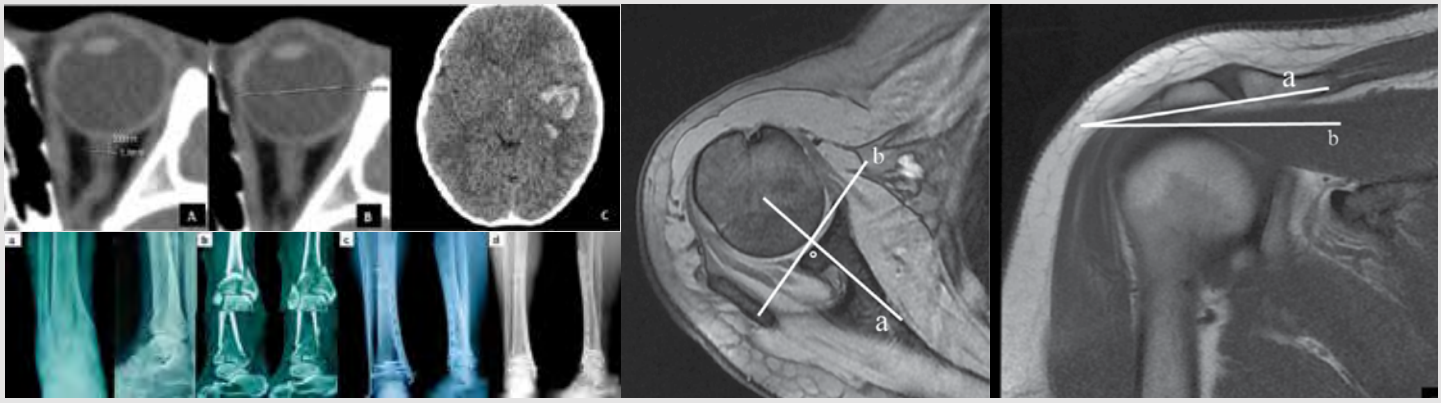
ISSN 2651-3153 • EISSN 2651-3153

European Archives of Medical Research

Formerly Okmeydanı Medical Journal

Volume: 39 • Number: 3 • September 2023



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Web: www.galenos.com.tr
Publisher Certificate Number: 14521

Publication Date: September 2023

ISSN: 2651-3137 **E-ISSN:** 2651-3153

International scientific journal published quarterly.

European Archives of Medical Research

Formerly Okmeydanı Medical Journal

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Tables should be included in the main document, presented after the reference list, and they should be numbered consecutively in the order they are referred to within the main text. A descriptive title must be placed above the tables.

Abbreviations used in the tables should be defined below the tables by footnotes (even if they are defined within the main text).

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Original Article	3500	250 (Structured)	40	6	7 or total of 15 images
Review Article	5000	250	80	6	10 or total of 20 images
Case Report	1000	200	15	No tables	10 or total of 20 images
Letter to the Editor	500	No abstract	5	No tables	No media

Tables should be created using the "insert table" command of the word processing software and they should be arranged clearly to provide easy reading. Data presented in the tables should not be a repetition of the data presented within the main text but should be supporting the main text.

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Figures, graphics, and photographs should be submitted as separate files (in TIFF or JPEG format) through the submission system. The files should not be embedded in a Word document or the main document. When there are figure subunits, the subunits should not be merged to form a single image. Each subunit should be submitted separately through the submission system. Images should not be labeled (a, b, c, etc.) to indicate figure subunits. Thick and thin arrows, arrowheads, stars, asterisks, and similar marks can be used on the images to support figure legends. Like the rest of the submission, the figures too should be blind. Any information within the images that may indicate an individual or institution should be blinded. The minimum resolution of each submitted figure should be 300 DPI. To prevent delays in the evaluation process, all submitted figures should be clear in resolution and large in size (minimum dimensions: 100 × 100 mm). Figure legends should be listed at the end of the main document.

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When a drug, product, hardware, or software program is mentioned within the main text, product information, including the name of the product, the producer of the product, and city and the country of the company (including the state if in USA), should be provided in parentheses in the following format: "Discovery St PET/CT scanner (General Electric, Milwaukee, WI, USA)"

All references, tables, and figures should be referred to within the main text, and they should be numbered consecutively in the order they are referred to within the main text.

Limitations, drawbacks, and the shortcomings of original articles should be mentioned in the Discussion section before the conclusion paragraph.

References

While citing publications, preference should be given to the latest, most up-to-date publications. If an ahead-of-print publication is cited, the DOI number should be provided. Authors are responsible for the accuracy of references. Journal titles should be abbreviated in accordance with the journal abbreviations in Index Medicus/ MEDLINE/PubMed. When there are six or fewer authors, all authors should be listed. If there are seven or more authors, the first six authors should be listed followed by "et al." In the main text of the manuscript, references should be cited using Arabic numbers in parentheses. The reference styles for different types of publications are presented in the following examples.

Journal Article: Stephane A. Management of Congenital Cholesteatoma with Otoendoscopic Surgery: Case Report. Turkiye Klinikleri J Med Sci 2010;30:803-7.

Book Section: Suh KN, Keystone JS. Malaria and babesiosis. Gorbach SL, Barlett JG, Blacklow NR, editors. Infectious Diseases. Philadelphia: Lippincott Williams; 2004.p.2290-308.

Books with a Single Author: Sweetman SC. Martindale the Complete Drug Reference. 34th ed. London: Pharmaceutical Press;2005.

Editor(s) as Author: Huizing EH, de Groot JAM, editors. Functional reconstructive nasal surgery. Stuttgart-New York: Thieme;2003.

Conference Proceedings: Bengisson S. Sothemin BG. Enforcement of data protection, privacy and security in medical informatics. In: Lun KC, Degoulet P, Piemme TE, Rienhoff O, editors. MEDINFO 92. Proceedings of the 7th World Congress on Medical Informatics; 1992 Sept 6-10; Geneva, Switzerland. Amsterdam: North-Holland;1992. pp.1561-5.

Scientific or Technical Report: Cusick M, Chew EY, Hoogwerf B, Agrón E, Wu L, Lindley A, et al. Early Treatment Diabetic Retinopathy Study Research Group. Risk factors for renal replacement therapy in the Early Treatment Diabetic Retinopathy Study (ETDRS), Early Treatment Diabetic Retinopathy Study Kidney Int: 2004. Report No: 26.

Thesis: Yılmaz B. Ankara Üniversitesindeki Öğrencilerin Beslenme Durumları, Fiziksel Aktiviteleri ve Beden Kitle İndeksleri Kan Lipidleri Arasındaki Ilişkiler. H.Ü. Sağlık Bilimleri Enstitüsü, Doktora Tezi. 2007.

Manuscripts Accepted for Publication, Not Published Yet: Slots J. The microflora of black stain on human primary teeth. Scand J Dçent Res. 1974. Epub Ahead of Print Articles: Cai L, Yeh BM, Westphalen AC, Roberts JP, Wang ZJ. Adult living donor liver imaging. Diagn Interv Radiol 2016 Feb 24. doi: 10.5152/dir.2016.15323. [Epub ahead of print].

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CONTENTS

REVIEW

DOI: 10.4274/eamr.galenos.2023.70037
Eur Arch Med Res 2023;39(3):134-140

Comprehensive Review of Hybrid Emergency Room Systems: Benefits, Challenges, and Future Prospects

Merve Nihal Akpınar, Buğra Koç, Berk Özşahin, Burak Uğur, Zeina Akçadağ, Ahmet Demirel, İlker Gündüz, Asım Kalkan

University of Health Sciences Turkey, Prof. Dr. Cemil Taşcıoğlu City Hospital, Clinic of Emergency Medicine, İstanbul, Turkey

Abstract

Hybrid Emergency Room Systems (HERS) have emerged as a promising solution to address the challenges of timely and effective trauma management and acute care interventions. This review provides an in-depth exploration of HERS, its definition, historical development, advantages, disadvantages, successful implementations, economic considerations, and its potential role in the future of emergency care. HERS is designed to facilitate rapid assessment, diagnosis, and interventions by integrating various medical specialties, advanced imaging technologies, and interventional capabilities within the emergency care environment. Through comprehensive literature review and case studies, this article demonstrates how HERS has been utilized to improve patient outcomes in cases of trauma, cardiovascular emergencies, and other critical conditions. The advantages of HERS include enhanced coordination among medical specialties, streamlined communication, real-time imaging capabilities, and optimized resource utilization. However, challenges such as high costs, complexity, and accessibility limitations need to be considered. This review also discusses the economic implications of implementing HERS and presents a model-based cost-benefit analysis, underscores the importance of carefully planning and evaluating the implementation of HERS, considering its potential benefits and challenges. As HERS continues to evolve and gain recognition globally, its role in modern healthcare and emergency services is poised to become increasingly significant.

Keywords: HERS, hybrid emergency room, hybrid operating room

INTRODUCTION TO HYBRID EMERGENCY ROOM SYSTEMS, ITS DEFINITION AND HISTORY

A significant portion of emergency room admissions comprise trauma patients. Trauma continues to be one of the most important causes of mortality in all age groups. Early intervention for these patients could be life-saving. Intervention in the early hours of admission is one of the most important factors affecting mortality. Rapid assessment bleeding control, imaging, and, if necessary, transfer to trauma centers are all part of trauma management. When these steps are distant from each other, it further limits the already restricted time we have.

The hybrid emergency room system (HERS) is formed to prevent time loss during trauma management. This system was initially launched to enable interventional radiologists to intervene at the patient's bedside using a computerized tomography (CT) table (1). Later it has been improved for intervention in many other diseases. The fundamental purpose of HERS is to provide interventions for patients in the room and to prevent time loss during their transfer to other units. Many potential benefits have been demonstrated with the implementation of hybrid emergency room systems (2). Most importantly, HERS helps rapid assessment, diagnosis, and management in trauma and acute cardiovascular events, where the golden hour is life-saving.

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Received: 30.08.2023
Accepted: 31.08.2023

Cite this article as: Akpınar MN, Koç B, Özşahin B, Uğur B, Akçadağ Z, Demirel A, Gündüz İ, Kalkan A. A Comprehensive Review of Hybrid Emergency Room Systems: Benefits, Challenges, and Future Prospects. Eur Arch Med Res 2023;39(3):134-140

With imaging methods readily available in the room, patients can be rapidly evaluated, and appropriate interventions can be initiated. HERS has been shown to improve patient outcomes and reduce morbidity and mortality (3).

In this article, we examine and evaluate the current status of hybrid emergency room systems. We will address the key components, benefits, challenges, and potential limitations of implementing these systems. By reviewing the existing literature and sharing insights from successful cases, we aim to comprehensively assess the impact and effectiveness of hybrid emergency room systems in enhancing accessibility, patient care, and overall emergency department management. Through our article, we hope to contribute to the ongoing debates regarding the future of emergency care and provide valuable insights to healthcare professionals considering the implementation of hybrid emergency room systems.

METHODS

For this review, a comprehensive search was conducted using ClinicalKey/Elsevier, Scopus, Google Scholar, and local ULAKBIM databases. The search was conducted in English, and articles in other languages were not included. The keywords "HERS", "Hybrid emergency room" and "HERS" were determined. In the initial search, 343 articles were identified. Through consecutive screening and analyzes it was found that among these articles, 59 specifically addressed the topic of the HERS. Further categorization revealed that 17 were case reports, 6 were reviews specifically focused on HERS, and 3 were reviews centered around hybrid operating rooms. This meticulously conducted methodology ensures that the review article is based on appropriate and valid literature selection, thereby facilitating a comprehensive exploration of the subject.

History

HERS was developed in response to changing healthcare needs and advancements in medical technology. The concept and implementation have developed over timeto provide more efficient and effective emergency services by managing patient loads and resource use. The history of hybrid healthcare systems can be traced back to the early 2000s when healthcare institutions began exploring alternative management approaches in emergency settings (2). AccordingClick or tap here to enter text. to Yamakawa et al. (1), one of the first hybrid room systems was implemented in August 2011 at Osaka General Medical Center in Japan. A computerized tomography (CT) unit with a movable table was added to this room, along with a monitor to display the performed interventions. The key medical professional for this unit was an interventional radiologist. This setup allowed interventions to occur more swiftly than traditional trauma management. This system was named the hybrid emergency room system.

The driving force behind the development of hybrid emergency room systems was the need to address challenges such as overcrowded emergency departments, lengthy waiting times, and limited resources. Healthcare institutions have begun to recognize the significance of integrating urgent care centers, specialized clinics, and observation units within the emergency care environment. They began embracing this approach to provide comprehensive and personalized treatments based on the specific needs of patients. Advancements in medical technology, particularly in the field of imaging, have played a significant role in the development of hybrid emergency room systems. The integration of advanced imaging technologies such as CT scanners, ultrasound devices, and digital radiography into the emergency room environment has enabled rapid and accurate diagnostics. The capability to perform real-time imaging has provided crucial information for timely decision-making and targeted interventions by physicians (4).

Since their first introduction in Japan in 2011, the concept of hybrid emergency room systems has continued to gain global recognition and development. Different healthcare institutions and regions have progressed in adapting this model to their needs and resources. The positive outcomes and benefits provided by hybrid emergency room systems, such as reducing waiting times, increasing patient satisfaction, and optimizing resource allocation, have contributed to their widespread adoption (1). In particular, many trauma centers in Japan have turned to hybrid emergency room systems. According to Wada et al. (5), since its initial establishment, 21 trauma centers in Japan have implemented HERS.

Coordination

In a hybrid emergency service system, ensuring the effective coordination among various medical specialties is important. In this system, various medical disciplines work together to provide comprehensive patient care in the emergency service setting. This enables rapid and effective assessment of patients and implementation of crucial interventions. Experts from different specialties collaborate to evaluate patients' emergencies, make diagnoses, and develop treatment plans. In particular, for patients with multisystem traumas, branch specialists work together to determine the most suitable treatment (6).

HERS promotes effective communication and collaboration among the medical team. Experts assess patients' conditions together, share their experiences, and make decisions collaboratively. This approach results in faster diagnosis, more accurate treatment, and better patient outcomes. Advanced medical technology support coordination among medical specialties within HERS. Imaging technologies, laboratory tests, and other diagnostic tools provide essential information for patient evaluation and diagnosis. The effective use of these technologies enables experts to better understand patients' conditions and develop appropriate treatment plans. HERS encourages a comprehensive approach to patient care. Regular meetings and case discussions among different medical disciplines provide a platform for determining the best treatment strategies for patients' conditions. This process strengthens communication among the medical team and improves patient care (6).

Hybrid Operating Rooms and Other Hybrid Systems

The term "hybrid" refers to the combination of two different things. In recent years, the implementation of hybrid systems in emergency services has increased, significantly altering the delivery of emergency care A hybrid system combines advanced imaging technologies, interventional capabilities, and streamlined workflows to enhance the efficiency and effectiveness of emergency care. For HERS, this means that examination, imaging, and treatment can be performed together. Figure 1 shows one of the first HERS units set by Wada et al. (7).

The concept of a hybrid operating room was introduced earlier than the hybrid emergency service system in the early 2000s. The first hybrid operating room was established to manage complex cases requiring advanced imaging methods and surgical procedures (8). The hybrid operating room includes a CT scanner with interventional radiological capabilities within a traditional operating room setting. Today, the concept of a hybrid operating room has been further developed, incorporating techniques such as esuscitation with angioplasty, percutaneous techniques, and operative repair) (9).

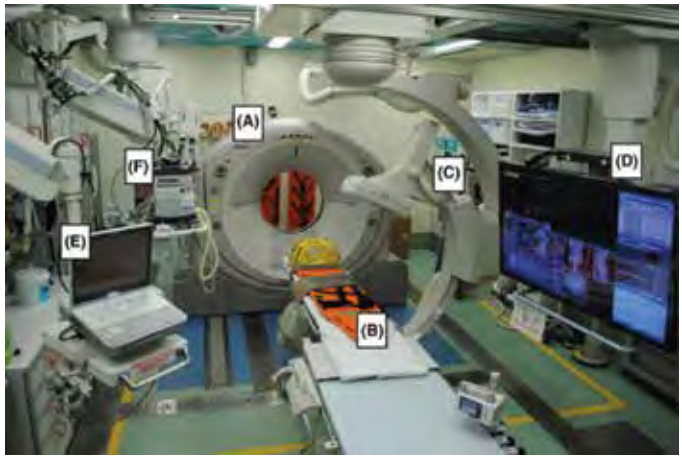

Figure 1. Shows a HERS unit set by Wada et al. (7), showing (A) CT scanner, (B) Intervention table, (C) Movable C-arm, (D) Monitor screen, (E) Ultrasound device, (F) Mechanical ventilator

Therefore, why are hybrid emergency service and hybrid operating room systems important, even though traditional methods have a certain success rate? This question can be answered under several main headings:

1. Hybrid systems establish seamless communication and integration among multiple branches and resources. By bringing together the emergency, surgical, and radiology branches, hybrid environments promote collaborative work and advanced coordination. This coordination ensures that patients receive comprehensive and timely treatment tailored to their needs (10).

2. HERS and hybrid operating rooms are equipped with state-of-the-art CT scanners. MRI and angioplasty devices are also available. Having these imaging methods in the same area reduces diagnostic delays and allows for the implementation of effective intervention methods without wasting time (11).

3. Hybrid systems optimize emergency service management by transferring cases with lower urgency to monitoring units or acute medical centers, thus maximizing resource utilization (1).

4. Advanced imaging methods, a multidisciplinary approach, and patient-specific treatment methods yield better patient outcomes than traditional trauma management. Simultaneous imaging during intervention enables more precise methods and eliminates complications (12).

In summary, HERS and hybrid operating rooms enable comprehensive, multidisciplinary patient management, merging surgical interventions with advanced imaging methods. These models improve patient outcomes, enable minimally invasive procedures, enhance emergency care, optimize resource utilization, and ultimately contribute to the advancement of modern healthcare.

Successful implementation of HERS

In a case presentation published by Wada et al. (13) in 2019, they described how a hybrid emergency room was used for a pediatric patient with a tracheobronchial injury. In this case, the HERS proved beneficial by facilitating the swift diagnosis of the injury, initiating veno-venous extracorporeal membrane oxygenation (VV ECMO) support, and subsequently performing

an emergency thoracotomy. This case highlights the potential of the HERS to ensure timely interventions in trauma cases and improve patient outcomes.

In another case presentation, Nishimura et al. (12) discussed the highly beneficial role of the HERS for treating a patient with a gunshot wound. Similar to what was demonstrated by Wada et al. (13), HERS enabled life-saving procedures such as CT scans and immediate surgical interventions to be performed at the same table without the need for patient transfer. This case also demonstrates how HERS has facilitated the precise evaluation of gunshot wounds, enabling surgeons to determine an optimal treatment strategy and quickly provide timely interventions. The use of HERS in the primary assessment stage has saved the patient's life by offering adequate and efficient treatment. This case underscores the significant advantage of HERS in providing rapid diagnosis and emergency surgical treatment for critical gunshot injuries.

Cardiac injuries have also demonstrated the utility of the hybrid emergency room system. In a case presentation published by Hara et al. (14) in 2022, they showcased how a hybrid emergency room (HER) equipped with advanced imaging technology and intervention capabilities provided rapid diagnosis and treatment for a patient without the need for patient relocation. In this case, the patient's unstable condition required immediate intervention, and HER provided rapid access to a CT scan for accurate diagnosis. In addition, HER allowed the safe and efficient implementation of venoarterial extracorporeal membrane oxygenation (VA-ECMO) for hemodynamic stabilization. Following patient stabilization in the hybrid emergency room, successful surgical treatment was performed in the operating room.

In a rare case series on HERS, Ito et al. (3) examined the impact of HERS on the management of bleeding due to pelvic fractures. The study was based on a retrospective analysis conducted from April 2015 to December 2018. This series included 96 patients; 72 patients were treated in a regular angio unit, called the non-HERS group, whereas 24 patients were treated in HERS. With advanced imaging and intervention capabilities, HERS has significantly increased the timely performance of angioembolization in pelvic fractures. This study emphasizes the importance of HERS in reducing morbidity and mortality due to pelvic fractures by reducing the time to intervention.

A case series by Miyazaki et al. (11) analyzed the use of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) in patients with severe pulmonary embolism requiring extracorporeal cardiopulmonary resuscitation in a hybrid emergency room. This article included nine patients who were treated between September 2014 and December 2017. Results showed that with HERS, the use of VA-ECMO provided an 88.9% survival rate by reducing the time from diagnosis to intervention.

Umemura et al. (4), in a retrospective case series more comprehensive than its priors, analyzed 1,050 severe blunt trauma patients. Three hundred-sixty patients were treated in the traditional group, and 690 patients were treated in HERS. In the HERS group, the median age was significantly higher (57 vs. 49). The percentage of patients who received endovascular treatments was also higher in the HERS group (25.1% vs 17.2 %). The time from patient presentation to CT scan was 10 min in the HERS group, while this time was 26 min in the traditional group. Similarly, the time between arrival to emergency surgery or bleeding control was significantly lower in the HERS group. Twenty-eight-day mortality was significantly lower in the HERS group (12.7% vs 21.7%). This survival benefit was especially pronounced in patients with higher injury severity scores and patients with active bleeding seen on CT.

Ito et al. (3) demonstrated the importance of HERS in non-surgical emergencies during the Coronavirus disease-19 (COVID-19) pandemic. In patients with serious respiratory symptoms, Ito et al. (3) used HERS's CT capability before COVID-19 tests and provided early diagnosis. Using this method, they diagnosed and treated 1,500 patients in their hybrid emergency rooms (15).

Economic Cost of HERS

Cost is an essential factor to consider when implementing a hybrid emergency service model. Because a considerable amount of capital investment will be required, it will be necessary to demonstrate first that this model is cost-effective in order to attract public or private funding.

In a study by Kinoshita et al. (16), a model-based cost-benefit analysis was performed. The analysis of patients with severe blunt trauma found that the hybrid emergency room provided a higher quality of life and better outcomes than the standard trauma process. However, the costs increased when considering the investment costs and maintenance requirements of the hybrid emergency room.

In the analysis, two critical criteria were used to evaluate the results of the two workflows: Quality-Adjusted Life Year (QALY) and Life Year (LY). QALY is a measure used to assess the impact of a treatment or health intervention on a patient's quality of life. The analysis found that the hybrid emergency room provided more QALY than the standard trauma process, meaning that patients had a higher quality of life.

LY, on the other hand, is a measure used to assess the effect of a treatment or intervention on a patient's lifespan. The analysis

determined that the use of the hybrid emergency room provided a longer LY than the standard trauma process, meaning that patients had a longer lifespan.

However, the costs of using the hybrid emergency room were also considered. Due to the investment costs and maintenance requirements of the hybrid emergency room, the costs of this workflow increased. The analysis concluded that the hybrid emergency room provided more QALY and LY, but these benefits were associated with increased costs. It was noted that the cost increased by $32,522 for each QALY gained (13).

In another study by Balch et al. (8), the cost-effectiveness of hybrid emergency operating rooms was discussed. A comparison was made between a control group consisting of 106 patients before the installation of the hybrid operating room and 186 patients after the installation. When comparing costs, there was no significant difference in overall costs between the two groups ($50,023 versus $54,740, p=0.637).

In conclusion, converting a standard trauma operating room into a hybrid operating room resulted in improvements in bleeding control, reduced transfusion requirements, and decreased incidence of postoperative pneumonia without a significant increase in costs. This study suggests that hybrid operating rooms can offer benefits in terms of patient outcomes without requiring significant additional costs (8).

Advantages and Disadvantages

While so far in this review, we have shown significant advantages of HERS, there are also some disadvantages to consider. One of them is the high costs. The fact that hybrid emergency services are more modern and technology-based compared with traditional emergency services can increase investment costs, and hiring additional specialist physicians and staff can also increase operational costs. Moreover, additional resources may be needed to operate these services and train the staff, which can increase the overall cost of healthcare (16).

Another disadvantage is that in some regions, there may be limited infrastructure and resources allocated for hybrid emergency services. In particular, in rural areas or developing countries, the widespread adoption of hybrid emergency services may be challenging. In such cases, patients may face difficulty in accessing appropriate emergency healthcare when traditional emergency services are insufficient.

In the field of emergency medicine, newly established hybrid emergency systems represent a mixed approach that can be used alongside traditional emergency systems, offering various advantages and disadvantages. Here are some advantages and disadvantages of hybrid emergency systems:

Advantages:

1. Integrated management: Hybrid emergency systems integrate different resources and expertize to manage various emergencies. This can improve coordination in emergency response and enhance response times (7).

2. Resource sharing: Hybrid systems can efficiently share various resources (humans, equipment, vehicles, and facilities) to respond to emergencies. This can optimize resource utilization and strengthen emergency response (3).

3. Flexibility and adaptability: Hybrid systems can provide a flexible structure to adapt to various emergency scenarios. They can be scaled according to change needs and support effective communication between different medical or emergency teams (12).

Disadvantages:

1. Complexity: Hybrid emergency systems can be complex because they require the integration of different resources and protocols. This complexity can pose challenges in terms of training, coordination, and management (17).

2. Communication challenges: Coordinating and communicating between different medical teams in hybrid systems can be challenging. Establishing effective communication channels among different systems is vital for their successful operation.

3. Team cohesion and training: Hybrid systems may require different medical and emergency teams to work together. Achieving cohesion and a harmonious working environment among teams may necessitate additional training and preparation.

Hybrid emergency systems should be carefully planned and implemented, considering their advantages and disadvantages. Proper training, communication, and

Management can contribute to the successful use of hybrid systems.

Accessibility and the Future of Hybrid Systems

The hybrid emergency system is inherently complex in structure, encompassing hardware, technicians, nurses, and various specialized doctors. This system initially started with portable CT and evolved to include interventional procedures such as angiography and ECMO. Following the benefits provided by the hybrid system in terms of temporal and diagnostic processes, improvements were made to the treatment process, leading

to the establishment of hybrid operating rooms. However, the limitation of benefiting only a single patient and the decrease in system efficiency over time led to the development of the concept of a dual hybrid room. In a dual hybrid room, there are two separate chambers in which interventions can be performed on two patients simultaneously. These rooms are interconnected with a passage, enabling both teams to simultaneously conduct interventions and assist each other. Currently, hybrid systems are being implemented in various parts of the world, primarily in countries such as Japan, and the number of centers using these systems is increasing. In our country, there is currently no hybrid emergency system. The feasibility of implementing this system in our country, which comes with a high economic cost, is subject to debate. Factors such as technical and hardware infrastructure, quantity and quality of personnel, transportation, and cost need to be evaluated to assess the applicability of the hybrid system in suitable trauma centers. This dynamic system, with its advantages and disadvantages, continues to evolve, increasing its feasibility (7). The number of hybrid systems in other countries is gradually growing. With sufficient data and development, this system can also be used in our country.

CONCLUSION

In conclusion, HERS is still under development worldwide. One of the most significant challenges in conventional emergency services is the delay in intervention for many life-threatening illnesses. The root cause of this delay lies in the transfer of patients to other units and the time it takes for consulting physicians to reach the emergency services for these patients. In traditional emergency services, procedures such as resuscitation, ECPR, and necessary ultrasound for diagnosing life-threatening illnesses are performed at the patient's bedside. Subsequently, the patient needs to be transported to the angiography unit or operating room. Then, there is a need to transfer the patient to the CT unit. All of these steps result in the loss of precious time critical for the patient's life. In conventional emergency settings, performing these procedures on specialized patients can lead to a significant loss of life. In HERS, however, after resuscitation, coronary angiography, embolization procedures, or embolectomy procedures, as well as CT and ultrasound for diagnosis, patients are transferred to the intensive care unit. Figure 2 shows the workflow difference between a traditional emergency room and HERS (7).

In our country, there is currently no hybrid emergency service. From our perspective, pioneering hybrid emergency services should be established in metropolitan cities. Considering the advantages, we believe that patient lives are far more important

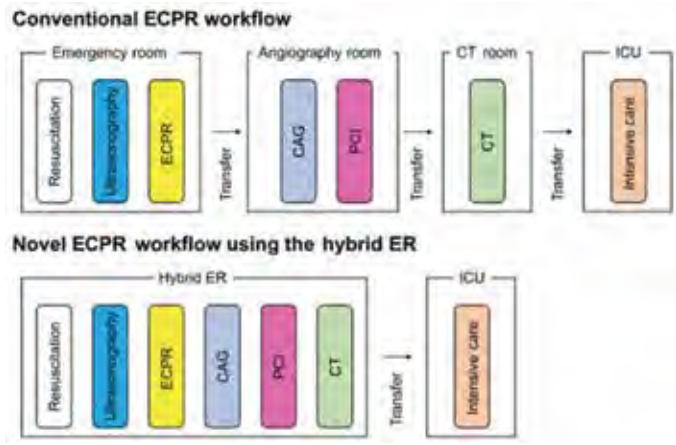

Figure 2. From an article by Wada et al. (7) shows the difference in workflows between a conventional emergency room and HERS. In a traditional emergency room, a patient is transferred at least 2 times during diagnosis and treatment, resulting in time losses during management. However, in HERS, patients do not need to be transferred, as diagnosis and treatment can be done in the same room

than costs. However, we have some reservations. One of these concerns is the traffic issue in Turkish metropolises. Transporting patients to established hybrid emergency services could take a long time. Therefore, in these Turkish metropolises, a few hospitals should be selected to use hybrid emergency services. Our concern is the employment of physicians in these established services. In our country, which is composed of seven regions, this issue could be addressed by employing interventional radiologists in nearby cities within specific regions. In this way, our concern about physician employment can be overcome.

Multitrauma patients, patients undergoing resuscitation, acute myocardial infarction patients, pelvic traumas, patients with aortic aneurysms or dissections, patients requiring ECMO, and especially hypotensive pulmonary embolism patients requiring embolectomy would be managed much more effectively and efficiently in hybrid emergency services than in conventional emergency services. Therefore, we think that a hybrid emergency service should be established in our country as soon as possible.

Ethics

Peer-review: Internally peer reviewed.

Authorship Contributions

Concept: M.N.A., B.K., B.Ö., A.K., Design: M.N.A., B.Ö., Z.A., Analysis or Interpretation: B.U., A.D., İ.G., A.K., Literature Search: B.K., A.D., İ.G., Writing: B.K., M.N.A., A.D., B.Ö., A.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.75537
Eur Arch Med Res 2023;39(3):141-145

Assessing the Learning Curve of the Minimally Invasive Direct Coronary Artery By-pass Technique

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Abstract

Objective: To clarify the effect of the learning curve (LC) on minimally invasive direct coronary artery by-pass (MIDCAB) outcomes for the first time.

Methods: Patients who underwent MIDCAB were enrolled in this study. The patients' characteristics were recorded prospectively. A 75 patients were divided into three groups, with the first 25 patients undergoing MIDCAB in group 1 and the last 25 patients undergoing MIDCAB in group 3.

Results: Comparison of the groups revealed that the operation time significantly decreased after 50 cases (p=0.003). Duration for access to the pericardium was similar between groups (p=0.094), but duration for preparing vessels progressively decreased from group 1 to group 3 (p=0.001). In addition, anastomosis duration significantly decreased in group 3 (p=0.005). In addition, the hospitalization time was significantly shorter in group 3 (p=0.018). The complication rate was significantly lower in group 3 and group 2 than in group 1 (p=0.030). Additionally, major cardiovascular and cerebrovascular events (MACCE) in the first postoperative year was detected in 20% of patients in group 1 and 8% of patients in group 2 and group 3, and the statistical difference was significantly better in favour of group 2 and group 3 (p=0.043).

Conclusion: The present study is the first to define the LC for MIDCAB, and we achieved significantly lower blood loss within 24 h after operation and lower complication rates after 25 cases, and perioperative transfusion rate, operation time, and hospitalization period were significantly decreased after 50 cases. Moreover, the number of MACCEs in the first postoperative year was significantly lower after 25 cases.

Keywords: Achievement, coronary artery by-pass, complications, learning curve

INTRODUCTION

The minimally invasive direct coronary artery by-pass (MIDCAB) technique was developed for cardiac by-pass surgery to reduce the morbidity and mortality associated with conventional coronary by-pass grafting (CABG) and to prevent the negative effects of sternotomy (1). Yang et al. (2) compared 126 patients who underwent MIDCAB and CABG at a 1:1 ratio, and the authors found significant reductions in blood transfusion and hospital stay duration in favour of the MIDCAB group without any negative impact on success. In another study, Repossini et al. (3) aimed to show the efficiency and safety of MIDCAB by analyzing long-term results and found a patency rate of 96.8% using coronary angiography in ten-year follow-ups. Despite its proven efficacy, the relative technical difficulty of MIDCAB precludes its widespread use in some centers.

The learning curve (LC) is accepted as the number of surgeries a surgeon must perform to achieve acceptable success and complication rates (4). Defining the LC for each procedure is important for predicting how many cases residents should perform before becoming specialists or how many cases the surgeon

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Received: 17.01.2023
Accepted: 15.05.2023

Cite this article as: Kanber EM, Köseoğlu M, Şahin M. Assessing the Learning Curve of the Minimally Invasive Direct Coronary Artery By-pass Technique. Eur Arch Med Res 2023;39(3):141-145

should perform with clinical supervision before performing the surgery on their own. It is wellknown that each procedure has its own difficulty and LC. Baytaroglu and Sevgili (5) investigated LC for percutaneous thrombosectomy in the management of lower extremity deep vein thrombosis, and the authors achieved a satisfactory success rate after 20 cases. In another study, Shen et al. (6) evaluated LC for vena cava thrombectomy due to renal tumors, and bleeding and postoperative complications were significantly decreased after 40 cases.

Although previous studies have shown the efficiency and safety of MIDCAB and investigated the LC for some cardiovascular surgeries, to our knowledge, no research has focused on the LC of MIDCAB. In this study, we aimed to clarify the effect of LC on MIDCAB outcomes for the first time.

METHODS

This study was conducted from June 2019 to January 2022, in accordance with Helsinki universal declaration of human rights. An informed consent form was obtained from all patients, and the study was approved by the Bezmialem Vakıf University Local Ethic Committe (meeting decision no: 2019/127). The purpose of the study was achieved when 75 procedures were performed. Patients who underwent MIDCAB because of ischemic coronary artery disease were enrolled in the study. All MIDCAB procedures were performed by one cardiovascular surgeon (Mazlum Şahin), who had the experience of more than 1,000 CABG surgeries. Additionally, the surgeon who performed all procedures had completed a three-month scholarship program and two-day experimental animal course on MIDCAB surgery. Indications for MIDCAB are similar to those for CABG, and the main purpose of MIDCAB is to provide left ventricle anterior wall vascularization using the left internal mammillary artery (LIMA) as the left anterior descending (LAD) artery graft. The presence of left subclavian artery occlusion and cardiogenic shock are accepted as absolute contraindications for MIDCAB. In addition, patients aged 18 years with a history of thoracotomy and chest operation, and patients with calcified LAD with diameter <15 mm were excluded from the study. The other exclusion criteria were the presence of morbid obesity, history of CABG surgery, and history of radiation therapy for the chest.

Patient characteristics including age, gender, body mass index (BMI), comorbidities, preoperative left ventricular ejection fraction (LEVF), severity of heart failure according to the New York Heart Association, myocardial infarction (MI) history, and number of lesions were recorded. In addition, the procedure was divided into three parts (access the pericardium, LIMA harvesting, and anastomosis), and the durations for each part of the operation and total operation time were noted. Moreover, the presence of perioperative blood transfusion, conversion to sternotomy, intensive care unit stay, hospital stay period, presence of postoperative pleural effusion, blood loss in 24th hour after operation, requirements for inotropic agents, complications including pneumothorax, subcutaneous emphysema, respiratory infection, wound infection, need for dialysis, atrial fibrillation, transfusion requirement, and mortality were recorded. Lastly, major cardiovascular and cerebrovascular events (MACCE) including cardiac death, non-cardiac death, MI, cerebrovascular accident, and target vessel revascularization were noted.

MIDCAB Surgical Technique

A standardized technique was used for each patient, and all operations were performed in the supine position with left chest elevation between 30 and 45 degrees. Access was obtained from 2 to 3 cm below the nipple with 5-6 cm incision through the 4th or 5th left intercostal area. The procedure is performed through a 5 cm left anterior thoracotomy located one-third medial and two-thirds lateral to the midclavicular line. The lower third of LIMA is harvested using a standard rib spreader, which allows better visualization of the distal LIMA segment. The entire length of LIMA was harvested using a Thoralift (Autosuture; US Surgical Corp, Norwalk, Conn). The LIMA was then harvested was dissected, LAD was identified, and anastomosis was performed. An end-to-end anastomosis with 7-0 or 8-0 polypropylene is performed between LIMA and LAD, preferably using a shunt. Blood flow was checked with a Doppler flow probe after opening the clamp on LIMA. A single drain was placed into the left pleural cavity, and the thoracotomy incision was closed in layers (7).

A 75 patients were divided into three groups, with the first 25 patients undergoing MIDCAB in group 1 and the last 25 patients undergoing MIDCAB in group 3. The three groups were compared according to patient preoperative characteristics, operative and postoperative results, and one-year follow-up outcomes.

Statistical Analysis

Statistical Package for the Social Sciences version 26 (SPSS IBM Corp., Armonk, NY, USA) was used for statistical analysis. The distribution of parameters was evaluated by the Shapiro-Wilk test. Continuous parameters were compared using the Kruskal-Wallis test, and continuous variables were described using median (interquartile range). If there was a significant difference between the groups, Tamhane's T2 test was used for post hoc analysis. The relationship between categorical variables was evaluated using the chi-square test and Fisher's exact test. The level of statistical significance was taken as $p<0.05$.

RESULTS

In total, 75 patients were included in the study, with 25 patients in each group. The mean age, gender ratio, mean BMI, presence of hypertension, diabetes mellitus, and chronic kidney disease rates were similar between groups (p=0.700, p=0.927, p=0.595, p=0.846, p=0.948, and p=0.869, respectively). In addition, preoperative LEVF was 58% in group 1, 57% in group 2, and 59% in group 3 (p=0.592). The preoperative characteristics of patients are summarized in Table 1.

Comparison of the groups revealed that operation time significantly decreased after 50 cases (205 minutes in group 1, 187 min in group 2, and 153 min in group 3, p=0.003). The duration for access to the pericardium was similar between groups (p=0.094), but the duration for LIMA harvesting progressively decreased from group 1 to group 3 (p=0.001). In addition, the anastomosis duration significantly decreased in group 3 (27 minutes in group 1, 24 min in group 2, and 22 min in group 3, p=0.005). No perioperative transfusion was required in group 3 (p=0.025). In addition, the hospital stay time was significantly shorter in group 3 than in groups 1 and 2 (p=0.018) (Table 2).

Postoperative blood effusion and requirements for inotropic agents were comparable between groups (p=0.507 and p=0.653). Blood loss in the first 24 h significantly decreased after 25 cases (639 mL in group 1, 485 mL in group 2, and 366 mL in group 3, p=0.007). Additionally, the complication rate was 28% in group 1, 12% in group 2, and 12% in group 3, and the complication rate was significantly lower in group 3 and group 2 compared with group 1 (p=0.030). The types of complications are presented in Table 3. Additionally, MACCE in the first postoperative year was detected in 20% of patients in group 1 and 8% of patients in groups 2 and 3, and a statistical difference was significantly better in favour of groups 2 and 3 (p=0.043). The types of MACCE are listed in Table 4.

DISCUSSION

The LC is considered as the number of cases that the surgeon should perform until the surgeon achieves competence to perform that particular surgery. Every procedure has a unique LC and it is crucial to define the LC of any procedure to ensure that the surgeon gains competence and the right to perform the procedure. Previous studies have focused on LC of different surgeries in the cardiovascular field, but to our knowledge, none of these studies have investigated the LC of MIDCAB. For the first time, our study showed that blood loss within 24th hours after operation and complication rates were significantly decreased after 25 cases, and perioperative transfusion rate, operation time, and hospital stay period were significantly decreased after 50 cases. Moreover, the number of MACCEs in the first postoperative year was significantly reduced after 25 cases.

The main goal of MIDCAB is to provide appropriate revascularization of the myocardium and ensure the patency of cardiac vessels. The correlation between LC and success was analyzed for different procedures in different medical disciplines. In a study that investigated LC for obstructed brain vessel

Table 1. Comparison of demographic characteristics of patients between groups

	Group 1 (n=25)	Group 2 (n=25)	Group 3 (n=25)	p value
Age (years)*	63.0 (57.0-69.0)	66.0 (58.5-69.0)	63.0 (56.5-68.0)	0.700
Gender Male Female	 20 (80.0%) 5 (20.0%)	 19 (76.0%) 6 (24.0%)	 19 (76.0%) 6 (24.0%)	0.927
BMI (kg/m^2)*	27.0 (23.5-31.5)	28.0 (25.0-34.0)	26.0 (22.5-32.0)	0.595
Hypertension	16 (64.0%)	14 (56.0%)	15 (60.0%)	0.846
Diabetes mellitus	13 (52.0%)	13 (52.0%)	14 (56.0%)	0.948
Chronic kidney disease	3 (12.0%)	3 (12.0%)	2 (8.0%)	0.869
Smoking	10 (40.0%)	8 (32.0%)	15 (60.0%)	0.121
Preoperative LVEF (%)*	58.0 (48.5-65.5)	57.0 (49.0-63.0)	59.0 (49.5-65.5)	0.592
NYHA classification Class 1 Class 2 Class 3 Class 4	 11 (44.0%) 9 (36.0%) 4 (16.0%) 1 (4.0%)	 10 (40.0%) 9 (36.0%) 5 (20.0%) 1 (4.0%)	 12 (48.0%) 8 () 3 () 2 ()	0.974
MI history	12 (48.0%)	7 (28.0%)	8 (32.0%)	0.297
Number of lesions	2.0 (2.0-3.0)	2.0 (1.5-3.0)	2.0 (1.0-3.0)	0.317

*Median (IQR), BMI: Body mass index, LVEF: Left ventricular ejection fraction, NYHA: New York Heart Association, MI: Myocardial infarction, IQR: Interquartile range

angiographic recanalization in acute stroke, the authors stated that 50 cases were necessary to achieve a satisfactory success rate (8). In another study, the success rate of percutaneous thrombectomy for lower extremity deep vein thrombosis significantly increased after 20 cases (5). However, none of these studies discussed the effect of LC on follow-up results. In this study, the patency rates of the groups were comparable. However, the MACCE in the first postoperative year significantly decreased after 25 cases. We believe that the improvement in surgical technique contributes to this outcome.

Achieving myocardial repercussion with minimal complications is critical for the treatment of MIDCAB. Complication rates following MIDCAB have a wide range due to the lack of standardized definition of complications, some surgeons not reporting non-serious complications or the focus only on MIDCAB success in some articles. Schauer et al. (9) investigated the role of LC in obesity surgery and concluded that the complication rate decreased by half after the first 100 cases. In another paper, Kempton et al. (10) stated that 40 procedures were sufficient to bring the complication rates to the desired level in shoulder arthroplasty. However, Baytaroglu and Sevgili (5) did not find any relationship between LC and the complication rate in percutaneous thrombosectomy for lower extremity deep vein thrombosis management. In this study, we observed significantly lower complication rates after 25-50 cases and 50-75 cases compared with the first 25 cases.

Table 2. Comparison of intraoperative and postoperative data between groups

	Group 1 (n=25)	Group 2 (n=25)	Group 3 (n=25)	p value
Operation time (min)* Reach the pericardium LIMA harvesting Anastomosis	205.0 (179.5-245.0)[a] 28 (22.0-30.5) 58 (52.5-76.0)[a] 27.0 (22.0-28.5)[a]	187.0 (159.5-221.5)[a] 27 (22.5-33.0) 56 (48.5-60.0)[b] 24.0 (18.5-28.0)[a]	153.0 (133.5-195.0)[b] 24 (28.0-33.0) 46 (39.5-54.5)[c] 22.0 (19.0-24.0)[b]	**0.003** 0.094 **0.001** **0.005**
Perioperative transfusion*	1.0 (0.5-2.0)[a]	1.0 (0-2.0)[a]	0 (0-1.0)[b]	**0.025**
Conversion to sternotomy	1 (4.0%)	1 (4.0%)	-	0.598
ICU stay (hours)*	41.0 (22.0-66.0)	17.0 (6.0-53.0)	30.0 (5.0-59.5)	0.136
Hospital stay (days)*	10 (6.5-14.0)[a]	9 (6.0 -20.0)[a]	6 (4.0-11.0)[b]	**0.018**
Hospital mortality	1 (4.0%)	-	-	0.363

Lower-case letters are used to identify the group that makes the difference. The same letters (such as [a-a]) indicate that there is no difference, different letters (such as [a-b]) indicate that there is a difference. *Median (IQR), ICU: Intensive care unit, IQR: Interquartile range, min: Minimum

Table 3. Comparison of postoperative complication data between groups

	Group 1 (n=25)	Group 2 (n=25)	Group 3 (n=25)	p value
Postop pleural effusion (mL)*	871.0 (431.0-1222.0)	654.0 (468.5-1125.5)	609.0 (438.0-1073.5)	0.507
Blood loss at 24 hour (mL)*	639.0 (472.0-716.0)[a]	485.0 (261.5-605.5)[b]	366.0 (258.0-577.5)[b]	**0.007**
Needs inotropic agents	5 (25.0%)	3 (15.0%)	3 (15.0%)	0.653
Complications Subcutaneous emphysema Respiratory infection Wound infection Need for dialysis	7 (28.0%)[a] 3 (12.0%) 2 (8.0%) 1 (4.0%) 1 (4.0%)	3 (12.0%)[b] 1 (4.0%) 1 (4.0%) 1 (4.0%) -	3 (12.0%)[b] 2 (8.0%) - 1 (4.0%) -	**0.030**

Lower-case letters are used to identify the group that makes the difference. The same letters (such as [a-a]) indicate that there is no difference, different letters (such as [a-b]) indicate that there is a difference. *Median (IQR), IQR: Interquartile range

Table 4. Comparison of patients who developed major adverse cardiovascular and cerebrovascular events in the first postoperative year between groups

	Group 1 (n=25)	Group 2 (n=25)	Group 3 (n=25)	p value
MACCE[#] Cardiac death Non-cardiac death MI CVA TVR	5 (20.0%)[a] 1 (4.0%) 1 (4.0%) 2 (8.0%) 1 (4.0%) 2 (8.0%)	2 (8.0%)[b] 1 (4.0%) - 1 (4.0%) - 1 (4.0%)	2 (8.0%)[b] 1 (4.0%) - 1 (4.0%) - 1 (4.0%)	**0.043**

[#]Some patients developed more than one event at the same time. The term complications indicate the number of patients who developed complications. Lower-case letters are used to identify the group that makes the difference. The same letters (such as [a-a]) indicate that there is no difference, different letters (such as [a-b]) indicate that there is a difference. MACCE: Major adverse cardiovascular and cerebrovascular events, MI: Myocardial infarction, CVA: Cerebrovascular accident, TVR: Target vessel revascularization

Previous reports have found significant correlations between prolonged operation time and undesired anaesthetic events, increases in procedure cost, and morbidity. In the first stages of LC, the operation time may be longer than expected due to reasons such as not knowing the surgical instruments adequately, the team not working in full harmony, and not knowing how to act in case of possible mishaps. Sahan et al. (11) analyzed the impact of surgical volume on operation time in renal stone surgery, and the authors found continuous decreases in operation time from 1st-15th case and from 46th-60th case. In another study, Baytaroglu and Sevgili (5) investigated the LC of percutaneous thrombosectomy for treating lower extremity deep vein thrombosis, and the operation time for percutaneous thrombosectomy significantly decreased until the 40th case and then reached a plateau. In this study, we found a significant decrease in the operation time after the 25th case. When we examined the duration of operation sections, the duration for LIMA harvesting continuously decreased from 1st-25th cases to 50th-75th cases, and the duration of anastomosis significantly decreased after 50 cases.

Study Limitations

Our study has some limitations. As all procedures have specific LC, each surgeon has his/her own LC. Therefore, our results should be confirmed by further studies. Second, we did not analyze the long-term results of MIDCAB; thus, we did not evaluate the effect of LC on the long-term outcomes of MIDCAB, which may be investigated in further studies. Moreover, we focused on success, complications, and operative and postoperative parameters in the present study without analyzing patient quality of life. The impact of LC on the quality of life of patients who underwent MIDCAB could be the subject of another paper. Lastly, we did not evaluate the correlation between the LC of MIDCAB and the cost-effectiveness of MIDCAB.

CONCLUSION

This study is the first to define the LC for MIDCAB, and we achieved significantly lower blood loss within 24 h after operation and lower complication rates after 25 cases, and the perioperative transfusion rate, operation time, and hospital stay period were significantly decreased after 50 cases. Moreover, the number of MACCEs in the first postoperative year was significantly lower after 25 cases.

Ethics

Ethics Committee Approval: Bezmialem Vakıf University Local Ethic Committe (meeting decision no: 2019/127).

Informed Consent: Informed consent form was obtained from all patients

Peer-review: Internally and externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: E.M.K., Concept: E.M.K., Design: E.M.K., Data Collection or Processing: M.K., Analysis or Interpretation: M.K., Literature Search: E.M.K., M.Ş., Writing: E.M.K., M.Ş.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.77045
Eur Arch Med Res 2023;39(3):146-152

Serum Progesterone and Serial β-hCG Levels in Predicting the Outcome of Early Pregnancies with Doubtful Viability: Prospective Research

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Abstract

Objective: To evaluate the doubling rate of maternal serum serial beta human chorionic gonadotropin (β-hCG) and a single initial serum progesterone level to predict fetal viability before ultrasonography in women diagnosed with intrauterine pregnancy (IUP) of undetectable viability.

Methods: Three hundred thirty six pregnant women who applied to the outpatient Clinic at Okmeydanı Hospital between March and December 2018 were evaluated on a "prospective observational" basis. The study was completed with 100 pregnant women diagnosed with IUP involving suspected fetal viability by transvaginal ultrasonography only, who met the inclusion criteria. Serum β-hCG and progesterone levels were measured at the first admission. After 48 h, control serum β-hCG was taken and the increase rates were calculated. Early pregnancy loss was diagnosed by (transvaginal) TV-USG. Patients were divided into two groups as fetal heartbeat (FHB) positive and FHB negative. Pregnancy results were compared with β-hCG increase rates and progesterone levels.

Results: No statistically significant result was obtained between FHB +/- groups in terms of maternal age, previous pregnancy anamnesis, nationality, presenting symptoms, or ultrasound findings. The study, which was conducted with a confidence interval of 95%, found the viability rate to be 70% with a β-hCG increase rate of 31% and 100% in the case of an increase of 181%. For progesterone, when the value was 5.9 ng/mL, the viability rate was 49% and 100% at 37.5 ng/mL and above. The efficacy values of β-hCG increase and first progesterone level in predicting viability were found to be ROC AUC: [0.748 (0.621-0.874)] and ROC AUC: [0.796 (0.685-0.907)], respectively.

Conclusion: Either Serial β-hCG ratio or serum progesterone level can be used alone to predict the pregnancy outcome in early pregnancy. With the dissemination of similar studies, estimation modalities can be improved, and TV-USG examinations can help shorten the waiting time for results to reduce the anxiety of families, hospital admissions and health expenses.

Keywords: Early pregnancy loss, viability, serial β, -hCG, progesterone

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Received: 15.01.2023
Accepted: 30.05.2023

Cite this article as: Yıldız M, Çiçek EN, Demirayak G, Genç S, Şahin O, Özkan Y, Mihmanlı V. Serum Progesterone and Serial β-hCG Levels in Predicting the Outcome of Early Pregnancies with Doubtful Viability: Prospective Research. Eur Arch Med Res 2023;39(3):146-152

INTRODUCTION

Early pregnancy loss is a frequently encountered problem during the reproductive period, which is the longest period of female life, and it is reported as the most common complication of pregnancy. It occurs in approximately 10-15% of all clinically recognized pregnancies and affects one in every three women (1). One-third of women and approximately 80% of all pregnancy loss cases occur in the first quarter (2).

Bleeding and pain are the most common reasons why women receive medical advice during early pregnancy. This is an important cause of anxiety in women. Detection of intrauterine pregnancy (IUP) by transvaginal ultrasonography (TV-USG) following a positive beta human chorionic gonadotropin (β-hCG) excludes ectopic pregnancy except heterotopic pregnancy. However, especially during the follow-up of pregnancy of unknown locations (PUL), pregnancy viability cannot be determined at the first visit when IUP is detected (3). When an IUP is detected, the second most important step is to determine its viability. These 1- or 2-week follow-up visits may cause long-term anxiety for women, and these visits increase the cost and workload in the related healthcare facilities (4).

β-hCG is called human chorionic gonadotropin and is a pioneer in the early detection of pregnancy (1). There are two types of this hormone, alpha and beta. β-hCG hormone in a non-pregnant woman is in the range of 0-10 mlU/mL. β-hCG hormone begins to be secreted by the placenta with the realization of fertilization. Approximately 11 days after fertilization, high values of β-hCG hormone can be detected in the blood sample. In the case of pregnancy, this value should increase and continue every 2 days, exponentially compared with the previous day. If no stable increase is observed, negative pregnancy-related conditions may be in question. Serum progesterone is a test used to measure the amount of progesterone in the blood (1). Progesterone is a hormone produced mainly in the ovaries. Progesterone plays a key role in pregnancy. It is produced after ovulation in the second half of the menstrual cycle. It helps prepare a woman 's uterus for a fertilized egg to be implanted. It also prepares the uterus for pregnancy by inhibiting contraction of the uterine muscle and the breasts for milk production. It has different values throughout the menstrual cycle, at menopause, and in each trimester of pregnancy. Its unit is ng/mL or nmol/L. (Example: Pregnancy 1st trimester: 11.2 to 90.0 ng/mL or 35.62 to 286.20 nmol/L). Serial measurements of serum β-hCG, the increase percentages, and serum progesterone measurement used for the same purpose as serum β-hCG in early pregnancies are highly important in the differentiation of normal and abnormal pregnancies as well as in the prediction of fetal viability. However, both involve significant differences in the literature (5,6). No cut-off value or predictive power of any of these markers could be determined for the definitive diagnosis of IUP viability.

The aim of this study was to compare maternal serum series β-hCG and a single serum progesterone level with TV-USG for predicting fetal viability in women with IUP and to create a prediction modality using only serum markers.

METHODS

Our study was conducted in the Obstetrics and Gynecology Clinic of University of Health Sciences Turkey, Prof. Dr. Cemil Taşcıoğlu City Hospital on a single-center "prospective observational" basis between March 2018 and December 2018. The study was started after obtaining the approval of the Ethics Committee for Clinical Research of University of Health Sciences Turkey, Prof. Dr. Cemil Taşcıoğlu City Hospital under protocol number 841 on 13/03/2018. The participants were informed verbally, and in writing, and written consent was obtained.

Inclusion criteria were as follows: consent for participation in the study, being older than 18 years of age, diagnosis of IUP by TV-USG, and early pregnancy with no fetal heartbeat detected/suspected (Crown-rump Length: CRL <7 mm, mean of three orthogonal measurements Gestational Sac Diameter: mGSD <25 mm). Exclusion criteria; Being under the age of 18, having multiple pregnancies, and chronic drug use were determined. The sample size was reached by performing G*power analysis considering at least 3 similar articles in the literature. Our study included 336 pregnant women who applied to our outpatient clinic and accepted to participate in the study. One hundred-fifty-six pregnant women did not meet at least one of the inclusion criteria, 28 pregnant women did not want to continue in the study, despite initially agreeing to participate in it, and 20 pregnant women who met at least one of the exclusion criteria were excluded from the study. During the follow-ups, 32 pregnant women could not be reached, and they were also excluded from the study. Therefore, the study was completed with 100 pregnant women (Figure 1). All women were evaluated by experienced obstetricians using ultrasound devices equipped with 6-12 MHz transvaginal transducer and B-mode imaging. Pregnancy of Uncertain Viability criteria in patients with IUP confirmed by TV-USG were taken as no heartbeat below CRL <7 mm, and no embryo below mGSD <25 mm. Anamnesis information such as maternal age, previous pregnancy anamnesis, nationality, admission symptoms, and ultrasound findings of the patients were noted at the first

admission. Viability determination was performed by TV-USG on days 7, 11, and 14 pregnant women with fetal heartbeat detected or diagnosed with fetal viability (Viable: FHB (fetal heartbeat): +) were not invited to further controls. Pregnant women with undetectable fetal heartbeat were held until day 14 at the latest, and if no fetal heartbeat could be detected they were diagnosed with "early pregnancy loss" (Non-viable: FHB: -).

Serum β-hCG and progesterone levels were measured at the first admission. After 48 h, control serum β-hCG was taken and the increase rates were calculated. Serum β-hCG and progesterone levels were measured with Roche β-hCG and Progesterone II Electrochemiluminescence Immunassay (ECLIA) in Roche Cobas e411 and e602 analyzers, respectively.

As a result, patients were divided into two groups as fetal heartbeat positive group (FHB: +) and early pregnancy loss group (FHB: -). These results were interpreted with the percentage of serum β-hCG increases and progesterone value at initial admission in light of the literature

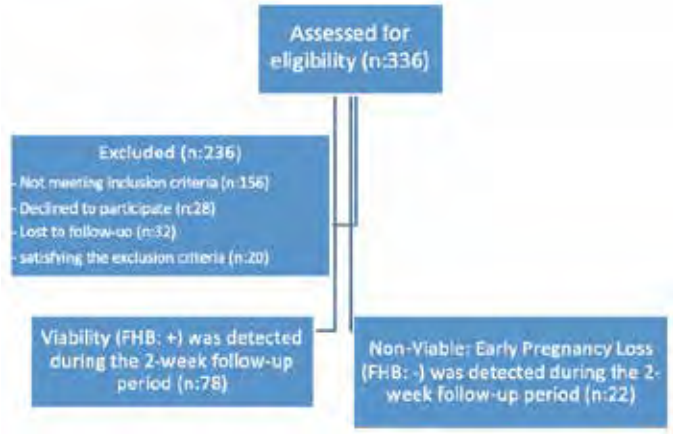

Figure 1. Flow diagram of the study

Statistical Evaluation

These two parameters were evaluated by means of the Mann-Whitney U test and Wilcoxon test. However, z-scores and percentiles adjusted according to the gestational week were used to calculate both β-hCG and serum progesterone levels. Thus, it was considered that the first progesterone level was not constant and β-hCG levels would decrease over time. A receiver operating characteristic (ROC) curve was used for the estimations, effect level, and cut-off values of numerical parameters. SPSS 22.0 (Chicago, IL, USA) was used for statistical analysis. A P-value: <0.050 is considered significant for a confidence interval of 95%.

RESULTS

Our study was started with 100 pregnant women. The patients were divided into two groups as the Viable Group; fetal heartbeat positive group (FHB:+) (n=78) and Non-viable group; (early pregnancy loss), fetal heartbeat negative group (FHB:-) (n=22) (Figure 1).

Table 1 shows the β-hCG values (control at first admission and at hour 48) and percentage of increase, serum progesterone value at first admission, TV-USG findings, and measurements of the patients participating in the study.

The mean increase in β-hCG was 54.3±36.2%, and the mean progesterone value at the first admission was 15.5±8.3. Fetal heartbeat was positive (viability +) in 78% of women (n=78) and negative (early pregnancy loss) in 22% (n=22).

Table 2 shows between the fetal heartbeat -positive and -negative groups, the serum β-hCG value at first admission showed no statistically significant difference (P>0.05). The control β-hCG values obtained after 48 h in both groups showed a significant increase (P<0.05) compared with the first admission. In the group with fetal heartbeat positive, the increase rate between

Table 1. Ultrasound and laboratory findings of patients participating in the study

All Cases	Min-max	Median	Mean ± SD/n-%
First examination β-hCG	302-200,727	18,430	25,880-30,951
Control β-hCG	848-235,654	28,817	35,962-38,268
Percentage increase in β-hCG %	0.8-181.3	52.5	54,3±36,2
Progesteron	3.3-50.0	13.7	15.5 8.3
Viability	Early pregnancy loss (FHB:)	22	22.0%
	Detected viability (FHB:+)	78	78.0%
Ultrasonography	mGSD (no CRL)	81	81.0%
	CRL detected	19	19.0%

FHB: Fetal heartbeat, USG: Ultrasoundgraphy, CRL: Crown rump length, mGSD: Mean orthogonal gestational sac diameter, Control: Second visit/β-hCG unit: mIU/mL, Serum progesterone unit: ng/mL

the two β-hCG values taken at 48 h intervals was found to be significantly higher than that in the group without fetal heartbeat (P<0.05). When the initial serum progesterone levels of the groups with and without fetal heartbeat were compared, a statistically significant difference was found between the groups (P=0.000). It was significantly higher in the FHB -positive group than in the negative group (P<0.05) (Table 3).

Figure 2 shows the predictive power graph of serum β-hCG increase rates taken at 48 h intervals in the likelihood of fetal heartbeat. According to the chart, the probability of fetal heartbeat was 70%, while the rate of increase in β-hCG value was 31%, and the probability of fetal heartbeat was 80%, 90%, 95%, and 100%, while the rate of increase in β-hCG value was 49%, 73%, 97%, and 181%, respectively. Significant efficacy (p=0.000) [0.748 (0.621-0.874] of β-hCG increase was observed in predicting the groups with and without fetal heartbeat (Figure 3: ROC curve). Significant efficacy (p=0.000) [0.796 (0.685-0.907)] of the progesterone value was observed in predicting the group with and without fetal heartbeat (Figure 4: ROC curve).

When the serum progesterone value was 5.9 ng/mL, the fetal heartbeat was 49%, and when the serum progesterone value was 10.5 ng/mL or above, the fetal heartbeat was 69%, 12 ng/mL and above 75%, 13.4 ng/mL and above 80%, 18.0 ng/mL and above 90%, 21.7 ng/mL and above 95%, 29.3 ng/mL and above 99%, and 37.5 ng/mL and above 100%.

There was no statistically significant difference in ultrasound findings between the two groups.

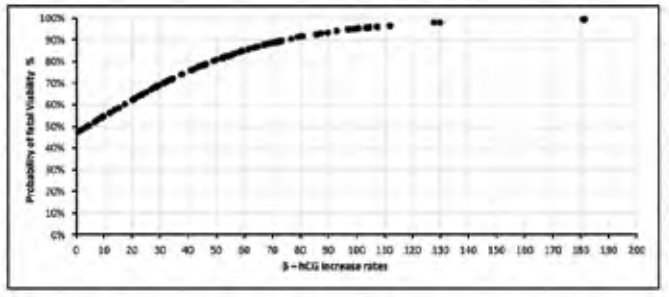

Figure 2. Chart of the likelihood of fetal heartbeat with serum β-hCG increase rates

β-hCG: Beta human chorionic gonadotropin

Table 2. Comparison of serial β-hCG, percentage of increase, and serum progesterone values between FHB +/- (viable/non-viable: Early pregnancy loss) groups

	Early pregnancy loss (FHB-)	Detected viability (FHB+)	P value
	Mean SD	**Mean SD**	
β-hCG			
First examination	16,874-16,029	28,420-33,644	0.090[m]
Control β-hCG	20,031-16,602	40,455-41,409	0.012[m]
Percentage increase(%)	32.5 32.7	60.4 34.9	0.001[m]
In-group change (P)	0.001[w]	0.001[w]	
Progesterone	9.9 6.5	17.1 8.1	0.001[m]

m: Mann-Whitney U test, [w]: Wilcoxon test
FHB: Fetal heartbeat/control: The second Visit/β-hCG unit: mIU/mL/Serum progesterone unit: ng/mL

Table 3. Comparison of TV-USG findings and measurements in FHB+/- groups

		Early pregnancy loss FHB:-		Detected viability (FHB:+)		P
		Mean ± SD/n-%	**Median**	**Mean ± SD/n-%**	**Median**	
USG	Only mGSD	19	86.4%	62	79.5%	0.468[X2]
	CRL detected	3	13.6%	16	20.5%	
USG measurement (mm)						
mGSD		10.8±4.7	10.0	11.8±4.9	12.0	0.419[m]
CRL		3.7±2.1	3.2	3.4±1.2	3.3	0.955[m]

[m]: Mann-Whitney U/[X2]: chi-squared test
FHB: Fetal heartbeat, CRL: Crown rump length, mGSD: Mean orthogonal gestational sac diameter, SD: Standard deviation, USG: Ultrasonography

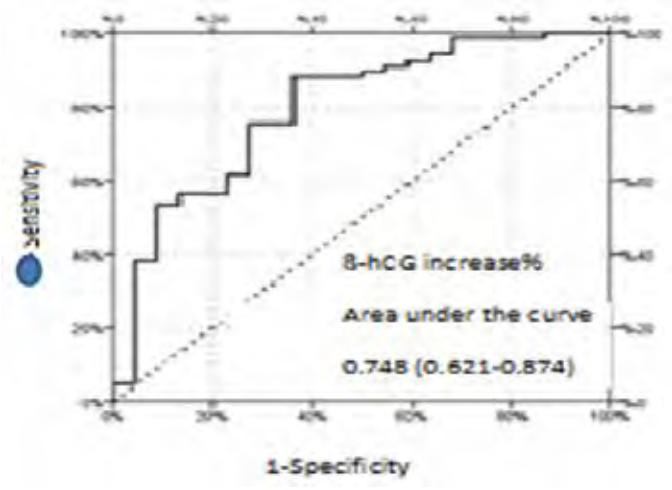

Figure 3. ROC analysis of β-hCG increase percentage in FHB +/- group prediction

β-hCG: Beta human chorionic gonadotropin, ROC: Receiver operating characteristic, FHB: Fetal heartbeat

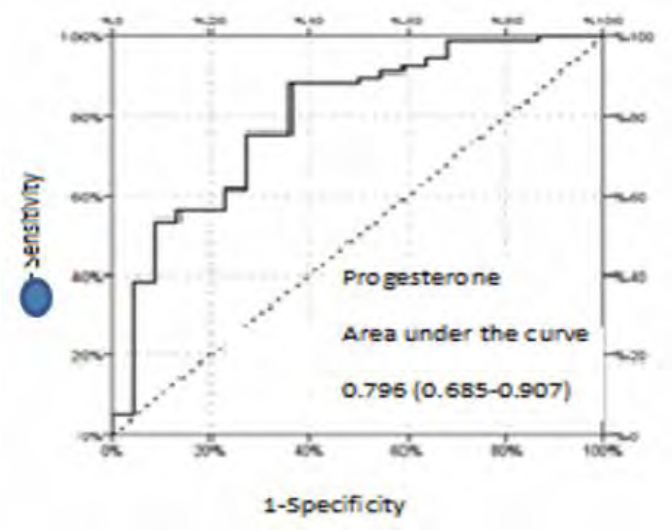

Figure 4. Serum progesterone level ROC analysis in FHB +/- group prediction

ROC: Receiver operating characteristic, FHB: Fetal heartbeat

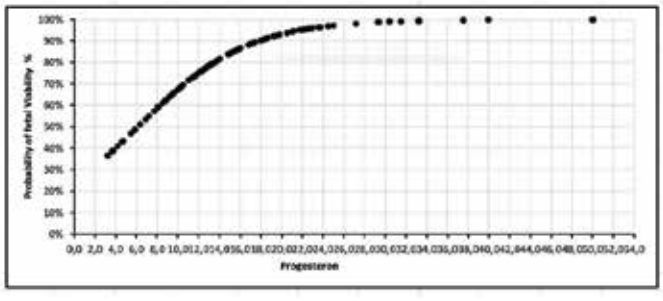

Figure 5. Serum progesterone unit: ng/mL

Chart of initial serum progesterone levels and the probability of fetal heartbeat

DISCUSSION

TV-USG has always been a classical method for predicting pregnancy outcomes in cases where viability is suspected in patients with early pregnancy, but many publications have recently studied β-hCG and progesterone values, which are serum biochemistry markers. In our study using these parameters, we found that serial β-hCG follow-ups and serum progesterone tests were effective in predicting the viability of pregnancy and compared our results with those of the current literature.

In the literature, the probability of an intrauterine cystic structure belonging to the gestational sac is 99.5% and the probability of a false sac is 0.5% (7,8). In ectopic pregnancies, the rate of false sacs was reported to be 10% (8-10). In our study, 2 of 100 patients were diagnosed with ectopic pregnancy. Considering that 81% of 100 patients had a gestational sac, the rate of false sacs in patients with an observed gestational sac was 2.46%. This is highly above the 0.5% rate stated in the literature. Considering that only 10% of ectopic pregnancies have a false sac, it is interesting that such a high rate was found only in a study on intrauterine pregnancies. This led us to conclude that clinicians should be more careful in ultrasonography examination and understand the distinction between double decidual ring appearance and actual gestational sac.

In the initial and 48-hour follow-up serum β-hCG controls, a statistically significant difference was found between the fetal heartbeat-positive group and the fetal heartbeat-negative group. Puget et al. (1) found that serum β-hCG predicts viability with 100% sensitivity and 31% specificity when the doubling rate is 75% Barnhart et al. (5) found the rate of determination of viability to be 124% increase in 2 days. Bignardi et al. (11) found that the rate of determining viability with β-hCG doubled was 78% sensitive and 67% specific. As the main purpose of our study, the fact that β-hCG doubling rate predicts viability is also consistent with many recent studies, although the rates are different. What makes our study different is that the prediction of viability is mentioned by giving only certain ratios in the literature (1,12), while in our study, a percentage is assigned to each patient in terms of viability at each increase rate of β-hCG (Figure 2). With this information, we believe that a clear rate will be provided to the patients during early pregnancy and that both the anxiety of the patients due to uncertainty and their own anxiety will be reduced by physicians providing clear information and ratio to the patients. In addition to creating an early pregnancy prediction modality, our study examined the increase rates of β-hCG in the ROC curve, determined high sensitivity cutoff values, and confirmed that the β-hCG increase rate in recent

literature could be used to predict early pregnancy outcomes. In our study, live pregnancy was achieved even with a low rate of β-hCG increase of 31%. Therefore, physicians should not diagnose pregnancy loss early, and early interventions should be avoided. The cut-off value determined in the 95% confidence interval was achieved with a minimum 97% increase in β-hCG at the hour 48. A 100% heartbeat positivity was achieved with an increase of 181%.

Puget et al. (1) found 100% pregnancy failure when the progesterone level was 6.2 ng/mL or less. In a recent French guideline, an abnormal IUP or ectopic pregnancy was found to be associated with an initial serum progesterone value of 3.2 ng/mL (3). In our study, a significant statistical result was obtained when the initial progesterone values of fetal and non-fetal heartbeats groups were compared. This was found to be consistent with the general literature (1,3). What makes our study different is that while the prediction of viability is mentioned in the literature only by giving certain ratios (11,13), in our study, a percentage can be assigned to patients in terms of viability at each value of the initial serum progesterone (Figure 5). This information makes it possible to give a clear rate to the patients during early pregnancy and reduce the anxiety of families caused by waiting for weeks. Furthermore, our study examined the initial serum progesterone level on the ROC curve, determined high sensitivity cutoff values, and confirmed that serum progesterone in the literature could be used to predict early pregnancy outcomes. A successful pregnancy was achieved even at an initial progesterone level of 3.71 ng/mL. Therefore, physicians are recommended to avoid early interventions. In addition, the cut-off value determined in the 95% confidence interval was provided at 21.7 ng/mL and above. A 100% heartbeat positivity was achieved with values of 37.5 ng/mL. The reason why we found slightly higher cut-off values compared with the general literature is the small number of patients, which is also a limitation of our study.

The 22% early pregnancy loss (EPL) rate obtained because of our study is higher than the EPL rate of 10-15% in the literature but also lower than the EPL rate of 31% after implantation (1,6,8). Although our population was a heterogeneous group of healthy and symptomatic patients, the presence of symptomatic patients at a higher rate than that in the community was considered as the likely reason for the higher rate of our EPL rates than the literature statistics. The reason why our EPL rate was lower than the EPL rate observed after implantation was considered to be the fact that patients with EPL were not evaluated without creating an intrauterine finding due to the inclusion of IUPs only with TV-USG in our population. Although the incidence of embryos was higher in the FHB -positive group than in the negative group, the incidence of gestational sacs or embryos between the FHB +/- groups was not statistically significant. This result is inconsistent with the literature because the literature states that the presence of embryos is more valuable than other ultrasound findings (yolk sac, GS) and is among the good prognostic factors (2,3). Pexster et al. (14) found variations of up to 20% between operators in CRL and mGSD measurement accuracy. It is possible to see many variations and cut-off values in the literature for diagnosis and definitions (15). Although our population is not as heterogeneous as the community and we do not study inter-operator variations, we believe that ultrasound is a subjective diagnostic tool. This is perhaps another reason why our ultrasound findings were not statistically significant in predicting early pregnancy outcomes.

Study Limitations

We acknowledge that this study has some limitations. This study did not evaluate female anxiety or satisfaction. However, there are observational findings that it provides psychological benefits. A limitation of our study was the small number of patients. Another limitation was that due to patients' previous pregnancy experiences and sociodemographic factors, patients who we predicted would be negative for FHB but could not demonstrate this ultrasonographically acknowledge this.

CONCLUSION

Because of the study, we planned to reduce the anxiety experienced by families due to the increasing patient burden and the length of time to wait for pregnancy results due to the early detection of pregnancies technologically, early detection of vitality, and a reproducible method

In this study, prediction scores for early pregnancy outcomes incorporating clinical signs, biological markers, or ultrasound findings in early pregnancy outcomes were developed, but a few studies are not sufficient to set aside TV-USG. Furthermore, the superiority of serum β-hCG and serum progesterone levels to each other was not evaluated in our study. TV-USG is an expensive examination tool for western countries, even if not for our country. Reducing subjectivity due to operators, such as ultrasound, and obtaining early results with diagnostic tools that do not require human interpretation can help reduce legal problems, families' anxiety, hospital admissions, and health costs. However, it should be noted that multicentric prospective studies with larger patient groups are needed.

Ethics

Ethics Committee Approval: The study was started after obtaining the approval of the Ethics Committee for Clinical Research of University of Health Sciences Turkey, Prof. Dr. Cemil Taşcıoğlu City Hospital under protocol number 841 on 13/03/2018.

Informed Consent: The participants were informed verbally, and in writing, and written consent was obtained.

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: M.Y., E.N.Ç., Y.Ö., V.M., Concept: M.Y., G.D., S.G., V.M., Design: M.Y., G.D., S.G., O.Ş., V.M., Data Collection or Processing: M.Y., E.N.Ç., Analysis or Interpretation: M.Y., G.D., O.Ş., Y.Ö., Literature Search: M.Y., G.D., O.Ş., Y.Ö., Writing: M.Y., E.N.Ç., S.G., O.Ş., V.M.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.49389
Eur Arch Med Res 2023;39(3):153-158

Quality and Reliability of YouTube Videos in the Dix-Hallpike Test

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Abstract

Objective: This study is designed to evaluate the quality and reliability of informative videos on YouTube about the Dix-Hallpike test.

Methods: A YouTube search was conducted with the keywords "dix-hallpike maneuver", "dix-hallpike test", "positional vertigo", "benign paroxysmal positional vertigo", "benign paroxysmal positional vertigo (BPPV) diagnosis". The top 100 videos were evaluated in terms of duration, time since upload date (days), number of total views, number of likes and dislikes, number of comments, and uploaded (healthcare provider/non-healthcare professional). Descriptive statistical data were obtained from the video duration, number of total views, number of likes and dislikes, number of comments and upload date

Results: There was no statistically significant difference between the healthcare provider and non-healthcare professional groups in terms of mean DISCERN, JAMA, and GQS scores (p=0.190, p=0.69 and p=0.946; respectively). The total view counts were higher in the healthcare provider group than in the non-healthcare professionals, the difference was not statistically significant (p=0.104). The mean number of likes was statistically higher in the videos uploaded by healthcare providers (p=0.012).

Conclusion: YouTube should still not be considered a fully reliable source of information on the diagnosis of BPPV in patients. It is essential to direct patients to videos that are updated, provide accurate and reliable information about the diagnosis and treatment of BPPV, and are free of misleading information about vertigo.

Keywords: Dix-hallpike, benign paroxysmal vertigo, YouTube, positional vertigo, BPPV diagnosis

INTRODUCTION

The internet has become one of the most popular and essential reference resources for health-related information (1). According to the report of the Health Information National Trends Survey (HINTS), there is a significant increase in the search for health information on the internet. Surveys show that 8 of 10 internet users access health information online (2,3). Social media platforms such as Youtube play an expanding role in the dissemination of medical information.

YouTube is the world's largest and most popular online video streaming site with over 5 billion daily views, 1.68 billion active users, and over 50 million content creators (4). It serves as an open access, simple, and integrated online platform where people can upload, share, watch, and comment on videos on any topic. However, the quality of unfiltered information may be unscientific, misleading, or even harmful (5). Many studies have shown that healthcare providers have concerns about the accuracy and quality of the information available on this platform. Two main reasons for this concern are; insufficient guidelines regulating the content of the material uploaded on the site and, more importantly, increased use of YouTube to post non-peer-reviewed anecdotal information (6,7).

One of the most common benign causes of vertigo is benign paroxysmal positional vertigo (BPPV), which occurs as a result of the displacement of otoliths into semicircular canals (8).

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Received: 01.03.2023
Accepted: 30.05.2023

Cite this article as: Çapar SH, Şenkaya D, Ertürk P, Çetin Kara H. Quality and Reliability of YouTube Videos in the Dix-Hallpike Test. Eur Arch Med Res 2023;39(3):153-158

The dix-hallpike test is the most commonly used bedside test for diagnosing BPPV (9). The use of the canalith repositioning maneuver is indicated in patients with positive test findings. If applied correctly, the dix-hallpike test enables accurate diagnosis and hence successful treatment of BPPV (10). Unsuccessful application of the dix-hallpike test leads to misdiagnosis, longer duration of symptoms, use of unnecessary imaging modalities, and unnecessary visits to emergency departments (11).

There is a lot of content related to the dix-hallpike test on YouTube. The purpose of this study was to evaluate the content quality of dix-hallpike test videos on YouTube as a health education resource.

METHODS

The study was exempted from ethics committee approval because only publicly available data were used. Within the scope of this prospective cross-sectional study, a YouTube search was conducted on June 12, 2022 with the keywords "dix-hallpike maneuver", "dix-hallpike test", "positional vertigo", "benign paroxysmal positional vertigo", "BPPV diagnosis" at https://www.youtube.com. No changes have been made to the standard search preferences of the website. The video search was performed without logging in as a user and clearing the search history of the browser. The default search preference was chosen as "sort videos by relevance". All English- narrated videos or videos with English subtitles accessible on YouTube as of June 12, 2022 with content related to dix-hallpike were included in the study. Videos in which the like-dislike button and/or comments were disabled by the uploaded were excluded from the study.

The recorded data consisted of duration, time since upload date (days), number of total views, number of likes and dislikes, number of comments, and uploader occupation obtained from "about" section of the video (healthcare provider: medical doctor, physioterapist, audiologist, healthcare institution etc.)/non-healthcare professional: uploaded occupied in other professions or videos with no uploaded information). Descriptive statistical data were obtained from the video duration, number of total views, number of likes and dislikes, number of comments, and upload date.

The top 100 videos were evaluated by two independent double-blinded reviewers with dix-hallpike maneuver experience. The aim for selecting the top 100 videos was that the search results were limited to the first 3 pages on the website because 95% of people conducting an online search will not look further than the first three pages of the search output (12). The DISCERN scoring system, Journal of the American Medical Association (JAMA) scoring system, and Global Quality Score (GQS) criteria were used to evaluate the quality and reliability of the videos.

DISCERN (Table 1) is a scoring system with two sections consisting of 15 items, each rated from 1 to 5 to evaluate the reliability of medical information and the quality of information on the treatment options offered in that particular publication. The first section consists of eight questions and evaluates the reliability of the publication, whereas the secondsection evaluates treatment-

Table 1. DISCERN scoring system. Each question is rated from 1 to 5
Section 1: Is the publication reliable?
1. Are the aims clear?
2. Does it achieves its aims?
3. Is it relevant?
4. Is it clear what sources of information were used to compile the publication (other than the author or producer)?
5. Is it clear when the information used or reported in the publication was produced?
6. Is it balanced and unbiased?
7. Does it provides details of additional sources of support and information?
8. Does it refers to areas of uncertainty?
Section 2: How good is the quality of information regarding treatment choices?
9. Does it describes how each treatment works?
10. Does it describes the benefits of each treatment?
11. Does it describes the risks of each treatment?
12. Does it describes what would happen if no treatment was used?
13. Does it describes how treatment choices affect overall quality of life?
14. Is it clear that there may be more than 1 possible treatment choice?
15. Does it provides support for shared decision making?

related information with seven questions. The DISCERN score ranges from 15 to 75 points and is classified into five groups as excellent (63-75 points), good (51-62 points), fair (39-50 points), poor (27-38 points), and very poor (16-26 points) (13).

JAMA (Table 2) is another scoring system that evaluates the reliability of online health-related resources using the four criteria of authorship, attribution, disclosure, and currency. Each criterion can be rated 0 or 1. A score of four points indicates the highest quality (14).

The GQS (Table 3), first proposed by Bernard et al. (15), allows users to assess the overall quality of a video's content on a scale ranging from 1 to 5. The system considers the flow, ease of use, and video quality of the information presented in online videos. A score of one point indicates the poorest quality, whereas a score of five points indicates excellent quality.

Statistical Analysis

SPSS software version 21.0 was used for statistical analyzes Descriptive analyzes were performed using means and standard deviations for normally distributed variables. Percentiles were used for non-normally distributed and ordinal variables. After investigating normality, independent-samples t-test or Mann-Whitney U test was used to compare the variables. While investigating the associations between the variables, the correlation coefficients and their significance were calculated using the Spearman test. A 5% type 1 error level was considered statistically significant.

RESULTS

A total of 93 videos were included in the study. While 65 (69.9%) videos were uploaded by healthcare providers, 28 (30.1%) videos were uploaded by non-healthcare professionals. A comparison of the videos' parameters and scoring system values according to their sources is given in Table 4. The mean DISCERN score was 44.1±11.5; the mean GQS score was 3.01±0.86 and the mean JAMA score was 1.85±0.72 for the videos uploaded by healthcare providers, whereas the mean DISCERN score was 41.4±7.6; the mean GQS score was 2.67±0.65 and the mean JAMA score was 1.86±0.73 for the non-healthcare professionals. There was no statistical difference between the groups regarding the aforementioned parameters (p=0.190, p=0.69, and p=0.946; respectively). The total view counts and the mean duration of the videos were also comparable between the healthcare providers

Table 2. Journal of the American Medical Association (JAMA) scoring system. Each question is rated 0 or 1

Authorship: Authors and contributors, their affiliations, and relevant credentials should be provided
Attribution: References and sources for all content should be clearly listed, and all relevant copyright information should be noted
Disclosure: Website "ownership" should be prominently and fully disclosed, as should any sponsorship, advertising, underwriting, commercial funding arrangements or support, or potential conflicts of interest.
Currency: Dates when content was posted and updated should be indicated

Table 3. Global Quality Score (GQS). Each question is rated from 1 to 5

1. Poor quality, very unlikely to be of any use to patients
2. Poor quality but some information present, of very limited use to patients
3. Suboptimal flow, some information covered but important topics missing, somewhat useful to patients
4. Good quality and flow, most important topics covered, useful to patients 5) Excellent quality and flow, highly useful to patients

Table 4. Videos' parameters and scoring system values

Parameters	Healthcare providers	Non-healthcare professionals	P value
Number of videos	61 (65.6%)	32 (34.4%)	
Mean DISCERN score	44.1±11.5	41.4±7.6	0.190[a]
Mean GQS scores	3.01±0.86	2.67±0.65	0.69[a]
Mean JAMA score	1.85±0.72	1.86±0.73	0.946[b]
Total views	104641.96±251247.16	43015.42±122612.68	0.104[b]
Mean duration	243.07±243.82	184.64±204.62	0.490[b]
Likes	487.04±1224.29	282.25±973.85	**0.012**[b]
Dislikes	0.00	0.00	

[a]Independent Samples t-test, [b]Mann-Whitney U test
GQS: Global Quality Scores, JAMA: Journal of the American Medical Association

Table 5. Crosstab of the correlation coefficient and p values of the variables

Parameters	Healthcare status		Mean DISCERN		Mean GQS scores		Mean JAMA score		Total views		Mean duration		Likes	
	r	p	p	r	p	r	p	r	p	r	p	r	p	r
Healthcare status	1.00	-	0.521	-0.101	0.336	-0.196	0.060	0.007	0.947	-0.169	0.105	-0.072	0.493	-0.260
Mean DISCERN score	-0.101	0.336	0.460	1.00	-	**0.878**	**<.001**	**0.528**	**<.001**	**0.283**	**<.006**	**0.656**	**<.001**	**0.345**
Mean GQS scores	-0.196	0.060	0.183	**0.878**	**<.001**	1.00	-	**0.534**	**<.001**	**0.326**	**0.001**	**0.639**	**<.001**	**0.459**
Mean JAMA score	0.007	0.947	0.227	**0.528**	**<.001**	**0.534**	**<.001**	1.00	-	-0.013	0.901	**0.402**	**<.001**	0.130
Total views	-0.169	0.105	0.487	**0.283**	**0.006**	**0.326**	**0.001**	-0.013	0.901	1.00	-	0.145	0.164	**0.816**
Mean duration	-0.072	0.493	0.627	**0.656**	**<.001**	**0.639**	**<.001**	**0.402**	**<.001**	0.145	0.164	1.00	-	**0.366**
Likes	**-0.260**	**0.012**	0.782	**0.345**	**0.001**	**0.459**	**<.001**	0.130	0.213	**0.816**	**<.001**	**0.366**	**<.001**	1.00

GQS: Global Quality Scores, JAMA: Journal of the American Medical Association
r: Spearman correlation coefficient

and non-healthcare professionals (104641.96±251247.16 versus 43015.42±122612.68 and 243.07±243.82 versus 184.64±204.62) (p=0.104 vs p=0.490; respectively). However, the mean number of likes was statistically higher in the videos uploaded by healthcare providers (487.04±1224.29 vs 282.25±973.85; p=0.012). The mean dislike count was null for all videos.

DISCUSSION

The content quality of dix-hallpike test videos on the YouTube platform was assessed in this study from a health education resource perspective. A video search was conducted with the keywords "dix-hallpike maneuver", "dix-hallpike test", "positional vertigo", "benign paroxysmal positional vertigo", "BPPV diagnosis" and top 100 videos were evaluated for content quality.

BPPV is the most common peripheral vestibular disorder with an estimated lifetime prevalence of 10% (16). It can have a significant negative impact on daily activities and quality of life. However, with an accurate diagnosis, it can be treated with a simple repositioning maneuver that can be performed in the examination room (9). The dix-hallpike test is widely accepted as a standard for the diagnosis of BPPV (17). Due to the large number of patients admitted to emergency departments with vertigo and lack of information or insufficient experience about the dix-hallpike maneuver among healthcare professionals, the application of the test in emergency rooms and primary healthcare institutions is limited (18,19). Self-diagnosis of the disease by the patients may help to overcome this limitation. Previous studies have shown that patients with BPPV can successfully perform the dix-hallpike maneuver when given face-to-face instructions by a specialist (20,21). However, it should be considered that misuse of the dix-hallpike maneuver may also lead to misdiagnosis. In their study, Dmitriew et al. (11) showed that the dix-hallpike test is both underutilized and frequently applied to patients whose symptoms are inconsistent with BPPV, which in return may result in prolonged patient discomfort and increased resource utilization, as well as increasing the risk of misdiagnosing central vertigo. Therefore, it is crucial to evaluate the quality of the training provided to healthcare professionals and patients.

Informative videos on social media and online platforms such as YouTube are becoming more widespread as sources of information, most probably because visually presented information is often preferred over written- and auditory information (22). YouTube was the first company to enable online video sharing in 2005 and currently receives billions of uploads and visits per day (23). Along with a great number of videos related to personal experiences, there are also a significant number of informative videos on various types of diseases and procedures. As YouTube has no policy of filtering videos according to their potency or effectiveness, there are myriads of videos on the platform, and while some may be useful, others may be misleading or even harmful (24). Therefore, the quality of dix-hallpike videos uploaded to YouTube was evaluated in our study.

Online videos about BPPV evaluated for reliability can serve many purposes. There are no studies in the literature on self-diagnosis in BPPV. Most patients may self-diagnose and self-treat BPPV with the help of reliable informative videos. When the comments section of the videos were evaluated, it was observed that the patients referred to

these videos for self-diagnotic and/or self-treatment purposes. There is evidence in the literature stating that BPPV can be self-treated (20,21). However, the limitation of these studies is that the maneuvers were evaluated after face-to-face instructions by healthcare professionals to the subjects.

A recent systematic review published by Ulep et al. (25) showed that studies on social media use in vestibular disorders are emerging, especially in the last decade. To our knowledge, there are no studies regarding online video education of the dix-hallpike test for self-diagnosing BPPV, and this is the first study assessing the quality and reliability of informative videos on YouTube about the dix-hallpike maneuver.

In our study, the top 100 videos were evaluated by two independent double-blinded reviewers with Dix Hallpike maneuver experience. The aim for selecting the top 100 videos was that the search results were limited to the first 3 pages on the website since 95% of people conducting an online search will not look further than the first three pages of the search output (12). Seven videos were excluded because there were no instructions about the dix-hallpike maneuver. Sixty-five videos (69.9%) were uploaded by healthcare providers, whereas 28 videos (30.1%) were uploaded by non-healthcare professionals.

We observed that there were a variety of dix-hallpike test videos on YouTube and that the view counts were fairly high. All videos were accessible with appropriate keywords, and the maneuver was performed correctly in each of them. Videos were evaluated using the DISCERN, GQS, and JAMA scoring systems, and the scores for the videos were 44.1 11.5, 3.01 0.86, and 1.85 0.72, respectively. The poor to fair results in DISCERN and low JAMA scores indicate that the reliability and credibility of the videos are fairly low. In addition, 3.01 GQS score out of 25 shows that the content quality of the videos is suboptimal, missing useful important information for patients. There was no statistically significant difference between the healthcare provider and non-healthcare professional groups in terms of mean DISCERN, JAMA, and GQS scores ($p=0.190$, $p=0.69$ and $p=0.946$; respectively). Even though the total view counts were higher in the healthcare provider group than in the non-healthcare professionals (104641.96 ± 251247.16 versus 43015.42 ± 122612.68), the difference was not statistically significant ($p=0.104$). This might be related to the fact that there was mostly no information about the uploaded in the video titles. However, the mean number of likes was statistically higher in the videos uploaded by healthcare providers (487.04 ± 1224.29 vs 282.25 ± 973.85; $p=0.012$). Similar to our study, Yildiz et al. (26) evaluated educational videos for vestibular rehabilitation on YouTube using the DISCERN, JAMA, and GQS scoring systems. They also observed that the quality of the videos used in vestibular rehabilitation training was poor and unreliable (26).

With easy accessibility of the videos and the high number of views, the potential limitation we would like to emphasize is that there is no information in the videos regarding the possible outcomes of misuse of the dix-hallpike maneuver and the conditions in which the maneuver is contraindicated. Another limitation of this study was the inclusion of only the first 100 videos for each keyword, as after applying the exclusion criteria, the sample size was limited.

Despite these limitations, this was the first study to assess the quality and reliability of informative videos on YouTube about the dix-hallpike test. Although most of the videos were rated moderate regarding their sufficiency of information, with only fair quality, this study demonstrated that YouTube should still not be considered a fully reliable source of information on the diagnosis of BPPV for patients. It is essential to direct patients to videos that are updated, provide accurate and reliable information about the diagnosis and treatment of BPPV, and are free of misleading information about vertigo.

Ethics

Ethics Committee Approval: The study was exempted from ethics committee approval because only publicly available data were used.

Peer-review: Internally and externally peer reviewed.

Authorship Contributions

Concept: S.H.Ç., Design: S.H.Ç., H.Ç.K., Data Collection or Processing: D.Ş., S.H.Ç., Analysis or Interpretation: S.H.Ç., P.E., Literature Search: H.Ç.K., Writing: S.H.Ç., P.E.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.20092
Eur Arch Med Res 2023;39(3):159-163

The Evaluation of Inflammation in Chronic Migraine Patients Using the Neutrophil-lymphocyte Ratio

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Abstract

Objective: Migraine is a common primary headache disease. Studies have supported the presence of neurogenic inflammation in the pathophysiology of migraine. The neutrophil/lymphocyte ratio (NLR) has been used as a marker of inflammation in recent years. Although it has been shown that NLR increases during migraine attacks, there are limited data on chronic migraine (CM) patients. We aimed to evaluate the inflammatory status in CM patients using NLR as a biomarker for inflammation.

Methods: Twenty three migraine patients without aura and 18 age-matched control participants were included. The migraine patients who had more than 15 headache days/month were grouped as having CM. The episodic migraine group included migraine patients who had less than 15 headache days/month. Another grouping was performed according to the total duration of migraine-type headaches. Patients having headaches over 10 years were grouped as long-term (LM) migraine patients, and those having headaches under 10 years were grouped as short-term (SM) migraine patients. The patients were in an interictal state during the evaluations. Demographic information, laboratory results, and definite diagnosis of the headache type of the participants were retrospectively collected from the files. NLR was calculated using the total counts of neutrophils and lymphocytes.

Results: The NLR was similar between the control, episodic, and CM groups. No correlation was found between NLR and the frequency of headaches. The NLR was similar between the SM and LM migraine patients.

Conclusion: There is no evidence of ongoing inflammation, which was evaluated by NLR, in the interictal state of patients with both episodic and CM.

Keywords: Migraine without aura, inflammation, neutrophil, lymphocyte, chronic headache

INTRODUCTION

Migraine is a common primary headache disease that affects approximately 15% of the population (1). Studies have supported the role of neurogenic inflammation in migraine pathophysiology. Neurogenic neuroinflammation is defined as inflammatory reactions in the trigeminovascular system in response to neuronal activity (2). The levels of some cytokines are altered in migraine patients. These cytokines include interleukin (IL) 1β, tumor necrosis factor (TNF), and IL-6. It has also been shown that the levels of proinflammatory cytokines and the prevalence of T helper 1 (Th1) lymphocytes increase, whereas there is a depletion in regulatory lymphocyte subsets, which also supports the role of inflammation (3-5).

During a migraine attack, an increase in blood flow and protein leakage from the vessels are observed. In addition, because of neurogenic inflammation, there is a composition of vasoactive peptides. A migraine attack is characterized by sterile inflammation at the end of this process (6-8). The neutrophil/lymphocyte ratio (NLR) has been used as an inflammatory marker in recent years. As a response to a stress factor, there is an increase in neutrophils and a decrease in lymphocyte counts (9,10). NLR can be detected by a total blood count test, which

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Received: 24.01.2023
Accepted: 12.06.2023

Cite this article as: Tavşanlı ME. The Evaluation of Inflammation in Chronic Migraine Patients Using the Neutrophil-lymphocyte Ratio. Eur Arch Med Res 2023;39(3):159-163

makes it a cheap and easy-to-access method. Several studies have compared the inflammatory biomarkers, including NLR, between migraine patients and the normal population, between episodic migraine (EM) patients and chronic pain, and between the interictal and attack periods of migraine-type headaches in the same patient (6,11,12). The results showed that NLR increases during a migraine attack, which supports the neuroinflammatory pathogenesis (11,12).

The International Classification of Headache Disorders-3rd edition (ICHD-3) divides migraine into two categories. EM is defined as having less than 15 headache days per month, whereas chronic migraine (CM) is characterized by having 15 or more headache days per month for at least three months and with at least eight days of characteristic migraine features (13,14). Both chronic and EM patients had higher serum levels of TNF-α than healthy individuals. On the other hand, neither TNF-α, nor C-reactive protein (CRP) did not show any difference between episodic and CM patients (15). However, the literature has limited data on the inflammatory status of CM patients using NLR as a biomarker.

This study aimed to detect a possible ongoing inflammatory status in CM patients using NLR as the biomarker for inflammation because NLR is found to be increased in acute attacks of migraine and can be detected with complete blood count, which is a simple test that can be performed at any medical center.

METHODS

This was a retrospective case-control study involving 23 migraine patients (15 episodic, 8 chronic) and 18 age-matched headache-free control participants. The confidence level of this study is 95%, and the margin of error is 15%. This study has a power of 80% and an effect size of 0.5. All participants were recruited from the Acıbadem Taksim Hospital Check-up and Neurology Outpatient Clinics. This study included subjects aged between 18 and 60 years. The diagnosis of episodic or CM was performed according to the criteria defined by ICHD-3 (13). To create a homogenous migraine patient group, only patients without an aura were included. All migraine patients were in an interictal state during their evaluation. This study excluded participants having: another type of headache than migraine, a new onset headache (started within the past 6 months), a neurodegenerative disease, a history of allergy, an infectious or inflammatory disease, a history of neoplasia, analgesic overuse, or regular use of anti-inflammatory medications. Participants were also excluded if they had a migraine attack or an infection (detected by either laboratory tests or examination) at the time of evaluation.

Patient files were scanned retrospectively between 2020 and 2022. All demographic information, headache features, laboratory results, and a definite diagnosis of headache type were collected from the files of the participants. The number of days per month with migraine-type headaches and the total time (in terms of year) that the patient had migraine-type headaches were recorded. NLR was calculated for each patient using the total counts of neutrophils and lymphocytes, which were detected by a complete blood test. All blood samples were taken before noon from the antecubital vein while the patient was fasting. All blood samples were analyzed on the same day.

Participants without a complaint of headache were grouped as the control group. According to the number of days with headache per month, EM and CM groups were created. The EM group included participants having headaches <15 days/month and the CM group included participants having headaches ≥15 days/month. Another classification of the participants was also performed as control, long-term (LM), and short-term (SM) migraine patients according to the total time of migraine-type headache to determine the effect of the total disease time on the inflammatory reaction. The LM group involved participants having migraine ≥10 years and the SM group involved participants having migraine <10 years.

The study protocol was approved by the Ethics Committee of Acıbadem University (approval no: 2023-1/22, date: 13.01.2023).

Statistical Analysis

The Shapiro-Wilk test was used to test the normality distribution of the data. The chi-square test was used to compare categorical variables. Numerical variables are given as mean ± standard deviation (SD). An analysis of variance (ANOVA) was used to compare continuous data. Equal variances were checked using Levene's test. Post-hoc analysis of the ANOVA test was performed by the Tukey test in equal variances and by the Tamhane test in unequal variances. Values are given as means and SD and numbers and percentages, according to the type of variables. Pearson correlation analysis was used to estimate the correlations between NLR, headache frequency, and total disease duration. The statistical significance level is considered $p<0.05$. All statistical analyzes were performed using the Statistical Package for the Social Sciences (SPSS) version 15 (IBM, Armonk, NW, US).

RESULTS

There was female dominance in the CM group (7 females, 1 male), whereas the gender distribution was similar in the EM (8 females, 7 males) and control groups (9 females, 9 males).

The mean ages of the groups were similar [F (2, 38): 0.625, p=0.541] (Table 1).

The effects of demographic differences in the NLR were checked by grouping the participants according to gender and age. The median age of all participants was 39 years, and the NLR was compared between the participants <39 years old and ≥39 years old. No significant difference was found [t (39): 1.09, p=0.281]. There was also no difference in the NLR between the genders [t (39): 1.59, p=0.119].

The participants of the control, EM, and CM groups showed similar NLR [F (2, 38): 1.245, p=0.299]. The comparison of the NLR between the control, SM, and LM migraine groups also showed no significant difference [F (2, 38): 0.142, p=0.868]. The correlation analysis between NLR and the frequency of migraine-type headaches (headache days per month) did not show any significance [r (23): 0.207, p=0.343]. There was also no significant correlation between NLR and the total duration of migraine-type headaches [r (23): -0.101, p=0.648].

DISCUSSION

It has been shown that inflammatory responses may differ between genders and between old and young populations (16). Healthy femalesunder 50 years of age were found to have higher NLR in recent studies (17-19). One of the suggested factors for this difference is estrogen hormone, which affects the neutrophil count and inflammatory response (20). However, the present study showed similar NLR between males and females and between younger and older participants. The limited number of cases in this study may be the reason for the failure to show the effect of demographic characteristics on the NLR.

In the literature, most studies concern the inflammatory response during a migraine attack. A recent example is a study conducted in 2021 by Panpallı et al. (11), who used NLR to compare the inflammatory response between migraine attacks with aura and interictal state. However, the studydid not include CM patients. It was found that the NLR was higher during a migraine attack than in the interictal state and control patients (11). The present study did not include patients during a migraine attack because the main purpose was to investigate a possible baseline inflammatory reaction in the interictal state.

Studies that compare the inflammatory biomarkers between the interictal state of migraine and healthy participants show various results. Panpallı (11) reported that the NLR was similar between the interictal period of EM patients and the control group. On the other hand, Vanmolkot and de Hoon (6) reported a significantly high level of CRP in the interictal period of EM patients, with and without aura, compared to the control group. Another study Martami et al. (15) used CRP and TNF-as inflammatory biomarkers during an interictal state. It was shown that CRP levels did not differ between the groups of EM, CM, and controls, but TNF- was higher in the episodic and CM patients than in the control group. Both CRP and TNF- did not show any correlation with attack frequency (15). However, there is a controversial result by Uzar et al. (21), who reported similar TNF- levels between migraine patients and the control group. Neuroinflammatory response is a complex process that includes several cytokines (IL-1β, TNF, IL-6, etc.) (3-5). The reason for the controversies in the literature may be the complexity of the inflammatory process. There is a need for studies that will include all the inflammatory biomarkers to make a more precise detection of inflammation in migraine patients and to prevent possible controversies between the studies.

It is also worth mentioning that migraine with aura may have a different pathophysiology than migraine without aura. It has been shown that the CRP level was higher more significantly in migraine patients without aura when compared with the healthy population (6). Although the present study only involved migraine patients without aura, we used NLR instead of CRP as the biomarker and found similar NLR levels between the patient and control groups. CRP could be accepted as another practical

Table 1. Analysis of the groups according to the headache frequency

	Control (n=18)	Episodic migraine (n=15)	Chronic migraine (n=8)	p
Age, years (mean ± SD) [min-max]	40.6±9 [26-59]	37.8±7.1 [26-47]	37.5±8.5 [29-57]	[F (2, 38) = 0.625, p=0.541]
Gender	Female: 9 Male: 9	Female: 8 Male: 7	Female: 7 Male: 1	-
NLR (mean ± SD) [min-max]	1.85±0.5 [0.95-2.8]	1.63±0.6 [0.89-2.95]	1.99±0.5 [1.38-2.79]	[F (2, 38) = 1.245, p=0.299]

SD: Standard deviation, NLR: Neutrophil/lymphocyte ratio

inflammatory biomarker, but it can be affected by other conditions besides inflammation, such as obesity, diabetes, and smoking (22-24). Therefore, we only used NLR for the evaluation of the inflammatory status. As mentioned above, inflammation is a complex process, which may be the reason for not finding a significant change in NLR. It may not be convenient to accept this result as a controversy to the study that used CRP as the biomarker.

Although the literature has limited evidence of a general neuronal inflammatory response in the ictal period of migraine; continuous release of neurotransmitters is thought to be the main pathophysiology in migraine chronification (25,26).

The present study shows that the inflammatory status, which was measured by the biomarker NLR, was similar between the control group and migraine patients, who were in the interictal state, regardless of having chronic or EM. The findings support the literature, which is against an increase in an inflammatory marker in the interictal period of migraine. There was also no correlation between NLR and both the total duration of migraine-type headaches and the frequency of migraine attacks, as supported by previous studies (15). These findings suggest that an interictal period of CM does not show evidence of an ongoing inflammation that could be detected by NLR.

Study Limitations

However, this study has several limitations. First, the sample size of the study was limited. Second, we only used NLR as a biomarker of inflammation. There are several inflammatory biomarkers including cytokines, CRP, serum amyloid A, and TNF. This study did not include all the biomarkers of inflammation because one of the aims of this study was to use a practical and easy-to-access biomarker, and NLR was a good candidate.

On the other hand, the literature has limited papers on the inflammatory response of CM patients, and this paper contributes to the literature by covering the interictal state of CM patients, which makes the strong side of the present study.

CONCLUSION

Although this study showed no evidence of ongoing inflammation in patients with CM, there is a need for future studies involving more inflammatory markers.

Ethics

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of Acıbadem University (approval no: 2023-1/22, date: 13.01.2023).

Informed Consent: Informed consent was waived since this is a retrospective study. All personal and medical informations of the subjects are kept confidential.

Peer-review: Externally peer reviewed.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.66487
Eur Arch Med Res 2023;39(3):164-170

Incidental Thorax CT Findings in Patients with Suspected COVID-19 Pneumonia

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Abstract

Objective: In this study, we aimed to emphasize the importance and frequency of incidental findings detected in chest computed tomography (CT) imaging with suspected coronavirus disease-2019 (COVID-19) pneumonia.

Methods: We evaluated lung nodules, emphysema, pleural and pericardial effusion, mediastinal and axillary lymphadenopathy (LAP), gallstones, kidney stones, hepatosteatosis, ascites, lung, breast, liver, adrenal gland, pancreas, and spleen masses whether or not the patients were positive for COVID-19 pneumonia and correlated with their gender and age. Polymerase chain reaction results of the patients were considered whose CT images were suspicious for COVID-19 pneumonia with chest CT. A total of 2,400 patients were included in the study. Patients who had major thoracic or abdominal operations, aged 18 and above 80 years, and images with artifacts were excluded from our study.

Results: In older patients, the COVID-19 positivity rate was higher in our study. We also found that the risk of positive COVID-19 results was higher in the presence of incidental findings regardless of their number. Furthermore, incidental findings such as mediastinal LAP (p=0.001), air cyst (p=0.021), and size above 5 mm parenchymal lung nodule (p=0.001) were higher in patients whose COVID-19 results were positive.

Conclusion: We demonstrated that clinicians and radiologists should be careful in terms of incidental findings when evaluating whether there is COVID-19 involvement in our study.

Keywords: Chest computed tomography, COVID-19 pneumonia, incidental findings, lung nodules, mediastinal lymphadenopathy

INTRODUCTION

Coronavirus disease-2019 (COVID-19) is the primary pandemic with a medical manifestation of an severe acute respiratory syndrome caused by coronavirus-2 (SARS-CoV-2) that was first detected in China in December 2019 (1). These signs may also progress to dyspenia and chest pain with pneumonia (2). Research has indicated that the intensity of symptoms can vary widely from fundamentally asymptomatic to mortal complications (3,4).

SARS-CoV-2 and Middle East respiratory syndrome (MERS-CoV) have similar symptoms and mechanisms. SARS-CoV-2 infection uses the angiotensin-converting enzyme 2 receptor, whereas MERS-CoV infection uses dipeptidyl peptidase 4 to enter human cells (5). Similar to pulmonary manifestations, patients can also present with vomiting, diarrhea, and stomach pain, which are atypical symptoms of the gastrointestinal (GI) system. Almost 20% of patients with COVID-19 present with GI signs and symptoms. Neurologic symptoms are prevalent at the same time in COVID-19 patients (6). There are numerous case reviews of individuals providing nothing but neurological symptoms, including confusion, headaches, diminished feeling of odor and taste, strokes, and seizures with encephalitis-like symptoms (3).

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Cite this article as: Nalbant MO, Yıldız Ö, Hocaoğlu E, İnci E, Polat Ö, Adaş GT. Incidental Thorax CT Findings in Patients with Suspected COVID-19 Pneumonia. Eur Arch Med Res 2023;39(3):164-170

Received: 31.05.2022
Accepted: 11.07.2023

Studies have demonstrated that COVID-19 patients with comorbidities may have a poor prognosis (7). A previous study suggested that individuals who are immunosuppressed do not exhibit a heightened susceptibility to severe pulmonary disease, and the factors that increase the likelihood of severe disease are advanced age, complications arising from obesity, coexisting medical conditions, and male gender (8). Conversely, alternative research revealed that individuals with immunodeficiency were at heightened susceptibility to experiencing more severe manifestations of COVID-19 and a greater likelihood of mortality (9). Research has verified that cancer patients are at a higher risk of intense COVID-19 symptoms and death than the normal population. Lung, blood, and metastatic cancer patients were identified as having the ultimate excessive consequences (10).

Patients with symptoms suggesting COVID-19 pneumonia underwent cross-sectional imaging that included portions of the abdomen out of necessity. In this study, we evaluated patients not known to be COVID-19 positive or negative who underwent computed tomography (CT) of the thorax for incidental findings such as lung nodules, emphysema, pleural and pericardial effusion, gallstones, kidney stones, lung, breast, and abdominal (liver, adrenal, pancreas, spleen) masses. We emphasized the importance and frequency of incidental findings detected by thoracic imaging.

METHODS

The study was conducted between March 11th and May 15th, 2020. This study received approval from the Human Subjects, University of Health Sciences Turkey, Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (approval no: 2022-08-05, date: 18.04.2022), and informed written consent was obtained from all patients. The study was conducted with 2,400 cases; 38.9% (n=934) were females and 61.1% (n=1,466) were males who had a suspicion of COVID-19 pneumonia. The ages of the patients ranged from 15 to 80, with an average of 46.62±15.43 years. We obtained all the medical and demographic information of the patients from the data processing center of our hospital.

All images were obtained using an MDCT scanner (Siemens Medical Solution, Erlanger, Germany) in the supine position with a CT protocol that was followed with a 1-mm slice thickness. Effective mAs were adjusted by Siemens "CARE dose", and the tube voltage was 120 kV. All patients underwent imaging from the thoracic inlet to the kidneys. CT images were transferred to an independent workstation (Syngo via console; Siemens, Erlangen, Germany) and then analyzed and evaluated.

We evaluated lung nodules, emphysema, pleural and pericardial effusion, mediastinal and axillary lymphadenopathy (LAP), gallstones, kidney stones, hepatosteatosis, ascites, lung, breast, liver, adrenal, pancreas, and spleen masses to determine whether or not the patients were positive for COVID-19 pneumonia and correlated these findings with their gender and age. Polymerase chain reaction (PCR) results of the patients were considered whose CT images were suspicious for COVID-19 pneumonia.

Patients who had major thoracic or abdominal operations, aged under 18 and above 80 years, were not included in the study. Furthermore, severe CT motion artifacts or other imaging artifacts were used as exclusion criteria. In this study, the first scans of patients who underwent repeated thoracic CT examinations were used for evaluation.

Statistical Analysis

The Number Breaker Statistics System (NBSS) 2007 (Kaysville, Utah, USA) program was used for statistical analysis. Descriptive statistical methods (mean, standard deviation, median, frequency, ratio, minimum, and maximum) were used to evaluate the study data. The suitability of quantitative data for a normal distribution was tested by the Kolmogorov-Smirnov test, the Shapiro-Wilk test, and graphical evaluations. Student's t-test was used to compare two groups of normally distributed quantitative data. For the comparison of qualitative data, the Pearson chi-square test and Fisher's exact test were used. Significance was evaluated at the level of $p<0.05$.

RESULTS

Approximately 317 images were excluded, depending on artifacts and major thoracic or abdominal operations. A total of 2,400 cases [61.1% (n=1,466) male, 38.9% (n=934) female] were evaluated in our study. While 37.1% (n=890) of the cases were under the age of 40, 23.2% (n=556) were between the ages of 40-49 years, 8.6% (n=446) were 50-59 years, 10.8% (n=258) were 60-69 years, and 10.4% (n=250) were over 70 years.

The COVID-19 results in 42.3% (n=1014) of the cases included in the study was positive (Table 1). While 39.1% (n=938) of the cases had no parenchymal lung nodule, 36.7% (n=880) had below 5 mm, and 24.3% (n=582) had 5 mm and above parenchymal lung nodules.

Emphysema in 7.7% (n=184), mediastinal LAP in 10.8% (n=260), lung mass in 2.8% (n=66), air cyst in 2.5% (n=60), cavitary lesion in 0.3% (n=6), pleural plaque in 1.2% (n=28), pleural effusion in 5.8% (n=138), pericardial effusion in 2.0% (n=48), breast mass in 1.1% (n=26), axillary LAP in 1.1% (n=26), hepatosteatosis in

Table 1. Distribution of descriptive features

		n	%
Age (years)	**Min-max (median)**	15-80 (45)	
	Mean ± SD	46.62±15.43	
	<40 years	890	37.1
	40-49 years	556	23.2
	50-59 years	446	18.6
	60-69 years	258	10.8
	≥70 years	250	10.4
Gender	Female	934	38.9
	Male	1466	61.1
COVID-19	Negative	1386	57.8
	Positive	1014	42.3
Parenchymal lung nodule	Negative	938	39.1
	<5 mm	880	36.7
	≥5 mm	582	24.3
Emphysema (+)		184	7.7
Mediastinal LAP (+)		260	10.8
Lung mass (+)		66	2.8
Air cyst (+)		60	2.5
Cavitary lesion (+)		6	0.3
Pleural plaque (+)		28	1.2
Pleural effusion (+)		138	5.8
Pericardial effusion (+)		48	2.0
Breast mass (+)		26	1.1
Axillary LAP (+)		26	1.1
Hepatosteatosis (+)		636	26.5
Liver mass (+)		220	9.2
Ascites (+)		14	0.6
Gallstones (+)		58	2.4
Adrenal mass (+)		134	5.6
Kidney mass (+)		196	8.2
Kidney stone (+)		96	4.0
Pancreatic mass (+)		10	0.4
Spleen mass (+)		10	0.4
Incidental findings	Negative	900	37.5
	Positive	1500	62.5
Total incidental findings	**Min-max (median)**	0-6 (1)	
	Mean ± SD	0.92±0.94	
	Negative	900	37.5
	1 finding	978	40.8
	2 findings	384	16.0
	≥3 findings	138	5.8

SD: Standard deviation, LAP: Lymphadenopathy, COVID-19: Coronavirus disease-2019, min: Minimum, max: Maximum

26.5% (n=636), liver mass in 9.2% (n=220), ascites in 0.6% (n=14), gallstones in 2.4% (n=58), adrenal mass in 5.6% (n=134), kidney mass in 8.2% (n=196), kidney stones in 4.0% (n=96), pancreatic mass in 0.4% (n=10), and spleen mass in 0.4% (n=10).

Incidental findings were not observed in 37.5% (n=900) of the patients, whereas they were observed in 62.5% (n=1500) of the patients. One incidental finding in 40.8% (n=978), two findings in 16.0% (n=384), and three or more findings in 5.8% (n=138) of the patients were determined (Table 2).

There was a statistically significant difference between the ages of the patients because of the presence of COVID-19 (p=0.001; p<0.05); the ages of COVID-19 cases were higher. There was no significant difference between the COVID-19 results by gender (p>0.05).

There was a statistically significant difference between the COVID-19 results of the cases in terms of parenchymal lung nodules (p=0.001; p<0.05). In CT examination, the rate of positive COVID-19 results among those with a nodule of 5 mm was higher than that of those with a parenchymal nodule of 5 mm (Figure 1).

COVID-19-positive rates did not differ statistically depending on findings such as emphysema, lung mass, cavitary lesion, pleural plaque, pleural effusion, pericardial effusion, breast mass, axillary LAP, hepatosteatosis, liver mass, ascites, gallbladder stone, adrenal mass, kidney mass, kidney stone, pancreatic mass, and spleen mass (p>0.05).

There was a statistically significant difference between the COVID-19 results of the patients in the presence of mediastial LAP (p=0.001; p<0.05); in cases with mediastinal LAP, the risk

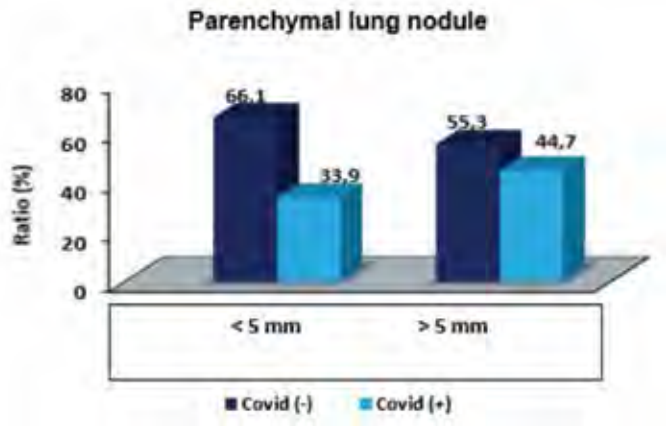

Figure 1. The rate of positive COVID-19 results of those who have a nodule of 5 mm and above was higher than those with a parenchymal nodule below 5 mm

COVID-19: Coronavirus disease-2019

Table 2. Assessments on COVID-19 presence				
		COVID-19		p
		Negative (n=1386)	Positive (n=1014)	
		n (%)	n (%)	
Age (years)	Min-max (median)	15-85 (43)	16-80 (47)	[a]0.001**
	Mean ± SD	45.25±15.59	48.49±15.03	
	<40 years	562 (63.1)	328 (36.9)	
	40-49 years	328 (59.0)	228 (41.0)	
	50-59 years	230 (51.6)	216 (48.4)	
	60-69 years	132 (51.2)	126 (48.8)	
	≥70 years	134 (53.6)	116 (46.4)	
Gender	Female	542 (58.0)	392 (42.0)	[b]0.875
	Male	844 (57.6)	622 (42.4)	
Parenchymal lung nodule	Negative	482 (51.4)	456 (48.6)	[b]0.001**
	<5 mm	582 (66.1)	298 (33.9)	
	≥5 mm	322 (55.3)	260 (44.7)	
Emphysema	Negative	1264 (57)	952 (43)	[b]0.084
	Positive	122 (66.3)	62 (33.7)	
Mediastinal LAP	Negative	1278 (59.7)	862 (40.3)	[b]0.001**
	Positive	108 (41.5)	152 (58.5)	
Lung mass	Negative	670 (57.4)	497 (42.6)	[b]0.159
	Positive	23 (69.7)	10 (30.3)	
Air cyst	Negative	1340 (57.3)	1000 (42.7)	[b]0.034*
	Positive	46 (76.7)	14 (23.3)	
Cavitary lesion	Negative	1384 (57.8)	1010 (42.2)	[c]0.577
	Positive	2 (33.3)	4 (66.7)	
Pleural plaque	Negative	1370 (57.8)	1002 (42.2)	[b]0.963
	Positive	32 (57.1)	12 (42.9)	
Pleural effusion	Negative	1310 (57.9)	952 (42.1)	[b]0.643
	Positive	76 (55.1)	62 (44.9)	
Pericardial effusion	Negative	1362 (57.9)	990 (42.1)	[b]0.437
	Positive	24 (50.0)	24 (50.0)	
Breast mass	Negative	1368 (57.6)	1006 (42.4)	[b]0.399
	Positive	18 (69.2)	8 (30.8)	
Axillary LAP	Negative	1370 (57.7)	1004 (42.3)	[b]0.781
	Positive	16 (61.5)	10 (38.5)	
Hepatosteatosis	Negative	1046 (59.3)	718 (40.7)	[b]0.071
	Positive	340 (53.5)	296 (46.5)	
Liver mass	Negative	1254 (57.5)	926 (42.5)	[b]0.616
	Positive	132 (60.0)	88 (40.0)	
Ascites	Negative	1380 (57.8)	1006 (42.2)	[c]0.464
	Positive	6 (42.9)	8 (57.1)	
Gallstones	Negative	1352 (57.7)	990 (42.3)	[b]0.923
	Positive	34 (58.6)	24 (41.4)	
Adrenal mass	Negative	1316 (58.1)	950 (41.9)	[b]0.347
	Positive	70 (52.2)	64 (47.8)	
Kidney mass	Negative	1276 (57.9)	928 (42.1)	[b]0.734
	Positive	110 (56.1)	86 (43.9)	
Kidney stone	Negative	1336 (58)	968 (42.0)	[b]0.417
	Positive	50 (52.1)	46 (47.9)	
Pancreatic mass	Negative	1378 (57.7)	1012 (42.3)	[c]0.404
	Positive	8 (80.0)	2 (20.0)	
Spleen mass	Negative	1378 (57.7)	1012 (42.3)	[c]0.404
	Positive	8 (80.0)	2 (20.0)	
Incidental findings	Negative	558 (62.0)	342 (38.0)	[b]0.021*
	Positive	828 (55.2)	672 (44.8)	

[a]Student t-test, [b]Pearson ki-kare test, [c]Fisher's exact test, *p<0.05, **p<0.01. SD: Standard deviation, LAP: Lymphadenopathy, COVID-19: Coronavirus disease-2019, min: Minimum, max: Maximum

of a positive COVID-19 result was 2.087 times higher. The odds ratio for mediastinal LAP was 2.087 [95% confidence interval (CI): 1.442-3.020] (Figure 2).

There was a statistically significant difference between the COVID-19 results of the cases based on the presence of air cysts ($p=0.034$; $p<0.05$); in cases without air cysts, the risk of a positive COVID-19 result was 2,452 times higher. The ODDS ratio for the air cyst was 2.452 (95% CI: 1.044-5.760).

There was a statistically significant difference between the COVID-19 results of the cases in the presence of incidental findings ($p=0.021$; $p<0.05$) (Figure 3); in cases with incidental findings, the risk of the COVID-19 result being positive was 1,324 times greater. The ODDS ratio for incidental findings was 1.324 (95% CI: 1.043-1.681). There was no statistically significant difference between the COVID-19 results and the number of incidental findings ($p>0.05$).

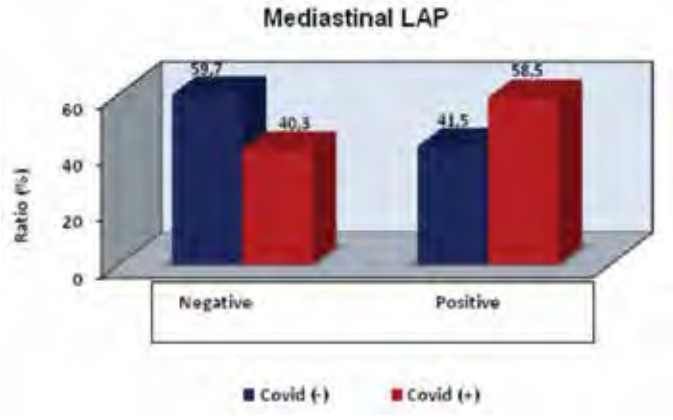

Figure 2. The risk of positive COVID-19 result was higher in cases with mediastinal LAP

LAP: Lymphadenopathy, COVID-19: Coronavirus disease-2019

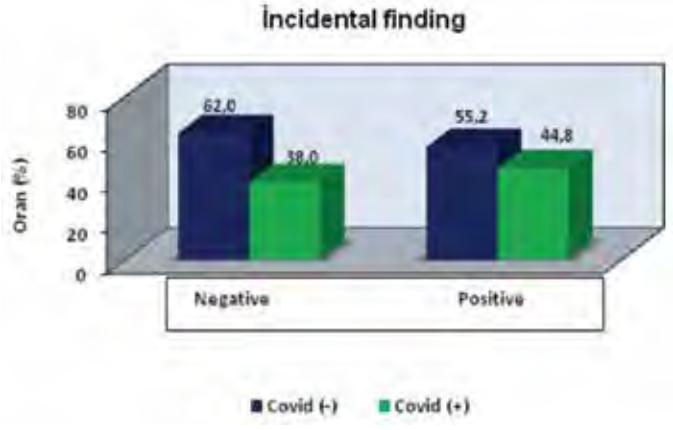

Figure 3. By the presence of incidental findings, there was a statistically significant difference between the COVID-19 results of the cases

COVID-19: Coronavirus disease-2019

DISCUSSION

In this study, we found that paraenchymal lung nodules smaller than 5 mm were the most common incidental finding in CT images, whether or not COVID-19 pneumonia was positive. Second, hepatosteatosis was the most common finding detected.

Under normal conditions, thoracic CT was not performed frequently; however, it was used as a screening method to determine whether there was COVID-19 pneumonia during the pandemic period. The detection of primary masses in patients has been based on the use of thoracic CT as a screening method during the pandemic period.

Chest X-ray examination has been indicated to have a lower susceptibility than chest CT examination, with CT having 93% sensitivity (11).

Kanesa-Thasan et al. (12) noticed that in 20.8% of patients with verified strokes who underwent computed tomography angiography (CTA) examination, incidental findings in the lung apices were present. Kihira et al. (13) confirmed that 37.5% of patients with verified stroke and 28% of all patients who had stroke had findings in the lung apex on CTA related to COVID-19 compatible with reverse transcription-PCR findings. They suggest that these findings can be the only sign of a patient's COVID-19 involvement during the first assessment of stroke patients, whereas other procedures take a long time to give results. Besides CTA imaging being the first modality used in the evaluation of suspected stroke patients, PCR has low trustworthiness and sensitivity.

Vuagnat et al. (14) showed that patients with breast cancer have the same imaging and clinical characteristics as a normal population. They also share the same risk factors (14). Hossain et al. (15) evaluated pulmonary findings of COVID-19 on non-chest CT images of patients with abdominal or neurological symptoms and emphasized the significance of assessing both lung aces or bases as findings may indicate COVID-19 pneumonia. Early diagnosis in these patients enables rapid treatment while helping management be performed correctly (15).

There have been several studies on COVID-19 patients presenting with GI symptoms. Gu et al. (16) reported that patients' symptoms presented proportionally with anorexia, vomiting, diarrhea, and abdominal pain.

Some patients have active colitis, which may be due to COVID-19-induced intestinal inflammation. The findings are similar to those of other viral, bacterial, and fungal infections, including mesenteric hypervascularity, mural hyperenhancement, circumferential wall thickening, and pericolic fat stranding (17).

A meta-analysis performed by Wang et al. (18) revealed that there was no correlation between malignancy, liver or renal disease, and COVID-19 aggravation. They concluded that cardiovascular and cerebrovascular disease, hypertension, and diabetes are increased risk factors for COVID-19 patients. Knowledge of these factors may be useful for clinicians to carry out suitable medical management of COVID-19 patients (18).

In older patients, the COVID-19 positivity rate was higher in our study. We also found that the risk of positive COVID-19 results was higher in the presence of incidental findings, regardless of their number. Furthermore, incidental findings such as mediastinal LAP, air cyst, and size above 5 mm of parenchymal lung nodule were higher in patients whose COVID-19 results were positive. To the best of our knowledge, a comparative study similar to our own has explored incidental findings in the form of intraparenchymal and extraparenchymal anomalies (19). The study revealed that the incidence of extraparenchymal incidental findings, such as LAP, breast lesions, thyroid nodules, bone, liver, and kidney lesions, was greater than that of parenchymal incidental findings, including primary malignant lung lesions, metastatic lesions, and benign pathologies, in contrast to our research. They found air cysts in one patient (0.06%), solitary pulmonary nodules in eight patients (0.52%), and mediastinal LAP in 48 patients (3.12%).

Radiologists must have a high degree of suspicion when assessing the lungs on chest CT examination for incidental findings in patients with suspected COVID-19. In our country, many thoracic CT images are taken daily, and they need to be reported quickly due to patient excess and for their treatment management to be done correctly. Therefore, clinicians and radiologists may omit other important findings, especially those that can be seen in abdominal images, including the examination area. In particular, early detection of lung or other organ masses in CT images helps the treatment and management of patients be done rapidly, and they may have a considerably better prognosis.

CONCLUSION

In conclusion, we demonstrated that clinicians and radiologists should be careful in terms of incidental findings when evaluating an examination to determine whether there is COVID-19 involvement. If adequate care is not taken during the assessment, important findings that can save the patient's life may be missed.

Ethics

Ethics Committee Approval: This study received approval from the Human Subjects, University of Health Sciences Turkey, Bakirköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (approval no: 2022-08-05, date: 18.04.2022).

Informed Consent: Written consent was obtained from all patients.

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: Ö.Y., E.H., Ö.P., G.T.A., Concept: M.O.N., E.H., E.İ., Design: M.O.N., Ö.Y., E.H., G.T.A., Data Collection or Processing: M.O.N., Ö.P., Analysis or Interpretation: M.O.N., E.İ., Literature Search: Ö.Y., E.İ., Ö.P., G.T.A., Writing: M.O.N., Ö.Y.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.85619
Eur Arch Med Res 2023;39(3):171-178

Long-term Results of Single-stage Minimally Invasive Surgery of Pilon Fractures

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Abstract

Objective: The purpose of this study was to assess the technical specifications and long-term results of "early minimally invasive surgery" that we have been implementing on AO 43-C3 pilon fractures.

Methods: Twelve patients with AO 43-C3 closed fracture were operated within the first 36 h of trauma with the goal of providing definitive treatment. After consideration of the associated fibular fracture, tibial articular surface was fixed with anatomical reduction and rigidly percutaneously. Subcutaneous anatomical medial plating was applied to provide relative stability between articular block and the comminuted metaphyso-diaphyseal part.

Results: The average age was 50 (range: 36-62) years. The average time between trauma and surgery was 18 (range: 6-36) hours. The average follow-up period was 60 (range: 24-78) months. There were no wound problems or infections. The reduction quality was excellent in 7 patients and good in 5 patients. Clinical results were excellent for 4 and good for 8 patients. Stage 1 arthrosis was observed in 4, stage 2 in 6, and stage 3 arthrosis in 2 patients.

Conclusion: Single-stage minimally invasive plating of AO 43-C3 pilon fractures may result in a satisfactory functional score in the long term because of the quality of joint reduction and the effect of the energy load of the trauma, which is important for the development of arthrosis.

Keywords: Pilon, mipo, tibia, fracture

INTRODUCTION

The treatment of pilon fractures presents technical challenges, and clinical results may remain below expectations. The intensity of the energy causing the trauma and its impact on the extremity determines the fracture type and the damage inflicted on the soft tissue (1,2). Treatment choice is dependent on the soft tissue condition and the type of the fracture, which also affect results. Infections and soft tissue coverage problems have been observed on single-stage open fracture restoration attempts (2,3). With the development of staged operative reduction and internal fixation techniques, infection and soft tissue problems have decreased remarkably (1,4).

With the development of low-profile plates and the use of indirect reduction techniques, staged open surgeries have evolved into staged minimally invasive surgery (5,6). Unfortunately, delayed definitive reduction and fixation frequently results in challenged reduction due to fibrosis between fragments (7).

Considering the easier reduction of fractured fragments at an early stage, which reduces the pressure created by displaced fragments and thus prevents soft tissue coverage issues, we examined the technical specifications and long-term effects of "early minimally invasive surgery" that we have been implementing on AO 43-C3 pilon fractures.

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Cite this article as: Bekmezci T, Demir T. Long-term Results of Single-stage Minimally Invasive Surgery of Pilon Fractures. Eur Arch Med Res 2023;39(3):171-178

Received: 31.05.2023
Accepted: 07.08.2023

Methods

The study was conducted with the permission of the Ümraniye Training and Research Hospital Clinical Research Ethics Committee (date: 15/05/2023, decision no: E-54 132726-000-215611251). The authors read the Helsinki Declaration and approved ethical obligations for the study. Informed consent was obtained from all patients. Closed AO 43-C3 fractures were included in the study, which were treated by minimally invasive medial plating within 36 hours of trauma. Open fractures, AO 43-A/B/C1/C2 fractures and staged surgeries were excluded. Twelve patients with AO 43-C3 closed-fracture were operated within the first 36 h of trauma with the goal of providing definitive treatment. Fibular fracture was in eight (66.6%) patients. Anteroposterior and lateral radiographs were taken from patients during submission to the clinic. A computed tomography (CT) scan of the ankle was provided for the preoperative evaluation of comminution.

Surgical Technique

1. The positioning of the patient is crucial for obtaining high-quality fluoroscopic images. During surgery, maintaining the extremity in a neutral position is crucial for preventing the loss of the achieved temporary reduction. The patients were operated under general anesthesia in the supine position. With the help of a slim pillow placed under the ipsilateral hip, external rotation of the extremity was prevented. The relevant limb was supported and elevated with the help of a hard pillow, extending from the popliteal region to the heel. Using this method, we aimed to obtain fixed angles for the anteroposterior and lateral fluoroscopic views.

2. Achieving reduction of the lateral malleolus and ensuring proper fibula length are essential for achieving the anatomical reduction of the distal tibial articular surface. To ensure the fibular length, we first applied fibular fracture reduction and fixation. Anatomic correction was provided in simple transverse fibular fractures using a percutaneous Rush pin on one patient. Two simple oblique and five comminuted fibular fractures were fixed using the bridge-plating method based on relative equilibrium principles with the help of 1/3 tubular plates (Synthes-Oberdorf) (1,8). The plates were applied through posterolateral double mini-incision. Anteroposterior and lateral fluoroscopic images were obtained for alignment control.

3. Joint distraction facilitates the manipulation of articular fragments. Therefore, unilateral external fixation was applied for indirect reduction of fractured segments on the surface of the distal tibial joint under distraction. The tibial joint was distracted by inserting 6 mm Schanz screws, 2 to 1/3 proximal tibia, 1 each to the medial part of the neck of the talus and calcaneous. Distraction performed using a unilateral external fixator from the medial side can lead to overalgization. This situation not only complicates the control of particular fragments but also subjects the identified fibula fracture to excessive loading, resulting in potential reduction loss.

4. Distal tibial articular fractures consist of three main components: the medial malleolus, Chaput fragment, and Volkmann fragment. In addition, depending on the severity of impaction, a die punch fragment can also be present (9). The Chaput fragment is a good starting point for achieving anatomical restoration of the articular surface through the length restoration of the lateral malleolus and posterior tibiofibular ligamentotaxis. The posterior part of the joint was used as the starting point for the anatomical reduction. The second important part of the joint defined as the die punch (9), which extends from the plafond center and wedges to the metaphysis, was pushed toward the joint with the help of a blunt K-wire or a thin elevator inserted in the cephalo-caudal direction. Before reducing the medial malleolus and Volkmann fragments, it is important to control the alignment of the die punch fragment with the Chaput fragment. The die punch fragment should be pushed craniocaudally using a K-wire or a thin periosteal elevator to align it with the articular surface of the Chaput fragment at the same level (Figure 1). It is crucial to lower the die punch fragment to the joint level before fixing the Volkmann and medial malleolus fragments; otherwise, compressed joint surfaces may hinder the reduction process.

5. Anterolateral, anterior, and medial fragments were reduced with the help of the K-wire joystick technique and were temporarily fixated to the posterior joint fragment with the same K-wires. Medial malleolus and Volkmann fragments were reduced with the help of the K-wire joystick technique and were temporarily fixated to the Chaput fragment with the same K-wires. At this stage, it is necessary for the Chaput and Volkman fragments to be steplessly reduced in the coronal plane and the medial malleolus and lateral joint line to be steplessly reduced in the sagittal plane. Fluoroscopic imaging was used to determine the various displacements and steps that might occur in the joint. Using frontal and sagittal fluoroscopic images, the compatibility of the tibial joint surface with the joint surface of the Talus and its anatomical fixation was targeted. Two safe screw zones were used for the fixation of the basic joint components. The first safe zone is reached by penetrating from the lateral of the extensor digitorum longus tendon and is used for fixation of the anterior or anterolateral fragment to the posterior or postomedial

part. The second safe zone is reached by penetration through the medial tibialis anterior tendon and targets the fixation of the anteromedial or medial fragment to the posterior or posterolateral part. Absolute stability was provided by the use of 4.0 mm cannulated screws sent via guidewires at safe intervals percutaneously (Figure 2).

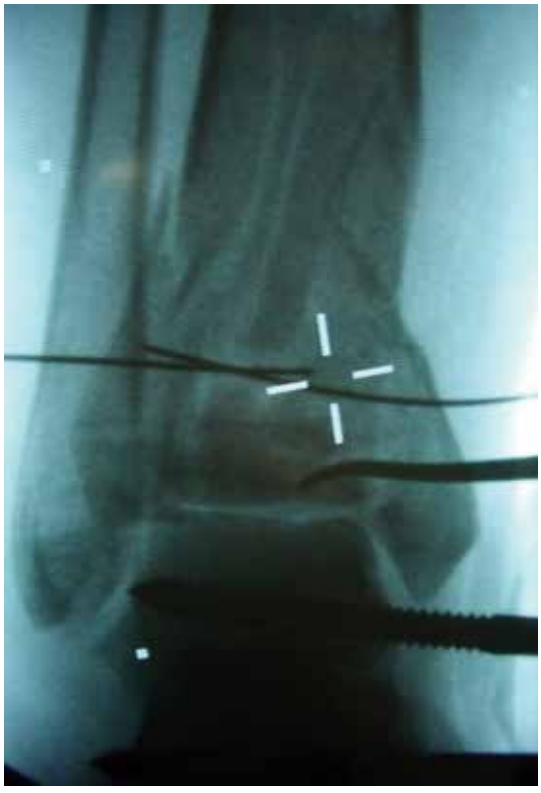

Figure 1. Die punch fragment reduction

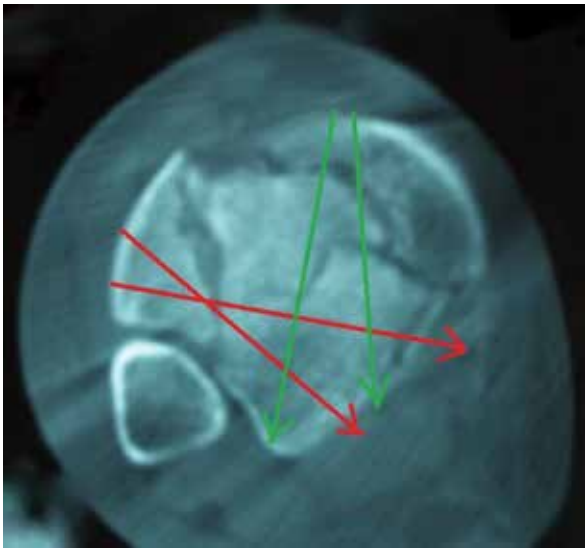

Figure 2. Axial plan, the configuration of safe-corridors for the identification of basic parts fragments. Red arrows show the anterolateral entry, the green arrows the anteromedial entry

6. The joint united by absolute equilibrium was fixed to the metaphyseal-diaphyseal section by the relative stability principle. After the fragments belonging to the joint are brought together using the lag screw technique with cannulated screws to achieve absolute stability, the next step is to proceed with the relative stabilization and fixation of the joint block with the metaphyseal-diaphyseal component (10). For this fixation, a distal medial tibial metaphyseal locking compression plate 3.5/4.4.5/5 (Synthes-Oberdorf) was applied by a subcutaneous tunnel created from a mini-incision to the medial crural region. Around the incision created over the medial malleolus, the saphenous vein and nerve are present. Proper dissection of this area and precise formation of the tunnel path for proximal subcutaneous advancement of the plate over the bone will help prevent complications such as skin compression and injury to the vein or nerve. The length of the plate was calculated as the sum of the joint unit, the metaphyseal fracture length, and the length of 5 or 6 holes over the metaphyseal fracture zone. The joint unit block was stabilized with 3.5 mm cortical or locked screws, and the diaphraseal portion was stabilized with 4.5 mm cortical and 5.0 mm locked screws (Figures 3, 4).

Postoperative Follow

An external fixator was kept in place for 10 days on our first two patients during the postoperative period to control pain and

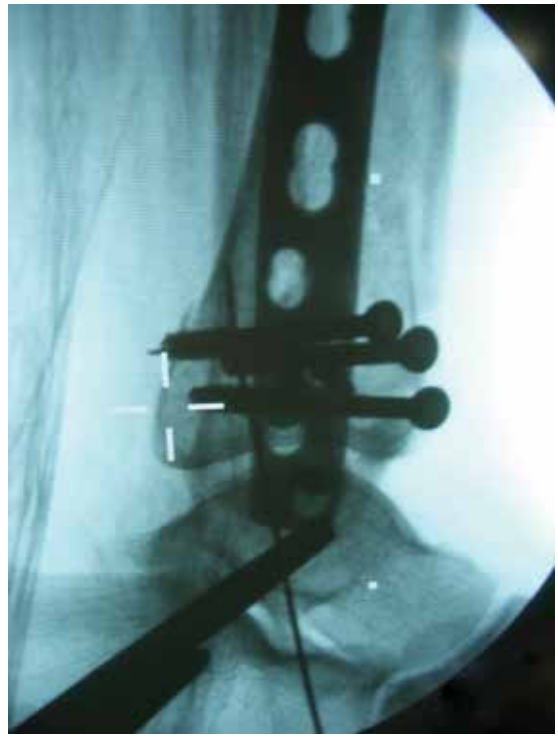

Figure 3. Fracture fixation under distraction with the external fixator. Lateral image under flouroscopy

swelling. We eliminated the use of an external fixator in our next cases and preferred to use short-leg splints instead. At the end of the second week, we removed the external fixators or splints. Active range motion of the ankle was permitted. Anti-edema stockings were applied. Toe-tip contact (not weight bearing) was permitted from the end of the second week until the end of the sixth week. From the sixth week to the 12th week, weight bearing was increased on a weekly basis as tolerated. Full weight bearing was allowed starting from week 12th single crutch use was permitted 4 weeks more according to patient confidence.

Data Collection

Anteroposterior and lateral radiographs of patients were evaluated at weeks 3-6 and at their final visits. The Teeny and Wiss (2) scoring system was used for clinical evaluation. We used Conroy et al. (11) criteria for evaluating the quality of fixation. According to these criteria; less than 2 mm separation on joint regularity and angulations below 5 degrees on the sagittal and coronal planes are considered as excellent results; 2-5 mm separation or 5-10 degree angulations are considered as good results and separations above 5 mm or angulations over 10 degree angulations are considered as poor results. Radiological arthrosis was assessed, and regular joint or subchondral sclerosis was considered as stage 0, whereas the presence of osteophytes without joint narrowing was considered as stage 1, joint narrowing without the presence of osteophytes as stage 2, and complete narrowing of the joint or total deformation was classified as stage 3.

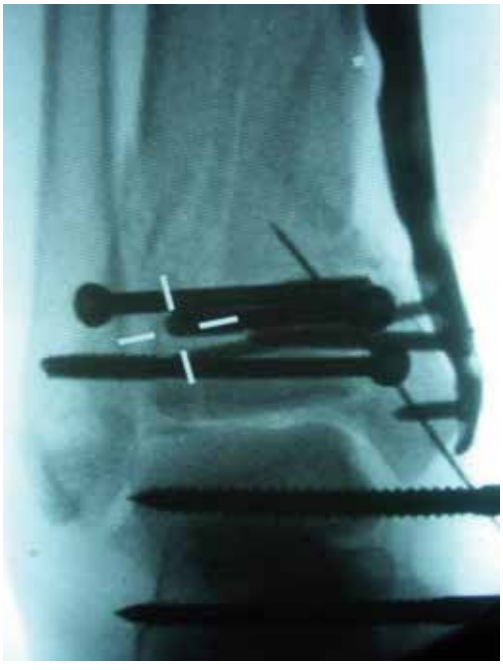

Figure 4. Fracture fixation under distraction with the external fixator. Anteroposterior image under flouroscopy

Statistical Analysis

The study is defined as level 4/case series, and power analysis or size sampling was not performed. Variables (Correction Quality, Radiological Arthrosis, Clinical Score and Fibula Fracture Type) were categorical data and sample size was less than 30. Normality tests were not performed because variables were categorical data. The relationship between the categorical variables was assessed with the chi-square test (non-parametric test). Results and statistical values were obtained using MedCalc (MedCalc Software Belgium 1993-2016).

RESULTS

Twelve patients (three female 25% and nine male 75%) with AO 43-C3 closed fracture were operated with the referred surgical technique. The average age was 50 (range: 36-62) years. Four patients had left (33.3%), eight patients had right (66.6%) pilon fractures. Six patients (50%) were admitted because of traffic accidents and six (50%) were admitted with injuries sustained from fall. Eight patients were diagnosed with fibula fracture (66.6%) (five comminuted 41.6%- three simple 25% fractures). The average time between trauma and surgery was 18 (range: 6-38) hours. The average follow-up period was 60 (range: 24-78) months (Table 1). No suture insufficiency was observed in the trauma area during the follow-up period. Soft tissue edema was recorded in all patients who were managed by elevation of the leg after surgery. No superficial or deep tissue infections were observed. The fixation quality according to Conroy et al. (11) was excellent in seven patients (58.3%) and the results in five patients (41.6%) were determined as a good. According to Teeny and Wiss (2) clinical scoring; the results obtained were rated excellent for four (33.3%) and good for eight (66.6%) patients. However, stage 1 arthrosis was observed on four patients (33.3%), stage 2 on six (50%) and stage 3 arthrosis was observed on two (16.6%) patients (Figures 5, 6).

The correction quality on four (33.3%) patients without fibula fracture was scored as excellent, the clinical scoring as excellent, and stage 1 arthrosis was observed on final follow-up. In three (25%) patients with simple fibula fracture, although the correction quality was scored as excellent, the clinical scores were rated good, and the development of stage 2 arthrosis was observed on final follow-up. In five (41.6%) patients with comminuted fibula fracture, the correction quality was scored as well as the clinical scores. On the follow-up radiographs, the existence of stage 2 arthrosis in three (25%) patients and stage 3 arthrosis in two (16.6) patients were diagnosed (Figure 7). Regarding the chi-square test, the relationship between correction quality and

fibula fracture, the relationship between clinical score and fibula fracture, and the relationship between arthrosis and fibula fracture were significant ($p<0.05$). On the other hand, correction quality was not related to clinical score and arthrosis (Table 2).

DISCUSSION

Minimally invasive osteosynthesis offers various benefits. Minimal invasive osteosynthesis preserves the vascular circulation of the bone, leading to fewer refractures, non-unions, grafting requirements, and lower infection rates compared with conventional open surgery (12). Early-stage minimally invasive surgery was performed with the aim of avoiding soft tissue problems by preventing progressive edema of the soft tissues. In high-energy injuries, early bone fixation decreases postoperativeinfection and pain by increasing blood flow and venous return of the limb (13). In addition, with the application of percutaneous screws, indirect reduction maneuvers, and the application of low profile plates from small incisions, the skin problems have been significantly significantly (14). There were no soft tissue complications observed in patients during follow-up. No superficial or deep tissue infection was observed.

The reshaping of the articular surface with percutaneous screws is possible only by a good understanding of the bone stock of the pieces creating the joint surface and by determining the direction and distance of the separation. For this purpose, CT is recommended (6,9). CT findings not only provide detailed information about the fracture fragments but also offer insights into reduction and fixation options (15). The orientation and entry points of the lag screws to be applied on the basic joint parts were determined by working on CT sections. The fixation of the joint fragments was accomplished by sticking to the predicted screwing angles prior to surgery. Distraction to mobilize the joint

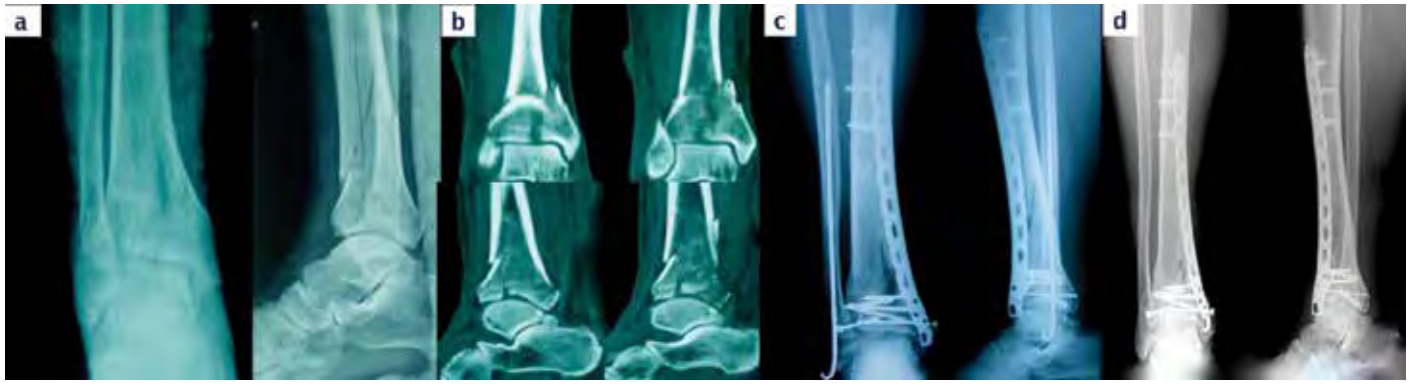

Figure 5. Case 1; preoperative AP-lateral radiographs (a), sagittal coronal CT scan (b), early postoperative (c) and 48th month radiographs are shown (d). Despite the development of stage 2 arthrosis, the result is one of the best with a 90 points Teeny & Wiss score

AP: Anterior posterior, CT: Computed tomography

Table 1. Demographic characteristics were listed on table			
Sex	**3 female (25%)**	**9 male (75%)**	
Age	50	SD: 6.55	Range: 36-62
Side	4 left (33.3%)	8 right (66.6%)	
Trauma	6 MVA (50%)	6 fall from height (50%)	
Fibula fracture	4 non (33.3%)	3 simple (25%)	5 comminuted (41.6%)
Trauma-surgery	Mean: 18 hours	SD: 10.39	Range: 6-38 hours
Follow	Mean: 60 months	SD: 14.35	Range: 24-78 months
SD: Standard deviation			

Table 2. Chi-square test results of the variables of the study. Existence and type of the fibula fracture was statistically significant regarding to correction quality, clinical score and arthrosis		
	Fibula fracture	**Correction quality**
Correction quality	p=0.0025	-
Clinical score	p=0.0025	p=0.1473
Arthrosis	p=0.0061	p=0.0542

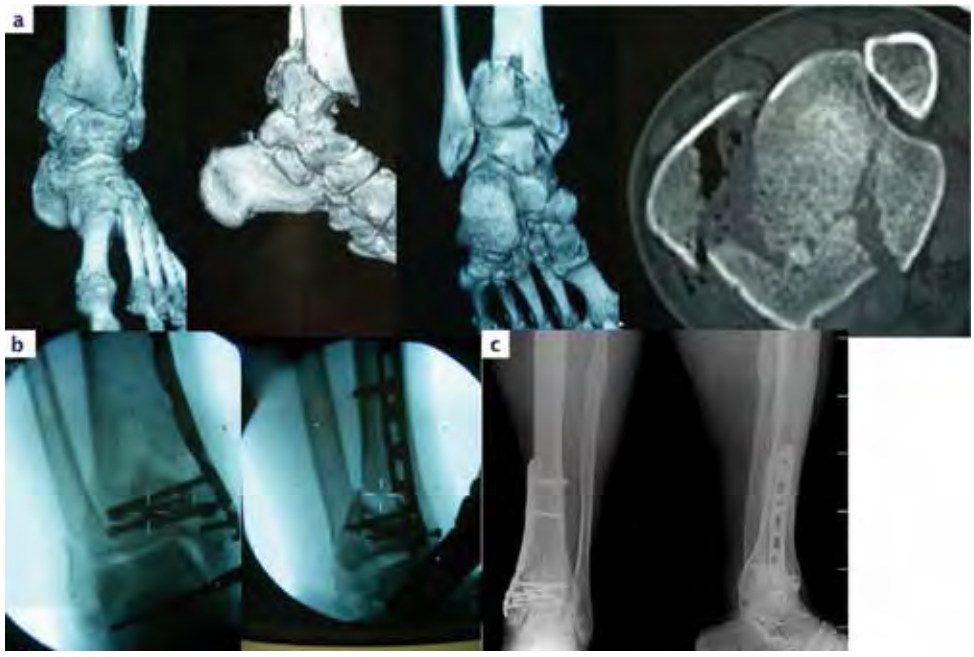

Figure 6. Case 2; preoperative 3D and axial CT scans (a), fluoroscopy images during the surgery (b) and 78th month follow-up radiographs are shown (c). Despite the development of stage 2 arthrosis, it is one of the excellent results with 97 points Teeny & Wiss score

CT: Computed tomography

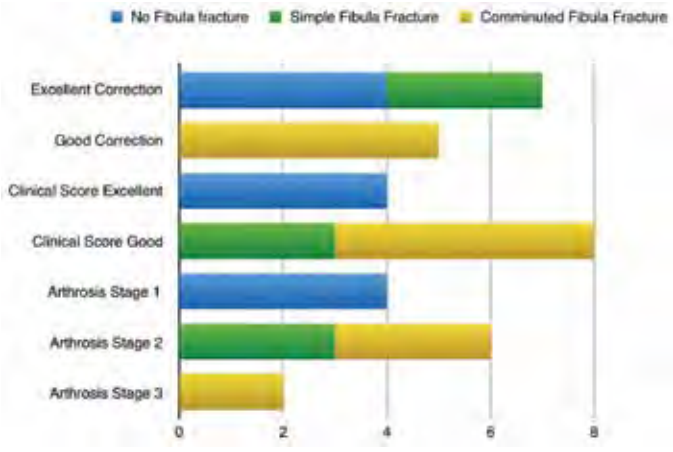

Figure 7. Distribution of the fixation quality, clinical score and radiological score according to fibular fracture

fragments was achieved by an external fixator. We observed that the medial implementation of the unilateral external fixator caused separation of the medial parts significantly more than the lateral parts. As prolonged use of an external fixator causes restriction of ankle motion, we avoided the use of a fixator during the postoperative stage (5).

For articular surface reduction, the goal is to achieve a step-off of less than 2 mm and an angulation of less than 5 degrees in both coronal and sagittal planes, as specified in the Conroy et al. (11) criteria. For reduction between the joint block and the metaphyseal-diaphyseal component, the goal is to achieve less than 5 degrees of varus, less than 10 degrees of valgus, and less than 10 degrees of sagittal plane deformity, as defined by Helfet et al. (16). The good correction was achieved in five (41.6%) patients according to Conroy et al. (11). These patients had comminuted fibula fractures and were subjected to a minimally invasive fibula fixation process. During the minimally invasive fibula surgery conducted on these cases, in which the length off the fibula was not fully restored, we observed anterior angulation off the posterior tibial joint fragment and stepping off the joint line due to relative shortening off the lateral column. The clinical scores of these patients were good. However, in the long-term radiological follow-up, we found stage 2 arthrosis in three (25%) patients and stage 3 arthrosis in two (16.6%).

Minimally invasive fibula fixation is recommended as long as the sagittal and coronal alignment of the fracture and the length of the fibula can be restored (1,8). Sagittal and coronal alignment can be achieved with fluoroscopic control. However, restoring the fibular length and its fixation with a minimally invasive procedure is not yet very clear. Evaluating the relationship between the tibial plafond and the subchondral ends of the lateral malleolus with the Mortise view or comparing the joint distance of the tibiotalar to talofibular joint are some of the methods used for fibular length control (13). However, it does not seems possible to make a healthy assessment of fibular length on pilon fractures where a fractured tibial plafond cannot be accepted as a landmark.

Assessing the fibular length by controlling the talocrural angle seems to be more useful. In any case, the anatomic alignment of the fibula fractures plays an important role in pilon surgery, and it is obvious that any alignment errors that might occur on fibula fixation will indirectly cause reduction errors of the tibial joint surface (1,3,17). Under these circumstances, we avoid insisting on minimally invasive fixation processes of fibula fractures when fibular length cannot be assessed radiologically.

According to Conroy et al. (11), the diagnostic quality scoring on seven (58.3%) patients was excellent, and the clinical scores for four of these patients were excellent whereas the scores for the remaining three (25%) patients were good. However, stage 1 arthrosis was present in four (33.3%) patients and stage 2 in three (25%) patients. These patients did not show any sign of alignment errors or stepping over 2 mm on the joint line that might have led to the development of arthrosis. The development of radiological arthrosis is associated with fracture fixation and the severity of the injury (18). In early open, staged open, and early minimally invasive series, the development of arthrosis in AO 43-C3 or Rudi type 3 cases, despite their excellent reduction quality, is higher than that in lower classified fractures (2,3,5,6). The post-traumatic occurrence of osteoarthritis on joints is directly related to the energy flow that the articular surface suffered at the time of the trauma and the shear forces that affectthe joint during the chronic phase. Non-anatomical correction of the articular surface causes chronic shear forces. This leads to an increase in the free oxygen radical volume, which in return leads to chondrocyte death (19). However, the same molecular changes and chondrocyte cell death also occur with the sudden energy charge that occurs at the same time as the trauma (20). Therefore, the possibility of developing arthrosis at an early stage increases with the higher energy level of the trauma (21).

High-energy injuries can lead to high-grade comminuted fractures, soft tissue damage that can create a coverage defect, and even vascular injuries, which delineate the boundaries of minimally invasive plate-screw osteosynthesis (22). Similarly, despite the encouraging results of minimally invasive plate osteosynthesis in pilon fractures, statistically significant differences can be observed in terms of functional scores and healing time when comparing AO 43-C fractures with AO 43-B and A fractures (23). High-grade comminuted fractures are challenging cases for the indirect closed reduction. Abdelgaid et al. (15) reported that in 7.69% of their case series, they could not achieve the closed reduction and resorted to open reduction.

There were no soft tissue complications observed in patients during follow-up. No superficial or deep tissue infection was observed. Although MIPO poses little or no damage to soft tissue, there are some challenges associated with the use of minimally invasive medial plate osteosynthesis in pilon fractures, including skin impingement, malunion, delayed union and intraoperative saphenous nerve, and vein injury (22-25).

CONCLUSION

We find the study to be meaningful on the basis that it covers the long-term follow-up results of a surgical method getting widespread in practice, which is performed only for AO 43-C3 fractures. We anticipate thatroviding anatomic reduction of the joint surface, early-stage minimally invasive plating of AO 43-C3 pilon fractures will help achieve satisfactory results and avoid soft tissue problems. The quality of the joint reduction and the effect of the energy load of the trauma bear great importance on the development of arthrosis. In addition, the importance of evaluating the joint fragments preoperatively and the need for a learning curve for correction techniques with the joystick method should be kept in mind.

Ethics

Ethics Committee Approval: The study was conducted with the permission of the Ümraniye Training and Research Hospital Clinical Research Ethics Committee (date: 15/05/2023, decision no: E-54 132726-000-215611251). The authors read the Helsinki Declaration and approved ethical obligations for the study.

Informed Consent: Informed consent was obtained from all patients.

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: T.B., Concept: T.B., Design: T.B., Data Collection or Processing: T.B., T.D., Analysis or Interpretation: T.B., T.D., Literature Search: T.B., T.D., Writing: T.B., T.D.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.56833
Eur Arch Med Res 2023;39(3):179-182

ECMO Use in Postcardiotomy Syndrome: A Single Center Experince

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Abstract

Objective: Extracorporeal membrane oxygenation (ECMO) is used as a life support system in patients with either cardiac or respiratory failure. The aim of our study was to evaluate our experience with ECMO used for cardiac support in patients with postcardiotomy syndrome (cardiogenic shock) at our center.

Methods: Fifty patients treated with ECMO with cardiac failure either in the intensive care unit or operative room due to failure to wean from cardiopulmonary by-pass were retrospectively inspected. Demographic data, ECMO protocols, and clinical follow-up data were collected and reviewed.

Results: All patients received venoarterial (VA) ECMO because of cardiogenic shock. The mean duration of ECMO was 3.7±3.4 days. The survival rate for ECMO and the survival rate to discharge were 72%. The overall cardiogenic shock mortality rate for ECMO was 28%.

Conclusion: ECMO use in patients with cardiogenic shock (postcardiotomy syndrome) is associated with high mortality. According to our data, VA ECMO may be a beneficial mechanical assist device in short-term for patients with cardiogenic shock with an acceptable weaning rate. The success rate of ECMO may depend on the time of initiation and duration of use.

Keywords: Extracorporeal membrane oxygenation, cardiogenic shock, mortality

INTRODUCTION

Cardiogenic shock is primarily associated with increased mortality and poor outcomes. The progression of cardiogenic shock due to multiple factors causing fatal cardiac dysfunction occurs when medical therapy fails to restore the hemodynamic state (1). Mechanical circulatory support (MCS) may be required to restore cardiac function at this point. Veno arterial extracorporeal membrane oxygenation (VA-ECMO) is a useful tool for patients with severe cardiogenic dysfunction (2). The study presented the outcomes of VA-ECMO use and evaluate early mortality in patients with perioperative cardiogenic shock at our center.

METHODS

Our study was approved by the Ethics Committee of University of Health Sciences Turkey, Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital (date: 18.05.2023/decision no: 2023-06). Because our study design was a retrospective review of prospectively collected data, the need for informed consent was waived. Between February 2014 and January 2019, 50 consecutive patients with VA-ECMO use due to perioperative cardiogenic shock (postcardiotomy) were identified and included in our retrospective study. ECMO was administered to patients who failed to wean from cardiopulmonary by-pass

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Received: 02.07.2023
Accepted: 07.08.2023

Cite this article as: Bayram M, Kyaruzi M. ECMO Use in Postcardiotomy Syndrome: A Single Center Experince. Eur Arch Med Res 2023;39(3):179-182

(CBP) or to patients with perioperative cardiogenic shock in the intensive care unit (ICU) with no response to inotropic support or intraortic balloon pump. Patients who failed to wean from CBP had VA-ECMO implanted through the central cannulas. Peripheral VA-ECMO was implanted via groin vessels using the percutaneous Seldinger technique.

Ecmo Protocol

The VA-ECMO initiation and weaning protocol at our institution are the same strategies applied by many other centers around the world. The anticoagulant protocol during VA-ECMO at our institution was performed with intravenous infusion of heparin targeting ACT of 180 to 200 s and aPTT between 60 and 80 s to overcome thromboembolic events. VA-ECMO flows were regulated by keeping the mean pressure above 50 mmHg and mixed oxygen concentration above 60%. Hemoglobin level was maintained above 7 g/L and platelet count was maintained above 50,000 cells/mm^3. Weaning from ECMO was considered at least 72 h from initiation after restoring cardiac functions were evaluated from echocardiogram and clinical hemodynamic parameters. A left ventricular ejection fraction of above 20% at a flow of 2 L/min with stable hemodynamic functions was considered to be an indicator of myocardial recovery. ECMO was terminated because of detorerating myocardial dysfunction and multiorgan dysfunction (mainly unresolved renal and hepatic dysfunction).

Variables

The analysis was performed using our institutional patient database. The variables included: baseline characteristics [patient demographics (age, sex, body mass index, ejection fraction]), presence of diabetes, hypertension, chronic renal insufficiency, pulmonary hypertension, chronic obstructive pulmonary disease, need for vasoactive drugs and preoperative mechanical ventilation, place of VA-ECMO implantation (operating room/intensive care unit), localization of VA-ECMO cannulas (central/peripheral), and outcome data after ECMO use (ECMO duration, ECMO weaning, length of hospital stay and early mortality).

Endpoints of the Study

The primary endpoint of our study was early outcome survival and 30-day mortality after initiation of VA-ECMO support. The mortality rate was observed to be 28%. Cardiac stabilization could not be maintained in 8% of patients who developed fetal arrhythmia and unresolvable cardiogenic shock during VA-ECMO. Eight percent of these patients developed disseminated intravascular coagulopathy. Sepsis and hemorrhagic complications developed in 8% and 4% respectively.

RESULTS

Our study consisted of 50 patients who were retrospectively reviewed. All patients received VA-ECMO either in the ICU (50%) or the operative room (50%). The baseline characteristics are summarized in Table 1. The mean age of our patients was 54.8±14.9 years. ECMO characteristics are summarized in Table 2. The mean duration of ECMO was 3.7±3.4 days. The survival rate for ECMO and the survival rate to discharge were 72%. The mortality rate for ECMO was 28%. Outcomes of ECMO use are summarized in Table 3.

DISCUSSION

Our study presents a single-center experience with patients who had received VA-ECMO support as a result of cardiogenic shock leading from failure to wean from CPB or postoperative acute cardiac dysfunction. Most patients with severe cardiogenic shock with no response to medical therapy are widely treated with transient MCS, which includes ventricular assist devices as well as VA-ECMO (3).

Table 1. Baseline characteristics of the study group

Age, years	54.8±14.9
Gender; Male, n (%) Female, n (%)	15 35
Body mass index, mean ± SD	25.2±4.7
Ejection fraction, mean ± SD (%)	52.4±8.7
Diabetes mellitus, n (%)	13 (26.0%)
Hypertension, n (%)	16 (32.0%)
Chronic renal insufficiency, n (%)	2 (4.0%)
Pulmonary hypertension, n (%)	1 (2.0%)
Chronic obstructive pulmonary disease, n (%)	14 (28.0%)
Need for vasoactive drugs, n (%)	5 (10.0%)
Preoperative mechanical ventilation	1 (2.0%)

SD: Standard deviation

Table 2. ECMO characteristics data

Neuroadrenaline dosage, mcg/kg/min	0.8
Adrenalin dosage, mcg/kg/min	0.5
Hemoglobin, g/dL	12.4±2.5
Place of ECMO implantation • Operatic room, n (%) • Intensive care unit, n (%)	 50% 50%
Localization of the ECMO cannulas • Central, n (%) • Peripheral, n (%)	 50% 50%
ECMO duration, n (days)	3.7±3.4

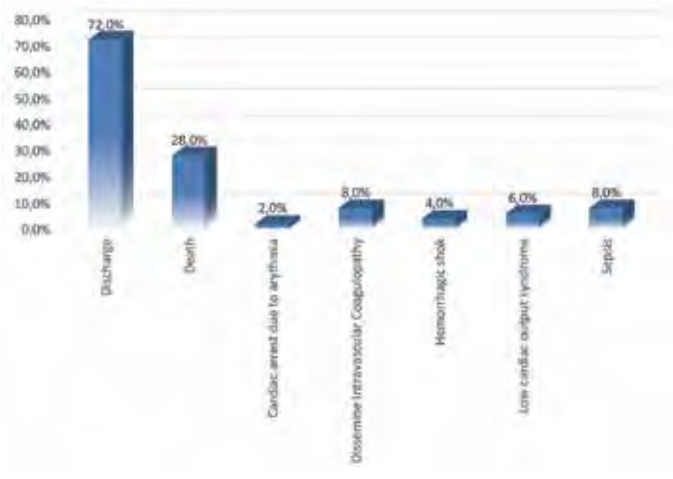
ECMO: Extracorporeal membrane oxygenation

Postoperative cardiogenic shock is associated with high morbidity and mortality (4). den Uil et al. (5) reported a high mortality rate of 62% in patients who had received VA-ECMO treatment due to right ventricular failure in comparison with our study, which revealed a mortality rate of 28%. This discrepancy may be because their study only focused on patients with isolated right or left ventricular failure.

Our study revealed a mortality of 28%. Although the level of mortality is too high incooperative to our patient's profile, this may be because most of our patients had received VA-ECMO because of postoperative cardiogenic shock, whereby some patients developed hemorrhage, sepsis and some had irreversible cardiogenic shock syndrome. In addition, the duration of VA-ECMO in these patients was high, causing negative effects associated with therapy occured as outlined in Table 3.

Postcardiotomy syndrome may be associated with high morbidity and mortality. This is due to the effect of CPB or poor myocardial protection, which may result in postoperative myocardial dysfunction. Postoperative myocardial dyscontractility may cause myocardial stunning that results in early postoperative cardiogenic shock (6). Proper treatment strategies to allow recovery of myocardial tissue should be taken after cardiogenic shock has occurred. Our study analysis revealed that ECMO weaning was possible 3.7±3.4 days in our patient group, which was slightly lower than that in other studies (7). This difference occurred because most of our patients had many other cormobodies, which may have contributed to high mortality as a result of postoperative infection that required massive therapy and cardiogenic failure. Our study revealed a mortality of 28% after VA-ECMO treatment due to cardiogenic shock. ECMO therapy-related comorbidities may have hindered the recovery process and contributed to the high mortality observed in our study.

Table 3. ECMO outcomes



ECMO: Extracorporeal membrane oxygenation

However, the best cardiac support for patients with acute cardiogenic shock is still regarded as VA-ECMO. In addition, there are other implantable cardiac systems, such as Impella Roller Pump, Tandem Right Ventricular Assist Device (RVAD), and Protek Duo, which can be used as direct right ventricular by-pass devices, whereas VA-ECMO is an indirect right ventricular by-pass (8). In addition, minimally invasive MCS is preferable in cardiogenic shock (9). During peripheral VA ECMO, RV function may be affected due to an increase in the pressure of the pulmonary circulation as a result of the undecompressed left ventricle. This may lead to RV dilatation pushing the ventricular septum into the left ventricle, thereby affecting the left ventricular geometry (10). In our study, 50% of our patients had peripheral VA-ECMO, which may have negatively affected our patient 's outcome. In this state, VA ECMO may be used in combination with RVAD to improve right ventricular function. Osaki et al. (11) have reported a case where RVAD with VA-ECMO was implanted, resulting in full recovery without heart failure.

During our study, anemia and high CK-MB during VA ECMO were associated with high mortality. Likewise, preoperative low hemoglobin levels are associated with high mortality, as reported in other studies (12). There are also other studies where my high CK-MB during VA ECMO therapy is considered an indicator of mortality (13).

Study Limitations

The retrospective nonrandomized nature and limited number of patients from a single institution reduces the statistical power of the study. Moreover, our single-center experience does not allow generalization. Our study focused on short-term outcomes and were not evaluate long-term results.

CONCLUSION

Our data revealed a high mortality rate for patients suffering from cardiogenic shock before VA-ECMO implantation, although 72% were successfully weaned off ECMO. Thus, VA-ECMO in patients with cardiogenic shock is a feasible and life saving. Further large-scale, multicenter studies are necessary to evaluate ECMO therapeutic measures in the treatment of cardiogenic shock.

Ethics

Ethics Committee Approval: University of Health Sciences Turkey, Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery

Training and Research Hospital (date: 18.05.2023/decision no: 2023-06).

Informed Consent: Retrospective sudy.

Peer-review: Internally and externally peer reviewed.

Authorship Contributions

Concept: M.B., M.K., Design: M.B., M.K., Data Collection or Processing: M.B., M.K., Analysis or Interpretation: M.B., Literature Search: M.K., Writing: M.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.84755
Eur Arch Med Res 2023;39(3):183-188

The Correlation of Optic Nerve Sheath Diameter with Radiological Classifications and Outcome in Pediatric Head Trauma

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Abstract

Objective: To demonstrate the correlation of optic nerve sheath diameter (ONSD) on initial computed tomography (CT) with outcome and radiological classification systems in pediatric intensive care unit (PICU) patients with head trauma.

Methods: Patients who were admitted to the PICU due to head trauma between June 2018-December 2022 were retrospectively analyzed. Both side ONSD and eye transverse diameters (ETD) were measured from head CTs at admission. CT findings were scored according to the Marshall and Rotterdam classifications of traumatic brain injury (TBI). Traumatic injury mechanisms, Glasgow coma scores, and outcomes were recorded from the hospital database.

Results: Mean ONSD differed significantly with age ($p<0.001$) and poor outcome ($p=0.005$). ONSD was also significantly higher in 0-2 and >10-year-old groups with severe TBI according to Rotterdam classification. The mean ONSD/ETD ratio was also significantly correlated with age, outcome, and Rotterdam classifications ($p<0.001$, $r2=0.583$; $p=0.031$, $r2=0.207$; $p=0.008$, $r2=252$, respectively.).

Conclusion: ONSD and ONSD/ETD ratio are feasible measurements that clearly correlate with prognosis and severe TBI in pediatric patients.

Keywords: Optic nerve sheath diameter, CT, pediatric, traumatic brain injury, intensive care

INTRODUCTION

Head trauma is the most frequent presentation to pediatric emergency departments, and traumatic brain injury (TBI) is the leading cause of mortality and morbidity in children (1). Increased intracranial pressure (ICP), hypotension, and hypoxia are known factors that increase mortality in these patients (1). ICP monitoring is recommended in the current guidelines for severe TBI Glasgow coma scores [(GCS ≤8)]. Although invasive methods are the gold standard, non-invasive monitoring has been increasingly studied and used in clinical practice because of the complications of surgery such as intracranial hemorrhage and infection (1).

The optic nerve sheath is a direct continuation of the dura mater and subarachnoid space. Hence, any increase in the cerebrospinal fluid (CSF) pressure may result in the expansion of the nerve sheath. Unlike papilledema, the change in optic nerve sheath diameter (ONSD) occurs in seconds, whereas papilledema may take days (2). Even though its non-ionizing nature makes ultrasound the preferred method for optic nerve sheath evaluation, it may not always be feasible, and the fact that the technique depends on the experience of the performer is a major disadvantage. Computerized tomography (CT), however, is widely used in trauma patients and enables objective interpretation and measurement. It also provides the opportunity to evaluate retrospectively (3,4).

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Received: 03.06.2023
Accepted: 18.08.2023

Cite this article as: Türk G, Bilgili M, Çelik B, Dursun A. The Correlation of Optic Nerve Sheath Diameter with Radiological Classifications and Outcome in Pediatric Head Trauma. Eur Arch Med Res 2023;39(3):183-188

CT is the method of choice for the initial examination of head trauma patients, particularly in high-energy traumas, which may easily demonstrate fractures and hemorrhages. Marshall and Rotterdam classifications are CT scan-derived metrics that predict the outcome in patients with TBI (5,6). Both systems use the presence of hemorrhages, edema, and midline shift to indicate prognosis in TBI. On the other hand, CT may not show every injury, especially injuries in minor traumas (7).

In this study, we aimed to investigate the correlation of ONSD on thin-slice CT scans with Marshall and Rotterdam classification scores and outcomes in head trauma patients admitted to the pediatric intensive care unit (PICU).

METHODS

Patient Selection

This is a single-centered retrospective study that was approved by the Regional Ethics Committee (date: 07/03/2023, decision number: 810). Informed consent was obtained from each patient's parent or guardian before CT. Because this study is retrospective and does not risk the patients' anonymity, a second informed consent was waived for the study.

Patients who were admitted to the PICU due to head trauma from June 2018 to December 2022 were retrospectively analyzed. Patients with known neurological diseases, intracranial mass lesions (e.g., arachnoid cysts, tumors), and hydrocephalus were excluded. Age, gender, traumatic injury mechanisms, GCS at admission, and outcomes were recorded from the hospital database.

Patients were further classified according to age groups asfollows: 0-2 years (2-year-old included), 2-4 years (4-year-old included), 4-10 years and older than 10 years. Trauma injury mechanisms were classified as low-energy traumas (ground level fall, running into a stationary object) and high-energy traumas (car accidents, fall from height, pedestrian hit by a vehicle, motorcycle accidents, assault). GCS scale at admission were also subgroup as 3-8, 9-13, and 14-15.

Radiological Imaging and Measurement

Head CT was performed using 256-row dual-core multidetector system (Siemens SOMATOM Definition Flash, Siemens Medical Solutions, Germany) with an initial thickness of 3 mm. Axial non-enhanced 1.5-mm-thick processed images were co-interpreted by two radiologists (GT and MB) who were blinded to the patients' age, traumatic injury mechanism, GCS, and outcome. If there was a discrepancy, a consensus was reached. The presence of fractures, pneumocephalus, epidural-subdural-subrachnoid and intraventricular hemorrhages, paraenchymal contusions, compression of basal cistern edema, and herniation/midline shift were recorded. Patients were scored according to the Rotterdam and Marshall classifications. Additional traumatic pathologies in the body were also recorded.

For measurements of ONSD and ETD, all images were displayed at a standardized window level with WW: 60, WL: 400. All measurements were performed using the same window, contrast, and brightness. Right and left ONSD were measured at a distance of 3 mm from the posterior wall of the bulbus on 1.5-mm thick slices, as described previously in the literature (8). All measurements were performed by a single radiologist. To make the measurements more practicable, routine axial slices without any reformatting were used. Then, the mean value was calculated. ETD (retina to retina) of the right and left eyes were also measured from the same images, and the mean value was calculated. The mean ONSD/ETD ratio was then calculated for each patient (Figure 1).

Statistical Analysis

The SPSS 22 statistical package program was used for statistical analysis. The distribution of the variables was assessed by the Kolmogorov-Smirnov test, and continuous variables were presented as mean ± standard deviation or median (with interquartile range) accordingly. Categorical variables are given as numbers and percentages. Comparison between the two groups for data with normal distribution was performed using Student's t-test. Comparison between groups for data that did not show a normal distribution was performed using the Mann-Whitney U test. Categorical variables were compared using the chi-square test. Kruskall-Wallis test was used for multiple group comparisons. Pearson correlation was used for numerical data, and Spearman correlation was used for ordinal data. Univariate analysis was used to determine the factors related to poor outcome separately, and the variables with statistical difference ($p<0.2$) were included in binary logistic regression analysis to predict the odds of being a case (poor outcome) based on the values of the independent variables. $P<0.05$ was accepted as the level of significance.

RESULTS

Patients who were admitted to the pediatric ICU between June 2018 and December 2022 because of head trauma were collected from the hospital database, and their images were retrospectively analyzed. Eighteen patients were excluded because of imaging artifacts, and 109 patients were included in the study. Sixty patients were male and 49 were female.

The median age was 4.5 years (0-17). The basic features of the patients are given in Table 1.

Mortality rate was 4.5% (n=5). Twelve patients (11%) were discharged with severe sequelae, 6 of which demonstrated diffuse axonal injury on follow-up magnetic resonance imaging (MRI) (5.5%). Forty-one patients (37.6%) manifested additional traumatic pathologies; 17 (15.6%) in the abdomen, 23 (21.1%) in the thorax, and 22 (20.2%) in the extremities.

Table 1. Characteristics of the patients and CT findings

		n	%
Age	0-2	34	31.2
	2-4	15	13.8
	4-10	31	28.4
	>10	29	26.6
Gender	Female	49	45
	Male	60	55
Traumatic injury mechanism	Low energy	32	29.3
	High energy	77	70.7
GCS at admission	3-8	16	14.7
	9-13	21	19.3
	14-15	72	66.1
Pathologies on head CT	Fractures	40	36.7
	Pneumocephalus	26	23.8
	Subarachnoid hemorrhage	22	20.2
	Subdural hemorrhage	18	16.5
	Epidural hemorrhage	16	14.7
	Contusion	13	11.9
	Brain edema	8	7.3
	Midline shift more than 5 mm	6	5.5

GCS: Glasgow coma scale, CT: Computed tomography

Forty-four patients' CTs were interpreted as normal. Head CT at admission demonstrated trauma-related pathologies in 65 patients (59.6%). The most common pathology was fractures (n=40, 36.7%). Fifty-one patients showed one-sided pathology on CT (78.4%). In addition, head CTs were scored according to the Marshall and Rotterdam classification systems for traumatic brain injury. CT pathologies and scores are listed in Tables 1 and 2, respectively. The presence of intracranial pathologies did not show a significant difference according to the trauma injury mechanisms (Table 3).

GCS was significantly negatively correlated with both the Marshall ($p<0.001$, r^2:-0.44) and Rotterdam classifications (p.0.001, r^2:-0.59). On the other hand, the classification systems showed no significant difference according to the injury mechanisms (p=0.64 for Marshall and p=0.17 for Rotterdam).

Table 2. Patient distribution according to the Marshall and Rotterdam classifications

Marshall classification			Rotterdam classification		
	n	%		n	%
1	47	43.1	**1**	64	58.7
2	44	40.4	**2**	27	24.8
3	9	8.3	**3**	7	6.4
4	2	1.8	**4**	7	6.4
5	2	1.8	**5**	3	2.8
6	5	4.6	**6**	1	0.9

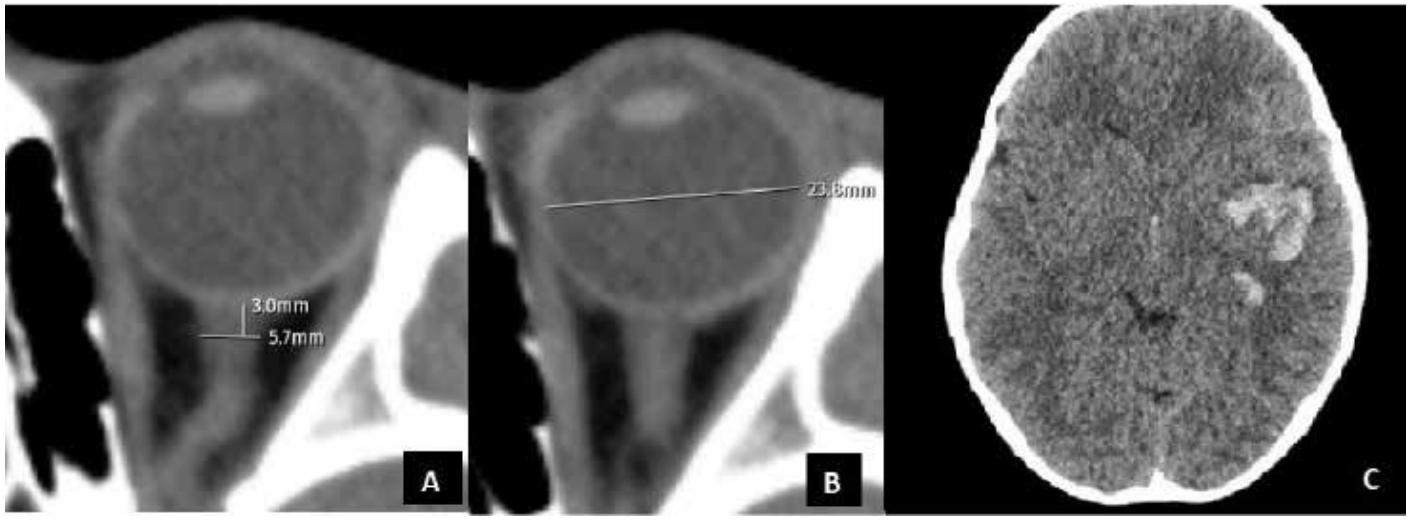

Figure 1. ONSD measurement (A), ETD measurement (B), and head CT scan images (C) of a 6-year-old boy who was hit by a car. (A) At a standardized window level, left ONSD is measured 3 mm behind the posterior wall of the bulbus. (B) ETD is measured from the retina to the retina. (C) Unenhanced CT scan shows left-sided parenchymal hematoma and blood in the left temporal horn

ONSD: Optic nerve sheath diameter, CT: Computer tomography, ETD: Eye transverse diameter

Right, left, and mean ONSD, ETD, and ONSD/ETD values according to age groups are given in Table 4. Mean ONSD values significantly increased with age (p<0.001). When the age subgroups were compared, significant differences were present in 0-2 vs 4-10 years (2.64±0.47 vs 3.8±0.8, p<0.001); 0–2 vs more than 10 years (2.64±0.47 vs 4.11±0.66, p<0.001); and 2-4 vs more than 10 years (3.28±0.61 vs 4.11±0.66, p=0.008).

Although not significant, the mean ONSD was higher in males (p=0.055).

No significant correlations were observed between ONSD and the Marshall and Rotterdam classifications. However, when Rotterdam scores were subgrouped into two as mild TBI (Rotterdam 1-2-3) and severe TBI (Rotterdam 4-5-6), ONSD was significantly higher in 0-2 and >10-year-old groups (2.642.64±0,48 vs 3.67±0,53, p=0.006 and 4.11±0.66 vs 5.07±0.95, p=0.017, respectively). Comparison could not be made for the 2–4-year group because there were no severe TBI patients (Table 5).

ONSD was significantly higher in patients with poor outcome (severe sequela or death) (3.40±0.89 vs 4.06±0.8, p=0.005). Subgroup analysis according to age groups was significant in 0-2 age group (2.62±0.46 vs 3.60±0.4, p=0.001). The difference was not significant in the other age groups (p=0.73 for 2-4 years, p=0.52 for 4-10 years and p=0.35 for more than 10 years).

Patients with one-sided intracranial pathology on CT were separately analyzed. In patients with left-sided pathologies, ONSD was significantly higher on the left (4.05±0.88 vs 3.5±0.93, p=0.037). However, the difference was not significant in patients with right-sided pathologies (3.56±0.99 vs 3.8±0.84, p=0.38).

ONSD/ETD ratios were significantly correlated with age (p<0.001, r^2=0.583). The correlation was also significant with Rotterdam classification (p=0.008, r^2=0.252). For further analysis, ONSD/ETD ratios were subgroup into two as (0.07-0.14) and (0.15-0.27). According to univariate analysis, age (p=0.191, F=2.69 [95% confidence interval (CI): 0.609-11.927)]; Rotterdam subgroup [p<0.01 F=50.63 (95% CI: 9.302-275.525)], and ONSD/ETD ratio subgroups [p=0.017 F=12.31 (95% CI: 1.566-96.750)] were significant predictors of poor outcome. Binary logistic regression analysis identified only Rotterdam subgroups as independent predictors of poor outcome [p<0.001 F=40.38 (95% CI: 6.499-250.87)].

Table 3. The distribution of trauma-related pathologies on head computed tomography according to traumatic injury mechanisms

	Fractures	PNC	SAH	EDH	SDH	Contusion	Edema	Shift
Total	40	26	22	16	18	13	8	6
Low energy	13	9	3	6	6	4	80	2
High energy	27	17	19	10	12	9	8	4
p-value	0.583	0.500	**0.070**	0.439	0.685	0.905	0.103	1

PNC: Pneumocephalus, SAH: Subarachnoid hemorrhage, EDH: Epidural hemorrhage, SDH: Subdural hemorrhage

Table 4. ONSD, ETD, and ONSD/ETD values of the right eye and left eye and mean values for age subgroups

Age	Right			Left			Mean		
	ONSD	ETD	OND/ETD	OND	ETD	OND/ETD	OND	ETD	OND/ETD
0-2	2.67	19.96	0.133	2,74	19.89	0.137	2,71	19.93	0.135
2-4	3.27	21.17	0.154	3.30	21.17	0.156	3.29	21.17	0.155
4-10	3.70	21.94	0.168	3.88	21.99	0.177	3.79	21.96	0.172
>10	4.23	22.76	0.186	4.26	22.83	0.187	4,24	22.80	0.187

ONSD: Optic nerve sheath diameter, ETD: Eye transverse diameter

Table 5. Comparison of ONSD values according to age groups and Rotterdam classification subgroups

	Rotterdam classification subgroups		
Age	Mild TBI	Severe TBI	p-value
0-2	2.64±0.47	3.68±0.53	**0.006**
2-4	3.28±0.61	N/A	
4-10	3.8±0.8	3.73±0.28	0.847
>10	4.11±0.66	5.08±0.95	**0.017**

TBI: Traumatic brain injury, ONSD: Optic nerve sheath diameter

DISCUSSION

Imaging and early detection of increased ICP is of major importance in the management of patients with TBI because early intervention plays a crucial role in preventing mortality. CT is the method of imaging for trauma patients. It is fast and easily accessible; it also provides a variety of information on the extent of the injury. Multidimensional and thin-slice reformatting makes CT scans indispensable in trauma, at the expense of radiation.

The possibility that ONSD may reflect CSF pressure was suggested in the early 1990s (8), and ever since then, many studies on ONSD measurements and correlation with outcomes in TBI have been published in the literature. However, most of these studies are in adult populations, whereas there are fewer studies on pediatric cases (1,3,4,8-12).

In our study, we found a significant correlation between ONSD and age, corroborating many studies in the literature (13-16). In this study, the mean ONSD was higher in males ($p=0.055$); however, we mainly attribute this difference to the heterogeneity of the sample size and the male predominancy in >10-year group. The normal distribution of ONSD among age groups has been provided by different studies using different imaging methods (13-15). CT and MRI reading data are usually similar, US and CT reading may not give the same results (11).

Legrand et al. (12) reported ONSD at admission CT was associated with a higher mortality rate in the ICU, with a cut-off value of 7.3 mm in the adult population. Similarly, Sekhon et al. (9) studied 220 severe TBI patients with invasive ICP monitoring and found that ONSD was associated with increased ICP. This study also revealed that a 1-mm increase in sheath diameter was associated with a 2-fold increase in mortality (9).

In their study, which involved 11 PICU patients with TBI, Agrawal and Brierley (10) compared the US measurement of ONSD 3 mm posterior to the optic disk and simultaneous invasive ICP measurement results. This study suggested that in children older than 1 year, ONSD more than 4.5 mm should be considered pathological (10). Another study by Bekerman et al. (11) on ONSD correlation with ICP changes showed that the most accurate interpretations were made in patients with 15-30 mmHg ICP. In the same study, ONSD readings of 5-13 mmHg were defined as "not informative" (11). In a similar study, Young et al. (16) measured the ONSD of TBI patients in PICU on CT scan and suggested a cut-off value of 6.1 mm for invasive ICP monitoring.

The correlation of ONSD with Rotterdam scores has been reported in a few studies (3,4,13). Compared with the Marshall classification, the Rotterdam classification additionally considers subrachnoid hemorrhage and evaluates epidural and subdural hematomas separately. In children, lower Rotterdam scores in TBI have been shown to result in lower mortality (17). In their study on 150 adults with TBI, Das et al. (4) found higher ONSD in patients with a Rotterdam score of 4 or higher, indicating moderate to severe TBI. The authors also suggested that a normal ONSD could be used to determine mild TBI patients, thus avoiding unnecessary follow-up CT scans (4). Waqas et al. (3) conducted their retrospective study on adults who underwent decompressive craniectomy. Similar to our study, for poor outcome and mortality prediction, Rotterdam scores were better predictors. Although ONSD was higher than normal at admission in these patients, it did not predict mortality or outcome (3).

Recently, Kayadibi et al. (13) compared ONSD at CT scans of pediatric patients with traumatic and non-traumatic complaints. Non-traumatic patients who had normal scans were included as a control group. Similar to our study, ONSD was also found to be correlated with age, and ONSD was higher in patients with severe TBI (Rotterdam 4-5-6) (13).

As a secondary end point, we evaluated patients with solely one-sided pathology on admission CT scan. When the intracranial pathology was only left-sided, the ipsilateral ONSD was significantly higher. However, this was not the case for the right-sided pathologies. Retrospective analysis for this discrepancy showed that the majority of patients with right-sided pathologies had focal subarachnoid hemorrhages and displaced fractures, without space-occupying hematomas, and with higher GCSs. In the case of increased ICP, a diffuse expansion of both sides of ONSD is expected, therefore, in the literature, the majority of studies take a mean value for analysis. However, when trauma is the etiology, intracranial pathologies can be unilateral, particularly in mild TBI cases (Rotterdam score 1-3). In these cases, measurement of only one side may lead to misconclusions.

Study Limitations

Our study has some limitations. First, it has a small sample size and a heterogeneous distribution of injury severity. The lack of severe TBI dominance interfered with further analysis. Second, the study did not have a control group, which would certainly help identify a cut-off point and add value. There was also lack of invasive ICP measurement in most of the cases because they were mild TBI patients.

CONCLUSION

In conclusion, CT is a fast and easily accessible imaging method in the emergency department and is frequently used in trauma patients. Initial head CT at admission is a pivotal scan that may provide the clinician with more than hemorrhages and fractures. ONSD on the initial CT should be evaluated because it may provide valuable information for the increased ICP and therefore the outcome. Unilateral ONSD changes in ipsilateral pathologies should warn the interpreter to always measure both eyes and compare the results.

Ethics

Ethics Committee Approval: This is a single-centered retrospective study that was approved by the regional ethics committee (date: 07/03/2023, decision number: 810).

Informed Consent: Informed consent was obtained from each patient's parent or guardian before CT.

Peer-review: Externally and internally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: B.Ç., A.D., Concept: G.T., MB., B.Ç., A.D., Design: G.T., MB., B.Ç., A.D., Data Collection or Processing: G.T., MB., B.Ç., A.D., Analysis or Interpretation: G.T.,Literature Search: G.T., MB., B.Ç., A.D., Writing: G.T., MB., B.Ç., A.D.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.16046
Eur Arch Med Res 2023;39(3):189-195

Urinary Tract Infections Caused by *Pseudomonas aeruginosa*: An 11-Year Retrospective Analysis on Antimicrobial Resistance

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Abstract

Objective: Urinary tract infections (UTIs) are among the most common infections worldwide. *Pseudomonas aeruginosa* is thought to cause 7% to 10% of UTIs. *P. aeruginosa* isolates from UTIs frequently show higher levels of antibiotic resistance than *E. coli* isolates. The aim of this study was to retrospectively determine the antimicrobial susceptibility profile of *Pseudomonas aeruginosa* strains detected as causative agents of UTIs during the 11 years (2009-2019) before the coronavirus disease-19 pandemic and to reveal epidemiologic data.

Methods: Between January 2009 and October 2019, retrospective data of 540 non-repetitive *Pseudomonas aeruginosa* strains were included in our study. For the diagnosis of UTI, results of $\geq 10^4$ CFU/mL in pure culture or $\geq 10^4$ CFU/mL growths of ≤2 bacterial species were accepted as positive urine culture criteria from midstream urine samples. Identification and antimicrobial resistance were determined using the Vitek 2 Compact System. The 11-year antimicrobial resistance and the three-year Minimal Inhibitory Concentration (MIC) data were extracted from the hospital automation system retrospectively.

Results: Of 540 non-repetitive *Pseudomonas aeruginosa* strains, 226 (41.8%) were isolated from male patients and 314 (58.2%) from female patients. The mean age of the patients was 66.54±32.62 years. Co-trimoxazole and colistin were found to be the most effective antimicrobials against *P. aeruginosa*. Piperacillin-tazobactam combination resistance was found to be 52.59%, third-generation ceftazidime, cefoxitin, and ceftriaxone resistance rates were 48.89%, 89.13%, and 60.37%, respectively, and the fourth-generation cefepime resistance rate was 53.7%. The mic50 values of ciprofloxacin and meropenem increased in 2019 compared with 2017.

Conclusion: In conclusion, although antimicrobial resistance fluctuated over the years, there was an increase pattern in MIC values over the years. An increase in MIC values in the quinolone groups should be monitored for UTI infections. Each hospital's monitoring of antimicrobial resistance status is critical for infection control and shedding light on reasonable antibiotic use.

Keywords: *Psedomonas aeruginosa*, urinary tract infections, retrospective analysis, antimicrobial resistance

INTRODUCTION

Urinary tract infections (UTIs) are among the most common infections worldwide, with an estimated annual burden of $1.6 billion in the United States alone (1). Uropathogenic *Escherichia coli* (UPEC) is the dominant causative agent, causing approximately 80% of UTIs. The incidence of UTIs is 10% in women and 3% in men in the United States (2). UTIs are also one of the most common illnesses in hospitalized patients, accounting for 20 to 50% of all noncomial infections. In the hospital setting, *Pseudomonas aeruginosa* is thought to cause 7% to 10% of UTIs (3). *P. aeruginosa* is a non-fermentative, bacillary Gram-negative opportunistic bacterium (1,3). It can cause infections with poorer prognosis because of its ability to adapt to unfavorable environmental conditions, such as pH and

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Received: 11.08.2023
Accepted: 31.08.2023

Cite this article as: Bayyiğit A, Erdem MG, Ünlü Ö, Demirci M. Urinary Tract Infections Caused by *Pseudomonas aeruginosa*: An 11-Year Retrospective Analysis on Antimicrobial Resistance. Eur Arch Med Res 2023;39(3):189-195

osmolarity of urine, and its ability to develop multidrug resistance (4). *P. aeruginosa* UTIs are associated with high morbidity and mortality in elderly patients. *P. aeruginosa* isolates from UTIs frequently show higher levels of antibiotic resistance than *E. coli* isolates (1,3,5). *P. aeruginosa* is one of the most important bacteria causing complicated clinical problems (6). Antimicrobial resistance is a significant global health problem. The increasing use of antimicrobials in recent years has made the treatment of infections difficult because of the development of antimicrobial resistance. In addition to the ability of *P. aeruginosa* to develop antimicrobial resistance, increased antimicrobial use during the COVID-19 pandemic has complicated the treatment of infections (7). The aim of this study was to retrospectively determine the antimicrobial susceptibility profile of *Pseudomonas aeruginosa* strains detected as causative agents of UTIs during the 11 years (2009-2019) before the COVID-19 pandemic and to reveal epidemiologic data.

METHODS

Between January 2009 and October 2019, retrospective data of 540 non-repetitive *Pseudomonas aeruginosa* strains were included in our study. These *Pseudomonas aeruginosa* strains were isolated from urine cultures of patients admitted to the internal medicine clinic of a private hospital in İstanbul after suspected UTI. The first positive result among consecutive samples of the same patient was included in the study, and the results of other strains were excluded from the study. Because this study was a retrospective study, there was no need for informed consent. Ethics committee approval was obtained for using retrospective data of *Pseudomonas aeruginosa* strains (Private MedicalPark Fatih Hospital Ethics Committee, application number: 2021-1-1).

For the diagnosis of UTI, results of $\geq 10^4$ CFU/mL in pure culture or $\geq 10^4$ CFU/mL growth of ≤2 bacterial species were accepted as positive urine culture criteria (8). Midstream urine samples from individuals with suspected UTIs were collected in a sterile container and delivered to the laboratory within 1 h. The urine sample was incubated on Cystine Lactose Electrolyte Deficient agar (CLED agar, Oxoid Ltd., Thermo Fisher, Heysham, UK) at 37 °C for 18 h using the colony counting method. Lactose-negative and oxidase-positive colonies on CLED agar were isolated on cetrimide agar (Oxoid Ltd., Thermo Fisher, Heysham, UK). Oxidase-positive and cetrimide-positive colonies were considered to be *P. aeruginosa*. Suspected strains that tested negative for cetrimide were identified using the Vitek 2 Compact System (Biomerieux, Marcy-l'Étoile, France) for confirmation. In addition to colistin, the susceptibilities of antimicrobials were determined using the Vitek 2 Compact System (Biomerieux, Marcy-l'Étoile, France). The broth microdilution method was used to assess colist susceptibility. Antimicrobial susceptibility results were evaluated according to the Clinical Laboratory Standards Institute criteria before 2016 and the European Committee on Antimicrobial Susceptibility Testing (EUCAST) criteria after 2016. *P. aeruginosa* ATCC 27853 was used for quality control in all procedures (9-11). The 11-year data of urine samples evaluated and cultured in the laboratory were retrospectively retrieved from the hospital automation system. In our hospital, MIC ranges were also presented in the results reports of 2017, 2018, and 2019. Therefore, MIC data of antimicrobials were also determined in the data of these years by removing them from the reports. Only descriptive statistical methods were used in this study.

RESULTS

A total of 540 non-repetitive *Pseudomonas aeruginosa* strains with positive urine cultures for suspected UTIs were included in this study. Of all strains, 226 (41.8%) were isolated from male patients and 314 (58.2%) from female patients. The mean age of the patients was 66.54±32.62 years. The distribution of *Pseudomonas aeruginosa* strains according to years is presented in Table 1.

When the antibiotic susceptibility of *Pseudomonas aeruginosa* strains that cause UTIs was analyzed, it was found that co-trimoxazole was the most effective antibiotic, and 94.07% of the strains were susceptible to it. With 90.37%, colistin was the next drug after co-trimoxazole. Cefazolin susceptibility was the lowest at 0.37% (Table 2).

The distribution of antibiotic resistance status of *Pseudomonas aeruginosa* strains found to be causative agents of UTIs according to years is shown in Table 3. Although an increase in the resistance profiles was observed over the years, there was no clear pattern of increase or decrease. As a result, it was determined whether antibiotic resistance increased or decreased over time.

According to the findings of our study, when the antimicrobial resistance of the strains from all years was analyzed, piperacillin resistance among antipseudomonal penicillins was found to be 60.74%, and piperacillin-tazobactam combination resistance was found to be 52.59%. This revealed that piperacillin should be used cautiously in treating infections caused by *Pseudomonas aeruginosa*. The 99.63% resistance to cefazolin, a first-generation cephalosporin, and 89.63% resistance to cefoxitin, a second-generation cephalosporin, were also suggestive. Ceftazidime, a third-generation cephalosporin, and cefepime, a fourth-generation cephalosporin, are antimicrobials with antipseudomonal

activity. The third-generation ceftazidime, cefoxitin, and ceftaxone resistance rates were 48.89%, 89.13%, and 60.37%, respectively, and the fourth-generation cefepime resistance rate was 53.7%. Meropenem susceptibility was studied to reveal resistance to carbapenems, which are recommended as last-line drugs and was found to be 43.7%. Considering all these data, resistance to beta lactam group antibiotics has reached dreadful levels in *P. aeruginosa* strains in our center. When the resistance to aminoglycosides, which are recommended to be used in combination with beta lactams, was analyzed, netilmicin and tobramycin resistance was found to be 43.33% and 27.78%, respectively. Resistance to quinolones was relatively low, with ciprofloxacin and levofloxacin resistance rates of 30% and 21.11%, respectively. However, only 5.93% of the strains to which co-trimoxazole was the most effective antibiotic were resistant. Co-trimoxazole was followed by colistin with a resistance rate of 9.63% (Table 3). In addition, while the resistance rate to colistin was zero in the first

Table 1. Distribution of *Pseudomonas aeruginosa* strains by year

Years	Positive participants n (%)	Male patients n (%)	Female patients n (%)
2009	10 (1.85)	4 (0.74)	6 (1.11)
2010	30 (5.56)	8 (1.48)	22 (4.07)
2011	40 (7.41)	14 (2.59)	26 (4.81)
2012	48 (8.89)	20 (3.70)	28 (5.19)
2013	56 (10.37)	16 (2.96)	40 (7.41)
2014	26 (4.81)	12 (2.22)	14 (2.59)
2015	24 (4.44)	12 (2.22)	12 (2.22)
2016	38 (7.04)	16 (2.96)	22 (4.07)
2017	76 (14.07)	24 (4.44)	52 (9.63)
2018	140 (25.93)	82 (15.19)	58 (10.74)
2019	52 (9.63)	18 (3.33)	34 (6.30)
Total	540 (100.00)	226 (41.85)	314 (58.15)

Table 2. The distribution of antibiotic susceptibility status of *Pseudomonas aeruginosa* strains as causative agents of UTIs

	Susceptible n (%)		Resistant n (%)	
Cefaperazone-sulbactam	80	14.81%	460	85.19%
Cefazolin	2	0.37%	538	99.63%
Cefepime	250	46.30%	290	53.70%
Cefixim	64	11.85%	476	88.15%
Cefoxitin	56	10.37%	484	89.63%
Ceftazidime	276	51.11%	264	48.89%
Ceftriaxon	214	39.63%	326	60.37%
Ciprofloxacin	378	70.00%	162	30.00%
Colistin	488	90.37%	52	9.63%
Co-trimoxazole	508	94.07%	32	5.93%
Levofloxacin	426	78.89%	114	21.11%
Meropenem	304	56.30%	236	43.70%
Netilmicin	306	56.67%	234	43.33%
Nitrofurantoin	6	1.11%	534	98.89%
Piperacillin	212	39.26%	328	60.74%
Piperacillin-tazobactam	256	47.41%	284	52.59%
Tobramycin	390	72.22%	150	27.78%

UTI: Urinary tract infection

three years of the period examined, this rate increased to 23% in 2019. When the first three and last three years were compared, it was discovered that resistance increased significantly ($p<0.05$).

According to the findings of our study, when the antimicrobial resistance rates detected in 3-year periods were compared, it was determined that the antimicrobial resistance rates detected for ceftazidime, ceftriaxone, and cefepime among cephalosporins in 2018-2019 did not increase compared with the antimicrobial resistance rates detected between 2008 and 2011. In contrast, the resistance rates of all other cephalosporin antibiotics increased. Furthermore, in the quinolone group of antibiotics, which are frequently used in treating UTIs, the antimicrobial resistance rates of ciprofloxacin and levofloxacin in 2018-2019 showed a slight increase compared with the antimicrobial resistance rates detected between 2008 and 2011.

MIC_{50} and MIC_{90} values of 268 *P. aeruginosa* strain between 2017 and 2019 are presented in Table 4. It was determined that the mic50 value of ciprofloxacin, which is frequently used for treating UTIs, increased in 2019 compared with 2017. For meropenem, it was found that the data of 2019 showed an increase in terms of both MIC_{50} and MIC_{90} values compared with the 2017 data. Although there was no clear pattern of increase in resistance rates over the years, there was a pattern of increase in MIC values against *P. aeruginosa* in most antimicrobials commonly used in UTIs over the years.

DISCUSSION

P. aeruginosa is an important nosocomial infection agent. In addition to its widespread presence in the hospital environment and its potential to grow on various antiseptics, antimicrobial resistance in these strains is an important public health problem. It is believed to be responsible for 10% of nosocomial UTIs, and the disease has a poor prognosis in elderly and hospitalized patients. Furthermore, the problem of antimicrobial resistance developing at the origin results in treatment failure and increase morbidity and mortality (3-5). In addition, it is thought that the increased use of antimicrobials during the coronavirus disease-19 (COVID-19) pandemic contributed to antimicrobial resistance and complicated the treatment of infections. Therefore, our study aimed to perform a retrospective analysis of the antimicrobial susceptibility profile of *P. aeruginosa* strains detected as causative agents of UTIs during the 11 years before the COVID-19 pandemic.

Erdoğan et al. (12) investigated the antimicrobial resistance status of *Pseudomonas aeruginosa* strains isolated from Malatya Training and Research Hospital intensive care unit patients between 2016 and 2019. The most effective antibiotics for *P.*

Table 3. The distribution of antibiotic resistance status of *Pseudomonas aeruginosa* strains found to be causative agents of UTIs according to years (%)

	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009
Cefaperazone-sulbactam	65.38	70.00	47.37	26.32	25.00	23.08	28.57	33.33	20.00	33.33	20.00
Cefazolin	100.00	100.00	100.00	100.00	100.00	92.31	100.00	100.00	100.00	100.00	100.00
Cefepime	38.46	44.29	36.84	84.21	50.00	30.77	64.29	83.33	80.00	66.67	0.00
Cefixim	80.77	84.29	89.47	94.74	91.67	69.23	100.00	100.00	100.00	73.33	60.00
Cefoxitin	76.92	95.71	92.11	84.21	100.00	61.54	100.00	100.00	95.00	73.33	40.00
Ceftazidime	7.69	34.29	52.63	73.68	58.33	61.54	57.14	66.67	70.00	73.33	0.00
Ceftriaxon	57.69	70.00	55.26	52.63	25.00	46.15	67.86	54.17	40.00	93.33	100.00
Ciprofloxacin	34.62	24.29	13.16	42.11	25.00	38.46	32.14	41.67	50.00	33.33	0.00
Colistin	23.08	11.43	2.63	15.79	8.33	38.46	0.00	8.33	0.00	0.00	0.00
Co-trimoxazole	0.00	0.00	21.05	0.00	8.33	0.00	7.14	4.17	5.00	13.33	20.00
Levofloxacin	11.54	28.57	7.89	31.58	16.67	30.77	17.86	20.83	35.00	13.33	0.00
Meropenem	30.77	27.14	28.95	63.16	41.67	38.46	67.86	50.00	65.00	73.33	60.00
Netilmicin	76.92	72.86	26.32	26.32	16.67	15.38	28.57	29.17	40.00	20.00	20.00
Nitrofurantoin	100.00	100.00	94.74	100.00	100.00	100.00	100.00	100.00	100.00	93.33	100.00
Piperacillin	34.62	60.00	47.37	73.68	58.33	92.31	71.43	54.17	65.00	86.67	60.00
Piperacillin-tazobactam	46.15	35.71	47.37	73.68	58.33	46.15	60.71	66.67	80.00	73.33	0.00
Tobramycin	11.54	40.00	26.32	15.79	33.33	76.92	10.71	8.33	35.00	26.67	20.00

UTIs: Urinary tract infections

aeruginosa strains were colistin and norfloxacin, whereas the lowest susceptibility among the antibiotics studied was found for aztreonam. Susceptibility rates were 76.5% for amikacin, 8.1% for aztreonam, 74.4% for gentamicin, 62.2% for imipenem, 97.1% for colistin, 57.5% for levofloxacin, 61.4% for meropenem, 57.4% for netilmicin, 89.9% for norfloxacin, and 48% for piperacillin/tazobactam,7%, piperacillin 35.7%, cefepime 57.7%, ceftazidime 62.7%, ciprofloxacin 66%, and tobramycin 80.9%, which were similar to the findings of our study (12). Behçet et al. (13) investigated the antimicrobial resistance status of *Pseudomonas aeruginosa* strains isolated from Bolu Abant İzzet Baysal University Medical Faculty Hospital between 2015 and2017. The rates of resistance to colistin 6.7%, amikacin 11.6%, gentamicin 19.7%, ceftazidime 21.6%, piperacillin/tazobactam 22.4%, cefepime 24.2%, levofloxacin 25.5%, ciprofloxacin 27.4%, imipenem 31.6%, and meropenem 32.1%. When the resistance increased during the analyzed years, a significant increase was found only in cefepime resistance (13). Between 2017 and 2021, Öner et al. (14) aimed to determine the antimicrobial resistance status of 2876 *P. aeruginosa* strains isolated from the Pamukkale University Faculty of Medicine between 2017 and 2021. Accordingly, the lowest resistance was found against amikacin (n=88, 3%) and gentamicin (n=174, 6%), whereas the highest resistance was found against ceftazidime (n=602, 21%) and imipenem (n=553, 19%) (14). Notably, the resistance rates found by Behçet et al. (13) and Öner et al. (14) in Bolu and Denizli provinces, respectively, were lower than the findings of our study. This difference may be due to changes in regional treatment regimens. To examine the worldwide *P. aeruginosa* resistance data, the 1997-2016 data of the SENTRY antimicrobial surveillance program, which includes the Asia-Pacific region, Europe, Latin America, and North America, can be considered. Accordingly, in the 20-year analysis of *P. aeruginosa* strains, the cefepime resistance rate was reported as 20.7% and the ceftazidime resistance rate as 22.5%. In addition, the piperacillin/tazobactam resistance rate, which is frequently used in empirical treatment in intensive care units, was found to be 26.8% (15). Considering these findings, it is noteworthy that the resistance to the relevant antibiotics was twice as high in our strains, suggesting that we are inadequate in rational antibiotic use.

The Infectious Diseases Society of America guidelines recognize nitrofurantoin and co-trimoxazole as the current standard of care for uncomplicated UTIs in women. However, all guidelines state that local or regional antimicrobial susceptibility patterns should be considered (16). Kalal and Nagaraj (16) reported in their study in India that aminopenicillins, ciprofloxacin, and co-trimoxazole may not be appropriate options for the empirical treatment of UTI. They reported that *P. aeruginosa*

Table 4. The distribution of MIC_{50} and MIC_{90} values of 268 *P. aeruginosa* strains detected as causative agents of UTI infections between 2017 and 2019

	2019 (52)		2018 (n=140)		2017 (n=76)	
	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	MIC_{50} (µg/mL)	MIC_{90} (µg/mL)
Cefaperazone-sulbactam	16	32	8	16	8	16
Cefazolin	64	64	64	64	64	64
Cefepime	4	16	8	16	4	16
Cefixim	32	64	32	64	32	64
Cefoxitin	32	64	32	64	32	64
Ceftazidime	8	32	16	32	16	32
Ceftriaxon	8	32	4	32	8	32
Ciprofloxacin	0.25	4	0.25	4	0.12	4
Colistin	0.5	2	0.5	2	0.5	2
Co-trimoxazole	4.75/0.25	9.5/0.5	4.75/0.25	9.5/0.5	4.75/0.25	9.5/0.5
Levofloxacin	0.12	4	0.25	4	0.25	4
Meropenem	16	32	16	32	32	64
Netilmicin	2	4	2	4	4	8
Nitrofurantoin	256	256	256	256	256	256
Piperacillin	4	32	8	64	4	64
Piperacillin-tazobactam	8	64	8	64	8	64
Tobramycin	2	16	2	16	2	16

UTI: Urinary tract infection

was resistant to most antibiotics and had a higher level of antibiotic resistance. They emphasized that antibiotic resistance may cause increased morbidity, mortality, cost, and hospital stay because carbapenems are the last line of defense against resistant gram-negative infections (16). Similarly, our data suggest that aminopenicillins, ciprofloxacin, and co-trimoxazole can be used for the empirical treatment of UTI. Jombo et al. (17) found that 92% of the *P. aeruginosa* strains in UTIs in Nigeria were sensitive to ciprofloxacin and 86% were sensitive to cecuroxime. However, all strains were resistant to nitrofurantoin (17). While high resistance to nitrofurantoin was similarly found in our study, our quinolone resistance rates were lower than those in this study. Perween et al. (18) reported a resistance rate of 42.3% for ciprofloxacin, 57.7% for cefepime, 64.3% for ceftazidime, 42.3% for piperacillin-tazobactam, 29.6% for meropenem, 7.4% for colistin, and 50% for nitrofurantoin because of their study analyzing UTI agents in children in India. It was observed that our data were similar to the data of this study, except for nitrofurantoin. Al Mamari et al. (19) observed a decreasing trend of resistance to most antibiotics except imipenem in 47 *P. aeruginosa* strains in 2018 compared with that in 2013. According to the data of our study, a similar decrease or increase in resistance patterns was not detected. Following COVID-19, quinolone and cephalosporin resistance increased significantly, particularly in nosocomial infection agents with high resistance development capabilities, such as *P. aeruginosa*, with lengthening of hospitalization and an increase in empirical treatments (20). In 2020 and 2022, a study conducted in Iran similarly reported an increase in antimicrobial resistance in P. aeruginosa strains, and researchers emphasized the importance of monitoring these data for global public health (21). Er et al. (22) reported in Turkey that the highest resistance rates were found against ceftazidime (85.4%) and piperecillin/tazobactam (86.6%) between 2008 and 2012, *P. aeruginosa* strains isolated from hospitalized patients with UTI. In this study, it is interesting to report that strains isolated from UTI had a similar resistance pattern to blood cultures (22). It was observed that the data of our study were similar. Sader et al. (23) reported that antimicrobial resistance rates of *P. aeruginosa* strains followed up in the USA between 2012 and 2015 were stable, and it was recommended that antimicrobial combination therapies should be selected for empirical treatment. Yayan et al. (24) reported that the antimicrobial resistance pattern of *P. aeruginosa* strains fluctuated over a 10-year period, similar to our study.

Study Limitations

The limitations of our study were that it was a single-center study and did not differentiate UTIs as complicated or uncomplicated. However, it is valuable in containing 11 years of epidemiological data from the pre-COVID-19 period and revealing the epidemiologic antimicrobial resistance pattern.

CONCLUSION

Antimicrobial resistance in *P. aeruginosa* strains is an important public health problem. Our study included patients admitted to a private hospital in İstanbul and revealed the resistance status of all strains isolated over an 11-year period. Accordingly, we believe that resistance is critically high in İstanbul, and empirical treatment should be planned according to the relevant results. Although antimicrobial resistance fluctuated over the years, there was an increase pattern in MIC values over the years. Each hospital's monitoring of antimicrobial resistance status is critical for infection control and shedding light on reasonable antibiotic use. In addition, we believe that these data will contribute to taking effective measures against the problem of antimicrobial resistance by showing the antimicrobial resistance rates that may be detected after COVID-19. We believe that antimicrobial resistance may have increased because of the widespread use of quinolones and cephalosporins in the COVID-19 pandemic. Studies similar to this study should be conducted during the pandemic period.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained for using retrospective data of *Pseudomonas aeruginosa* strains (Private MedicalPark Fatih Hospital Ethics Committee, application number: 2021-1-1).

Informed Consent: Retrospective study.

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: M.G.E., Concept: Ö.Ü., M.D., Design: A.B., M.D., Data Collection or Processing: A.B., M.G.E., Ö.Ü., Analysis or Interpretation: Ö.Ü., Literature Search: A.B., M.G.E., Writing: A.B., M.D.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.51422
Eur Arch Med Res 2023;39(3):196-202

The Relationship Between the Morphology of the Shoulder Joint and Supraspinatus Tendinosis: An MRI Study

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Abstract

Objective: To examine the relationship between the morphological parameters of the shoulder joint and supraspinatus tendinosis.

Methods: A patient group (n=44) was formed from patients diagnosed with supraspinatus tendinosis from medical records and magnetic resonance imaging (MRI) findings. A control group (n=44) was formed by randomly selecting people of similar age and gender to the patient group, who met the exclusion criteria for the patient group, and had normal rotator cuffs on MRI. Coracoacromial ligament thickness (CLT), acromial angle [(AA), delta angle], acromioglenoid angle (AGA), supraspinatus fossa (SFA) glenoid angle on the axial (SGAX) views, SFA glenoid angle on the anterior-posterior (SGAP) views, acromiohumeral distance (AHD), and coracoacromial arch angle (CAA) were measured on MRI images in both groups. Morphological differences between groups were compared using Student's t-test.

Results: Patient group had statistically significant higher CLT and lower AHD values (0.73±0.33 mm and 6.55±0.97 mm, respectively; p=0.007) than control group (1.02±0.53 mm and 7.45±1.61 mm, respectively; p=0.006). Also, there were statistically significant differences between the groups in terms of acromial angle (3.09±5.04° for patient group and 7.9±8.1° for control group; p=0.006). However, there were no statistically significant differences between the groups for AGA, SGAX, SGAP, and CAA (p>0.05).

Conclusion: These findings suggest that CLT, AA, and AHD are important predisposing anatomical factors for developing supraspinatus tendinosis.

Keywords: Supraspinatus tendinosis, magnetic resonance imaging, rotator cuff, coracoacromial ligament thickness, acromial angle

INTRODUCTION

Injuries of the rotator cuff tendon are the most prevalent cause of shoulderache and affect repetitive movements related to work and daily living. Rotator cuff pathologies result from genetic and anatomical risk factors (1). Tendinopathy is a large group of diseases that affect tendons and surrounding structures; it was revealed that rotator cuff lesions are a process that starts with inflammation and progresses to the tear, and the first pathological change is tendinosis (2,3). This change is mostly observed in the supraspinatus tendon. Because of the role of the initiation of abduction of the supraspinatus muscle, supraspinatus tendinosis can cause an important loss of function (4).

It is extremely important to reveal the anatomical factors that predispose patients to supraspinatus tendinosis to better understand this common pathology, which can cause serious deterioration in quality of life. For this reason, there has recently been an increase in the number of studies examining the differences in shoulder morphology in the literature. However, these studies mainly investigated the relationship between shoulder morphology and rotator cuff tears (5-8). To the best of our knowledge, no study has investigated the relationship between shoulder morphology and supraspinatus tendinosis.

This study examined the relationship between supraspinatus tendinosis and morphological parameters of the shoulder.

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Received: 19.08.2023
Accepted: 13.09.2023

Cite this article as: Yüksel Y, Torun E. The Relationship Between the Morphology of the Shoulder Joint and Supraspinatus Tendinosis: An MRI Study. Eur Arch Med Res 2023;39(3):196-202

METHODS

This case-controlled study was designed as randomized and conducted in a university hospital between 2020 and 2021. Shoulder magnetic resonance imaging (MRI) images of adult patients aged 18-65 years who presented with decreased shoulder function such as painful shoulder movements, weakness, restlessness, and stiffness and who were referred to our clinic with the preliminary diagnosis of supraspinatus tendinosis due to the presence of weakness in external rotators, weakness in supraspinatus, and impingement findings in clinical evaluation were retrospectively analyzed.

The patient group was formed from cases with tendinosis [increased intensity in the short time echo (TE) sequence, which is not as bright as the fluid signal in T2-weighted image (WI)] in the supraspinatus tendon on shoulder MRI.

To distinguish tendinosis from the magic angle phenomenon, the persistence of the signal change in the long TE sequence was used to distinguish tendinosis from the magic angle (55°) phenomenon that can be observed in the normal tendon. Patients with a history of trauma or shoulder surgery, inflammatory arthritis, mass lesions, pathology in the tendons forming the rotator cuff other than the supraspinatus tendon, adhesive capsulitis, and a tear or calcific tendinitis in the supraspinatus tendon were excluded from the study.

A control group was formed by randomly selecting people of similar age and gender to the patient group who met the exclusion criteria for the patient group and had normal rotator cuffs on MRI.

Radiologic Evaluation

All MRI studies of the shoulder were performed on a 1.5 Tesla Signa HD, GE Medical Systems (Milwaukee, USA) using an 8-channel dedicated shoulder coil.

The patients were placed in the supine position with the arm in external rotation. In accordance with the study of Madden, the arm was in the external rotation position throughout the acquisition to reduce the frequency of the magic angle (55°) effect due to the orientation of the supraspinatus tendon to the magnetic field (9). Proton density (PD), T1WI, T2WI, and fat-suppressed spin echo (SE) images were obtained in the axial, oblique coronal, and oblique sagittal imaging planes. To avoid misinterpretations due to magic angle artifacts, abnormal signal intensity in PD images was compared with T2WI. The magic angle effect was distinguished from tendinopathy because it had a weaker signal in the long TE sequence than in the short TE sequence (9).

All measurements were performed electronically using digital images. Each measurement was repeated twice and averaged to minimize random errors. The pathological changes and measurements detected in shoulder MRI were reached because of the joint decision of two radiologists experienced in musculoskeletal radiology.

Measured Parameters

Coracoacromial ligament thickness (CLT): CLT was measured at the insertion site of the coracoacromial ligament in the lateral part of the acromion (Figure 1) (10).

Acromial angle (AA) (delta angle): It is the angle between the line parallel to the lower surface of the acromion (a) and the ground plane (b) (Figure 2) (10).

Acromioglenoid angle (AGA): The angle between the lower surface of the acromion (a) and the line parallel to the glenoid bone structure (b) (Figure 3) (11).

Supraspinatus fossa glenoid angle on the axial views (SGAX): This angle was measured on axial MRIs taken immediately beneath the supraspinatus muscle as the angle between the glenoid cavity and the axis of the supraspinatus fossa (SFA) (Figure 4) (12).

Glenoid Version (GV): GV is calculated by subtracting 90° from α angle (GV=α-90°) (13).

Supraspinatus fossa glenoid angle on the anterior-posterior views (SGAP): The SGAP was measured as the angle between the bed of the supraspinatus muscle (supraspinatus fossa) and the bony outline of the glenoid cavity on the oblique coronal MR

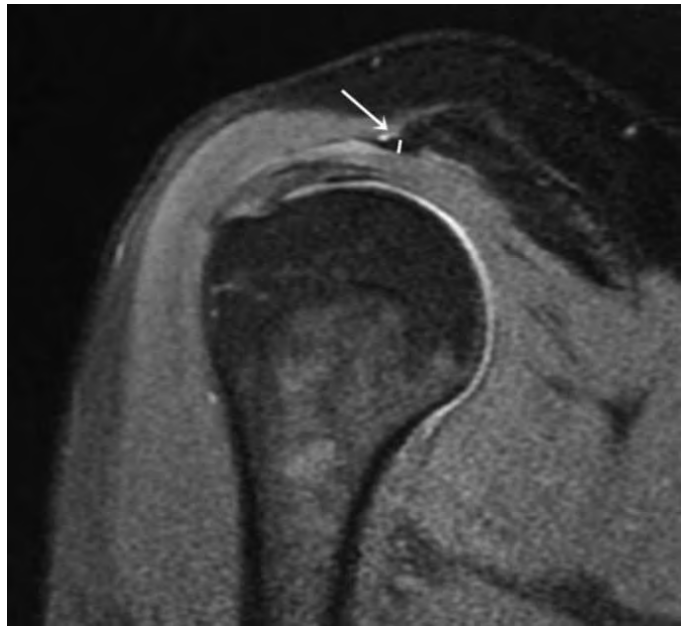

Figure 1. Coracoacromial ligament thickness (CLT)

image (true anteroposterior view) taken immediately posterior to the acromioclavicular joint (Figure 5) (12).

Acromiohumeral distance: This is the shortest distance between the acromion and humerus (Figure 6) (14).

Coracoacromial arch angle (CAA): The angle between the coracocromial ligament axis (which extends from the coracoid process to acromion) (a) and the line tangential to the inferior surface of the acromion (acromial axis) (b) (Figure 7) (15).

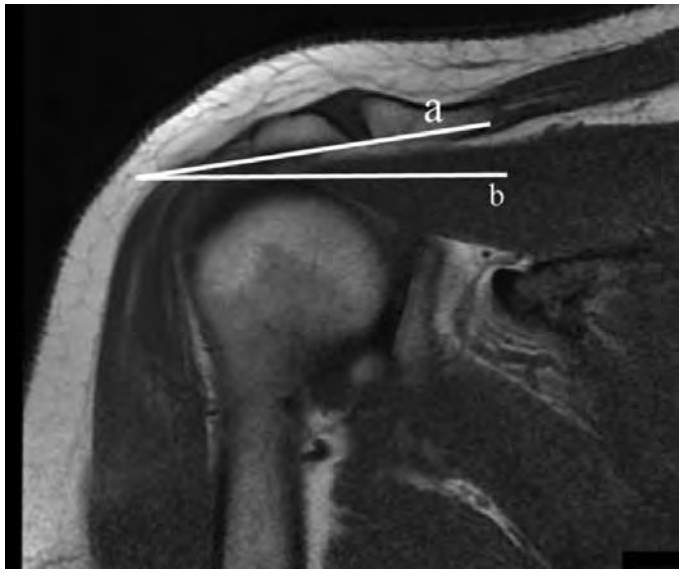

Figure 2. Acromial angle (delta angle)

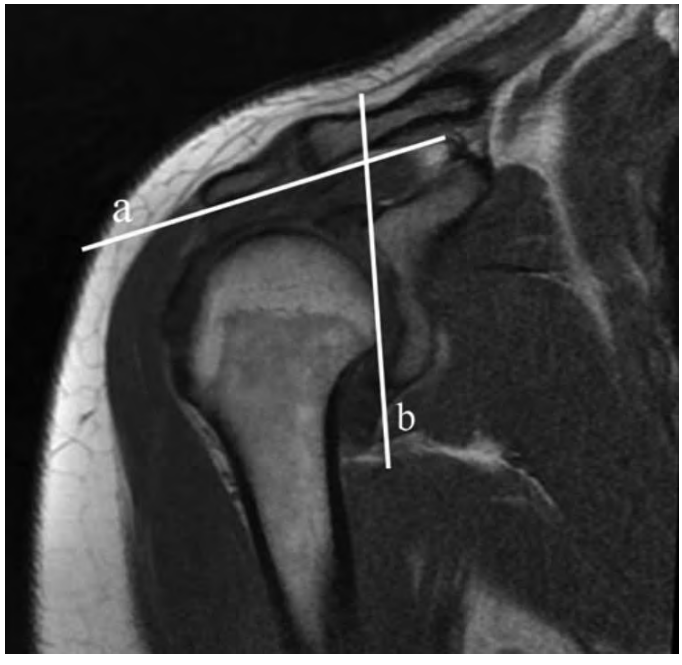

Figure 3. Acromioglenoid angle (AGA)

Ethical Principles

The Alanya Alaaddin Keykubat University Ethics Committee approved the study protocol (date/issue: 07.07.2021,10354421-2021/12-06). This study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical Analysis

Statistical program SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.)

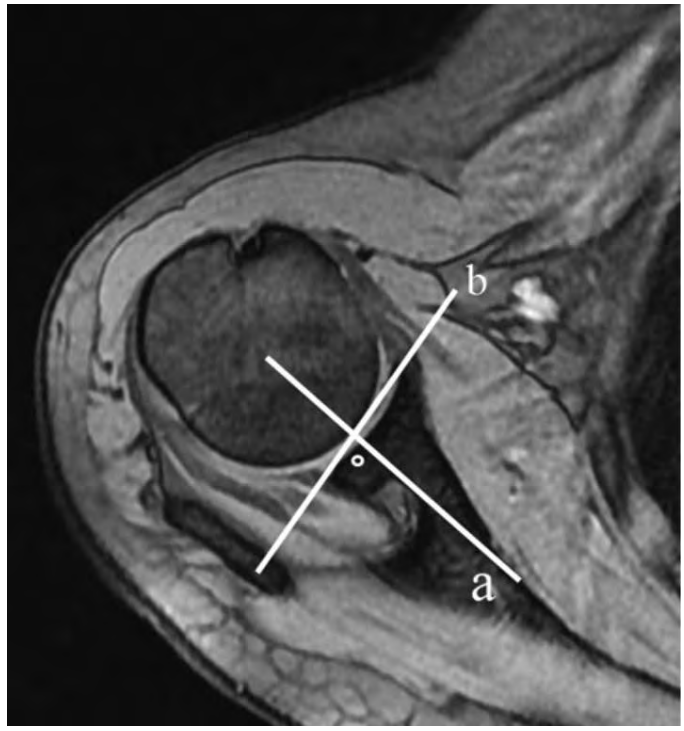

Figure 4. Supraspinatus fossa glenoid angle on axial views (SGAX)

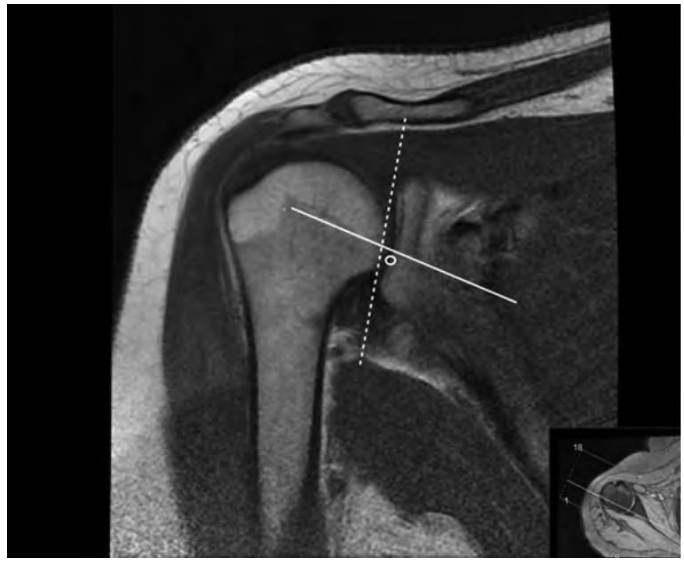

Figure 5. Supraspinatus fossa glenoid angle on anterior-posterior views (SGAP)

was used to analyze the data. The Kolmogorov-Smirnov test was performed for normality analysis. Means and standard deviations are given as descriptive statistics. Student 's t-test to compare differences between both groups was used. P<0.05 was considered significant.

Power and Sample Size Software (PASS; NCSS, Utah, USA) was used to calculate the sample size.

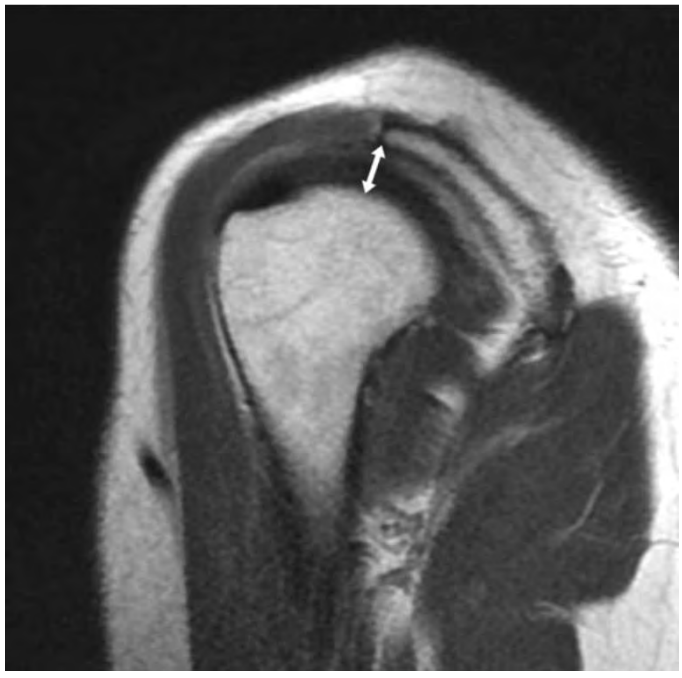

Figure 6. Acromiohumeral distance

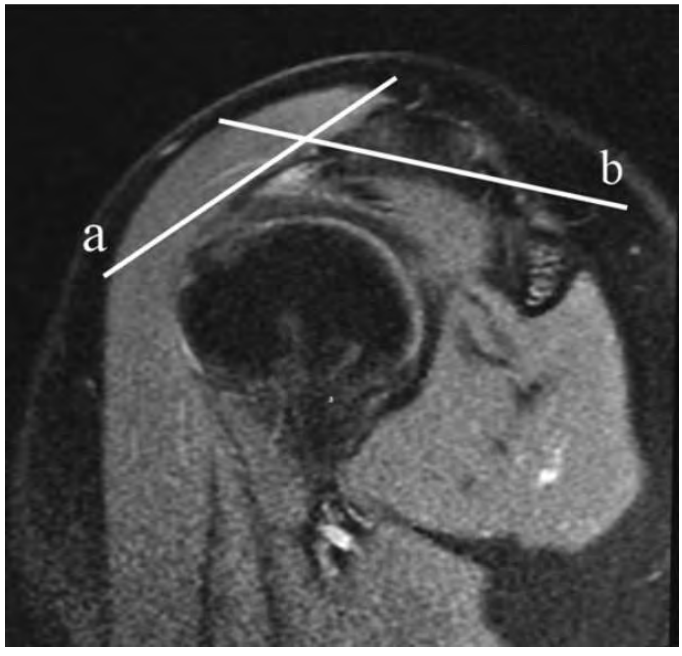

Figure 7. Coracoacromial arch angle (CAA)

With reference to the study of Longo et al., the power of the study was 80%; When the type-1 error was accepted as 0.05 and the effect size was 0.5, it was seen that 88 patients should be included (16).

RESULTS

Eighty-eight subjects were included in the study. There were 25 females (mean age 52.16±6.039) and 19 males (mean age 48.64±4.829) in the patient group and 29 females (mean age 52.18±8.015) and 15 males (mean age 50.34±8.453) in the control group (Table 1). There was no statistically significant difference between the groups in terms of age and gender (p=0.057 and 0.384 respectively).

The patient group had statistically significantly higher CLT values (0.73±0.33 mm) than the control group (1.02±0.53 mm) (p=0.007). The patient group had statistically significantly lower AA values (3.09±5.04°) than the control group (7.87±8.07°) (p=0.006) (Table 2).

The mean AGA values were measured as 80.51±6.38° for the patient group and 82.27±7.75° for the control group (p=0.243). The mean SGAX values were measured as 85.40±4.28° for the Patient Group and 82.27±7.75° for the control group (p=0.655). The mean GV values were measured as -4.593±4.287° for the patient group and -5.472±9.096° for the control group (p=0.655). The mean SGAP values were measured as 79.62±4.44° for the Patient Group and 77.72±5.87° for the control group (p=0.317). There were no statistically significant differences between the groups for AGA, SGAX, and SGAP values (p>0.005) (Table 2).

The patient group had statistically significantly lower AHD values (6.55±0.97 mm) than the control group (7.45±1.61 mm) (p=0.027) (Table 2).

The mean CAA values were measured as 124.12±10.80° for the patient group and 149.00±12.66° for the control group (p=0.667). There were no statistically significant differences between the groups for CAA between the groups (p>0.05) (Table 2).

DISCUSSION

This study is the first to examine the relationship between shoulder joint morphology and supraspinatus tendinosis, and we believe that our study is extremely important in terms of revealing a close relationship between shoulder morphology and the presence of supraspinatus tendinosis. Some studies have been conducted on changes in shoulder morphology related to age and gender. Syed et al. (17) reported significant differences in humeral diameter, humeral head size, greater tuberosity

Table 1. Demographic characteristics of the patient and control groups			
Variables	**Patient group (n=44)**	**Control group (n=44)**	**p**
Age (mean ± SD)	50.16±5.603	53.30±9.00	**0.111**
Sex (female/male)	25/19	29/15	**0.384**
SD: Standard deviation			

Table 2. Comparison of morphological parameters of patient and control groups			
Variables	**Patient group (n=44) mean ± SD**	**Control group (n=44) mean ± SD**	**p**
Coracoacromial ligament thickness (CLT)	0.725±0.332 mm	1.02±0.53 mm	**0.007***
Acromial angle (delta angle) (AA)	3.097±5.042°	7.87±8.07°	**0.006***
Acromioglenoid angle (AGA)	80.51±6.38°	82.27±7.75°	**0.243**
Supraspinatus fossa glenoid angle on axial views (SGAX)	85.40±4.28°	84.53±9.09°	**0.655**
Glenoid version (GV)	-4.593±4.287°	-5.472±9.096°	**0.655**
Supraspinatus fossa glenoid angle on anterior-posterior views (SGAP)	79.62±4.44°	77,72±5,87°	**0.317**
Acromiohumeral distance (AHD)	7.45±1.61 mm	6.55±0.97 mm	**0.027***
Coracoacromial arch angle (CAA)	124.12±10.80°	149.00±12.66°	**0.667**
*p<0.05, SD: Standard deviation			

width, and glenoid neck length between men and women. Tackett and Ablove (18) found that humeral head height, width, and greater tuberosity distance differed significantly between genders. Gumina et al. (19) found that the mean critical shoulder angle (CSA) was significantly lower in the 15-19 age group than in other age groups. They also reported that CSA showed a positive correlation with age (19). For this reason, in order to eliminate the differences that can be observed in shoulder morphology depending on age and gender, this study was conducted by forming a control group from patients of similar age and gender with the patient group, and it was determined that the shoulder structure is a determinant in the development of supraspinatus tendinosis.

Previous studies have clearly mentioned that age-dependent changes due to chronic stress and cellular degradation can cause thickening of the CLT, which may contribute to rotator cuff pathologies (20). Coracoacromial ligament changes and coracoacromial arch angle are associated with rotator cuff tears (21). In Kanatli et al. (22), it was found that coracoacromial ligament degeneration is a strong predictive factor for impingement syndrome. On the other hand, in a study by Cay et al. (15), the authors investigated the relationship between coracoacromial arch structures and rotator cuff pathologies and revealed that there was no statistically significant difference between normal subjects and patients with rotator cuff tear in terms of CLT. Similarly, Zuckerman et al. (23) found no statistically significant difference between normal and tore rotator cuffs for CLT in their study with cadaveric subjects. Consistent with Cay et al. (15) and Zuckerman et al. (23) studies, we found no significant difference in CLT between the patient and control groups.

MRI is the best imaging method for the diagnosis of rotator cuff tendinopathy. Kjellin et al. (24) compared MRI findings with histological analysis of cadaver shoulders and showed that the articular side of the supraspinatus tendon on PD-weighted images corresponded to scarring with eosinophilic, fibrillar, and mucoid degeneration at the unclear border and in the area where the signal intensity increased (without further increasing the signal intensity on T2-weighted images). Williams et al. (25) Gagey et al. (26) found that MRI abnormalities of the rotator cuff correspond to histological changes consistent with tendon degeneration.

In McGinley et al. (10), the authors revealed that steep acromion angulation is associated with CLT and decreased subacromial space. They showed that; a delta angle greater than 7.5° is significantly associated with a higher incidence of supraspinatus tendon tear (10). The results of this study were consistent with McGinley's study; we found a statistically significant difference between the groups for AA.

AGA and SGAP are known parameters that represent the space for the supraspinatus tendon outlet (13). Tokgoz et al. (13) retrospectively studied 42 subjects with supraspinatus tendon tear and 50 asymptomatic controls and found no significant difference in AGA and SGAP. On the other hand, in a study by Tétreault et al. (12), 94 patients who underwent rotator cuff repair and 30 controls with increased SGAP and decreased AGA were found in the patient group when compared with the control group. The results of this study were consistent with Tokgoz et al.'s (13) study. There was no significant difference in AGA and SGAP between the patient and control groups. Different from these studies, our study population had no shoulder surgery; therefore, further studies with subjects both who underwent surgery and who did not undergo surgery should be designed.

The glenohumeral joint has a high susceptibility to instability because of its high mobility. Therefore, the glenoid version (GV) may have an important place in rotator cuff pathologies. Tetrault's study revealed a highly significant difference between patient and control groups in terms of GV (12). Maalouly et al. (27) conducted a study with 41 patients (rotator cuff tears) and 41 controls; they found a significant difference between the groups for GV.

Superior dislocation of the humeral head results in a smaller AHD, which is associated with rotator cuff tears (14,28). Previous studies revealed that the mean AHD in patients with an intact rotator cuff is 10 mm (7-14 mm) (14,29). Goutallier et al. (30) defined the cut-off value as 6 mm for the diagnosis of a full-thickness rotator cuff tear. Various studies have evaluated the relationship between AHD and rotator cuff pathologies (5-8). In Cay et al. (15) study, AHD was found to be narrower than normal limits in patients with rotator cuff tears. In another study by Park et al. (31), investigators measured AHD at three different points in 56 male and 24 female patients; they found that AHD measurement from the lateral and center of the acromion decreased in subjects with impingement syndrome. Similarly, in Ertekin and Kasar's (32) study with 159 patients with impingement syndrome and 201 controls, a correlation was found between AHD and impingement syndrome. Consistent with these studies, we found a significant difference between the patient and control groups for AH distance.

The coracoacromial arch results from the continuous parts of the acromion, coracoacromial ligament, and the coracoid process with each other (33). It is known that if the coracoacromial arch is located lower, then the pressure over the rotator cuff may increase; due to this possibility, some studies have investigated the relationship between CAA and rotator cuff pathologies (33). In a study by Cay et al. (15), with 40 patients having shoulder arthroscopy due to rotator cuff tears and 28 patients with normal shoulder MRI; they found a significant difference between two groups for CAA. On the other hand, in another cadaveric study, there was no significant difference between them (23). There were different measurements in Cay et al. (15) and Zuckerman et al.'s (23) studies. In this study, we measured CAA as in Cay et al. (15). In contrast to Cay et al. (15) study, there was no statistically significant difference in CAA between patients and normal patients. Different from Cay et al. (15) study, the patient group in our study was more specific; this study only included patients with supraspinatus tendinosis, no other shoulder problem. There is a need for further studies with various shoulder pathologies and different measurements of CAA.

Study Limitations

This study has some strengths and limitations. Being a randomized controlled study, evaluating different parameters and the selection of sampling group from specific age and gender to eliminate degenerative changes and gender-related differences are the strengths of this study. When examining the shoulder joint, which is a dynamic and three-dimensional structure, static and two-dimensional evaluation methods may give insufficient results. On the other hand, examining only supraspinatus tendinosis, not examining different gender and age conditions in different patient groups, and not knowing the duration of symptoms and physical activity of the subjects are the limitations of this study.

CONCLUSION

The results of this study suggest that CLT, acromial angle, and AHD are important predisposing anatomical factors for the development of supraspinatus tendinosis. Prospective randomized controlled studies with larger samples should be planned in the background by comparing them with other imaging modalities and considering other leading pathologies related to the rotator cuff.

Ethics

Ethics Committee Approval: This study was conducted in accordance with the principles of the Declaration of Helsinki. This study was approved by the Alanya Alaaddin Keykubat University Medical Ethics Committee (approval date/issue: 07.07.2021,10354421-2021/12-06).

Informed Consent: A retrospective study.

Peer-review: Externally and internally peer reviewed.

Authorship Contributions

Concept: Y.Y., E.T., Design: Y.Y., Data Collection or Processing: Y.Y., E.T., Analysis or Interpretation: Y.Y., E.T., Literature Search: Y.Y., Writing: Y.Y., E.T.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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ORIGINAL ARTICLE

DOI: 10.4274/eamr.galenos.2023.03411
Eur Arch Med Res 2023;39(3):203-213

Comparison of Surgical Apgar Score and Time-Based Modification for Predicting Postoperative Complications in Major Abdominal and Orthopedics Surgery

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Abstract

Objective: The primary aim of this study was to compare surgical Apgar score (SAS) and time-based modification, modified SAS (mSAS), for predicting postoperative 30-day complications and mortality in major abdominal and orthopedic surgeries.

Methods: This prospective study included 308 patients who underwent major abdominal and orthopedic surgery between June and September 2017 at University of Health Sciences Turkey, Prof. Dr. Cemil Taşcıoğlu City Hospital. SAS was calculated based on estimated blood loss, lowest heart rate, and mean arterial pressure. mSAS was calculated by adding surgical duration to SAS. If the surgical duration >480 min, we added -4 points to the SAS score; 421-480 min, -3 points; 301-420 min, -2 points; 181-300 min, -1 points; and <180 min, 0 points.

Results: The comparison of area under curve (AUCs) revealed that the mSAS had a higher diagnostic accuracy for predicting ICU admission [AUC: 0.680, confidence interval (CI) 95% 0.620-0.738, p<0.001], ventilator support more than 48 h (AUC: 0.791, CI 95% 0.657-0.885, p=0.020), reintubation (AUC: 0.665, CI 95% 0.509-0.813, p=0.025), reoperation (AUC: 0.682, CI 95% 0.580-0.777, p=0.019), pneumonia (AUC: 0.626, CI 95% 0.498-0.747, p<0.001), need for albumin replacement (AUC: 0.712, CI 95% 0.648-0.772, p<0.001), and vasopressor requirement (AUC: 0.640, CI 95% 0.470-0.781, p<0.001) than the SAS.

Conclusion: We suggest that operation time should be added as a simple, objective, and practical parameter to SAS. mSAS might be more effective in predicting postoperative outcomes.

Keywords: Morbidity, mortality, perioperative care, postoperative complications, surgery

INTRODUCTION

Over the past decades, high-risk surgical procedures have become more common because of medical developments (1,2). In terms of health economics and patient safety, the rational use of limited resources with the goal of reducing mortality and postoperative complication rates is essential (2). To this end, many types of scoring systems have been developed to predict the risk of perioperative mortality and morbidity (1-4). However, surgical teams have not had a reliable tool for routine use at the end of surgery (5).

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Received: 21.08.2023
Accepted: 14.09.2023

Cite this article as: Yakar MN, Yakar ND, Öztürk AC, Akdaş Tekin E, Turgut N. Comparison of Surgical Apgar Score and Time-Based Modification for Predicting Postoperative Complications in Major Abdominal and Orthopedics Surgery. Eur Arch Med Res 2023;39(3):203-213

Gawande et al. (5) defined the surgical Apgar score (SAS) in 2007. The score was based on three intraoperative parameters, including the lowest heart rate (HR), estimated blood loss (EBL), and mean arterial pressure (MAP). SAS was initially validated randomly selected patients undergoing colectomy. Subsequently, the score has been validated in various surgical procedures to predict postoperative complications and mortality (6-10). In addition, some investigators have created modified versions of SAS for patients with various diseases. Yu et al. (11) added plasma brain natriuretic peptide as a parameter to predict postoperative cardiac events. Pearson et al. (12) used the intraoperative blood transfusion volume instead of the EBL parameter. In elderly patients undergoing abdominal cancer surgery, combining the comprehensive geriatric assessment tool and SAS improved short-term outcome prediction (13). On the other hand, the effect of operation duration on postoperative complications and mortality has been demonstrated in previous studies (14,15). Iino et al. (16) reported that prolonged cross-clamping during aortic valve replacement is an independent factor for postoperative complications and mortality. A previous study also presented a modified version by adding the operation duration as a parameter to the SAS in emergency surgery (17).

Here, we presented a study analyzing patients undergoing major abdominal and orthopedic surgery using SAS for predicting postoperative complications and mortality. We also added the operation duration to the SAS as a simple parameter and determined the diagnostic accuracy of this novel modification in this cohort.

METHODS

Participants and Settings

This prospective study was approved by the local ethics committee of Prof. Dr. Cemil Taşcıoğlu City Hospital, University of Health Sciences Turkey (IRB number: 658; date: May 9th, 2017).

The study protocol was registered at clinicaltrials.gov (ID: NCT04010474). Patients who underwent major abdominal and orthopedic surgery under general or regional anesthesia between June and September 2017 were enrolled in the study. Patients <18 years were excluded. All procedures in this study were performed in accordance with the standards described in the Declaration of Helsinki, revised in 2013 (18). Written informed consent was obtained from the participants or their next of kin.

The sample size calculation revealed a minimum of 275 patients to detect an area under the receiver operator characteristics curve (AUC) value of 0.70 with a power of 90% and an α error of 0.05 (19). Finally, 313 patients were enrolled in the study to compensate for possible dropouts.

Variables

Demographic data, ASA scores, type of surgery, diagnosis, type and amount of preoperative blood product transfusions, and anesthetic methods were recorded. The Glasgow Coma Scale was calculated on the 24th hour after surgery for all patients. The SOFA score was determined on the first day of the intensive care unit (ICU) stay. The length of hospital and ICU stay were recorded.

Major events were defined as mental alterations, acute kidney injury (AKI), major bleeding, cardiopulmonary resuscitation, reoperation, deep venous thrombosis, septicemia, septic shock, acute myocardial injury, new-onset arrhythmia, reintubation, need for invasive mechanical ventilation more than 48 hours, pulmonary thromboembolism, vasopressor requirement, surgical site infection, and need for albumin replacement.

Definition of the Variables

Mental alterations were defined as a comatose state or unconsciousness for ≥24 hours. AKI was defined according to kidney disease: improving global outcomes (20). Major bleeding is defined as bleeding requiring more than 4 units of red blood cell transfusion within 72 h. The diagnosis of thromboembolic events depends on the ultrasonographic or angiographic evidence. Septicemia or septic shock was diagnosed according to the current guidelines (21). Acute myocardial injury was identified as a higher serum concentration of high-sensitive troponin I than the upper reference limit. Diagnosis of surgical site infection based on a previous study (22).

Definition of Modified SAS

The modified SAS (mSAS) score was calculated by adding the duration of surgery to the SAS parameters of the lowest HR, EBL, and MAP. If the surgical duration >480 min, we added -4 points to the SAS score; 421-480 min, -3 points; 301-420 min, -2 points; 181-300 min, -1 points; and <180 min, 0 points (Table 1). Risk categories were defined as low (8-10 points), medium (5-7 points), and high (0-4 points) for bothSAS and mSAS.

For each patient, radial artery catheterization was performed 30 min before surgery to allow real-time MAP and HR monitoring The calculation of EBL was based on the sum of the aspirated blood volume and the number of blood packs. The lowest HR and MAP values were documented from the electronic medical record. The duration of surgery was defined as the time from the induction of anesthesia to the end of surgery.

Table 1. Modified Surgical Apgar score					
mSAS parameters	**0**	**1**	**2**	**3**	**4**
Estimated blood loss (ml)	>1,000	601-1,000	101-600	≤100	-
Lowest MAP (mmHg)	<40	40-54	55-69	≥70	-
Lowest HR (/min)	>85	76-85	66-75	56-65	≤55
	-4	**-3**	**-2**	**-1**	**0**
Surgical duration (min)	>480	421-480	301-420	181-300	≤180
Risk categorization					
High	**Medium**		**Low**		
0-4 points	5-7 points		8-10 points		
The lowest score might be 0 points. MAP: Mean arterial pressure, HR: Heart rate					

Outcomes

The primary outcome of the study was to compare SAS and mSAS. Secondary outcomes are to determine the diagnostic accuracy of SAS and mSAS for postoperative mortality and major complications within 30 days after surgery and to reveal the effect of operation duration on these outcomes.

Statistical Analysis

Statistical analysis was performed using the Number Cruncher Statistical System (NCSS, Kaysville, Utah, USA) version 2007. All data are presented as mean ± standard deviation, frequency and percentage, and median with minimum and maximum values. Chi-square test and Fisher-Freeman-Halton test were used to compare the qualitative data. Spearman's correlation analysis was used to evaluate the association between variables. The intraclass correlation coefficient was used to assess the agreement between the SAS and mSAS scores and risk groups.

Predictive abilities of SAS and mSAS for each complication and death were evaluated using the AUC with the pROC library in the R statistical program (version 3.6.1, R Core Team; R Foundation for Statistical Computing, Austria) (23). Bootstrap with 10,000 replications was used for bias correction in AUC with 95% confidence interval estimations. Results based on both original data and bootstrapped samples are presented. Comparison of SAS and mSAS regarding the AUCs were performed using the DeLong and Bootstrap methods. The p-values obtained from both the De-Long and bootstrap methods are presented. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 308 patients were included in the study after excluding 5 patients because of the decision of inoperability after laparotomy or surgical plan changed to a minor procedure (Figure 1). Four patients died after hospital discharge. Thus, the analysis of major complications within 30 days after surgery was completed in 304 patients. Of the patients, 54.92% were male, and most patients were ≤65 years (Table 2). Most patients underwent abdominal surgery. The ASA II and ASA III rates were 54.5% and 26.0%, respectively. Most patients (88.6%) underwent surgery under general anesthesia. The median operation duration was 190 (140.0-269.5) min. The operation duration of most patients was 180 min. The rates of patients with operation durations of 181-300 min and 301-420 min were 33.8% and 14.3%, respectively. The median length of hospital and ICU stays was 6 (4-8) and 1 (0-1) days, respectively. The median SOFA score of the patients was 1 (0-2). The mean duration of ventilator support was 0.27±2.02.

The rates of the lowest HR during operations were 29.2% for ≤55/min, 34.4% for 56-65 in, 20.1% for 66-75 in, 10.4% for 76-85 in, and 5.8% for <85 min. The distribution of the lowest MAP was as

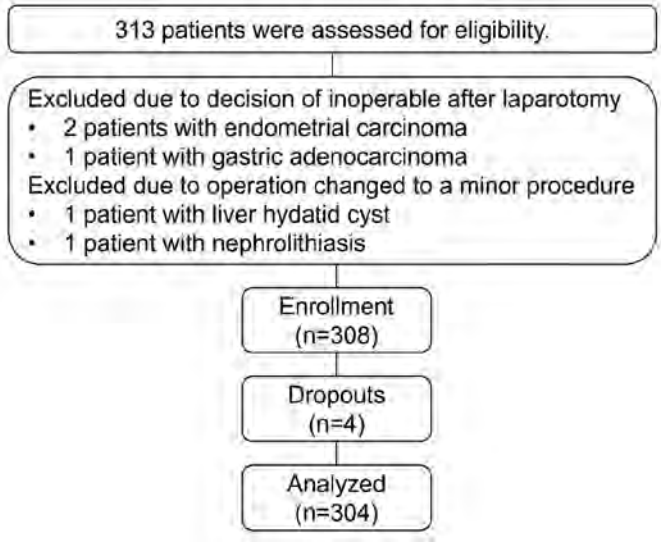

Figure 1. Flow chart of the study

follows: <40 mmHg (1.3%), 40-54 mmHg (18.8%), 55-70 mmHg (38.3%), and more than 70 mmHg (41.6%). EBL was <1,000 mL in 10.7% of the patients, 601-1,000 mL in 14.9%, 101-600 mL in 61.4%, and <100 mL in 13.0%.

The means of the SAS and mSAS risk scores were 7±2 and 6±2 points, respectively (Figure 2). Of the patients, 10.4% (n=32) were at high risk, 54.5% (n=168) at medium risk, and 35.1% (n=108) at low risk, according to the SAS. However, evaluation of the patients with mSAS revealed that 22.4% (n=69) of the patients were at high risk, 54.2% (n=167) at medium, and 23.4% (n=72) at low risk. The relationship between the SAS and mSAS risk groups and the total number of complications are presented in Figures 3 and 4. Statistical analysis determined a significant relationship between the SAS risk score and the total number of complications (p=0.002) and between the mSAS risk score and the number of complications (p=0.001). The rates of patients without a complication in the low-risk group and with one or more complications in the medium-risk group were significantly high, according to mSAS. Additionally, the rate of patients with complications ≥4 was significantly high in the high-risk group of mSAS.

The correlation analysis revealed a significant negative correlation between the SAS (r=-0.270; p=0.001) and mSAS (r=-0.389; p=0.001) scores and the total number of complications. In addition, a positive correlation was observed between the length of operation duration and the total number of complications (r=0.345; p=0.001).

Table 2. Characteristics of patients and operations

Variables	All patients (n=308)
Age, years	
≤65	191 (62.0)
66-75	70 (22.7)
75-85	35 (11.4)
>85	12 (3.9)
Gender, male	169 (54.9)
Surgical branch	
General surgery	139 (45.1)
Orthopedics	101 (32.8)
Urology	68 (22.1)
ASA score	
ASA I	60 (19.5)
ASA II	168 (54.5)
ASA III	80 (26)
Anesthesia type	
General	273 (88.6)
Regional	35 (11.4)
Glasgow coma scale	15-15 (15)
	15±1
Duration of operation, min	140-269.5 (190)
>480	9 (2.9)
421-480	3 (1.0)
301-420	44 (14.3)
181-300	104 (33.8)
≤180	148 (48.1)
Length of, days	
Hospital stay	6 (4-8)
ICU stay	1 (0-1)
SOFA score	1.0 (0.0-2.0)
	1.0±1.0
Duration of ventilatory support, days	0 (0-0)
	0.27±2.02

All values are expressed as number (percentages), median (interquartile range) and/or mean ± standard deviation.
ASA: American Society of Anesthesiologists, SOFA: Score, Sequential Organ Failure Assessment score.

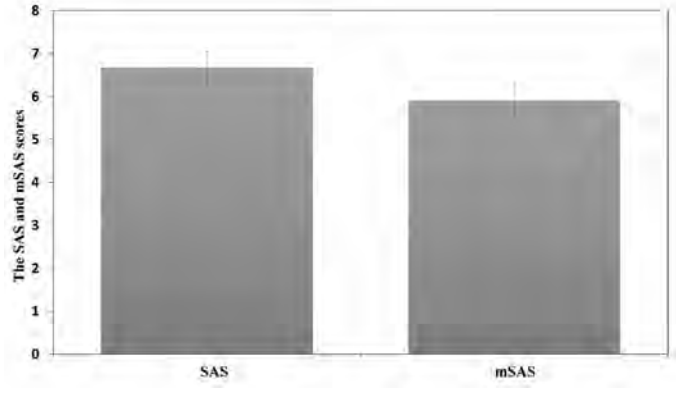

Figure 2. Distribution of SAS and mSAS scores
SAS: Surgical Apgar score

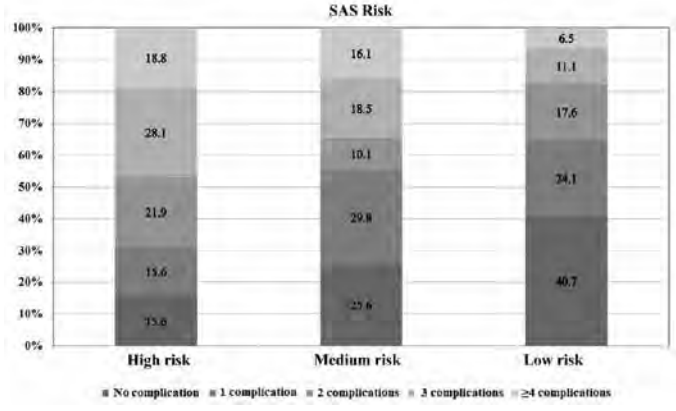

Figure 3. Relationship between SAS risk level and total number of complications
SAS: Surgical Apgar score

Thirty-two of the patients were in the high-risk group, according to SAS and mSAS. SAS revealed that 168 patients were in the medium-risk group. However, 36 of these 168 patients were in the high-risk group, according to the mSAS. Additionally, 36 of 108 patients with low risk based on the SAS were in the medium-risk group, according to the mSAS. The SAS and mSAS levels showed an agreement of 76.6%. The analysis revealed significant agreements between the SAS and mSAS risk levels (ICC=0.742, p=0.001) and scores (ICC=0.822, p=0.001).

A comparison of SAS and mSAS risk levels and complications and mortality are shown in Table 3. The analysis revealed that ICU admission (p=0.037), ventilator support more than 48 h (p=0.042), bleeding requiring transfusion (p=0.001), and need for albumin replacement (p=0.001) were significantly higher in high-risk patients than in lower-risk, according to the SAS. However, the postoperative major events, including ICU admission (p=0.001), ventilator support more than 48 h (p=0.005), reoperation (p=0.009), bleeding requiring transfusion (p=0.001), and need for albumin replacement (p=0.001), were significantly higher in high-risk patients than in lower-risk.

The relationship between the operation duration and postoperative complications and mortality is shown in Table 4. The analysis revealed a significant difference between the duration of ICU admission (p=0.001), ventilator support >48 h (p=0.002), reintubation (p=0.014), reoperation (p=0.001), bleeding requiring transfusion (p=0.001), new-onset arrhythmia (p=0.002), pneumonia (p=0.003), sepsis or septic shock (p=0.002), cardiac arrest (p=0.049), cardiopulmonary resuscitation (p=0.049), need for albumin replacement (p=0.001), and vasopressor requirement (p=0.010). The post-hoc analysis with the Bonferroni correction test revealed that the rate of patients with bleeding requiring transfusion was higher in patients with

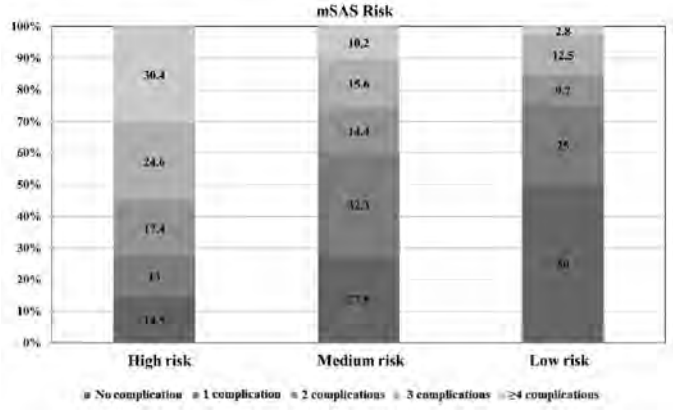

Figure 4. Relationship between mSAS risk level and total number of complications

SAS: Surgical Apgar score

operation duration >420 min than in patients with operation duration between 301 and 420 min (p=0.042). Additionally, the rate of ICU admission (p=0.006), ventilator support more than 48 h (p=0.025), bleeding requiring transfusion (p<0.001), new-onset arrhythmia (p=0.018), sepsis or septic shock (p=0.048), cardiac arrest (p=0.019), cardiopulmonary resuscitation (p=0.017), and need for albumin replacement (p=0.006) were higher in patients with operation duration >420 min than in those with operation duration between 181 and 300 min. Similarly, the rate of ICU admission (p<0.001), ventilator support more than 48 h (p<0.001), bleeding requiring transfusion (p<0.001), and need for albumin replacement (p<0.001) were higher in patients with an operation duration >420 min than in patients with operation duration ≤180 minutes. In patients with operation duration between 301 and 420 min, the rates of ICU admission (p=0.006), reoperation (p=0.006), bleeding requiring transfusion (p=0.018), new-onset arrhythmia (p<0.001), sepsis or septic shock (p=0.007), and need for albumin replacement (p<0.001) were higher than those in patients with operation duration between 181 and 300 min. Additionally, in patients with an operation duration of 301-420 min, the rates of ICU admission (p<0.001), reintubation (p=0.013), reoperation (p<0.001), new-onset arrhythmia (p=0.023), pneumonia (p<0.001), sepsis or septic shock (p=0.019), need for albumin replacement (p<0.001), and vasopressor requirement (p<0.001) were higher than those in patients with operation duration ≤180 minutes.

ROC analyzes were conducted for each complication and death to test the diagnostic accuracy of the SAS and mSAS scores (Table 5 and Figure 5). The areas under the ROC curves were compared to test whether the proposed score was more effective than the SAS score in prognosis. Similar results were obtained based on the original data and bootstrapped samples. In the bootstrapped samples, the comparison of AUCs of complications, including ICU admission (AUC: 0.680, CI 95% 0.620-0.738, p<0.001), ventilator support more than 48 h (AUC: 0.791, CI 95% 0.657-0.885, p=0.020), reintubation (AUC: 0.665, CI 95% 0.509-0.813, p=0.025), reoperation (AUC: 0.682, CI 95% 0.580-0.777, p=0.019), pneumonia (AUC: 0.626, CI 95% 0.498-0.747, p<0.001), need for albumin replacement (AUC: 0.712, CI 95% 0.648-0.772, p<0.001), and vasopressor requirement (AUC: 0.640, CI 95% 0.470-0.781, p<0.001), determined significant differences between SAS and mSAS.

DISCUSSION

In the present study, we aimed to develop a novel SAS by adding operation duration as a simple parameter to the lowest HR, EBL, and MAP. The new modification, mSAS, showed high diagnostic

accuracy for predicting postoperative complications such as ICU admission, ventilator support >48 h, reoperation, and bleeding requiring transfusion in patients in the high-risk group. However, in this study, both SAS and mSAS were insufficient to predict 30-day mortality. AUC analysis showed that mSAS has higher diagnostic accuracy than SAS for predicting reintubation, ICU admission, albumin replacement, vasopressor requirement, reoperation, pneumonia, and ventilator support more than 48 hours. However, SAS is more effective than mSAS in predicting the risk of deep venous thrombosis.

Many diagnostic tools have been developed to predict postoperative complications and mortality (2). How intraoperative variables affect the risk factors associated with postoperative complications and mortality is still debated. Although a quantitative measure of intraoperative care has not been established, optimal management of intraoperative procedures improves postoperative outcomes. Researchers have developed various diagnostic tools that assess measurable intraoperative parameters such as arterial blood pressure, body temperature, heart rate, and blood loss to predict postoperative complications and mortality (3,4,24,25).

SAS has been validated in various surgical subgroups such as abdominal, vascular, urologic, gynecologic, orthopedic, and neurosurgical procedures (10,26-29). Perioperative measures should be monitored early to allow optimal timing of decisions regarding the need for intensive care in the postoperative period (1). Standard tools for predicting postoperative complications and mortality focused on preoperative risk assessment (19,30,31). In addition, intraoperative hemodynamic instability and bleeding volume were rarely included in diagnostic tools (32). Although SAS does not reveal the specific mechanisms that put patients at high risk for postoperative complications and mortality, it determines which patients require intensive care in the early postoperative period (5).

SAS is effective in various surgical subgroups but plays a limited role in orthopedic and elective surgical procedures (33). Similarly, Nair et al. (34) showed that SAS has variability in predicting postoperative complications and mortality in different surgical

Table 3. Comparison of complications and mortality based on SAS and mSAS risk levels

Complications	SAS risk levels				mSAS risk levels			
	High (n=32)	Medium (n=168)	Low (n=108)	p-value	High (n=68)	Medium (n=168)	Low (n=72)	p-value
Unconsciousness	0 (0.0)	5 (3.0)	2 (1.9)	*0.87	0 (0.0)	7 (4.2)	0 (0.0)	*0.07
ICU admission	23 (71.9)	91 (54.2)	50 (46.3)	†**0.037**	49 (72.1)	89 (53.0)	26 (36.1)	†**0.001**
Ventilator support more than 48 h	3 (9.4)	9 (5.4)	1 (0.9)	***0.042**	8 (11.8)	4 (2.4)	1 (1.4)	***0.005**
Reintubation	2 (6.3)	4 (2.4)	3 (2.8)	*0.40	3 (4.4)	6 (3.6)	0 (0.0)	*0.18
Reoperation	3 (9.4)	13 (7.7)	4 (3.7)	†0.33	7 (10.3)	13 (7.7)	0 (0.0)	***0.009**
Bleeding requiring transfusion	20 (62.5)	81 (48.2)	32 (29.6)	†0.001	45 (66.2)	70 (41.7)	18 (25.0)	†**0.001**
Surgical site infection	2 (6.5)	9 (5.4)	9 (8.4)	†0.62	5 (7.5)	10 (6.0)	5 (7.0)	*0.86
New-onset arrhythmia	0 (0.0)	7 (4.2)	2 (1.9)	*0.52	1 (1.5)	7 (4.2)	1 (1.4)	*0.47
Myocardial injury	0 (0.0)	2 (1.2)	0 (0.0)	*0.61	1 (1.5)	1 (0.6)	0 (0.0)	*0.45
Pneumonia	1 (3.2)	10 (6.0)	5 (4.7)	†0.77	6 (9.0)	9 (5.4)	1 (1.4)	*0.14
Sepsis or septic shock	1 (3.2)	8 (4.8)	7 (6.5)	†0.71	3 (4.5)	11 (6.6)	2 (2.8)	*0.48
Bacteraemia	2 (6.5)	5 (3.0)	5 (4.7)	*0.46	5 (7.5)	4 (2.4)	3 (4.2)	*0.19
Acute kidney injury	1 (3.2)	3 (1.8)	0 (0.0)	*0.15	1 (1.5)	3 (1.8)	0 (0.0)	*0.66
Deep venous thrombosis	0 (0.0)	2 (1.2)	0 (0.0)	*0.61	0 (0.0)	2 (1.2)	0 (0.0)	*1.00
Pulmonary embolism	0 (0.0)	1 (0.6)	0 (0.0)	*1.00	0 (0.0)	1 (0.6)	0 (0.0)	*1.00
Cardiac arrest	1 (3.2)	2 (1.2)	0 (0.0)	*0.21	1 (1.5)	2 (1.2)	0 (0.0)	*0.79
Cardiopulmonary resuscitation	1 (3.2)	2 (1.2)	0 (0.0)	*0.21	1 (1.5)	2 (1.2)	0 (0.0)	*0.79
Need for albumin replacement	18 (56.3)	56 (33.3)	22 (20.4)	†**0.001**	41 (60.3)	46 (27.4)	9 (12.5)	†**0.001**
Vasopressor requirement	0 (0.0)	7 (4.2)	2 (1.9)	*0.52	4 (6.0)	4 (2.4)	1 (1.4)	*0.34
Death	1 (3.1)	4 (2.4)	1 (0.9)	*0.47	1 (1.5)	4 (2.4)	1 (1.4)	*1.00

*Fisher-Freeman-Halton test. †Pearson chi-square test. All values are expressed as a number (percentage).
SAS: Surgical Apgar score, mSAS: Modified surgical Apgar score, ICU: Intensive care unit

subgroups. In two different esophagectomy cohorts, SAS suggested a high diagnostic accuracy for postoperative outcomes. In addition, preoperative chemotherapy, intraoperative bleeding volume, and organ reconstruction were other factors associated with postoperative complications and mortality (33,35). A previous retrospective study including patients undergoing arthroplasty revealed that SAS is insufficient for postoperative risk assessment (28). In addition, a prospective study showed that a SAS score of 4 was not considered sufficient for 30-day or 6-month mortality, but the SAS effectively predicted 30-day postoperative complications (36). In the present study, the diagnostic accuracies of SAS and mSAS were statistically significant for predicting ICU admission, ventilator support >48 h, bleeding requiring transfusion, and albumin replacement. Furthermore, mSAS also significantly predicted reoperation.

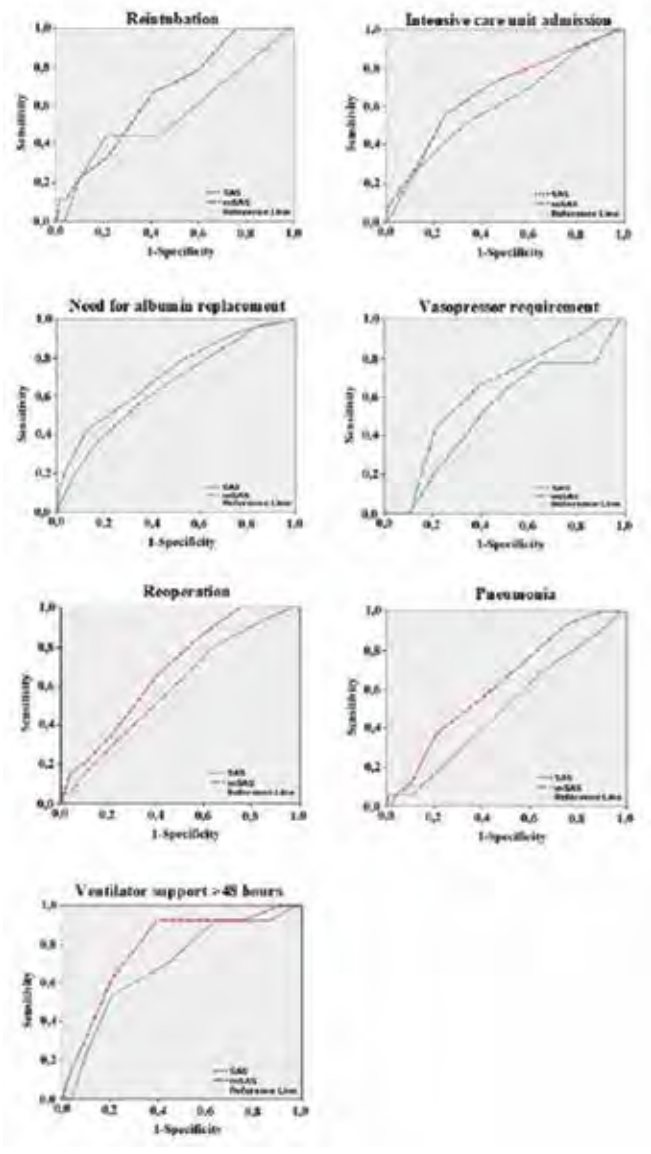

Figure 5. Comparison of the ROC curves

The modification of the SAS in this study is based on the addition of operation duration as a novel parameter. Studies defining the relationship between the duration of operation and postoperative outcomes are limited in the literature. Reich et al. (24) analyzed the physiological parameters of the POSSUM (Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity) score such as HR, systolic blood pressure, and MAP like the SAS in noncardiac surgery, and found that increased HR, systolic blood pressure, and operation duration longer than 220 min were related to postoperative complications. Another study analyzing 8501 patients who underwent abdominal surgery revealed that 24.4% of the patients with an operation duration longer than 6 h were admitted to the ICU. The rate of intensive care admission was 3.5% in patients with an operation duration between 2 and 6 h and 0.7% in those with a duration of less than 2 h (37). Another study on cardiac surgery determined that a cross-clamp duration longer than 150 min was associated with postoperative mortality and morbidity (16). Lee et al. (14) showed that the number of lymph nodes, age, intraoperative bleeding volume, and operation duration were risk factors associated with postoperative complications in radical hysterectomy procedures for cervix neoplasm. Shim et al. (38) also defined operation duration as a risk factor related to postoperative 30-day outcomes in addition to urinary complications, wound infection, blood transfusion >4 units, Charlson comorbidity index ≥2, and bleeding in patients who underwent hysterectomy for benign diseases. In the present study, subgroup analysis based on the duration of surgery showed that the rates of complications such as ventilator support more than 48 h, bleeding requiring transfusion, new-onset arrhythmia, need for albumin replacement, ICU admission, sepsis or septic shock, and pneumonia were higher in patients with longer duration of surgery than in those with shorter duration.

In the present study, the analysis of AUCs for predicting reintubation, ICU admission, need for albumin replacement, need for vasopressor requirement, reoperation, pneumonia, and ventilatory support more than 48 h revealed improved diagnostic accuracy of mSAS compared with SAS. However, SAS showed higher diagnostic accuracy in predicting the risk of deep venous thrombosis than mSAS. The abovementioned findings suggest that adding operation duration as a simple intraoperative parameter to SAS may predict postoperative outcomes at the end of the intraoperative period.

This study has several limitations. First, the study was conducted in a single center with a limited sample size. New studies with larger sample sizes are required to generalize the results. The number of patients with surgical duration longer than 480 min,

Table 4. Relationship between complications, mortality, and operation duration					
Complications	**Operation duration**				**p-value**
	>420 min	**301-420 min**	**181-300 min**	**≤180 min**	
Unconsciousness	0 (0.0)	2 (4.5)	3 (2.9)	2 (1.4)	*0.45
ICU admission	12 (100.0)	36 (81.8)	56 (53.8)	60 (40.5)	***0.001**
Ventilator support more than 48 h	3 (25.0)	4 (9.1)	4 (3.8)	2 (1.4)	***0.002**
Reintubation	1 (8.3)	4 (9.1)	3 (2.9)	1 (0.7)	***0.014**
Reoperation	2 (16.7)	9 (20.5)	4 (3.8)	5 (3.4)	***0.001**
Bleeding requiring transfusion	12 (100.0)	26 (59.1)	34 (32.7)	61 (41.2)	†**0.001**
Surgical site infection	1 (8.3)	6 (13.6)	4 (3.8)	9 (6.3)	*0.15
New-onset arrhythmia	1 (8.3)	5 (11.4)	0 (0.0)	3 (2.1)	***0.002**
Myocardial injury	0 (0.0)	1 (2.3)	0 (0.0)	1 (0.7)	*0.45
Pneumonia	1 (8.3)	7 (15.9)	6 (5.8)	2 (1.4)	***0.003**
Sepsis or septic shock	2 (16.7)	7 (15.9)	2 (1.9)	5 (3.5)	***0.002**
Bacteremia	1 (8.3)	3 (6.8)	2 (1.9)	6 (4.2)	*0.24
Acute kidney injury	0 (0.0)	1 (2.3)	0 (0.0)	3 (2.1)	*0.39
Deep venous thrombosis	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.4)	*0.67
Pulmonary embolism	0 (0.0)	1 (2.3)	0 (0.0)	0 (0.0)	*0.18
Cardiac arrest	1 (8.3)	1 (2.3)	0 (0.0)	1 (0.7)	***0.049**
Cardiopulmonary resuscitation	1 (8.3)	1 (2.3)	0 (0.0)	1 (0.7)	***0.049**
Need for albumin replacement	9 (75.0)	27 (61.4)	28 (26.9)	32 (21.6)	†**0.001**
Vasopressor requirement	0 (0.0)	5 (11.4)	3 (2.9)	1 (0.7)	***0.010**
Death	0 (0.0)	1 (2.3)	0 (0.0)	5 (3.4)	*0.23

*Fisher-Freeman-Halton test. †Pearson chi-square test. All values are expressed as a number (percentage).
SAS: Surgical Apgar score, mSAS: Modified surgical Apgar score, ICU: Intensive care unit

Table 5. Comparison of the predictive ability of SAS and mSAS			
Complications	**SAS**	**mSAS**	**p-value**
	AUC (95% CI)	**AUC (95% CI)**	
Unconsciousness	0.510 (0.452-0.567)	0.552 (0.495-0.609)	0.50
	0.512 (0.310-0.705)	0.555 (0.422-0.671)	0.46
ICU admission	0.610 (0.553-0.665)	0.680 (0.625-0.732)	**<0.001**
	0.610 (0.548-0.670)	0.680 (0.620-0.738)	**<0.001**
Ventilator support more than 48 h	0.694 (0.639-0.745)	0.786 (0.735-0.830)	**0.024**
	0.698 (0.547-0.823)	0.791 (0.657-0.885)	**0.020**
Reintubation	0.557 (0.499-0.613)	0.664 (0.608-0.716)	**0.031**
	0.557 (0.343-0.765)	0.665 (0.509-0.813)	**0.025**
Reoperation	0.595 (0.538-0.650)	0.681 (0.626-0.733)	**0.023**
	0.596 (0.476-0.711)	0.682 (0.580-0.777)	**0.019**
Bleeding requiring transfusion	0.645 (0.589-0.699)	0.669 (0.613-0.721)	0.12
	0.645 (0.584-0.704)	0.669 (0.609-0.728)	0.12
Surgical site infection	0.530 (0.472-0.587)	0.510 (0.453-0.568)	0.88
	0.531 (0.398-0.659)	0.510 (0.377-0.645)	0.88
New-onset arrhythmia	0.525 (0.467-0.582)	0.605 (0.547-0.660)	0.58
	0.525 (0.367-0.676)	0.608 (0.457-0.730)	0.56

Table 5. Continued

Complications	SAS	mSAS	p-value
	AUC (95% CI)	AUC (95% CI)	
Myocardial injury	0.758 (0.706-0.805)	0.762 (0.710-0.808)	0.98
	0.758 (0.646-0.866)	0.762 (0.656-0.863)	0.98
Pneumonia	0.504 (0.447-0.562)	0.625 (0.568-0.680)	**<0.001**
	0.504 (0.369-0.643)	0.626 (0.498-0.747)	**<0.001**
Sepsis or septic shock	0.511 (0.453-0.568)	0.594 (0.536-0.649)	0.55
	0.510 (0.358-0.660)	0.596 (0.462-0.712)	0.54
Bacteraemia	0.537 (0.479-0.594)	0.560 (0.502-0.616)	0.56
	0.538 (0.343-0.727)	0.563 (0.363-0.752)	0.55
Acute kidney injury	0.674 (0.618-0.726)	0.632 (0.575-0.686)	0.65
	0.673 (0.455-0.896)	0.637 (0.419-0.795)	0.60
Deep venous thrombosis	0.650 (0.593-0.703)	0.501 (0.443-0.558)	**<0.001**
	0.650 (0.425-0.864)	0.501 (0.288-0.710)	**<0.001**
Cardiac arrest	0.745 (0.692-0.793)	0.788 (0.738-0.833)	0.70
	0.749 (0.473-0.930)	0.787 (0.653-0.992)	0.64
Cardiopulmonary resuscitation	0.745 (0.692-0.793)	0.788 (0.738-0.833)	0.70
	0.749 (0.473-0.930)	0.787 (0.653-0.992)	0.64
Need for albumin replacement	0.653 (0.597-0.706)	0.711 (0.657-0.761)	**<0.001**
	0.654 (0.586-0.718)	0.712 (0.648-0.772)	**<0.001**
Vasopressor requirement	0.530 (0.473-0.588)	0.636 (0.580-0.691)	**0.014**
	0.533 (0.334-0.701)	0.640 (0.47-0.781)	**0.010**
Death	0.664 (0.609-0.717)	0.592 (0.534-0.647)	0.24
	0.669 (0.455-0.847)	0.600 (0.400-0.748)	0.21

The first row shows areas under the ROC curve and its 95% CI based on the original data, and those based on bootstrapped samples are shown in the second row.
SAS: Surgical Apgar score, mSAS: Modified surgical Apgar score, ICU: Intensive care unit

between 421 and 480 min, and between 301 and 420 min is limited. A larger sample size in these groups may provide more reliable results than the present. In addition, another limitation is the heterogeneous characteristics of the sample size, which includes different disciplines. Therefore, our study has some strengths. The prospective nature of this study provides reliable data. This study is the first on this topic. Beyond the effect of mSAS, the analysis revealed the importance of operation duration for postoperative outcomes.

CONCLUSION

Depending on the results of this study, operation duration should be added to the SAS as a simple, objective, and practical parameter for predicting postoperative outcomes in major abdominal and orthopedic surgeries. This study demonstrated that this novel modification has high diagnostic accuracy for predicting postoperative complications. The combination of electronic medical records, mSAS, and the assessment of preoperative risk factors may help improve postoperative outcomes. Future studies may focus on using undefined intraoperative objective parameters that facilitate the achievement of postoperative care goals.

Ethics

Ethics Committee Approval: This prospective study was approved by the local ethics committee of Prof. Dr. Cemil Taşcıoğlu City Hospital, University of Health Sciences Turkey (IRB number: 658; date: May 9th, 2017).

Informed Consent: Written informed consent was obtained from patients or their next of kin.

Peer-review: Externally and internally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: M.N.Y., N.D.Y., A.C.Ö., E.A.T., N.T., Concept: M.N.Y., N.D.Y., A.C.Ö., E.A.T., N.T., Design: M.N.Y.,

N.T., Data Collection or Processing: M.N.Y., N.D.Y., A.C.Ö., E.A.T., Analysis or Interpretation: M.N.Y., N.D.Y., A.C.Ö., E.A.T., N.T., Literature Search: M.N.Y., N.D.Y., Writing: M.N.Y., N.D.Y., A.C.Ö., E.A.T., N.T.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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CASE SERIES

DOI: 10.4274/eamr.galenos.2023.57855
Eur Arch Med Res 2023;39(3):214-216

A New Digital Method Proposition for Depth Measurement in Patients with Pectus Excavatum

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Abstract

The follow-up of patients with minimal pectus excavatum is generally made by depth measurement of the concavity. The measurement is usually performed with a manual ruler extended to depth. Here we present a measurement method with a digital caliper to standardize and sensitize the assessment. This measurement technique is not intended to replace the radiologically measured pectus index. Our aim with this technique is to digitize the manual technique currently used. The device consists of a combination of a ruler and a digital caliper. The ruler was attached to the sternum at the level of the deepest part of the deformity, the tip of the caliper was pushed until the depth of the deformity was reached, and the value on the screen was recorded. Measurements were made by two surgeons unaware of each other's measurement results. We used this technique in 60 patients with pectus excavatum deformity. There were 17 females (28.3%) and 43 males (71.7%). Median age was 10 (range: 2-18) and median depth of deformity was 11.3 mm (range: 4-37.3 mm). There was no significant difference between the values recorded by 2 surgeons. As a result, we concluded that digital measurement can be safely used in the follow-up of patients with pectus excavatum.

Keywords: Pectus excavatum, funnel chest, vacuum bell, deformity

INTRODUCTION

Pectus excavatum (PE) has been reported to be the most common congenital chest deformity in many articles. Treatment decisions and follow-up of patients with PE are made using clinical and radiological measurements (1). Thoracic computed tomography is generally not required in patients with minimal deformity, and depth grade are used in patient follow-up. There are different methods in the literature for measuring pectus depth. The depth measurement of concavity, which is most widely used, is made with a ruler placed on the sternal edges and a measuring stick inserted from there to the depth of the deformity (2,3). The course of deformity in patients with PE who underwent vacuum bell therapy was determined by measuring the depth of concavity at each outpatient control. Standard, precise, and objective measurements are very important for follow-up. Here, we describe a digital measurement method using a device called a digital pectusmeter for measuring the depth of PE deformity.

Technique

The new method used in our technique consists of a ruler measuring 17x150 mm and 1.5 mm thick and a digital caliper adapted to measure depth. The caliper is made of carbon fiber raw material and has a 40x15 mm LCD screen. Measurement options are available in millimeters (mm) and inches. Measurement options are available in millimeters and inches. Its measurement accuracy is 0.1 millimeter (mm) and the device can be calibrated for every measurement. The part-measuring the depth by moving into the concavity is plastic and has a blunt tip, so it does not do any damage to the skin. The measurement technique has been described on the model. The wooden ruler is placed on both edges of the

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Received: 14.01.2023
Accepted: 12.06.2023

Cite this article as: Sayan M, Tombul İ, Aslan MT, Kurtoğlu A, Ahmedova G, Çelik A. A New Digital Method Proposition for Depth Measurement in Patients with Pectus Excavatum. Eur Arch Med Res 2023;39(3):214-216

sternum transversely, and the LCD screen of the digital caliper is opened. The value 0.0 should be displayed on the screen, and if a different value is seen, it should be calibrated with the "zero" key (Figure 1A, B). The tip of the digital pectusmeter device is advanced toward the concavity of the deformity. When the end of the deformity is reached, the value on the LCD is recorded (Figure 2A, B). Measurements were made by 2 different surgeons who were unaware of each other.

CASE PRESENTATION

The records of patients whose depth of PE deformity was measured digitally between January 2022 and September 2022 were retrospectively reviewed. Data of the patients, including age, gender, and depth of pectus concavity were collected. Analyses were performed using SPSS 25 (IBM Corp., Armonk, NY, USA). Continuous variables are given as median with minimum maximum and mean with standard deviation according to the distribution of values. Categorical variables are given as n and percentage (%). Whether there was a difference between the measurement values of the 2 different surgeons was investigated using the paired sample t-test. A p value of <0.05 was considered statistically significant.

A total of 60 patients whose pectus deformity was assessed digitally were included in the study. There were 17 females (28.3%) and 43 males (71.7%). Median age was 10 (range: 2-18) and median depth of deformity was 11.3 mm (range: 4-37.3 mm). There was no significant difference between the values recorded by 2 surgeons.

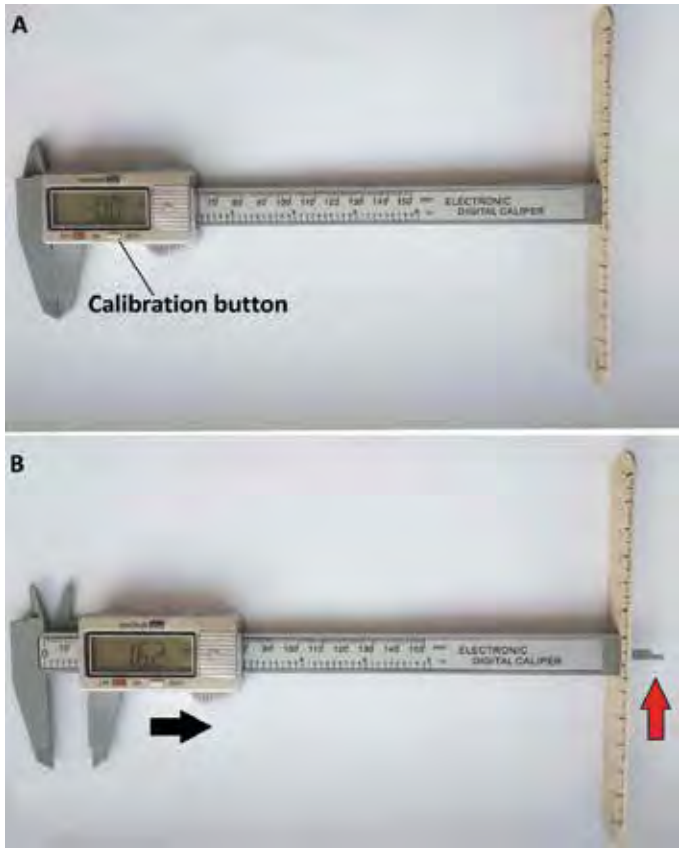

Figure 1. (A) Figure shows resetting the digital pectusmeter to prepare for measurement. (B) The black arrow indicates the direction of advancement of the tip of the device. The red arrow indicates the tip of the device advancing into the pectus concavity

DISCUSSION

Here, we describe a digital method for depth measurement of PE deformity. Depth measurement is very important in the follow-up of patients suffering from PE, especially in the evaluation of the effect of vacuum bell therapy. Toselli et al. emphasized the importance of the initial depth in PE deformity (4). We believe that making this measurement digitally will increase the sensitivity. Sesia et al. (5) developed a pressure-controlled vacuum bell device in the treatment of PE and evaluated the treatment effectiveness by measuring the depth of the pectus. For the evaluation of patients with PE to be optimal, depth measurement should be precise and standardized and should be performed in the same way at every outpatient control. Here, we propose to avoid subjectivity with digital measurement and standardize follow-ups with precise values (one-tenth of a

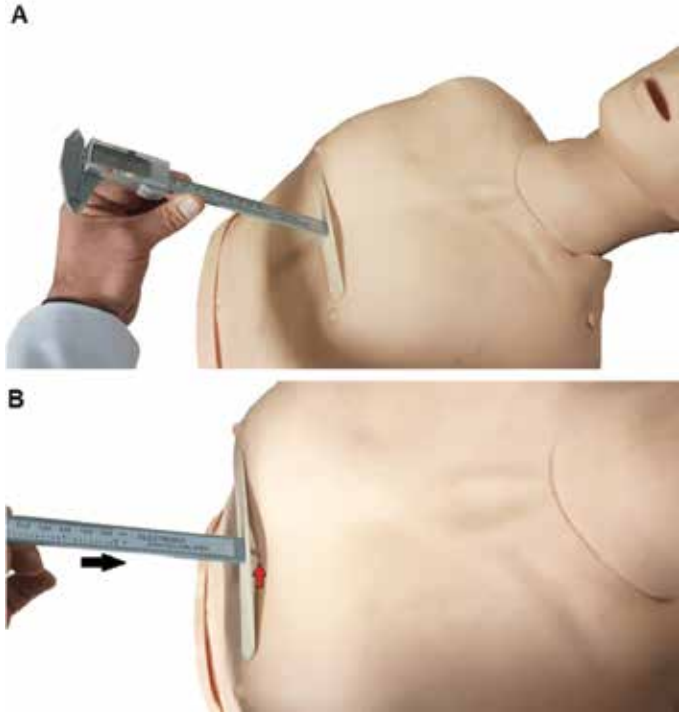

Figure 2. (A) The placement of the digital pectusmeter appears on the model. (B) The red arrow indicates the measurement of concavity of pectus excavatum deformity

millimeter) for each application. Surgical treatment is generally preferred for large deformities, and the Haller index is measured by tomography for treatment indication (6). However, thoracic computed tomography contains high-dose radiation and is not needed in small deformities that can be treated by non-surgical methods such as vacuum bell devices. The effectiveness of follow-up and treatment in these patients is determined by depth measurement. Liu et al. (7) defined the sternum index to calculate pectus severity and determine surgical indication using a radiation-free method. In their formula, a sagittal measurement is made from the deepest part of the cavity, and the distance between the sternum and vertebral body is divided by the patient's height. As a result of this study, the authors concluded that the sternum index can determine both pectus severity and surgical treatment efficacy (7). Our digital pectusmeter device, which is described here, does not claim to be an alternative to computed tomography for calculating the Haller index. It is recommended for the initial evaluation and follow-up of patients with relatively mild PE deformities.

CONCLUSION

As a result, the initial evaluation and follow-up of patients with PE can be made standard and more sensitive with the digital pectusmeter device proposed in this technical report. The feasibility of the digital pectusmeter device is that it is easy to apply, can measure small deformities, is suitable for all ages including infants, can be calibrated in every measurement, and is non-invasive. Although we applied this technique to a model, a clinical study comparing it with conventional measuring methods in the initial examination and follow-up of patients suffering from PE may show its usability.

Ethics

Informed Consent: Obtained.

Peer-review: Externally and internally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: M.S., İ.T., M.T.A., A.K., G.A., A.Ç., Concept: M.S., İ.T., M.T.A., A.K., G.A., A.Ç., Design: M.S., İ.T., M.T.A., A.K., G.A., A.Ç., Data Collection or Processing: M.S., İ.T., A.Ç., Analysis or Interpretation: M.S., İ.T., A.K., A.Ç., Literature Search: M.S., M.T.A., A.K., G.A., Writing: M.S., İ.T., M.T.A., A.K., G.A., A.Ç.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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INTERESTING IMAGE

DOI: 10.4274/eamr.galenos.2023.61587
Eur Arch Med Res 2023;39(3):217-218

Erythematous Nodule on the Right Knee of a Child: Dermatofibrosarcoma Protuberans

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Keywords: Nodule, immunohistochemistry, storiform

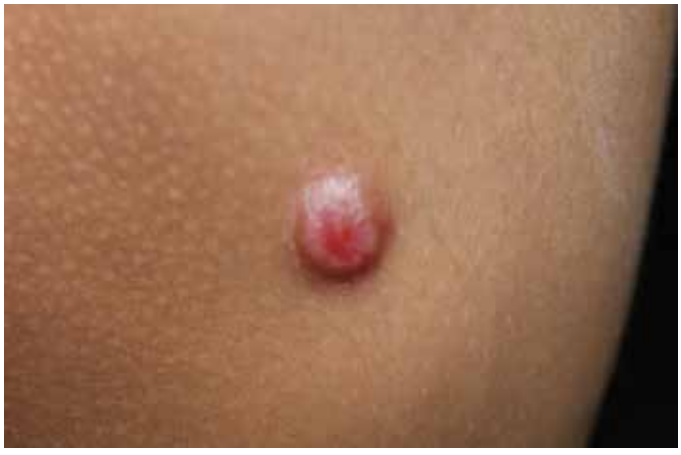

Figure 1. A 10 years-old male patient presented to our outpatient clinic because of a painless mass for 2 months on the right knee. There was no comorbidity in his history. Dermatological examination revealed a 2x2 cm erythematous nodule in the medial region of the right knee.

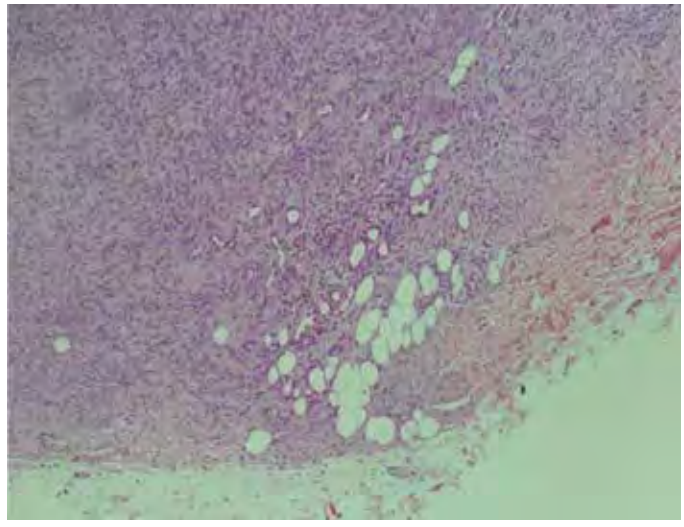

Figure 2a. Excisional biopsy obtained from the lesion. Histopathological examination showed the infiltration of the atypical elongated spindle cells with nuclear monomorphism along the subcutaneous fat tissue [hematoxylin and eosin (H&E) x10].

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Cite this article as: Tepe Ç, Çelik MÖ, Aktaş E, İlteriş Oğuz Topal İO, Şenkaya E. Erythematous Nodule on the Right Knee of a Child: Dermatofibrosarcoma Protuberans. Eur Arch Med Res 2023;39(3):217-218

Received: 15.03.2023
Accepted: 12.06.2023

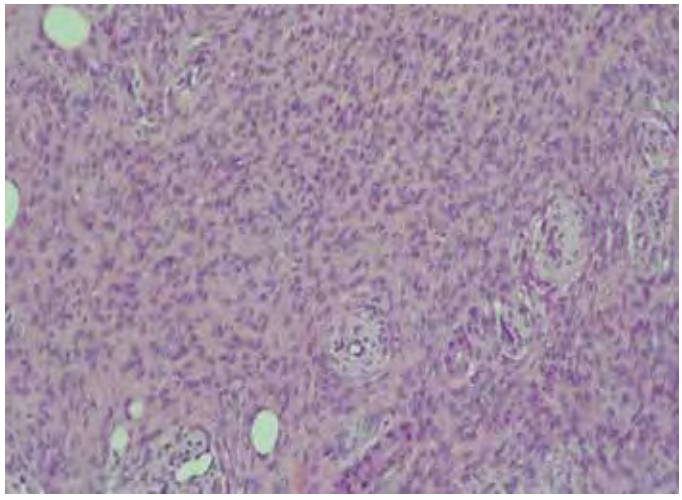

Figure 2b. A storiform pattern was observed in the dermis (H&E x20).

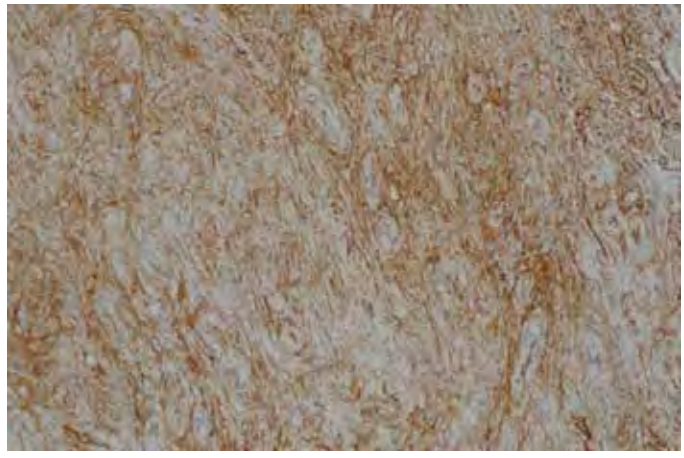

Figure 2c. Immunohistochemical examination revealed CD34 (+), S100 (-), Kİ 67 (-), HHV8 (-). Based on these findings, the patient was diagnosed with dermatofibrosarcoma protuberans (DFSP) (x20).

DFSP is an uncommon soft tissue tumor that involves the dermis, subcutaneous fat, and, in rare cases, muscle and fascia. Diagnosis is made via skin biopsy (1). Tumors occur most often in adults in the third to fifth decades of life but have rarely been reported in the pediatric population. The prevalence of DFSP before 20 years of age is 1.0 per million (2).

Although most of the nodules are usually benign in pediatric patients, if the lesions are resistant to treatment and have an atypical clinical appearance, further examinations should be performed in terms of malignancy.

Ethics

Informed Consent: Informed consent was obtained from the patient.

Peer-review: Internally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: İ.O.T., Concept: E.A., İ.O.T., Design: E.A., İ.O.T., Data Collection or Processing: E.A., İ.O.T., Analysis or Interpretation: İ.O.T., M.Ö.Ç., Literature Search: Ç.T., M.Ö.Ç., İ.O.T., Writing: Ç.T., İ.O.T.

Conflict of Interest: No conflict of interest was declared by the authors.

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

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