liver were the most commonly affected organs.[14] When assessed in terms of injured organ distribution, the findings of our study are consistent with those reported in the literature.

In our study, when the association between trauma origin and findings suggestive of neglect was examined, it was determined that 19 of the 25 cases involving falls from height (76%) could potentially be attributed to neglect due to unsafe play environments (Table 2). In a study conducted among 185 mothers in the province of Kilis, 32.4% reported leaving their children alone at home, 9.7% reported confining their children to a room, and emotional abuse/neglect behaviors were identified in 79.5% of participants. Among the 25 cases of falls from height in our study, 11 cases (44%) were classified as medicolegal incidents, whereas 8 cases presenting

findings suggestive of neglect were not evaluated as medicolegal cases.[15] The World Health Organization (WHO) defines an accident as "an unexpected event that occurs suddenly and outside human intent, causing physical or psychological harm." Injuries resulting from accidents, particularly those involving children, constitute a significant public health problem.[16] In our study, the assessment was based on findings suggestive of neglect; however, establishing definitive neglect requires comprehensive social and medicolegal investigations, after which an informed conclusion can be reached.

When the cases in our study were evaluated in terms of mechanism of origin and sex, it was found that among the 25 fall-from-height cases, 18 (72%) were male and 7 (28%) were female. In a study conducted by Fidanci et al.[17] on individuals aged 0–18 years, 60% of the 210 pediatric fall cases were reported to be male. Similarly, in the study by Rajagopal et al.,[18] which evaluated patients presenting to the emergency department due to falls, 63.7% of the 102 cases were identified as male. The sex distribution of fall-from-height cases in our study appears consistent with the findings reported in the literature.

In our study, findings suggestive of neglect were identified in 41 cases (64%) (Table 1), and no evidence of physical abuse or genital injury was detected in any case. In a thesis evaluating blunt trauma cases in the pediatric age group presenting to the Emergency Department, 8 of the 1,524 cases were assessed for abuse; among these, 1 case was diagnosed with physical abuse, neglect was suspected in 1 case, 5 cases were classified as suspected abuse, and abuse was ruled out in 1 case.[8] In a study by Taitz et al.[19] evaluating long-bone fractures in 100 children under the age of three presenting to the emergency department, the most common mechanism of injury was falls (79%), and 31 cases were considered suspicious for abuse; however, only 1 of these children was referred to a child protection unit. In the study by Chang et al.,[20] among 11,919 pediatric trauma service admissions, child abuse was identified in 171 cases (1.4%). Given that our study relied on available medical records to retrospectively assess patient history and physical examination findings – which may be incomplete – and considering that most studies on child abuse in Türkiye consist of case reports rather than comprehensive data reflecting the national population, a robust comparison with the existing literature could not be achieved.

CONCLUSION

Deficiencies in educational environments, insufficient parental supervision, socioeconomic challenges, ongoing conflicts, and migration are factors that increase the likelihood of children being exposed to traumatic events. Within both the family environment and the educational setting, parents and teachers should implement training programs aimed at enhancing awareness of circumstances and environments in which children may encounter traumatic situations. For children living apart from their families or those without parental care, the level of social support and monitoring should be strengthened, and necessary preventive measures should be implemented within the scope of preventive health services.

Although trauma in children does not typically result in death, it may lead to significant injuries and potentially cause long-term sequelae. Preventive measures can be implemented particularly in home and school environments to reduce the risk of accidental injuries. Such measures include installing protective covers on sharp-edged household items; storing cutting and piercing instruments out of children's reach; placing fragile decorative objects in inaccessible areas; keeping hot food and beverages away from children; installing safety covers on electrical outlets; securing cabinets and drawers with locks; using child safety locks on stairs, windows, balconies, and doors; anchoring furniture, such as televisions and cabinets to the wall; securing carpets to prevent slipping; and ensuring that floors are not left wet. These precautions play a critical role in minimizing preventable childhood trauma.

In bicycle-related accidents, which children frequently engage in, the use of protective equipment should be encouraged to prevent injuries or minimize their severity. Children who are pedestrians in traffic should receive age-appropriate traffic education beginning as early as possible, and the use of child safety seats in vehicles should be strictly monitored and enforced.

The reporting of cases in which child maltreatment is suspected constitutes an ethical, humanitarian, and legal obligation for all healthcare professionals. Awareness of relevant risk factors, warning signs, and differential diagnostic considerations can provide a more informed basis for clinical suspicion and improve the accuracy of evaluations. Knowledge of national legal regulations is essential to prevent secondary victimization and further exposure to abuse; when necessary, suspected victims may be monitored and protected until an authorized judicial decision is issued.

Ethics Committee Approval: This study received ethical approval from the Scientific Research Ethics Committee of Karadeniz Technical University Faculty of Medicine (Date: 24.02.2026, Decision No: 24237859-139).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: H.S.B., G.S.K., E.Ö.; Design: H.S.B., G.S.K., E.Ö.; Supervision: H.S.B., G.S.K., E.Ö.; Resource: H.S.B., G.S.K., E.Ö.; Materials: H.S.B., G.S.K., E.Ö.; Data collection and/or processing: H.S.B., G.S.K., E.Ö.; Analysis and/or interpretation: H.S.B., G.S.K., E.Ö.; Literature review: H.S.B., G.S.K., E.Ö.; Writing: H.S.B., G.S.K., E.Ö.; Critical review: H.S.B., G.S.K., E.Ö.

Informed Consent: Retrospective study.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Melek M, Çobanoğlu U, Bilici S, Ceylan A, Beğer B, Epçaçan Set, et al. Çocukluk Çağı Travmalarına Genel Yaklaşım. Van Tıp Dergisi 2013;20:266–73.
2. UNICEF. Research study on child abuse and domestic violence in Turkey: summary report. Ankara: UNICEF; 2010. Available at: https://www.unicef.org/turkiye/en/reports/research-study-child-abuse-and-domestic-violence-turkey-summary-report-2010. Acccessed July 03, 2026
3. Kepron C, Walker A, Milroy CM. Are There Hallmarks of Child Abuse? II. Non-Osseous Injuries. Acad Forensic Pathol 2016;6:591–607. [CrossRef]
4. Demir T. Çocuklarda batın travmalarının değerlendirilmesi (bir çocuk travma merkezinin analizi) [thesis]. Ankara (TR): Ankara Şehir Hastanesi, Department of Pediatric Surgery; 2022.
5. Yasak İH, Giden R. Künt abdominal travma sonrası solid organ hasarı gelişen çocukların incelenmesi. Harran Üniversitesi Tıp Fakültesi Dergisi 2022;19:600–4. [Article in Turkish] [CrossRef]
6. Ameh EA, Chirdan LB, Nmadu PT. Blunt abdominal trauma in children: epidemiology, management, and management problems in a developing country. Pediatr Surg Int 2000;16:505–9. [CrossRef]
7. Kılınç B. Atatürk Üniversitesi Tıp Fakültesi Adli Tıp Anabilim Dalında 2016–2018 yılları arasında adli değerlendirilmesi yapılan çocuk travma olgularının retrospektif incelenmesi [thesis]. Erzurum: Atatürk Üniversitesi Tıp Fakültesi, Adli Tıp Anabilim Dalı; 2020. [in Turkish]
8. Uygul E. Ondokuz Mayıs Üniversitesi Sağlık Uygulama ve Araştırma Merkezi Acil Servisine 2015–2020 yılları arasında başvuran çocuk yaş grubu künt travma olgularının adli tıp açısından değerlendirilmesi [thesis]. Samsun: Ondokuz Mayıs Üniversitesi; 2021. [in Turkish]
9. Durak D, Çoltu A, Fedakar R. Konservatif tedavi uygulanan künt batın travmalı çocuklarda teşhis kriterleri ve dalak lezyonlarının adli tıp açısından değerlendirilmesi. Bull Leg Med 1996;1:127–31. [Article in Turkish]
10. Günal Y. Üçüncü basamak bir hastaneye bir yıl içinde künt travma nedeniyle başvuran çocuk hastaların incelenmesi. Kırıkkale Üni Tıp Derg 2020;22:216–24.
11. Akay MA, Gürbüz N, Yayla D, Elemen EL, Yıldız GE, Esen HK, et al. Acil servise başvuran pediatrik travma olgularının değerlendirilmesi. Kocaeli Tıp Dergisi 2013;2:1–5. [Article in Turkish]
12. Sayan A, Şafak K, Okay T, Arıkan A. Çocuklarda bisiklet travmaları. Çocuk Cerrahisi Dergisi 2021;21:86–92. [Article in Turkish]
13. Günaydın M. Çocuklarda travma. Derman Tıbbi Yayıncılık; 2015 Oct 1. Available at: https://www.mithatgunaydin.com/wp-content/uploads/2019/06/Derman-kitap-KATD-3886.pdf. Accessed July 03, 2026 [in Turkish]
14. Buğdaycı R. Adli Tıp Anabilim Dalı tarafından adli raporları düzenlenmiş olan çocukluk çağı fiziksel travma olgularının değerlendirilmesi [Master's thesis]. Diyarbakır: Dicle University; 2021. [Article in Turkish]
15. Karasu F, Bilgen F gül. Anneleri tarafından çocuklara uygulanan duygusal ve fiziksel istismar/ihmal davranışları. Kilis 7 Aralık Üniversitesi Sosyal Bilimler Dergisi 2017;7:22–34. [Article in Turkish]
16. Aslan F, Yaşar Teke H, Kıhtır HS, Pakiş I. Kaza ihmali mi-yoksa ihmal kazayı mı aklımıza getirir?-olgu sunumu. Bulletin of Legal Medicine 2023;28:207–11. [Article in Turkish] [CrossRef]
17. Fidancı İ, Derinöz O, Tokgöz A. Çocuk acil servise düşmeye bağlı travma nedeniyle getirilen olgular. pediatr pract res 2021;9:5–10. [Article in Turkish] [CrossRef]
18. Rajagopal M, Kundra M, Mabood N, Ali S, Rankin T, Dow N, et al. Paediatric injuries due to falls from windows and balconies: an 8-year prospective and retrospective review. Paediatr Child Health 2020;26:e222–8. [CrossRef]
19. Taitz J, Moran K, O'Meara M. Long bone fractures in children under 3 years of age: is abuse being missed in Emergency Department presentations?. Journal of Paediatrics and Child Health 2004;40:170–4. [CrossRef]
20. Chang D, Knight V, Ziegfeld S, Haider A, WarieldD, Paidas C. Share Favorites Permissions Original Articles The Tip of the Iceberg for Child Abuse: The Critical Roles of the Pediatric Trauma Service and its Registry. The Journal of Trauma: Injury, Infection, and Critical Care 2004;57:1189–98.

ORİJİNAL ÇALIŞMA - *ÖZ*

Karadeniz Teknik Üniversitesi Tıp Fakültesi Hastanesi Çocuk Cerrahisi Servisine 2019-2022 yılları arasında batın travması nedeniyle kabul edilen olguların çocuk istismarı açısından değerlendirilmesi

AMAÇ: Travma, pediatrik yaş grubunda yüksek ölüm ve hastalık riskine yol açmaktadır. Bu yaş grubundaki travma vakalarının büyük bir kısmının önlenebilir olması, dikkate değer bir durumu ortaya koymaktadır. Çalışmamızda; Karadeniz Teknik Üniversitesi Tıp Fakültesi Hastanesi Çocuk Cerrahi Servisi'ne 2019-2022 yılları arasında batın travması nedeniyle başvuru yapmış olguların, cinsiyet, yaş, orijin, yaralanan organ, multitravma varlığı, hastaneye geliş süresi, gerçekleştiği ay ve yıl, yatış süresi, fiziksel istismar bulguları, genital yaralanma varlığı, psikiyatrik özgeçmiş, olayın kaza mı önlenebilir bir durum olup olmadığı, sorumlu olduğu düşünülen kişi, vaka türü, ihmal düşündüren bulgular, travma özgeçmişi, yaşamsal tehlike, kemik kırığı ve basit tıbbi müdahale ile giderilip giderilemeyeceği bakımından inceleyerek, batın travması sonucu yaralanmaların düzeyleri, adli boyutu ile çocuk istismarı konularında farkındalık yaratmak amaçlanmıştır.

GEREÇ VE YÖNTEM: Araştırmanın yapısı kesitsel tanımlayıcı bir çalışma niteliğinde olup, Karadeniz Teknik Üniversitesi Tıp Fakültesi Hastanesi Çocuk Cerrahi Servisi'ne 2019–2022 yılları arasında batın travması nedeniyle başvuru yapmış olguların dosyalarının elektronik ve fiziki ortamda geriye dönük olarak incelenmesi ile yapılmıştır.

BULGULAR: Batın travması nedeniyle başvuran 64 olgudan 47'sinin (%73.4) erkek, 17'sinin (%26.6) kız olduğu görüldü. Orijin dağılımları incelendiğinde; 25 (%39.1) olgu ile yüksekten düşme ilk sırada gelirken, 18 (%28.1) olgu ile bisikletten düşme ikinci sırada yer almaktadır. Yaralanan organ dağılımlarına bakıldığında; 15 (%23.4) olguda birden fazla batın bölgesi organın yaralandığı, 15 (%23.4) olguda karaciğer yaralanması olduğu, 12 (%18.8) olguda batında serbest mayi olduğu saptanmıştır. 35 olgunun (54.7) adli vaka olduğu görüldü. 41 olguda (%64) ihmal düşündüren bulgu saptandı.

SONUÇ: Pediatrik travmanın travma oluş mekanizmaları ve çocuk istismarı, adli tıbbi açıdan ele alınması gereken bir konudur. Pediatrik yaş grubu için travmayı önleyici tedbirler düzenlenmeli ve gözden geçirilmeli, adli travmatik yaralanmalarda sağlık personeli adli bildirim yükümlülüğünü unutmamalıdır.

Anahtar sözcükler: Adli tıp; çocuk istismarı; travmatik yaralanma.

Ulus Travma Acil Cerrahi Derg 2026;32(8):980-986 DOI: 10.14744/tjtes.2026.17339

ORIGINAL ARTICLE

From fracture-related injury to surgically modifiable risk: a trauma-focused bibliometric analysis of craniofacial nerve injuries

Burak Karip,[1,2] Fatma Ok,[1] Fulya Temizsoy Korkmaz[1]

[1]Department of Anatomy, Hamidiye Faculty of Medicine, University of Health Sciences, İstanbul-*Türkiye*
[2]Council of Forensic Medicine, Ministry of Justice, İstanbul-*Türkiye*

ABSTRACT

BACKGROUND: Craniofacial nerve injuries are a major source of long-term morbidity following maxillofacial trauma, often resulting in substantial functional impairment and psychosocial burden. This study aimed to perform a trauma-focused bibliometric analysis of the evolving research landscape on craniofacial nerve injuries and to determine whether the literature reflects a shift from trauma-related injury mechanisms toward surgically modifiable risk factors.

METHODS: A bibliometric analysis was conducted using publications indexed in the Web of Science (WoS) Core Collection and Scopus databases. Articles and reviews were retrieved using predefined trauma-related search terms. The search identified 119 records in WoS and 449 records in Scopus. Following database integration, duplicate removal, and PRISMA-guided (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) screening, 118 publications were included in the final analysis. Bibliographic data were evaluated to characterize thematic distribution, temporal trends, and comparative patterns among facial, inferior alveolar, and lingual nerve injuries. Keyword-based thematic clustering was used to identify major research domains.

RESULTS: Three principal trauma-related anatomical clusters were identified: facial nerve, inferior alveolar nerve, and lingual nerve injuries. Facial nerve injury emerged as the dominant research theme and was primarily associated with risks related to surgical approaches and operative management. Inferior alveolar nerve injury was more commonly linked to mandibular fracture patterns and fixation-related complications, whereas lingual nerve injury, although less frequently studied, demonstrated a disproportionately high functional impact. Temporal analysis revealed a gradual shift in research emphasis from fracture-driven inferior alveolar nerve injury toward facial nerve injury as a surgically modifiable risk factor.

CONCLUSION: The findings demonstrate a clear evolution in craniofacial nerve injury research, highlighting the growing importance of anatomical knowledge and surgical decision-making in optimizing long-term neurological and functional outcomes following maxillofacial trauma.

Keywords: Bibliometrics; cranial nerve injuries; facial nerve injuries; maxillofacial trauma.

INTRODUCTION

Craniofacial nerve injuries are a significant source of long-term morbidity in patients who sustain maxillofacial trauma. These injuries frequently involve the trigeminal nerve, and the resulting damage manifests as somatosensory changes that profoundly impair functional capacity.[1] These changes, ranging from decreased touch sensitivity to chronic neuropathic pain, significantly reduce patients' quality of life and result in substantial societal costs.[2,3] The craniofacial nerve network,

Cite this article as: Karip B, Ok F, Temizsoy Korkmaz F. From fracture-related injury to surgically modifiable risk: a trauma-focused bibliometric analysis of craniofacial nerve injuries. Ulus Travma Acil Cerrahi Derg 2026;32:987-997.

Address for correspondence: Burak Karip
Department of Anatomy, Hamidiye Faculty of Medicine, University of Health Sciences, İstanbul, Türkiye
E-mail: burak.karip@sbu.edu.tr

Ulus Travma Acil Cerrahi Derg 2026;32(8):987-997 DOI: 10.14744/tjtes.2026.46993
Submitted: 04.01.2026 Revised: 11.03.2026 Accepted: 21.04.2026 Published: 10.08.2026

which includes the trigeminal and facial nerves, is particularly susceptible to injury from various etiologies, including trauma, infection, inflammation, tumors, and iatrogenic factors.[4,5] Although these injuries rarely threaten life in the acute phase, they can lead to permanent functional loss, aesthetic impairment, and significant psychosocial burden. Because of their potential for delayed complications and chronic sequelae, these injuries often require long-term follow-up and management by experienced multidisciplinary teams.[6]

Injuries involving the facial, inferior alveolar, and lingual nerves, in particular, have profound effects on facial expression, sensation, speech, and quality of life, underscoring the critical yet often underemphasized importance of preserving these nerves in trauma care. Given the complex anatomy of the trigeminal nerve, injuries to this nerve can cause severe and frequently debilitating pain; the incidence of post-traumatic trigeminal neuropathic pain involving the inferior alveolar and lingual nerves has been reported to range from 0.45% to 70%.[7] Despite this variability, these injuries often result in permanent neurosensory deficits, creating a substantial psychosocial and emotional burden by complicating daily activities such as eating, drinking, and oral hygiene.

Traditionally, craniofacial nerve injuries in the context of trauma have been viewed primarily as a direct consequence of injury severity, fracture pattern, or impact mechanism. Consequently, neurological deficits have often been regarded as inevitable sequelae of high-energy trauma associated with disruption of skeletal integrity. However, given the complex anatomy of the cranial nerves and surrounding soft tissues, increasing attention has been directed toward the decisive role of early and meticulous surgical intervention on functional recovery.[8]

In recent years, the influence of surgical decision-making processes—particularly approach selection and understanding of anatomical risk—on neurological outcomes has become increasingly evident. For example, the coronal approach has been shown to preserve nerve integrity by minimizing the risk of postoperative neural impairment commonly associated with conventional fracture treatment methods, while also providing improved access for precise anatomical reduction in complex facial fractures.[9]

Despite this evolving clinical understanding, the trauma literature addressing craniofacial nerve injuries remains fragmented. This highlights the need for a comprehensive analysis to identify research trends related to post-traumatic craniofacial nerve injuries and to reveal critical gaps in the literature.[10] Such an analysis can identify emerging areas of interest by mapping the knowledge structure of the field and can provide valuable insights into future research directions and improvements in publication quality.[11,12]

Bibliometric analysis offers a valuable approach for systematically evaluating research trends, thematic development, and conceptual priorities. By analyzing objective indicators such as publications, citations, and keyword frequencies, bibliometric methods can elucidate the structure of scientific knowledge and its evolution over time.[13] This rigorous quantitative approach enables the analysis of large volumes of literature and the synthesis of unstructured information within a consistent framework applicable to both established and emerging fields.[14,15] Bibliometric techniques also provide insights into how a field defines its core problems, directs scientific attention, and responds to emerging clinical challenges.

In the context of maxillofacial trauma, bibliometric analysis may help clarify whether craniofacial nerve injury is increasingly perceived as an inevitable consequence of trauma or as a potentially modifiable condition influenced by surgical strategy. Furthermore, this analytical approach can identify leading authors, major research themes, and the relationships among them through a systematic evaluation of the literature.[16]

Accordingly, the aim of this study was to perform a trauma-focused bibliometric analysis of the literature on craniofacial nerve injuries using data from the Web of Science and Scopus databases. By analyzing thematic distributions, temporal trends, and comparative patterns among facial, inferior alveolar, and lingual nerve injuries, we sought to characterize the evolution of the conceptual framework surrounding nerve injury in maxillofacial trauma. Additionally, we assessed whether the contemporary literature reflects increasing recognition of surgically modifiable risk factors.

MATERIALS AND METHODS

This study was designed as a trauma-focused bibliometric analysis aimed at characterizing the anatomical and clinical evolution of research on craniofacial nerve injuries in the context of acute maxillofacial trauma. Within this analytical framework, facial nerve injuries constituted the primary focus, whereas injuries involving the inferior alveolar and lingual nerves were examined comparatively to provide additional context regarding clinical decision-making and functional outcomes. The analysis aimed to identify clinically relevant patterns, particularly those related to surgical approach selection, fracture management, and preventable mechanisms of nerve injury, rather than merely providing a descriptive overview of the literature.

A comprehensive literature search was conducted using the Web of Science Core Collection and Scopus databases. The following search strategy was applied in the Web of Science Core Collection:

TS = ((“maxillofacial trauma” OR “mandibular fracture”) AND (“lingual nerve” OR “inferior alveolar nerve” OR “facial nerve”))

To ensure conceptual consistency, an equivalent search strategy was performed using the TITLE-ABS-KEY field in Scopus. Both searches were limited to articles and reviews published in English, with no restrictions on publication year.

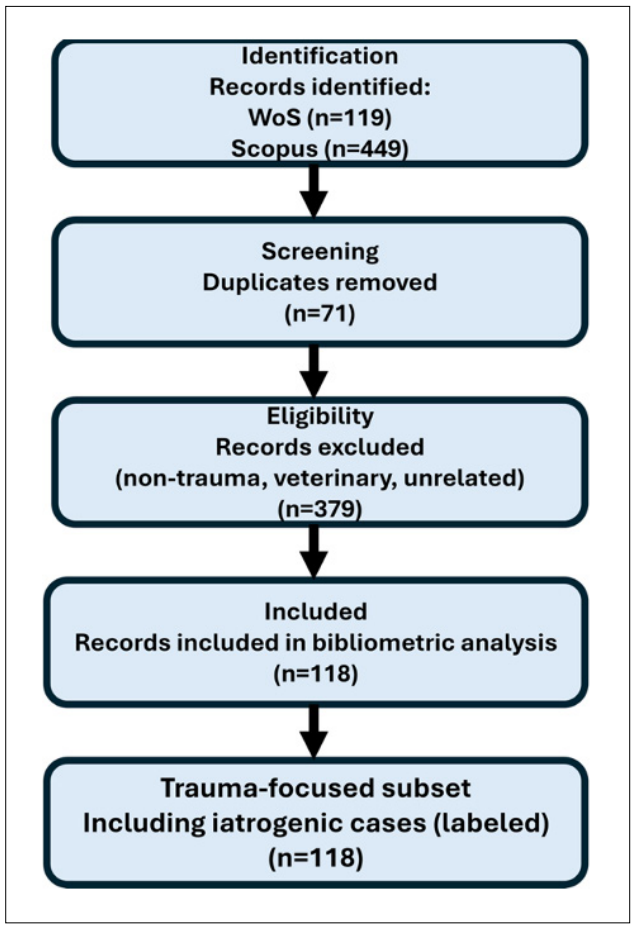

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of study selection.

The database search retrieved 119 records from Web of Science and 449 records from Scopus. Records from both databases were merged into a single dataset. Duplicate publications were identified primarily through Digital Object Identifier (DOI) matching and, when DOI information was unavailable, through title-based comparison. A total of 71 duplicate records were removed during this process.

Study selection was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines adapted for bibliometric research (Fig. 1). During title and abstract screening, publications unrelated to acute trauma, non-human studies, and records lacking anatomical relevance were excluded. Publications describing iatrogenic or implant-related mandibular fractures were retained and explicitly labeled to demonstrate the relationship between traumatic and procedure-related mechanisms of nerve injury. Following eligibility assessment, 118 publications were included in the final bibliometric analysis.

Inclusion criteria comprised peer-reviewed articles and reviews focusing on craniofacial nerve injuries associated with maxillofacial trauma. Exclusion criteria included non-human studies, publications unrelated to trauma-associated nerve injury, and records lacking anatomical relevance to the craniofacial nerve structures evaluated in this study.

Bibliographic data, including publication year, journal information, abstracts, keywords, and cited references, were extracted for each included publication. Bibliometric analyses were conducted using the combined Web of Science–Scopus dataset. Additionally, database-specific trends were evaluated to assess the consistency of thematic patterns across sources.

To strengthen the methodological depth of the study, additional bibliometric performance indicators and science-mapping procedures were applied to the merged dataset. Citation analysis, source productivity, author productivity, and country distribution were evaluated descriptively. Network visualization analyses were used to identify keyword co-occurrence patterns, country collaboration structures, and co-authorship relationships. For records with complete metadata available after matching and deduplication, citation-based indicators, including total citation count and dataset h-index, were also calculated. These complementary analyses were performed to enhance the methodological rigor of the bibliometric evaluation. Network visualizations were generated using bibliometric mapping techniques implemented through established tools, including VOSviewer and spreadsheet-based bibliometric analysis.

Duplicate records were identified primarily through DOI matching and secondarily through title-based comparison. Following record harmonization, the final dataset was used for descriptive bibliometric analysis. Author productivity, source productivity, and publication-year trends were evaluated across the complete corpus, whereas citation- and affiliation-based analyses were performed on the metadata-complete matched subset where appropriate.

Table 1. Major themes in trauma-related craniofacial nerve injury research

Nerve	Trauma context	Clinical focus
Facial nerve	Mandibular angle/condylar fractures	Surgical approach–related risk
Inferior alveolar nerve	Mandibular body fractures	Sensory deficits, fixation-related injury
Lingual nerve	Penetrating trauma/angle injuries	Functional impairment, neuropathic pain

Table 2. Comparative characteristics of facial and inferior alveolar nerve injuries

Feature	Facial nerve injury	Inferior alveolar nerve injury
Predominant association	Surgical approach	Mandibular fracture pattern
Relationship to trauma	Secondary	Primary
Typical clinical manifestation	Motor dysfunction	Sensory deficit/paresthesia
Iatrogenic contribution	Moderate	High (implant-related/fixation-related)

RESULTS

After duplicate removal and eligibility screening, 118 publications were included in the bibliometric analysis. Across both databases, studies on trauma-related craniofacial nerve injuries demonstrated a heterogeneous yet thematically organized distribution reflecting distinct anatomical and clinical priorities (Tables 1 and 2).

Citation analysis of the metadata-complete matched subset identified a total of 1,366 citations and a dataset h-index of 22. The most highly cited publications primarily focused on trigeminal nerve injury, post-traumatic neurosensory dysfunction, and mandibular fracture-related nerve deficits (Table 3). Source analysis further demonstrated that the Journal of Craniofacial Surgery was the most productive journal in the dataset, whereas the Journal of Oral and Maxillofacial Surgery exhibited the highest citation impact among the leading sources (Table 4).

Author productivity analysis showed that publication output was concentrated among a limited number of contributors, reflecting the presence of a relatively small but active research community in this field (Table 5). Co-authorship mapping indicated clustered patterns of collaboration rather than a broadly interconnected author network, suggesting that the literature has evolved through several focused research groups (Fig. 2).

Country distribution analysis indicated that research output was concentrated in a relatively small number of countries (Table 6). The country collaboration network demonstrated the existence of international cooperation, although it was largely driven by a limited number of recurring collaborative partnerships (Fig. 3).

Keyword co-occurrence analysis supported the thematic structure identified in the descriptive review and demonstrated that the field is organized around three major conceptual domains: facial nerve injury associated with surgical approach–related risk; inferior alveolar nerve injury associated with mandibular fractures and fixation-related sensory disturbances; and lingual nerve injury associated with functional impairment and neuropathic symptoms (Fig. 4).

Thematic analysis identified three principal anatomical cat-

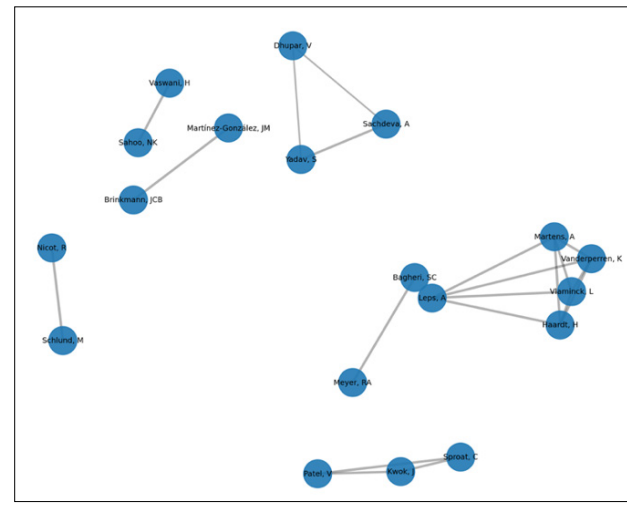

Figure 2. Co-authorship network of researchers contributing to the literature on craniofacial nerve injuries associated with maxillofacial trauma. Links represent collaborative relationships among authors.

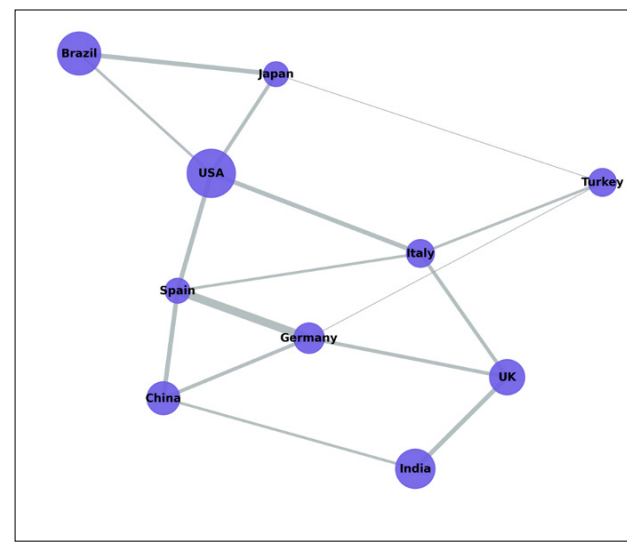

Figure 3. Country collaboration network in craniofacial nerve injury research. Node size represents publication output, whereas link thickness indicates the strength of collaboration between countries.

Table 3. Most-cited publications in the bibliometric dataset on craniofacial nerve injuries associated with maxillofacial trauma

Article title	Authors	Publication year	Journal	Citations
Rigid Internal Fixation of Mandibular Fractures - An Analysis of 270 Fractures Treated Using the AO/ASIF Method	Iızuka, T; Lındqvıst, C	1992	International Journal of Oral and Maxillofacial Surgery	118
Fixation of Mandibular Fractures with 2.0-mm Miniplates: Review of 191 cases	Gabrielli, MAC; Gabrielli, MFR; Marcantonio, E; Hochuli-Vieira, E	2003	Journal of Oral and Maxillofacial Surgery	117
Epidemiology and Pattern of Oral and Maxillo-facial Trauma	Wusiman, P; Maimaititu-erxun, B; Guli; Saimaiti, A; Moming, A	2020	Journal of Craniofacial Surgery	91
Use of Straight and Curved Three-Dimensional Titanium Miniplates for Fracture Fixation at the Mandibular Angle	Zix, J; Lieger, O; Iizuka, T	2007	Journal of Oral and Maxillofacial Surgery	70
Prospective Study on Post-traumatic and Postoperative Sensory Disturbances of the Inferior Alveolar and Infraorbital Nerves in Mandibular and Midfacial Fractures	Schultze-Mosgau, S; Erbe, M; Rudolph, D; Ott, R; Neukam, FW	1999	Journal of Cranio-Maxillofacial Surgery	69
Microsurgical Repair of Peripheral Trigeminal Nerve Injuries Following Maxillofacial Trauma	Bagheri, SC; Meyer, RA; Khan, HA; Steed, MB	2009	Journal of Oral and Maxillofacial Surgery	59
Open Reduction and Rigid Internal Fixation of Mandibular Condylar Fractures by an Intraoral Approach: A Long-Term Follow-Up Study of 15 Patients	Jensen, T; Jensen, J; Norholt, SE; Dahl, M; Lenk-Hansen, L; Svensson, P	2006	Journal of Oral and Maxillofacial Surgery	58
Mandibular Fracture After Endosseous Implant Placement in Conjunction with Inferior Alveolar Nerve Transposition: A Patient Treatment Report	Kan, JYK; Lozada, JL; Boyne, PJ; Goodacre, CJ; Rungcharassaeng, K	1997	International Journal of Oral & Maxillofacial Implants	53
Etiology and Pattern of Maxillofacial Trauma	Khan, TU; Rahat, S; Khan, ZA; Shahid, L; Banouri, SS; Muhammad, N	2022	PLOS ONE	49
Inferior Alveolar and Mental Nerve Injuries As-sociated with Open Reduction and Internal Fixa-tion of Mandibular Fractures: A Seven-Year Ret-rospective Study	Song, QY; Li, SH; Patil, PM	2014	Journal of Cranio-Maxillofacial Surgery	38

Table 4. Leading journals in the bibliometric dataset ranked by publication output and citation impact

Journal	Publications	Citations
Journal of Oral and Maxillofacial Surgery	8	360
International Journal of Oral and Maxillofacial Surgery	6	209
Journal of Cranio-Maxillofacial Surgery	6	189
Journal of Craniofacial Surgery	6	112
International Journal of Oral & Maxillofacial Implants	4	92
Quintessence International	3	18
British Journal of Oral & Maxillofacial Surgery	2	40
Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology	2	35
International Journal of Surgery Case Reports	2	13
Oral and Maxillofacial Surgery-Heidelberg	2	13
Journal of Stomatology, Oral, and Maxillofacial Sur-gery	2	9
Journal of Oral and Maxillofacial Surgery, Medicine, and Pathology	2	4

Table 5. Leading authors in the bibliometric dataset ranked by publication output

Author	Publications
Anehosur, V	2
Bagheri, SC	2
Brinkmann, JCB	2
Callahan, N	2
Dhupar, V	2
Haardt, H	2
Hochuli-Vieira, E	2
Kwok, J	2
Leps, A	2
Luna, AHB	2
Martens, A	2
Martínez-González, JM	2

Table 6. Geographic distribution of publications included in the bibliometric analysis

Country	Publications
Brazil	11
United States	10
India	8
United Kingdom	7
Iran	5
Japan	4
China	3
France	3
Saudi Arabia	3
Austria	2
Germany	2
Israel	2

egories related to trauma. Facial nerve injuries represented the most prevalent topic (Fig. 5), followed by injuries involving the inferior alveolar and lingual nerves. Publications concerning facial nerve injury predominantly emphasized risks associated with surgical approaches (Fig. 6). In contrast, inferior alveolar nerve injuries were more frequently linked to mandibular fracture patterns and fixation-related complications. Although less commonly reported, lingual nerve injuries were associated with a disproportionately high functional burden.

Comparative analysis showed clear distinctions between facial nerve and inferior alveolar nerve injuries. Facial nerve injuries were most commonly associated with transbuccal, extraoral, or retromandibular approaches. In contrast, inferior alveolar nerve injuries were typically related to mandibular fractures, with sensory disturbance representing the primary clinical manifestation. Many studies focusing on inferior alveolar nerve injury also addressed iatrogenic and implant-related fractures.

Temporal trend analysis revealed a gradual shift in research focus over time. Earlier publications primarily emphasized

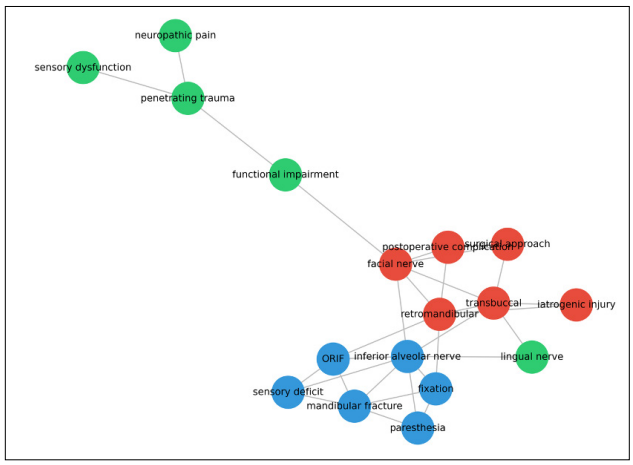

Figure 4. Keyword co-occurrence network illustrating thematic clusters in craniofacial nerve injury research. Colors represent conceptual clusters related to facial nerve injuries and surgical approach–related risks (red), inferior alveolar nerve injuries associated with mandibular fractures and fixation procedures (blue), and lingual nerve injuries associated with functional impairment and neuropathic symptoms (green).

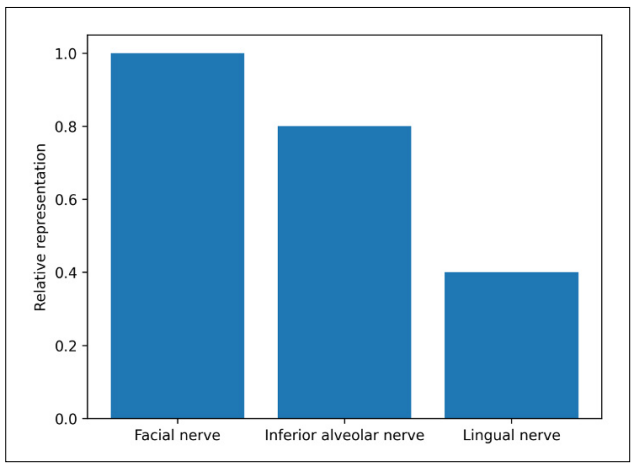

Figure 5. Major thematic categories of trauma-related craniofacial nerve injury research.

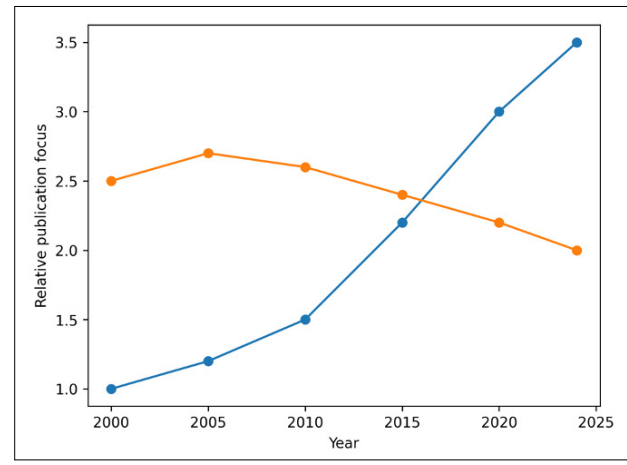

Figure 6. The two curves illustrate a shift from fracture-driven inferior alveolar nerve injury research toward facial nerve injury as a surgically modifiable risk factor in the maxillofacial trauma literature.

fracture-related inferior alveolar nerve injuries, whereas more recent studies increasingly focused on facial nerve injuries as a surgically modifiable risk factor. This pattern was consistently observed across both the Web of Science and Scopus datasets. Keyword co-occurrence and collaboration analyses further supported this trend, demonstrating that contemporary research increasingly clusters around surgically influenced facial nerve risk and anatomically guided operative planning (Figs. 2–4).

Keyword-based thematic clustering identified three clinically meaningful groups: one related to facial nerve injury and surgical risk; another associated with inferior alveolar nerve injury and fracture-related sensory deficits; and a third associated with lingual nerve injury, functional impairment, and neuropathic pain (Fig. 7).

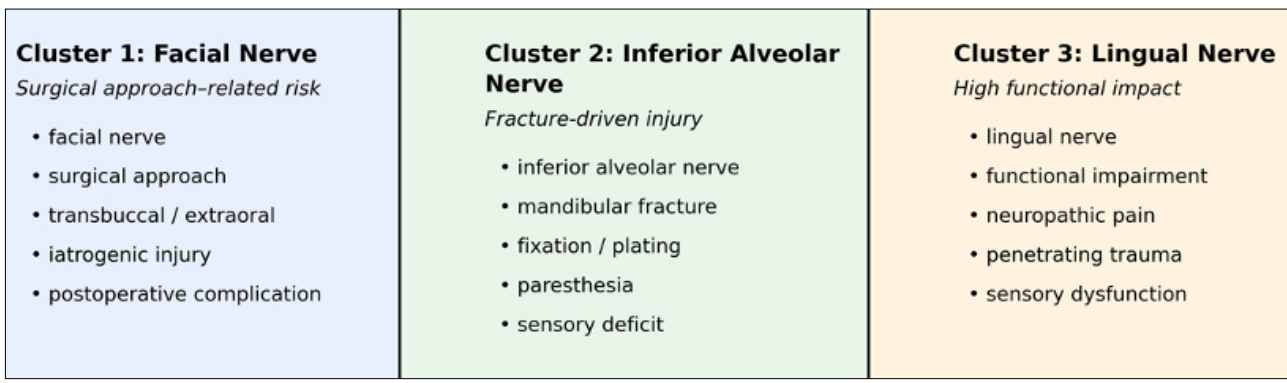

Figure 7. Keyword-based thematic clustering of trauma-related craniofacial nerve injury research.

DISCUSSION

This bibliometric analysis examined the evolution of research on craniofacial nerve injuries from a trauma-oriented perspective, highlighting a clear shift in both anatomical focus and clinical interpretation. While facial and trigeminal nerve injuries have long attracted considerable attention because of their functional and aesthetic consequences, recent trends indicate increasing interest in other craniofacial nerves, such as the infraorbital nerve, particularly in the setting of complex cranio-maxillofacial trauma.[17,18]

These findings extend beyond publication patterns and reflect a broader transformation in how nerve injury is conceptualized within maxillofacial trauma care. The analysis suggests an increasing interdisciplinary focus that moves beyond isolated nerve classifications and considers the broader effects of nerve injury on patient morbidity and functional recovery.[10,19]

The additional bibliometric indicators further support this interpretation. Citation analysis demonstrated that the most influential publications predominantly addressed trigeminal nerve dysfunction, post-traumatic sensory deficits, and mandibular fracture-related neurosensory outcomes, indicating that sensory nerve injury has historically shaped the intellectual foundation of the field. At the same time, keyword and collaboration mapping revealed that contemporary conceptual organization increasingly emphasizes facial nerve vulnerability, surgical approach selection, and modifiable operative risk. Collectively, these findings suggest that the field has evolved from predominantly descriptive injury-focused research toward a more strategy-sensitive and outcome-oriented framework.

The concentration of publications within a relatively limited number of journals, countries, and author groups suggests that craniofacial nerve injury research remains a specialized niche within the broader maxillofacial trauma literature. This pattern may partly explain the fragmented structure previously observed in the field and underscores the need for broader multicenter and international collaboration in future research.

One of the most notable observations is the growing recognition of facial nerve injury within the trauma literature. While earlier studies largely viewed craniofacial nerve damage as an unavoidable consequence of fracture severity and injury mechanism, more recent research highlights facial nerve injury as a distinct and clinically important complication with substantial effects on patient morbidity and quality of life.[20] This shift in perspective underscores the importance of accurate assessment and timely management of facial nerve paralysis in patients who survive head trauma, particularly because of its profound influence on self-image, facial appearance, and functional ability.[21] In parallel, recent publications increasingly associate facial nerve injury with surgical approach selection, reframing it as a potentially modifiable condition rather than an inevitable consequence of trauma. This evolution reflects a growing appreciation of how awareness of anatomical risk zones and operative decision-making influence neurological outcomes. Careful planning of surgical corridors and strategic use of intraoperative nerve-monitoring systems are increasingly emphasized as measured to preserve facial nerve integrity.[22] This shift also has important implications for clinical practice. Although facial nerve injury rarely threatens life during the acute phase of trauma, it is associated with substantial long-term functional, psychosocial, and medicolegal consequences. Facial nerve paralysis, in particular, can markedly diminish quality of life due through impaired self-image, cosmetic deformity, and functional limitations.[21,23]

The increasing emphasis on approach-related risks, including transbuccal and extraoral approaches, further demonstrates that contemporary trauma care increasingly recognizes the role of surgical exposure and fixation strategies in nerve preservation. Within this framework, nerve injury is viewed not only as an indicator of injury severity but also as a complication influenced by modifiable operative factors. This evolving understanding necessitates careful assessment of facial nerve function following both trauma and intervention to optimize patient outcomes and minimize potential medicolegal consequences.[24] Given the complex physiological functions of the facial nerve, including motor control, lacrimation, salivation, and taste, the House–Brackmann grading system remains a widely accepted and reliable method for standardized assessment of facial nerve function.[25]

In contrast, inferior alveolar nerve injury continues to be viewed primarily as a fracture-related phenomenon closely associated with mandibular fracture patterns and fixation-related factors. However, the frequent occurrence of iatrogenic and implant-related mandibular fractures within the literature underscores the persistent overlap between traumatic and procedure-related mechanisms of nerve injury. Rather than representing a limitation, this overlap highlights the challenge of distinguishing trauma from intervention in real-world clinical practice. It further highlights the importance of a comprehensive understanding of nerve injury mechanisms. The reported prevalence of inferior alveolar nerve deficits following mandibular fractures ranges from 5.7% to 58.5%, encompassing both traumatic and iatrogenic causes.[26] This broad range is largely attributable to inconsistencies in diagnostic criteria, subjective patient reports, and differences in the timing of neurosensory deficit assessments.[26,27] For example, postoperative neurosensory dysfunction rates ranging from 77.0% to 91.3% have been reported, whereas permanent deficits have been observed in 0.9%–45.0% of cases.[28]

The temporal trends identified in this analysis further support this emerging paradigm. While earlier publications focused on sensory deficits associated with mandibular fractures, more recent studies increasingly emphasize the risk of surgically related facial nerve injury. This shift reflects growing recognition of iatrogenic factors contributing to neurosensory impair-

ment, particularly in procedures involving open reduction and internal fixation.[28] These developments parallel advances in surgical techniques and increasing expectations for functional preservation, indicating that contemporary trauma management is shaped not only by the nature of the injury but also by the manner in which it is treated. Further complicating this issue, reported recovery outcomes vary substantially across studies. Although neurosensory recovery has been reported in approximately 73.23% of patients, abnormal inferior alveolar nerve function persists in up to 23.3% of patients at one-year follow-up.[8,26] This variability is compounded by the absence of standardized methods for assessing inferior alveolar nerve injury and by the use of diverse evaluation methodologies.[29]

Finally, the implications of these findings extend beyond academic mapping and directly influence daily trauma practice. The increasing focus on surgically modifiable craniofacial nerve injury risk highlights the importance of anatomical awareness during acute fracture management. This perspective is particularly relevant given evidence suggesting that surgical interventions performed closer to the time of injury can result in functional sensory improvement in a significant proportion of patients.[19] From the perspective of trauma teams, these findings demonstrate that nerve preservation is not determined solely by injury severity but is also influenced by operative choices made during surgical exposure and fixation. Consequently, early intervention and meticulous surgical technique are essential for minimizing post-traumatic neurosensory deficits and facilitating recovery.[8,26]

Consideration of facial nerve vulnerability during early operative planning may improve long-term functional outcomes without compromising the priorities or urgency of acute trauma care. In this context, bibliometric trends reflect a broader transition toward anatomy-based and outcome-focused decision-making in contemporary maxillofacial trauma management. Nevertheless, the lack of consensus regarding the optimal timing and method of intervention for trigeminal nerve injuries remains a significant obstacle to the development of effective treatment strategies.[19]

Limitations

This study has several limitations. First, the analysis was restricted to publications indexed in the Web of Science Core Collection and Scopus databases. Although these databases provide comprehensive coverage and are widely used in bibliometric research, relevant studies indexed elsewhere may not have been captured. Second, bibliometric analyses depend on the quality and consistency of indexed metadata, including keywords and abstracts, which may vary across journals. Third, the study prioritized clinically meaningful thematic interpretation over detailed quantitative network analysis. Although collaboration networks and keyword co-occurrence structures were visualized, advanced network metrics such as citation centrality and cluster modularity were not calculated. Fourth, iatrogenic and implant-related mandibular fractures were retained and explicitly labeled rather than excluded. Although this approach may have introduced heterogeneity into the dataset, it reflects the clinical overlap observed in real-world practice. Finally, bibliometric findings reflect patterns of scientific attention rather than true epidemiological incidence and should therefore be interpreted accordingly.

An additional limitation is that some advanced bibliometric indicators depended on metadata completeness after database matching and deduplication. Consequently, citation-, affiliation-, and keyword-based network analyses were conducted using the metadata-complete matched subset, whereas publication productivity analyses were based on the entire final corpus. Although this approach may have influenced the absolute values of certain bibliometric indicators, it is unlikely to have affected the overall thematic or interpretive conclusions of the study.

CONCLUSION

This bibliometric analysis demonstrates a clear shift in craniofacial nerve injury research from viewing nerve damage as an inevitable consequence of trauma toward recognizing it as a surgically modifiable risk influenced by operative strategy. In particular, the growing emphasis on facial nerve vulnerability highlights the critical role of anatomical awareness and surgical decision-making in improving long-term functional outcomes following maxillofacial trauma.

The expanded bibliometric analyses further support the view that contemporary research increasingly frames craniofacial nerve injury not only as a consequence of trauma but also as a clinically relevant and partially modifiable risk shaped by operative decision-making.

Acknowledgments: The authors used language-support tools (ChatGPT 4.0®, OpenAI, San Francisco, USA, and Grammarly®) to assist with language review, grammatical refinement, and stylistic consistency during manuscript preparation.

Ethics Committee Approval: This study is a bibliometric analysis based solely on published literature; therefore, ethical committee approval was not required.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: B.K.; Design: B.K.; Supervision: B.K.; Resource: B.K., F.O., F.T.K.; Materials: B.K., F.O., F.T.K.; Data collection and/or processing: B.K., F.O., F.T.K.; Analysis and/or interpretation: B.K.; Literature review: B.K., F.O., F.T.K.; Writing: B.K.; Critical review: B.K., F.O., F.T.K.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Rodrigues EC, Wendland EMDR, Vidor DCGM, Santos KW. Diagnostic properties of sensitivity changes in patients with maxillofacial fractures: a systematic review. Braz J Oral Sci 2021;20:e211223. [CrossRef]
2. Essick GK, Phillips C, Turvey TA, Tucker M. Facial altered sensation and sensory impairment after orthognathic surgery. Int J Oral Maxillofac Surg 2007;36:577–82. [CrossRef]
3. Rosén A, Tardast A, Shi TJ. How far have we come in the field of nerve regeneration after trigeminal nerve ınjury? Curr Oral Health Rep 2016;3:309–13. [CrossRef]
4. Rink-Notzon S, Reuscher J, Nohroudi K, Manthou M, Gordon T, Angelov DN. Trigeminal sensory supply ıs essential for motor recovery after facial nerve ınjury. Int J Mol Sci 2022;23:15101. [CrossRef]
5. Sun S, Lu D, Zhong H, Li C, Yang N, Huang B, et al. Donors for nerve transplantation in craniofacial soft tissue injuries. Front Bioeng Biotechnol 2022;10:978980. [CrossRef]
6. Vahidi N, Kwak P, Sismanis D, Schuman T, Hawkins D, Lee TS. Management of complications and secondary deformity after fractures of the midface, orbit, and upper third of the maxillofacial skeleton. Otolaryngol Clin North Am 2023;56:1151–67. [CrossRef]
7. Zuniga JR, Renton TF. Managing post-traumatic trigeminal neuropathic pain: Is surgery enough? J Neurol Neuromed 2016;1:10–4. [CrossRef]
8. Abdulkawi MA, Lutf MA, Ahmed AA, Hassan AA. Evaluation of neurosensory recovery in infraorbital and inferior alveolar nerve impairments after maxillofacial fractures: a systematic review. Univ J Pharm Res 2025;10:62–8.
9. Pattnayak A, Awasthi N, Penumatsa NV, Panicker P, Ferdous S, Soni M. Postoperative evaluation of nerve function following coronal ıncisions for facial fractures: a clinical study. J Contemp Dent Pract 2024;25:1135–40. [CrossRef]
10. Yau V, Ma B, Lin S, Zhu S, Turner MD. Insights from the 100 most-cited articles on orbital fractures: a bibliometric and sentiment analysis. J Oral Maxillofac Surg 2025;83:1496–518. [CrossRef]
11. Zhang S, Huang M, Zhi J, Wu S, Wang Y, Pei F. Research hotspots and trends of peripheral nerve ınjuries based on web of science from 2017 to 2021: a bibliometric analysis. Front Neurol 2022;13:872261. [CrossRef]
12. Borges AFM, Leão LO, Silva RDD, Cardenas SHR, Araujo CMD, Cavalcanti RVA, et al. Mapping the knowledge of stomatognathic functions and orthognathic surgery. Braz J Oral Sci 2025;24:e258712. [CrossRef]
13. Kumar M, Kumari S, Guntipally SS, Chhabra A, Kumar A, Kumar P. A step-by-step guide of bibliometric study for healthcare and allied research. J Pharm Bioallied Sci 2024;16:S4114–6. [CrossRef]
14. Al Fozaie MT. Identifying the absence of knowledge using bibliometric analysis: the case of the "bad behavior index". Int J Sustain Dev Plan 2023;18:77–91. [CrossRef]
15. Simion PS, Ciornei L, Todirica IC, Petcu V, Joita-Pacureanu M. A decade of bibliometric analysis of biodiversity. Ann Valahia Univ Targoviste Agric 2023;15:43–9. [CrossRef]
16. Filipov I, Chirila L, Bolognesi F, Sandulescu M, Drafta S, Cristache CM. Research trends and perspectives on immediate facial reanimation in radical parotidectomy (Review). Biomed Rep 2023;19:81. [CrossRef]
17. Dubron K, Verbist M, Shaheen E, Dormaar TJ, Jacobs R, Politis C. Incidence, aetiology, and associated fracture patterns of ınfraorbital nerve ınjuries following zygomaticomaxillary complex fractures: a retrospective analysis of 272 patients. Craniomaxillofac Trauma Reconstr 2022;15:139–46. [CrossRef]
18. Radwan AM, Boxx C, Zuniga J. Post-traumatic ınjuries of the trigeminal and facial nerve. Atlas Oral Maxillofac Surg Clin North Am 2019;27:127–33. [CrossRef]
19. Weyh A, Pucci R, Valentini V, Fernandes R, Salman S. Injuries of the peripheral mandibular nerve, evaluation of ınterventions and outcomes: a systematic review. Craniomaxillofac Trauma Reconstr 2021;14:337–48. [CrossRef]
20. Elshahidi MH. Marin-amat syndrome: a case report of a rare facial synkinesis following traumatic facial nerve ınjury. Bull Emerg Trauma 2025;13:227–30.
21. Wamkpah NS, Kallogjeri D, Snyder-Warwick AK, Buss JL, Durakovic N. Incidence and management of facial paralysis after skull base trauma, an administrative database study. Otol Neurotol 2022;43:e1180–6. [CrossRef]
22. Franz L, Marioni G, Mazzoni A, de Filippis C, Zanoletti E. Contemporary perspectives in pathophysiology of facial nerve damage in otoneurological and skull base surgical procedures: a narrative review. J Clin Med 2023;12:6788. [CrossRef]
23. Tsymbaliuk YV, Tretyak IB, Tsymbaliuk VI, Tretyakova AI, Gatskii OO. Clinical picture and diagnosis of consequences of traumatic damage to the facial nerve. Int Neurol J 2021;5:12–8. [CrossRef]
24. Vahidi N, Wang W, Lee T, Inman J, Ducic Y. Medicolegal aspects of craniofacial trauma. Facial Plast Surg 2019;35:657–65. [CrossRef]
25. Prabhu RK, Sinha R, Chowdhury SK, Chattopadhyay PK. Evaluation of facial nerve function following surgical approaches for maxillofacial trauma. Ann Maxillofac Surg 2012;2:36–40. [CrossRef]
26. Yadav S, Mittal HC, Malik S, Dhupar V, Sachdeva A, Malhotra V, et al. Post-traumatic and postoperative neurosensory deficits of the inferior alveolar nerve in mandibular fracture: a prospective study. J Korean Assoc Oral Maxillofac Surg 2016;42:259–64. [CrossRef]
27. Tay AB, Lai JB, Lye KW, Wong WY, Nadkarni NV, Li W, Bautista D. Inferior alveolar nerve ınjury in trauma-ınduced mandible fractures. J Oral Maxillofac Surg 2015;73:1328–40. [CrossRef]
28. Sulistyani L, Julia V, Noviantika D, Irfan I, Muskab M, Kawisana P. Evaluation of neurosensory disturbances of the inferior alveolar nerve after ORIF procedure in mandibular fracture. J Stomatol 2022;75:130–7. [CrossRef]
29. Poort LJ, van Neck JW, van der Wal KGH. Sensory testing of inferior alveolar nerve injuries. J Oral Maxillofac Surg 2009;67:292–300. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Kırığa bağlı hasardan cerrahi olarak değiştirilebilir riski odağına: Kraniyofasiyal sinir yaralanmalarının travma odaklı bibliyometrik analizi

AMAÇ: Kraniyofasiyal sinir yaralanmaları, maksillofasiyal travma sonrasında uzun dönem morbiditenin başlıca nedenlerinden biri olup, önemli fonksiyonel ve psikososyal sonuçlara yol açmaktadır. Bu çalışmanın amacı, kraniyofasiyal sinir yaralanmalarına ilişkin araştırma alanının zaman içindeki gelişimini değerlendirmek ve mevcut literatürde travmaya bağlı hasardan cerrahi olarak değiştirilebilir riske doğru bir yönelim olup olmadığını ortaya koymak üzere travma odaklı bir bibliyometrik analiz gerçekleştirmektir.

GEREÇ VE YÖNTEM: Web of Science [WoS] Core Collection ve Scopus veri tabanlarında indekslenen yayınlar kullanılarak bir bibliyometrik analiz yapılmıştır. Önceden belirlenmiş travma ile ilişkili arama terimleri kullanılarak makaleler ve derlemeler taranmıştır. Tarama sonucunda WoS'ta 119, Scopus'ta 449 yayın elde edilmiştir. Veri tabanlarının birleştirilmesi, tekrar eden kayıtların çıkarılması ve PRISMA rehberli tarama sürecinin ardından toplam 118 yayın analize dahil edilmiştir. Bibliyografik veriler; tematik dağılım, zamansal eğilimler ve fasiyal sinir, inferior alveolar sinir ve lingual sinir yaralanmaları arasındaki karşılaştırmalı örüntüleri değerlendirmek amacıyla, anahtar kelime temelli tematik kümelendirme desteğiyle analiz edilmiştir.

BULGULAR: Travma ile ilişkili üç ana anatomik küme tanımlanmıştır: fasiyal sinir, inferior alveolar sinir ve lingual sinir yaralanmaları. Fasiyal sinir yaralanmaları baskın tema olarak öne çıkmış ve ağırlıklı olarak cerrahi yaklaşıma bağlı risklerle ilişkilendirilmiştir. İnferior alveolar sinir yaralanmaları daha çok mandibula kırık paternleri ve fiksasyona bağlı komplikasyonlarla bağlantılı bulunmuştur. Lingual sinir yaralanmaları ise daha az sıklıkla rapor edilmesine rağmen orantısız derecede yüksek fonksiyonel etki göstermiştir. Zamansal analiz, kırığa bağlı inferior alveolar sinir yaralanmalarından, cerrahi olarak değiştirilebilir bir risk olarak değerlendirilen fasiyal sinir yaralanmalarına doğru kademeli bir yönelim olduğunu ortaya koymuştur.

SONUÇ: Bulgular, kraniyofasiyal sinir yaralanmaları araştırmalarında belirgin bir evrimi göstermekte olup, maksillofasiyal travma sonrası uzun dönem nörolojik ve fonksiyonel sonuçların iyileştirilmesinde anatomik bilginin ve cerrahi karar verme süreçlerinin giderek artan önemini vurgulamaktadır.

Anahtar sözcükler: Bibliyometri, fasiyal sinir yaralanmaları, kraniyal sinir yaralanmaları, maksillofasiyal travma.

Ulus Travma Acil Cerrahi Derg 2026;32(8):987-997 DOI: 10.14744/tjtes.2026.46993

ORIGINAL ARTICLE

Red cell distribution width and modified 5-item frailty index to predict short-term mortality in patients undergoing surgery for hip fracture

Selim Değirmenci,[1] Hakan Tirin,[2] Erhan Arikan,[1] Kemal Andiç,[2]

[1]Department of Emergency Medicine, Bilecik Şeyh Edebali University Faculty of Medicine, Bilecik-*Türkiye*
[2]Department of Orthopedics and Traumatology, Bilecik Training and Research Hospital, Bilecik-*Türkiye*

ABSTRACT

BACKGROUND: Hip fractures (HFs), which are common in the geriatric population and have a high mortality rate, are among the pathologies frequently encountered in emergency departments (EDs). The aim of this study was to investigate the prognostic value of red cell distribution width (RDW) and modified 5-item frailty index (mFI-5) scores in the prediction of short-term mortality and intensive care unit (ICU) admission in patients with HFs.

METHODS: Patients who presented to the ED due to HF between January 01, 2019, and December 31, 2023, were evaluated. Patients who underwent surgery for femoral neck, intertrochanteric, or subtrochanteric fractures were included in the study. Baseline demographics (age and sex), comorbidities, ICU admission status, and in-hospital and 30-day mortality rates were recorded. Univariate and multivariable logistic regression analyses were performed to identify independent predictors of ICU admission and 30-day mortality.

RESULTS: A total of 413 patients undergoing surgical treatment for HFs were included. The mean age of the patients was 80±11 years, and 271 (65.6%) were female. ICU admission was required for 43 patients (10%), while in-hospital and 30-day mortality rates were 7% (n=30) and 9.9% (n=41), respectively. Multivariable logistic regression analysis identified RDW as an independent predictor of both ICU admission (odds ratio [OR] 1.22, 95% confidence interval [CI] 1.05–1.41; p=0.009) and 30-day mortality (OR 1.20, 95% CI 1.03–1.39; p=0.016). Atrial fibrillation (AF) and Alzheimer's disease were also identified as independent predictors of ICU admission, while AF and age independently predicted 30-day mortality. The mFI-5 score did not reach statistical significance in univariate analysis for either outcome. A predictive model incorporating RDW and other covariates achieved area under the curve values of 0.74 for ICU admission and 0.70 for 30-day mortality.

CONCLUSION: RDW emerged as an independent predictor of ICU admission and 30-day mortality in surgically managed HF patients, with improved discriminatory performance when integrated into a multiparametric model. Advanced age, Alzheimer's disease, and AF further contribute to increased risk and should be closely monitored in clinical management. These findings support the incorporation of RDW into routine emergency risk stratification for this vulnerable population.

Keywords: 30-day mortality; comorbidities; intensive care unit admission; monocyte–lymphocyte ratio; neutrophil–lymphocyte ratio; systemic immune–inflammation index; systemic inflammation response index.

INTRODUCTION

Hip fractures (HFs) are among the most common causes of mortality and morbidity following trauma, particularly in geriatric individuals. A meta-analysis reported a median (Q1–Q3) 1-month mortality rate of 8% (6.5–9.6%) in HF patients.[1] This high early mortality rate is due to major surgical interventions, comorbidities, and diminished physiological reserves in geriatric patients rather than the severity of the trauma.[2]

Cite this article as: Değirmenci S, Tirin H, Arikan E, Andiç K. Red cell distribution width and modified 5-item frailty index to predict short-term mortality in patients undergoing surgery for hip fracture. Ulus Travma Acil Cerrahi Derg 2026;32:998-1007.

Address for correspondence: Selim Değirmenci
Department of Emergency Medicine, Bilecik Şeyh Edebali University Faculty of Medicine, Bilecik, Türkiye
E-mail: selim.degirmenci@bilecik.edu.tr

Ulus Travma Acil Cerrahi Derg 2026;32(8):998-1007 DOI: 10.14744/tjtes.2026.20432
Submitted: 24.12.2025 Revised: 23.05.2026 Accepted: 22.06.2026 Published: 10.08.2026

Such high risk levels emphasize the necessity of biomarkers and scoring systems that can optimize patient care by identifying intensive care unit (ICU) requirements and mortality risk at an early stage.

Numerous studies have evaluated various biomarkers and indices aimed at predicting mortality and morbidity in patients with HF.[3-5] Among these, red cell distribution width (RDW), a standardized component of the complete blood count (CBC), reflects the variability in erythrocyte volume. RDW levels tend to rise under conditions of inflammation and oxidative stress, and have been established as prognostic markers in many conditions, such as sepsis, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), stroke, and oncological diseases. Beyond RDW, the literature extensively discusses the neutrophil/lymphocyte ratio (NLR), monocyte/lymphocyte ratio (MLR), systemic ımmuno-ınflammation ındex (SII), and systemic ınflammatory response ındex (SIRI), all of which are derived from platelet, neutrophil, lymphocyte, and monocyte values.[4-6]

Frailty is defined as a state of increased vulnerability resulting from reduced physiological reserve and an impaired ability to adapt to stressors with advancing age. The 5-factor modified frailty index (mFI-5) is a simplified scoring tool derived from a patient's comorbidities, developed to predict post-operative complications and mortality across various surgical populations.[7] Despite its simplicity, its high predictive utility has led to its widespread adoption in clinical and research settings.

This study aimed to evaluate the prognostic value of RDW, CBC-derived inflammatory indices, and the mFI-5 score in predicting short-term mortality and ICU admission requirements in patients who presented to the emergency department (ED) and underwent surgery for HF.

MATERIALS AND METHODS

In this single-center, retrospective observational study, patients presenting to the ED with HF and undergoing surgery between January 01, 2019, and December 31, 2023, were evaluated. A total of 413 patients aged 18 years and older who underwent surgery for femoral neck, intertrochanteric, or subtrochanteric fractures, and for whom complete medical records were available, were included in the study. The exclusion criteria were as follows: Hematological malignancy, active infection, or known inflammatory disorders. The patient selection process is summarized in Figure 1.

During the data collection process, patient demographics, such as age and sex, comorbidities, ICU admission status, and in-hospital and 30-day mortality rates, were recorded. ICU admission decisions were made by attending anesthesiologists based on standard clinical criteria, independent of RDW or mFI-5 values, which were not utilized as ICU admission indicators at our institution. Admission to the ICU was based on the patient's clinical status and could occur either pre-operatively or post-operatively. Intertrochanteric femoral fractures

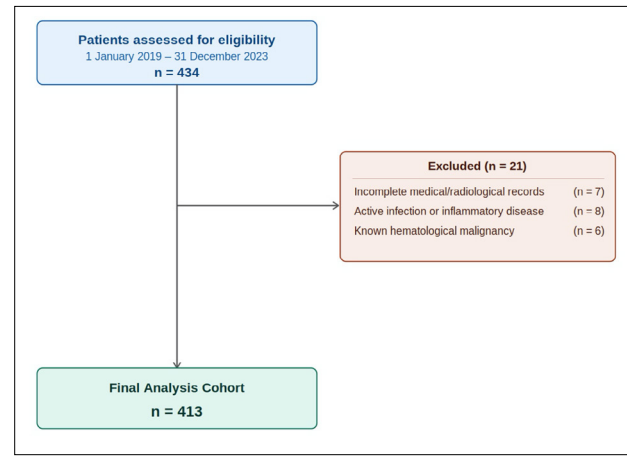

Figure 1. Flow diagram of patient selection. Of 434 patients assessed for eligibility, 21 were excluded due to incomplete medical or radiological records (n=7), active infection or inflammatory disease (n=8), or known hematological malignancy (n=6). A total of 413 patients were included in the final analysis.

were categorized as either stable or unstable according to the Evans classification.[8] For analytical purposes, surgical techniques were grouped into three categories: İntramedullary nailing (ıntramedullary nailing, including proximal femoral nailing [PFN]), open reduction and internal fixation (including cannulated screw fixation and plate fixation), and arthroplasty (including partial and total hip arthroplasty). Laboratory parameters were obtained from blood samples collected during initial ED presentation. As this was a retrospective study, the precise timing of sampling could not be systematically verified; all values were derived from the first recorded CBC at admission. All CBC analyses were performed using the Mindray BC-760 automated hematology analyzer (Mindray, Shenzhen, China) with an institutional reference range for RDW of 11–16%.

This study received ethical approval from the Non-Interventional Clinical Research Ethics Committee of the Bilecik Şeyh Edebali University Faculty of Medicine (approval no. 9/4, dated November 06, 2024).

Calculation of Indices

Laboratory parameters

The patient's white blood cell, RDW, platelet, neutrophil, lymphocyte, and monocyte values were obtained from the CBC. Using these values, the NLR, MLR, SII, and SIRI were calculated as follows:

$$NLR = \frac{\text{Neutrophil}}{\text{Lymphocyte}}$$

$$MLR = \frac{\text{Monocyte}}{\text{Lymphocyte}}$$

$$\text{SII} = \frac{\text{Neutrophil} \times \text{Platelet}}{\text{Lymphocyte}}$$

$$\text{SIRI} = \frac{\text{Neutrophil} \times \text{Monocyte}}{\text{Lymphocyte}}$$

Table 1. Baseline demographic and clinical characteristics of the study population by sex

	Female (n=271)	Male (n=142)	Total (n=413)	p
Age	81±10	78±12	80±11	NS
Age ≥65 years	261 (96)	123 (87)	384 (93)	0.001
Fracture side				
Left	135 (50)	73 (51)	208 (50.4)	NS
Right	136 (50)	69 (49)	205 (49.6)	
Fracture type				
Femoral neck	88 (32)	44 (31)	132 (32)	NS
Unstable intertrochanteric	107 (40)	50 (35)	157 (38)	
Stable intertrochanteric	62 (23)	39 (27)	101 (24.5)	
Subtrochanteric	11 (4)	8 (6)	19 (4.5)	
Reverse obliquity intertro-chanteric	3 (1)	1 (1)	4 (1)	
Surgery				
Intramedullary nailing	1 (0.4)	2 (1)	3 (0.7)	NS
Cannulated screw fixation	3 (1)	3 (2)	6 (1.4)	
Partial hip arthroplasty	100 (37)	48 (34)	148 (36)	
Proximal femoral nailing	162 (60)	85 (60)	247 (60)	
Plate fixation	1 (0.4)	-	1 (0.2)	
Total hip arthroplasty	4 (1.2)	4 (3)	8 (1.9)	
ASA score*				
1	10 (3.7)	5 (3.5)	15 (3.6)	NS
2	55 (20.4)	27 (19)	82 (19.9)	
3	180 (66.7)	90 (63.4)	270 (65.5)	
4	25 (9.3)	20 (14.1)	45 (10.9)	
mFI-5 score				
0	38 (14)	27 (19)	65 (15.7)	NS
1	85 (31.4)	51 (36)	136 (32.9)	
2	102 (37.6)	47 (33)	149 (36.1)	
3	39 (14.4)	14 (10)	53 (12.8)	
4	7 (2.6)	3 (2)	10 (2.4)	
5	0 (0)	0 (0)	0 (0)	
Admission status				
Ward	243 (90)	127 (89)	370 (90)	NS
ICU	28 (10)	15 (11)	43 (10)	
In-hospital mortality				
Discharged	253 (93)	130 (92)	383 (93)	NS
Deceased	18 (7)	12 (8)	30 (7)	
7-day mortality				
Alive	267(98.5)	130 (91.5)	397 (96.1	0.001
Deceased	4 (1.5)	12 (8.5)	16 (3.9)	
30-day mortality				
Alive	249 (91.9)	123 (86.6)	372 (90.1)	NS
Deceased	22 (8.1)	19 (13.4)	41 (9.9)	

Data reported as number (%) or mean±standard deviation. Statistical significance was defined as p≤0.05. *ASA score was not available for one patient. mFI-5: Modified 5-item frailty index,. ICU: Intensive care unit, ASA: American society of anesthesiologists, NS: Not significant (p>0.05)

mFI-5

The mFI-5 score was calculated by assigning one point for each of the following five comorbidities: Hypertension requiring pharmacological treatment, diabetes mellitus, COPD, CHF, and non-independent (partially or completely dependent) functional status.[7] These points were summed to obtain a total mFI-5 score ranging from 0 to 5, with higher scores indicating greater frailty.

Statistical Analysis

Patient characteristics were summarized using descriptive statistics. Differences in categorical variables (such as fracture side, fracture type, mFI-5 score group, admission status, mortality variables presented in Table 1, and comorbidities in Table 2) between groups were assessed using Chi-square tests, and reported as counts (percentages). The normality of distribution for continuous variables (such as age and laboratory test measurements) was evaluated using the Shapiro–Wilk test. The Wilcoxon rank-sum test was used for non-normally distributed variables, while the student t-test was used to compare continuous variables with a normal distribution. Continuous numerical variables were expressed as the means±standard deviations for normally distributed data, and as medians (interquartile range) for non-normally distributed data. Univariate and multivariable logistic regression analyses were performed to identify independent factors associated with ICU admission and 30-day mortality. Variables that did not reach statistical significance in univariate analysis were not entered into multivariable modeling. Odds ratios (OR) and corresponding 95% confidence intervals were presented. Receiver operating characteristic (ROC) analyses derived from the logistic regression models were performed using the pROC package.[9] Statistical significance was set at P<0.05. Statistical analyses were conducted with the IBM Statistical Package for the Social Sciences Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA), and R version 3.6.1.[10]

RESULTS

In this study, of the 434 patients undergoing surgery for HF over a 5-year period, 413 met the inclusion criteria and were included in the final analysis. The mean age of the patients was 80±11 years, 384 (93%) were aged 65 years or older, and 271 (65.6%) were female. The most common fracture type was intertrochanteric fracture (n=258, 62.5%), comprising 157 (38%) unstable and 101 (24.5%) stable patterns. Femoral neck fractures accounted for 32% (n=132) of the total cases.

Regarding surgical procedures, PFN was the most frequently performed technique (n=247, 60%), followed by partial hip replacement in 148 patients (36%). A total of 43 patients (10%) required ICU admission, either pre-operatively or post-operatively. The mortality rates were as follows: 3.9% (n=16) within the first 7 days, 7% (n=30) during hospitalization, and 9.9% (n=41) at the 30-day follow-up (Table 1).

Analysis of comorbidities in relation to ICU admission and 30-day mortality revealed that all patients admitted to the ICU, and 95% of those who died within 30 days had at least one comorbidity. When evaluating the prognostic impact of specific conditions, significantly higher rates of ICU admission and 30-day mortality were observed in patients with atrial fibrillation (AF) (Table 2).

Among the clinical and perioperative variables assessed, including fracture type, surgical technique, American Society

Table 2. Associations between comorbidities and ICU admission and 30-day mortality

	Total	ICU admission		p	30-day mortality		p
	n (%)	Ward (n=370)	ICU (n=43)		Alive (n=372)	Deceased (n=41)	
Presence of comorbidity	376 (91)	333 (90)	43 (100)	0.02	337 (91)	39 (95)	NS
Hypertension	265 (64)	240 (65)	25 (58)	NS	242 (65)	23 (56)	NS
Diabetes melli-tus	117 (28)	107 (29)	10 (23)	NS	106 (29)	11 (27)	NS
Congestive heart failure	46 (11)	37 (10)	9 (21)	0.04	42 (11)	4 (10)	NS
COPD	75 (18)	62 (17)	13 (30)	0.03	63 (17)	12 (29)	NS
Alzheimer's disease	90 (22)	75 (20)	15 (35)	0.03	78 (21)	12 (29)	NS
History of stroke	45 (11)	40 (11)	5 (12)	NS	38 (10)	7 (17)	NS
Chronic kid-ney disease	29 (7)	23 (6)	6 (14)	NS	24 (7)	5 (12)	NS
Atrial fibrilla-tion	55 (13)	42 (11)	13 (30)	0.001	43 (12)	12 (29)	0.002
Coronary ar-tery disease	81 (20)	71 (19)	10 (23)	NS	70 (19)	11 (27)	NS

Data reported as number (%). Statistical significance was defined as p≤0.05. ICU: Inten-sive care unit, COPD: Chronic obstructive pulmonary disease, NS: Not significant (p>0.05).

Table 3. Age, fracture type, surgical technique, ASA score, anesthesia, and laboratory findings in relation to ICU admission and 30-day mortality

	ICU admission		p	30-day mortality		p
	Ward (n=370)	ICU (n=43)		Alive (n=372)	Deceased (n=41)	
Age	79±11	83±9	NS	79±11	84±7	0.003
Fracture type (%)						
Femoral neck	120 (32)	12 (28)	NS	120 (32)	12 (29)	NS
Unstable intertro-chanteric	141 (38)	16 (37)		139 (37)	18 (44)	
Stable intertrochan-teric	88 (24)	13 (30)		94 (25)	7 (17)	
Subtrochanteric	18 (5)	1 (2)		16 (4)	3 (7)	
Reverse obliquity intertrochanteric	3 (1)	1 (2)		3 (1)	1 (2)	
Surgery (%)						
IMN	222 (60)	28 (65)	NS	228 (61)	22 (54)	NS
ORIF	7 (2)	0 (0)		7 (2)	0 (0)	
Arthroplasty	141 (38)	15 (35)		137 (37)	19 (46)	
ASA score* (%)						
1	14 (4)	1 (2)	NS	13 (4)	2 (5)	NS
2	77(21)	5 (12)		76 (20)	6 (15)	
3	242(66)	28 (65)		243 (65)	27 (66)	
4	36(10)	9 (21)		39 (11)	6 (15)	
Anesthesia (%)						
Femoral block	2 (1)	1 (2)	NS	2 (1)	1 (2)	NS
General anesthesia	26(7)	4 (9)		27 (7)	3 (7)	
Spinal anesthesia	342 (92)	38 (88)		343 (92)	37 (90)	
Laboratory tests						
WBC ($\times 10^9$/L)	11±3.8	11±4.2	NS	11±3.7	11.1±4.5	NS
Plt ($\times 10^9$/L)	232±76	237±97	NS	233±76	233±96	NS
RDW (%)	14.5±1.8	15.6±2.4	0.003	14.5±1.8	15.5±2.7	0.03
Lymphocyte count	1.3±0.7	1.3±0.9	NS	1.3±0.7	1.4±1	NS
Neutrophil count	9±3.7	9±4.2	NS	9±3.7	9±4.4	NS
Monocyte count	0.57±0.22	0.62±0.36	NS	0.57±0.24	0.60±0.26	NS
NLR	9.2±7.7	9.6±9	NS	9.3±7.9	9±7.5	NS
MLR	0.54±0.37	0.59±0.43	NS	0.55±0.38	0.57±0.39	NS
SII	2185±2120	2280±2211	NS	2216±2171	2004±1684	NS
SIRI	5.6±6.2	6±5.7	NS	5.6±6.2	5.8±6	NS

Data reported as number (%) or mean±standard deviation. Statistical significance was defined as p≤0.05. *ASA score was not available for one patient. ICU: Intensive care unit, IMN: Intramedullary nailing, ORIF: Open reduction and internal fixation, ASA: American society of anesthesiologists, WBC: White blood cell, Plt: Platelet, RDW: Red cell distribution width, NLR: Neutrophil/lymphocyte ratio, MLR: Mono-cyte/lymphocyte ratio, SII: Systemic immuno-inflammation index, SIRI: Systemic inflammatory response index, NS: Not significant (p>0.05)

of Anesthesiologists score, and anesthesia type, none were significantly associated with ICU admission or 30-day mortality. Age was significantly associated with 30-day mortality (84±7 vs. 79±11 years; p=0.003) but not with ICU admission. Of the laboratory parameters evaluated, RDW was the only parameter to reach statistical significance, with higher values observed in patients requiring ICU admission (15.6±2.4 vs. 14.5±1.8; p=0.003) and in non-survivors at 30 days (15.5±2.7 vs. 14.5±1.8; p=0.03). No other blood values or derived inflammatory indices reached statistical significance for either outcome (Table 3).

Univariate and multivariable logistic regression analyses were

Table 4. Univariate and multivariable logistic regression models examining the relationship between demographic and clinical variables, ICU admission and 30-day mortality

	ICU admission				30-day mortality			
	OR (95%)	p	OR_{adj} (95%)	P_{adj}	OR (95%)	p	OR_{adj} (95%)	P_{adj}
Age	1.05 (1.01–1.09)	0.02	1.03 (0.99–1.07)	0.16	1.06 (1.02–1.11)	0.004	1.06 (1.02–1.11)	0.009
Sex, Male	1.02 (0.52–1.96)	0.94	–	–	1.74 (0.90–3.35)	0.09	–	–
Comorbidi-ties								
CHF	2.39 (1.01–5.18)	0.04	1.20 (0.43–3.10)	0.72	0.85 (0.25–2.25)	0.77	–	–
COPD	2.15 (1.03–4.28)	0.03	1.93 (0.87–4.11)	0.09	2.02 (0.95–4.10)	0.06	–	–
Alzheimer's disease	2.11 (1.05–4.10)	0.03	2.43 (1.13–5.14)	0.03	1.56 (0.74–3.12)	0.23	–	–
AF	3.38 (1.60–6.88)	0.001	2.82 (1.14–6.70)	0.02	3.16 (1.46–6.54)	0.002	2.62 (1.19–5.53)	0.01
RDW	1.27 (1.19–1.45)	0.001	1.22 (1.05–1.41)	0.009	1.23 (1.07–1.42)	0.003	1.20 (1.03–1.39)	0.016
mFI-5 score	1.34 (0.98–1.85)	0.07	–	–	1.15 (0.83–1.60)	0.39	–	–

OR and P report results of univariate models. ORadj and Padj report results of multivariable models that include variables that were significant in univariate model analyses. ICU: Intensive care unit, CHF: Congestive heart failure, COPD: Chronic obstructive pulmonary disease, AF: Atrial fibrillation, RDW: Red cell distribution width, mFI-5: Modified 5-item frailty index. Age, RDW, and mFI-5 are modelled as numeric, whereas comorbidities are modelled as categorical variables.

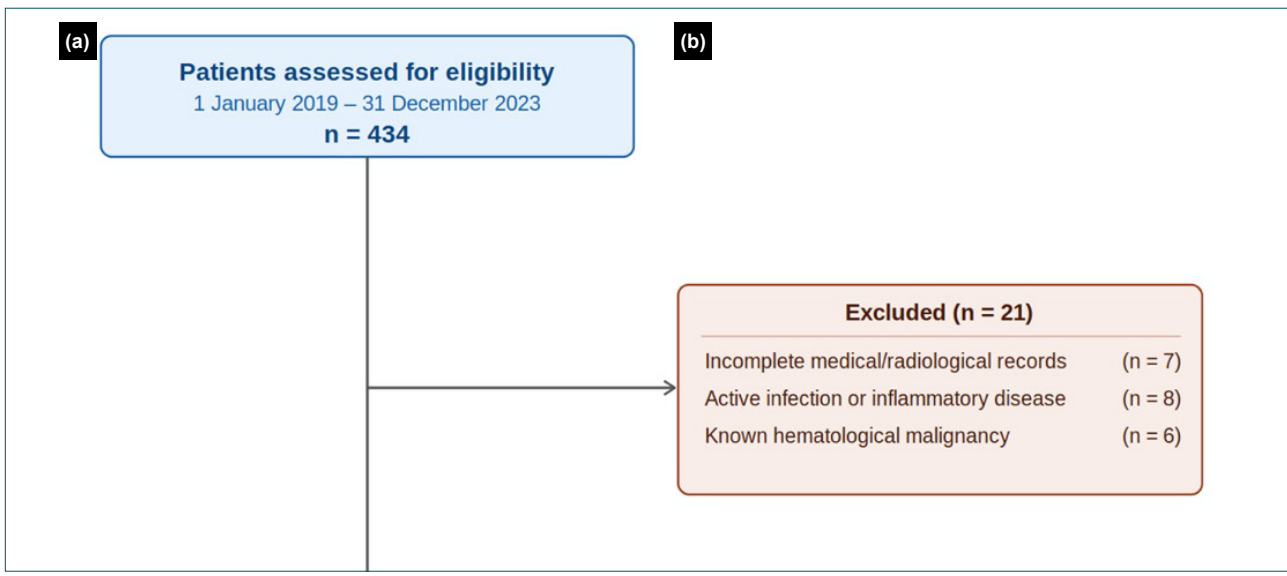

Figure 2. Receiver operating characteristic analysis for admission red cell distribution width values in predicting clinical outcomes. **(a)** Intensive care unit admission: Area under the curve (AUC) = 0.640, standard error (SE) = 0.048, 95% confidence interval [CI]: 0.546–0.733, p=0.003. **(b)** 30-day mortality: AUC = 0.606, SE = 0.046, 95% CI: 0.515–0.696, p=0.03

performed to evaluate the clinical and laboratory predictors of outcomes. In the multivariable models, RDW, AF, and Alzheimer's disease emerged as independent risk factors for ICU admission, while RDW, age, and AF were independently associated with 30-day mortality (Table 4).

ROC curve analysis revealed that RDW achieved area under the curve (AUC) values of 0.640 (p=0.003) and 0.606 (p=0.03) for ICU admission and 30-day mortality, respectively (Fig. 2). The integration of AF and Alzheimer's disease with RDW in the predictive model for ICU admission increased the AUC to 0.74. Similarly, incorporating age and AF alongside RDW in the 30-day mortality model improved the AUC to 0.70 (Fig. 3).

DISCUSSION

This study evaluated the predictive value of RDW and mFI-5 for ICU admission and short-term mortality in patients undergoing surgery for HF. Multivariable logistic regression

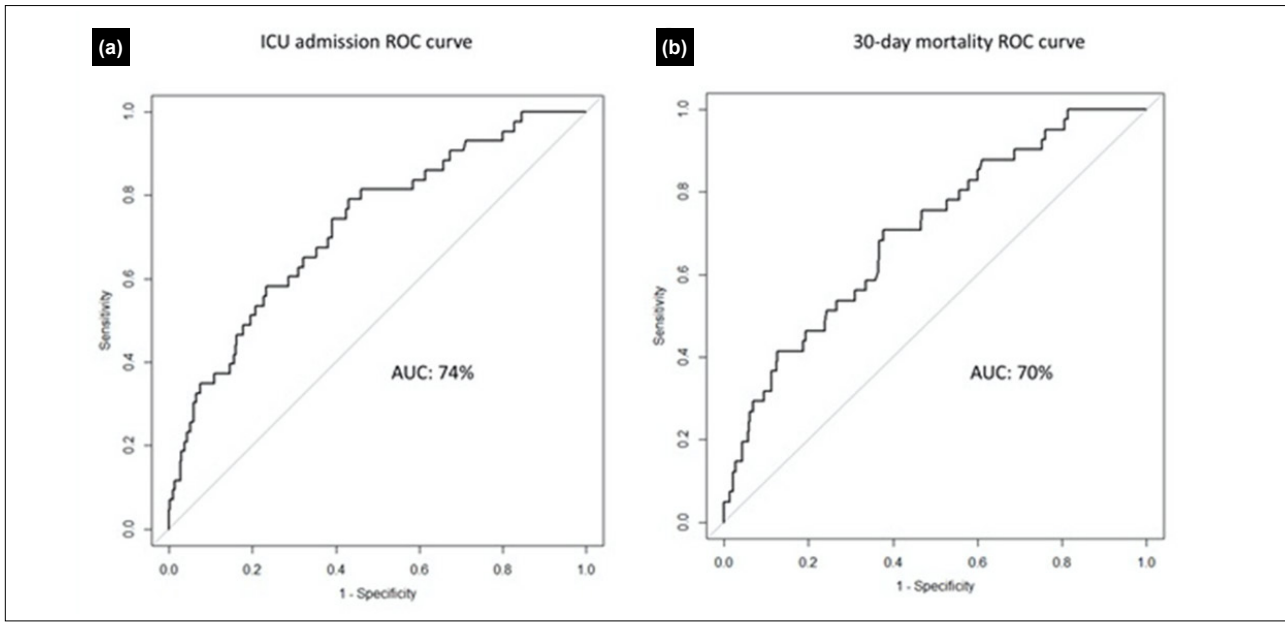

Figure 3. Receiver operating characteristic (ROC) analysis for the combined predictive models. **(a)** Intensive care unit admission model (red cell distribution width [RDW] + atrial fibrillation [AF] + Alzheimer's disease): Area under the curve (AUC) = 0.74, 95% confidence interval [CI]: 0.65–0.81, p<0.001. **(b)** 30-day mortality model (RDW + AF + age): AUC = 0.70, 95% CI: 0.62–0.79, p<0.001.

analysis demonstrated that RDW independently predicts both ICU admission and 30-day mortality after adjusting for age, sex, and relevant comorbidities. The mFI-5 score did not reach statistical significance in univariate analysis for either ICU admission or 30-day mortality, and was therefore excluded from multivariable modeling. When considered in isolation, RDW demonstrated modest discriminatory performance, with AUC values of 0.640 for ICU admission and 0.606 for 30-day mortality. However, when combined with other independent clinical variables – AF and Alzheimer's disease for ICU admission, and AF and age for 30-day mortality – the combined models achieved AUC values of 0.74 and 0.70, respectively, representing a clinically meaningful improvement in risk stratification. These findings suggest that RDW is best utilized not as a standalone screening tool, but as a valuable adjunct marker within a broader multifactorial risk assessment framework.

Intertrochanteric fractures are among the most prevalent HF types in elderly and osteoporotic populations,[11] a pattern reflected in our cohort (62.5%), consistent with previously reported rates.[12] The 30-day mortality rate of 9.9% in our study falls within the range reported in the literature (6–15.4%).[13-16] A consistent sex-based disparity in mortality has been documented across studies, with men facing disproportionately higher early mortality despite lower fracture incidence.[2,12,14,17] Although male sex did not emerge as an independent predictor in our multivariable analysis, the consistently higher observed mortality rates in men suggest that sex-based differences in outcomes warrant further investigation.

Comorbidity burden is well established as a key determinant of post-operative outcomes in HF patients. In a study conducted by Hamdan et al.,[12] cardiovascular disease was identified as the only comorbidity independently associated with mortality, whereas Orhan et al.[18] demonstrated that AF was specifically linked to higher long-term mortality following HF surgery. Our findings corroborate and extend these observations: In our multivariable analysis, AF emerged as an independent predictor of both ICU admission (OR 2.82, 95% CI 1.14–6.70; p=0.02) and 30-day mortality (OR 2.62, 95% CI 1.19–5.53; p=0.01), confirming its role as a robust perioperative risk factor. In addition, Alzheimer's disease was identified as an independent predictor of ICU admission (OR 2.43, 95% CI 1.13–5.14; p=0.03). This finding likely reflects the compounded vulnerability of cognitively impaired patients in the post-operative period, stemming from impaired physiological reserve, limited capacity for rehabilitation, and increased susceptibility to delirium and respiratory complications.

Several CBC-derived inflammatory indices, including NLR, MLR, SII, and SIRI, have been proposed as prognostic markers in HF patients. A study examining HF in patients over 65 years of age demonstrated that NLR and MLR values were significantly higher among those who died at 30 days and 1 year compared with survivors.[6] In contrast, none of these indices – including SII and SIRI – reached statistical significance in predicting ICU admission or 30-day mortality in our cohort, either in univariate comparisons or in multivariable regression modeling. This discrepancy may be attributable to the chronic low-grade inflammation (often termed "inflammaging") characteristic of the geriatric population, which can

reduce the discriminatory capacity of inflammation-based markers by diminishing the margin between high- and low-risk individuals. Furthermore, the dynamic and fluctuating nature of these indices renders single-point measurements at admission susceptible to confounding by acute physiological perturbations, such as the surgical stress response, pain, and fluid shifts occurring in the perioperative setting.

The association between RDW and adverse clinical outcomes reflects the broader role of this parameter as an integrative marker of systemic physiological dysregulation. Elevated RDW is mechanistically linked to chronic low-grade inflammation, oxidative stress, ineffective erythropoiesis, and nutritional deficiencies – pathways that are not only interrelated but also independently associated with increased mortality risk, particularly in geriatric populations with a high comorbidity burden. Several studies have investigated this relationship specifically in HF patients. Garbharran et al.[19] demonstrated that RDW independently predicted both 4-month and 1-year mortality, while higher pre-operative RDW values were significantly associated with increased 30-day mortality in surgically managed HF patients.[13] Dülgeroğlu et al.[14] observed higher RDW values in non-survivors compared with survivors, and Hamdan et al.,[12] reported that elevated RDW was associated with increased 6-month mortality risk, even in the absence of a statistically significant intergroup difference.[12] In a cohort restricted to patients over 70 years of age, RDW was reported as a significant predictor of mortality, suggesting that its prognostic utility may be particularly pronounced in the oldest patient subgroups.[20] Our findings are consistent with this body of evidence: RDW remained an independent predictor of both ICU admission (OR 1.22, 95% CI 1.05–1.41; p=0.009) and 30-day mortality (OR 1.20, 95% CI 1.03–1.39; p=0.016) in multivariable analysis. While RDW alone demonstrated modest discriminatory performance (AUC 0.640 and 0.606, respectively), its integration into combined clinical models substantially improved predictive accuracy, underscoring its value as an adjunct rather than a standalone risk marker.

The mFI-5 is a practical comorbidity-based scoring tool that has been associated with post-operative complications and prolonged length of stay, though its ability to independently predict mortality has yielded conflicting results across the literature. In patients undergoing surgical fixation for thoracolumbar fractures, mFI-5 scores of 2 or higher were associated with increased 30-day mortality risk, whereas a score of 1 conferred no significant excess risk.[21] In HF patients over 65 years of age, both 30-day and 1-year mortality rates increased progressively with rising mFI-5 scores,[6] a pattern also observed by Traven et al.,[22] who reported an overall mortality rate of 6.6% with a notably lower rate of 3.6% in patients with an mFI-5 score of 0. In our cohort, mFI-5 did not reach statistical significance in univariate analysis for either ICU admission (OR 1.34, 95% CI 0.98–1.85; p=0.07) or 30-day mortality (OR 1.15, 95% CI 0.83–1.60; p=0.39), and was therefore not entered into multivariable modeling. This is likely attributable to the limited number of patients at the higher end of the score distribution – only 10 patients had an mFI-5 score of ≥4 – which substantially constrains statistical power for detecting an independent effect.

These findings have practical implications for patient management and clinical follow-up. RDW can be integrated with clinical risk factors, such as AF, Alzheimer's disease, and age to identify high-risk patients early and support timely multidisciplinary intervention.

This study has several strengths worth acknowledging. The relatively large patient cohort accumulated over a 5-year period enhances the robustness of the findings, while the use of multivariable logistic regression analysis strengthens the validity of RDW and comorbidities as independent predictors. Nevertheless, several limitations should be considered when interpreting these results. The retrospective single-center design may introduce heterogeneity in data quality and limits the generalizability of the results to broader patient populations. In addition, the inability to determine specific causes of death precludes a definitive analysis of the underlying pathophysiological mechanisms, particularly for early mortality. Furthermore, the limited number of patients in the higher mFI-5 score categories may have constrained statistical power to detect an independent predictive effect of this index. These limitations underscore the need for prospective, multicenter studies with standardized outcome definitions to validate and extend the present findings.

CONCLUSION

Early identification of patients at elevated risk for adverse outcomes remains a critical challenge in the perioperative management of HF. This study demonstrated that RDW, measured at ED admission, independently predicts both ICU admission and 30-day mortality in surgically managed HF patients, and that its predictive performance improves substantially when integrated with other clinical variables, including AF, Alzheimer's disease, and age. Advanced age, Alzheimer's disease, and AF further contribute to increased risk and should be closely monitored in clinical management. While mFI-5 did not reach statistical significance as a predictor in this cohort, its potential value in larger prospective studies cannot be excluded. Given its routine availability and ease of calculation, RDW represents a practical adjunct marker for rapid risk stratification in the emergency setting. Future multicenter, prospective studies are warranted to validate and further define the clinical utility of these parameters.

Ethics Committee Approval: This study received ethical approval from the Non-Interventional Clinical Research Ethics Committee of the Bilecik Şeyh Edebali University Faculty of Medicine (Date: 06.11.2025, Decision No: 9/4).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: S.D., H.T.; Design: E.A., K.A.; Supervision: E.A., K.A.; Resource: S.D., H.T.; Materials: S.D., E.A., H.T.; Data collection and/or processing: S.D., H.T., E.A., K.A.; Analysis and/or interpretation: S.D.; Literature review: K.A.; Writing: S.D., E.A.; Critical review: H.T., K.A.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Bui M, Nijmeijer WS, Hegeman JH, Witteveen A, Groothuis-Oudshoorn CGM. Systematic review and meta-analysis of preoperative predictors for early mortality following hip fracture surgery. Osteoporos Int 2024;35:561–74. [CrossRef]
2. Forget P, Moreau N, Engel H, Cornu O, Boland B, De Kock M, et al. The neutrophil-to-lymphocyte ratio (NLR) after surgery for hip fracture (HF). Arch Gerontol Geriatr 2015;60:366–71. [CrossRef]
3. Zhu XF, Weng HY, Huang SF. Red cell distribution width as a predictor of mortality after hip fracture: a systematic review and meta-analysis. Eur Rev Med Pharmacol Sci 2023;27:6996–7004.
4. Pan WG, Chou YC, Wu JL, Yeh TT. Impact of hematologic inflammatory markers on the prognosis of geriatric hip fracture: a systematic review and meta-analysis. Eur J Med Res 2024;29:609. [CrossRef]
5. Fang Z, Gao B, Wang Z, Chen X, Liu M. Association of systemic inflammation response index with mortality risk in older patients with hip fracture: a 10-year retrospective cohort study. Front Med (Lausanne) 2024;11:1401443. [CrossRef]
6. Bingol O, Ozdemir G, Kulakoglu B, Keskin OH, Korkmaz I, Kilic E. Admission neutrophil-to-lymphocyte ratio and monocyte-to-lymphocyte ratio to predict 30-day and 1-year mortality in geriatric hip fractures. Injury 2020;51:2663–7. [CrossRef]
7. Subramaniam S, Aalberg JJ, Soriano RP, Divino CM. New 5-factor modified frailty ındex using american college of surgeons NSQIP data. J Am Coll Surg 2018;226:173–81.e8. [CrossRef]
8. Evans EM. The treatment of trochanteric fractures of the femur. J Bone Joint Surg Br 1949;31B:190–203.
9. Robin X, Turck N, Hainard A, Tiberti N, Lisacek F, Sanchez JC, et al. pROC: an open-source package for R and S+ to analyze and compare ROC curves. BMC Bioinformatics 2011;12:77. [CrossRef]
10. R Core Team. R: A Language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2019. Available at: https://www.r-project.org/ Accessed 02 July, 2026.
11. Adeyemi A, Delhougne G. Incidence and economic burden of intertrochanteric fracture: a medicare claims database analysis. JB JS Open Access 2019;4:e0045. [CrossRef]
12. Hamdan M, Haddad BI, Jabaiti M, Alryalat SA, Abdulelah AA, Alabed SH, et al. Does red cell distribution width predict hip fracture mortality among the arab population? A single-center retrospective cohort study. Int J Gen Med 2021;14:10195–202. [CrossRef]
13. Wei-Hsiang H, Zhu Y, Zhang J, Zhang Y. Pretreatment red blood cell distribution width as an efficient predictor of survival in older patients undergoing hip fracture surgery. Int J Clin Pract 2021;75:e14791. [CrossRef]
14. Dülgeroğlu TC, Kurt M, Üzümcigil AO, Yilmaz S, Karaaslan F. Multivariate analysis of blood parameters for predicting mortality in patients with hip fractures. Exp Ther Med 2024;28:414. [CrossRef]
15. Blanco JF, da Casa C, Pablos-Hernández C, González-Ramírez A, Julián-Enríquez JM, Díaz-Álvarez A. 30-day mortality after hip fracture surgery: Influence of postoperative factors. PLoS One 2021;16:e0246963. [CrossRef]
16. Khan MA, Hossain FS, Ahmed I, Muthukumar N, Mohsen A. Predictors of early mortality after hip fracture surgery. Int Orthop 2013;37:2119–24. [CrossRef]
17. Bajracharya R, Guralnik JM, Shardell MD, Rathbun AM, Yamashita T, Hochberg MC, et al. Long-term sex differences in all-cause and infection-specific mortality post hip fracture. J Am Geriatr Soc 2022;70:2107–14. [CrossRef]
18. Orhan AL, Çınar T, Hayıroğlu Mİ, Çiçek V, Selçuk M, Doğan S, Asal S, Yavuz S, Orhan S, Keser N. Atrial fibrillation as a preoperative risk factor predicts long-term mortality in elderly patients without heart failure and undergoing hip fracture surgery. Rev Assoc Med Bras (1992) 2021;67:1633–8. [CrossRef]
19. Garbharran U, Chinthapalli S, Hopper I, George M, Back DL, Dockery F. Red cell distribution width is an independent predictor of mortality in hip fracture. Age Ageing 2013;42:258–61. [CrossRef]
20. Karadeniz S, Yurtbay A. Predicting mortality rate in elderly patients operated for hip fracture using red blood cell distribution width, neutrophil-to-lymphocyte ratio, and Nottingham Hip Fracture Score. Jt Dis Relat Surg 2022;33:538–46. [CrossRef]
21. Taghlabi KM, Quaddoura AA, Nisar A, Gupta P, Bhenderu LS, Guerrero JR, et al. Modified 5-ıtem frailty ındex: a useful tool for assessing the ımpact of frailty on postoperative morbidity and mortality following surgical fixation of thoracolumbar fractures. World Neurosurg 2024;187:e1062-e71. [CrossRef]
22. Traven SA, Reeves RA, Althoff AD, Slone HS, Walton ZJ. New five-factor modified frailty ındex predicts morbidity and mortality in geriatric hip fractures. J Orthop Trauma 2019;33:319–23. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Kalça kırığı nedeniyle ameliyat edilen hastalarda kısa vadeli mortaliteyi tahmin etmede eritrosit dağılım genişliği ve modifiye 5-maddelik kırılganlık indeksi

AMAÇ: Yaşlı bireylerde yaygın olarak görülen ve yüksek mortaliteye sahip kalça kırıkları, acil servislerde sıklıkla karşılaşılan patolojiler arasındadır. Bu çalışmanın amacı, kalça kırığı olan hastalarda kısa dönem mortalite ve yoğun bakım ünitesine (YBÜ) yatış gereksinimlerini tahmin etmede eritrosit dağılım genişliği (RDW) ve modifiye 5-maddelik kırılganlık indeksi (mFI-5) skorlarının prognostik değerini araştırmaktır.

GEREÇ VE YÖNTEM: 1 Ocak 2019 ile 31 Aralık 2023 tarihleri arasında kalça kırığı nedeniyle acil servise başvuran hastalar değerlendirildi. Femur boyun, intertrokanterik veya subtrokanterik kırıklar nedeniyle ameliyat geçiren hastalar çalışmaya dahil edildi. Temel demografik veriler (yaş ve cinsiyet), eşlik eden hastalıklar, YBÜ'ye yatış durumu, hastane-içi ve 30 günlük mortalite oranları kaydedildi. YBÜ'ye yatış ve 30-günlük mortalitenin bağımsız belirleyicilerini tespit etmek için tek değişkenli ve çok değişkenli lojistik regresyon analizleri yapıldı.

BULGULAR: Kalça kırığı nedeniyle ameliyat yapılan toplam 413 hasta incelenmiştir. Hastaların ortalama yaşı 80±11 yıl olup, 271'i (%65.6) kadındı. Kırk üç hasta (%10) YBÜ'ye yatırılırken, hastane-içi ve 30-günlük mortalite oranları sırasıyla %7 (n=30) ve %9.9 (n=41) idi. Çok değişkenli lojistik regresyon analizi sonucunda RDW hem YBÜ'ye yatış (OR 1.22, %95 CI 1.05–1.41; p=0.009) hem de 30-günlük mortalite oranı (OR 1.20, %95 CI 1.03–1.39; p=0.016) için bağımsız bir öngörücü olarak belirlendi. Atriyal fibrilasyon ve Alzheimer hastalığı YBÜ'ye yatışın bağımsız öngörücüleri olarak belirlenirken, atriyal fibrilasyon ve yaş ise 30-günlük mortaliteyi bağımsız olarak öngördü. mFI-5 skoru, tek değişkenli analizde her iki sonuç için de istatistiksel olarak anlamlılığa ulaşmadı. RDW ve diğer kovaryatları içeren bir tahmin modeli, YBÜ'ye yatış için 0.74 ve 30 günlük mortalite için 0,70 AUC değerlerine ulaştı.

SONUÇ: RDW cerrahi olarak tedavi edilen kalça kırığı hastalarında YBÜ'ye yatış ve 30 günlük mortalitenin bağımsız olarak öngörücüsü olarak belirlendi ve çok parametreli bir modele entegre edildiğinde ayırt edici performansı iyileşti. İleri yaş, Alzheimer hastalığı ve atriyal fibrilasyon risk artışına daha fazla katkıda bulunur ve klinik yönetim sürecinde yakından takip edilmelidir. Bu bulgular, bu hasta grubu için RDW'nin rutin acil risk sınıflandırmasına dahil edilmesini desteklemektedir.

Anahtar sözcükler: 30 günlük mortalite; eşlik eden hastalıklar; monosit-lenfosit oranı; nötrofil-lenfosit oranı; sistemik immün-enflamasyon indeksi; sistemik inflamasyon yanıt indeksi; yoğun bakım yatışı.

Ulus Travma Acil Cerrahi Derg 2026;32(8):998-1007 DOI: 10.14744/tjtes.2026.20432

CASE REPORT

Retroperitoneal ectopic spleen identified during emergency laparotomy

Burcu Belen Aydoğmuş,[1] Mehlika Bilgi Kırmacı,[2] Müberra Konur,[1] Emre Ballı,[2] Yusuf Burak Aydoğmuş,[3] İhsan Canbek,[4] Çiğdem Özdemir[1]

[1]Department of Medical Pathology, Surgical Medical Sciences, Afyonkarahisar Health Sciences University Faculty of Medicine, Afyonkarahisar-*Türkiye*

[2]Department of General Surgery, Surgical Medical Sciences, Afyonkarahisar Health Sciences University Faculty of Medicine, Afyonkarahisar-*Türkiye*

[3]Department of Emergency Medicine, Afyonkarahisar State Hospital, Afyonkarahisar-*Türkiye*

[4]Department of Neurosurgery, Surgical Medical Sciences, Afyonkarahisar Health Sciences University Faculty of Medicine, Afyonkarahisar-*Türkiye*

ABSTRACT

An ectopic spleen refers to splenic tissue or lobules located outside the normal anatomical position of the spleen and is most commonly found near the splenic hilum. Ectopic splenic tissue is typically found in characteristic anatomical locations but may rarely occur in atypical sites. Owing to its unusual localization, it can be radiologically mistaken for a variety of tumors. This case is notable because a large retroperitoneal mass requiring emergency laparotomy was ultimately diagnosed as ectopic splenic tissue. A 44-year-old man underwent emergency diagnostic laparotomy for acute abdominal symptoms. Preoperative imaging revealed a heterogeneous lesion medial to the left psoas muscle that was radiologically suggestive of a soft tissue tumor. Intraoperative frozen section examination demonstrated lymphoid tissue suggestive of splenic origin, and the diagnosis was subsequently confirmed on paraffin sections. Histopathological evaluation revealed a well-circumscribed nodular lesion composed of follicle-like lymphoid structures and sinusoidal vascular channels, consistent with ectopic splenic tissue. Unlike most reported cases, which typically occur in women aged 20–40 years and involve lesions measuring 1–3 cm, our patient was male and presented with a retroperitoneal lesion measuring 6.5×3×2.5 cm, an uncommon presentation. The unusual location and relatively large size of the lesion led to its initial radiological interpretation as a soft tissue tumor, highlighting the importance of comprehensive radiologic evaluation and histopathological examination for accurate diagnosis.

Keywords: Ectopic; retroperitoneum; spleen.

INTRODUCTION

The spleen may exhibit a variety of anomalies involving its shape, location, size, and number. Although some of these abnormalities may be acquired, most are congenital in origin.[1] An ectopic or accessory spleen is defined as splenic tissue or splenic lobules located outside the normal anatomical position of the spleen and is most commonly detected incidentally in asymptomatic individuals.[2] Ectopic splenic tissue has been reported in approximately 10%–30% of the population and may occasionally present with acute abdominal symptoms.[3]

Cite this article as: Belen Aydoğmuş B, Bilgi Kırmacı M, Konur M, Ballı E, Aydoğmuş YB, Canbek İ, et al. A retroperitoneal ectopic spleen encountered during urgent laparotomy. Ulus Travma Acil Cerrahi Derg 2026;32:1008-1013.

Address for correspondence: Burcu Belen Aydoğmuş
Department of Medical Pathology, Surgical Medical Sciences, Faculty of Medicine, Afyonkarahisar Health Sciences University, Afyonkarahisar, Türkiye
E-mail: burcubelenbb@gmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):1008-1013 DOI: 10.14744/tjtes.2026.11568
Submitted: 13.12.2025 Revised: 13.01.2026 Accepted: 11.02.2026 Published: 10.08.2026

CASE REPORT

A 44-year-old man presented to the emergency department with left-sided abdominal pain. His medical history was significant only for polycythemia. Physical examination revealed tenderness on deep palpation extending into the left lumbar region. Laboratory evaluation demonstrated a white blood cell count (WBC) of 15,000/μL and a hemoglobin level of 19.2 g/dL, while all other biochemical parameters were within normal limits. Computed tomography (CT) of the abdomen revealed a 90 × 51 mm lesion adjacent to the left psoas muscle, and further evaluation with magnetic resonance imaging was recommended (Fig. 1).

The patient was admitted to the general surgery department for further evaluation and management. Contrast-enhanced magnetic resonance imaging (MRI) of the upper abdomen demonstrated a heterogeneous lesion located medial to the left psoas muscle, measuring 86×49 mm. The lesion contained macroscopic fat and peripheral fatty components, exhibited mild hyperintensity on pre-contrast T1-weighted images, and showed marked contrast enhancement. The differential diagnosis included hematoma, abscess, and sarcoma (Fig. 2). The interventional radiology team was consulted regarding ultrasound-guided drainage; however, the procedure was considered inappropriate.

During hospitalization, the patient's fever and left flank pain worsened, prompting urgent diagnostic laparotomy. Surgical exploration revealed a lesion compressing the left psoas muscle and lumbar plexus. The mass was excised using a combination of sharp and blunt dissection. Given the suspicion of a malignant mesenchymal tumor or sarcoma, the specimen was submitted for frozen section examination. Macroscopic examination of the specimen, measuring 9×7×4 cm, revealed a well-circumscribed nodular lesion measuring 6.5×3×2.5 cm that was sharply demarcated from the surrounding adipose tissue. Intraoperative frozen section examination was performed because of a preliminary diagnosis of sarcoma. The cut surface of the lesion was pink-tan and soft in consistency (Fig. 3).

Frozen section analysis demonstrated lymphoid tissue suggestive of splenic origin; however, distinction between benign and malignant processes and definitive diagnosis required evaluation of paraffin sections.

The patient's left flank pain improved during postoperative follow-up, and he was discharged without complications on postoperative day 4.

Following routine fixation in 10% formaldehyde, histopathological examination of hematoxylin and eosin (H&E)-stained sections revealed a well-circumscribed, nodular lesion embedded within adipose tissue. The lesion consisted of lymphocytes arranged in follicle-like structures together with vascular channels exhibiting sinusoidal architecture (Fig. 4).

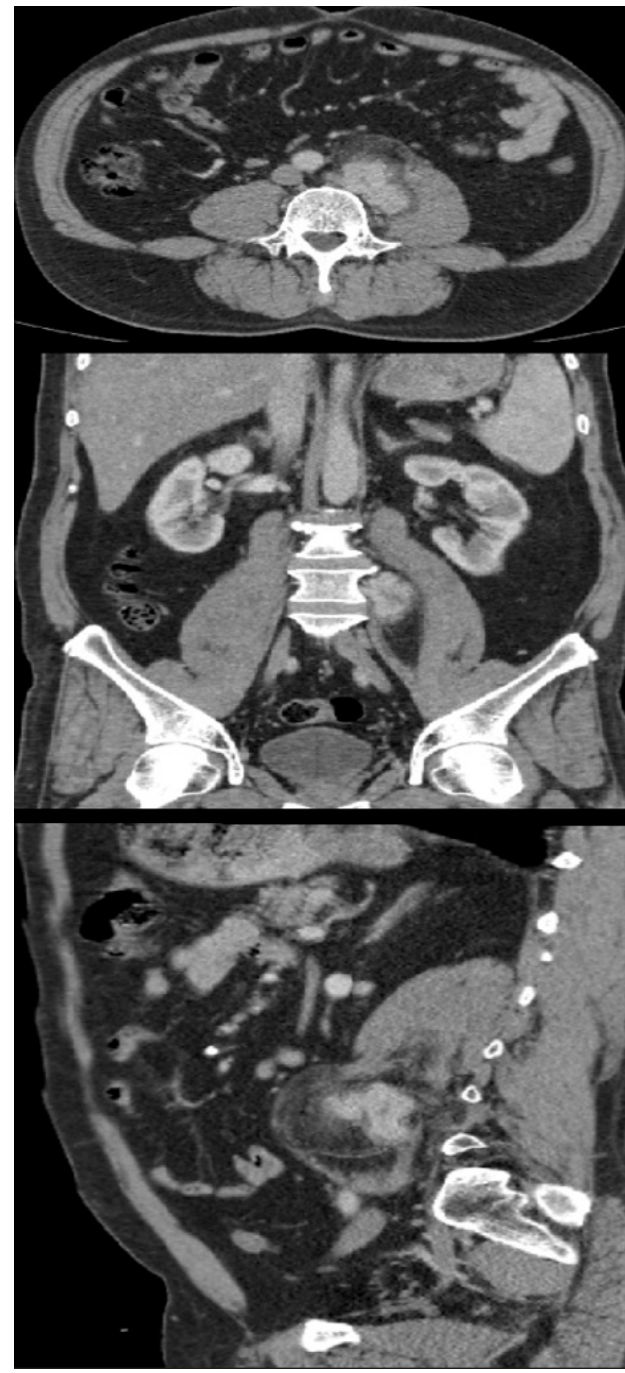

Figure 1. Computed tomography (CT) image demonstrating the identified lesion.

Immunohistochemical staining was performed using antibodies against cluster of differentiation 20 (CD20), CD3, CD15, CD10, CD23, CD30, CD5, CD19, CD79A, paired box protein 5 (PAX5), B-cell lymphoma 2 (BCL-2), BCL-6, CD34, CD31, and Ki-67 (Fig. 5). Based on the overall histopathological findings, a diagnosis of ectopic spleen was established.

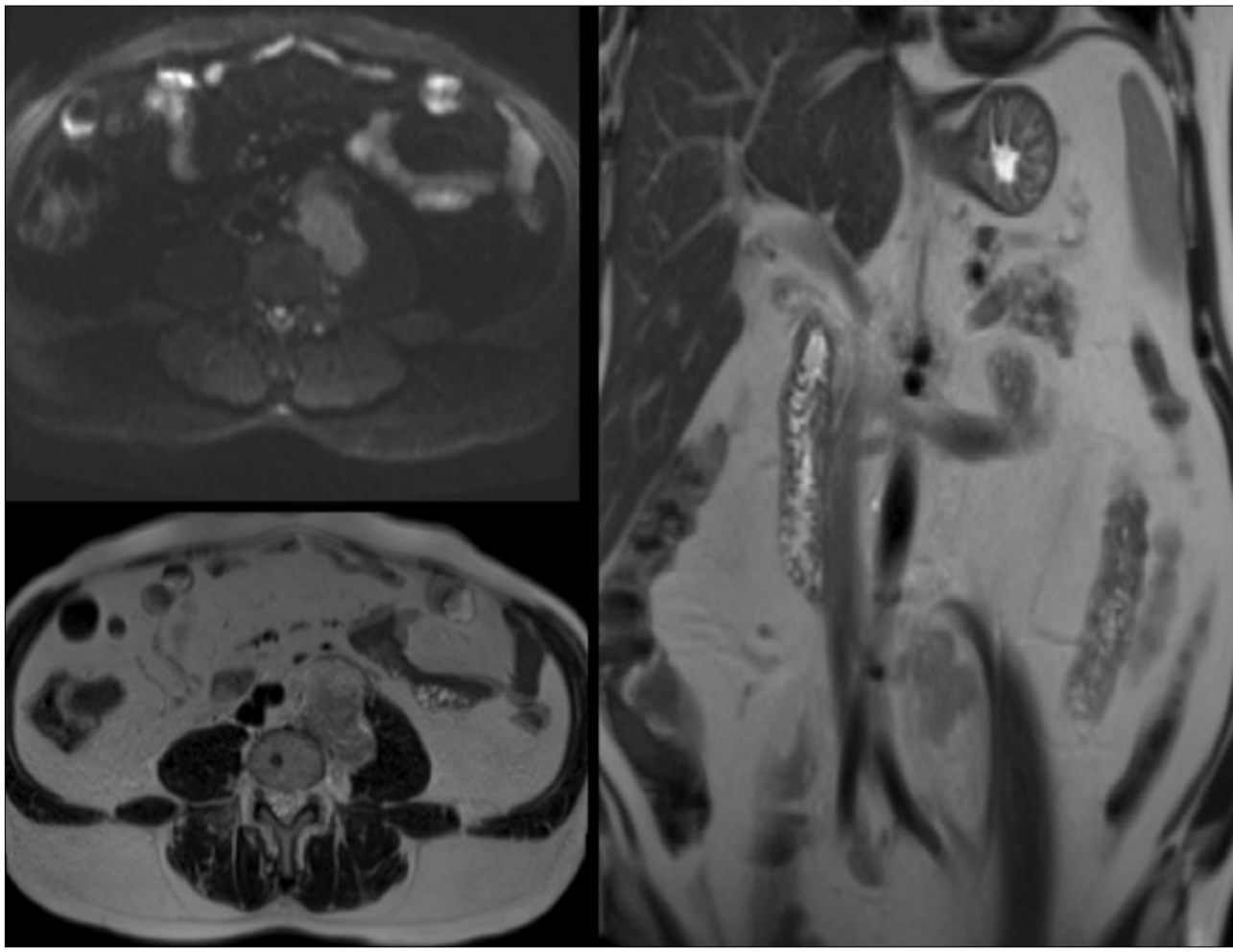

Figure 2. Magnetic resonance imaging (MRI) showing the lesion in question.

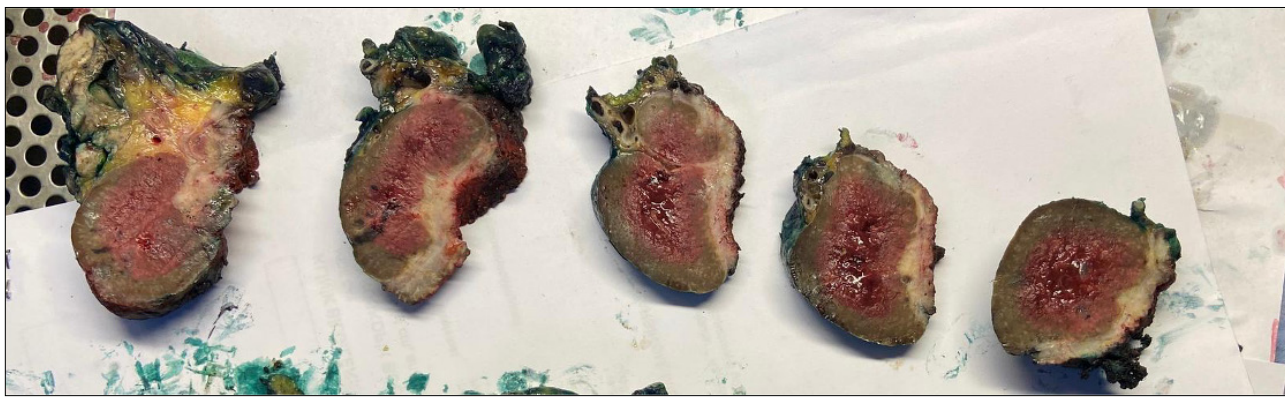

Figure 3. Gross examination showing a soft nodular lesion sharply demarcated from the surrounding adipose tissue.

DISCUSSION

The present case is noteworthy because a retroperitoneal mass discovered during emergency laparotomy for acute abdominal symptoms was ultimately diagnosed as ectopic splenic tissue. Retroperitoneal tumors constitute a relatively small proportion of abdominal neoplasms but present significant diagnostic and therapeutic challenges owing to their anatomi-

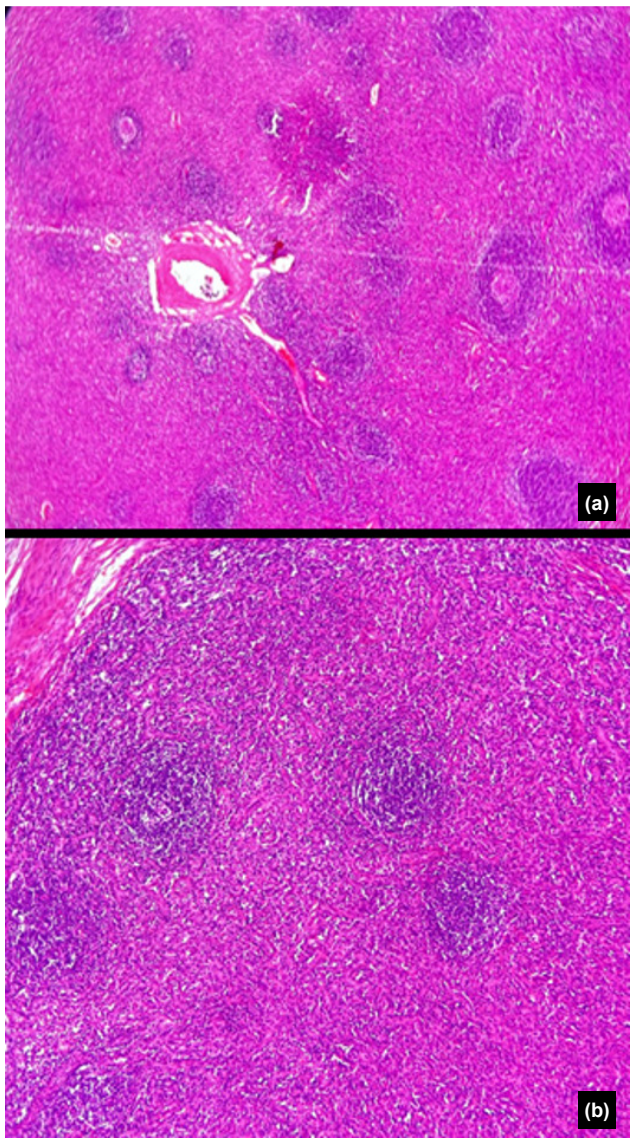

Figure 4. (a) Splenic tissue composed of follicles of varying sizes with intervening sinusoidal vascular channels (hematoxylin and eosin [H&E], ×40). **(b)** Splenic tissue showing sinusoidal spaces and follicles beneath the capsule (H&E, ×100).

cal location, size at presentation, and frequently delayed diagnosis.[4] Approximately 75% of retroperitoneal masses are malignant, with sarcomas representing the most common histological subtype.[5] These lesions often remain clinically silent until they become large enough to compress adjacent organs or vascular structures.[6] Common clinical manifestations include abdominal pain, distension, and, less frequently, bowel obstruction. Emergency laparotomy is indicated when life-threatening complications occur. In patients with retroperitoneal tumors, this may be necessary in the setting of hemodynamic instability, rupture, infection, or significant diagnostic uncertainty.

In the present case, we believe that the patient's acute ab-

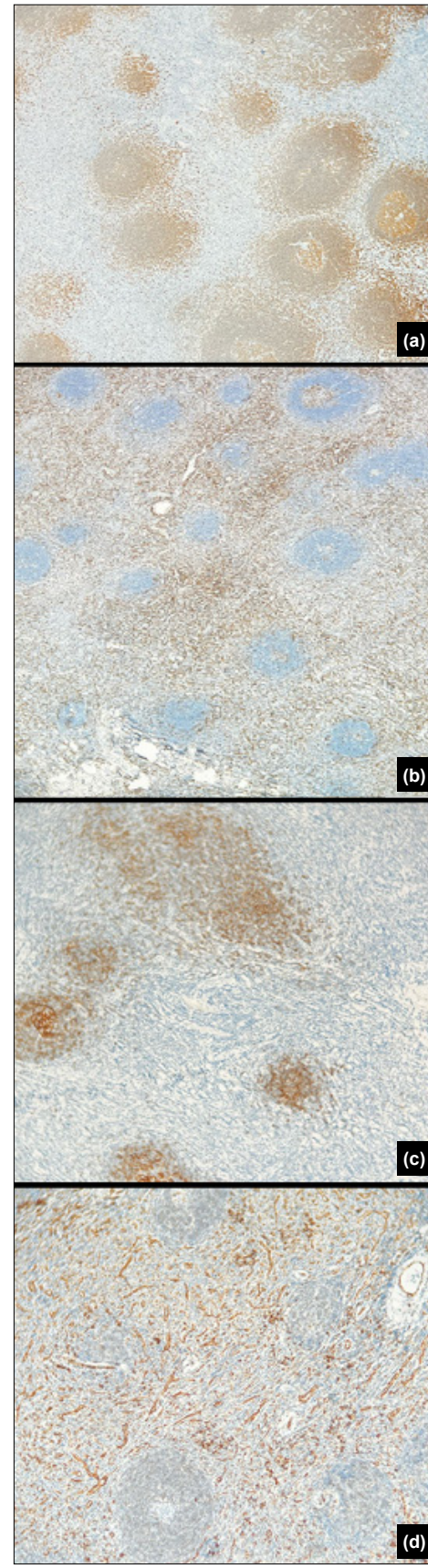

Figure 5. Immunohistochemical findings. **(a)** CD20, (×100). **(b)** CD3, (×40). **(c)** CD23, (×100). **(d)** CD31, (×100).

dominal symptoms were caused by compression of the lumbar plexus by the retroperitoneal mass, which was initially suspected to be a sarcoma. This interpretation is supported by the absence of intra-abdominal pathology at laparotomy and the lack of evidence of hemorrhage or infection within the lesion.

The spleen plays a critical role in both hematologic and immunologic function. Ectopic splenic tissue results from congenital developmental anomalies or ligamentous laxity.[7] Accessory spleens are most commonly located near the splenic hilum (approximately 75%), followed by the pancreatic tail (approximately 20%), with less frequent locations including the renal and gonadal regions.[8] In cases of wandering spleen, ligamentous laxity may allow migration of splenic tissue into the lower abdomen or pelvis.[9] Splenosis implants are often distributed throughout the peritoneal cavity, including the abdominal and pelvic peritoneal surfaces.[10] Retroperitoneal localization of ectopic splenic tissue is exceedingly rare. Although splenosis may theoretically occur in any anatomical compartment, most reported cases involve intraperitoneal surfaces. Consequently, reports of retroperitoneal ectopic spleen or splenosis are limited to isolated case reports.[10,11] Therefore, retroperitoneal ectopic splenic tissue should be considered a rare but important differential diagnosis when evaluating retroperitoneal masses. Potential complications include pedicle torsion resulting in ischemia and necrosis, spontaneous or traumatic rupture, and splenomegaly.[12] When such complications occur, patients may present with acute abdominal symptoms and, in severe cases, hemodynamic instability.[13]

In our case, since the patient presented with an acute abdomen secondary to retroperitoneal sarcoma, we anticipated a sarcoma-related complication. Further imaging studies were not obtained because of financial limitations. The patient's clinical symptoms were attributed to compression of the lumbar plexus, and the pain resolved within 3–4 weeks postoperatively.

A review of the literature suggests that reports of ectopic splenic tissue initially diagnosed as retroperitoneal sarcoma are exceedingly rare. Ectopic splenic tissue results from congenital developmental anomalies or ligamentous laxity.[7] Although ectopic spleen is often asymptomatic, it may lead to life-threatening complications when torsion or rupture occurs.[14] Furthermore, most reported cases involve female patients and relatively small lesions, whereas our patient was male and presented with a comparatively large lesion.[15,16]

Radiologically, ectopic splenic tissue may closely mimic soft tissue tumors. One reported case described a 4.9×3 cm ectopic spleen located within the parietal peritoneum of the right lower quadrant that was initially interpreted as an abdominal fibroma on CT imaging.[17] Similarly, the lesion in our patient was initially interpreted as a sarcoma on radiological imaging. Because of their atypical location, ectopic spleens may be mistaken for soft tissue tumors. Therefore, in addition to ultrasonography and CT, 99mTc-nanocolloid scintigraphy, which is more specific for detecting accessory splenic tissue, may be considered as part of the diagnostic work-up.[2]

In the literature, intraoperative frozen section examination has been performed in cases in which an abdominal fibroma of the parietal peritoneum or a solid pseudopapillary tumor of the pancreatic tail was suspected. In both cases, the presence of sinusoidal channels and lymphoid tissue on histomorphological examination led to the diagnosis of ectopic splenic tissue.[17,18] Similarly, intraoperative frozen section examination in our case revealed lymphoid tissue suggestive of splenic origin. The characteristic encapsulated architecture, lymphoid follicles, and splenic sinusoids are often identifiable on frozen sections, aiding intraoperative diagnosis.

CONCLUSION

Although the retroperitoneum is a common site for sarcomas, ectopic splenic tissue should also be considered in the differential diagnosis of retroperitoneal masses. Because ectopic spleen may closely mimic mesenchymal tumors on imaging studies, diagnostic modalities capable of demonstrating splenic tissue characteristics may improve preoperative identification. Histomorphologically, recognition of splenic sinusoids is an important clue to the diagnosis of ectopic splenic tissue.

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: B.B.A., Ç.Ö., M.K., E.B., M.B.K., Y.B.A., İ.C.; Design: B.B.A., Ç.Ö., M.K., E.B., M.B.K., Y.B.A., İ.C.; Supervision: B.B.A., Ç.Ö., M.K., E.B., M.B.K., Y.B.A., İ.C.; Resource: M.B.K., E.B., B.B.A.; Materials: İ.C., M.B.K., E.B.; Data collection and/or processing: B.B.A., Y.B.A.; Analysis and/or interpretation: Ç.Ö.; Literature review: Ç.Ö., B.B.A.; Writing: B.B.A., Y.B.A.; Critical review: M.K.

Informed Consent: Written informed consent was obtained from the patient for publication of clinical findings and imaging studies.

Conflict of Interest: The authors declare no conflicts of interest related to this study.

Financial Disclosure: The authors received no financial support for this work.

REFERENCES

1. Yildiz AE, Ariyurek MO, Karcaaltincaba M. Splenic anomalies of shape, size, and location: pictorial essay. Scientific World Journal 2013;2013:321810. [CrossRef]
2. Bajwa SA, Kasi A. Anatomy, Abdomen and Pelvis: Accessory Spleen. Treasure Island (FL): StatPearls Publishing; 2025. Available at: https://

www.ncbi.nlm.nih.gov/books/NBK519040/
3. Mohammadi S, Hedjazi A, Sajjadian M, Ghrobi N, Moghadam MD, Mohammadi M. Accessory spleen in the splenic hilum: a cadaveric study with clinical significance. Med Arch 2016;70:389–1. [CrossRef]
4. Carbone F, Pizzolorusso A, Di Lorenzo G, Di Marzo M, Cannella L, Barretta ML, et al. Multidisciplinary management of retroperitoneal sarcoma: diagnosis, prognostic factors and treatment. Cancers (Basel) 2021;13:4016. [CrossRef]
5. Dominguez DA, Sampath S, Agulnik M, Liang Y, Nguyen B, Trisal V, et al. Surgical management of retroperitoneal sarcoma. Curr Oncol 2023;30:4618–31. [CrossRef]
6. Fisher S, Haack C. Abdominal compartment syndrome. In: Practical emergency resuscitation and critical care. Cambridge: Cambridge University Press; 2013. p. 274–7. [CrossRef]
7. Magowska A. Wandering spleen: a medical enigma, its natural history and rationalization. World J Surg 2013;37:545–50. [CrossRef]
8. Bayanduuren B, Altankhuyag B, Enkhbayar D, Uyanga T, Bulgan CH, Mishigdorj L. Ruptured huge ectopic spleen: a case presentation review of literature. Ann Clin Case Rep 2020;5:1784.
9. Wandering spleen. In: Radiopaedia. 2024. Available at: https://radiopaedia.org/articles/wandering-spleen Accessed June 25, 2026
10. Smoot T, Revels J, Soliman M, Liu P, Menias CO, Hussain HH, et al. Abdominal and pelvic splenosis: atypical findings, pitfalls, and mimics. Abdom Radiol [NY] 2022;47:923–47. [CrossRef]
11. Xiao M, Liang J, Ren J, Zheng R, Wu L. The imaging features of ectopic spleen: which modality is more consistent? A cases series report and literature reviews. Front Oncol 2024;14:1310394. [CrossRef]
12. Sarimurat N, Tekant GT, Hüseyin S, Söylet Y, Senyüz OF. Wandering spleen in childhood: a report of three cases. Surg Today 1997;27:1086–8. [CrossRef]
13. Yıldırım D, Apaydın T, Yıldırım T. Ektopik dalak torsiyonu: olgu sunumu ve literatür derlemesi. Ulus Cerrahi Derg 2019;35:123–7. [Article in Turkish]
14. Sheflin JR, Lee CM, Kretchmar KA. Torsion of wandering spleen and distal pancreas. AJR Am J Roentgenol 1984;142:100-1. [CrossRef]
15. Ronot M, Aguiar D, Assalino M, Terraz S. Retroperitoneal ectopic splenic tissue: Imaging findings. Diagn Interv Imaging 2016;97:935–7. [CrossRef]
16. Maksoud SF, Swamy N, Khater NH. Tale of a wandering spleen: 1800 degree torsion with infarcted spleen and secondary involvement of liver. J Radiol Case Rep 2014;8:18–26. [CrossRef]
17. Xu SY, Sun K, Xie HY, Zhou L, Zheng SS, Wang W. Accessory spleen located in the right parietal peritoneum: The first case report. Medicine (Baltimore) 2017;96:e7957. [CrossRef]
18. Luo J, Chen J, Huang F, Zhou P, Huang P. Heterotopic accessory spleen with squamous epithelial cyst in pancreas mimicking other pancreatic tumor: a case report. Ann Transl Med 2020;8:507. [CrossRef]

OLGU SUNUMU - *ÖZ*

Acil laparotomi sırasında retroperitoneal bölgede saptanan ektopik dalak

Ektopik dalak, normal dalağın dışında bulunan ve genellikle dalak hilusuna yakın konumda yer alan dalak dokusu veya lobüllerini ifade eder. Ektopik dalak genellikle karakteristik anatomik bölgelerde gözlenmekle birlikte, nadiren atipik lokalizasyonlarda da görülebilir. Bu olağandışı yerleşim nedeniyle radyolojik olarak çeşitli tümörlerle karıştırılabilmektedir. Bu olgu, büyük bir retroperitoneal kitle nedeniyle acil laparotomi gerektirmesi ve sonuçta ektopik dalak tanısı alması nedeniyle dikkat çekicidir. Bu olgu sunumunda, akut karın ağrısı nedeniyle acil tanısal laparotomi uygulanan 44 yaşındaki bir erkek hasta sunulmaktadır. Ameliyat öncesi görüntüleme, sol psoas kasının medialinde, radyolojik olarak yumuşak doku tümörünü düşündüren heterojen bir lezyon ortaya koymuştur. Ameliyat sırasında değerlendirilen frozen kesit, dalak kökenini düşündüren lenfoid dokuyu göstermiş, kesin tanı ise daha sonra parafin kesitlerde doğrulanmıştır. Histopatolojik değerlendirmede, ektopik dalak dokusuyla uyumlu, folikül benzeri lenfoid yapılar ve sinüzoidal vasküler kanallardan oluşan, iyi sınırlı nodüler bir lezyon saptanmıştır. Literatürde bildirilen çoğu olgudan farklı olarak, genellikle 20-40 yaş arası kadınlarda görülen ve 1-3 cm boyutlarında olan lezyonların aksine, bu olgu 6.5×3×2.5 cm boyutlarında retroperitoneal lezyona sahip erkek bir hastada görülmüştür. Ektopik dalak dokusunun atipik lokalizasyonu ve alışılmadık derecede büyük boyutu, başlangıçta yumuşak doku tümörü olarak değerlendirilmesine neden olmuş ve doğru tanı için kapsamlı radyolojik inceleme ile histopatolojik değerlendirmenin önemini ortaya koymuştur.

Anahtar sözcükler: Dalak; ektopik; retroperiton.

Ulus Travma Acil Cerrahi Derg 2026;32(8):1008-1013 DOI: 10.14744/tjtes.2025.11568

CASE REPORT

A rare cause of late benign biliary stricture after laparoscopic cholecystectomy: gossypiboma

Alperen Dalkıran, Necdet Güler, Yamaç Erhan

Department of General Surgery, Manisa Celal Bayar University Faculty of Medicine, Manisa-*Türkiye*

ABSTRACT

Gossypiboma refers to a retained cotton-based, non-absorbable foreign body left in the operative field after surgery. Its detection is often difficult and may lead to significant morbidity and mortality. In this case report, we present a case of biliary stricture caused by gossypiboma in a patient who had undergone laparoscopic cholecystectomy 9 months earlier and presented with jaundice. A 64-year-old male had previously undergone laparoscopic cholecystectomy for cholelithiasis. Postoperatively, he experienced recurrent abdominal pain, nausea, and vomiting. In the 9th post-operative month, jaundice and pruritus developed, and laboratory tests revealed cholestasis (total bilirubin: 11.66 mg/dL; gamma-glutamyl transferase: 930 U/L). Magnetic resonance imaging demonstrated intrahepatic bile duct dilatation and a stricture adjacent to a metallic clip. Endoscopic retrograde cholangiopancreatography and percutaneous cholangiography confirmed the obstruction. During laparotomy, a retained surgical sponge (gossypiboma) was identified and removed, and a Roux-en-Y hepaticojejunostomy was performed. The patient recovered uneventfully and was discharged on post-operative day 13. In accordance with surgical safety protocols, performing a final count at the end of the operation, using radio-opaque materials, and maintaining effective team communication are critical measures for preventing such errors. Delayed diagnosis may result in prolonged asymptomatic periods or misdiagnosis due to non-specific clinical findings. In patients with a history of surgery who present with symptoms such as infection, pain, fistula, or a mass, gossypiboma should be considered, and computed tomography should be the preferred imaging modality. Multidisciplinary awareness and meticulous perioperative protocols may significantly reduce this risk. In conclusion, gossypiboma is a complication that is far easier to prevent than to treat.

Keywords: Biliary stricture, gossypiboma, pseudotumor.

INTRODUCTION

Gossypiboma refers to a retained cotton-based, non-absorbable foreign body left in the operative field after surgery.[1] The term derives from the gossypium (cotton) and the boma (enclosure or protected place).[2] Due to its rarity and difficulty of detection through imaging methods, gossypiboma can lead to serious morbidity and mortality.[1] The exact incidence remains uncertain because surgeons are often reluctant to report such cases for medicolegal reasons.

Gossypiboma may occur following any surgical procedure but is more frequently encountered in intra-abdominal surgeries.[3] The incidence of retained surgical items after operations is reported to range from 0.01% to 0.001%, and approximately 80% of these cases are gossypibomas. It may remain asymptomatic or present with various clinical findings such as ileus, hollow-organ perforation, abscess, peritonitis, intra-abdominal adhesions, or fistula formation. Patients may present with abdominal pain, weight loss, anorexia, nausea, or vomiting.[4]

For diagnosis, imaging modalities such as plain radiography, ultrasonography (USG), computed tomography (CT), and magnetic resonance imaging (MRI) may be utilized, with CT being considered the most effective tool among them. However, the absence of radio-opaque markers in surgical sponges may complicate the detection of gossypiboma.[5]

Cite this article as: Dalkıran A, Güler N, Erhan Y. A rare cause of late benign biliary stricture after laparoscopic cholecystectomy: gossypiboma. Ulus Travma Acil Cerrahi Derg 2026;32:1014-1019.

Address for correspondence: Alperen Dalkıran

Department of General Surgery, Manisa Celal Bayar University Faculty of Medicine, Manisa, Türkiye

E-mail: alperendalkiran5@gmail.com

Ulus Travma Acil Cerrahi Derg 2026;32(8):1014-1019 DOI: 10.14744/tjtes.2026.22617

Submitted: 14.11.2025 Revised: 19.02.2026 Accepted: 16.03.2026 Published: 10.08.2026

In cases of gossypiboma, plain radiographs may demonstrate curvilinear or band-like radio-opaque lines.[6] On USG, it may appear as a cystic or solid lesion with posterior acoustic shadowing; however, due to its rarity, it is frequently misinterpreted. On CT, internal air bubbles within cotton-like structures, wall calcifications, and contrast enhancement may be observed. If the surgical sponges used during the operation contain radio-opaque markers, these can be visualized on CT.[7]

On contrast-enhanced MRI, gossypiboma typically appears as a well-circumscribed mass with a defined capsule. Following intravenous contrast administration, an external capsule and a heterogeneous signal pattern may be observed on T1-weighted images, depending on the fluid and protein content.[8]

However, in thoracic textilomas, the spongiform appearance may be lost due to the absorptive capacity of the pleura, resulting in the disappearance of internal air bubbles. In such cases, radiological imaging may reveal only a non-specific solid mass. Despite these imaging characteristics, gossypiboma remains difficult to diagnose even with modern imaging modalities due to its rarity. Therefore, in patients presenting with abdominal symptoms, a detailed medical history should be obtained, and a prior surgical history must always be thoroughly investigated. The onset of symptoms should be clearly established. Definitive treatment consists of complete surgical removal of the retained foreign body.[9]

In this report, we present a rare complication of gossypiboma that was referred to our clinic.

CASE REPORT

A 64-year-old male patient underwent laparoscopic cholecystectomy for cholelithiasis at an external center 9 months earlier and was discharged in good condition. The pathological examination revealed chronic cholecystitis. Beginning in the 1st post-operative month, the patient presented 3 times to the same center with intermittent complaints of abdominal pain, nausea, and vomiting. No significant findings were detected on radiological or biochemical evaluations at that time.

In the 9th post-operative month, the patient was admitted to the gastroenterology department of our hospital with complaints of generalized pruritus, jaundice, and dark-colored urine and was hospitalized for further evaluation and treatment.

Initial laboratory investigations revealed a total bilirubin level of 11.66 mg/dL, direct bilirubin of 5.95 mg/dL, gamma-glutamyl transferase of 930 U/L, alanine aminotransferase (ALT) of 79 U/L, and aspartate aminotransferase of 68 U/L. MRI demonstrated intrahepatic bile duct dilatation and a 32×25 mm lesion in the operative area with high T1 signal intensity, heterogeneous internal structure, and no contrast enhancement (Fig. 1). Adjacent to this lesion, an abrupt narrowing was observed in the common hepatic duct, with a metallic clip at the same level.

Endoscopic retrograde cholangiopancreatography (ERCP) revealed an inability to advance the guidewire beyond the proximal portion of the common hepatic duct, suggesting an

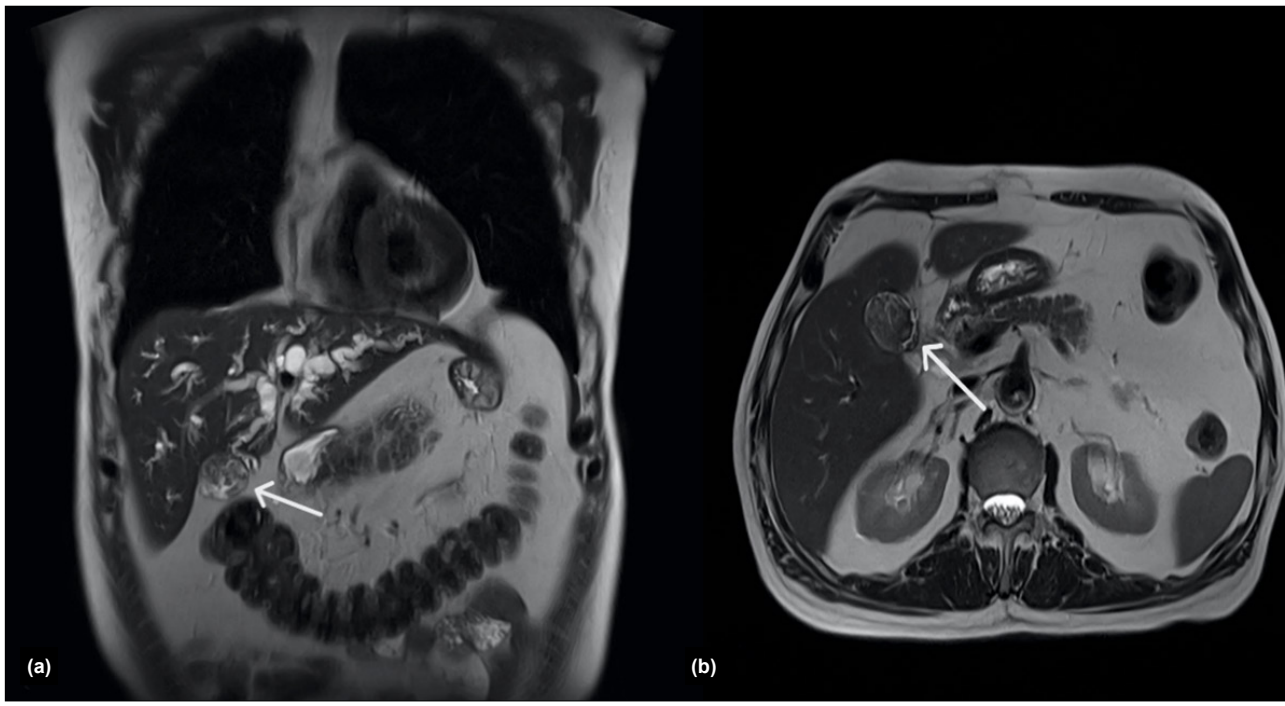

Figure 1. T2-weighted coronal **(a)** and axial **(b)** magnetic resonance images showing a 32×25 mm pseudotumoral lesion in the inferior part of the liver and dilatation of the intrahepatic bile ducts.

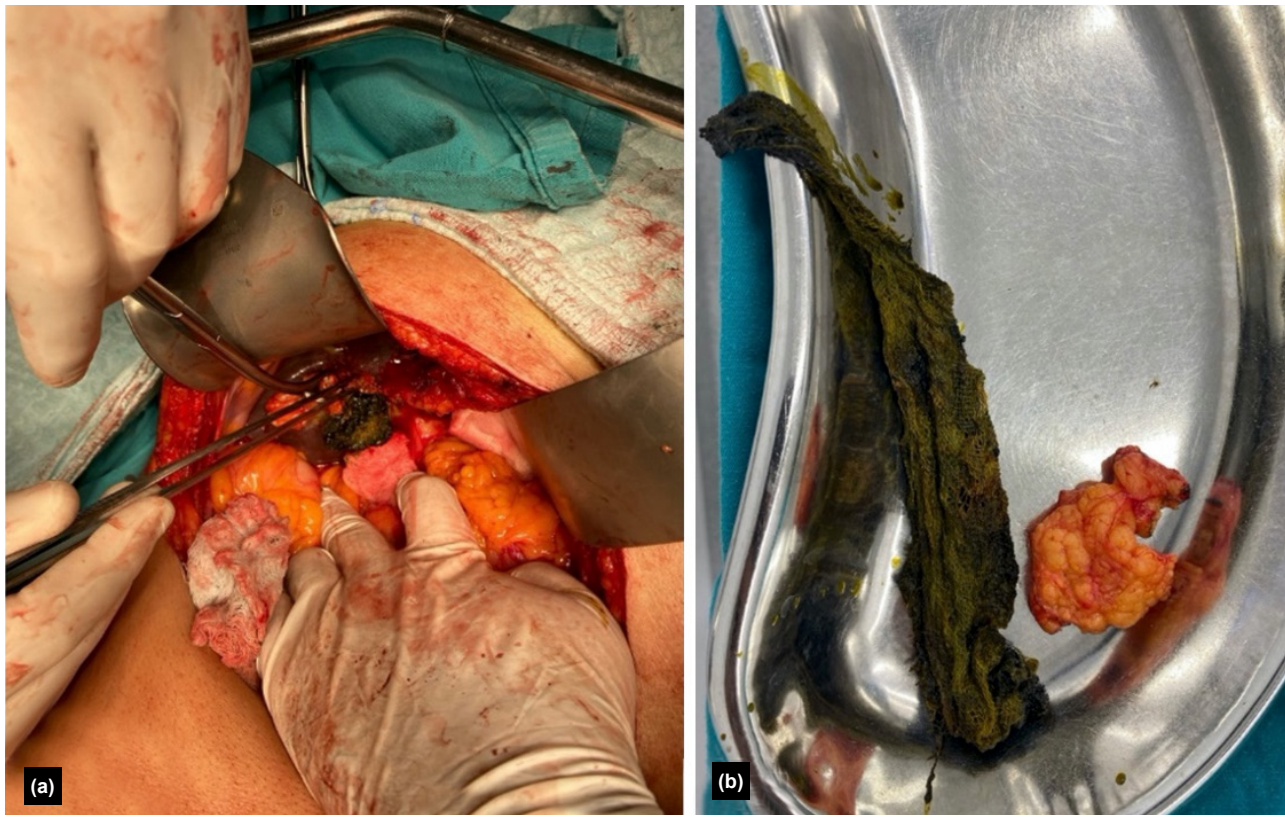

Figure 2. (a) Intraoperative view showing a lesion consistent with a retained surgical sponge (gossypiboma) in the previous operative site after adhesiolysis and **(b)** bile contamination observed after removal of the gossypiboma.

external biliary stricture related to the laparoscopic metallic clip. Subsequently, percutaneous transhepatic cholangiography under fluoroscopic guidance demonstrated an obstruction at the level of the common bile duct. The obstructed segment could not be traversed, and an external biliary drainage catheter was inserted for decompression. Following these procedures, the patient was referred to our surgical clinic and was prepared for the operation.

The patient underwent surgery following anesthetic preparation. During laparotomy, the omentum and surrounding adipose tissues were found to be adherent to the previous operative site. A firm, fixed mass measuring approximately 5×5 cm was observed in the gallbladder bed. After careful dissection of the adhesions, the lesion was identified as a retained surgical sponge (gossypiboma) from the previous operation (Fig. 2).

After removal of the foreign body, contrast material was administered through the previously placed biliary drainage catheter, and fluoroscopy was performed (Fig. 3). The contrast agent was observed not to pass into the duodenum. A Roux-en-Y hepaticojejunostomy was then performed, and the operation was completed. The patient was monitored in the intensive care unit postoperatively and transferred to the ward on the 2nd post-operative day. On post-operative day 5, fluoroscopic imaging showed that the contrast agent passed into the duodenum without any leakage (Fig. 4). The post-operative course was uneventful, biochemical parameters returned to normal levels, and the patient was discharged in

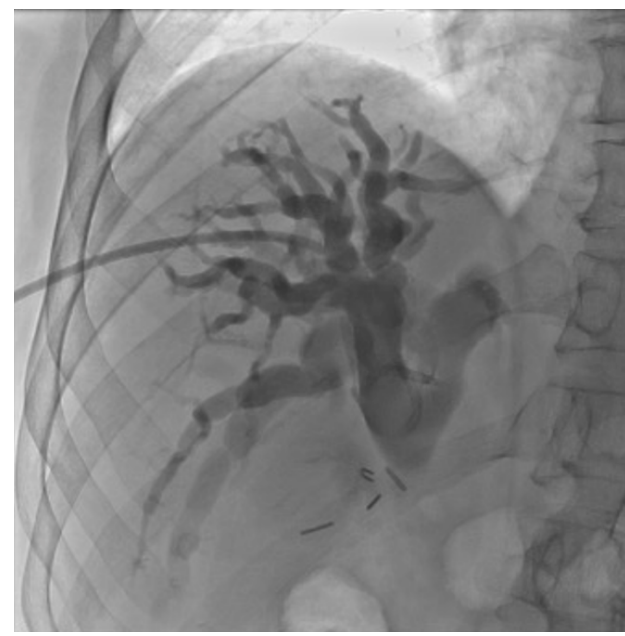

Figure 3. Fluoroscopic image showing dilatation of the biliary tree and metallic clips remaining from the previous operation.

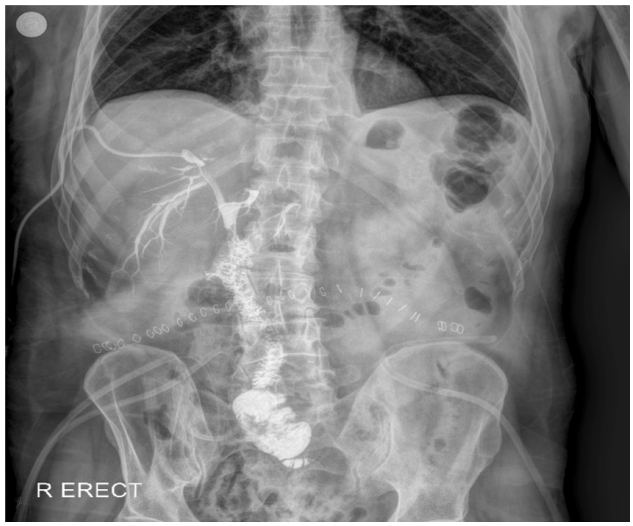

Figure 4. Fluoroscopic image obtained after Roux-en-Y hepaticojejunostomy showing passage of contrast material from the drainage catheter into the jejunum.

good condition on post-operative day 13. Written consent was obtained from the patient for publication of this case report and its images.

DISCUSSION

Gossypiboma may cause an exudative or fibrinous inflammatory response in the body. The exudative response resulting from local inflammation generally occurs in the early post-operative period, whereas the fibrinous reaction develops in the late period due to encapsulation of the foreign body within scar tissue over time. This condition has become a serious problem for clinics because of the diagnostic difficulties it presents and the medicolegal issues it may cause.

The first case was reported in 1884, and cases in which the foreign body remained in the body for up to 52 years after surgery have also been documented, demonstrating that gossypiboma may present with symptoms even after a long latency period.[10] Therefore, it should be considered during the diagnostic process in patients with a history of surgery who present with a mass.[11]

In a systematic review, the most frequently affected regions were reported to be the abdomen (56%), pelvis (18%), and thorax (11%). Gossypibomas related to abdominal surgery are usually associated with gastrointestinal findings such as intestinal obstruction, nausea, vomiting, and diarrhea. In some cases, multiple symptoms may occur simultaneously. In the present case, skin jaundice, dark-colored urine, and pale stools developed approximately 9 months after surgery. This finding highlights the variable clinical course of gossypiboma and the diagnostic challenges it presents.[12] The most common signs and symptoms include pain (42%), a palpable mass (27%), and fever (12%). Multiple symptoms are observed in 48% of cases, whereas 6% of patients are completely asymptomatic and are diagnosed incidentally. Common complications of gossypiboma include adhesions (31%), abscess formation (24%), and fistula formation (20%).[12,13] A retained foreign body may cause intestinal obstruction and gastrointestinal bleeding due to vascular injury. Perforation may occur as a result of intestinal erosion, which can persist for years and present with abdominal pain, anemia, diarrhea, and anorexia.[14] Particularly in patients presenting with jaundice and cholestatic findings, this represents an important clinical condition requiring early diagnosis and urgent management. When investigating the etiology of biliary obstruction, the anatomical level of obstruction should be carefully evaluated. The most common causes of cholestasis include choledocholithiasis, choledochal cysts, primary sclerosing cholangitis, cholangiocarcinoma, parasitic cholangiopathies, and, less frequently, obstruction secondary to retained foreign bodies. Therefore, a comprehensive physical examination and detailed medical history are of great importance. In all patients with obstructive jaundice, a history of prior abdominal surgery should be carefully investigated, and the onset of symptoms should be thoroughly assessed, as treatment strategies largely depend on the clinical condition and underlying etiology.[15] A review of the literature indicates that cases of biliary stricture secondary to gossypiboma are extremely rare. In one reported case, a biliary stricture developed due to a bile stone formed around a retained fragment left during a previous ERCP procedure.[16] In another study, biliary stricture was attributed to migration of a metal clip following laparoscopic cholecystectomy, and resolution of symptoms was observed after endoscopic removal of the clip during ERCP.[17] In our case, the patient presented with persistent post-operative abdominal pain and jaundice. The pseudotumoral lesion, due to its location, caused a biliary stricture secondary to surrounding inflammatory reaction and fibrosis. This condition is among the rarely reported cases in the scientific literature.

In the literature, the interval between the initial surgical procedure and the diagnosis or removal of gossypiboma has been reported to vary widely.[18] In some cases, the diagnosis is made within a few months, whereas in others, it may take several years or even decades. In a large series, this interval ranged from 1 to 120 months, with a mean duration of 30.6 months, while another review reported an average detection time of 6.9 years and noted that 38% of cases were diagnosed within the 1st year.[12,18] In our case, gossypiboma was identified approximately 9 months after surgery. This duration is consistent with the broad time range reported in the literature and further emphasizes the variable clinical presentation of gossypiboma.

Due to the highly variable clinical presentation of gossypiboma and the frequent delay in diagnosis, imaging modalities play a critical role in achieving accurate and early detection. In the literature, CT is reported as the most commonly used diagnostic method. Typical CT findings include a whorled or spongiform appearance, a mass with variable wall thickness,

and internal gas bubbles. Over time, lesions may appear as single, dense-centered structures or as multiple concentric rings with varying attenuation patterns. However, in some cases, gossypiboma may be mistaken for an echinococcal cyst or an intracavitary fungal mass. These pseudotumoral lesions may create significant diagnostic challenges, leading to unsuccessful biopsy attempts and unnecessary investigations.[9] This highlights the importance of careful differential diagnosis given the heterogeneous radiological features of gossypiboma.[12]

In the present case, radiological examinations were not diagnostic because the surgical sponges used in the previous operation lacked radio-opaque markers. Consequently, gossypiboma could not be identified preoperatively, and the lesion was incidentally discovered during intraoperative exploration. Although gossypiboma can occur in any type of surgical procedure, its incidence increases significantly in the presence of certain risk factors. Various factors associated with its development have been identified in the literature.[12] Commonly reported risk factors include case-specific circumstances such as emergency surgical procedures and unexpected intraoperative complications, as well as operating room-related issues such as poor team communication, counting errors, inadequate supervision, prolonged operations, team fatigue, changes in the surgical team, obesity, and complex surgical planning.[19-21] The coexistence of these factors increases the likelihood of retained surgical materials in the post-operative period and may lead to delayed diagnosis.

Accurate counting of all sponges and compresses before initiating surgery and the use of radio-opaque materials whenever possible constitute fundamental safety practices. In accordance with the standards of the Association of Perioperative Registered Nurses, performing a final verification before surgical closure, independently confirming counts by two individuals, and using exclusively radio-opaque surgical materials are recommended safety measures.[3] Effective communication during staff changes and re-verification of counts is of paramount importance. Before wound closure, the surgeon should systematically inspect the operative field, ensure that all materials have been removed, and request a final count. In suspicious situations, the surgical field should be reassessed, and intraoperative direct radiography should be performed if necessary.[5] In the present case, a counting error related to the surgical sponge used during the procedure was considered the most likely contributing factor.

Although rare, gossypiboma is a preventable surgical complication that can lead to serious morbidity, mortality, and legal consequences. When diagnosis is delayed, patients may remain asymptomatic for years or may be misdiagnosed due to non-specific findings. Therefore, in patients with a history of surgery who present with signs such as infection, pain, fistula, or a mass, the possibility of gossypiboma should always be considered. A high level of clinical suspicion should be maintained during the diagnostic process, and appropriate imaging modalities – particularly CT – should be preferred.

Surgical intervention remains the primary treatment modality in cases of gossypiboma. Although the complete elimination of this complication may appear challenging given the complexity of surgical procedures, it should be emphasized that gossypiboma is largely preventable. Therefore, the main focus should be on the meticulous and systematic implementation of preventive strategies. Multidisciplinary awareness, effective team communication, technology-assisted control mechanisms, and strictly applied perioperative protocols can significantly reduce this risk. Accurate counting of all sponges and compresses before surgery, the use of radio-opaque materials, and re-verification of counts during staff changes constitute fundamental safety measures. Before wound closure, the surgical field should be systematically inspected, a final count must be performed, and intraoperative imaging should be considered in suspicious situations.

CONCLUSION

In conclusion, gossypiboma is a complication that is far easier to prevent than to treat and is directly related to patient safety. Therefore, every surgical procedure should be evaluated not only in terms of technical success but also with respect to adherence to safety protocols and collective team responsibility.

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: A.D., N.G.; Design: A.D., N.G.; Supervision: N.G., Y.E.; Resource: A.D., N.G., Y.E.; Materials: A.D., N.G.; Data collection and/or processing: A.D., N.G.; Analysis and/or interpretation: A.D., N.G., Y.E.; Literature review: A.D., N.G.; Writing: A.D., N.G.; Critical review: A.D., N.G.

Informed Consent: Written consent was obtained from the patient for publication of this case report and its images.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Alemu BN, Tiruneh AG. Gossypiboma: A Case Series and Literature Review. Ethiop J Health Sci 2020;30:147–9. [CrossRef]
2. Arıkan Y, Ozdemir O, Seker KG, Eksi M, Guner E, Kalfazade N, et al. Gossypiboma: A Dramatic Result of Human Error, Case Report and Literature Review. Prague Med Rep 2019;120:144–9. [CrossRef]
3. Hameed A, Naeem A, Azhar M, Fatimi SH. Intrathoracic gossypiboma. BMJ Case Rep 2014;2014:bcr2013201814. [CrossRef]
4. Dinsa LH, Workineh BB, Hunde CR. Gossypiboma with enterocutaneous fistula after cesarean section: a case report and review of the literature. J Med Case Rep 2024;18:515. [CrossRef]
5. Sözütek A, Karabuğa T, Bozdağ AD et al. Asymptomatic gossypiboma mimicking a liver mass. Turk J Surg 2010;26:225–8. [CrossRef]

6. Yildirim S, Tarim A, Nursal TZ, Yildirim T, Caliskan K, Torer N, et al. Retained surgical sponge (gossypiboma) after intraabdominal or retroperitoneal surgery: 14 cases treated at a single center. Langenbecks Arch Surg 2006;391:390–5. [CrossRef]
7. Akbulut S, Arikanoglu Z, Yagmur Y, Basbug M. Gossypibomas mimicking a splenic hydatid cyst and ileal tumor: a case report and literature review. J Gastrointest Surg 2011;15:2101–7. [CrossRef]
8. Bozkurt H, Öğüt B. A gossypiboma masquerading as a mesenteric cyst. Malawi Med J 2021;33:68–70.
9. Sayan B, Yamansavci Sirzai E, Yildizeli B. A word of caution for gossypiboma. Thorac Cardiovasc Surg 2022;70:579–82. [CrossRef]
10. Parra M, Oppliger F, Berríos R, Schiappacasse G. Intrathoracic gossypiboma presenting 52 years later as a chest mass. Asian Cardiovasc Thorac Ann 2015;23:596–8. [CrossRef]
11. Taşar P, Kılıçturgay SA. Gossypiboma mimicking hepatic hydatid cyst after 22 years: a case report. Ulus Travma Acil Cerrahi Derg 2024;30:68–71. [CrossRef]
12. Wan W, Le T, Riskin L, Macario A. Improving safety in the operating room: a systematic literature review of retained surgical sponges. Curr Opin Anaesthesiol 2009;22:207–14. [CrossRef]
13. Hempel S, Maggard-Gibbons M, Nguyen DK, Dawes AJ, Miake-Lye I, Beroes JM, et al. Wrong-Site Surgery, Retained Surgical Items, and Surgical Fires: A Systematic Review of Surgical Never Events. JAMA Surg 2015;150:796–805. [CrossRef]
14. de Sousa JB, Alves Martins BA, Rocha Ferreira IA, E Silva SM, de Oliveira PG. Transmural migration of gossypiboma with intraluminal small-bowel obstruction: a case report. Am J Case Rep 2020;21:e924506. [CrossRef]
15. Coucke EM, Akbar H, Kahloon A, Lopez PP. Biliary obstruction. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2022.
16. Braimakis I, Leventaki F, Papadopoulos N, Tsibouris P, Apostolopoulos P. Hepatic Duct Foreign Body Mimicking Cholangiocarcinoma: Case Analysis, Diagnostic Challenges, and Literature Review. Cureus 2025;17:e98361. [CrossRef]
17. Kaur N, Kaur A, Singh M, Shergill JS. Obstructive biliopathy with acute cholangitis secondary to post-cholecystectomy clip migration: a rare complication managed with ERCP. BMJ Case Rep 2025;18:e265485. [CrossRef]
18. Machado DM, Zanetti G, Araujo Neto CA, Nobre LF, Meirelles GS, Silva JL, et al. Thoracic textilomas: CT findings. J Bras Pneumol 2014;40:535–42. [CrossRef]
19. Othman SA, AlSafwani JQ, AlSahwan A, Aljehani Y. Intrathoracic gossypiboma: an overlooked entity. Am J Case Rep 2020;21:e923992. [CrossRef]
20. Mejri A, Arfaoui K, Aloui B, Yaakoubi J. Gossypiboma: the failure of a successful intervention. Pan Afr Med J 2020;36:335. [CrossRef]
21. Pandey S, Aggarwal A, Singh V, Sinha RJ. Gossypiboma masquerading as nephrocutaneous fistula. BMJ Case Rep 2018;2018:bcr2018225992. [CrossRef]

OLGU SUNUMU - *ÖZ*

Laparoskopik kolesistektomi sonrası geç dönem benign biliyer darlık gelişimi için nadir bir neden: Gossipiboma

Gossipiboma, cerrahi işlem sonrası operasyon sahasında unutulan pamuk kökenli, emilemeyen yabancı cisim olarak tanımlanır. Tanısının konulması genellikle zordur ve bu durum ciddi morbidite ve mortaliteye yol açabilir. Bu olgu sunumunda, dokuz ay önce laparoskopik kolesistektomi geçirmiş ve sarılık şikayeti ile başvuran bir hastada gossipibomaya bağlı gelişen biliyer darlık olgusu sunulmuştur. 64 yaşındaki erkek hasta daha önce kolelithiazis nedeniyle laparoskopik kolesistektomi geçirmiştir. Ameliyat sonrasında tekrarlayan karın ağrısı, bulantı ve kusma şikayetleri olmuştur. Dokuzuncu ayda sarılık ve kaşıntı gelişmiş, laboratuvar testlerinde kolestaz saptanmıştır (total bilirubin: 11.66 mg/dL; gama-glutamil transferaz: 930 U/L). Manyetik rezonans görüntülemede intrahepatik safra yollarında dilatasyon ve metal klips komşuluğunda darlık görülmüştür. Endoskopik retrograd kolanjiyopankreatografi ve perkütan kolanjiografi ile obstrüksiyon doğrulanmıştır. Laparotomi sırasında unutulmuş cerrahi spanç (gossipiboma) saptanmış ve çıkarılmış, ardından Roux-en-Y hepatikojejunostomi yapılmıştır. Hasta sorunsuz iyileşmiş ve ameliyat sonrası 13. günde taburcu edilmiştir. Gossipiboma, nadir görülen ancak ciddi morbidite, mortalite ve hukuki sonuçlara yol açabilen, büyük ölçüde önlenebilir bir cerrahi komplikasyondur. Cerrahi güvenlik protokollerine uygun olarak ameliyat sonunda yapılan son sayım, radyo-opak materyal kullanımı ve ekip içi etkili iletişim bu hataların önlenmesinde kritik öneme sahiptir. Tanının gecikmesi, hastaların uzun süre asemptomatik kalmasına veya nonspesifik klinik bulgulara bağlı olarak yanlış tanı almasına neden olabilir. Cerrahi öyküsü olan hastalarda enfeksiyon, ağrı, fistül veya kitle gibi bulgular görüldüğünde gossipiboma akılda tutulmalı ve görüntülemede özellikle bilgisayarlı tomografi tercih edilmelidir. Multidisipliner farkındalık ve titiz perioperatif protokoller bu riskin azaltılmasını sağlar. Sonuç olarak, gossipiboma tedavisinden çok önlenmesi daha kolay olan bir komplikasyondur.

Anahtar sözcükler: Biliyer darlık; gossipiboma, psödotümör.

Ulus Travma Acil Cerrahi Derg 2026;32(8):1014-1019 DOI: 10.14744/tjtes.2026.22617