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EURASIAN JOURNAL OF EMERGENCY MEDICINE
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Integrating Disaster Medicine into Emergency Department Protocols

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Keywords: Disaster medicine, emergency department, surge capacity planning

The increasing frequency and intensity of natural disasters, pandemics, and mass casualty events have highlighted the urgent need for robust disaster preparedness in emergency departments (EDs). Because EDs are at the forefront of disaster response, integrated disaster medicine practices are essential. By minimizing casualties and maximizing care, these protocols guarantee a streamlined, efficient and successful response to the unexpected rush of patients during disasters.

In this editorial, we focus on integrating disaster medicine into ED protocols and highlight strategies for preparedness, staff training, resource allocation, communication, and patient care during disasters.

Disaster medicine includes mass casualty medical management and the planning and deployment of medical personnel during natural, technical, or man-made disasters. This approach is distinct from standard emergency medicine in that it requires an emphasis on the scope, synchronization, and prompt use of resources when managing excessive patient numbers in limited spaces.

The scope of disaster medicine includes (1):

1. Triage and treatment of casualties
2. Resource management (staff, facilities, equipment)
3. Coordination with external agencies [electromyostimulation (EMS), public health, military]
4. Public health considerations, including disease outbreak prevention
5. Ethical decision-making in resource-limited situations

To prepare for any type of disaster, EDs must adopt an "all-hazards approach" to disaster medicine (2). This means that protocols should be designed to be adaptable, regardless of the specific nature of the disaster, whether it be a pandemic, chemical spill, earthquake, or terrorist attack.

The Key Elements of the "All-hazards Approach" Are (3):

1. Hazard Identification and Risk Assessment: ED protocols should begin with a thorough assessment of the types of disasters most likely to affect the region. This includes natural disasters (e.g., earthquakes, floods), technological accidents (e.g., industrial spills), and intentional disasters (e.g., terrorism).

2. Flexible and Scalable Protocols: Disaster protocols should be created with flexible solutions to handle different patient numbers and medical demands, and they should be scalable based on the severity of the disaster.

Disaster medicine integration within ED protocols should cover the following key areas:

Disaster Triage and Patient Flow Management

During a disaster, EDs can be quickly crowded with an influx of patients. Disaster triage systems, such as simple triage and rapid treatment prioritize patients based on the severity of their injuries

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and likelihood of survival (4). The protocol should define precise triaging of patients that adjust to mass casualty situations. Specific areas for triage and patient flow should be designated that include overflow areas within or outside the hospital to manage patient surges. Moreover, to minimize ED congestion, alternative care locations like mobile units or repurposed spaces, should be provided.

Surge Capacity Planning

One of the primary concerns during disasters is surge capacity-the ability to handle an influx of patients far beyond the usual patient load (5). Disaster protocols should ensure bed surge capacity by identifying areas for patient expansion, such as hallways, waiting rooms, and non-clinical spaces. Staff surge capacity, which involves the cross-training of hospital staff to provide emergency care in crises. In addition, resource surge capacity includes medical supplies (oxygen, medications) and equipment (ventilators, stretchers), with an emphasis on rationing critical resources during prolonged disasters.

Communication Systems and Coordination

Smooth communication both within the hospital and with outside organizations (EMS, public health, military) is essential for an efficient disaster response. Protocols should use redundant communication systems (e.g., radio, satellite phones) to maintain contact with field teams and command centers. An incident command system is to be assigned to coordinate emergency response within the hospital and ensure proper alignment with city, state, and federal disaster plans. Furthermore, regular updates to ED staff regarding the disaster status and ongoing patient flow are to be ensured.

Staff Training and Simulation Drills

The integration of disaster medicine requires continuous staff education and training. Interdisciplinary simulation drills that mimic different disaster scenarios help ensure that staff are familiar with disaster protocols and can execute them under pressure. Triage, mass casualty treatment, patient transport, and coordination with external agencies should all be part of these simulations.

Resource Allocation and Supply Chain Management

During disasters, supplies such as medications, personal protective equipment (PPE), and ventilators may be limited. Therefore, EDs must develop a disaster stock of critical resources to ensure they are readily available during emergencies. Memoranda of understanding with local suppliers and other hospitals to share resources during shortages need to be established. Furthermore, a resource rationing plan to manage the fair allocation of limited resources when demand exceeds supply is to be established.

Mental Health Care During Disasters

Both patients and healthcare professionals may experience severe psychological stress as a result of disasters (6). ED disaster protocols must incorporate mental health care and provide psychological first aid and crisis counseling to survivors and their families. Mental health support for healthcare workers who are likely to experience burnout, post-traumatic stress disorder, or emotional trauma after prolonged exposure to disaster scenarios must be ensured. Finally, to assist personnel in processing their experiences both during and after the disaster, a strategy for peer support programs within the ED should be put into action.

Decontamination and Infection Control Protocols

Certain disasters, such as chemical spills and infectious disease outbreaks, require special handling of patients and the environment. The protocols should establish a decontamination unit within or near the ED for handling patients exposed to hazardous materials. Stringent infection control protocols, including isolation areas for patients with contagious diseases and PPE guidelines for staff, are to be developed.

Post-disaster recovery plans are essential for the ongoing well-being of patients and staff (7). The integration of disaster medicine does not end when the immediate crisis is over. ED protocols should include debriefing sessions for staff members to discuss what went well and what needs to be done to improve. The effectiveness of disaster protocols and identification of gaps for future improvement must be evaluated. Continuous patient care during follow-up is required after the initial disaster response.

Conclusion

In conclusion, integrating disaster medicine into ED protocols is not an option but a necessity in today's environment of frequent and unpredictable disasters. EDs must be equipped with flexible, scalable protocols that ensure rapid and coordinated responses. By focusing on preparedness, training, surge capacity, communication, and collaboration, EDs can be better prepared to manage disasters and provide life-saving care in the most challenging conditions.

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Use of Technology in Disaster Medicine

Jameel Abualenain

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Abstract

This review explores the impact of telemedicine, mobile health (mHealth) applications, and point-of-care ultrasound in disaster scenarios. A comprehensive literature review was conducted using databases such as PubMed, MEDLINE, and Google Scholar to identify relevant studies on technology in disaster medicine. The findings indicate that telemedicine significantly enhances communication and coordination among emergency teams, mHealth applications improve patient tracking and triage, and point-of-care ultrasound provides rapid and accurate diagnostics in disaster settings. These technological advancements have contributed to efficient and effective disaster response efforts, highlighting the critical role of technology in modern disaster medicine.

Keywords: Disaster medicine, technology, telemedicine, mobile health, point-of-care ultrasound, emergency response

Introduction

Disaster medicine is a critical field focused on providing medical care in the aftermath of natural and human disasters. These events can overwhelm healthcare systems, leading to significant challenges in timely and effective care delivery to affected populations. Recent technological advancements have the potential to transform disaster medicine by enhancing preparedness, response, and recovery efforts. This literature review explores the role of various technological innovations, including telemedicine, mobile health (mHealth) applications, and point-of-care ultrasound, in improving disaster response and management. By examining the current state of technology in disaster medicine, we highlight the benefits, challenges, and future directions of research and practice.

Natural disasters, such as earthquakes, hurricanes, and floods, as well as man-made crises like terrorist attacks and industrial accidents, can result in mass casualties and significant disruptions to healthcare infrastructure (1,2). In such scenarios, the rapid deployment of medical resources and effective coordination among emergency responders are critical for saving lives and reducing morbidity (3). Traditional disaster response methods often struggle to meet these demands, leading to delays and inefficiencies in care delivery (4).

Technological innovations offer promising solutions to these challenges by enabling real-time communication, remote diagnosis and treatment, and efficient resource management (5,6). For example, telemedicine allows healthcare providers to deliver medical care remotely, bridging the gap between affected areas and specialized medical centers (7). mHealth applications further enhance disaster response by providing tools for patient tracking, triage and information management (8). These applications can streamline the flow of information, ensuring that responders have up-to-date data on patient status and resource availability. Additionally, point-of-care ultrasound devices offer portable, easy-to-use diagnostic tools that can be deployed in the field to rapidly assess and treat injuries (9).

Despite the potential benefits of such technologies, their implementation in disaster medicine is not without challenges. Issues such as the interoperability of different systems, the reliability of communication networks, and the need for training and support must be addressed to fully realize the advantages of technological solutions (10). This review aims to provide a comprehensive overview of the state of technology in disaster medicine, identify key areas for improvement, and suggest future research and development directions.

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Brief Literature Review

A literature search was conducted to identify relevant studies on the use of technology in disaster medicine. The databases that were searched were PubMed, MEDLINE, and Google Scholar. The search terms used were "disaster medicine," "technology," "telemedicine," "mobile health," "mHealth," "point-of-care ultrasound," and "emergency response." The search was limited to articles published in English between 2000 and 2023. The inclusion criteria were studies that discussed the application of these technologies in disaster scenarios, provided empirical data or case studies, and contributed to understanding the benefits and challenges of telemedicine, mHealth applications, and point-of-care ultrasound in disaster settings. The exclusion criteria included articles not focused on disaster scenarios or those lacking empirical data.

Relevant articles were selected based on their contributions to understanding the benefits and challenges of the technologies under consideration. The selected articles were then analyzed using a thematic analysis approach to highlight key findings and trends. This process involved data coding to identify common themes and synthesizing results to provide a comprehensive overview of the current state of technology in disaster medicine.

Review Outcomes

A total of 24 studies were included in this review. These studies highlight the significant impact of telemedicine, mHealth applications, and point-of-care ultrasound on disaster response and management. The findings from these studies are categorized and summarized below.

Telemedicine in Disaster Response

Telemedicine provides remote medical support and enhances communication and coordination among emergency teams. Several studies have demonstrated the significant benefits of telemedicine in disaster settings:

Real-time Communication: Telemedicine facilitates real-time communication between on-site responders and remote medical specialists, allowing for timely decision-making and expert consultation. For example, Benner et al. (1) highlighted the use of telemedicine during a natural disaster in Germany, where remote specialists provided critical support to on-site teams and improved patient outcomes. Additionally, Callaway et al. (3) described the effective use of telemedicine during the Haiti earthquake, where it enabled efficient coordination and resource allocation.

Remote Diagnostics: Remote diagnostic capabilities enable healthcare providers to assess patients' conditions without the need for physical presence, which is particularly valuable in inaccessible or hazardous areas. Boeriu et al. (2) reported the successful deployment of telemedicine in remote areas during a flood disaster in Romania, where remote diagnostic methods significantly enhanced the speed and accuracy of patient assessments.

Improved Coordination: Enhanced coordination among emergency teams and healthcare facilities ensures that resources are allocated efficiently and that patient care is prioritized based on severity and need. Franc-Law et al. (7) found that telemedicine improved coordination during a simulated disaster exercise, resulting in more efficient resource utilization and better patient management, a finding also supported by Mazur and Rippey (11).

mHealth Applications

mHealth applications improve patient tracking and triage during disasters. Several studies have demonstrated the significant benefits of mHealth applications in disaster settings:

Patient Tracking: mHealth applications provide real-time patient tracking, enabling responders to monitor their status, location, and medical needs. Harrison et al. (8) reported that mHealth applications are crucial for tracking patient movements and needs during hurricanes in the United States.

Triage Management: These applications assist in the triage process by providing standardized assessment tools and algorithms, ensuring that patients are prioritized according to the severity of their conditions. Madanian et al. (12) described the use of mHealth applications in earthquake response scenarios, where they improved the triage accuracy and speed.

Resource Allocation: mHealth applications help manage resources by providing up-to-date information about the availability of medical supplies, personnel, and facilities. Case et al. (4) found that mHealth applications were instrumental in managing resources during a simulated pandemic, ensuring that critical supplies were directed where they were needed most. This finding is further supported by Doarn and Merrell (13), who highlighted the effectiveness of mHealth applications in crisis situations, emphasizing their role in resource management.

Point-of-care Ultrasound

Portable ultrasound devices enable rapid diagnosis in disaster situations. Several studies have demonstrated the significant benefits of point-of-care ultrasound in disaster medicine:

Rapid Diagnostics: Point-of-care ultrasound allows for quick and accurate diagnosis of injuries and conditions, facilitating timely and appropriate treatment. Lee C. et al. (14), through a systematic review and meta-analysis, highlighted the accuracy and critical role of the Focused Assessment with Sonography for Trauma in disaster settings, supporting its utility in improving diagnostic processes during mass casualty incidents.

Portability: These devices are compact and easy to transport, making them suitable for use in field settings and remote areas. Chan et al. (5) described the deployment of portable ultrasound devices during a major disaster, where their portability was critical for providing diagnostic services in challenging environments. This was further evidenced by Wydo et al. (15), who emphasized the critical role of portable ultrasound devices in disaster triage, particularly in mass casualty incidents, where rapid assessment in remote and resource-limited settings is crucial.

Non-Invasive: Ultrasound is a non-invasive diagnostic tool, reducing the risk of complications and enhancing patient safety. Haynes et al. (9) highlighted the safety and efficacy of point-of-care ultrasound in disaster scenarios and noted its advantages over more invasive diagnostic techniques.

The integration of technology into disaster medicine enhances the efficiency and effectiveness of emergency response. Telemedicine, mHealth applications, and point-of-care ultrasound are critical tools that improve communication, patient management, and healthcare provider preparedness. However, several challenges must be addressed to fully realize the benefits of these technologies.

Interoperability Issues: One of the primary challenges is the interoperability of different systems. In disaster settings, multiple agencies and organizations often work together, each using their own technologies and communication platforms. Ensuring that these systems can communicate and share data seamlessly is essential for effective coordination and response (2,6,8). This requires standardizing protocols and investing in interoperable technologies to overcome this barrier (5,16,17). The development of universal standards for data sharing and communication is crucial for improving interoperability among disparate systems used by various organizations during disasters (5,6,16).

Reliability of Communication Networks: Another challenge is the reliability of communication networks. Disasters can disrupt communication infrastructures, making it difficult for responders and medical teams to maintain contact. Developing resilient communication networks that can withstand disaster conditions is crucial for maintaining effective communication and coordination (6,18). This involves investing in satellite communication systems, portable mobile networks, and other technologies that provide reliable communication in the absence of traditional infrastructure (7,10,19).

Training and Support: Training and support are essential for successful implementation of these technologies. Healthcare providers and emergency responders must be trained to use telemedicine, mHealth applications, and point-of-care ultrasound effectively (7,20). Simulation-based training programs have been shown to significantly improve healthcare provider preparedness and confidence in disaster scenarios (9,21). Continuous education and training are necessary to ensure personnel are proficient in using these technologies under stressful and rapidly changing conditions (9,22).

Ethical and Legal Considerations: The rapid pace of technological advancement presents ethical and legal challenges. Ensuring patient privacy and data security is paramount in the chaotic environment of a disaster response (10,23). There may be legal issues related to the use of telemedicine across state or national borders, as well as the liability of remote practitioners (11). Clear guidelines and policies must be established to address these concerns (11,24).

Despite these promising findings, this review has several limitations. The selection of articles was limited to those published in English, potentially excluding relevant studies in other languages. The rapid pace of technological development means that some reviewed technologies may be outdated or surpassed by new innovations. The variability in study designs and contexts makes it challenging to generalize findings across different disaster scenarios. Reliance on self-reported data in some studies may introduce bias and affect the reliability of the findings. Future research should address these limitations by including a broader range of studies, regularly updating reviews, and utilizing standardized methodologies.

Conclusion

Technological advancements in disaster medicine, including telemedicine, mHealth applications and point-of-care ultrasound, significantly enhance the efficiency and effectiveness of disaster response. These technologies improve communication, patient management, and healthcare provider preparedness, leading to better disaster outcomes. However, challenges such as system interoperability, communication network reliability, training, and ethical considerations must be addressed to fully realize the potential of these innovations. Continued research, investment, and collaboration are essential for advancing the role of technology in disaster medicine and improving global disaster preparedness and response.

Ethics

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

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Predictive Parameters for Hospital Admission Among Liver Transplant Recipients Presenting to the Emergency Department: A 5-Year Study

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Abstract

Aim: Liver transplantation (LT) has significantly improved patient outcomes, leading to increased numbers of LT recipients seeking emergency department (ED) care. However, there is a lack of comprehensive information regarding their outcomes and parameters influencing hospital admission decisions. This study aims to address the gap in knowledge by analyzing critical parameters influencing hospital admission decisions for LT recipients presenting at the ED.

Materials and Methods: A retrospective observational case-control study was conducted with 247 consecutive LT patients who visited a tertiary care center's ED between 2018 and 2023. Demographic information, transplantation details, presenting complaints, laboratory results, and ED outcomes were evaluated. Univariate analysis identified significant predictors for an artificial neural network (ANN) analysis to predict admission decisions.

Results: Among 247 LT recipients presenting at the ED, 48.2% were admitted. The most common complaints among admitted patients were abdominal pain and fever. Patients admitted had higher levels of alanine aminotransferase, aspartate aminotransferase (AST), alkaline phosphatase, gamma-glutamyl transferase, and C-reactive protein (CRP) and lower levels of total protein and albumin compared to discharged patients. Ultrasonography findings of perihepatic fluid collection were more common in admitted patients. The ANN analysis identified total protein, conjugated bilirubin, CRP, total bilirubin, and AST as the most influential factors predicting hospital admission decisions.

Conclusion: The ANN analysis identified total protein, conjugated bilirubin, CRP, total bilirubin, and AST influencing hospital admission decisions for liver transplant recipients in the ED. Emphasizing the significance of these parameters can guide evidence-based guidelines for improved patient care and resource allocation in emergency settings.

Keywords: Liver transplantation, hospital admission decisions, emergency department outcomes, artificial neural network analysis, clinical decision-making

Introduction

Liver transplantation (LT) represents the established treatment for end-stage liver diseases within contemporary medical practice (1). The historical trajectory of this medical advancement has significantly improved patient outcomes in terms of both quality of life and long-term survival (2). Pioneered in 1967 by Dr. Starzl in the United States (US) and later achieved in Turkey by Dr. Haberal in 1988, the success of LT has since been fortified by advancements in surgical techniques, augmented public awareness initiatives, and dedicated efforts from transplant centers (3). As a result, the number of successful LTs has substantially increased, positively impacting an estimated 100.000 patients in the US alone (4). While Turkey's annual

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liver transplant volume may differ from the US, the country's per capita transplantation rate remains commendable on the global stage (3). The expanding success and improved survival rates post-transplantation have concurrently led to a notable rise in LT recipients seeking care at emergency departments (ED) (5). Approximately 30-45% of patients have been observed to present to EDs within the first two years post-transplantation, underscoring the clinical significance of this subject matter (6,7).

After LT, the occurrence of various early and late complications has been extensively documented (8). Early complications often involve intricate aspects such as surgical technique, liver graft dysfunction, rejection, or infection (9). In the medium to long-term, complications are primarily linked to the administration of immunosuppressive therapy, with the exception of chronic rejection (10,11). Following LT, patients initially receive care from transplant surgeons and/or hepatologists. However, after several months, the overall medical management of LT recipients is typically handed back to primary care clinicians (12). While practices may differ among transplant centers, managing immunosuppressive agents to treat recurrent liver disease and address biliary complications constitutes standard responsibilities of transplant centers. Consequently, when patients encounter unforeseen medical issues or require urgent care outside regular working hours, EDs become the primary recourse for immediate medical attention. The management of LT recipients requires a multi-systemic evaluation and a multi-hierarchical approach. The roles of emergency physicians in LT patients include the recognition and management of various emergent conditions that may arise due to LT, such as acute or chronic rejection, emergencies related to hypertension, kidney failure, infections, diverse dermatological conditions, and acute metabolic states associated with diabetes mellitus, in addition to being proficient in recognizing and managing complications related to immunosuppression, biliary complications, and the recurrence of primary liver disease, while ensuring early referral of patients to their primary transplant centers for appropriate management (7,10,13,14).

Notably, despite the abundance of guidelines for managing liver diseases, there is a conspicuous dearth of specific algorithms concerning the management of emergency visits by LT recipients, whether pertaining to liver-related complications or unrelated medical issues (15). Despite extensive attention devoted to early and late complications in the literature, the significance of lifelong care to ensure graft and patient survival remains emphasized (16). This underscores the crucial roles played by emergency physicians, to some extent general practitioners, and primary care centers in the ongoing follow-up care of these patients, particularly when dealing with issues directly associated with transplantation or other medical conditions necessitating attention within the context of transplant recipients. Furthermore, there is a notable lack of guidance and shared experiences for non-transplant team physicians in managing post-transplant care (16). This is attributed to the fact that while the transplant team predominantly comprises professionals responsible for identifying the need for transplantation, performing the transplantation procedure, and monitoring post-transplant care, emergency physicians are often not integrated into these teams in many centers (17-19). Nevertheless, considering the medications employed, surgical history, and pre-existing conditions of transplant recipients, the identification of clearly defined indications for transferring these patients to transplant centers or teams remains an area yet to be fully addressed.

Upon meticulous review of the literature, it is evident that there exists only partial analysis of postoperative complications and ED visit reasons among LT recipients. This dearth of parameters influencing admission and discharge decisions from the ED presents a notable gap, hindering the formulation of essential guiding principles for emergency physicians. Thus, our study's primary objective is to undertake a comprehensive analysis of the critical parameters impacting the decision-making process regarding the admission of LT recipients who present at the ED.

Materials and Methods

Study Design

This study was designed as a retrospective observational case-control study and obtained ethical approval from the Memorial Şişli Hospital Ethics Committee prior to its commencement (decision no: 003, date: 03.06.2023). Written consent was obtained from the patients or their legal guardians, and in the case of deceased individuals, from their next of kin, prior to the study. The study adhered to the principles outlined in the Helsinki Declaration.

Study Setting and Population

Consecutive LT patients who presented to the Memorial Şişli Hospital ED between 2018 and 2023 were included in this study. The hospital, a tertiary care center, performs a considerable number of liver transplants annually (approximately 60 LT operations per year), while its ED handles approximately 20.000 visits each year. The study encompassed both orthotopic and liver donor transplant recipients. The study excluded patients with pre-hospital cardiac arrest, as well as those with in-ED cardiac arrest, and trauma patients.

All LT patients presenting to the ED during the study period were initially considered for inclusion. The total number of patients identified was Each patient's eligibility was assessed, and their records were reviewed. Out of the 301 patients identified, 247

met the inclusion criteria and were included in the study. Fifty-four patients were excluded based on the following criteria: pre-hospital cardiac arrest (1 patients), in-ED cardiac arrest (1 patients), trauma (46 patients), and patients whose files could not be reached (6 patients). No patients declined participation after being approached.

Study Protocol and Measurements

Data were extracted from the hospital's electronic medical records system. The collected data included demographic information (age, gender), details about the transplantation procedure (emergency or elective), time elapsed from transplantation to ED visit, presenting complaints (including the four most common complaints: fever, weakness, nausea, and abdominal pain), complete blood count parameters [white blood cells (WBC), hematocrit (HCT), platelet count (PLT), activated partial thromboplastin time (aPTT), international normalized ratio (INR), biochemical parameters (alanin aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), lactate dehydrogenase (LDH), total bilirubin, conjugated bilirubin, albumin, total protein, urea, creatinine, c-reactive protein (CRP)], ultrasonography findings (perihepatic fluid, perihepatic collection, free abdominal fluid), and ED outcomes (admission or discharge). Relevant parameters had <5% missing data, which was addressed using the multiple imputation method.

Statistical Analysis

Data were evaluated using Statistical Package for Social Sciences v29 (IBM Corp., Armonk, NY). For categorical variables, descriptive statistics included frequency and percentage, while continuous variables were presented as mean ± standard deviation or median with interquartile range (25^{th} -75^{th}). The normality of data distribution was assessed using the Shapiro-Wilk test and histograms. For between group comparisons of categorical variables (e.g., gender, presenting symptoms), the Chi-Square test was applied. The Chi-Square test was chosen because it evaluates whether there is a significant association between two categorical variables, which is appropriate for determining the relationship between patient characteristics and admission status. The assumptions of the Chi-Square test were confirmed for all categorical variables. For normally distributed continuous variables (e.g., age), the t-test was used to compare the means between groups. This test was chosen because it is suitable for comparing the means of two independent groups when the data are normally distributed. For non-normally distributed continuous variables (e.g., time elapsed from transplantation to ED visit), the Mann-Whitney U test was applied to compare medians. This non-parametric test was chosen because it does not assume normal distribution and is appropriate for comparing medians of two independent groups. Univariate analysis identified statistically significant parameters as predictors for the artificial neural network (ANN) analysis. ANN was chosen for this study due to its ability to model complex, non-linear relationships between multiple predictors and outcomes, which traditional statistical methods might not capture effectively. The ANN method involved the use of a multilayer perceptron with one hidden layer, employing hyperbolic tangent as the activation function for the hidden layers and softmax for the output layer (Figure 1). This architecture was selected to balance model

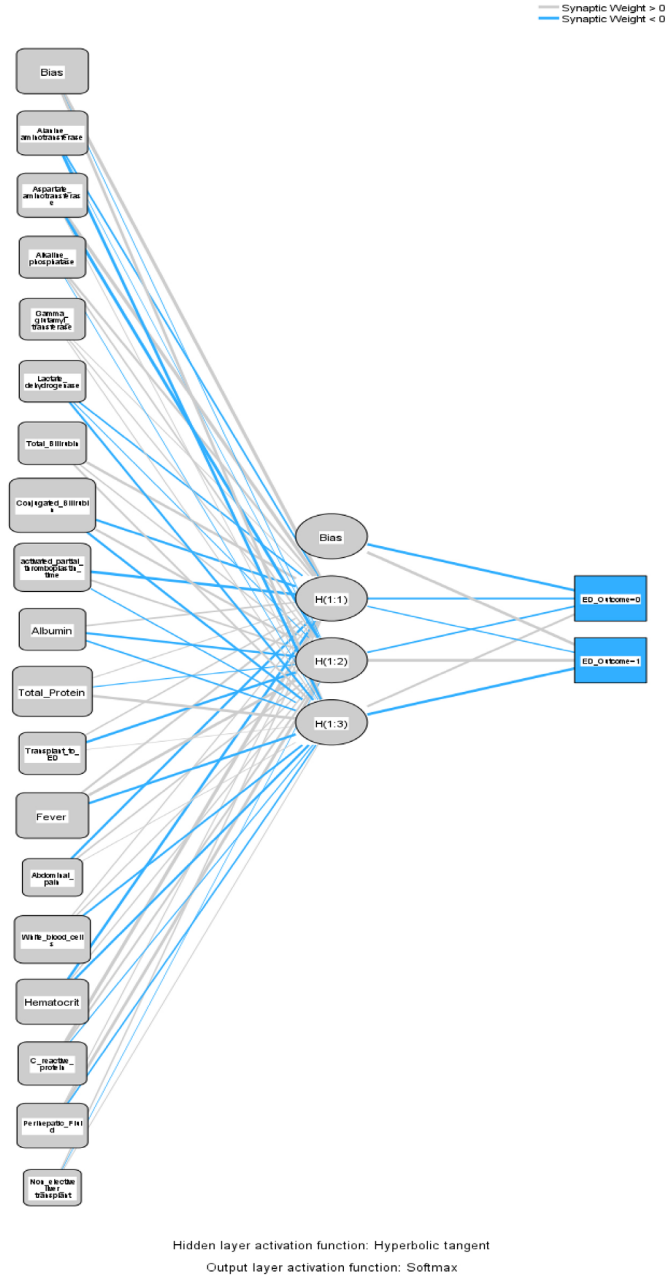

Figure 1. Synaptic weight figure of the neural network analysis model

complexity and interpretability. The model was trained using 70% of the data and validated using the remaining 30% to assess its robustness and generalizability. The ANN was specifically chosen to leverage its strengths in handling large datasets with numerous predictors, allowing for the identification of subtle patterns and interactions. The diagnostic accuracy of the model was assessed using the area under the receiver operator characteristics.

To control for potential confounding factors, we included all significant variables from the univariate analysis as input features in the ANN model. The ANN inherently considers multiple variables simultaneously, thereby accounting for the potential confounding effects by analyzing the combined influence of these variables on the outcome. Additionally, we performed sensitivity analyses by systematically excluding individual variables to assess their impact on the model's performance and ensure robustness of the findings. This approach helps to minimize the risk of biased results due to confounding factors.

Results

A total of 247 LT recipients were enrolled in this study. Based on their ED outcomes, the patients were categorized into two groups: admission (n=119, 48.2%) and discharge (n=128, 51.8%). There were no statistically significant differences in median age and gender distribution between the two groups (Table 1) (Man-Whitney U test for age comparison p=0.105, Chi square test for gender distribution p=0.127). Notably, the admission group exhibited a statistically higher proportion of patients presenting with fever and abdominal pain compared to the discharge group (Chi-square test for both comparisons; p<0.001, p=0.007, respectively). Furthermore, the median duration between transplantation and ED visit was found to be significantly longer in the admission group [122.5 days (IQR 58.25-232 days)] compared to the discharge group [98 days (IQR 42-234 days)] (Mann-Whitney U test; p=0.004).

In the discharge group (Table 2), the mean WBC (8.81 ± 5.18 $x10^9$/L) was observed to be 1.35 (95% CI 0.69-2.02) $x10^9$/L lower than that of the admission group (10.16 ± 7.77 $x10^9$/L) (Students' t-test; p<0.001). Additionally, the mean HCT (34.09 ± 4.42 %) was found to be 0.75% [(95% confidence Interval (CI) 0.24% -1.26%)] units higher than the admission group (33.34 ± 5.61%) (Students' t-test; p=0.005). However, there was no statistically significant difference in mean PLT between the two groups (Students' t-test; p=0.519).

Interestingly, the admission group exhibited statistically higher median levels of ALT, AST, ALP, GGT, LDH, total bilirubin, and conjugated bilirubin compared to the discharge group (Table 3) (Mann-Whitney U test; p<0.001 for all parameters). Moreover, the mean albumin (3.83 ± 0.54 g/dL) in the admission group was 0.3 g/dL (95% CI 0.24-0.35 g/dL) lower than the discharge group (4.13 ± 0.41 g/dL) (Students' t-test; p<0.001), while the mean total protein (6.27 ± 0.72 g/dL) in the admission group was 0.59 g/dL (95% CI 0.51-0.67 g/dL) lower than the discharge group

Table 1. Demographic characteristics, transplant history, and presenting complaints of patients

		discharge (n=119)	admission (n=128)	p value
Age (in years)		40 (27-56)	46 (16-60)	0.105
Sex (female)		63 (54.3%)	57 (44.5%)	0.127
Liver transplantation status (emergent)		26 (21.8%)	14 (10.9%)	0.02
Time to ED after transplant (days)		98 (42-234)	122.5 (58.25-232)	0.004
Presenting symptom	Fever	29 (24.4%)	59 (46.1%)	<0.001
	Fatigue	17 (14.3%)	29 (22.7%)	0.091
	Nausea	19 (16%)	28 (21.9%)	0.237
	Abdominal pain	22 (18.5%)	43 (33.6%)	0.007

ED: Emergency department

Table 2. Comparison of complete blood count and bleeding profile parameters between groups

	discharge (n=119)	admission (n=128)	p value	Mean difference (95% CI)
WBC ($x10^9$/L)	8.81 ± 5.18	10.16 ± 7.77	<0.001	1.35 (0.69-2.02)
HCT (%)	34.09 ± 4.42	33.34 ± 5.61	0.005	0.75 (0.24-1.26)
Platelet ($x10^3$/µL)	242.44 ± 124.3	237.57 ± 164.8	0.519	
aPTT (seconds)	31 (28-34.7)	33.45 (30-37.37)	<0.001	
INR	1.25 (1.09-1.59)	1.24 (1.11-1.46)	0.6	

WBC: White blood cell, HCT: Hematocrit, aPTT: Activated partial thromboplastin clotting time, INR: International normalized ratio, CI: Confidence Interval

Table 3. Comparative analysis of hepatic and inflammatory blood markers between discharge and admission groups				
	discharge (n=119)	**admission (n=128)**	**p value**	**Mean difference (95% CI)**
ALT (U/L)	26 (15-62)	31 (19-76)	<0.001	
AST (U/L)	26 (17-48)	32 (22-52)	<0.001	
ALP (U/L)	113 (82-233)	148 (93-239)	<0.001	
GGT (U/L)	43 (27-90)	63 (23-133)	<0.001	
LDH (U/L)	208 (172-287)	236 (184-310)	<0.001	
Total bilirubin (mg/dL)	0.58 (0.36-0.86)	0.86 (0.48-1.48)	<0.001	
Conjugated bilirubin (mg/dL)	0.29 (0.18-0.45)	0.42 (0.2-0.87)	<0.001	
Albumin (g/dL)	4.13±0.41	3.83±0.54	<0.001	0.3 (0.24-0.35)
Total protein (g/dL)	6.86±0.67	6.27±0.72	<0.001	0.59 (0.51-0.67)
Urea (mg/dL)	37 (27-46)	38 (27-51)	0.068	
Creatinin (mg/dL)	0.77 (0.53-1.07)	0.78 (0.5-1.02)	0.115	
CRP (mg/L)	6.17 (2.38-18.92)	23.22 (5.22-69.13)	<0.001	

AST: Aspartate aminotransferase, ALT: Alanine transaminase, ALP: Alkaline phosphatase, GGT: Gamma-glutamyl transferase, LDH: Lactate dehydrogenase, CRP: C-Reactive Protein, CI: Confidence Interval

Table 4. Comparison of groups based on pathological findings in ultrasonography imaging			
Pathologic sign	**discharge (n=119)**	**admission (n=128)**	**p value**
Perihepatic fluid	4 (3.4%)	18 (14.1%)	0.003
Perihepatic collection	5 (4.2%)	13 (10.2%)	0.072
Free fluid in the abdomen	7 (5.9%)	16 (12.5%)	0.074

(6.86 ± 0.67 g/dL) (Students' t-test; p<0.001). Surprisingly, there was no statistically significant difference in median INR values between the groups (Mann-Whitney U test; p=0.6). However, the admission group showed a statistically higher median aPTT value [33.45 (IQR 30-37.37)] compared to the discharge group [31 (IQR 28-34.8)] (Mann-Whitney U test; p<0.001). Additionally, there were no statistically significant differences in median urea and creatinine values between the two groups (Mann-Whitney U test for both; p=0.068, p=0.115, respectively).

Furthermore, the admission group demonstrated a statistically higher median CRP level [23.22 (IQR 5.22-69.13) mg/L)] compared to the discharge group [(6.17 [IQR 2.38-18.92)] mg/L) (Mann-Whitney U test; p<0.001). (Table 4) The rate of perihepatic fluid collection was significantly higher in the admission group (14.1%) than in the discharge group (3.4%) (Chi-Square test; p=0.003). Nevertheless, there were no statistically significant differences in the rates of perihepatic collection and free fluid in the abdomen between the two groups (Chi-Square test; p=0.072, p=0.074, respectively).

For the ANN analysis, we incorporated the parameters that exhibited statistical significance in the univariate analysis into the model. Following gradient descent optimization, the final

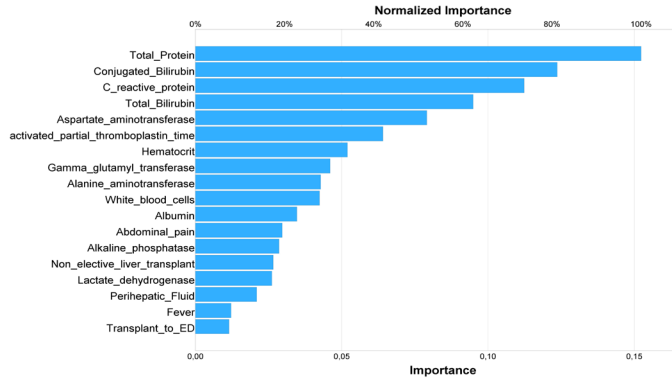

Figure 2. Importance analysis results from artificial neural network analysis

model displayed an accuracy of 77.6% in predicting the outcome. Notably, the most influential predictor variables in the model were total protein, conjugate bilirubin, CRP, total bilirubin, and AST (Figure 2). In the derivation cohort, the model's area under the curve was 0.826 (95% CI 0.761-0.879).

Discussion

In this study, a significant observation was made, indicating that nearly half of all patients who presented to the ED were ultimately admitted to the hospital. This finding aligns with a similar study conducted by Savitsky et al. (13) in 2000, where approximately two-thirds of LT recipients seeking care at the ED were admitted, demonstrating a higher probability of hospital admission. Conversely, the National Hospital Ambulatory Medical Care Survey of 2020 reported a hospital admission rate of 14.2% for all ED visits in the general population (20). This suggests that

when seeking medical attention, LT patients are admitted to the hospital at a rate approximately 3-5 times higher than that of the general population. Consequently, clinicians should be cognizant of the potential necessity for hospital admission to manage treatment and follow-up when these LT patients seek care at an ED outside their transplant center.

Previous studies have suggested that urgent LT for acute liver failure is (ALF) is associated with poorer short and medium-term outcomes compared to non-urgent cases (21). In our study, we observed that urgent LT (10.9% of admitted patients) had a significant impact on hospital admission rates compared to non-urgent cases (21.8% of admitted patients) in the univariate analysis ($p=0.02$). This finding aligns with existing literature indicating that urgent LT cases tend to have more complex clinical presentations requiring hospitalization. However, despite this significant difference, our ANN analysis revealed that urgency of LT was not among the most important predictors for hospital admission. This suggests that while urgency of LT plays a role, other biochemical parameters are more influential in guiding hospital admission decisions for LT recipients in the ED.

According to Stolper et al. (22) proposed concept of the "sense of alarm" specific symptoms are triggered in certain diseases, prompting physicians to take action. As is well-known, individuals with a history of LT who present with acute or chronic graft rejection may have undergone prior organ or tissue transplants (e.g., kidney, liver, and lung) for various medical conditions (23). The manifestation of rejection symptoms can vary among individuals and may include a range of manifestations such as high fever, jaundice, dark urine, itching, abdominal swelling, pain or tenderness, fatigue, irritability, and headaches (24). In our study, despite four prominent complaints being identified among patients seeking ED care (fever, weakness, nausea, and abdominal pain), it was observed that abdominal pain and fever were more prevalent in admitted patients compared to discharged patients. Specifically, fever was reported in 46.1% of admitted patients compared to 24.4% of discharged patients ($p<0.001$), and abdominal pain was reported in 33.6% of admitted patients compared to 18.5% of discharged patients. This suggests that abdominal pain and fever might be considered "highly probable complaints" indicative of graft rejection in LT patients, potentially evoking a "sense of alarm" among clinicians and leading to the decision to hospitalize and closely monitor these patients.

In this study, we investigated the complete blood count parameters of LT recipients who presented to the Transplant Center ED and underwent decisions regarding hospital admission or discharge. The results showed that admitted patients had lower HCT per cents compared to those who were discharged. Lower HCT levels are expected in patients with compromised liver function, and maintaining such levels has been recommended to reduce the risk of hepatic artery thrombosis in LT recipients (25). Factors like liver disease, bleeding, and medications can cause HCT fluctuations post-transplantation, with the immunosuppressive drug FK506 potentially impacting HCT pharmacokinetics and clinical outcomes (26). Hence, close monitoring of HCT levels is crucial for patient management, with patients exhibiting low HCT values being admitted for appropriate follow-up and treatment. Additionally, we observed higher WBC counts in admitted patients ($10.16 \pm 7.77 \times 10^9$/L) compared to those discharged ($8.81 \pm 5.18 \times 10^9$/L). Elevated WBC counts can indicate the presence of infections, which are a leading cause of mortality and morbidity in LT recipients (27). Elevated WBC counts have been associated with post-LT mortality and graft survival, but the significance of perioperative procalcitonin and CRP levels has been debated (28). Our findings contradict the mentioned study, as both CRP and WBC values were significantly higher in admitted patients. Our findings are consistent with previous studies that identify bacterial infections as prevalent and difficult to diagnose in LT patients due to immunosuppression (27). Post-transplant infections remain a leading cause of mortality, particularly in the first three months after LT, with infection-related mortality rates being notably higher during this period (29,30). Moreover, our research identified the third and fourth months post-transplant as the most common periods for ED visits. Taken together, this suggests that patients with elevated infectious parameters are more likely to be admitted to the hospital for close monitoring and timely interventions.

When assessing the association between the time of admission and the length of hospital stay, it was observed that patients who presented to the ED and were subsequently admitted had a longer hospital stay compared to those who were discharged. LT extends beyond a mere surgical procedure, as it categorizes individuals as "transplant recipients," introducing a distinct category. Consequently, both LT and organ transplantation, in general, entail specific risk factors and complications (31). These encompass short-term risks associated with the surgical procedure, medium-term risks related to LT, and medium to long-term risks that may arise from organ transplantation (32,33). Although our study identified a statistically significant difference in the time from LT to ED presentation between the two groups, the clinical significance of this duration and its relatively low importance in the neural network analysis suggest that it may have limited significance in the decision-making process. In this study, we assessed the bleeding profile as an essential parameter in LT recipients who presented to the ED. Surgical Intensive Care Units commonly use a combination of surgical drain fluid

characteristics, INR, Partial Thromboplastin Time (PTT), PLT, and functional assessment to manage post-transplant coagulopathy (34). Scoring systems like Model for End-Stage Liver Disease (MELD), MELD-Na, and Chronic Liver Failure-Specific Organ Failure Assessment have been incorporated to evaluate liver disease severity (35). However, perioperative and postoperative approaches for parameters like INR and PLT vary, and there is no consensus on routine institution-wide procedures. The study found no significant difference in PLT between admitted and discharged patients. aPTT was significantly lower in admitted patients, but no notable difference in INR was observed between the two groups.

A definitive follow-up profile for LT patients has not been established; however, a comprehensive metabolic profile panel for liver diseases typically includes AST, ALT, ALP, bilirubin, and albumin (15). Hepatic-origin high levels of ALP can be confirmed with elevated GGT or ALP fractionation. LDH is believed to be associated with acute hepatic hypoxic conditions during the development of ALF and excessive macrophage activation in the liver (36). In this study, the admission group showed statistically significant elevations in ALT, AST, ALP, GGT, LDH, total bilirubin, and conugated bilirubin, while albumin levels were significantly lower compared to the discharge group. These results suggest that clinicians may have utilized the comprehensive metabolic profile panel for liver diseases when making decisions about hospital admission during the initial ED presentation of these patients. Additionally, the admitted patients had lower total protein levels in peripheral blood compared to those who were discharged. The total serum protein test primarily measures the quantities of two main protein groups in the blood, albumin, and globulin (37). In our study, albumin levels were significantly lower in the admitted group, while univariate analysis in the ANN model identified total protein as the most important predictor variable, along with conjugated bilirubin, CRP, total bilirubin, and AST. Notably, albumin was not among the most important predictors, which raises questions about the marked decrease in globulin levels, particularly Gc-globulin levels, argued to decrease in liver disease, especially ALF 38 its main physiologic function is presumably actin binding and actin scavenging. Actin is a major cellular protein released during cell necrosis that may cause fatal formation of actin-containing thrombi in the circulation if the actin scavenging capacity of Gc-globulin is exceeded. In my studies, I found serum Gc-globulin levels to be reduced in liver disease, most so in patients with ALF. Research findings regarding test interpretations in the follow-up of LT patients often lack specificity. Nevertheless, both ED clinicians and transplant teams utilize their expertise to devise algorithms for determining ED dispositions and planning the management of post-transplant patients who seek care in the ED. In this study, we focused on evaluating total protein as a crucial parameter influencing clinicians' treatment decisions for LT patients following their ED visits.

In post- LT patient follow-ups, imaging findings play a crucial role in decision-making and management. This study examined liver imaging indications, which revealed significant perihepatic fluid in admitted patients compared to discharged ones. Ultrasonography is a valuable noninvasive method for assessing liver vessels and nonvascular complications in LT recipients (39). However, no imaging method has proven sensitivity or specificity for diagnosing rejection; graft biopsy remains the reliable diagnostic approach (40). Large-volume perihepatic fluid may indicate potential complications like hepatic venous outflow obstruction, renal failure, or infection (41 although uncommon, usually represents a serious adverse event. The pathogenesis of this complication has not been adequately investigated. To determine the incidence, characteristics, and pathogenic factors of massive ascites after LT (ascitic fluid > 500 mL/d for >10 days). Therefore, vigilant monitoring is essential. Overall, imaging findings hold importance in the clinical assessment of post-LT patients. Notably, this study also found perihepatic fluid to be more frequently observed in admitted patients.

In this study, we analyzed patients who underwent LT and subsequently presented to the ED for various reasons. Among them, those who were admitted displayed distinctive characteristics compared to those who were discharged. The primary complaints upon ED arrival were abdominal pain and fever, which were more prevalent in the admitted group. Additionally, the complete blood count revealed significantly higher WBC and lower HCT levels in the admitted patients. Regarding the bleeding profile, there were no significant differences in PLT and INR values between the two groups, but aPTT was notably lower in the admitted patients. In terms of biochemical parameters, the admitted group showed significantly elevated levels of ALT, AST, ALP, GGT, LDH, total bilirubin, and conjugated bilirubin, while albumin and total protein levels were significantly lower. Moreover, the ultrasound imaging revealed a frequent occurrence of perihepatic collection in the admitted patients. Our model analysis identified five predictive factors for admission: total protein, conjugated bilirubin, CRP, total bilirubin, and AST. Notably, total protein deficiency emerged as the most robust predictor, suggesting its potential significance as an indicator of ALF.

Despite the advancements in LT management and existing research, there remains a need for guidelines in handling emergency situations that may arise either related or unrelated to the transplantation process during ED presentations of these patients. This study aimed to identify factors influencing post-

ED management decisions for liver transplant recipients within a 5-year period at our international transplant center.

In summary, this study provides new insights into the management of LT recipients in the ED by identifying total protein, conjugated bilirubin, CRP, total bilirubin, and AST as key predictors of hospital admission using an ANN model. While previous studies have highlighted the importance of clinical symptoms and urgent LT status, our findings underscore the superior predictive value of specific biochemical parameters. This novel application of ANN in this context offers a more nuanced understanding of the factors driving admission decisions, which can enhance clinical practice by prioritizing critical metabolic markers over traditional indicators. By integrating these predictors into clinical protocols, emergency physicians can make more informed, evidence-based decisions, ultimately improving the care and outcomes of LT patients.

Study Limitations

This study has several limitations that should be considered when interpreting the results. First, the study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other healthcare settings. Different centers may have varying patient populations and management approaches, impacting the admission decisions in the ED. Second, the retrospective design of the study relied on data from electronic medical records, which might introduce biases and limitations in data completeness and accuracy. Despite efforts to address missing data through multiple imputation, there may still be residual confounding or unmeasured variables that could influence the results. Additionally, while the study identified important predictors for hospital admission using the ANN model, the model's validation was based on a single 70-30 split of the data. Although this provided insights into the model's performance, external validation using independent datasets would increase the model's reliability. Furthermore, not all potential confounding variables may have been accounted for in the analysis. Despite adjusting for relevant parameters, there might be other factors influencing admission decisions that were not included in the study. Moreover, the decision-making process in the ED involves complex clinical judgment, taking into account various factors beyond the examined parameters. The model, while helpful, cannot capture the full breadth of clinical considerations made by emergency physicians.

Conclusion

In conclusion, this study highlights the crucial role of specific parameters in determining hospital admission for LT recipients in the ED. Total protein, conjugated bilirubin, CRP, total bilirubin, and AST emerged as the most influential factors. These findings underscore the importance of a comprehensive metabolic profile, guiding clinicians in making informed decisions and optimizing care for these patients. Further research and guidelines are needed to enhance our understanding and improve the management of liver transplant recipients in emergency settings.

Ethics

Ethics Committee Approval: The study was approved by Memorial Şişli Hospital Ethics Committee (decision no: 003, date: 03.06.2023).

Informed Consent: Written consent was obtained from the patients or their legal guardians, and in the case of deceased individuals, from their next of kin, prior to the study. The study adhered to the principles outlined in the Helsinki Declaration.

Authorship Contribution

Surgical and Medical Practices: Ö.F.A, T.G., A.C.T., S.Y., Concept: Ö.F.A, S.Y, Design: Ö.F.A, A.C.T., Data Collection or Processing: T.G., Analysis or Interpretation: A.C.T., Literature Search: Ö.F.A, S.Y., Writing: Ö.F.A, A.C.T., S.Y.

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The Experience of the Floating Hospital During the Acute Period of the Earthquake

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Abstract

Aim: Two earthquakes with magnitudes of 7.7 and 7.6, which occurred in Kahramanmaraş on February 6, 2023, have caused distress to residents of Turkey and Syria. With the authorization of the Ministry of Health and the Ministry of Defense, two large armored ships have been positioned in the region as floating field hospitals. In our study, we aim to provide disaster management resources by retrospectively examining the examination records of patients admitted to these floating hospitals due to earthquakes and by researching the organization of hospitals and emergency departments.

Materials and Methods: In this study, data on patients received by 2 floating hospitals in the Gulf of İskenderun within the first 10 days after they started to work during the acute period of the February 6, 2023 earthquake were evaluated. In this respect, the study is a retrospective study.

Results: According to data obtained from floating hospitals, an average of 400-500 patient applications per day. It has been determined that patients frequently apply as outpatients with green triage, and the most common complaints are upper respiratory tract infections and extremity trauma.

Conclusion: After these earthquakes, people who suffered from them preferred safer field hospitals and floating hospitals. It is estimated that from the 400-500 patient applications per day, the hospital's laboratory tests arrived 2 weeks later and there were no computed tomography or magnetic resonance imaging. Based on this, keeping floating hospitals ready, training personnel who can participate, and keeping them ready in terms of material deficiencies are very valuable in this type of disaster situation.

Keywords: Emergency department, disasters, earthquake, floating hospital

Introduction

Earthquakes pose a threat to human life and lead to the rapid loss of life and property (1). Incidents related to earthquakes have revealed deficiencies in construction, infrastructure, emergency preparedness, and emergency response, resulting in fatal consequences (2). Two earthquakes with magnitudes of 7.7 and 7.6, which occurred on February 6, 2023, in Kahramanmaraş, Turkey and Syria, have caused significant changes in the lives of millions of people. It is estimated that over a million people have become homeless in Turkey alone due to the collapse or rendering uninhabitable of more than 15.000 buildings. Immediately following the earthquakes, limitations in the training of personnel, adequate equipment and coordination within local intervention teams became evident. The destruction or damage to hospitals during the earthquake rendered access to healthcare services extremely challenging (2).

Our country is situated at the intersection of an active tectonic line, where the European, Asian and African plates meet. The experiences gained from past earthquakes contribute to our

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understanding of future seismic events. In a country surrounded by seas on three sides, concerns about the safety of terrestrial environments, disruptions in land and air transportation, and the management of natural disasters such as earthquakes highlight the potential benefits of maritime transportation and floating hospitals at sea. In this context, with authorization from the Ministry of Health and the armed forces, two large armored ships have been positioned in the region as floating hospitals. These ships have been reconfigured by healthcare personnel to include emergency departments, inpatient wards, and operating rooms, providing essential medical services to the public beyond their primary purposes.

Epidemiological studies conducted by healthcare institutions can significantly contribute to the management and organization of injuries caused by future earthquakes (1). Emergency services must be well-prepared for disasters like earthquakes, ensuring accurate record keeping, systematic triage determination and the availability of adequate resources, equipment and treatment areas. Additionally, comprehensive disaster training, implementable disaster relief plans, and regular drills should be conducted (3).

In our study, we aim to provide disaster management resources by retrospectively examining the medical records of patients who sought treatment at a floating hospital due to an earthquake. We will analyze demographic information, such as age and gender, triage complaints, reasons for hospitalization, surgical interventions and procedures, and evaluate hospital and emergency service organization.

Materials and Methods

Our study is a retrospective analysis of data from two floating hospitals in the Gulf of İskenderun following the February 6, 2023, earthquake. The analysis covers the first 10 days from the start of operations during the acute phase of the earthquake.

Data were obtained from the emergency service, operating room and inpatient record book of the floating hospital. All patients who presented to the floating hospital between February 10, 2023, and February 20, 2023, were triaged, examined in the emergency department, admitted, or underwent surgery had their age, gender, reasons for admission and surgery investigated.

The study was approved by Muğla Sıtkı Koçman University Medical and Health Sciences Ethics Committee (decision number: 230042-60, date: 03.06.2023).

The inclusion criteria for participants were as follows:

All age groups of patients who presented to the floating hospital after the earthquake.

Exclusion criteria for participants:

Patients with missing data.

Features of Each Floating Hospital

Tank landing ships with a length of 138.75 meters, a width of 19.6 meters, and the capability to remain at sea without resupply for 30 days were converted into floating hospitals immediately after the earthquake. The rear part of the ship approached the shore, establishing a connection with land for patient reception. The initial section served as a triage area, where patient records, complaints, and vital signs were documented. Subsequently, a 120-bed emergency service was set up on the deck connected to triage and was equipped with a delivery room, electrocardiogram room, resuscitation room, ultrasound room, X-ray room, and laboratory room for the initial examinations of patients. The laboratory was set up two weeks after the ship docked at the port, and during the study period, blood tests could not be conducted on-site, and the results had to be followed up by another institution. Patients requiring hospitalization and surgical interventions were transported by elevator to the inpatient service and operating rooms located on the upper floor, with healthcare personnel assisting in the transportation.

Conditions of the Work

Each hospital had a staff of 20 physicians and 60 non-physician healthcare personnel, totaling 80 individuals. Depending on the patient's load, the staff worked in shifts of 2 or 3 per day. Due to accommodation onboard the ship, personnel were available for service 24 hours a day, adapting to fluctuating patient volumes.

Statistical Analysis

All data obtained from the study will be recorded and analyzed using the Statistical Package for Social Sciences for Windows 20 software. Numerical variables will be summarized as mean ± standard deviation, and categorical variables will be presented as counts and percentages, with frequency analysis. A significance level of $p \leq 0.05$ will be considered statistically significant.

Results

In our study, which included a total of 5251 patients, 2695 (51.32%) were male and 2556 (48.68%) were female, with a mean age of 30.00±21.90 years. Among the included patients, 290 (5.5%) presented on the first day, 222 (4.2%) on the second day, 671 (12.8%) on the third day, and 678 (12.9%) on the fourth day (Table 1). Among the patients, 4702 (89.5%) sought hospital care independently and 549 (10.5%) used ambulances for transportation. The reasons for hospitalization included 1636 (31.3%) upper respiratory tract infections,

598 (11.4%) extremity trauma, 447 (8.5%) pneumonia, 233 (4.4%) depression, and 124 (2.2%) pregnancy and pregnancy-related complications (Table 2).

Among our patients, 3403 (64.8%) were in the green triage category and 94 (1.8%) were in the red category (Table 3). Of our patients, 56 were hospitalized, and one died. Additionally, 234 patients were referred to other hospitals (Table 3).

Of the 96 patients who underwent pseudoanalgesia and surgery in our hospital, 24 received splint application, 22 underwent suturing, 2 underwent appendectomy, 1 underwent cesarean section, and 1 underwent hernia repair (Table 4).

Discussion

Following two earthquakes with magnitudes of 7.7 and 7.6 that occurred in Kahramanmaraş on February 6, 2023, we analyzed data from two floating hospitals stationed between İskenderun and Dörtyol. The analysis revealed a daily average of 400-500 patient admissions during the first 10 days of the acute phase of the earthquakes. Patients frequently sought outpatient care, with upper respiratory tract infections and extremity trauma being the most common reasons for admission. Additionally, a significant number of patients had green triage codes and were discharged after treatment, whereas those receiving sedoanalgesia/anesthesia often received these interventions due to traumatic conditions. In another retrospective study evaluating the role of floating hospitals during earthquakes, it was emphasized that two United States (US) navy ships most frequently encountered patients with extremity trauma during the Indonesia and Haiti earthquakes (4). The most important reasons for this situation are the traumatic damage caused by earthquakes and the resulting adverse environmental conditions. Failure to meet basic needs such as weather conditions, shelter, hygiene, and clean water after an earthquake may lead to increased upper respiratory tract infections. At the same time, injuries resulting from material damage or contact with debris frequently cause extremity trauma.

Table 1. Demographic characteristics of patients

Application day	Number of patients (n)	Percentage (%)
1st day	290	5.5
2nd day	222	4.2
3rd day	671	12.8
4th day	678	12.9
5th day	594	11.3
6th day	572	10.9
7th day	499	9.5
8th day	462	8.8
9th day	434	8.3
10th day	423	8.1
11th day	406	7.7

Table 2. Reasons of the application

Reason for application	Number of patients (n)	Percentage (%)
URTI	1636	31.1
Extremity trauma	598	11.4
Pneumonia	447	8.5
Myalgia	368	7.0
Depression	233	4.4
Gastroenteritis	222	4.2
Stomach pain	205	3.9
Dermatological problems	196	3.7
Injection/dressing	163	3.1
Pregnancy and complications	124	2.2
Chest pain	113	2.2
Toothache	101	1.9
Eye problems	86	1.6
Ear pain	81	1.5
Asthma attack	77	1.5
Hypertension	76	1.4
COPD attack	75	1.4
Urinary tract infection	57	1.1
Headache	56	1.1
Dizziness	46	0.9
Cut	38	0.7
Diabetes mellitus complications	33	0.6
Palpitations	32	0.6
Chest trauma	30	0.6
Multitrauma	24	0.5
Lower back pain	22	0.4
Skin burn	21	0.4
Vertebral injury	19	0.4
Head trauma	15	0.3
Care patient	11	0.2
Epileptic seizure	9	0.2
Stroke (cerebrovascular accident)	7	0.1
Chronic renal failure/dialysis need	4	0.1
Inguinal hernia	3	0.1
DVT	1	0.0
Malignancy	1	0.0

URTI: Upper respiratory tract infection, COPD: Chronic obstructive pulmonary disease, DVT: Deep vein thrombosis

Despite the presence of the seismically isolated Dörtyol State Hospital and several field hospitals near our location, the number of admissions exceeded expectations. This could be attributed to people's reluctance to enter hospitals, even if they are structurally sound. However, during the initial two weeks in the floating hospital, the limitations in laboratory testing and imaging might have led to the admission of patients with less severe symptoms.

In our country, earthquakes have caused great destruction, loss of life, injury, permanent disabilities, and chronic diseases. As experienced in the August 17, 1999 earthquake in the Marmara Region, transportation disruptions due to damage to airports, bridges, viaducts, and highways in the earthquakes that occurred on February 6, 2023 caused delays and interruptions in transportation to disaster areas. It is of utmost importance for rescue and evacuation operations, including emergency and advanced first aid for the injured, to be initiated rapidly from the moment the earthquake strikes (5). The earthquake that occurred in Haiti in 2012 caused similar massive destruction, and the country's healthcare system almost collapsed. During this period, a floating hospital belonging to the US army provided effective patient care and humanitarian aid (6).

Table 3. Triage, referral, hospitalization and discharge status of patients

Triage	**Number of patients (n)**	**Percentage (%)**
Green	3403	64.8
Yellow	1754	33.4
Red	94	1.8
Latest status	**Number of patients**	**Percentage (%)**
Referral to another hospital	234	4.5
Hospitalization	56	1.1
Discharge	4960	94.5
Death	1	0.0

Table 4. Patients receiving interventional treatment

Interventional procedures	**Number of patients (n)**	**Percentage (%)**
No operation	5155	98.2
Application of a cast	24	0.05
Incision suturing	22	0.05
Wound debridement	11	0.02
Abscess drainage	9	0.02
Fasciotomy	4	0.01
Patellar dislocation	4	0.01
Burn debridement	4	0.01
Shoulder reduction	4	0.01
Chest tube insertion	2	0.00
Tendon repair	2	0.00
Appendectomy	2	0.00
Cesarean section	1	0.00
Hernia repair	1	0.00
Childbirth	1	0.00
Pilonidal sinus surgery	1	0.00
Arterial incision repair	1	0.00

Every region in our country is at risk of earthquakes and hosts active fault lines. Recent discussions in the public domain and statements by reputable professors in earthquake-related scientific fields suggest that serious consideration should be given to earthquakes, especially in İstanbul and other parts of our country in the future.

In the earthquakes we have experienced, both land and air transportation have suffered significant damage, nearly grinding to a halt. The impairment of hospitals and other health facilities due to earthquake damage, coupled with healthcare professionals, including city workers who are victims of earthquakes, and the disruption of urban transportation due to debris and damaged infrastructure, underscore the importance of maritime transportation in critical aspects, such as rescue efforts, vital interventions for the injured, and logistical support during these disasters.

In the studies on floating hospitals in the literature, these ships are war-class ships. However, in difficult conditions, such as natural disasters, they can be converted into hospitals to provide health services. The use of floating hospitals during natural disasters has created a sense of confidence among disaster victims. Instead of going to hospital buildings to receive healthcare, people preferred tent field hospitals or floating hospitals, which they considered safer (6-8). Laboratory tests were conducted in a floating hospital two weeks after the earthquake. However, computed tomography and magnetic resonance imaging were not performed. Even under these conditions, there were approximately 400-500 patient applications daily. It is clear that the earthquake victims preferred the floating hospital rather than Dörtyol State Hospital, which is a health institution equipped with seismic isolators, examination laboratories, and physicians, located close to the floating hospital. These data demonstrate that it is extremely important for floating hospitals to be ready and medically equipped and to plan and organize the personnel who can participate in floating hospitals during these types of disasters and crisis periods.

This research, which includes the determination and interpretation of data from the floating hospital, is the first study conducted in our country and reveals the demographic data,

admission complaints, referral, hospitalization, and surgical status of patients admitted to the floating hospital at Role 2 level during the acute period after the earthquake. As a result, the obtained data will guide medical intervention strategies, such as preparing the role level of floating hospitals and appropriate health equipment in advance, planning the number of health personnel, providing the necessary health equipment in advance, and establishing health services more effectively in case of a disaster.

Study Limitations

One of the main limitations of our study was the unreliability of demographic data for patients treated after the earthquake. Additionally, due to the time taken for field hospital ships to reach the disaster site, patients who presented immediately after the earthquake were not included in our study. Consequently, the patients evaluated in our study were those with minor injuries and those affected by environmental conditions, rather than those with major traumas from the acute impact of the earthquake.

Conclusion

This research, which includes the determination and interpretation of the data of the floating hospital, is the first study conducted in our country and reveals the demographic data, admission complaints, referral, hospitalization, and surgery status of the patients admitted to the floating hospital at Role 2 level in the acute period after the earthquake. As a result, the data obtained will guide medical intervention strategies such as preparing the role level of floating hospitals and appropriate health equipment in advance, planning the number of health personnel, providing the necessary health equipment in advance, and establishing health services more effectively in case of disaster.

Ethics

Ethics Committee Approval: The study was approved by Muğla Sıtkı Koçman University Medical and Health Sciences Ethics Committee (decision number: 230042-60, date: 03.06.2023).

Informed Consent: This retrospective study.

Authorship Contributions

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

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Utilization of Healthcare Sources by Elder Abuse Victim at the Emergency Department

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Abstract

Aim: Elder abuse may result in serious injuries with significant psychological consequences, leading to increased use of emergency department (ED) for trauma-related presentations. We aimed to describe the utilization of healthcare resources by victims of elder abuse.

Materials and Methods: This retrospective study was conducted. Victims of elder abuse that were 65 years or older and presented between August 2018 and December 2020 were included. Information on demographics, mode of arrival, place and mechanism of injury, sustained injuries, injury severity score (ISS), disposition, and length of stay were collected and analyzed.

Results: There were 33 (0.3%) victims of elder abuse. The median age was 69-year old (interquartile range: 66 to 76) and 23 (68.8%) participants were female. Majority (n=32, 97.0%) of patients sustained blunt injuries, with contusions to the limbs and head being the most common. The injuries were mostly minor to moderate in severity (ISS 8 or less: n=32, 97.0%). The utilization of healthcare resources was low: only two (6.1%) required ambulance transport to the ED, one (3.0%) required activation of the trauma team, one (3.0%) required surgery, and one (3.0%) required transfusion of blood products. However, 12 (36.4%) patients were admitted to the hospital, and five (15.2%) were admitted to the observation unit of the ED.

Conclusion: Utilization of healthcare resource for injuries related to elder abuse was low. However, identification remains a challenge, and it is crucial for teams in the ED to be cognizant of elder abuse, as management should go beyond treating the injuries by including case notification, psychosocial assessment, and caregiver support.

Keywords: Abuse, emergency, geriatric, trauma

Introduction

Elder abuse is an action or inaction occurring within any trusted relationship that threatens the safety or well-being of an older person and results in harm or distress (1). The types of abuse include physical, emotional, sexual, financial, neglect, and abandonment (2). The perpetrator of abuse may be a family member, friend, or even a professional who the elderly rely on for services such as healthcare, personal care, or transportation. Elder abuse may result in serious physical injuries with significant psychological consequences, leading to increased use of emergency services and hospitalization for trauma-related presentations (1).

Multiple individual, interpersonal, and community factors can lead to elder abuse, making it a complex issue. At an individual level, elderly individuals with dementia, cognitive impairment, disabilities, and functional dependence have been consistently found to have a higher risk of being victims of abuse (3-5). This finding is attributed to the need for caregivers to have higher levels of tolerance and patience when caring for vulnerable individuals. At the interpersonal level, relationships between the elderly and abuser may be strained by physical and emotional stress arising from prior violence, drugs or substance abuse, alcohol dependence, family tension, and marriage instability. At the community level, social isolation and lack of access to

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eldercare services are also associated with abuse in Mexico, Ireland and Canada (6).

This worldwide social phenomenon may be more common as the population grows older, but it is of uncertain magnitude due to poor detection and reporting rates: approximately 10% of all people above 65 years old suffer from elder abuse (7). Elder abuse is subtle, making it difficult to distinguish between accidental injury and deliberate assault. Victims may be reluctant to report perpetrators because of the fear of consequences and loss of social support. It is estimated that billions of dollars are spent in the United States (US) each year on medical expenses directly related to elder abuse (8). However, this may be just the tip of the iceberg, as fewer than 1 in 24 cases of elder abuse were reported (9).

In a scoping review on elder abuse at emergency departments (EDs) by Mercier et al (10), available evidence on the epidemiology, clinical characteristics, patient and caregiver-associated factors, screening tools, and perspectives of health care professionals on elder abuse was synthesized. They found that: (a) the prevalence of elder abuse at the ED was lower than the prevalence in the community; (b) neglect was the most common type of elder abuse, followed by physical abuse; (c) female sex, cognitive impairment, functional disability, frailty, social isolation, and lower socioeconomic status were common factors among victims of elder abuse; (d) psychiatric and substance use were common factors among caregivers of victims; (e) screening tools lacked multicenter validation and evaluation based on patient outcomes; and (f) healthcare professionals were poorly trained in elder abuse at the ED. However, the scoping review did not describe the burden that victims of elder abuse pose on EDs with regard to the utilization of healthcare resources, which may be attributed to the lack of available data.

To fill this gap in the existing literature, this study aimed to describe the utilization of healthcare resources by victims of elder abuse who presented to the ED with trauma-related presentations so that EDs could ensure the availability of resources to care for them.

Materials and Methods

Study Setting

This study was conducted at the general ED of a 1000-bed tertiary public hospital in Singapore. The annual ED attendance was 105.000, with 15% having trauma-related presentations. The ED was staffed by emergency physicians certified by the Specialists Accreditation Board.

Paramedics from Singapore Civil Defence Force (SCDF) provide pre-hospital trauma care by evaluating and treating injured patients at the accident site before transporting them by ambulance to the ED of the nearest public hospital. Injured patients may also be transported to the ED by personal transport. Upon arrival at the ED, patients are triaged by nurses using the Patient Acuity Category Scale to emergent (P1), urgent (P2), or ambulatory (P3) based on assessment of their presenting complaints and vital signs. Emergent (P1) patients are in a state of cardiovascular collapse or at imminent risk of collapse, urgent (P2) patients are non-ambulant and ill with severe symptoms, and ambulatory (P3) patients are ambulant with mild to moderate symptoms (11). Subsequently, they will be attended to by physicians who will manage their conditions and devise disposition plans.

Our hospital has a single-tier trauma team that is activated by a pre-defined criteria consisting of the mechanism of injury, anatomical injury, and physiological parameters. The trauma team is led by a general surgery consultant and consists of members from the ED, general surgery, and orthopedic departments. Other departments, such as neurosurgery, may provide assistance to the trauma team when necessary.

Study Design

This retrospective study involved the review of case records from the hospital's trauma registry. Patients were included if they were 65 years or older, attended the ED for trauma-related presentations between August 2018 and December 2020, or were victims of elder abuse identified by a report of physical injury due to an assailant during the ED consult. Information including demographics, mode of arrival to the ED, place and mechanism of injury, sustained injuries, injury severity score (ISS), disposition, and length of stay were collected in standardized forms and analyzed. ISS is calculated based on the abbreviated injury scale (AIS), which consists of minor (1 point), moderate (2 points), serious (3 points), severe (4 points), critical (5 points), and not survivable (6 points), as well as six body systems, consisting of the head, face, chest, abdomen, extremity, and external (12). The scores of the three body systems with the highest AIS scores were squared individually and then added together to compute the ISS. Utilization of healthcare resources was defined as the need for ambulance at the pre-hospital level, as well as the need for hospital admission, trauma team activation, blood product transfusion, and surgery at the hospital level.

This study was determined by the SingHealth Centralized Institutional Review Board (decision no: 2021/2417, date: 03.07.2021) to not require ethical deliberation because it involved de-identified data. A waiver of informed consent was granted.

Statistical Analysis

For statistical analysis, Statistical Package for the Social Sciences (SPSS) version 22 (SPSS, Chicago, IL) was used. Categorical and continuous data were presented using frequencies with percentages and medians with interquartile ranges (IQR), respectively. Chi-square test was used to assess associations between categorical variables. Statistical significance was set at a p value of 0.05.

Results

A total of 39995 patients presented to the ED with trauma during the study period. There were 10095 (25.2%) patients who were 65 years or older, and among these, there were 33 (0.3%) patients who were victims of elder abuse: two (6.1%) patients were triaged as emergent (P1), 18 (54.5%) patients were triaged as urgent (P2), and 13 (39.4%) patients were triaged as ambulatory (P3).

Demographics

The median age of the 33 victims was 69 years (IQR: 66 to 76). Among the participants, 23 (69.7%) were female and 10 (30.3%) were male. Table 1 presents the circumstances of elder abuse. Cognitive impairment (n=8, 24.2%) and psychiatric illness (n=6, 18.2%) were the most common patient characteristics. These incidents of elder abuse occurred most often at home (n=30, 90.9%), and children (n=12, 36.4%) were the most common assailants.

Injuries Related to Elder Abuse

These patients sustained blunt injuries (n=32, 97.0%) instead of penetrating injury (n=1, 3.0%). For the injury pattern (Table 2), soft tissue contusion (n=23) was the most common injury sustained, while limbs (n=16) and head (n=14) were the most common body regions affected. Consequentially, the majority (n=32, 97.0%) of patients had minor to moderate injury as defined by an ISS of 0 to 8, and there were no deaths among the patients.

Table 1. Circumstance of elder abuse (n=33)

Variable	n (%)
Patient characteristics	
Impaired cognition	8 (24.2)
Psychiatric condition	6 (18.2)
Dependent on activities of daily living	2 (6.1)
Disability	1 (3.0)
Place of occurrence	
Own home	30 (90.9)
Nursing home	2 (6.1)
Destitute home	1 (3.0)
Assailant*	
Child	12 (36.4)
Spouse	8 (24.2)
Child-in-law	4 (12.1)
Sibling	2 (6.1)
Grandchild	1 (3.0)
Domestic helper	1 (3.0)
Nursing home staff	1 (3.0)

*There was unknown information about the assailant in three (9.1%) patients

Healthcare Resource Utilization

The majority (n=31, 93.9%) were transported to the ED by their own transport, and two (6.1%) were transported by SCDF ambulance. The length of stay in the ED was 197 min (IQR 126-757). Sixteen (48.5%) patients were discharged from the hospital, five (15.2%) were admitted to the observation unit of the ED, and 12 (36.4%) were admitted to the hospital. Non-required admission to the high dependency or intensive care units. All patients admitted to the observation unit of the ED were discharged within 24 hours. Except for one patient who was hospitalized for 50 days due to the development of ischemic stroke and waiting for placement at a nursing home, the other victims had a median length of stay of 3 days (IQR 1.8-7.5).

One (3.0%) patient required activation of the trauma team due to mechanism criteria of penetrating injury because she was slashed multiple times with a kitchen knife by her husband. She subsequently underwent wound exploration, debridement, and closure of multiple stab wounds. No other patients required surgery. One (3.0%) patient required platelet transfusion for subdural hematoma sustained from an assault by her son-in-law while she was taking aspirin for the primary prevention of cardiovascular events. No other patients required blood product transfusion.

Table 2. Pattern of injury (n=33)

Variable	n (%)
Injuries sustained*	
Soft tissue	
Contusion	23
Laceration	5
Abrasion	3
Bone	
Fracture	8
Intracranial hemorrhage	1
Body region affected*	
Limbs	16
Head	14
Face	8
Chest	4
Back	2
Perineum	1
Injury severity score (ISS)	
0-8 (minor to moderate)	32 (97.0)
9-15 (serious)	1 (3.0)
16-24 (severe)	0 (0)
≥25 (critical to not survivable)	0 (0)

*Patients had more than one body region affected, or more than one type of injuries
ISS: Injury severity score

Discussion

The problem of elder abuse is a growing public interest. In this study, we found that elder abuse was uncommon among patients aged 65 years or older with trauma-related presentations to our ED. Among these victims, most sustained blunt injuries to the limbs and head, which were of minor to moderate severity. The utilization of healthcare resources at the pre-hospital, as well as in the ED and inpatient units for their injuries were correspondingly low.

Although it is a worldwide issue, data regarding the prevalence of elder abuse vary widely across continents. Compared with a US study using a national database that estimated a prevalence of 0.013% among 29 million ED visits of adults aged 60 years and older, the prevalence in our study was much higher at 0.3% (13). The differences in prevalence across studies could be attributed to variations in methodology such as sample population, inclusion criteria, case definition, and study setting. Regardless, the trends observed in our study were like those of other studies - the victims were often women, soft tissue injuries were common, and injuries sustained were not severe (14,15).

Billions of dollars are estimated to be lost each year as victims require medical attention and healthcare resources for their presentations (16). Furthermore, even with treatment, patients are at increased risk of mortality and poorer outcomes (17). Although a systematic review identified victims presenting to the ED by ambulance, our study found that the majority of patients arrived at the ED by their own transport (10). This could be attributed to the health-seeking behavior of the local population who visit EDs as the initial point of call for medical ailments instead of primary care physicians. The median length of stay in the ED was approximately 3 hours, similar to another study in which victims stayed in the ED between one to six hours for assessment and treatment of their injuries (15). Regarding their injuries, given that most injuries were minor to moderate, utilization of high-level resources in the ED, such as trauma team activation, blood product transfusion, or surgery, was uncommon. However, more than half of the patients required admission to the inpatient unit or monitoring in the observation unit. These findings are consistent with existing literature where victims were more likely to be admitted to the hospital (18). The average length of stay of four days in our study was significantly shorter than another study that found an average length of stay of eight days among their cohort of elder abuse patients (13). This was attributable to the victims in our study only having to undergo treatment for their injuries and psychosocial evaluation, unlike patients in the other study who developed concurrent medical conditions such as pneumonia, sepsis, or cardiac dysrhythmia, which resulted in a longer stay. It is important to also remember that the utilization of healthcare resources by victims of elder abuse goes beyond the hospital. Resources such as elder day care services, case management services, institutional placement, and home nursing care were not captured by this study.

The prevalence of elder abuse at the ED is consistently lower than that in the community and this suggests an underrepresentation of the true prevalence of the problem (13). This could be attributed to the lack of consideration or difficulty in recognizing elder abuse at the ED. Possible reasons include inadequate training on the symptoms and signs of elder abuse, inability to differentiate between accidental or abuse injuries, and time and space constraints in a chaotic ED environment. According to a research study conducted among emergency physicians in the US, more than half did not believe that they could accurately identify elder abuse, and only a quarter recalled some form of training regarding elder abuse during residency (19).

Over the past decade, many screening tools have been developed to assist medical teams in uncovering victims of elder abuse (20). Despite the availability of resources, most emergency physicians are unaware of their existence and unsure of their application to clinical practice (19). Furthermore, the process by which victims of elder abuse are reported to authorities is also unknown. In view of the above, we recommend that all EDs have clearly written guidelines and standardized department protocols on elder abuse that are contextualized to their settings. These guidelines and protocols should include when to suspect elder abuse, how to screen for elder abuse, and ED management, such as reporting and onward referral to an interdisciplinary team consisting of emergency physicians, geriatricians, psychiatrists, nurses, and social workers to coordinate interventions needed for this vulnerable population. Training staff will increase their familiarity with and usage of the guidelines and protocols. EDs can then take a proactive approach to detecting elder abuse and managing victims beyond the reasons for their acute presentation.

Elder abuse is indeed a complex social and public health issue. Addressing elder abuse in the ED is not only about managing the victims. There may be opportunities for primary prevention upstream at the ED by addressing the needs of caregivers of elderly patients. Caregiver burden is a combination of caregivers' physical, psychological, and financial stress experienced by caregivers. Caregivers of patients with Alzheimer's disease frequently perceived higher levels of stress and depressive symptoms (21). Given that most elder abuse cases occurred at home, caregivers who experience stress at the ED should be referred onwards for interventions such as psychological education, counseling, family intervention programs, and

welfare assistance. These measures may help prevent elder abuse and thus reduce the prevalence of elder abuse. Beyond the ED, widespread public campaigns are needed to increase awareness and provide education about elder abuse. Efforts could be made to prevent and early detect elder abuse in society, even before these victims arrive at the ED. For example, training is provided to individuals who work with elderly persons, such as community hub workers, so they know how to recognize and respond to suspected cases. Community programs, such as home visits by nurses or volunteers for individuals at high risk of abuse, are also effective measures to prevent elder abuse.

Moving forward, we believe that this work would call to attention the need for collaborative efforts to target elder abuse at the national level. For a start, a prospective study with involvement of primary care services and all EDs could provide deeper insight into the issues reported in this work. With time, this information will impact policy making and legislation on elder abuse so that preventive measures can be put in place to protect vulnerable elderly individuals, thereby reducing the occurrence of elder abuse and associated morbidity and mortality.

Study Limitations

The experience of a single ED was the main limitation of this study. The scale of the elder abuse problem among patients with trauma-related presentations was likely higher than that reported, as these patients could have presented to other EDs and primary care services. Correspondingly, the utilization of healthcare resources and eventual cost would be higher even though we did not assess the latter. Next, incomplete information was found in the case records due to the retrospective nature of this work. Therefore, we had to work with available case records, leading to the inability to determine certain predictors and outcomes. For instance, we were unable to perform detailed analyses of patient, caregiver, and injury characteristics that could impact the utilization of healthcare resources.

Conclusion

In conclusion, there was a relatively low prevalence of elder abuse among those with trauma-related presentations at the ED; correspondingly, the utilization of healthcare resources was low. Regardless, healthcare teams should be cognizant of the injuries related to elder abuse and the healthcare resources that may be needed to care for these patients. In addition, the identification of potential victims of elder abuse remains a challenge in busy ED settings. It is crucial for healthcare teams to detect and manage elder abuse to provide assistance and support to patients and their caregivers.

Ethics

Ethics Committee Approval: This study was determined by the SingHealth Centralized Institutional Review Board (decision no: 2021/2417, date: 03.07.2021) to not require ethical deliberation because it involved de-identified data.

Informed Consent: This retrospective study.

Authorship Contributions

Surgical and Medical Practices: S.G., C.Y.E.C., S.-H.C.L., J.H.K., J.H.P., S.Y.L., Concept: J.H.P., Design: S.G., C.Y.E.C., J.H.P., S.Y.L., Data Collection or Processing: S.G., S.-H.C.L., J.H.K., Analysis or Interpretation: S.G., C.Y.E.C., S.-H.C.L., J.H.K., J.H.P., S.Y.L., Literature Search: S.G., J.H.P., Writing: S.G., C.Y.E.C., S.-H.C.L., J.H.K., J.H.P., S.Y.L.

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Role of Laboratory Parameters in the Diagnosis of OMI/NOMI

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Abstract

Aim: The occlusion myocardial infarction (OMI) and non-OMI (NOMI) paradigms aim to improve the quality to ensure effective diagnosis and treatment. Due to the lack of universally accepted diagnostic criteria, the study aimed to investigate the correlation between laboratory parameters commonly analyzed in the emergency department in patients with and non-segment elevation myocardial infarction and OMI/NOMI definitions.

Materials and Methods: Demographic characteristics, mortality status, laboratory parameters and thrombolysis in MI (TIMI) scores of patients were recorded. Patients with TIMI scores of 0-2 and 3 were considered OMI and NOMI. Findings were considered significant when $p<0.05$.

Results: In 107 patients, white blood cell value was 10.3 (8.30-2.8) and neutrophil was 7.30 (5.45-10.0) in the OMI group (p values=0.023, 0.008). The median troponin was 0.68 (0.15-4.82), C-reactive protein (CRP) was 11.8 (4.3-26.5), in the OMI group (p=0.014, 0.004). Upon logistic regression analysis, the neutrophil was independent in OMI/NOMI discrimination. The effectiveness of neutrophil in determining OMI, sensitivity, specificity, positive predictive value, and negative predictive value were 82.69%, 40.00%, 56.58%, and 70.97%, respectively (area under the curve: 0.650), when the neutrophil was set to 5.1×10^9/L.

Conclusion: Neutrophil level can be considered an independent variable for the differentiation of OMI/NOMI patients. Troponin and CRP values significantly differ between these two groups.

Keywords: Acute coronary syndrome, biomarkers, coronary occlusion, myocardial infarction

Introduction

The concepts of ST-segment elevation myocardial infarction (STEMI) and non-STEMI (NSTEMI) have accounted for a significant proportion of diagnoses requiring emergency intervention for >30 years (1). It is well-established that these concepts, which are currently used to determine acute coronary occlusion and the need for urgent reperfusion, are inadequate in selecting patients who require rapid intervention (2). STEMI diagnosis was based on the criteria associated with the Fourth Universal Definition of Myocardial Infarction (FUDMI) (3), and patients who did not meet the definition of STEMI were included in the NSTEMI group. Although NSTEMI is considered myocardial necrosis causing incomplete blood flow interruptions in the coronary arteries, total coronary artery occlusion was observed in almost 30% of patients with NSTEMI (1-6). The gap in studies has not been adequately closed, even though guidelines recommend urgent (<2 hours) invasive evaluation regardless of electrocardiogram (ECG) findings in patients with persistent chest pain, hemodynamic instability, severe heart failure, and/or arrhythmia (7,8). As a result, patients with NSTEMI are deprived of emergency reperfusion therapy, which may lead to large infarct areas and an approximately 1.5-fold higher risk of short/long-term mortality (1,5). Observational studies have indicated that early intervention in patients with NSTEMI and total coronary occlusion is potentially beneficial (4).

The occlusion MI (OMI) and non-OMI (NOMI) paradigms have recently been debated for the aforementioned reasons and basically aim to early identify patients diagnosed with NSTEMI but actually have total coronary occlusion. Therefore, these patients may benefit from early intervention. By definition,

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OMI is MI caused by total coronary artery occlusion requiring acute reperfusion (1). Although its definition does not mention any specific examination, it has a conceptual definition, suggesting the inadequacy of using ECG alone for the diagnosis of acute coronary occlusion (1). There are several drawbacks to the OMI concept. First, universally accepted diagnostic criteria are lacking, and the various definitions suggested in the literature are unclear. Second, although ECG is not the only factor in the definition, it is still a crucial part of the paradigm. Finally, the diagnostic limitations associated with ECG also impact the concept of OMI. Therefore, it may be efficient to use objective biomarkers that can be assessed within a relatively shorter presentation time and support the diagnosis of OMI, especially in emergency department settings. The current study aimed to investigate the correlation between laboratory parameters commonly analyzed in the emergency department of patients with NSTEMI and OMI/NOMI definitions.

Materials and Methods

Study Design and Setting

The present study was designed as a cross-sectional observational study. The study was conducted in the emergency department of a tertiary university hospital. The emergency department had an admission rate of 300,000 patients/year, and the required approval for the commencement of the study was obtained from the Karabük University Faculty of Medicine, Non-Interventional Clinical Research Ethics Committee (decision number: 2024/1744, date: 05.05.2024). All study data were anonymized, and statistical analyses were performed thereafter.

Selection of Patients

The study included patients who presented to the emergency department with symptoms suggestive of acute coronary syndrome (ACS) between January 1, 2023, and December 31, 2023. Patients diagnosed with STEMI, patients aged <18 years, pregnant, with peri/myocarditis, secondary myocardial injury due to other diseases, those with incomplete data, and those without angiography or unavailable images were excluded. Among the remaining patients, those diagnosed with NSTEMI were included in the study.

Measurements

Demographic characteristics, including age, sex, comorbidities (diabetes mellitus, hypertension, history of cardiac disease, malignancy, chronic obstructive pulmonary disease, chronic renal failure, cerebrovascular disease), and in-hospital mortality status were recorded. Laboratory parameters [(white blood cell (WBC)], platelets, neutrophils, lymphocytes, monocytes, urea, creatinine, aspartate transferase, alanine transaminase (ALT), sodium, potassium, chlorine, C-reactive protein (CRP), and high-sensitivity troponin I levels were recorded. Furthermore, the angiography images of the patients were assessed by a cardiologist who did not have information about the comorbidities and laboratory results of the patients based on the Thrombolysis in MI (TIMI) Coronary Grade Flow classification (9). Based on this classification, TIMI 0 was considered total occlusion without collateral circulation; TIMI 1, flow after the lesion but incomplete distal filling or distal collateral flow after total occlusion; TIMI 2, complete but delayed distal filling after the lesion; and TIMI 3, no lesion, which restricts flow (8).

The OMI/NOMI classification was established by researchers based on TIMI scores. Patients with TIMI scores of 0-2 were considered to have OMI, whereas those with TIMI scores of 3 were considered to have NOMI. Accordingly, based on the OMI/NOMI subgroups, the relationship between the groups and demographic characteristics and laboratory parameters was reviewed.

Outcome

The outcome was considered to determine the relationship between the OMI and NOMI subgroups and the laboratory parameters.

Statistical Analysis

Data analysis was calculated using Jamovi version 2.3.38. continuous data were expressed as means ± standard deviation for normally distributed data or as median with 25^{th}-75^{th} centiles if they did not normally distribute. Categorical data are presented as numbers and percentages. To compare two groups of continuous variables, we used Student's t-test (for normally distributed variables) or the Mann-Whitney U test (for non-normally distributed variables). The χ^2 test or Fisher's exact test was used to compare categorical variables. All tests were two-tailed. To examine independent variables related to OMI, binary logistic regression analysis was conducted. First, we included variables with $p<0.05$ in the comparison analysis and univariate logistic regression analysis. If data had $p<0.05$ in the univariate analysis, they were included in the multivariate logistic regression analysis. Receiver operating characteristic curve analysis was used to evaluate the performance of predictive models for OMI, and reference limits were predicted using Youden's index. Findings were considered significant when $p<0.05$ unless otherwise specified.

Results

Of 1137 patients who presented to the emergency department with suspected ACS within the study period, 233 were diagnosed with NSTEMI. Patients referred to an external center who

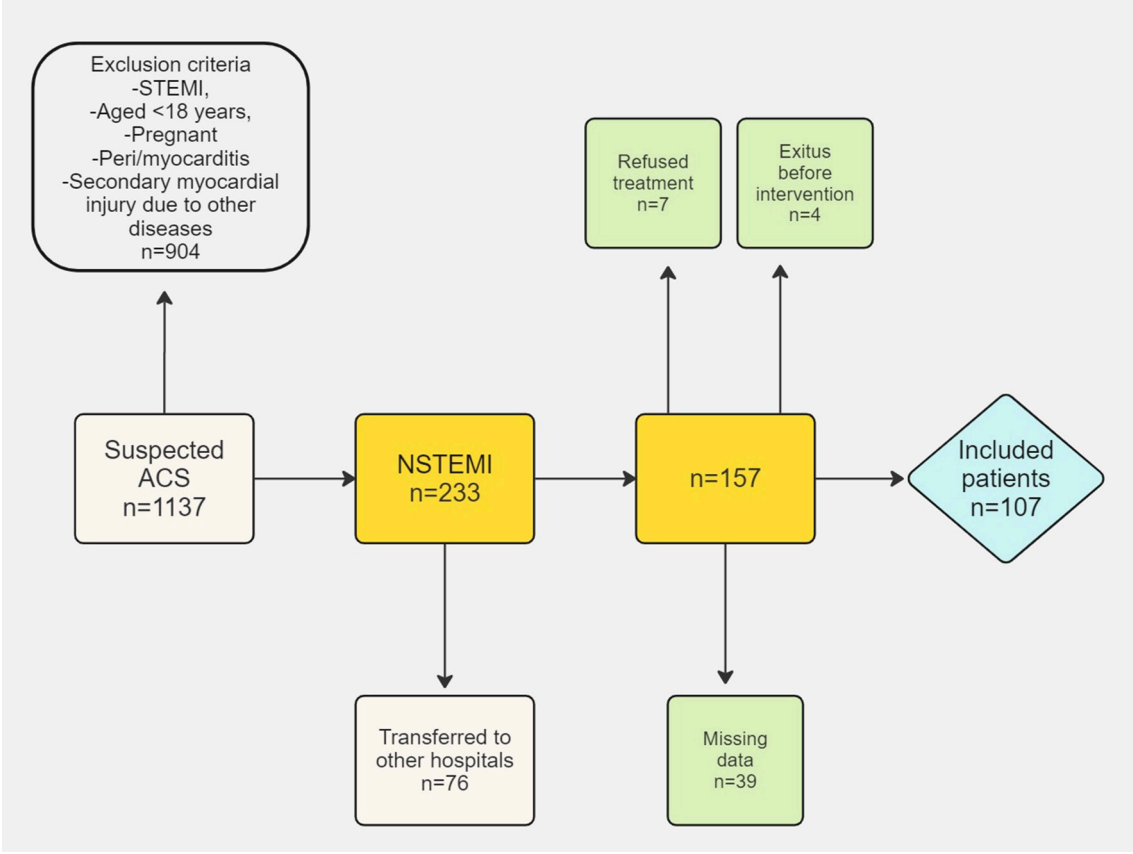

Figure 1. Flow chart
ACS: Acute coronary syndrome, NSTEMİ: non-STEMI

had incomplete data, refused treatment, or had exits before angiography were excluded from the study. The study included 107 patients. Data for excluded patients are presented in Figure 1.

The median age of the patients included in the study was 64 years (55-74), where 65.4% were male (n=70). Upon review of the patients' comorbidities, 76.6% had hypertension (n=82), 75.7% had coronary artery disease (n=81), and 47.7% had diabetes mellitus (n=51). Mortality occurred in only 3.7% (n=4) of patients. A summary of the patients' demographic characteristics is presented in Table 1.

When the demographic data of patients were compared between the OMI and NOMI groups, no significant differences were observed according to age, sex, comorbidity, or mortality. Table 2 presents the relationship between demographic data and subgroups.

Upon review of the relationship between laboratory parameters and OMI/NOMI subgroups, the WBC count was 10.3 (8.30-2.8) and neutrophil count was 7.30 (5.45-10.0) in the OMI group, whereas the WBC count was 9.0 (6.80-10.6) and neutrophil count was 5.90 (3.95-7.90) in the NOMI group (respectively p values=0.023, 0.008). When troponin values were evaluated, the median troponin was found to be 0.68 (0.15-4.82) in the OMI group, which was higher than that in the NOMI group (p=0.014).

Table 1. Demographic data of the patients

Variable (n=107)	**Median (Q1-Q3)**
Age (year)	64 (55-74)
	n (%)
Gender	
Female	37 (34.6)
Male	70 (65.4)
Comorbidities	
Hypertension	82 (76.6)
Coronary artery disease	81 (75.7)
Diabetes mellitus	51 (47.7)
Chronic obstructive pulmonary disease	8 (7.5)
Cerebrovascular event	8 (7.5)
Chronic renal failure	9 (8.4)
Mortality	
Yes	4 (3.7%)
No	103 (96.3%)

Apart from these values, in the OMI group, ALT was found to be 23.5 (17.0-30.0) and CRP was 11.8 (4.3-26.5), and these values were found to be higher than the NOMI group (p=0.027, 0.004). There were no significant correlations between the other laboratory parameters and the groups (p>0.05). A summary of the relationships between parameters and subgroups is presented in Table 3.

Upon logistic regression analysis of the parameters, the neutrophil count was independent of OMI/NOMI discrimination (Table 4). Upon receiver operating characteristic analysis aimed to test the effectiveness of neutrophil value in determining OMI, sensitivity, specificity, positive predictive value, and negative predictive value were 82.69%, 40.00%, 56.58%, and 70.97%, respectively (area under the curve: 0.650) (Figure 2), when the neutrophil value was set to 5.1×10^9/L.

Discussion

In the present study, neutrophil counts were significantly higher in the OMI group, suggesting that neutrophil counts can be an independent parameter for differentiating OMI from NOMI.

Table 2. Relationship between demographic characteristics and OMI/NOMI subgroups

Variable	OMI 52 (48.6%)	NOMI 55 (51.4%)	p value
Age (year) Median (Q1-Q3)	62.0 (54.8-72.5)	68.0 (57.5-75.0)	0.270
Male n (%)	36 (69.2)	34 (61.8)	0.420
Comorbidities n (%) Hypertension Coronary artery disease Diabetes mellitus Chronic obstructive pulmonary disease cerebrovascular event Chronic renal failure	36 (69.2) 36 (69.2) 23 (44.2) 4 (7.7) 2 (3.8) 5 (9.6)	46 (83.6) 45 (81.8) 28 (50.9) 4 (7.3) 6 (10.9) 4 (7.3)	0.078 0.129 0.489 0.934¥ 0.165¥ 0.663¥
Mortality n (%) Yes No	 3 (5.8) 49 (94.2)	 1 (1.8) 54 (98.2)	0.282¥

OMI: Occlusion myocardial infarction, NOMI: Non-OMI
¥Fisher's exact test was used

Table 3. Relationship between laboratory parameters and OMI/NOMI subgroups

Variable	OMI n (%)	NOMI n (%)	p value
	Mean ± SD	Mean ± SD	
K mEq/L	4.52±0.51	4.37±0.56	0.161¥
	Median (Q1-Q3)	Median (Q1-Q3)	
WBC (10^9/L)	10.3 (8.30-12.8)	9.0 (6.80-10.6)	0.023*
Lymphocyte (10^9/L)	1.70 (1.28-2.40)	2.30 (1.40-2.50)	0.231
Neutrophil (10^9/L)	7.30 (5.45-10.0)	5.90 (3.95-7.90)	0.008*
Platelet (10^9/L)	218 (166-259)	208 (172-264)	0.658
Monocyte (10^9/L)	0.53 (0.43-0.73)	0.490 (0.430-0.695)	0.658
Urea (mg/dL)	41 (33-59)	40 (31-48)	0.218
Creatinine (mg/dL)	0.850 (0.700-1.13)	0.900 (0.700-1.10)	0.767
AST (U/L)	33.0 (23.8-52.3)	27 (20-36)	0.071
ALT (U/L)	23.5 (17.0-30.0)	19.0 (13.5-24.0)	0.027*
Na mEq/L	139 (137-140)	139 (137-140)	0.855
Cl mEq/L	106 (103-107)	104 (10-107)	0.670
CRP mg/L	11.8 (4.3-26.5)	4.0 (2.1-9.5)	0.004*
Trop ng/mL	0.68 (0.15-4.82)	0.21 (0.03-1.19)	0.014*

K: Potassium, WBC: White blood cell, AST: Aspartate aminotransferase, ALT: Alanine transaminase, Na: Sodium, Cl: Chlorine, CRP: C-reactive protein, Trop: Troponin, Occlusion myocardial infarction, NOMI: Non-OMI, SD: Standard deviation
¥Student's t-test was used p<0.05. Mann-Whitney U test was used

Table 4. Logistic regression analysis of parameters				
Parameter	**Estimate**	**Odds ratio**	**%95 confidence interval**	
CRP	0.00385	1.004	0.991	1.017
Troponin	-0.09825	0.906	0.810	1.014
Neutrophil*	-0.14552	0.865	0.751	0.995
CRP: C-reactive protein Omnibus χ^2 (3) = 9.95 p=0.019 R^2 = 0.121 (Negelkerke) * p<0.005				

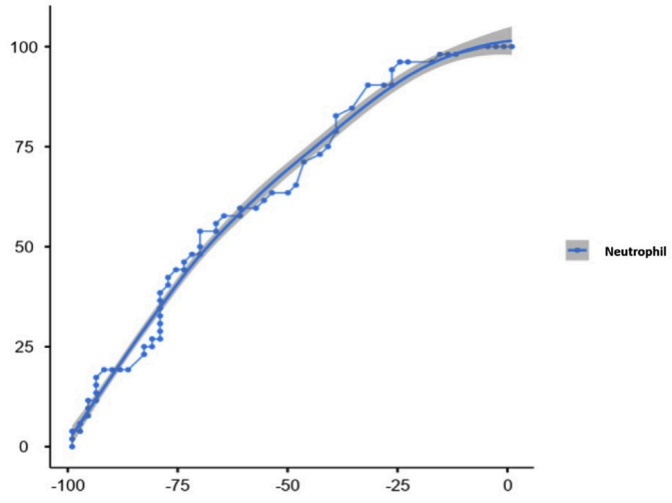

Figure 2. Receiver operating characteristic analysis of neutrophils

Inflammation is a key determinant of atherosclerosis, and previous studies reported that increased neutrophil counts were correlated with coronary artery disease (10,11). Mangold et al. (12) reported that polymorphonuclear cells were highly active in STEMI and that extracellular traps developed by neutrophils could predict infarct size. Another study by Liang et al. (10) reported that neutrophil count was independently associated with high thrombus burden and total coronary occlusion. Previous studies have reported that the percentage of neutrophils in fresh thrombi was higher than that in lytic and organized thrombi in patients with STEMI. The number of lymphocytes was also significantly decreased. In contrast, the number of neutrophils was significantly increased in patients with coronary thrombi (13,14). The results of the present study are consistent with the data reported in the relevant pathophysiological literature. Although OMI/NOMI is a recently introduced paradigm, to our knowledge, this study is one of the few to investigate the relationship between these definitions and laboratory parameters.

In one of the few studies on this subject, patients with STEMI (-) OMI had very high troponin levels, similar to those in STEMI (+) OMI patients, and these values were higher compared with those in the NOMI group (15). In the present study, troponin levels were significantly higher in the OMI group than in the NOMI group.

Occur due to the interruption of oxygen supply to myocardial tissue due to a blockage of blood flow into the coronary vessels (16). In OMI, the cause is total occlusion of the coronary vessels, whereas in NOMI, there is a partial mismatch between oxygen demand and delivery due to non-occlusive reasons (17). Accordingly, this might have accounted for the differences in troponin levels between the two groups, and the results of our study are consistent with those of previous studies.

Certain recent studies have suggested that CRP might predict ACS and that acute phase proteins, including CRP, are considered to accumulate in the necrotic center of infarcted myocardial tissue (18,19). In the present study, there was a significant difference between the OMI and NOMI groups according to CRP levels, consistent with previous studies considering the severity of inflammatory response to total coronary occlusion. However, larger case groups should be studied to determine whether CRP is an independent variable.

The concept of OMI/NOMI is limited by the absence of universal criteria and the significant influence of ECG on the definitions. Incorporating laboratory parameters can enrich definitions and bridge gaps stemming from delays in interventional procedures caused by STEMI/NSTEMI diagnoses. Our study will be pivotal in expanding the literature on OMI/NOMI by integrating laboratory parameters.

Study Limitations

This retrospective study was designed and conducted only with patients diagnosed with NSTEMI based on the data retrieved from the hospital information system. Patients with STEMI and serial ECG findings were not included in the study, and their laboratory parameters might have affected the study data.

In addition, there is limited inter-rater reliability for the criteria of STEMI among cardiologists (20). Thus, differences may have been observed in the final diagnosis of patients examined with the preliminary diagnosis of ACS.

Conclusion

Neutrophil levels can be considered independent variables, along with suggested indicators for the differentiation of OMI/NOMI patients. Troponin and CRP levels significantly differ between these two groups.

Ethics

Ethics Committee Approval: Ethical approval for our research was secured from the Ethics Committee of Karabük University Faculty of Medicine, Non-Interventional Clinical Research (decision number: 2024/1744, date: 05.05.2024).

Informed Consent: This retrospective study.

Authorship Contribution

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

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

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Evaluation of Hookah Smoking-Induced Hemodynamic Changes According to the PVI

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Abstract

Aim: Hookah smoking is increasing all over the world, and it can cause many health problems that are rarely known to be experienced by smokers. The aim of this study was to evaluate the acute impact of hookah smoking on hemodynamic parameters using perfusion index (PI) and pleth variability index (PVI).

Materials and Methods: This prospective observational study was conducted in a hookah cafe with 84 participants. Systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse, oxygen saturation (SpO2), carboxyhemoglobin (COHb) PI, and PVI values of the participants were measured immediately before and 30 min after hookah smoking.

Results: Sixty-three (75%) participants were male, and the median age was 26 [interquartile range (IQR) 22-29]. There were no significant changes in SBP, DBP, pulse, and SpO2 following hookah smoking. There was a 2% (IQR 2-3) increase in COHb level ($p<0.001$) and a 1.4% (IQR 0.6-0.4) decrease in PI value ($p=0.02$) with hookah smoking. No difference was detected in PVI value with hookah smoking ($p=0.3$).

Conclusion: Hookah smoking caused a significant decrease in the PI and an increase in COHb levels. Conversely, PVI did not change with hookah smoking. It should be known that hookah is a harmful, not innocent, tobacco product that can cause many hemodynamic changes.

Keywords: Hookah, carbon monoxide, carboxyhemoglobin, PVI, perfusion index

Introduction

Hookah, a kind of smoked tobacco product, has been used widely, especially in Middle Eastern countries since the 16th century; became very popular among young people all over the world after the 1990s (1). Studies have demonstrated that hookah smokers have little knowledge about the impact of hookah on health, and even many of them have false beliefs that hookah smoking is less harmful than cigarette smoking (2,3). However, unlike cigarettes, using charcoal as a heating source in hookah causes hookah smokers to inhale charcoal combustion products in addition to products originating from the tobacco mixture (4). It was found that a single session of hookah smoking contains many times more carbon monoxide (CO), nicotine, and carcinogenic polycyclic aromatic hydrocarbons (PAH) than the smoke of a single cigarette (4). Exposure to such toxins is associated with numerous disorders, such as cancers, respiratory illnesses, cardiovascular disorders, but there are also acute effects of hookah smoking on vital parameters (5). Increased blood pressure and heart rate and decreased perfusion index (PI) were some of the vital changes observed due to hookah smoking (6,7).

Pleth variability index (PVI) is a non-invasive, dynamic measurement that is calculated by measuring changes in PI during a complete respiratory cycle (8). PVI is affected by physiological factors, such as circulating blood volume, vascular tonus, and intrathoracic pressure changes. Many of the studies in the literature focused on the relationship between PVI and the volume status of patients (8,9). However, some studies have evaluated changes in vascular tonus and hemodynamic parameters with PVI under different clinical conditions in normovolemic patients (10,11).

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The aim of this study was to evaluate the acute impact of hookah smoking on hemodynamic parameters using PI and PVI.

Materials and Methods

This was a prospective observational study conducted in a hookah cafe that was operating in accordance with the relevant legal regulations (according to relevant regulations, smoking of tobacco products must be done in open area). This study was conducted in accordance with the Ankara Keçiören Training and Research Hospital Clinical Research Ethics Committee (decision number: 2012-KAEK-15/1785, date: 26.12.2018). Participants were not encouraged to smoke hookah in any way. People who had already come to the relevant cafe to smoke hookah were included in the study. Participation was voluntarily. Written informed consent was obtained from the participants.

Study population: Volunteers aged between 18 and 40 were included in the study. Pregnant and lactating women, persons with known chronic comorbid diseases, and volunteers with a hookah smoking period of less than 30 min were excluded.

Study process: First, the participants rested for 5 min in the sitting position. At the end of the 5th min blood pressure was measured from the left arm (Omron M3 Comfort Hem-7134-E®); simultaneously pulse, oxygen saturation (SO2), carboxyhemoglobin (COHb), PI, and PVI were measured from the 4th digit of the right arm with a non-invasive pulse oximeter (Masimo Root Rainbow Set®). Measured values and demographic variables of the participants were recorded on the study forms.

Participants were advised not to smoke any other tobacco product and not to drink beverages containing alcohol while smoking hookah. Alcohol-free beverages were freely consumed. The researchers did not intervene in the hookah smoking style, inhalation frequency, and inhalation duration of the participants. At the end of 30 min hookah smoking, all the parameters mentioned above were measured again using the same technique.

Sample size estimation: The sample size of the study was calculated using G*Power v3.1.9.7 software. The calculation was performed using Cohen's medium effect size. To determine the differences in PI and PVI among hookah smokers, a medium effect size (d=0.5), 1% type I error, and 95% power two-tailed calculation was performed. The sample size was calculated as 75. To prevent protocol violations, it was decided to include 84 participants in the study.

Statistical Analysis

Statistical analyses of the study were performed using SPSS for Windows 20. The distribution of normality was tested with Kolmogorov-Smirnov test, and continuous variables were defined as median and interquartile range (IQR). Categorical variables were defined as case numbers and percentages. Analyses between categorical variables were tested using the chi-square test, and analyses between dependent continuous variables were tested using the Wilcoxon signed-rank test. P value <0.05 considered statistically significant.

Results

Among the 84 participants, 21 were women, and the median age of all participants was 26 (IQR 22-29). Nearly three-fourths of the participants were cigarette smokers. The demographic data of the participants are summarized in Table 1.

There was no difference in systolic blood pressure, diastolic blood pressure, pulse rate, and SpO2 between before and after hookah smoking. On the other hand, there was a significant increase in COHb levels in the participants after hookah smoking (p<0.001).

There was a significant decrease in the PI after hookah smoking [5.7 (IQR 2.8-7.8) and 4.3 (IQR 2.2-7.4), before and after hookah smoking, respectively, p=0.02]. There was also a decrease in the PVI value of the patient with hookah smoking, but this difference was not statistically significant [27 (IQR 21-32) and 24 (IQR 19-31), before and after hookah smoking respectively, p=0.3]. Changes in the vital parameters with hookah smoking are summarized in Table 2.

Differences among basal (before hookah smoking) COHb levels and PIs of participants with and without cigarette smoking habits were evaluated. The median COHb level was significantly high in cigarette smokers [5 (IQR 3-7) and 2 (0-3.25), cigarette smokers and non-smokers respectively, p<0.001]. Conversely, there were no significant differences among the basal PI, basal PVI, delta (difference between before and after hookah smoking) PI, and delta PVI values of the participants with and without cigarette smoking habits. Data were summarized in Table 3.

Table 1. General characteristics of the participants

Variable	
Gender n (%) Male Female	 63 (75) 21 (25)
Age (year) (median IQR 25-75)	26 (22-29)
Height (cm) (median IQR 25-75)	175 (170-180)
Weight (kg) (median IQR 25-75)	76 (67.25-85)
Cigarette smoking n (%) Yes No	 62 (73.8) 22 (26.2)

IQR: Interquartile range

Table 2. Changes in vital parameters due to hookah smoking			
Parameter	**Before hookah smoking**	**After hookah smoking**	**p value**
Systolic blood pressure (mmHg)	119 (107.75-127.75)	117 (106-126.75)	0.1
Diastolic blood pressure (mmHg)	77.50 (71.25-85.75)	78 (70-86)	0.7
Pulse rate (beat/minute)	87.50 (80.25-97)	90.50 (78.50-98)	0.5
Oxygen saturation (%)	97 (96-97)	97 (96-97)	0.1
Carboxy hemoglobin level (%)	4 (3-6)	6 (5-9)	**<0.001**
Perfusion index (%)	5.7 (2.8-7.8)	4.3 (2.2-7.4)	**0.02**
Pleth variability index (%)	27 (21-32.5)	24 (19-31)	0.3
*All the data were given as median and IQR 25-75, IQR: Interquartile range			

Table 3. Difference among carboxyhemoglobin level and perfusion parameters between participant with and without cigarette smoking habit			
Parameter	**Cigarette smokers**	**Cigarette non-smokers**	**p value**
Carboxy hemoglobin level (%)	5 (3-7)	2 (0-3.25)	**<0.001**
Basal** perfusion index (%)	5.8 (2.8-8.1)	5.4 (2.6-7.1)	0.5
Delta*** perfusion index (%)	27 (20.75-33.25)	26 (21.5-29)	0.6
Basal** pleth variability index (%)	-0.4 (-3.5-1.8)	-1.5 (-2.2--0.2)	0.3
Delta*** pleth variability index (%)	-2.5 (-8-5.2)	-0.5 (-7.2-5.2)	0.4
*All the data given as median and IQR 25-75 **Basal means the value, before starting to hookah smoking ***Delta means the difference between the measurement done before and after hookah smoking			

Discussion

This study, in which the impact of single session hookah smoking on vascular tonus and hemodynamic parameters using PVI was evaluated, had two main results. First, we demonstrated that hookah smoking causes a decrease in the PI. Second, there was a decrease in PVI with hookah smoking, but this was not statistically significant.

Hookah, which may seem like an innocent habit by smokers, is a tobacco product with serious side effects on health in the acute and chronic periods. To the best of our knowledge, the first study on the impact of hookah smoking on vital parameters was conducted in Jordan in 1999 (12). Shafagoj et al. (12) demonstrated increases in heart rate and systolic and diastolic blood pressure with hookah smoking in otherwise healthy 18 hookah smokers. Similar results have been observed in many studies (13-15). Nicotine by increasing sympathetic activity is thought to be the mechanism responsible for hemodynamic changes in hookah smoking (6). Similar to the literature, despite not being statistically significant, there was an increase in the heart rate and blood pressure of the participants after hookah smoking in our study.

Another harmful effect of hookah smoking is increased carboxyhemoglobulin (COHb) levels (16). Yıldırım et al. (16) showed an increase at COHb level from 0 (IQR 0-6) to 22 (IQR 6-44) with 30 min hookah smoking. In another study, researchers compared the end-tidal carbon monoxide (eCO) levels of cigarette smokers (5 cigarettes in 30 minutes), passive cigarette smokers, hookah smokers (for 30 minutes), and passive hookah smokers and showed that the mean increases at eCO levels were 9.4+/4.6 ($p<0.005$), 3.5+/2.5 ($p<0.05$), 57.9+/27.4 ($p<0.005$), and 13.3+/4.6 ($p=0.03$), respectively (17). These studies show us that CO production due to hookah smoking is many times greater than cigarette smoking; and hookah smoking may lead to subclinical CO poisoning in hookah smokers. In a study that analyzed the content of the mainstream smoke of hookah, it was demonstrated that a single hookah smoking session contains 143 mg CO; which was 12.6 mg in average in a single cigarette (18). Likewise, there was an increase in the COHb levels of the participants after hookah smoking in our study. In addition, basal COHb levels were higher in participants who smoked cigarette.

When the impact of hookah smoking on the PI was researched, there was only one study on this subject in the literature; and according to the best of our knowledge, our study is the first to investigate the impact of hookah smoking on PVI. Martinasek et al. (7) demonstrated that the mean PI decreased from 3.1% to 2.7% ($p=0.002$) after visiting a hookah lounge. That was the only study about the effect of hookah on PI; but it had an important limitation. Measurements were performed while entering and

leaving of a hookah lounge, and the time spent in there varied between 32 and 314 min. Our results are similar to those of this study. The reason for the decrease in PI with hookah smoking might be due to the increase in vascular tone. Rezk-Hanna et al. (19) demonstrated that hookah smoking led to a decrease in skin blood flow by 23%, as a consequence of the acute vasoconstrictor effect of nicotine.

PVI is a parameter derived from the PI based on the difference between the minimum and maximum PI values over a sufficient period of time (20). Therefore, in the case of a decrease in the PI, an increase in PVI is predicted. However, despite the decrease in the PI, no significant change in PVI was observed in our study. This finding might be due to other variables that may affect PVI indirectly, such as respiratory variations, arterial and venous distensibility, local skin microcirculation, and sympathetic nervous system activity (21). Hookah smoke contains many different chemicals like tar, nicotine, PAH, and CO, and these chemicals affect these variables in different ways; nicotine causes vasoconstriction on the skin, and CO causes vasodilation (18). Therefore, the cumulative effect of chemicals may have prevented the expected unidirectional change in PVI.

Study Limitations

The most important limitation of this study was that it did not standardize the hookah smoking style (smoke inhalation frequency and duration) of the participants. In addition, according to relevant legal regulations, consumption of tobacco products may only be open air. It is possible that being outdoors reduced the amount of smoke inhaled. Although participants were warned to not smoke any other tobacco product during the study period, we did not know the amount of tobacco products they were exposed to or consumed in the immediate past. However, given the very limited data on this subject, we believe that our study is valuable.

Conclusion

This study demonstrated that hookah smoking caused a significant decrease in the PI and an increase in COHb levels. Conversely, PVI did not change with hookah smoking. It should be known that hookah is a harmful, not innocent, tobacco product that can cause many hemodynamic changes.

Ethics

Ethics Committee Approval: This study was conducted in accordance with the Ankara Keçiören Training and Research Hospital Clinical Research Ethics Committee (decision number: 2012-KAEK-15/1785, date: 26.12.2018).

Informed Consent: Written informed consent was obtained from the participants.

Authorship Contributions

Surgical and Medical Practices: M.A.Ö., Concept: M.A.Ö., Y.Ç., Design: M.A.Ö., Ş.K.Ç., Data Collection or Processing: M.A.Ö., G.Ç.I., Analysis or Interpretation: M.A.Ö., G.Ç.I., Y.Ç., Ş.K.Ç., Literature Search: M.A.Ö., G.Ç.I., Writing: M.A.Ö., G.Ç.I., Y.Ç., Ş.K.Ç.

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Assessing Healthcare Worker Perspectives on Telemedicine in Preoperative Surgical Care: A Survey Study in Azerbaijan

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Abstract

Aim: This study aimed to explore the perspectives of healthcare workers, particularly those involved in emergency medical services, regarding telemedicine's role in preoperative surgical care in Azerbaijan.

Materials and Methods: This cross-sectional survey study was conducted among healthcare workers at medical institutions providing emergency services in Azerbaijan. A total of 2293 participants, including physicians and nurses, were surveyed to assess their awareness, attitudes, and training needs regarding telemedicine in preoperative surgical care.

Results: The survey revealed a considerable gap in awareness among healthcare workers regarding telemedicine in preoperative surgical care, with the majority expressing moderate to satisfactory knowledge [72.3%, 95% confidence interval (CI): 69.8%-74.7%]. While willingness to embrace telemedicine was prevalent among respondents, participation in relevant training events remained limited, particularly among younger healthcare workers (25.6%, 95% CI: 23.2%-28.1%). Positive attitudes toward the application of telemedicine were observed, particularly in managing cardiac emergencies and post-trauma care (87.4%, 95% CI: 85.2%-89.5%). This study highlights the urgent need for targeted training programs to enhance telemedicine skills and awareness among healthcare personnel, particularly in the context of preoperative surgical care. By addressing these training needs and fostering a culture of telemedicine adoption, healthcare systems can capitalize on telemedicine's potential to improve preoperative assessment, optimize surgical planning, and enhance patient outcomes.

Conclusion: These findings provide valuable insights into shaping future telemedicine initiatives and training strategies in the context of surgical care, ultimately leading to better patient outcomes and patient satisfaction.

Keywords: Surveys and questionnaires, emergency medical services, telemedicine, preoperative care, training support/education

Introduction

Despite progress in healthcare, providing quality emergency medical services (EMS) to rural and remote populations remains a significant challenge. Currently, approximately 5 million people worldwide lack the necessary infrastructure for emergency care, necessitating an additional 143 million surgical interventions annually to address delayed hospitalizations and disabilities (1-3).

Over the past two decades, many countries have implemented telemedicine as a method of providing distant medical services, with the goal of enhancing specialized healthcare delivery in rural areas. Telemedicine enables the receipt of theoretical and practical guidance from experienced specialists and facilitates the provision of specialized assistance to patients using information technologies in real-time during emergencies in remote regions (4-6).

In the context of surgical care, telemedicine is increasingly recognized for its potential to transform preoperative, intraoperative, and postoperative management. Preoperative telemedicine consultations can improve patient assessment, optimize surgical planning, and enhance patient education and preparation. This approach is particularly valuable in remote settings where access to medical expertise is limited. Telemedicine can bridge the gap by allowing surgeons to evaluate patients remotely, thus ensuring that critical

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preoperative information is communicated effectively and timely decisions are made (7-9).

Moreover, telemedicine can facilitate remote surgical mentorship and guidance during surgeries, especially in emergency surgeries where time and expertise are critical. Postoperatively, telemedicine enables continuous monitoring and follow-up, reducing the need for frequent in-person visits and allowing for timely intervention if complications arise. This holistic approach not only improves surgical outcomes, enhances patient satisfaction, and reduces healthcare costs (10-13).

Although telemedicine has been used in Azerbaijan over the past 5-6 years, it has primarily served as a limited communication platform between physicians for information exchange. Various factors, including organizational, technical, financial, and ethical considerations, have hindered the wider adoption of telemedicine. However, we believe that the primary barrier lies in the insufficient awareness of telemedicine by healthcare personnel. Additionally, there is a lack of cohesive and effective communication channels between emergency medical personnel and specialists from central hospitals, which is crucial for establishing a systematic telemedicine program nationwide. The purpose of this study was to investigate the perceptions and experiences of healthcare workers regarding presurgical issues in the context of telemedicine. With the increasing adoption of telemedicine in surgical care, understanding the challenges and concerns faced by healthcare providers is crucial for optimizing patient outcomes and healthcare delivery.

Specifically, this study aims to:

a) Assess the awareness and utilization of telemedicine platforms by healthcare workers involved in surgical care.

b) Identify common presurgical issues encountered by healthcare workers in telemedicine settings, such as patient assessment, informed consent, preoperative preparation, and patient education.

c) Explore the perceived barriers and facilitators of addressing presurgical issues through telemedicine.

d) Examine the impact of telemedicine on healthcare workers' workload, job satisfaction, and overall efficiency in managing presurgical care.

e) Investigate healthcare workers' perspectives on the effectiveness and safety of telemedicine interventions in addressing presurgical concerns compared with traditional in-person consultations.

By conducting a comprehensive survey among healthcare workers, this study aimed to provide valuable insights into the current landscape of presurgical care in telemedicine and highlight areas for improvement and intervention. The findings of this research will contribute to the development of evidence-based strategies and guidelines aimed at enhancing the quality and efficacy of telemedicine services in surgical practice, ultimately leading to better patient outcomes and patient satisfaction.

Materials and Methods

The study was approved by the Ethical Committee at the Azerbaijan State Advanced Training Institute for Doctors named after A. Aliyev (decision number: 5, date: 26.11.2019). Ethical principles of the World Medical Association Declaration of Helsinki (World Medical Association Declaration of Helsinki, 1964, ed. 2013) were adhered to.

Survey instrument: To assess the knowledge, attitudes, and training needs regarding telemedicine among healthcare workers, a structured questionnaire was developed. The anonymous voluntary survey questionnaire started with 4 demographic questions.

The demographic questions and response options were as follows:

1. Current workplace regional or (district hospital, central specialized institutions, pre-hospital EMS).

2. Position (physician or nurse).

3. Age group (20-30, 30-40, 40-50, 50-60).

4. Length of work experience (1-5 years, 5-10 years, 10-15 years, 15-20 years, 20-30 years, more than 30 years).

The main part of the questionnaire consisted of 10 questions designed to evaluate respondents' awareness of telemedicine, their participation in relevant training events, and their views on the applicability and future potential of telemedicine in their practice. The survey also included questions on the use of telemedicine in specific medical scenarios, such as emergency care, as well as the legal and ethical considerations associated with its implementation. The full questionnaire, which was distributed electronically to healthcare institutions across the country, is provided below:

1. How would you rate your knowledge about telemedicine?

☐ I have extensive knowledge.

☐ I have moderate knowledge.

☐ I have satisfactory knowledge.

☐ I have no knowledge at all.

2. Have you participated in any training, conferences, or other events related to telemedicine?

☐ No

☐ Yes

☐ If yes, please specify the name, location, and date of the event.....

3. What is your opinion on using computer equipment, smartphones, and other information technologies to access the necessary information?

☐ It is appropriate.

☐ It is appropriate only in certain critical situations.

☐ It is not appropriate.

☐ Other comments: .....

4. How would you rate your ability to use the equipment and software necessary for telemedicine (e.g., cameras, smartphones, live streaming, transmission of images and videos, etc.)?

☐ Excellent

☐ Adequate

☐ Inadequate

☐ I am not able to use them.

☐ Other comments: .....

5. How informed are you about the legal and ethical issues associated with telemedicine, including patient data confidentiality?

☐ I am well informed.

☐ I have moderate knowledge.

☐ My knowledge is satisfactory.

☐ I am not informed.

6. What are your opinions on the application of telemedicine in the Republic of Azerbaijan?

☐ It is appropriate.

☐ It is appropriate only in certain critical situations.

☐ It is not appropriate.

☐ Other comments: .....

7. Have you used telemedicine in your practice?

☐ No

☐ Yes

☐ If yes, please provide more details below: .....

.....

8. Which types of telemedicine training would you prefer to participate in?

☐ Conferences, synmposia, or seminars

☐ Classroom-based training in small groups

☐ Seminars and lectures online

☐ Simulative exercises or role-play training

☐ Hybrid form (a mix of the above)

☐ Other suggestions: .....

9. In which cases or conditions do you think telemedicine could be most effective for EMS?

☐ Road traffic accidents

☐ Acute cardiovascular diseases

☐ Traumatic injuries

☐ During pregnancy

☐ Critical conditions in children

☐ Other suggestions: .....

10. How can you assess the future possibilities of telemedicine implementation?

☐ It will be successful.

☐ It is not appropriate.

☐ Other comments: .....

The questionnaire was distributed to all medical institutions providing EMS nationwide. Responses from physicians and nurses were collected in our Google Form database within 10 days. Subsequently, we analyzed the survey data and responses.

Reliability and validity of the questionnaire: To ensure the reliability of the questionnaire, internal consistency was evaluated using Cronbach's alpha. The Cronbach's alpha values for different sections of the survey were as follows: awareness of telemedicine (α=0.85), attitudes toward telemedicine (α=0.82), and training needs related to telemedicine (α=0.87). These values indicate an acceptable to good level of internal consistency for the various sections of the survey, ensuring that the questionnaire reliably measures the intended constructs.

In terms of validity, content validity was established by consulting with a panel of experts in telemedicine and EMS. These experts reviewed the questionnaire to ensure that it adequately covered the key areas of interest, such as awareness, training needs, and practical application of telemedicine in healthcare settings. Based on feedback received, minor revisions were made to enhance clarity and relevance before the questionnaire was distributed to participants.

Demographic characteristics of survey participants: A total of 2293 healthcare workers participated in the survey, comprising 884 (38.6%) physicians and 1409 (61.4%) nurses. Among the participants, 29.7% worked in regional hospitals, 5.7% in secondary care, and 2.1% in tertiary care medical institutions in the capital. EMS personnel, serving the capital and suburban areas, accounted for 62.5% of the survey participants.

The distribution of respondents by age group was as follows: 10.6% aged 20-30, 24.8% aged 30-40, 29.9% aged 40-50, and 34.7% aged 50-60. Regarding work experience, 17.4% had 1-5 years, 9.4% had 5-10 years, 15.4% had 10-15 years, 14.7% had 15-20 years, 20.5% had 20-30 years, and 22.6% had more than 30 years of experience.

Statistical Analysis

All data were compiled in an Excel sheet and then analyzed using IBM SPSS Statistics 22. The analysis included frequency distributions, and differences between variables were evaluated using Fisher's χ^2 and Student's t-tests, with a significance level set at $p<0.05$ (14,15).

Results

In the 1st question of the survey, the participants were asked to evaluate their awareness of telemedicine. The responses were carefully analyzed and are presented in Table 1.

For the 2nd question, which aimed to evaluate the attendance of medical personnel at events dedicated to telemedicine, 22.5% of respondents indicated participation, whereas 77.5% reported no participation. Among prehospital EMS personnel, 23.5% reported attendance, whereas 76.5% did not.

The 3rd question assessed respondents' attitudes toward obtaining information through computer equipment, smartphones, and other technologies. Most respondents (83.3%) found remote information exchange appropriate, and 13.2% considered it suitable only in certain critical cases.

Further analysis revealed that 82.8% of prehospital EMS employees and 82.6% of hospital staff in Baku considered remote information exchange to be suitable, whereas 13.5% and 15.2%, respectively, viewed it as acceptable only in critical cases.

The 4th question evaluated respondents' self-rated skills in using equipment and software for telemedicine. 56.2% reported good skills, 28.8% reported sufficient skills, and 7.1% reported insufficient skills, with 6.6% expressing unfamiliarity with such tools.

In response to the 5th question regarding knowledge of legal and ethical issues related to telemedicine, 29.4% provided detailed information, 36.4% provided average knowledge, and 18.8% provided satisfaction, while 15.4% reported no information.

The 6th question assessed respondents' attitudes toward telemedicine applications in Azerbaijan, with 90.8% expressing support, 4.2% opposition, and 4.9% conditional approval.

Regarding the 7th question on whether respondents had utilized telemedicine in practice, 36.5% answered affirmatively, with some sharing their experiences in the comments section.

The 8th question investigated preferred types of telemedicine training, with 61.8% favoring mass events like conferences and seminars, followed by online events (20.5%), simulation exercises (3%), and live training in small groups (0.1%).

The 9th question explored which cases or diseases could be more effectively managed by telemedicine in emergency and urgent medical care. Responses varied, with acute cardiovascular conditions (28.2%) and traffic accidents (17.8%) being cited most frequently.

Finally, the tenth question assessed respondents' perceptions of telemedicine's future possibilities, with 90.8% expecting success.

Discussion

For telemedicine to be actively and effectively utilized in surgical emergencies, two crucial components must interact closely: medical staff in EMS and qualified specialists in central hospitals. Accurate information transmission by EMS workers significantly affects EMS processing in central hospitals. Our survey results indicate that both EMS employees and central hospital physicians consider remote information exchange to be appropriate in the context of telemedicine. The fact that the vast majority of the survey participants (85%) possess adequate skills in the equipment necessary for telemedicine applications is encouraging. Over 80% of the participants expressed positive sentiments, highlighting the significant potential for telemedicine in Azerbaijan.

Preoperative telemedicine consultations can improve patient assessment, optimize surgical planning, and enhance patient education and preparation, particularly in remote settings where access to expert surgical staff is limited. Telemedicine bridges the gap by allowing surgeons to evaluate patients remotely, thereby ensuring that critical preoperative information is communicated effectively and timely decisions are made. Studies have demonstrated the effectiveness of telemedicine in preoperative care, emphasizing its role in improving patient outcomes and satisfaction (16,17).

However, the role of telemedicine in surgical care is not without controversy. Some researchers have argued that a lack of physical

Table 1. Knowledge level of the survey participants regarding telemedicine

			Detailed	Moderate	Satisfactory	No knowledge	Total
Regional hospitals		n	148	261	177	96	682
		%	21.7%	38.3%	26.0%	14.1%	100.0%
Central capital hospitals	Secondary care	n	36	50	32	12	130
		%	27.7%	38.5%	24.6%	9.2%	100.0%
	Tertiary care	n	15	15	9	9	48
		%	31.3%	31.3%	18.8%	18.8%	100.0%
Pre-hospital EMS		n	264	538	399	232	1433
		%	37.5%	27.8%	16.2%	100.0%	

EMS: Emergency medical services

examination can lead to diagnostic errors and compromise patient safety (18). Additionally, technical issues such as connectivity problems and the digital divide between urban and rural areas can hinder the effectiveness of telemedicine (19). Despite these challenges, most of our survey participants expressed confidence in the successful implementation of telemedicine.

A notable finding was the preference of survey participants for live conferences and seminars to enhance their telemedicine knowledge. Interestingly, younger employees showed greater interest in online training and simulation exercises. This suggests that while traditional training methods are still valued, there is a growing recognition of the benefits of modern, technology-driven educational tools.

Regardless of age and experience, most EMS physicians believe that telemedicine is particularly effective in managing cardiac critical cases and providing specialized care after traffic accidents. This is consistent with existing literature highlighting the benefits of telemedicine in emergency and critical care settings (20). Telemedicine can facilitate remote surgical mentorship and guidance during surgeries, especially in emergency surgeries where time and expertise are critical. Postoperatively, telemedicine enables continuous monitoring and follow-up, reducing the need for frequent in-person visits and allowing for timely intervention if complications arise. This holistic approach not only improves surgical outcomes, enhances patient satisfaction, and reduces healthcare costs (21).

The strengths of our study were expressed below: the study conducted a large-scale survey among healthcare workers, providing valuable insights into their awareness, attitudes, and training needs regarding telemedicine in surgical care; the aims of the study were well-defined, focusing on understanding the perceptions and experiences of healthcare workers regarding pre-operative surgical care in the context of telemedicine; the findings have practical implications for healthcare policy and practice in Azerbaijan, highlighting the importance of targeted training programs and infrastructure development to enhance telemedicine utilization in surgical emergencies.

Overall, the strengths of this study lie in its comprehensive survey design and clear objectives, while its limitations include potential biases in self-reporting and the lack of longitudinal data.

Study Limitations

The study was conducted in Azerbaijan, which may limit the generalizability of the findings to other settings with different healthcare systems and resource availability. The data collected through surveys are subject to self-reporting bias, which may influence the accuracy of responses regarding the participants' knowledge, attitudes, and experiences with telemedicine. The cross-sectional nature of the study limits the assessment of changes in perceptions and practices over time, and longitudinal data would provide a more comprehensive understanding of telemedicine utilization in surgical care.

Conclusion

Telemedicine represents an innovative frontier with broad applications in areas where EMS are critical. Most medical workers in Azerbaijan express confidence in the successful implementation of telemedicine services. Cardiovascular diseases and traffic accidents have emerged as the primary areas where telemedicine is most necessary. Our study of medical staff training needs revealed a preference for live conferences and seminars, indicating a demand for increased telemedicine training opportunities. Given the novelty and specificity of telemedicine, there is an urgent need to expand both the quantity and quality of telemedicine training due to the limited information available in the literature.

Ethics

Ethics Committee Approval: The study was approved by the Ethical Committee at the Azerbaijan State Advanced Training Institute for Doctors named after A. Aliyev decision number: 5, date: 26.11.2019). Ethical principles of the World Medical Association Declaration of Helsinki (World Medical Association Declaration of Helsinki, 1964, ed. 2013) were adhered to.

Informed Consent: Survey questionnaire study.

Authorship Contributions

Concept: E.I., Design: E.I., Data Collection or Processing: M.J., Analysis or Interpretation: M.J., Literature Search: S.R., Writing: E.I.

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

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Evaluation of Mortality in Height-Experiencing Falls in Patients with Height and Traffic Accidents

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Abstract

Aim: To evaluate the factors influencing mortality in patients admitted to the emergency department due to falls from height and traffic accidents, based on injury patterns and clinical characteristics.

Materials and Methods: This retrospective analysis included 2348 trauma patients who experienced traffic accidents or falls from a height. The demographic and clinical characteristics of the patients were examined. Factors affecting mortality were evaluated using statistical methods.

Results: Among the traumas, 90.3% were due to traffic accidents and 9.7% to falls from a height. Patients who fell from a height were found to have a lower Glasgow Coma scale (GCS) score (p=0.002). Hospitalization and mortality rates were higher in patients who fell from heights (p=0.001 and p=0.038, respectively). Mortality was significantly higher in patients with injuries to three or more organs and in those with intracranial injuries (p=0.001 and p=0.001, respectively).

Conclusion: Mortality is higher in patients who fall from height than in those who are involved in traffic accidents. Parameters directly associated with mortality include craniocerebral, multiorgan, and low GCS scores.

Keywords: Traffic accident, fall from height, mortality, trauma

Introduction

Trauma patients comprise a significant portion of emergency department presentations. Traumas range from low-energy to high-energy injuries (1). Traffic accidents are the most common type of trauma, followed by falls from height (2). Several factors affect the mortality of patients with high-energy trauma (3). Based on the mechanism of injury, the presence of head injuries and intra-abdominal hemorrhage is a critical, life-threatening condition (4). Falls from a height and road accidents are classified as high-energy traumas. The clinical management of these patients should be considered as multi-trauma patients, in accordance with trauma guidelines. This is because the patient's history may not provide sufficient clinical information for the physician. Consequently, a comprehensive systemic examination is necessary for these patients. Pathologies that could lead to mortality should be promptly identified and diagnosed, followed by immediate initiation of treatment (5).

In this study, we aimed to evaluate the factors affecting the mortality of patients presenting to the emergency department due to falls from height and traffic accidents, based on the injury patterns and clinical characteristics.

Materials and Methods

The study was conducted in the emergency department of a tertiary care hospital, which serves as a regional center for trauma patients, handling all trauma cases in the area. The

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emergency department evaluates approximately 800 patients daily, including an average of 150 patients with general trauma. This study retrospectively assessed patients who presented to the emergency department due to falls from a height and traffic accidents between January 1, 2020, and December 30, 2021. Ethical approval for our research was secured from the Atatürk University Faculty of Medicine Research Ethics Committee (decision number: B.30.2.ATA.0.01.00/185, date: 15.04.2021).

Patients included in the study were those who had fallen from a height or were involved in vehicular traffic accidents, such as passengers, drivers, or pedestrians. Excluded from the study were pregnant and breastfeeding women, patients with trauma mechanisms other than falls from height or traffic accidents, and those with incomplete medical records.

Patients were evaluated using the hospital's automation system and were subsequently reviewed in patient files. Screening was conducted using the hospital's automation system with the International Classification of Diseases codes. The screening codes included W19, R29.6, V39.4, V39.5, V39.6, V39.9, V79.9, V86.0, V86.1, V86.2, V86.3, V69.4, V69.5, V69.6, V69.9, V79.6, V79.4, V79.5, V49.4, V49.5, V49.6, V59.4, V59.5, V59.9, V87, V82.1, V82.9, Z04.1, V85.0, V85.1, V85.2, V85.3, and V81.1. Subsequently, the medical records of these patients were reviewed, and patients with incomplete data were excluded from the study.

Patients were categorized into two groups: those involved in traffic accidents and those who fell from a height. The following parameters were evaluated: age, sex, type of injury, whether the patient was a pedestrian or vehicle occupant for those involved in a traffic accident, initial Glasgow Coma scale (GCS) score upon presentation, time of presentation, injury locations, clinical pathologies identified, and mortality status. The GCS scores were categorized into five groups: 3, 4-6, 7-10, 11-14, and 15. Age groups were categorized as follows: 0-5, 6-18, 19-30, 31-45, 46-60, and 61. Injury locations were assessed in regions such as the head and neck, lower extremity, upper extremity, abdomen, thorax, face, pelvis, multiple trauma areas, and back scapula. Diagnoses included head trauma, upper extremity fractures, vascular injuries, lower extremity fractures, vascular injuries, intra-abdominal injuries, rib fractures, contusions, hemopneumothorax, vertebral fractures, injuries involving three or more organs, facial bone fractures, and other pathologies, such as cuts, ecchymosis, dermabrasions, hematomas, and lacerations.

Statistical Analysis

Data analysis was performed using IBM SPSS version 24. Normal variables are expressed as means, standard deviations, percentages, and numbers. The Kolmogorov-Smirnov test was used to check for normal distribution. The independent-samples t-test was used to compare normally distributed variables between the two groups, whereas the Mann-Whitney U test was used to compare non-normally distributed variables. Pearson's chi-square test was used for categorical variables. The statistical significance level was taken as $p<0.05$.

Results

The study included a total of 2.348 patients, of whom 2120 (90.3%) had been involved in traffic accidents and 228 (9.7%) had fallen from a height. The gender distribution showed that 67.7% of patients were male and 32.3% were female. The mean age of the patients was 33.23±18.7 years. Detailed clinical and demographic data are presented in Table 1.

Among the traffic accident injuries, car accidents were the most common (88.9%, with 42.7% of the injuries being pedestrians and 42.6% being drivers. Of the patients who fell from heights, 76.3% fell from heights of 1.1-4 meters, with 81 (35.5%) falling from balconies and 48 (32.2%) from scaffolding. The specific demographic data of the patients are presented in Table 2.

When comparing the clinical and demographic characteristics of patients involved in traffic accidents with those who fell from height, it was found that the latter group had a higher proportion of males (p=0.001). GCS scores were lower in patients who fell from the height (p=0.002). The 0-5 age group was more prevalent among those who fell from height compared to those involved in traffic accidents (p=0.035). In terms of injury regions, multi-trauma (32.0%), pelvis (5.7%), and back scapula (14%) injuries were more common in patients who fell from height than in those involved in traffic accidents, and these differences were statistically significant (p=0.001). Head-neck and extremity injuries were more common in traffic accidents (p=0.001). There was a statistically significant difference between the groups with respect to diagnoses based on injury region (p=0.001). Hospitalization and mortality rates were higher in patients who fell from height (p=0.001 and p=0.038, respectively) (Table 3).

Factors affecting mortality showed that patients who died had lower GCS scores (p=0.001). Among patients with multi-trauma, 71.4% had a fatal outcome, indicating a significant association with mortality (p=0.001). Head injuries were noted in 54.3% of deceased patients (p=0.001). In addition, the mortality rate was higher in patients with injuries involving three or more organs (p=0.001). Subarachnoid hemorrhage was the most common intracranial injury among deceased patients (69.7%), whereas liver and multi-organ injuries were the most frequently identified abdominal pathologies (p=0.001) (Table 4).

Table 1. Demographic and clinical characteristics of patients		
		n (%)
Gender	Male	1.590 (67.7)
	Female	758 (32.3)
Age (min-max) (mean)/years	(1-93) 33.23±18.7	
Glasgow Coma scale score	15	2.234 (95.1)
	11-14	29 (1.2)
	7-10	21 (0.9)
	4-6	23 (1.0)
	3	41 (1.7)
Age group	0-5 years	139 (5.9)
	6-18 years	364 (15.5)
	19-30 years	674 (28.7)
	31-45 years	579 (24.7)
	46-60 years	366 (15.6)
	61 years and above	226 (9.6)
Group	Traffic accident	2,120 (90.3)
	Falling from a height	228 (9.7)
Emergency arrival time	00:01-06:00	138 (5.9)
	06:01-12:00	686 (29.2)
	12:01-18:00	909 (38.7)
	18:01-00:00	615 (26.2)
Time of incident	00:01-06:00	208 (8.9)
	06:01-12:00	462 (19.7)
	12:01-18:00	898 (38.2)
	18:01-00:00	782 (33.3)
Injury location	Head-neck	563 (24.0)
	Lower extremity	360 (15.3)
	Upper extremity	438 (18.7)
	Abdomen	80 (3.4)
	Thorax	165 (7.0)
	Facial area	201 (8.6)
	Pelvis	73 (3.1)
	Multi-trauma	296 (12.6)
	Back-scapula	172 (7.3)
Diagnosis	Head trauma	186 (7.9)
	Upper extremity fractures/dislocations, vascular injury	134 (5.7)
	Lower extremity fractures/dislocations, vascular injury	243 (10.3)
	Intra-abdominal injuries	75 (3.2)
	Rib fractures, contusion, and hemopneumothorax	162 (6.9)
	Vertebral fracture	145 (6.2)
	Injury to three or more organs	76 (3.2)
	Facial bone fractures	106 (4.5)
	Cuts, ecchymosis, dermabrasion, hematoma, and lacerations	1214 (51.7)
	Other	8 (0.3)
Patient outcome	Discharge	1.192 (50.8)
	Hospitalization	1.135 (48.3)
	Mortality in the emergency department	21 (0.9)
Mortality	Discharge	2313 (98.5)
	Mortality	35 (1.5)

Table 2. Specific demographic data about the injuries		
Data on traffic accidents		**n (%)**
Vehicle type	Car	1885 (88.9)
	Tractor	49 (2.3)
	Motorbike	58 (2.7)
	Pedestrian	37 (1.7)
	Truck	13 (0.6)
	Other	78 (3.7)
Injured person	Driver	904 (42.6)
	Passenger	905 (42.7)
	Pedestrian	311 (14.7)
Data for falls from height		**n (%)**
Fall height (m)	<1	5 (2.2)
	1.1-4	174 (76.3)
	4.1-9	43 (18.9)
	9.1 and above	6 (2.6)
Fall location	Balcony	81 (35.5)
	Stairs	16 (7.0)
	Tree	18 (7.9)
	Furniture	10 (4.4)
	Roof	47 (20.6)
	Scaffold	48 (21.1)
	Other	7 (3.1)

Discussion

Trauma is the leading cause of death among young people (6). When examining the causes of trauma, traffic accidents are the most common, followed by falls from height and other injuries (2). Among blunt traumas, falls from a height are the most common cause (7). Although traffic accidents are the leading cause of trauma-related mortality, factors such as age, cause of fall, body part, and organ injuries significantly influence morbidity and mortality in patients who fall from height (8,9). Our study revealed a higher mortality rate among patients who fell from height compared with those who were involved in traffic accidents. However, consistent with the literature, traffic accidents were found to be more frequent than falls from a height in general trauma cases.

The mechanism underlying injury is crucial in trauma-related mortality. Studies have shown that patients with craniocerebral and multi-organ injuries have higher mortality rates (10-12). Rastogi et al. (13) reported that 51% of patients with major trauma presented with craniocerebral injuries. Similarly, Turgut et al. (14) identified craniocerebral injuries as the leading cause of death in patients who fell from heights. Our study similarly showed that head-brain injuries significantly affected mortality. When evaluating patients involved in traffic accidents alongside those who have suffered falls from height, we determined that individuals involved in traffic accidents exhibited a higher incidence of craniocerebral injuries. This is likely due to the mechanical impact inside the vehicle.

Regarding mortality among trauma patients, previous studies have indicated that 17.1% of trauma-related hospital deaths are due to trauma (15). Another study found a mortality rate of 1.3% due to traffic accidents (16), whereas falls from height accounted for a mortality rate of 7.1% in another study (17). In the current study, the mortality rate among patients who fell from height was 3.2%, which was higher than that for traffic accidents, which is consistent with the literature.

Another factor affecting trauma-related mortality is the specific mechanism of injury. Higher mortality rates have been reported for falls from heights of 18 meters or more (18). Another study identified a height of 6 meters as a risk factor for increased mortality (19). In traffic accidents, mortality is higher in collisions involving cars and drivers (16). In our study, 20.5% of the patients who suffered falls had fallen from a height of 4 meters or more, and the majority of the patients involved in traffic accidents were drivers. These findings are consistent with those reported in the literature.

Table 3. Comparison of the clinical and demographic characteristics of the study groups				
		Traffic accidents (n=2.120; 100%)	**Falling from a height (n=228; 100%)**	**p value**
Gender	Male	1.413 (66.7)	177 (77.6)	0.001
	Female	707 (33.3)	51 (22.4)	
Glasgow Coma scale score	15	2031 (95.8)	203 (89.0)	0.002
	11-14	18 (0.8)	11 (4.8)	
	7-10	18 (0.8)	3 (1.3)	
	4-6	20 (0.9)	3 (1.3)	
	3	33 (1.6)	8 (3.5)	
Age group	0-5 years	117 (5.5)	22 (9.6)	0.038
	6-18 years	323 (15.2)	41 (18.0)	
	19-30 years	625 (29.5)	49 (21.5)	
	31-45 years	522 (24.6)	57 (25.0)	
	46-60 years	329 (15.5	37 (16.2)	
	61 years and above	204 (9.6)	22 (9.6)	
Emergency arrival time	00:01-06:00	136 (6.4)	2 (0.9)	0.004
	06:01-12:00	621 (29.3)	65 (28.5)	
	12:01-18:00	807 (38.1)	102 (44.7)	
	18:01-00:00	556 (26.2)	59 (25.9)	
Time of incident	00:01-06:00	186 (8.8)	22 (9.6)	0.322
	06:01-12:00	4.228 (20.2)	34 (14.9)	
	12:01-18:00	800 (37.7)	96 (42.1)	
	18:01-00:00	706 (33.3)	76 (33.3)	
Injury location	Head-neck	525 (24.8)	38 (16.7)	0.001
	Lower extremity	329 (15.5)	31 (13.6)	
	Upper extremity	424 (20.0)	14 (6.1)	
	Abdomen	72 (3.4)	8 (3.5)	
	Thorax	146 (6.9)	19 (8.3)	
	Facial area	201 (9.5)	0 (0)	
	Pelvis	60 (2.8)	13 (5.7)	
	Multi-trauma	223 (10.5)	73 (32.0)	
	Back-scapula	140 (6.5)	32 (14.0)	
Diagnosis	Head trauma	153 (7.2)	33 (14.5)	0.001
	Upper extremity fractures/dislocations, vascular injury	120 (5.7)	14 (6.1)	
	Lower extremity fractures/dislocations, vascular injury	203 (9.6)	40 (17.5)	
	Intra-abdominal injuries	64 (3.0)	10 (4.4)	
	Rib fracture, contusion, and hemopneumothorax	136 (6.4)	26 (11.4)	
	Vertebral fracture	103 (4.9)	42 (18.4)	
	Injury to three or more organs	62 (2.9)	14 (6.1)	
	Facial bone fracture	99 (4.7)	7 (3.1)	
	Cuts, ecchymosis, dermabrasion, hematoma, and lacerations	1.178 (55.6)	36 (15.8)	
	Other	2 (0.1)	6 (2.6)	
Patient outcome	Discharge	1.173 (55.3)	19 (8.3)	0.001
	Hospitalization	931 (43.9)	204 (89.9)	
	Mortality in the emergency department	16 (0.8)	5 (2.2)	
Mortality status	Discharge	2.092 (98.7)	221 (96.9)	0.038
	Mortality	28 (1.3)	7 (3.1)	

Table 4. Comparison of the characteristics of the groups according to mortality status				
		Discharge n=2.313 (%)	**Mortality n=35 (%)**	**p value**
Gender	Male	1.562 (67.5)	28 (80.0)	0.079
	Female	751 (32.5)	7 (20.0)	
Glasgow coma scale score	15	2.230 (96.4)	4 (11.4)	0.001
	11-14	26 (1.1)	3 (8.6)	
	7-10	20 (0.9)	1 (2.9)	
	4-6	19 (0.8)	4 (11.4)	
	3	18 (0.8)	23 (65.7)	
Age group	0-5 years	137 (5.9)	2 (5.7)	0.433
	6-18 years	358 (15.5)	6 (17.1)	
	19-30 years	668 (28.9)	6 (17.1)	
	31-45 years	568 (24.6)	11 (31.4)	
	46-60 years	362 (15.79)	4 (11.4)	
	61 years and above	220 (9.5)	6 (17.1)	
Emergency arrival time	00:01-06:00	133 (5.8)	5 (14.3)	0.034
	06:01-12:00	682 (29.5)	4 (11.4)	
	12:01-18:00	893 (38.6)	16 (45.7)	
	18:01-00:00	605 (26.2)	10 (28.6)	
Time of incident	00:01-06:00	204 (8.8)	4 (11.4)	0.456
	06:01-12:00	458 (19.8)	4 (11.4)	
	12:01-18:00	884 (38.2)	12 (34.3)	
	18:01-00:00	767 (33.2)	15 (42.9)	
Injury location	Head-neck	555 (24.0)	8 (22.9)	0.001
	Lower extremity	360 (15.6)	0 (0)	
	Upper extremity	438 (18.9)	0 (0)	
	Abdomen	78 (3.4)	2 (5.7)	
	Thorax	165 (7.1)	0 (0)	
	Facial area	201 (8.7)	0 (0)	
	Pelvis	73 (3.2)	0 (0)	
	Multi-trauma	271 (11.7)	25 (71.4)	
	Back-scapula	172 (7.4)	0 (0)	
Diagnosis	Head trauma	168 (7.3)	19 (54.3)	0.001
	Upper extremity fractures/dislocations, vascular injury	134 (5.8)	0 (0)	
	Lower extremity fractures/dislocations, vascular injury	241 (10.4)	2 (5.7)	
	Intra-abdominal injuries	72 (3.1)	2 (5.7)	
	Rib fracture, contusion, and hemopneumothorax	158 (6.8)	4 (11.4)	
	Vertebral fracture	143 (6.2)	2 (5.7)	
	Injury to three or more organs	70 (3.0)	6 (17.1)	
	Facial bone fracture	106 (4.6)	0 (0)	
	Cuts, ecchymosis, dermabrasion, hematoma, and lacerations	1.214 (52.5)	0 (0)	
	Other	7 (0.3)	0 (0)	
Intracranial diagnosis	Cephalic hematoma	93 (54.3)	0 (0)	0.001
	Subarachnoid hemorrhage	37 (21.6)	16 (69.7)	
	Epidural-subdural bleeding	16 (9.4)	0 (0)	
	Intracranial hemorrhage	3 (1.8)	5 (21.7)	
	Contusion cerebri	21 (12.3)	0 (0)	
	Brain edema-axonal damage	1 (0.6)	2 (8.6)	
Abdominal diagnosis	Liver laceration	37 (51.3)	1 (50.0)	0.001
	Spleen laceration	11 (15.2)	0 (0)	
	Multi-organ injury	17 (23.6)	1 (50.0)	
	Perforation	7 (9.9)	0 (0)	

The GCS is a scoring system used to evaluate trauma patients. Lower GCS scores are associated with higher mortality rates in patients with trauma (20,21). In our study, the mortality rate was higher among patients involved in traffic accidents than among those who fell from a height. Consequently, patients who fell from height tended to have lower GCS scores, indicating an association with higher mortality.

Study Limitations

One limitation of this study is that it was conducted at a single center. In addition, other parameters that might influence mortality were not investigated due to the retrospective nature of the study. Furthermore, demographic data were obtained retrospectively from patient files; therefore, the heights of falls were recorded based on the patients' own statements, potentially affecting data accuracy.

Conclusion

Numerous factors affect mortality in trauma patients. Mortality is higher among patients who have fallen from a height compared to those involved in traffic accidents. Parameters directly associated with mortality include craniocerebral, multiorgan, and low GCS scores.

Ethics

Ethics Committee Approval: Ethical approval for our research was secured from the Atatürk University Faculty of Medicine Research Ethics Committee (decision number: B.30.2.ATA.0.01.00/185, date: 15.04.2021).

Informed Consent: This retrospective study.

Authorship Contributions

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

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Is Asymotomatic Low-Dose Carbonmonoxide Poisoning Harmless at Emergency Department Presentation?

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Abstract

Aim: Carbon monoxide (CO) poisoning is a common inhalation poisoning in emergency department (ED) admissions. In this study, we aimed to determine the negligible biochemical and electrocardiogram (ECG) pathological findings of this group of patients with CO poisoning and asymptomatic clinical cases with a CO level below 15% at first admission who are frequently discharged from the ED.

Materials and Methods: A total of 68 patients who were exposed to CO poisoning who did not have any clinical complaints or symptoms at the first examination and whose carboxyhemoglobin (COHb) level was between 5% and 15% were included in the study. The group with a COHb level of 5-10% was considered to have a very low level, whereas the group with a COHb level of 10-15% was considered to have a low level. Among the laboratory findings at the time of admission, the COHb level measured at the time of admission to the ED, troponin a cardiac marker, potential of hydrogen and lactate measurements, and white blood cell (WBC) and neutrophil levels were recorded. ECG data were recorded.

Results: With regard to COHb levels of low-dose and very low-dose CO poisoning, ECG parameters showed a significant difference, but not in heart rate (p=0.001) between the groups. Regression analysis was performed between ECG heart rate and COHb level, and the linear regression equation was found to be $y=2.38x+58.32$ ($r^2=0.68$).

Conclusion: It should be kept in mind that patients may sometimes present with low COHb levels at ED presentation. If patients have available ECGs, they should definitely be compared with their previous ECGs, and blood parameters, especially lactate, troponin, WBC, and neutrophil levels, should be evaluated. It should not be forgotten that tissue and organ damage can occur with low-dose poisoning.

Keywords: Carbon monoxide, electrocardiogram, emergency department, blood parameters, heart rate

Introduction

Carbon monoxide (CO) is an odorless, tasteless, colorless, and extremely toxic gas formed with the combustion of hydrocarbons (1).

CO reacts with hemoglobin in the blood, metalloproteins such as myoglobin in the tissues it reaches through the blood, and metalloenzymes such as cytochrome c oxidase, cytochrome P450, tryptophan oxygenase, and dopamine hydroxylase, causing tissue and organ damage (2,3).

Of the absorbed CO, 80% binds to hemoglobin in erythrocytes and form carboxyhemoglobin (COHb). Of it, 10-15% reacts with myoglobin in muscle cells. The affinity of myoglobin for CO is one-eighth that of hemoglobin. Cardiac muscle cells retain more CO than skeletal muscle cells (4).

Furthermore, CO causes lipid peroxidation in the brain (3). In the clinic, patients frequently encounter symptoms and signs of CO poisoning, especially in the central nervous and cardiovascular systems (3,4).

COHb levels of 5% and above in non-smokers and 10% and above in smokers are considered significant. In normal cases, a COHb level below 10% is considered very low-level poisoning (5). In low-level CO poisoning, asymptomatic patients, patients with mild non-specific symptoms, and patients with a CO level of 15% or below are considered low doses (6).

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Since there are no serious side effects of low-dose CO poisoning in the emergency department (ED), changes in the physiologic limits are ignored by physicians, and it is thought that there is no problem. However, we believe that this may affect the side effects and outcomes of low-dose CO poisoning at the cellular level and may cause serious cardiac problems in patients with comorbidities.

In this study, we aimed to determine the negligible biochemical and electrocardiogram (ECG) pathological findings of a group of patients with CO poisoning and asymptomatic clinical cases with a CO level below 15% at first admission who are frequently discharged from ED.

Materials and Methods

The study was initiated with the approval of the Niğde Ömer Halisdemir University Non-Invasive Clinical Research Ethics Committee (decision number: 2023/56, date: 24.08.2023). However, due to the retrospective study design, the requirement for informed consent was waived.

This study was conducted with strict adherence to the methods and recommendations of Worster et al. (7) for medical record review in emergency medicine research. Among patients who presented to Niğde Ömer Halisdemir Training and Research Hospital between 01.11.2021 and 30.06.2023, patients diagnosed with toxic effect of CO toxic effect of carbon monoxide (T58) ICD10 code were retrospectively screened through our hospital's automation system (Karmed). The patient data were created digitally (in the Microsoft Excel program) and added to the study data form. In this data form, demographic data included the gender of the patients, and among the information regarding CO exposure, whether the source of CO was from the stove/water heater/heater, fire/smoke, or exhaust gases was recorded. Patients' chronic diseases were recorded in the medical history section of the data form. The study investigated whether patients had chronic diseases, such as diabetes, coronary artery disease, hypertension, cerebrovascular diseases, congestive heart failure, or chronic obstructive pulmonary disease (COPD). All patients who were exposed to CO poisoning and brought by emergency ambulance teams, did not have any clinical complaints or symptoms at the first examination, and had a COHb level between 5% and 15% were included in the study. The group with a COHb level of 5-10% was considered very low, and the group with a COHb level of 10-15% was considered low. Among the laboratory findings at the time of admission, the COHb level measured at the time of admission to the ED, troponin a cardiac marker, [potential of hydrogen (pH) and lactate measurements, and white blood cell (WBC)] and neutrophil levels, which are among the blood gas parameters, were recorded.

The ECGs of patients during their admission to the ED were evaluated, and the QT interval, rate in beat/min, and PR interval were evaluated on the ECG and added to the digitally created study data form (in the Microsoft Excel program).

Inclusion Criteria

Non-pregnant patients over the age of 18 and under the age of 65 with a COHb level between 5-15% who presented to the adult ED of Niğde Ömer Halisdemir Training and Research Hospital between 01.11.2021 and 30.06.2023 and were evaluated using the T58 ICD10 diagnostic code were included in the study regardless of the source of CO poisoning in acute CO poisoning.

Exclusion Criteria

Patients whose data to be used in the study could not be accessed through our hospital's automation system in the retrospective screening, patients with T58 diagnosis code entry without measuring CO levels but whose CO levels were measured lower than 5% and higher than 15%, and patients whose file data could not be accessed or whose data were missing were excluded from the study.

Patients younger than 18 years and older than 65 years during the first admission were not included in the study.

Patients working in closed areas where they may be exposed to chronic CO were excluded from the study. Smokers were excluded from the study.

Pregnant women were excluded from the study. According to the information obtained from the anamnesis records upon admission to the ED, patients with agitation and anxiety were excluded from the study.

Statistical Analysis

Along with descriptive statistics, continuous data were expressed as mean ± standard deviation. Categorical variables were presented as frequency and percentage. χ^2 was used to test for significant differences in terms of CO levels between the study groups (study group 1:5-10% CO level and study group 2:10-15% CO level), and appropriate Statistical tests (t-test) were employed for pairwise or multiple comparisons of continuous variables. Spearman's correlation analysis was performed on the basis of the relationship between quantitative data. Additionally, simple linear regression analysis was performed to assess the relationship between ECG parameters and COHb levels. Because our study was planned as a retrospective study, power analysis was not performed because all data that met the inclusion criteria were included. A p value <0.05 was considered statistically significant. All data were entered into an Excel database (Microsoft Office 2010, Redmond, WA, USA), and statistical analysis was conducted using SPSS (IBM SPSS Statistics Version 22, SPSS Inc., Chicago, IL).

Results

Of the 102 patients initially included in the study, 28 who smoked, two who were pregnant, and four whose data were not clearly accessible were excluded from the study. Ultimately, a total of 68 patients were included in the study. The patients' mean age was 37.9 ± 13.71 years. They comprised 38.2% males and 61.8%. While 94.1% of the cases were caused by radiators, water heaters, combi boilers, solid fuel stoves such as wood and coal, and natural gas stoves, 5.9% occurred as a result of fire and exposure to exhaust gas. Fourteen patients (20.5%) had a history of chronic disease (1 coronary artery disease, 1 chronic COPD, 1 heart failure, 7 diabetes mellitus, 1 previous ischemic cerebrovascular disease history, and 3 a history of hypertension).

When the CO level was divided into two groups of very low and low, the very low level was proportionally higher in non-heater-related CO exposures concerning the source of poisoning, but it was statistically insignificant at p=0.06. When the patient groups with low and very low CO levels and the two groups with and without a history of chronic disease were separated, no significant difference was found between the groups (p=0.134).

The mean ECG PR distance was 210.59 ± 8.44 milliseconds, with a mean QRS distance of 84.97 ± 1.39 milliseconds, and a mean rate of 81.60 ± 8.50 beats per minute.

In 47 patients, the PR distance on ECG was longer than the normal range (120-200 ms). Sinus tachycardia >100 beats per minute was present in three of these patients. Notably, the QRS distance of all patients was within the normal range (<100 ms).

With regard to COHb levels of low-dose and very low-dose CO poisoning, ECG parameters (for PR interval, p=0.384; for QRS interval, p=0.342), blood parameters of troponin (p=0.338), lactate (p=0.676), pH (p=0.166), WBC (p=0.474), and neutrophil (p=0.341), no statistical difference was found, whereas a significant difference was revealed in terms of heart rate (p=0.001) between the groups (Table 1). There was a strong positive correlation between blood COHb level and heart rate (p=0.001, r=-0.823**). Regression analysis was performed between ECG heart rate and COHb level, and the linear regression equation was found to be y=2.38x+58.32 (r^2=0.68) (Figure 1). The mean level of lactate, troponin I, WBC, and neutrophils were 2.1 ± 1.5 (0-2 mmol/L), 10.9 ± 8.7 (2-14 ng/L), 9.9 ± 3.3 (4-10x100^3/uL), and 7.0 ± 3.0 (1.7-7.2 x100^3/uL), respectively (Table 2).

In the ROC analysis, The ECG parameters associated with CO poisoning are presented in Table 3 and Figure 2. Among these parameters, the power of heart rate to distinguish low- and very-low-dose CO poisoning at the optimum threshold level (79 beats/min) with a sensitivity of 0.97 and a specificity of 0.857 was stronger than the other two parameters [area under curve: 0.974, 95% confidence interval: (0.943-1.000), p<0.001].

Discussion

CO affects almost all organs and tissues, such as the brain, heart, kidneys, skeletal muscle, and peripheral nerves. Symptoms vary depending on whether the poisoning is acute or chronic and the CO concentration to which the poisoner is exposed (6,8). Regarding the etiology of CO poisoning, water heaters, combi boilers, solid fuel stoves such as catalytic and wood-coal-burning stoves, and natural gas stoves are the most common examples of these systems (9,10). This study is consistent with the literature, and cold seasons and water heater-related poisoning were present in the etiologies of most of our patients.

The main complications of CO poisoning are hypotension, angina, myocardial infarction, atherosclerosis, arrhythmias (sinus tachycardia, ventricular tachycardia and fibrillation, atrial flutter and fibrillation), and electrocardiographic changes (a decrease in the R wave size, ST elevation, T wave inversion, and heart blocks) (11).

Table 1. Comparison of ECG and blood parameters of patients with low- and very low-dose CO poisoning

	COHb 5-10%		COHb 10-15%		
	n	**mean ± SD**	**n**	**mean ± SD**	**p value**
PR interval (ms)	35	209.7 ± 8.2	33	211.5 ± 8.7	0.384
QRS interval (ms)	35	83.8 ± 1.4	33	85.2 ± 1.5	0.342
Heart rate (bpm)	35	75.4 ± 4	33	88.2 ± 6.9	0.001
Lactate	35	2.03 ± 1.21	33	2.19 ± 1.62	0.676
pH	35	7.41 ± 0.04	33	7.39 ± 0.05	0.166
Troponin I	35	8.04 ± 7.12	33	13.29 ± 9.74	0.338
White blood cell	35	9.55 ± 3.46	33	10.15 ± 3.16	0.474
Neutrophil	35	6.64 ± 2.51	33	7.37 ± 3.44	0.341

t-test, p<0.05, ECG: Electrocardiogram, CO: Carbon monoxide, COHb: Carboxyhemoglobin, pH: potential of hydrogen, SD: Standard deviation

A clinical study showed that all patients presenting to the hospital with moderate or severe CO poisoning should routinely undergo serial evaluation of ECG and cardiac markers, and those with positive signs of myocardial cytonecrosis or pre-existing ischemic heart disease should also undergo echocardiography (12).

In a study by Gandini et al. (13), transient myocardium and mitral valve function disorders were reported in a 12-year-old child who presented with an asymptomatic clinical picture and did not have a high COHb level.

In a study, it was indicated that cardiac performance was decreased and cardiac ischemia was increased in patients with underlying coronary artery disease and low-level CO poisoning (14). Another study reported that the angina threshold decreased in patients with coronary artery disease with low-level CO poisoning (6). In another study, it was stated that PR and QRS intervals on ECG were longer than normal in all patients with CO poisoning. Ischemia is believed to be the cause of this prolongation. Cell death, intracellular mitochondrial damage, and free radical formation as a result of CO poisoning is a known pathway of damage. This study argued that cellular damage secondary to hypoxia and free radical formation causes PR prolongation (15,16).

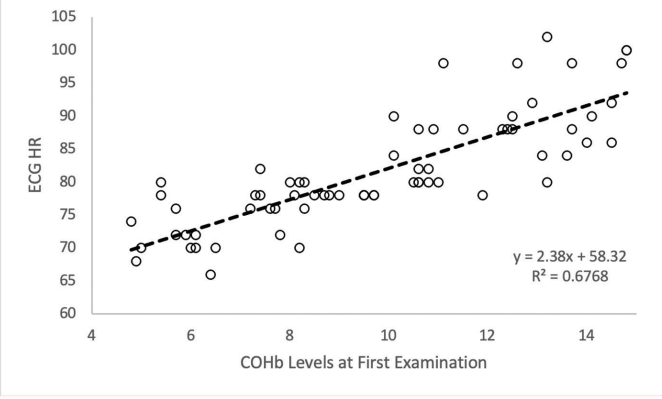

Figure 1. Regression analysis was performed between ECG heart rate and carboxyhemoglobin

ECG: Electrocardiogram, COHb: Carboxyhemoglobin

Table 2. The initial heart rate and blood parameters of patients at ED admission

n=68		Mean	SD ±
1	Heart rate	81.6	8.5
2	Lactate	2.1	1.5
3	Troponin I	10.9	8.7
4	White blood cell	9.9	3.3
5	Neutrophil	7.0	3.0
6	Carbon monoxide	9.8	2.9

ED: Emergency department, SD: Standard deviation

This study found that in low-dose asymptomatic CO poisoning, as the COHb level increased, the heart rate increased, and there was a very strong positive correlation, but no significant difference was determined in the PR and QRS intervals on ECG. The PR and QRS intervals on ECG differed at low and very low COHb levels in the ROC analysis. We believe that clinicians ignore and neglect this increase because it is not noticeable for patients in the clinic and because this increase on ECG is within the normal reference range in low-dose CO poisoning, but low doses of CO cause cardiac muscle cell damage due to CO affinity and tissue hypoxia, even in asymptomatic cases. Hence, we believe that studies with larger patient groups will contribute significantly to the literature on heart rate and ECG changes. It is known that cardiac scintigraphy is the preferred method for evaluating cardiac damage in patients after acute CO intoxication (17). We propose that cardiac scintigraphy can be used to diagnose cardiac damage caused by low-dose CO poisoning.

Eichhorn et al. (18) found a relationship between CO poisoning and troponin I value and revealed that there might be a correlation between the severity of CO poisoning and myocardial damage. Another study reported that troponin I was effective in demonstrating cardiac damage in symptomatic patients with CO poisoning admission (19). A study by Ilano and Raffin (6) reported that the angina threshold decreased in patients with coronary artery disease who experienced low-level CO poisoning.

When CO is at toxic levels, thrombosis is increased. Increasing the expression of inducible nitric oxide (NO) synthase, it increases

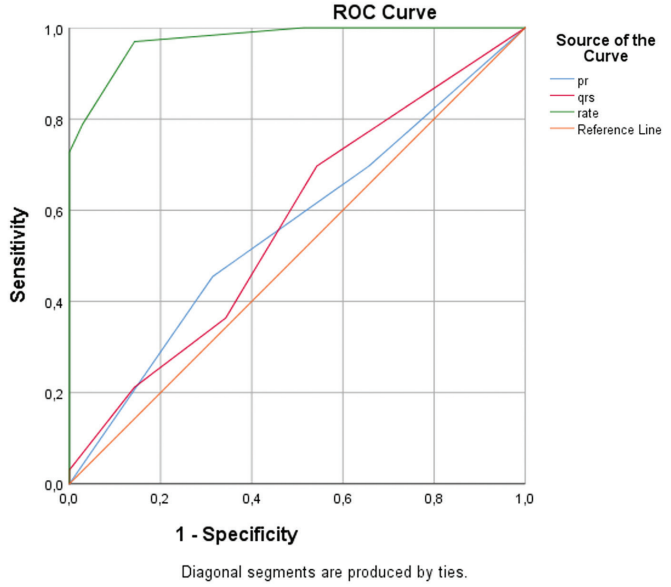

Figure 2. ROC curve analysis. The data show that heart rate has a higher power to discriminate low and very low COHB levels than PR distance and QRS interval

ROC: Receiver operating characteristic, COHb: Carboxyhemoglobin

Table 3. Comparison of the ability of ECG parameters to predict low- or very-low-dose COHb levels

Factor	AUC	CI 95% Lower-upper	Sensitivity	Spesificity	Youden index	Cut-off
Heart rate (beats/min)	0.974	0.943-1.000	0.970	0.857	0.827	79.00
PR interval (ms)	0.560	0.422-0.697	0.555	0.686	0.240	215.00
QRS interval (ms)	0.569	0.432-0.707	0.697	0.457	0.154	84.50

AUC: Area under curve, CI: Confidence interval, ECG: Electrocardiogram, COHb: Carboxyhemoglobin

NO-related myocardial damage that occurs during ischemia-reperfusion (20).

In the present study, we found that cardiac troponin I values did not statistically significantly differ in very low and low-dose CO poisoning and were within the normal reference range, but troponin I values were different between low- and very low-dose CO poisoning, although they were insignificant. However, hs-troponin has a higher affinity for detecting cardiac damage than normal troponins (21). Therefore, we conclude that hs-troponin examination will be more sensitive in detecting cardiac damage, even in asymptomatic low-dose CO poisoning cases. Approximately 10-15% of CO is extravascular and bound to molecules such as myoglobin, cytochromes, and NADPH reductase, leading to impairment of oxidative phosphorylation at the mitochondrial level.

CO causes anaerobic glycolysis and lactate production by causing tissue hypoxia. Moreover, CO has systemic effects that may lead to lactate production, including seizures, hyperventilation, and cardiac dysfunction (22,23). We found that lactate levels and pH were within the normal reference range because hyperventilation and serious cardiac damage did not occur because our study model included low-dose CO poisoning. Although these values differed between low-dose and very low-dose CO poisoning, no statistically significant difference was observed.

CO has a toxic effect on hypoxia and inflammation. Additionally, CO exposure causes inflammation in many ways other than hypoxia. Inflammation caused by oxidative factors and cytokines is a response to damaging stimuli. Different parameters indicate inflammation. Circulating white blood cells and neutrophils increase in response to inflammation. Troponin levels increase during cardiac injury, whereas lactate increases secondary to anaerobic glycolysis in tissues and increases secondary to inflammation (5,24). Although there was no statistical difference between the mean lactate, troponin, WBC, and neutrophil levels in low- and very low-dose CO poisoning, these inflammatory biochemicals had higher values in low-dose CO poisoning. Therefore, we believe that as the COHb level increases, inflammatory markers, such as troponin, lactate, white blood cells, and neutrophils, increase in a correlated manner, and many mechanisms, such as inflammation, glycolysis, and cardiac damage, are effective. We propose that histopathological studies be conducted to reveal the cellular damage caused by these changes in biomarkers detected in low-dose poisoning cases.

Study Limitations

This study has some significant limitations. This was a retrospective study. Thus, other factors influencing heart rates and clinic changes over time are missing. More extensive and long-term prospective cohort studies are needed to confirm the causal link between heart rate and COHb levels. Furthermore, the study's single-center design may restrict the generalizability of the results. The necessity of conducting studies with larger patient groups arises because of the retrospective nature of our study and the limited number of cases.

Conclusion

In conclusion, it should be kept in mind that patients may sometimes present with low COHb levels in the clinic. If patients have available ECGs, they should definitely be compared with their previous ECGs, and blood parameters, especially lactate, troponin, WBC, and neutrophil levels, should be evaluated. It should not be forgotten that tissue and organ damage can occur with low-dose poisoning. Early diagnosis and treatment are important for preventing tissue and organ damage.

Ethics

Ethics Committee Approval: The study was initiated with the approval of the Niğde Ömer Halisdemir University Non-Invasive Clinical Research Ethics Committee (decision number: 2023/56, date: 24.08.2023).

Informed Consent: This retrospective study.

Authorship Contributions

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

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Letter to the Editor
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Cornual Pregnancy with Uterine Rupture

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Keywords: Cornual pregnancy, interstitial ectopic pregnancy, uterine rupture

Dear Editor

Elangovan and Pek (1) presented in their published case report, an interesting case report of ruptured cornual pregnancy (CP) at 30 weeks^{+6d}, and mentioned that CP tends to present at 7-12 gestational weeks. Elangovan and Pek (1) reported in a published case report that CP occurs in the interstitial segment of the fallopian tube and invades the uterine muscles.

The published Elangovan and Pek (1) case reports are confusing to readers. William's textbook considers CP to be a pregnancy that occurs in the rudimentary horn of the uterus with Müllerian anomaly (2-4), while interstitial ectopic pregnancy (IEP) is a pregnancy that occurs in the interstitial segment of the fallopian tube, where it crosses the uterine muscles to enter the uterine cavity (5,6).

Cornual pregnancies (CPs) are usually diagnosed at mid-trimester of pregnancy (16 weeks for un-ruptured CPs, and 20-21 weeks for ruptured CPs) (7). In the past, interstitial ectopic pregnancies (IEPs) were usually diagnosed at 8-16 gestational weeks following ruptured IEPs (8-10). After advancements in sonographic techniques, IEPs can be diagnosed early (<8-16 weeks), and before rupture using the IEPs diagnostic sonographic findings/criteria which includes an empty uterus with a gestational sac located >1 cm away from the endometrial margin and surrounded by <5 mm myometrium (8-10). The interstitial line is a sonographic line that extends from the gestational sac to the endometrium and represents the interstitial segment of the fallopian tube with 80% sensitivity for diagnosing IEPs (8-10).

Ethics

Authorship Contribution

Concept: M.O., I.A., M.A.-F., Design: M.O., I.A., M.A.-F., Data Collection or Processing: M.O., I.A., M.A.-F., Analysis or Interpretation: M.O., I.A., M.A.-F., Literature Search: M.O., I.A., M.A.-F., Writing: M.O., I.A., M.A.-F.

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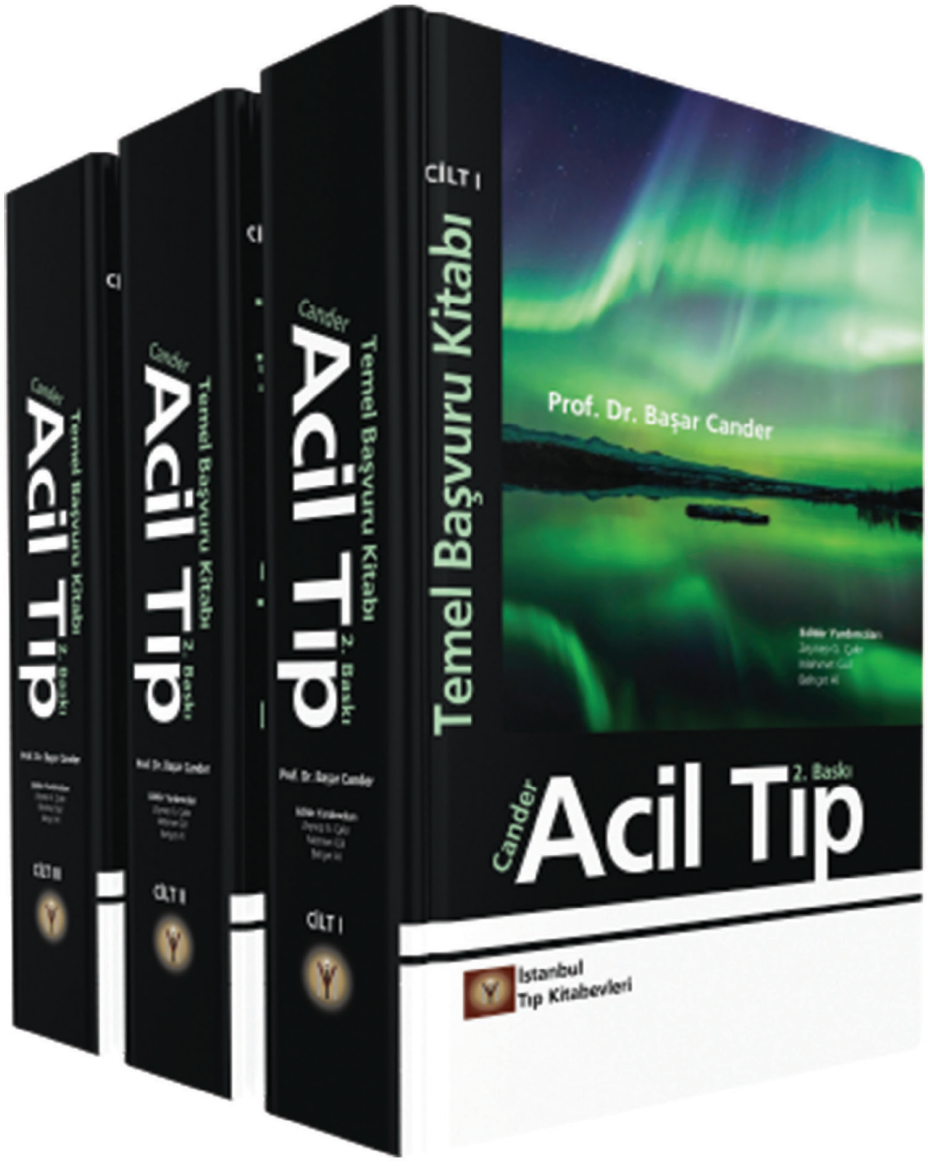

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