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ORIGINAL RESEARCHES

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ORIGINAL RESEARCH

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Stretcher Angles: Impact on Vital Signs and Optic Nerve Sheath Diameter in Prehospital Stroke Patients

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Abstract

Objective: Post-stroke hypoperfusion of brain tissue often results from increased intracranial pressure, compromising cerebral blood flow. This study investigated the relationships between the stretcher angles, the optic nerve sheath diameter (ONSD), and vital signs of stroke patients brought to the emergency department by emergency medical services (EMS).

Materials and Methods: This was a prospective, cross-sectional, single-center study. The study included individuals over 18 years of age with a stroke according to the Cincinnati Stroke Scale. Patient age, sex, time to hospital arrival with an EMS, the ONSD, vital signs, clinical findings, the stretcher angle, and Glasgow Coma Scale (GCS) scores were recorded. Stretcher angles were adjusted into one of four different group.

Results: The study included 82 patients, and the average age was 74 years. The mean systolic blood pressure was 163±35 mmHg, the mean diastolic blood pressure was 91±17 mmHg, the mean right ONSD was 0.36±0.07 cm, and the mean left ONSD was 0.37±0.07 cm. The mean GCS of the patients was 13. The GCS was lower in Group 1 than in Group 3 (p=0.002); the DBP was greater in Group 4 than in Group 3 (p=0.023); and the ONSD was more significant in Group 4 than in Group 2 (p=0.007).

Conclusion: We recommend that EMS personnel carry stroke patients at 46-60° at a stretcher angle during transport. Prehospital EMS personnel must pay more attention to the stretcher angle and be informed about it when transporting patients with suspected strokes.

Keywords: Stroke, stretcher angle, intracranial pressure, optic nerve sheath diameter, prehospital, emergency department

Introduction

According to the World Health Organization, "15 million people in the world suffer from stroke every year. Of these, 5 million die and 5 million are permanently disabled, placing a burden on families and society" [1]. Ischemic stroke accounts for 80% of strokes and usually occurs due to factors such as large vessel disease, small vessel disease, or cardioembolism [1].

Studies have shown that neurological pathologies, such as traumatic brain injury, hydrocephalus, intracerebral hemorrhage, and stroke, cause an increase in intracranial pressure (ICP). They have also investigated the underlying mechanisms [2-6]. Changes in ICP are among the markers affecting the prognosis of stroke patients [3,4].

The sonographic measurement of the optic nerve sheath diameter (ONSD) is a simple, noninvasive tool with reasonable diagnostic accuracy for estimating the ICP [7]. Compared with traditional neuroimaging methods such as computed tomography and magnetic resonance imaging, ONSD measurements have the advantages of low cost, short investigation times, good reproducibility, and bedside usability [7,8].

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Stabilization of vital signs is important in patients with suspected stroke and is included in the guidelines [9]. Some studies examine the stabilization of vital signs before hospitalization [10]. Blood pressure balance is multifactorial [11]. The effect of the transportation position on the emergency medical services (EMS) stretcher on vital signs is reversible and needs to be investigated.

The time from symptom onset to hospital arrival is vital in stroke patients. This period changes both patient prognosis and treatment options [9]. Most of these patients apply to prehospital emergency health services and are brought to emergency departments (EDs) with EMS. No standard carrying angle is specified when transporting these patients in the prehospital period. Patients to the ED vary due to local factors, and the EMS transports patients at nonstandard stretcher angles.

In this study, we aimed to investigate the relationships among the stretcher angle during transportation, vital signs, and the ONSD of stroke patients brought to the ED by the EMS.

Materials and Methods

Study Design, Ethical Statements, and Population

This was a prospective, cross-sectional, single-center study. Stroke patients who visited our ED between 15/01/2024 and 31/03/2024 were included in the study.

Ethics committee approval was received from Ankara Bilkent City Hospital Clinical Research No. 2 Ethics Committee (decision number: E2-23-5911, date: 21.12.2023). The researchers complied with the Declaration of Helsinki. Informed consent was obtained from the patient or their relatives.

The study was conducted at our ED, which has approximately 150 EMSs and 2,000 patient admissions daily. This third-level hospital has all the technical equipment to perform surgical and interventional procedures 24 hours a day, seven days a week.

Patient Selection

EMS personnel checked the Cincinnati Pre-hospital Stroke Scale (CPHSS) on the patients included in the study. According to this scale, patients with suspected stroke and patients over 18 were included in the study.

Protocols for transporting stroke patients are recommended for EMS personnel. However, there are no definitive rules. Patient transport varies according to the patient's condition and the personnel's experience. There was no intervention in the angle at which EMS personnel brought the patients.

EMS personnel were asked whether the patient's stretcher angle was changed during the transfer to the hospital. Patients who were verbally confirmed not to have changed were included in the study.

Patients with an intracranial mass, intracranial aneurysm, or intracranial metastasis; diseases that may cause brain edema, such as a postictal seizure, transient ischemic attack (TIA), hydrocephalus, sarcoidosis, ventriculoperitoneal shunt, optic neuritis, head trauma, or prosthetic eye; or diseases that may affect the ONSD by creating increased ICP; and patients who did not agree to participate in the study were excluded.

Sample Size Analysis

Sample size analysis was conducted using data from the study by Maissan et al. [5] Considering a 0.2 mm difference in ONSD between supine and angled positions, it was calculated that at least 16 patients should be included in the group with 80% power, and 5% type-1 error. Considering data loss, it was planned to include 80 patients, with 16 patients in each angle Group.

Data Collection

The patient's age, sex, time of onset of symptoms, time of patient reaching the EMS phone call, time of reaching the patient, time of reaching the patient to the hospital, time taken by the patient to be brought to the hospital by the EMS, right and left ONSD, vital signs, current clinical findings of the CPHSS (e.g., facial asymmetry, unilateral weakness, and speech impairment), stretcher angle, Glasgow Coma Scale (GCS) score, diagnosis after imaging, and emergency department outcomes were recorded in the study form.

Stretcher Angles of Patients

Stretcher angle group were made by considering the group in the reference articles.

The patients were divided into four groups according to the stretcher angles: Group 1, 0-30°; Group 2, 31-45°; Group 3, 46-60°; and Group 4, 61-90°.

Optic Nerve Sheath Diameter Measurement of Patients and Measurement Technique

Clinical evaluations, stretcher angles, and ONSD measurements of the patients included in our study were performed by a single physician with basic ultrasonography training and experience without changing the stretcher angle. The physician performing the measurement is not blinded to the stretcher angle. The person measuring the stretcher angles and performing the ultrasound is the same. Patient selection is limited to those who applied when the physician worked. Therefore, randomization was not performed.

The patients' stretcher angles were measured with protractor-exa mobile, an iOS digital angle measurement program on an iPhone 14 Plus, and recorded on the patient follow-up form (Figure 1).

The ONSD was measured at least twice in both the transverse and sagittal planes using the Butterfly IQ + Ultrasound System (USB-C), a Guilford USA ultrasound device, at a point 0.30 cm posterior to where the optic nerve enters the eyeball. A linear probe was used. The patient's position was not changed; they were lying on the EMS stretcher with the eyelids closed. The eyes were covered with a transparent material, and gel was applied. The average of these measurements was calculated and evaluated [12].

Outcome Measure

The primary outcome measure was the relationship between the patient's vital signs ONSD with the stretcher angle, while the secondary outcome measure was the patient's ED outcome.

Scoring System

Cincinnati Pre-hospital Stroke Scale

The CPHSS evaluates facial paralysis, asymmetric arm weakness, and speech abnormalities in patients with potential stroke. When applied to patients presenting to the ED, this scale provides high sensitivity and specificity in detecting stroke [13]. EMS personnel calculated the CPHSS before arrival at the hospital and noted it on the patient's follow-up form.

Statistical Analysis

Statistical analysis were performed with IBM SPSS Statistics for Windows, Version 20.0 (Armonk, NY: IBM Corp). Distribution analysis of continuous data was performed using the Shapiro–Wilk test and the QQ plot with histogram graphics. One-Way ANOVA was used for mean comparisons between more than two Group for variables with a normal distribution, and the Kruskal-Wallis test was used for distribution comparisons between more than two Group for variables not normally distributed. According to the distribution analysis, continuous data are expressed as either the mean and standard deviation or the median and interquartile range (25-75% quartiles). Proportion comparisons of categorical data were made using the Pearson chi-square test and data are expressed as the number of samples and percentages, depending on availability. Correlations between continuous numerical variables that were not normally distributed were evaluated with Spearman correlation analysis. The results of this analysis were interpreted with the Rho coefficient. A p value <0.05 was considered to indicate statistical significance.

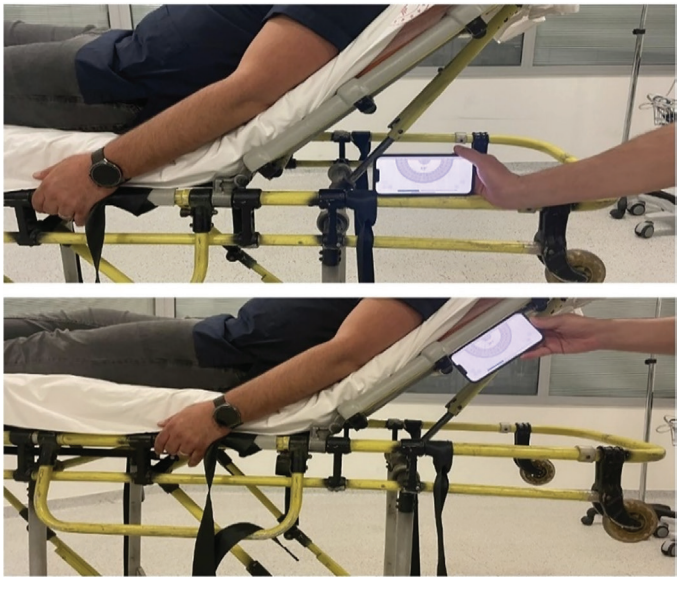

Figure 1. Measuring the angle of transportation of patients on the emergency medical services stretcher

Results

A total of 110 patients who met the CPHSS were included in the study. Among these patients, 18 patients were excluded from the study because they had TIA 2 patients had seizure-Todd's paralysis 2 patients were started on antihypertensives 3 patients had an intracranial mass 2 patients had aneurysms and 1 patient could not measure ONSD after left eye prosthesis. For these reasons, 82 patients were included in our study.

Patient Demographic and Clinical Characteristics

The average age of the patients included in the study was 74 years (range, 38-95 years). The average time from symptom onset to hospital admission was 203±204 minutes, and the average time from symptom onset to hospital arrival was 40±16 minutes. The average GCS score of patients was 13. Regarding vital signs, the mean SBP was 163±35 mmHg, the DBP was 91±17 mmHg, the average pulse was 79 beats per minute, the respiratory rate (RR) was 16±2/min., and the body temperature was 36.7±0.3 °C. The patient's blood sugar was 154±69 mg/dL. When the patients were evaluated on the EMS stretcher, the average stretcher angle was 44±17°, the average right ONSD was 0.36±0.07 cm, and the left ONSD was 0.37±0.07 cm (Table 1).

Among our patients, 42.7% (n=35) were male, and 57.3% (n=47) were female. According to the CPHSS, the presenting symptoms of the patients were facial paralysis in 73.2% (n=60), upper extremity weakness in 82.9% (n=68), and speech disturbance in 70.7% (n=58) (Table 2).

The distribution of patients according to angle groups was as follows: Group 1 19.5% (n=16); Group 2 32.9% (n=27); Group 3 26.8% (n=22); and Group 4 20.7% (n=17) (Table 2).

Ischemic stroke was detected in 85.4% (n=70) of our patients, and hemorrhagic stroke was detected in 14.6% (n=12) of our patients. After admission to the ED, 73.2% (n=60) of the patients were admitted to the intensive care unit (ICU), while 26.8% (n=22) were admitted to the inpatient service (Table 2).

Table 1. The time from the onset of symptoms until the patients reach the hospital and the time they are transported in EMS, GCS, vital signs, EMS stretcher angles, Right and left ONSD values

	Mean ± SD	Median	Min.-max.	95.0% Confidence interval for the mean
Age, year	74±12	75	38-95	71-76
Time elapsed from symptom onset to hospital admission, minute	203±204	124	45-931	159-248
Ambulance transport time, minute	40±16	38	16-92	37-44
GCS	13±3	13	3-15	12-13
SBP, (mmHg)	167±35	165	92-238	160-175
DBP, (mmHg)	91±17	92	45-136	88-95
Pulse (beats/minute)	79±20	76	41-142	74-83
RR (breath/minute)	16±2	16	12-22	16-17
BT, (°C)	36.7±0.3	36.7	36.0-37.3	36.6-36.7
BS, (mg/dL)	154±69	137	88-531	139-169
Stretcher angle, degree	44±17	44	0-90	
Right ONSD, cm	0.36±0.07	0.36	0.19-0.53	
Left ONSD, cm	0.37±0.07	0.36	0.18-0.58	

GCS: Glasgow Coma Scale, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, RR: Respiratory rate, BT: Body temperature, BS: Blood sugar, Min.-max.: Minimum-maximum, ONSD: Optic nerve sheath diameter, SD: Standard deviation, EMS: Emergency medical services

Table 2. Distribution table of patients' gender, presenting symptoms, stretcher angle group, stroke type, and emergency department outcome

		n, %
Gender	Man	35, 42.7
	Woman	47, 57.3
Presenting symptom	Facial paralysis	60, 73.2
	Upper extremity weakness	68, 82.9
	Speech disorder	58, 70.7
Stretcher angle group	Group 1 (0-30°)	16, 19.5
	Group 2 (31-45°)	27, 32.9
	Group 3 (46-60°)	22, 26.8
	Group 4 (61-90°)	17, 20.7
Stroke type	Ischemic stroke	70, 85.4
	Hemorrhagic stroke	12, 14.6
Emergency department outcome	Inpatient service	22, 26.8
	Intensive care unit	60, 73.2

Outcomes

Comparison of the Stretcher Angle Group with the Vital Signs, Glasgow Coma Scale, and Optic Nerve Sheath Diameter

A significant difference was found among the stroke type (ischemic or hemorrhagic) Group and the stretcher angle Group (p<0.001) (Table 3). Ischemic stroke was more frequently detected in Group 2, 3, and 4. A statistically significant difference was found between the stretcher angle Group and the inpatient service-ICU admission Group (p=0.020) (Table 3). The rate of ICU admission was greater in Group 1, 2, and 4 compared to Group 3.

A significant difference was found between the GCS and stretcher angle Group, specifically between Group 1 and Group 3 (p=0.002). GCS was lower in Group 1 than in Group 3 (Table 4).

A statistically significant difference was found between the RR and stretcher Group, but no significant difference was observed in specific subGroup analyses (p=0.037 may refer to general group comparison). When comparing DBP between the stretcher angle group, a statistically significant difference was found between Group 3 and Group 4 (p=0.028). DBP was higher in Group 4 than in Group 3. When comparing the right and left ONSD with the stretcher angle group, a significant difference was found between Group 2, 3, and 4 (right ONSD p=0.007, left ONSD p=0.043) (Table 4). ONSD was wider in Group 4 compared to Group 2 and 3.

Comparison of Stretcher Angle and Emergency Department Outcomes

A statistically significant difference was found when comparing the stretcher angle Group with the inpatient service-ICU admission group. The rate of ICU admission was higher in Group 1, 2, and 4 (Table 3).

Correlation Analysis

No correlation was found between the Group in our study on the relationship between stretcher angle Group, and between vital signs and ONSD. A weak correlation was found between stretcher angle and GCS (p=0.003; Rho=0.324). A weak correlation was found between DBP and right and left ONSD (right ONSD p=0.13, Rho=0.274/left ONSD p=0.45, Rho=0.222). A high correlation was found between right ONSD and left ONSD (p<0.001) (Rho=0.729) (Table 5).

Table 3. This table shows the relationship between patients' gender, emergency department admission symptoms, stroke type, and emergency department outcome with stretcher angle group

		Stretcher angle group				
		Group 1	Group 2	Group 3	Group 4	p
		n, %	n, %	n, %	n, %	
Gender	Man	6, 37.5	13, 48.1	8, 36.4	8, 47.1	0.802
	Woman	10, 62.5	14, 51.9	14, 63.6	9, 52.9	
Emergency department presenting symptom	Facial paralysis	13, 81.3	15, 55.6	19, 86.4	13, 76.5	0.077*
	Upper extremity weakness	16, 100.0	23, 85.2	17, 77.3	12, 70.6	0.126*
	Speech disorder	8, 50.0	23, 85.2	14, 63.6	13, 76.5	0.077*
Stroke type	Ischemic	8, 50.0	26, 96.3	21, 95.5	15, 88.2	<0.001*
	Hemorrhagic	8, 50.0	1, 3.7	1, 4.5	2, 11.8	
Hospitalization	Inpatient service	0, 0.0	7, 25.9	10, 45.5	5, 29.4	0.020*
	Intensive care unit	16, 100.0	20, 74.1	12, 54.5	12, 70.6	

Pearson chi-square test.

*Expected values in cells are insufficient; analysis is not reliable

Table 4. Comparison of vital signs, EMS duration, ONSD, age, GCS with Stretcher angle group of patients

	Stretcher Angle								
	Group 1		Group 2		Group 3		Group 4		p
	Med	25-75%	Med	25-75%	Med	25-75%	Med	25-75%	
Age,year	74	65-85	76	68-82	75	66-83	73	67-87	0.887*
TSHA	159	78-358	130	77-275	117	75-215	114	74-162	0.0607**
ATT	40	30-47	43	31-53	34	26-41	38	32-42	0.112**
GCS	11	8-14	13	11-15	15	14-15	13	12-15	0.002**
SBP, mmHg	159	132-189	161	132-193	165	144-180	188	149-193	0.389*
DBP, mmHg	88	76-108	90	80-100	82	76-96	98	93-110	0.028*
Pulse, beath/minute	82	75-96	74	63-85	73	64-88	80	65-97	0.264**
RR/minute	17	16-18	16	16-17	15	14-16	16	15-18	0.037**
BT, °C	36.7	36.5-36.8	36.7	36.3-36.9	36.7	36.3-36.9	36.7	36.4-36.9	0.939**
Blood Sugar	154	137-184	130	104-176	142	113-162	119	110-153	0.374**
Right ONSD	0.39	0.33-0.42	0.33	0.27-0.37	0.35	0.33-0.39	0.41	0.37-0.44	0.007**
Left ONSD	0.39	0.32-0.42	0.33	0.30-0.38	0.35	0.33-0.41			0.043**

*One-Way ANOVA, **Kruskall-Wallis test. The difference in the DKB parameter is due to the difference between Group 3 and 4. The difference in the GCS parameter is due to the difference between Group 1 and 3. No difference was found in the sub Group analysis for the SS parameter. The differences in both right and left ONSD parameters are due to the differences between Group 2, 3, and 4.

TSHA: Time elapsed from symptom onset to hospital admission, ATT: Ambulance transport time, GCS: Glasgow Coma Scale, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, RR: Respiratory rate, BT: Body temperature, ONSD: Optic nerve sheath diameter, Med: Median

Discussion

This study investigated the effects of prehospital stretcher angle on vital signs and ONSD in patients with suspected stroke, a subject that remains underrepresented in the current literature. A total of 82 patients were included. The mean time from symptom onset to hospital arrival was 203 minutes, with an average EMS transport duration of 40 minutes. The average initial GCS score was 13, SBP was 167 mmHg, and DBP was 91 mmHg. A statistically significant relationship was observed between stretcher angle and several clinical parameters. ICU admission rates were higher in Group 1, 2, and 4 compared to Group 3. Notably, GCS was significantly lower in Group 1 than in Group 3, suggesting that flatter transport positions may be associated with reduced consciousness. Additionally, DBP was significantly higher in Group 4 than in Group 3, and ONSD was significantly larger in Group 4 compared to Group 2. Although the correlations between stretcher angle and GCS (Rho=0.324) and DBP and ONSD (Rho<0.30) were statistically significant, they were weak, implying limited clinical relevance. However, the strong correlation between right and left ONSD (Rho=0.729) supports the internal consistency of ultrasonographic measurements.

Table 5. Vital signs, stretcher angle, and ONSD correlation table

		GCS	SBP	DBP	Pulse	Respiratory Rate	Fever	Stretcher angle	Right ONSD	Left ONSD
Age	Rho	-0.0293**	0.066	-0.144	0.027	0.025	-0.002	-0.095	-0.145	-0.119
	p	0.007	0.559	0.197	0.807	0.824	0.982	0.397	0.193	0.289
GCS	Rho		0.003	-0.074	-0.158	-0.382**	-0.028	0.324**	-0.074	0.006
	p		0.982	0.509	0.156	0.000	0.799	0.003	0.507	0.955
SBP	Rho			0.700**	-0.104	0.039	-0.016	0.136	0.140	0.042
	p			0.000	0.354	0.727	0.884	0.225	0.209	0.708
DBP	Rho				0.014	0.130	0.112	0.163	0.274*	0.222*
	p				0.904	0.245	0.317	0.142	0.013	0.045
Pulse	Rho					0.025	0.120	-0.046	0.058	0.219*
	p					0.820	0.282	0.678	0.607	0.048
Respiratory rate	Rho						-0.040	-0.118	-0.124	-0.172
	p						0.719	0.290	0.268	0.122
Fever	Rho							0.030	0.140	0.153
	p							0.790	0.209	0.169
Stretcher angle	Rho								0.164	0.154
	p								0.141	0.168
Right ONSD	Rho									0.729**
	p									0.000

Spearman's Rho, *Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed).
GCM: Glascow Coma Scale, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, ONSD: Optic nerve sheath diameter

Our onset-to-hospital time was shorter than the 674 to 775 minutes reported by Ikramuddin et al. [14], and Anees et al. [15], likely due to our inclusion of only EMS-transported patients. EMS transport durations in the literature range from 26.5 minutes [16] to 99 minutes [17]. A local report indicated an EMS response time of 6 minutes and 12 seconds in 2019 [18]. The 40-minute EMS time in our study may reflect urban traffic, interfacility referrals, and local protocols prioritizing transport to the nearest equipped hospital.

Blood pressure management plays a critical role in the prognosis of stroke patients. Studies have linked elevated blood pressure to increased mortality within 90 days post-stroke [19,20]. While most Western guidelines emphasize SBP control, some Asian studies have demonstrated associations with both SBP and DBP [21]. In the study by Gregori-Pla et al. [22] head-of-bed (HOB) elevations between -5° and 30° affected mean arterial pressure in patients with carotid stenosis. Although we found no significant correlation between SBP and stretcher angle, DBP was significantly higher in group 4 compared to group 3. These findings suggest that stretcher positioning may influence diastolic pressure during prehospital care.

When the ONSD values were compared with the literature, Patel et al. [23] reported mean values of 0.59 cm (right) and 0.60 cm (left) in stroke patients, and Geeraerts et al. [24] found a mean of 0.59 cm in critically ill individuals with elevated ICP. Seyedhosseini et al. [3] reported a mean ONSD of 3.89±0.59 mm, which aligns closely with our findings. Differences in reported ONSD may stem from variations in patient age, measurement timing, race, stroke subtype, and patient positioning during ultrasonography.

73.2% of our patients were admitted to the ICU and 26.8% to the neurology inpatient ward, which is consistent with previous reports on stroke patient dispositions [25,26].

In their study on patients with traumatic brain injury and other intracranial pathologies, Altun Uğraş et al. [27] demonstrated that changes in HOB angle significantly influenced ICP and cerebral perfusion pressure, especially in patients with low GCS scores. In another study, Momtaz et al. [28] observed an inverse correlation between GCS and ONSD in confused patients positioned supine. In contrast, we did not find a significant relationship between GCS and ONSD. However, GCS was significantly associated with stretcher angle, particularly lower in the 0-30° Group compared to the 46-60° Group. As EMS personnel did not receive positioning instructions, it is unclear whether flatter positioning was selected due to altered consciousness or if the positioning itself contributed to lower GCS. This bidirectionality highlights the need for prospective, randomized studies to clarify causal relationships.

Favilla et al. [29] examined the relationship between HOB positioning and cerebral blood flow (CBF) in acute ischemic stroke patients and found significant, individualized effects of

positioning on CBF [30]. While our study did not involve serial measurements of ONSD at different angles, our findings suggest that stretcher positioning may influence ICP-related parameters such as ONSD and GCS, warranting further investigation.

Taken together, our results indicate that stretcher angle may have important prognostic implications in acute stroke patients. The significantly lower GCS scores and higher ICU admission rates observed in patients transported at flatter angles (0-30°) may reflect either more severe neurological compromise or a potential physiological disadvantage associated with this position. Although causality cannot be determined from this observational study, it is possible that flatter positions may impair cerebral venous drainage or contribute to elevated ICP, thereby worsening clinical status. Conversely, the 46-60° Group showed relatively better neurological scores and lower ICU admission rates, suggesting that this angle range may provide an optimal balance for cerebral perfusion during prehospital transport. While higher ONSD values in more upright Group (61-90°) might indicate either compensatory ICP responses or selection bias toward more severe cases, previous research has demonstrated that HOB elevation significantly influences CBF and arterial pressure [22,30]. Therefore, stretcher positioning during EMS care may not only reflect a patient's clinical severity but also play a role in modifying early outcomes. Further prospective studies are needed to determine whether standardized stretcher angles can contribute to improved neurological prognosis and long-term recovery in stroke patients.

Study Limitations

This study has several limitations that should be considered when interpreting the results. It was conducted as a single-center study, which may limit the generalizability of the findings. Future multicenter studies with larger sample sizes are needed to confirm our results and increase the strength of the evidence.

A single physician performed ONSD and HOB measurements. Although this approach reduced interobserver variability, it introduced potential operator bias. Furthermore, the physician performing the ONSD measurements was not blinded to HOB, which may have introduced measurement bias.

Patient inclusion was limited to the time periods when the designated physician was on duty. As a result, random sampling was not possible, which may have introduced selection bias and influenced the distribution of patient characteristics.

We did not intervene in the HOB chosen by EMS personnel during patient transport. The rationale behind the angle choices was not systematically evaluated, and the possibility that EMS personnel chose certain angles based on the clinical status of the patients (e.g., lower GCS) cannot be excluded. This makes it difficult to establish causality between HOB and patient outcomes.

This study included only stroke patients, and the results may not apply to other conditions that may affect vital signs or ONSD. Therefore, the findings should be interpreted in the context of acute stroke management. HOB was recorded as a single measurement upon arrival at the ED, and measurements were not repeated at different angles. Assessing dynamic changes in ONSD and vital signs in response to HOB adjustments would provide more robust evidence of a causal relationship.

Despite these limitations, our study provides important preliminary data suggesting that HOB during EMS transport may affect neurologic and physiologic parameters in stroke patients and warrants further investigation.

Conclusion

Rapid intervention can reduce stroke morbidity and mortality. The prehospital period is one of the most critical intervention periods. Our study revealed that the angles of the stretcher while in EMS affect ICP, DBP, GCS, and ONSD in patients brought to the ED. In line with this finding, we concluded that the angle of the stretcher of 46° to 60° during the time spent in both EMS and during hospital follow-up may have a positive relationship with the patient's ICP, DBP, GCS, and ONSD values. We recommend that prehospital EMS personnel be informed to provide more effective patient care.

Ethics

Ethics Committee Approval: Ethics committee approval was received from Ankara Bilkent City Hospital Clinical Research No. 2 Ethics Committee (decision number: E2-23-5911, date: 21.12.2023).

Informed Consent: The patient and his/her relatives provided informed consent, and their consent was obtained.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.B., H.S.Ö., Concept: B.B., A.Ö., B.B., A.Ş., Design: B.B., A.Ö., H.S.Ö., B.B., Data Collection or Processing: B.B., H.S.Ö., Analysis or Interpretation: H.S.Ö., B.B., A.Ş., Literature Search: B.B., A.Ö., A.Ş., Writing: B.B., A.Ö., H.S.Ö., B.B., A.Ş.

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ORIGINAL RESEARCH

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Disease Severity, Volume Status, Cognition and Delirium in Older Patients in the Emergency Department, a Pilot Study

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Abstract

Objective: Cognitive impairment and delirium occur frequently in older emergency department (ED) patients and could be caused by low volume status and acute disease severity. Unfortunately, frail older patients can be difficult to include in clinical trials due to problems with informed consent and the burden of participation. To assess the feasibility and acceptability of obtaining informed consent, cognitive impairment, frailty, volume status and disease severity of older ED patients. Secondly, to assess disease severity and volume status in the patients with or without cognitive impairment and delirium.

Materials and Methods: A prospective study including ED patients ≥70 years who were hospitalized with a suspected infection or hip fracture was conducted. We assessed the Modified Early Warning score (MEWS; acute disease severity) and inferior vena cava (IVC) collapsibility with ultrasound; low volume status. Primary outcomes were the feasibility of obtaining informed consent and the experienced burden. Secondary outcomes were cognitive impairment in the ED [4 'A's test (4AT) score] and delirium (Delirium Observation Screening score) on the ward.

Results: Health-care professionals found the study feasible, and all 28 included patients experienced no burden. Eighteen of 28 (64%) patients had >50% vena cava inferior-collapsibility, despite fluids being hardly administered. Patients with a 4AT ≥1 had higher MEWS. Nine of 28 (32%) patients developed delirium during hospitalization, of whom 56% had 4AT ≥1 and all had IVC <2.1 cm.

Conclusion: The study was feasible and acceptable for health care professionals and older ED patients. Acute disease severity in these patients was associated with impaired cognition, which was highly prevalent in those who developed delirium during hospitalization. Low volume status was also observed in these patients.

Keywords: Fluid resuscitation, geriatrics, geriatric emergency medicine, cognitive function, delirium

Introduction

Cognitive impairment is a common problem in older emergency department (ED) patients. It may be caused by dementia, delirium, and primary neurologic disorders, but could also be a subtle sign of occult hypoperfusion of the brain [1,2]. For this reason, cognitive impairment might be used as an endpoint in fluid resuscitation. If this is the case, improvement of brain perfusion, i.e., by improving cardiac output with fluid resuscitation, should then lead to improvement of cognitive status.

This relationship between the heart and brain has been studied in long-term settings [3], but not in the acute ED setting. Especially in older ED patients, recognition of hypoperfusion is notoriously difficult because of non-specific disease presentation and different interpretation of vital signs; i.e., a systolic blood pressure of 120 mmHg is normal in younger

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patients but may indicate hypotension in older patients, which is often not recognized as such [4]. The impaired recognition of hypoperfusion in addition to the fear of fluid overload in, for example, older patients with sepsis, may lead to delayed and inappropriate fluid resuscitation in older patients [5] who are already more prone to dehydration because of an impaired thirst mechanism [6]. The use of cognition as an endpoint for resuscitation might improve both short-term outcomes by preventing further hemodynamic deterioration and may also prevent the development of delirium and its sequelae during hospitalization.

However, testing this may be difficult because older patients are frequently excluded from large RCTs because of their multimorbidity, difficulty obtaining informed consent, and burden of participation [7,8]. Assessment of informed consent is even more difficult in older ED patients with time-sensitive medical conditions like sepsis or severe trauma, who often experience hypoperfusion. In addition, disease severity, volume, and cognitive status should be assessed before ED treatment, potentially causing unethical time delays. Previous studies have shown difficulties understanding consent forms, the complexity of the consent process, limited accessibility of information, and concerns about cognitive capacity, underscoring the ethical need to balance research burden with potential benefits.

Therefore, the aim of this pilot study was twofold. First, we aimed to assess the feasibility and acceptability (for patients and professionals) of obtaining informed consent, as well as evaluating cognitive impairment, frailty, volume status, and disease severity of older ED patients who were hospitalized with a suspected infection or hip fracture within a 20-minute timeframe. Secondly, we aimed to assess disease severity and volume status in the aforementioned patients with or without cognitive impairment and delirium.

Materials and Methods

Study Design and Setting

This was a single-centre prospective observational pilot study, performed during a two-week period in January 2023 in the ED of Spaarne Gasthuis Hospital, which has an annual census of approximately 45,000 visits. The study was evaluated by the medical ethical committee of the Amsterdam University Medical Center, who decided that it did not fall under the "Medical Research in Humans Act (approval number: 2022.0075, date: 17.06.2022)". Oral and written informed consent was obtained.

Participants

ED patients aged 70 years and older who were hospitalized with either a suspected infection but no clinically apparent signs of acute organ failure, and those with hip fractures, were included. In the patients with suspected infection, we expected abnormal vital signs, elevated Early Warning scores (EWSs), and low volume status. The patients with a hip fracture served as a control group in which we expected normal vital signs and EWS, and normal volume status. In both groups impaired cognition and frailty were expected to be prevalent. Patients were recruited and included between 16/1/2023 and 27/1/2023.

Patients triaged as most urgent (category red/U0), known to have any form of dementia or cognitive decline, requiring acute medical or surgical interventions (<1 hour of ED arrival), having with fluid overload, a known LVEF <25%, receiving more than 250 mL of fluid in the ambulance, having meningitis or other suspected CNS infectionand those who were excluded.

Data Collection

During the inclusion period, a physician researcher was available during the daytime shift (10:00-19:00 h) to monitor announcements from the ambulance about potential patients. The physician researcher obtained informed consent and collected the data described below in a structured case report form.

Demographic characteristics, medication use, urgency, vital parameters, Modified EWS scores (MEWS) [9], and predisposition-infection-response-organ dysfunction (PIRO) [10] scores were measured as indicators of disease severity. Results of routine blood tests were registered. Frailty was assessed with the Clinical Frailty score (CFS) [11] and morbidity with the Charlson Comorbidity score [12]. Patients and healthcare staff completed questionnaires to assess implementation feasibility, acceptability, and perceived burden.

Outcome Measures

The primary outcomes were the feasibility, quantified by the number (%) of patients from whom informed consent was obtained and scores were assessed within 20 minutes, as well as the number (%) of healthcare workers who found the implementation of the study feasible. Feasibility was defined as at least 75% consent for participation by patients and at least 75% approval by healthcare staff. The secondary outcomes were number (%) of patients with low volume status, [inferior vena cava (IVC) <2.1 cm and/or >50% collapsibility] [13], cognitive impairment [4A's test alertness, AMT4, attention, acute change (4AT) score ≥2] [14], and delirium on the ward (Delirium Observation Scale) [15].

Sample Size

This pilot study was not powered to find significant differences in cognitive status and delirium incidence between groups but it should be able to show whether there are potential differences.

Statistical Analysis

Baseline characteristics were reported as mean standard deviation (SD) for normally distributed data and as median interquartile range (IQR) when skewed. Categorical data were

reported as number (%). Differences between groups (suspected infection vs. hip fracture; 4AT =0 vs. 4AT ≥1; delirium vs. no delirium on ward) were tested using chi-square tests, Mann-Whitney U test, and/or independent t-test, as appropriate. $p<0.05$ was considered significant. IBM SPSS Statistics package version 24 (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp. USA) was used for statistical analyses.

Results

We included 28 patients (Figure 1). Patients in the infection group were younger and more often male. Furthermore, they more frequently had a high MEWS score (MEWS score >3 points, n=7 (35%), in the infection group versus 0 in the hip fracture group). The Charlson Comorbidity score had a mean of 7 (SD 2.2 in the infection group and 4.9 (SD 1.2) in the hip fracture group. Both groups were equally frail, with a median CFS of 4 (IQR 3.3-5.0) in the infection group, and 5 (IQR 4.0-5.0) in the hip fracture group (Table 1). Length of stay in the ED did not differ between groups. Most patients were admitted to the hospital (80% vs. 87.5%, p=0.64). Patients with suspected infection received more antibiotics (35% vs. 0%, p=0.05), while those with hip fractures received more opiates (5% vs. 50%, p=0.01).

Table 2 shows that bedside time for inclusion was similar between groups and were all within 20 minutes. All approached patients provided informed consent and were not subjected to any undue hardship. All healthcare professionals considered the study feasible and reported no interference with patient care (Supplementary Table 1).

In Table 3, it is shown that MEWS and PIRO score tended to be higher in patients with a 4AT ≥1, i.e. impaired cognition, while IVC collapsibility and diameter and urea/creatinine were similar in patients with normal and impaired cognition.

Finally, Table 4 shows that delirium during hospitalization occurs more frequently in patients who were experiencing frailty (CFS ≥5) and had impaired cognition in the ED (4AT ≥1).

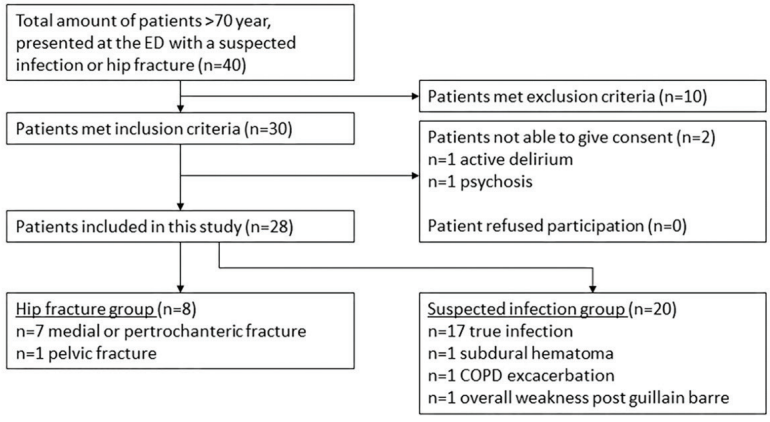

Figure 1. Patient flow through study

COPD: Chronic obstructive pulmonary disease, ED: Emergency department

Table 1. Patient characteristics

	Suspected infection (n=20)	Hip fracture (n=8)
Demographic data		
Age, mean (SD)	82.2 (8.1)	84.0 (5.1)
Gender, male (%)	14 (70)	4 (50)
Nursing home resident (%)	0 (0)	1 (12.5)
Clinical features		
Triage code		
U1 (%)	2 (10)	0 (0)
U2 (%)	4 (20)	7 (87.5)
U3 (%)	14 (70)	1 (12.5)
Vital parameters, mean (SD)		
MAP	99 (15.9)	100 (16.6)
Temperature	37.2 (1.1)	36.2 (0.5)
Heart rate	84 (19.4)	75 (13.4)
Respiratory rate	19 (6.5)	15 (1.4)

Table 1. Continued

	Suspected infection (n=20)	Hip fracture (n=8)
Disease severity		
MEWS score		
Score 0-2 (%)	13 (65)	8 (100)
Score 3 or higher (%)	7 (35)	0 (0)
MEWS score, median (IQR)	2 (0-3)	0 (0-1)
PIRO score, median (IQR)	5 (2.3-8.8)	2 (1-2)
PI score, median (IQR)	4 (2-5.8)	2 (1-2)
RO score, median (IQR)	2 (0-3)	0 (0-0)
IVC diameter in cm before fluid, mean (95% CI)	1.61 (1.30-1.92)	1.28 (0.95-1.60)
Collapsibility >50% before fluid, n (%)	12 (66.7)	6 (75)
IVC diameter in cm after fluid, mean (95% CI)	1.64 (1.33-1.95)	1.29 (0.91-1.67)
Collapsibility >50% after fluid, n (%)	12 (63.2)	5 (71.4)
Geriatric characteristics		
Charlson Comorbidity Score, mean (SD)	7 (2.2)	4.9 (1.2)
Clinical Frailty Score, median (IQR)	4 (3.3-5.0)	5 (4.0-5.0)
4AT score before fluid, mean (95% CI)	0.95 (0.18-1.72)	0.13 (0-0.42)
4AT score after fluid, mean (95% CI)	0.90 (0.22-1.58)	0.13 (0-0.42)
DOS score at time of admission, mean (95% CI)	1.1 (0.4-1.9)	0.1 (0-0.5)
Delirium during admission, n (%)	5 (31.3)	4 (57.1)
Medication use		
Antihypertensives, n (%)	17 (85)	5 (62.5)
Diuretics, n (%)	6 (30)	1 (12.5)
Antibiotics, n (%)	9 (45)	0 (0)
Number of medications, mean (SD)	11 (5.4)	6 (3.0)
Laboratory results		
Leukocytes, mean (SD)	11.1 (3.7)	9.6 (3.1)
Sodium, mean (SD)	136 (4.6)	136 (4.4)
Creat, median (IQR)	101 (72-137)	73 (68-101)
CRP, mean (SD)	80 (86.6)	18 (30.2)
ED treatment		
Fluid in liters, mean (95% CI)	0.26 (0.13-0.39)	0.18 (0-0.35)
Medication		
Opiate, number (%)	1 (5)	4 (50)
Paracetamol, number (%)	3 (15)	3 (37.5)
NSAID, number (%)	1 (5)	0 (0)
Furosemide, number (%)	1 (5)	0 (0)
Antibiotics, number (%)	7 (35)	0 (0)
Corticosteroids, number (%)	1 (5)	0 (0)
None, number (%)	12 (60)	3 (37.5)

Missing data: Temperature n=2 (hip fracture), respiratory rate n=5 (infection) and n=6 (hip fracture), leukocytes n=1 (infection), CRP n=1 (infection), sodium n=2 (infection) and n=1 (hip fracture), creat n=1 (infection) and n=1 (hip fracture), DOS score n=1 (infection) and n=1 (hip fracture), delirium during admission n=4 (infection) n=1 (hip fracture), missing data first ultrasound n=1 (infection), first collapsibility n=2 (infection), second ultrasound n=1 (infection) and n=1 (hip fracture), second collapsibility n=1 (infection) and n=1 (hip fracture).

n: number, SD: Standard deviation, IQR: Interquartile range, CI: Confidence interval, MEWS: Modified Early Warning score, PIRO: Predisposition infection response organ dysfunction, CRP: C-reactive protein, MAP: Mean arterial pressure, NSAID: Non-steroidal anti-inflammatory drug, IVC: Inferior vena cava, 4AT: 4A's test (alertness, AMT4, attention, acute change), DOS: Delirium Observation Scale, ED: Emergency department

Table 2. Primary outcome-feasibility

	Suspected infection (n=20)	Hip fracture (n=8)	p
Minutes at the patient's bedside, mean (SD)	17 (2.3)	18 (2.1)	0.60
Participation was experienced as a burden	0 (0)	0 (0)	NA
Opinion healthcare staff: Nurse	n=13	n=7	
Feasibility, Yes	13 (100)	7 (100)	NA
Interfere with acute care, No	13 (100)	7 (100)	NA
Opinion healthcare staff: Doctor	n=15	n=3	
Feasibility, Yes	15 (100)	3 (100)	NA
Interfere with acute care, No	15 (100)	3 (100)	NA

Minutes at the patient's bedside is the spend at the patients bedside to gain informed consent and perform all study measurements. p value calculated using independent t-test and chi-square test. Missing data nurses n=8, missing data doctor n=10.

n: number, SD: Standard deviation

Table 3. 4AT during ED stay and signs of acute disease

	4AT =0 (total n=19)	4AT = >1 (total n=9)	p
IVC collapsibility <50 (n, %)	6 (33.3)	3 (37.5)	0.84
IVC collapsibility >50 (n, %)	12 (66.7)	5 (62.5)	
IVC >2.1 cm (n, %)	2 (11.1)	1 (12.5)	0.92
IVC <2.1 cm (n, %)	16 (88.9)	7 (87.5)	
MEWS 0-2 (n, %)	16 (84.2)	5 (55.6)	0.10
MEWS >3 (n, %)	3 (15.8)	4 (44.4)	
PIRO (mean, SD)	4.05 (3.58)	6.44 (3.4)	0.11
Ureum/creatinine ratio (mean, SD)	0.89 (0.03)	0.10 (0.04)	0.53
SBP/HR ratio (shock index) (mean, SD)	1.82 (0.56)	2.05 (0.31)	0.27
Saturation/resp. rate ratio (mean, SD)	5.89 (1.6)	5.37 (1.96)	0.56

IVC collapsibility missing n=2, ureum/creatinine ratio missing =15, saturation/respiration missing =11. p values are calculated using chi-square and t-test.

IVC: Inferior vena cava, 4AT: 4A's test (alertness, AMT4, attention, acute change), MEWS: Modified Early Warning score, SBP: Systolic blood pressure, HR: Heart rate, resp. rate: Respiratory rate, SD: Standard deviation, PIRO: Predisposition infection response organ

Table 4. Delirium during hospitalization and geriatric factors

	No delirium during hospitalisation (total n=14)	Delirium during hospitalisation (total n=9)	p
IVC collapsibility >50 (n, %) IVC collapsibility >50 (n, %)	5 (38.5) 8 (61.5)	2 (25.0) 6 (75.0)	0.53
IVC >2.1 cm (n, %) IVC <2.1 cm (n, %)	3 (23.1) 10 (76.9)	0 (0) 8 (100.0)	0.14
CFS <4 (n, %)	11 (78.6)	2 (22.2)	0.008
CFS ≥5 (n, %)	3 (21.4)	7 (77.8)	
4AT ≥1 (n, %)	3 (21.4)	5 (55.6)	0.094
Charlston Comorbidity Index (mean, SD)	6.86 (2.35)	5.33 (1.41)	0.096
DOS score at admission (mean, SD)	0.43 (0.94)	1.88 (1.89)	0.025

Patients with missing delirium scores (n=5) were not included in this table. P-values are calculated using chi-square and t-test. Missing DOS score n=1.

IVC: Inferior vena cava, 4AT= 4A's test (alertness, AMT4, attention, acute change), CFS: Clinical Frailty Scale, DOS: Delirium Observation Scale, n: number, SD: Standard deviation

Discussion

This study shows that it is feasible and acceptable for health care professionals to obtain informed consent and assess the 4AT, CFS, IVC, vital signs, and disease severity scores of older ED patients with suspected infection or a hip fracture before ED treatment within 20 min. In addition, our preliminary results suggest that in ED patients with elevated MEWS or PIRO as measures of acute disease severity, signs of cognitive impairment and delirium (4AT) are more frequently present, which are subsequently associated with the development of delirium during hospitalization, as is frailty (high CFS). Elevated MEWS or PIRO per se is not associated with the development of delirium during hospitalization. Finally, the majority of ED patients with suspected infection but also with a hip fracture have a small IVC or elevated collapsibility, suggesting low volume status. However, this was not associated with 4AT, although all patients who developed delirium during hospitalization had a small IVC with a tendency for higher collapsibility in the ED.

Obtaining informed consent in acute patients can be difficult, especially in frail older people. The literature shows problems due to the accessibility of information, including font size and reading level of patient information leaflets, difficulties in hearing verbal information understanding the project, and loss of cognitive agility or confidence to make an autonomous decision [7]. In a review published by Gobat et al. [16], different papers investigating consent models in acute care research are described and show prospective informed consent, third party consent, and deferred consent as possible options. In studies in patients with acute myocardial infarction, only 19-28% of patients read the information sheet, and a mismatch between the educational level and the level required to comprehend the information sheet existed. This review also shows that patients in the ED might have negative views about third-party consent. In low-risk studies, patients found deferred consent acceptable, but as risk increased, patients preferred to make the decision themselves or involve a family member. In a review performed by Southerland et al. [17] it was shown that in older patients in the ED who participated in a study requiring informed consent, it was assessed in only 4.3% whether patients had the capacity to make decisions and 5.1% used a legal representative. In acute care settings, it has been shown that it is possible to obtain prospective informed consent in adults; we now find that this also applies to older adults in the ED. Prusaczyk et al. [18]. Describe the challenges and opportunities of performing research in patients with cognitive impairments and show that it is also unethical not to perform research in this group; they are a large and growing population, with specific problems that also need to be investigated. While older patients, especially those with lower formal learning, show less comprehension of consent information, they tend to make the same decision as younger patients [19]. One of the possible solutions to gain informed consent is proper timing, a factor we also found to be significant in our study. During the wait time in the ED, patients had no problem participating in the study. Doctors and nurses agreed that the study did not interfere with their work, showing that it is possible to perform this study on a larger scale. While it would be best to give patients time to extensively review all options, the setup requires the study to be performed in the ED, and we show that it is possible to obtain informed consent. However, screening for competency using a formal tool might be a future step in the research process if we perform a larger study.

The association between elevated MEWS and PIRO and 4AT are in line with findings of a previous study showing that vital signs are associated with impaired cognition [1]. In contrast to what we expected, low volume status was not associated with signs of impaired cognition, which may partially be explained as by the previous observations that especially oxygen saturation and respiratory rate are associated with impaired cognition, while hemodynamic parameters like blood pressure and heart rate have a much weaker association. Since IVC is mainly considered a hemodynamic parameter, it may not be surprising that we did not find a strong association with cognition in the ED.

The high frequency of older patients with a collapsing IVC and the scarce fluid administration correspond with findings of a previous study suggesting insufficient fluid resuscitation in older patients with a suspected infection, and suggests that more fluids may need to be administered. Interestingly, all the patients who developed delirium during hospitalization had a small IVC. It would be interesting to investigate if increasing the IVC with administration of more fluids may have the potential to reduce delirium incidence on the ward [20]. The amount of fluids administered in patients with suspected infection and hip fracture in this study was too small to draw conclusions about the immediate impact of fluids on cognition and development of delirium.

The high frequency of low volume status in older ED patients with a hip fracture was an unexpected finding in the present study, even though these patients did not have a high MEWS score. Although we do not have an explanation for this observation, it would be interesting to investigate in future studies whether the low volume status contributed to the fall in this patient group. In addition, these patients may also benefit from fluid administration. Larger studies could help to assess the influence of possible confounders on volume status, such as the use of medication.

This study has several limitations. It is a small, single center study, limiting external validity. Not all healthcare providers could be interviewed due to other clinical care obligations or

shift-changes, possibly introducing selection bias. However, 64% of doctors could be interviewed and 71% of the nurses could be interviewed. Not all patients had family members with them in the ED, so the reliability of using the 4AT score to assess cognitive fluctuations over the past two weeks varied.

Conclusion

In the ED, obtaining informed consent and assessing cognitive impairment, frailty, disease severity, and volume status in older acutely ill or injured patients before treatment is feasible and acceptable. The present study shows a high frequency of low volume status and delirium in older ED patients with a suspected infection and hip fracture. The complex interplay among acute disease severity, cognitive impairment, frailty, and the development of delirium warrants larger future studies investigating the impact of early fluid resuscitation on cognitive function and delirium incidence in this patient group.

Ethics

Ethics Committee Approval: The study was evaluated by the medical ethical committee of the Amsterdam University Medical Center, who decided that it did not fall under the "Medical Research in Humans Act (approval number: 2022.0075, date: 17.06.2022)".

Informed Consent: Oral and written informed consent was obtained.

Footnotes

Authorship Contributions

Concept: B. de G., Design: J.A.L., B. de G., Data Collection or Processing: E.L., Analysis or Interpretation: J.A.L., E.L., K.v.S., B. de G., Literature Search: J.A.L., E.L., Writing: J.A.L., E.L., B. de G.

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

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Supplementary Table 1. Responses to questionnaires from healthcare personnel regarding feasibility

	Feasible? (Nurse)	Feasible? (Doctor)	Interfere? (Nurse)	Interfere? (Doctor)	Suggestions or comments* (Nurse)	Suggestions or comments* (Doctor)
Patient 1	Yes	Yes	No	No	As you already do: be aware of when you can step into the patient room, please in consultation with nurse and/or when nurse is ready	Use time when patient is waiting for results, this feels like extra attention for the patient
Patient 2	Yes	Yes	No	No	Went fine	Can imagine that during a very busy shift, your examination could possibly be delayed if the doctor cannot get to the patient because investigator is busy. however, was not the case now
Patient 3	Yes	Missing	No	Missing	None	Missing
Patient 4	Yes	Yes	No	No	None	Coordinate with the treating physician how long you think you will need as a researcher
Patient 5	Yes	Missing	No	Missing	You can tell nurse in advance how long you expect to be with the patient, take your ultrasound machine into the room only after patient's permission	Missing
Patient 6	Yes	Yes	No	No	You checked carefully whether there was place to go into the patient's room	Fine, I didn't see you
Patient 7	Yes	Yes	No	No	None	None
Patient 8	Yes	Yes	No	No	Went fine	May consider wearing a white coat as a researcher, patient may experience the research as even more confidential
Patient 9	Yes	Missing	No	Missing	None	Missing
Patient 10	Yes	Yes	No	No	None	None
Patient 11	Missing	Yes	Missing	No	Missing	None, just went smoothly
Patient 12	Missing	Yes	Missing	No	Missing	None, patient is waiting a long time anyway
Patient 13	Yes	Missing	No	Missing	You ask politely if it's a good time, communication is important	Missing
Patient 14	Yes	Yes	No	No	Went fine, especially if it's a quiet shift	None
Patient 15	Yes	Yes	No	No	None	No, when I had to go into the room for needed patient care you went out of the room and waited your turn
Patient 16	Yes	Yes	No	No	None	No, you have not obstructed me
Patient 17	Yes	Missing	No	Missing	Given the long duration of ED time a feasible study, keep an eye on the admission time	Missing
Patient 18	Missing	Yes	Missing	No	Missing	None
Patient 19	Yes	Yes	No	No	As long as you communicate with healthcare personnel, much is possible	None
Patient 20	Missing	Yes	Missing	No	Missing	Fine
Patient 21	Missing	Yes	Missing	No	Missing	None
Patient 22	Yes	Missing	No	Missing	None	Missing
Patient 23	Missing	Yes	Missing	No	Missing	None

Patient 24	Yes	Missing	No	Missing	None	Missing
Patient 25	Yes	Missing	No	Missing	Patient was in the ED for a long time so you had all the time you needed	Missing
Patient 26	Missing	Missing	Missing	Missing	Missing	Missing
Patient 27	Yes	Missing	No	Missing	None	Missing
Patient 28	Missing	Yes	Missing	No	Missing	None

Question feasibility: "This research is feasible to implement in the emergency department, Yes/No". Question interferes: "This research interferes too much with my essential patient care, Yes/No". *Healthcare personnel were actively asked for suggestions for improvement. Reasons for missing data: End of shift of healthcare personnel, acute situation elsewhere in the ED or hospital, unavailability otherwise.

ED: Emergency department

ORIGINAL RESEARCH

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The Role of the Count and Percentage of Immature Granulocytes in the Differentiation of Acute Complicated and Non-Complicated Appendicitis

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Abstract

Objective: The objective of this study was to ascertain the effectiveness of the immature granulocyte (IG) count and percentage in diagnosing and discriminating between non-complicated acute appendicitis (NCAA) and complicated acute appendicitis (CAA).

Materials and Methods: This study was conducted using data from 244 adult patients who underwent appendectomy. A retrospective assessment of demographic details, preoperative white blood cell (WBC) count, number and percentage of neutrophils, neutrophil-to-lymphocyte ratio (NLR), lymphocyte (LYM) count (IGC), IG count and IG percentage (IG%), operation findings, and pathology results was conducted. Patients diagnosed with acute appendicitis (AA) were categorised as NCAA and CAA according to pathology reports and surgical outcomes.

Results: The WBC, NLR, IGC and IG% did not differ significantly ($p>0.05$) between the CAA and NCAA groups.

Conclusion: The findings of this study indicate that AA is statistically more prevalent in the early 30s.The number and percentage of neutrophil counts, NLR, IG in the diagnoses of AA, in conjunction with the elevated number of WBC, prove negligible in differentiating between CAA and NCAA. In the emergency room, examining the hemogram parameters merely reveals that the prediction of complications is rendered meaningless. The study revealed no statistically significant relationship between the groups. Consequently, hemogram parameters (LYM, WBC, NLR, IGC, and IG%) were deemed unreliable for distinguishing between CAA and NCAA.

Keywords: Appendicitis, immature granulocytes, complicated, emergency medicine

Introduction

Acute appendicitis (AA) is one of the most common causes of acute abdomen requiring surgical intervention in the emergency department (ED) [1]. The highly variable clinical presentation of AA makes its diagnosis in the ED challenging. The time taken to establish a diagnosis is known to increase the risk of appendiceal perforation and complications [2]. Approximately 10% of ED visits are due to abdominal pain [3]. AA is the most common abdominal surgical emergency worldwide, with a lifetime incidence of 8.6% in men and 6.9% in women [4].

The physical examination findings and clinical presentation of AA can vary considerably. The classic triad of pain radiating to the right lower quadrant, right lower quadrant tenderness, and leukocytosis is observed in only 50% of patients [5]. Despite advances in laboratory tests and imaging, the diagnosis of AA remains challenging. In particular, early surgical intervention in women of childbearing age results in a negative appendectomy (NA) rate of 20-30% [6]. The increase in NA rates leads to unnecessary morbidity and complications, increases treatment costs, and exposes physicians to malpractice lawsuits [7].

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A plethora of biochemical and haematological tests are requested in EDs with a view to detecting AA in its early stages. However, studies have demonstrated that the specificity and sensitivity of these tests are low [7]. Consequently, various parameters have been proposed for the early diagnosis of AA. One such parameter is the immature granulocyte (IG), which is known to increase in cases of infection and inflammation [8].

IG (Delta Neutrophil Index) refers to myelocytes, promyelocytes, and metamyelocytes, precursors of granulocytes, which are normally found in the bone marrow and absent in peripheral blood except in the neonatal period [9]. The clinical significance of IG count has been scientifically demonstrated by counting metamyelocytes, myelocytes, and promyelocytes [9]. To ensure accurate diagnosis, band cells, myeloblasts, and type 1 myelocytes must be excluded, as these cells share a similar granule formation but belong to different categories. The presence of IG in peripheral blood, with the exception of newborns and pregnant women, signifies a serious infection, inflammation, or the onset of a bone marrow disorder [10].

The accelerated granulopoiesis observed in acute systemic inflammatory or infectious states is mechanistically driven by proinflammatory cytokine cascades-principally interleukin-1, tumor necrosis factor-alpha, and interleukin-6- which induce the upregulation of granulocyte colony-stimulating factor. This pivotal hematopoietic cytokine orchestrates the proliferation and premature egress of immature myeloid progenitors from medullary compartments into peripheral circulation, a process substantiated in prior experimental and clinical models [8,9].

This hematologic derangement, pathognomonically termed a “left shift” frequently precedes detectable leukocytosis, functioning as a sentinel marker of nascent innate immune activation. In complicated AA (CAA), characterized by transmural necrosis or perforation, localized tissue devitalization and microbial translocation elicit a systemic inflammatory milieu, via pathogen- and damage-associated molecular pattern signaling, culminating in elevated circulating IG concentrations. Consequently, IG quantification, whether absolute or proportional, has been validated as a prognostically robust biomarker, reflecting both the magnitude of inflammatory dysregulation and its correlation with advanced disease phenotypes, as demonstrated in recent clinical cohorts [9,10].

IG appears in peripheral blood as immature polymorphonuclear cells present following bone marrow activation. Research has demonstrated the potential of IG as an early marker in inflammatory and infectious processes, as it emerges in the peripheral blood prior to the observation of leukocytosis [10]. Early and assertive treatment is paramount in cases of AA, as there is a 16% to 36% risk of perforation within the first 36 hours of abdominal pain. This risk escalates by 5% for every 12-hour delay [11]. Perforation, the most common complication of AA, has been shown to significantly increase mortality and morbidity [12].

Notably, IGs exhibit superior kinetic fidelity relative to conventional leukocytic indices. Total leukocyte and neutrophil (NEU) counts may demonstrate diagnostic latency during incipient inflammation or resolution phases, with further susceptibility to perturbation by exogenous variables (e.g., glucocorticoid therapy, adrenergic demargination) [10,11]. In contrast, IG elevation manifests with greater temporal concordance to inflammatory onset and persists during protracted or severe infections, underscoring their pathophysiologic specificity. This discriminative capacity positions IG enumeration as a critical adjunct for delineating complicated inflammatory pathologies (e.g., gangrenous/perforated AA) from uncomplicated counterparts [12]. The operational efficiency of automated hematology analyzers in delivering rapid, reproducible IG quantification further augments their integration into evidence-based diagnostic frameworks, circumventing subjectivity inherent to manual methodologies [8,9].

Therefore, it is vital that AA is accurately diagnosed and treated without delay in the ED [12]. The present study aims to evaluate the diagnostic power of IG, a hemogram parameter frequently employed by ED physicians to confirm diagnoses, in differentiating CAA from uncomplicated AA (NCAA).

Materials and Methods

Ethics Committee Approval

This study was approved by the Ethics Committee of University of Health Sciences Türkiye Hamidiye Faculty of Medicine (decision number: 84, date: 20.08.2019). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Population

This observational-retrospective study included patients over the age of 18 who presented to the ED with abdominal pain, and underwent surgery with a preliminary diagnosis of AA between 6 September 2018 and 31 March 2019. Patients with a pathology report confirming AA were included in the study, while those with other pathologies or missing data were excluded. Data were accessed through the hospital information system.

Patients who presented to the ED with abdominal pain, underwent evaluation and testing, had complete access to laboratory and pathology records, and were operated on with a preliminary diagnosis of AA, were included at the age of 18 or older. Patients with hematological diseases affecting hemogram parameters, pregnant women, those followed up for plastron appendicitis, those recently undergoing

chemotherapy, those with a clearly identifiable infectious focus on examination, patients under 18 years, and those with recurrent abdominal pain admissions were excluded.

The diagnosis of AA in this study was ultimately confirmed by. Histopathological examination, which served as the definitive diagnostic reference. During the clinical decision-making process in the ED, imaging modalities such as ultrasonography and computed tomography were frequently used at the discretion of the treating physician to support the diagnosis. However, in the context of this retrospective study, radiological findings were not used as inclusion criteria or outcome measures, and classification into complicated or uncomplicated AA was based exclusively on histopathological reports.

Patients were stratified into two groups based on postoperative histopathological evaluation: positive appendectomy (PA) and NA. The PA group consisted of patients with histologically confirmed AA, which was further subclassified into NCAA and CAA. In this study, CAA was strictly defined by histopathological criteria, including specimens demonstrating gangrenous changes, necrosis, or perforation. NCAA was characterized by histologically confirmed AA without evidence of these complications. Final categorization into CAA or NCAA subgroups relied solely on histopathological findings, with no consideration given to intraoperative observations or preoperative imaging results.

Data Collection

A comprehensive statistical comparison was conducted on various hemogram parameters, including IG count, IG percentage, white blood cell count (WBC), lymphocyte count (LYM), NEU, and neutrophil-to-lymphocyte ratio (NLR), which have been previously associated with acute inflammation. Receiver operating characteristic analyses were performed to evaluate the diagnostic performance of statistically significant hemogram parameters. Biochemical markers, such as C-reactive protein and procalcitonin-which are not included in routine practice-as well as urinalysis results were excluded.

Statistical Analysis

Statistical analyses were performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics included mean, standard deviation, median, minimum, maximum, frequency, and proportions. The Kolmogorov-Smirnov test was used to assess the distribution of continuous variables, and since the data did not show a normal distribution, non-parametric tests were selected for analysis. The Mann-Whitney U test was used for comparing independent quantitative variables, while the chi-square test was applied for categorical variables. Statistical significance was set at $p<0.05$.

Results

A total of 266 patients who underwent surgery with a preliminary diagnosis of AA at University of Health Sciences Türkiye, İstanbul Training and Research Hospital between September 6, 2018, and March 31, 2019 were included in our study. According to pathology reports, 17 patients who were not diagnosed with appendicitis were excluded from the study, and pathology reports for 5 patients were unavailable. Thus, a total of 244 patients with accessible pathology reports were included in the study (Figure 1).

When examining the demographic characteristics of these patients, 147 (60.2%) were male, and 97 (39.8%) were female (Table 1). The median age of the patients was calculated as 32.77.

The patients included in the study were divided into two groups based on pathology reports: CAA and NCAA. In the NCAA group, 88 patients (40.7%) were female, and 128 patients (59.3%) were male (Table 2). There was no significant difference in gender distribution between the CAA and NCAA groups ($p>0.05$).

The mean age of patients in the CAA group was 40.75±19.48, while the mean age of patients in the NCAA group was

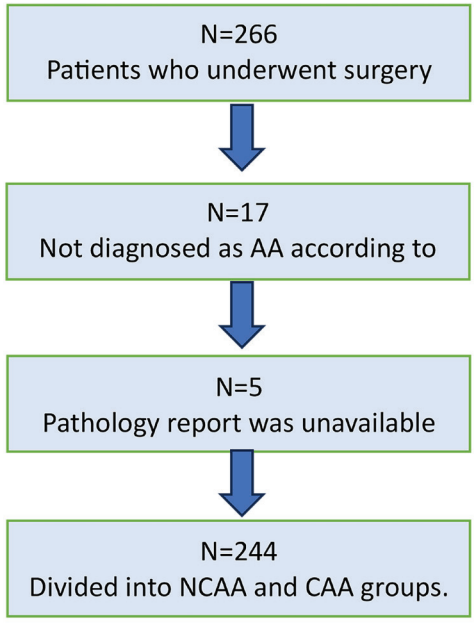

Figure 1. Patient flowchart

NCAA: Non-complicated acute appendicitis, CAA: Complicated acute appendicitis

Table 1. Gender distribution

Gender	Frequency	Percentage (%)
Male	147	60.2
Female	97	39.8
Total	244	100.0

31.73±13.22 (Table 2). The age of patients in the CAA group was found to be significantly higher compared to the NCAA group (p<0.05) (Table 2).

In our study, NEU count and percentage, LYM, NLR, IG count and percentage, and WBC values were calculated and compared between CAA and NCAA patients. No statistically significant difference was found between these parameters.

In the CAA group, the mean WBC was 13.59±3.95, while in the NCAA group, it was 13.88±4.14. The median WBC value was 13.44 in the CAA group and 13.88 in the NCAA group. No significant difference was detected between the two groups in terms of WBC (p=0.708) (Table 3).

In the CAA group, the mean IG was 0.06±0.04, similar to that in the NCAA group. The IG percentage was 0.43±0.20 in the CAA group and 0.42±0.32 in the NCAA group. No significant difference was observed between the two groups in terms of IG count and percentage (p=0.884; p=0.374) (Table 3).

Regarding NEU count and percentage, the mean NEU count was 10.54±4.05 in the CAA group and 10.81±4.12 in the NCAA group. The median values were 10.71 in the CAA group and 10.81 in the NCAA group. No significant difference was found between the two groups in terms of NEU count and percentage (p=0.839; p=0.672) (Table 3).

Regarding LYM count, the mean value was 1.88±1.16 in the CAA group and 1.97±0.92 in the NCAA group. No significant difference was found between the two groups in terms of LYM count (p=0.348, Table 3).

Finally, the NLR was 7.94±5.31 in the CAA group and 7.33±6.46 in the NCAA group. The median NLR was 6.85 in the CAA group and 5.57 in the NCAA group. There was no significant difference in NLR between the two groups (p=0.348) (Table 3).

Discussion

AA is one of the most common causes of surgical acute abdomen, affecting all age groups. The CAA condition is a serious clinical situation that can lead to prolonged recovery time, increased hospital stay, higher costs, and negatively affected treatment outcomes [13]. In addition to physical examination and clinical history, laboratory tests, scoring systems, and imaging methods are widely used in the diagnosis of AA [14]. However, despite these advancements, perforation rates are still reported at high levels. In particular, complication rates in elderly patients can reach up to 50% [15]. Therefore, determining whether appendicitis is complicated plays an important role in selecting the treatment method [16]. In our study, we examined hemogram parameters in adult AA patients and revealed the role of these parameters in distinguishing CAA from NCAA.

Finding appropriate, easily accessible, and cost-effective markers for the early diagnosis of diseases frequently attracts

Table 2. Relationship between age, gender, and CAA/NCAA

Variable	NCAA (n=216)	Median	CAA (n=28)	Median	p
Age	(mean ± SD) 31.73±13.22	28.00	(mean ± SD) 40.75±19.48	39.00	0.040[m]
Gender					
Female	88 (40.7%)	-	9 (32.1%)	-	0.382[x2]
Male	128 (59.3%)	-	19 (67.9%)	-	-

[m]Mann-Whitney U test/[x2]chi-square test

CAA: Complicated acute appendicitis, NCAA: Non-complicated acute appendicitis, SD: Standard deviation

Table 3. Relationship between IG count and percentage, WBC, NEU count and percentage, LYM, NLR with NCAA and CAA

Variable	NCAA (mean ± SD)	NCAA (median)	CAA (mean ± SD)	CAA (median)	p
WBC	13777±1892	1395	13480±1700	1370	0.070[m]
IG count	0.06±0.08	0.05	0.08±0.05	0.07	0.065[m]
IG %	0.42±0.32	0.40	0.30±0.20	0.28	0.048[m]
NEU count	10530±7735	7550	9989±7580	7000	0.089[m]
NEU %	74.12±10.65	75.00	72.05±10.45	70.50	0.052[m]
LYM	1987±1092	1800	1520±820	1500	0.033[m]
NLR	7.33±4.65	5.57	7.94±5.31	6.85	0.041[m]

[m]Mann-Whitney U test

IG: Immature granulocyte, WBC: White blood cell count, NEU: Neutrophil counts, LYM: Lymphocyte, NLR: Neutrophil/lymphocyte ratio, NCAA: Non-complicated acute appendicitis, CAA: Complicated acute appendicitis

researchers' interest [17]. Due to increased morbidity and mortality caused by diagnostic delays in patients presenting to the ED with abdominal pain, researchers widely investigate biochemical tests that can be used for early diagnosis [18]. One of the easily accessible and rapidly evaluated tests in the ED is the complete blood count. Inflammatory markers such as IG, NEU, WBC, and NLR, which are included in the complete blood count, have been examined in many studies. In recent years, determining appropriate threshold values for these parameters and evaluating their sensitivity and specificity have also become important research topics [19].

In our study, significant differences were found between the groups in terms of demographic characteristics such as age and gender. In the literature, AA diagnosis is reported to be more common in males. In our study, 60.2% of the patient group was male, and 39.8% was female, which is consistent with the literature. However, no difference was found between the CAA and NCAA groups. The mean age of patients in the CAA group was found to be higher than in the NCAA group. Similar results have been reported in the literature [19,20]. This can be explained by the fact that AA presents with more atypical symptoms in geriatric patients, making diagnosis more challenging than in younger patients [21]. Additionally, although the literature states that CAA cases are more common in males, no significant difference was found in our study.

There are numerous reports in the literature on the relationship between complete blood count parameters and inflammatory or infectious pathologies. Although WBC elevation is frequently observed in AA diagnosis, it is not sufficient as a standalone diagnostic marker. Paragiotopoulou et al. [22] reported that WBC could be used in the diagnosis of appendicitis, but was not sufficient for distinguishing perforation. Yang et al. [23] stated that an increase in WBC and NEU percentage correlated with the degree of appendix inflammation. A meta-analysis reported that the sensitivity of leukocytosis (WBC>10,000/mm³) in AA diagnosis was 83%, and specificity was 67%, while the sensitivity of neutrophilia (NEU>6,500/mm³) ranged between 71-89% and specificity between 48-80% [24]. Guraya et al. [25] also stated that leukocytosis is frequently observed in AA patients. In our study, leukocytosis was observed in all patients diagnosed with AA. However, no statistically significant relationship was found in distinguishing CAA from NCAA (p=0.708).

NLR is used as an inflammatory marker that reflects the physiological leukocyte response [26,27]. Kahramanca et al. [28] reported that NLR could be used in both the diagnosis of appendicitis and the distinction between CAA and NCAA. However, in our study, NLR values were not found to be statistically significant in CAA patients (p=0.348).

In the study conducted by Yılmaz Ünal [29] the role of IG count and percentage in the diagnosis of CAA was investigated. This study reported that the sensitivity and specificity of IG count and percentage in CAA diagnosis were high (sensitivity 93% and specificity 93.8%) [29].

In the study by Turkes et al. [30], WBC, polymorphonuclear leukocyte, monocyte, IG count, and IG percentage were found to be significantly higher in CAA patients compared to AA patients (p=0.009, p=0.047, p=0.001, p=0.018, respectively). The negative predictive value of IG for AA was calculated as 85%, and this value was found to be the same as that of WBC [30].

In the study by Yazla et al. [31], IG percentage, IG count, WBC, and NEU values were reported to be significantly higher in CAA patients compared to the NCAA group (p<0.001). The specificity of IG percentage in predicting CAA was found to be 92.6%, while its sensitivity was 23.5%. The low sensitivity rate of IG percentage suggests that these parameters should be used in combination with clinical evaluation and other diagnostic methods [31]. Studies have shown that IG's sensitivity and specificity rates are variable, indicating the need for further research on IG in CAA diagnosis. These data suggest that IG alone is insufficient for detecting CAA and should be evaluated together with other inflammatory parameters. In our study, no statistically significant difference was found between the CAA and NCAA groups in terms of IG count and percentage (p=0.884 and p=0.374).

Study Limitations

Our study was designed retrospectively and observationally, which brings certain limitations. Firstly, the study was based on pathology reports and was conducted within a limited time frame, which may have contributed to the lack of statistical significance in the results. Additionally, only hemogram parameters obtained at the initial ED presentation were evaluated in our study. Possible changes in parameters after treatment could not be monitored. The time of surgical intervention following diagnosis was also not specified, and the risk of perforation and complications developing during this period was not considered. Furthermore, the duration of abdominal pain in patients presenting to the ED was not recorded, making it impossible to determine the stage of the inflammatory process they were at. These limitations should be taken into account when interpreting the results.

Conclusion

IG count and percentage is not an effective hemogram parameter in distinguishing between CAA and NCAA.

Ethics

Ethics Committee Approval: This study was approved by the Ethics Committee of University of Health Sciences Türkiye

Hamidiye Faculty of Medicine (decision number: 84, date: 20.08.2019).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

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

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ORIGINAL RESEARCH

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Predicting Mortality in Non-Variceal Upper Gastrointestinal Bleeding: A Comparative Analysis of Five Risk Scores

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Abstract

Objective: This study aimed to compare the predictive accuracy of five commonly used clinical scoring systems - albumin, international normalised ratio,altered mental status, systolic blood pressure, age (AIMS65), Charlson Comorbidity Index ≥2, in-hospital onset, albumin <2.5 g/dL, altered mental status, Eastern Cooperative Oncology Group performance status ≥2, and steroid use (CHAMPS), age, blood tests, and comorbidities (ABC), Glasgow-Blatchford score (GBS), and Complete Rockall score (CRS)- in estimating in-hospital mortality among patients presenting with non-variceal upper gastrointestinal bleeding (UGIB).

Materials and Methods: This retrospective, single-center observational study included 917 adult patients diagnosed with non-variceal UGIB between January 2020 and January 2025. Clinical data were extracted from electronic medical records. Each patient's risk scores (AIMS65, CHAMPS, ABC, GBS, and CRS) were calculated based on admission data. The predictive performance of each scoring system for in-hospital mortality was assessed using receiver operating characteristic curve analysis, and area under the curve (AUC) values were compared using the DeLong test.

Results: The overall in-hospital mortality rate was 5.2%. AIMS65 demonstrated the highest predictive performance (AUC: 0.815, 95% confidence interval: 0.788-0.840), significantly outperforming GBS (AUC: 0.631, p<0.001) and showing comparable accuracy to CHAMPS (AUC: 0.801, p=0.493). The CHAMPS score also showed good discriminatory power, particularly in high-risk patients. The ABC score (AUC: 0.708) and CRS (AUC: 0.702) demonstrated moderate predictive ability, while GBS had the lowest accuracy.

Conclusion: Among the five evaluated scoring systems, AIMS65 exhibited the best performance in predicting in-hospital mortality in non-variceal UGIB patients, followed closely by CHAMPS.

Keywords: Gastrointestinal hemorrhage, risk assessment, prognosis, mortality, emergency medical services

Introduction

Acute upper gastrointestinal bleeding (UGIB) is a frequently encountered and potentially life-threatening clinical condition in emergency departments and hospitals [1]. Despite advances in pharmacological and endoscopic therapies, the estimated mortality rate for UGIB remains between 2% and 10% [2,3]. Non-variceal causes-such as peptic ulcers, gastritis, and Mallory-Weiss tears-account for a significant proportion of UGIB cases. Early risk stratification in these patients is critically important for reducing both mortality and morbidity [4].

Risk scoring systems have been developed to support clinical decision-making, predict patient prognosis, and guide appropriate treatment strategies [4]. Currently, several risk scores are commonly used in clinical practice, including the Glasgow-Blatchford score (GBS); albumin, international normalised ratio,altered mental status, systolic blood pressure, age (AIMS65) age, blood tests, and comorbidities (ABC score); Charlson Comorbidity Index (CCI) ≥2, in-hospital onset, albumin <2.5 g/dL, altered mental status, Eastern Cooperative Oncology Group (ECOG) performance status ≥2, and steroid use (CHAMPS

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score); and the Complete Rockall score (CRS) [5-8]. However, there is ongoing debate regarding the relative accuracy and predictive value of these scoring systems for in-hospital mortality [5,9].

The aim of this study is to compare the predictive performance of the CHAMPS, GBS, AIMS65, ABC, and CRS scores in estimating in-hospital mortality among patients with non-variceal UGIB. The findings are expected to provide clinically relevant guidance for physicians in managing these patients more effectively.

Materials and Methods

Ethics, Study Design, and Data Collection

This study was approved by the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee on May 21, 2025 (protocol number: 2025/157, decision number: 2025-10-07, date: 21.05.2025). The research was conducted in accordance with the ethical principles of the Declaration of Helsinki and international data protection standards [10]. Due to the retrospective nature of the study, the requirement for additional informed consent was waived by the ethics committee. However, all patients provided written informed consent regarding the diagnosis and treatment of UGIB as part of standard clinical care upon admission.

Data Handling and Confidentiality

Clinical data were obtained in encrypted form from the hospital's electronic medical record system and stored in a secure database accessible only to the research team. During the analysis phase, all personal identifiers were anonymized, and only clinical parameters were evaluated. The data processing procedures strictly adhered to the standards of the General Data Protection Regulation to ensure patient privacy [11]. The methodological design and findings of the study were reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for observational research [12].

Study Design

This single-center, retrospective observational study was conducted in the emergency department of a tertiary care training and research hospital, involving patients diagnosed with non-variceal UGIB. The study site is a high-volume referral center, with approximately 400,000 emergency department visits annually, continuous 24-hour endoscopy availability, and frequent referrals from surrounding healthcare facilities for suspected UGIB cases.

Study Population

This retrospective study included adult patients (aged ≥18 years) who presented to the emergency department of University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital between January 1, 2020, and January 1, 2025, and were diagnosed with non-variceal UGIB. Diagnosis of UGIB was confirmed endoscopically and supported by at least one of the following clinical criteria: (1) presence of hematemesis or melena; or (2) a drop of ≥2 g/dL in hemoglobin levels compared to previous values. Exclusion criteria included (1) bleeding secondary to endoscopic mucosal resection, and (2) cases with insufficient data to calculate risk scores. These criteria were applied to ensure a homogeneous study population and enhance the reliability of the findings.

Data Collection and Definitions

All cases presenting to the hospital during the specified study period were retrospectively reviewed using the hospital's electronic medical record system. Medical records of patients diagnosed with non-variceal UGIB were examined in detail, and the relevant data were recorded using a pre-designed standardized data collection form. This form included demographic characteristics (age, sex, and comorbidities), presenting symptoms to the emergency department (hematemesis, melena, syncope, and altered mental status), and the setting of presentation (in-hospital vs. out-of-hospital onset).

The etiology of bleeding was classified as gastric ulcer, duodenal ulcer, or other causes. Vital signs at presentation (systolic blood pressure and pulse rate) and laboratory parameters (hemoglobin, albumin, creatinine, blood urea nitrogen, and international normalized ratio) were recorded. Additionally, data were collected on the patients' medication history (use of anticoagulants, antiplatelet agents, nonsteroidal anti-inflammatory drugs, corticosteroids, and antisecretory agents), physical performance status (ECOG performance status), comorbidity burden (CCI), and operative risk assessment (American Society of Anesthesiologists score).

Rebleeding was defined as the occurrence of fresh hematemesis, melena, or hemodynamic instability within seven days of the initial presentation, is confirmed endoscopically to have originated from the same source as the initial bleeding. The primary outcome of the study was all-cause in-hospital mortality.

Statistical Analysis

Data analyses were performed using SPSS Statistics for Windows, version 23.0 (SPSS Inc., Chicago, IL, USA) and MedCalc version 16.8.4 (MedCalc Software, Mariakerke, Belgium). The normality of distribution for continuous variables was assessed using the Kolmogorov-Smirnov test and histograms. Descriptive statistics were reported as mean ± standard deviation for normally distributed variables, and as median and interquartile range for non-normally distributed variables. Categorical variables

were expressed as counts and percentages (%). For group comparisons, Student's t-test was used for normally distributed continuous variables, while the Mann-Whitney U test was employed for non-normally distributed variables. The Pearson chi-square test was used to compare categorical variables.

The predictive performance of each risk scoring system was assessed using receiver operating characteristic curve analysis. The area under the curve (AUC) was calculated for each score, and comparisons between scores were made using the DeLong test. Based on previous literature, the cut-off values for low-risk classification were defined as follows: ABC score ≤3, AIMS65 ≤1, CHAMPS = 0, CRS ≤1, and GBS ≤1. High-risk thresholds were set at ABC score ≥8, AIMS65 ≥2, CHAMPS ≥3, CRS ≥5, and GBS ≥5 [4-9]. The performance of the prediction scores was evaluated in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and weighted accuracy. A $p<0.05$ was considered statistically significant.

Results

A total of 917 consecutive adult patients who met the eligibility criteria were included in the study (Figure 1). The mean age of the patients was 64.1±20.8 years, and 73.8% (n=677) were male. The rebleeding rate was 7.5% (n=69), and the in-hospital mortality rate was 5.2% (n=48). The mean age of patients who did not survive was significantly higher than that of survivors (78.9±9.7 vs. 63.4±21.1 years; $p<0.001$). The baseline characteristics of the study population are presented in Table 1.

The ABC score, AIMS65, CHAMPS, CRS, and GBS classified 57.3%, 72.1%, 24.5%, 12.4%, and 4.2% of patients, respectively, as low risk. The in-hospital mortality rates among these low-risk groups were 4.0%, 1.7%, 0.4%, 0.9%, and 2.3%, respectively. Conversely, the same scoring systems classified 10.6%, 27.9%, 11.3%, 47.3%, and 88.6% of patients, respectively, as high-risk. In-hospital mortality rates among the high-risk groups were calculated as 16.5% for the ABC score, 16.4% for AIMS65, 33.7% for CHAMPS, 9.2% for CRS, and 6.6% for GBS.

The sensitivity, specificity, PPV, and NPV of each scoring system in predicting in-hospital mortality are presented in Table 2. Among patients with non-variceal UGIB, the AIMS65 score demonstrated good predictive performance for in-hospital mortality, with an AUC of 0.815 [95% confidence interval (CI): 0.788-0.840]. The performance of the AIMS65 score was significantly superior to that of the GBS (AUC: 0.631, 95% CI: 0.599-0.663; $p<0.001$), and comparable to the CHAMPS score (AUC: 0.801, 95% CI: 0.773-0.872; $p=0.493$). It also showed statistically better discrimination than both the ABC score (AUC: 0.708, 95% CI: 0.678-0.738; $p=0.026$) and the CRS (AUC: 0.702, 95% CI: 0.671-0.731; $p=0.018$).

Discussion

This study aimed to evaluate and compare the predictive performance of five widely used clinical risk scoring systems, -CHAMPS, AIMS65, ABC score, GBS, and CRS-in estimating in-hospital mortality among patients presenting with non-variceal UGIB.

Emergency departments in Türkiye are often severely overcrowded [13], with approximately one million emergency surgical procedures performed annually [14]. In such high-volume and resource-constrained settings, clinical risk scoring systems play a pivotal role in optimizing triage and management decisions [15,16]. Moreover, these tools have proven particularly valuable during global crises such as pandemics, when infection control is paramount. By identifying patients at low risk, they help prevent unnecessary hospital admissions and support more efficient allocation of healthcare resources [17]. Our findings provide important insights into the relative strengths and limitations of these scoring systems in early mortality risk stratification-a process that is essential for guiding timely and appropriate patient management in emergency care settings.

Among the evaluated scoring systems, the AIMS65 demonstrated the highest predictive value for in-hospital mortality, with an AUC of 0.815 (95% CI: 0.788-0.840),

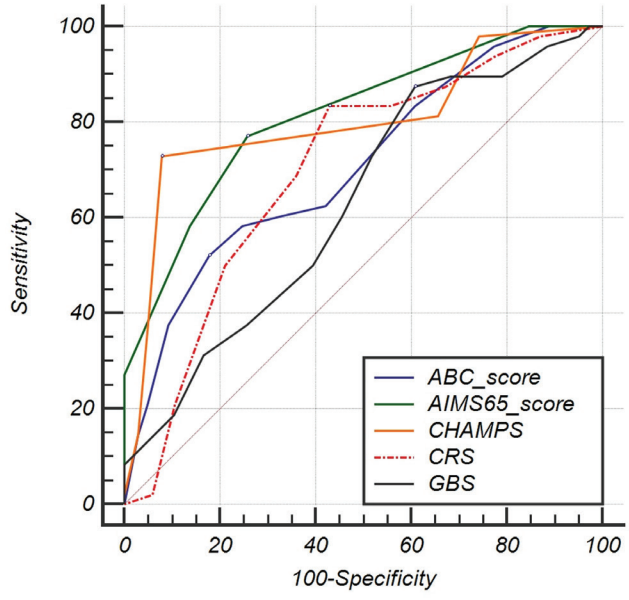

Figure 1. Receiver operating characteristic analysis of risk scores for predicting mortality

ABC: Age, blood tests, and comorbidities, AIMS65: Albumin <3.0 g/dL, international normalized ratio >1.5, altered mental status, systolic blood pressure <90 mmHg, and age ≥65 years, CHAMPS: Charlson Comorbidity Index ≥2, in-hospital onset, albumin <2.5 g/dL, altered mental status, Eastern Cooperative Oncology Group (ECOG) performance status ≥2, and steroid use, CRS: Complete Rockall score, GBS: Glasgow-Blatchford score

Table 1. Descriptive statistics of study population in terms of in-hospital mortality

Variable	Survivor n=869	Non-survivor n=48	p value
Age (years), mean ± SD	63.4±21.0	78.9±9.7	<0.001
Sex: female, n (%)	226 (26.0)	14 (29.2)	0.628
Systolic blood pressure (mmHg)	118.7±9.2	107.4±11.5	<0.001
Pulse (bpm)	83.7±11.6	114.2±19.3	<0.001
Hemoglobin (g/dL)	9.1±3.1	8.4±1.6	0.014
Albumin (g/dL)	3.4±0.8	2.7±0.8	<0.001
Creatinine (mg/dL)	1.0±0.3	1.3±0.8	0.038
INR	0.9±0.2	1.4±0.3	<0.001
Vomiting of fresh blood	248 (28.5)	29 (60.4)	<0.001
Melena, n (%)	700 (80.6)	33 (68.8)	0.047
Syncope	15 (1.7)	9 (18.8)	<0.001
Altered mental status	9 (1.0)	11 (22.9)	<0.001
Anticoagulants	112 (12.9)	8 (16.7)	0.450
Antiplatelet agents	169 (19.4)	12 (25.0)	0.347
NSAIDs	223 (25.7)	9 (18.8)	0.284
Steroids	45 (5.2)	4 (8.3)	0.344
Antisecretory agents	171 (19.7)	10 (20.8)	0.845
Cause of non-variceal UGIB, n (%)			
Gastric ulcer	394 (45.3)	23 (47.9)	0.100
Duodenal ulcer	358 (41.2)	14 (29.2)	
Others	117 (13.5)	11 (22.9)	
Scoring system, median IQR			
ABC score	3.6±2.6	5.9±2.9	<0.001
AIMS65 score	1.2±0.8	2.8±1.3	<0.001
CHAMPS score	1.6±1.1	3.1±1.4	<0.001
Complete Rockall score	4.9±3.5	7.5±2.9	<0.001
Glasgow-Blatchford score	10.0±4.5	12.2±4.0	<0.001
Rebleeding, n (%)	99 (11.4)	8 (16.7)	0.268

SD: Standard deviation, INR: International normalized ratio, NSAIDs: Non-steroidal anti-inflammatory drugs, UGIB: Upper gastrointestinal bleeding, IQR: Interquartile range, ABC: Age, blood tests, and comorbidities, AIMS65: Albumin <3.0 g/dL, international normalized ratio >1.5, altered mental status, systolic blood pressure <90 mmHg, and age ≥65 years, CHAMPS: Charlson Comorbidity Index ≥2, in-hospital onset, albumin <2.5 g/dL, altered mental status, Eastern Cooperative Oncology Group (ECOG) performance status ≥2, and steroid use

indicating good discriminatory performance. This finding is consistent with previous literature suggesting that AIMS65 is a reliable tool for predicting mortality in patients with UGIB [18]. Its simple structure, reliance on readily available clinical and laboratory parameters, and consistent performance across diverse patient populations make it particularly practical for use in routine clinical settings. Notably, AIMS65 outperformed GBS significantly, while showing comparable predictive ability to the CHAMPS, ABC, and CRS scores [4].

The CHAMPS score also demonstrated strong predictive capability, particularly within the high-risk classification group, which had a 32.4% mortality rate. Although the CHAMPS score lacks a universally accepted high-risk threshold, a cut-off of ≥3 was selected based on prior evidence suggesting, increased mortality with the accumulation of multiple adverse features [4,7]. This threshold also aligned with the mortality distribution in our cohort and allowed meaningful stratification. Further validation in diverse settings is needed. By incorporating variables such as ECOG performance status, albumin level, and steroid use, the CHAMPS score may offer enhanced prognostic accuracy, especially in elderly patients or those with significant comorbidities [4,7]. However, its lower sensitivity compared to AIMS65 (72.9% vs. 77.1%) may limit its utility as a standalone tool during the initial triage process. The ABC score and CRS showed moderate discriminatory ability, with AUCs of 0.708 and 0.702 respectively. Although both scores were able to identify high-risk patients associated with

Table 2. Risk scores and mortality prediction

	Score	Cut-off	Patients n (%)	Mortality n (%)	Sens. %	Spec. %	PPV, %	NPV, %
Low risk	CHAMPS	0	225 (24.5)	1 (0.4)	97.2	25.8	6.8	99.6
	AIMS65	≤1	656 (71.5)	11 (1.7)	100	15.4	6.1	100
	ABC score	≤3	525 (57.3)	21 (4.0)	83.3	39.1	7.0	97.7
	GBS	≤1	44 (4.8)	1 (2.3)	100	2.76	5.4	100
	CRS	≤1	114 (12.4)	1 (0.9)	97.2	13.0	5.9	99.1
High-risk	CHAMPS	≥3	108 (11.8)	35 (32.4)	72.9	92.1	6.4	97.1
	AIMS65	≥2	261 (28.5)	37 (14.2)	77.1	74.2	14.2	98.3
	ABC score	≥8	97 (10.6)	16 (16.5)	37.5	90.7	18.2	95.6
	GBS	≥5	730 (79.6)	43 (5.9)	89.6	20.9	5.9	97.3
	CRS	≥5	434 (47.3)	40 (9.2)	83.3	54.6	9.2	98.3

PPV: Positive predictive value, NPV: Negative predictive value, CHAMPS: Charlson Comorbidity Index ≥2, in-hospital onset, albumin <2.5 g/dL, altered mental status, Eastern Cooperative Oncology Group (ECOG) performance status ≥2, and steroid use, AIMS65: Albumin <3.0 g/dL, international normalized ratio >1.5, altered mental status, systolic blood pressure <90 mmHg, and age ≥65 years, ABC: Age, blood tests, and comorbidities, GBS: Glasgow-Blatchford score, CRS: Complete Rockall score

higher mortality rates, their lower sensitivity and specificity values suggest that their predictive effectiveness may be limited when used independently [19,20]. Nonetheless, when applied in conjunction with more robust tools such as AIMS65 or CHAMPS, they may provide additional value, particularly in complex clinical scenarios.

The ABC score, which incorporates age, basic laboratory results, and comorbidity burden, has been proposed as a simplified tool for mortality risk stratification in gastrointestinal bleeding [21]. Its moderate performance in this study (AUC: 0.708) is consistent with international data, highlighting its utility in settings where rapid decision-making is required. Although it did not out-perform AIMS65 or CHAMPS, its reliance on objective parameters and ease of use may make it a practical alternative in centers lacking comprehensive clinical assessment resources. Further validation across different healthcare systems could help define its role in UGIB management pathways.

Although the GBS is widely used in the assessment of UGIB, it demonstrated poor performance in predicting in-hospital mortality in this study. This finding aligns with previous research indicating that GBS is more effective in predicting the need for clinical interventions such as blood transfusion or endoscopy rather than mortality itself [22]. Its high sensitivity (89.6%) coupled with low specificity (20.9%) suggests a tendency to overestimate mortality risk. In clinical practice, scoring systems with a high NPV, such as AIMS65 and CHAMPS, are particularly useful for identifying low-risk patients who may be suitable for conservative management. On the other hand, although their PPVs are relatively low, these scores can aid in the early identification of high-risk patients who may require intensive monitoring or intervention.

Study Limitations

This study has several limitations. First, its retrospective and single-center design may introduce selection and information bias, thereby limiting the generalizability of the findings. Since the study was conducted in a well-resourced tertiary care hospital with 24-hour endoscopy access, the results may not be fully applicable to rural or resource-limited settings. Future multicenter studies are needed to confirm these findings in more diverse healthcare environments. Second, the study focused exclusively on non-variceal UGIB cases, which restricts the applicability of the results to patients with variceal bleeding. Finally, although the scoring systems were calculated based on data obtained at the time of admission, dynamic changes in patients' clinical conditions and physician judgment during management may have influenced the outcomes.

Conclusion

In conclusion, this study demonstrates that the AIMS65 score has the highest predictive value for in-hospital mortality among patients with non-variceal UGIB, with the CHAMPS score offering comparable utility. The use of these scoring systems for early risk stratification can support clinical decision-making and facilitate more efficient allocation of healthcare resources in the management of UGIB patients.

Ethics

Ethics Committee Approval: This study was approved by the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee on May 21, 2025 (protocol number: 2025/157, decision number: 2025-10-07, date: 21.05.2025). The research was conducted in accordance with the ethical principles of the Declaration of Helsinki and international data protection standards.

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: E.G., C.A, Concept: E.G., C.A, Design: E.G., C.A, Data Collection or Processing: E.G., C.A, Analysis or Interpretation: E.G., C.A, Literature Search: E.G., C.A, Writing: E.G., C.A.

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ORIGINAL RESEARCH

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Comparing CRP/Albumin Ratio and sPESI for Pulmonary Embolism Prognosis

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Abstract

Objective: The aim of this study is to evaluate the prognostic value of the C-reactive protein (CRP)/albumin ratio (CAR) compared to the simplified pulmonary embolism severity index (sPESI)in predicting 30-day and 180-day mortality in patients with pulmonary embolism (PE).

Materials and Methods: This retrospective cross-sectional study included patients over 18 years of age, diagnosed with PE and admitted to the intensive care or pulmonary diseases departments. The study investigated the relationship between CRP/CAR, sPESI, and clinical outcomes such as 30-day and 180-day mortality, and hospital admissions.

Results: Among 111 patients, 17 died within 180 days and 7 within 30 days. While no significant association was found between 30-day mortality and the CRP/CAR or the sPESI the CRP/CAR was significantly higher in those with 180-day mortality ($p<0.001$). The area under the curve for the CRP/CAR in predicting 180-day mortality was 0.782 ($p<0.001$), compared to 0.593 for the the sPESI ($p=0.224$).The DeLong test confirmed the superior predictive performance of the CRP/CAR.

Conclusion: This study shows that the CRP/CAR has greater prognostic value than the sPESI in predicting 180-day mortality in PE patients, though no significant association was found for 30-day mortality.

Keywords: CRP/albumin ratio, pulmonary embolism, simplified pulmonary embolism severity index, mortality

Introduction

Pulmonary embolism (PE) is a prevalent condition encountered in emergency departments, resulting in significant morbidity and mortality [1,2]. To predict mortality in PE, various risk scoring systems have been developed. The pulmonary embolism severity index (PESI) and the simplified pulmonary embolism severity index (sPESI) are two such systems [3]. The prognostic strength of sPESI lies in its ability to identify patients with low 30-day mortality. However, sPESI may also categorize low-risk patients as high-risk [4,5]. Although the sPESI score was originally developed to predict 30-day mortality in patients with PE, studies have demonstrated that it also holds significant prognostic value in predicting 90-day and 180-day mortality [6,7]. The sPESI score is more practical for use in emergency departments due to its ease of application and its comparable prognostic significance to the original PESI score [3,4].

Inflammation, by triggering thrombosis, constitutes the core pathological mechanism in patients with PE. Moreover, elevated

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levels of inflammation have been found not only to contribute to the development of PE but also to be closely associated with increased mortality [8]. C-reactive protein (CRP) is an acute phase reactant secreted by the liver, whereas albumin is a negative acute phase reactant. Elevated CRP and decreased albumin levels are recognized as key indicators of systemic inflammation. Due to their short half-lives, easy accessibility, and close association with disease prognosis, certain biomarkers are utilized in diagnosis, treatment, and mortality follow-up [9,10]. An increased CRP and decreased albumin ratio has recently been linked to mortality in PE patients [10]. The CRP/albumin ratio (CAR) is a novel indicator of systemic inflammation, calculated by dividing CRP by albumin [11]. Recent studies have suggested that CAR may be associated with mortality in PE patients [11,12]. One study concluded that CAR was more effective than PESI at predicting 180-day mortality in PE patients [12]. The sPESI is a scoring system that is simpler to apply in emergency departments for PE patients. A study evaluating the effectiveness of CAR in predicting 30-day and 180-day mortality in PE patients and comparing it with sPESI could enhance the ability to predict prognosis and manage PE patients in emergency departments.

The primary aim of this study is to evaluate the performance of CAR compared to sPESI in predicting 30-day and 180-day mortality in PE patients. The secondary aim is to assess the performance of CAR in predicting intensive care unit (ICU) admission.

Materials and Methods

This study was designed as a retrospective observational, analytical, cross-sectional study conducted using data obtained from the emergency department of a tertiary care hospital. This hospital receives 300,000-400,000 adult patients annually and accepts numerous referrals from surrounding hospitals. Our study retrospectively analyzed patients who presented to the emergency department between July 1, 2017, and June 30, 2022, and were subsequently admitted to the pulmonary diseases department diagnosed with PE. This study was approved by the local Hitit University Faculty of Medicine Clinical Research Local Ethics Committee (decision number: 2023-05, date: 12.01.2023).

Patients over 18 years of age diagnosed with PE and admitted to the pulmonary diseases department or the ICU were included in the study. Exclusion criteria included a prior diagnosis of autoimmune disease, active infection, acute transient ischemic attack/stroke, albuminuria, or chronic liver disease. Patient selection and data collection were performed using the hospital's automation system. Demographic data, chronic diseases, and laboratory values, including CRP and albumin, were recorded for each case. Laboratory values obtained during the emergency department visit were used for CRP and albumin. The CAR was calculated by dividing CRP by albumin, and the result was recorded. Additionally, sPESI scores were calculated based on patient records and system information. Patients with an sPESI score of 0 were classified as low risk, while those with a score of 1 or higher were classified as high-risk [3].

Measurements were taken from the computed tomographic pulmonary angiography images obtained during the patients' emergency department visits. Two axial sections perpendicular to the long axis of the heart showing the maximum distance between the ventricular endocardium and the interventricular septum were identified. The measurements of the right ventricle (RV) were then divided by the measurements of the left ventricle (LV) to calculate the RV/LV ratio [13]. Additionally, it was recorded whether the patients received thrombolytic therapy.

Subsequently, 30-day mortality, 180-day mortality, and ward-ICU admissions were identified and recorded through the hospital automation system. For patients whose 30-day and 180-day mortality data were not accessible through the system, mortality data were recorded by contacting their relatives via the phone numbers registered in the system. Following this, the relationship between patients' age, gender, chronic diseases, CRP, albumin, CAR, sPESI, RV/LV ratios, thrombolytic therapy administration, 30-day mortality, 180-day mortality, and ward-ICU admissions were statistically analyzed.

Statistical Analysis

Statistical analyses were conducted using SPSS version 25 software. The normality of variable distributions was assessed using histograms and Shapiro-Wilk tests. Descriptive statistics for non-normally distributed variables were reported as median and interquartile range. The Mann-Whitney U test was utilized for non-normally distributed numerical variables, while chi-square or Fisher's exact tests (when chi-square test assumptions were not met) were employed for nominal variables. Diagnostic decision-making characteristics for predicting mortality and ICU admission were analyzed using receiver operating characteristic (ROC) curve analysis. For significant cut-off values, sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), positive predictive value (PPV), and negative predictive value (NPV) were calculated. A p value of <0.005 was considered statistically significant.

Results

A total of 256 patients were identified in the hospital database for this study. After excluding 145 patients who did not meet the study criteria, 111 patients were included in the analysis (Figure 1).

Among the included patients, 17 experienced deaths within 180 days, and 7 experienced deaths within 30 days. Of the

included patients, 43 were admitted to the ICU, while 68 were admitted to the ward. There was no difference in chronic diseases between patients admitted to the ward and those admitted to the ICU. In terms of 30-day mortality, there was no difference regarding additional diseases; however, a history of cancer was found to be a factor affecting 180-day mortality (p<0.001). Detailed information is presented in Table 1. Albumin levels were significantly lower in patients with 180-day mortality and those admitted to the ICU (p=0.002 and p<0.001, respectively), while CRP levels were significantly higher in both groups (p<0.001 and p=0.001, respectively). No difference was found in albumin, and CRP levels concerning 30-day mortality (Table 2).

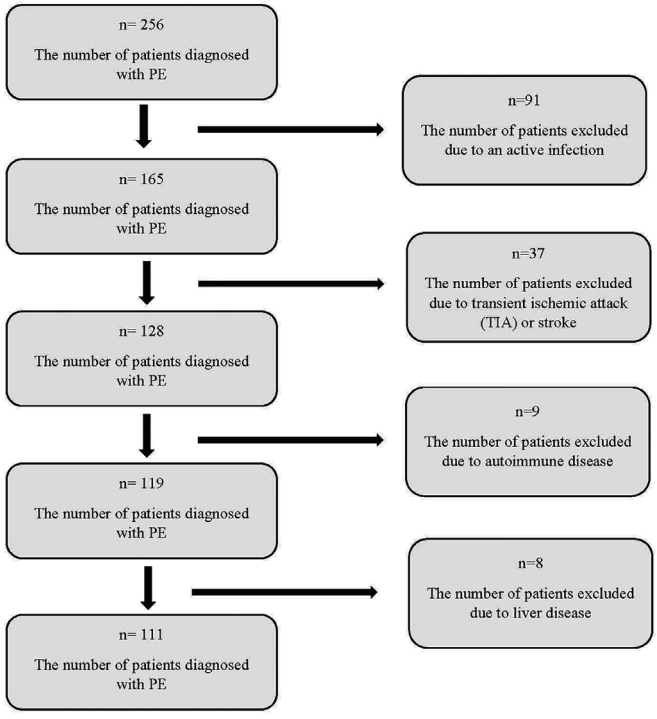

Figure 1. Flowcharts of study design

PE: Pulmonary embolism

When examining ICU and ward admissions, the CAR and RV/LV ratios were significantly higher in patients admitted to the ICU (both p<0.001). Additionally, all patients admitted to the ICU had an sPESI score of 1 or higher (p<0.001). Furthermore, all patients who received thrombolytic therapy were admitted to the ICU. In terms of 30-day mortality, there was no statistically significant difference regarding CAR, RV/LV ratio, sPESI, and thrombolytic therapy. However, for 180-day mortality, CAR was significantly higher in patients who experienced mortality within 180 days (p<0.001). No statistically significant differences were observed between sPESI, RV/LV ratio, and thrombolytic therapy for 180-day mortality. Detailed information is provided in Table 3.

The performance of CAR, sPESI, and the RV/LV ratio in predicting ICU admission, as well as the performance of CAR and sPESI in predicting 180-day mortality, were assessed using ROC curve analysis (Figure 2). For predicting ICU admission, the AUC value for CAR was 0.711 [95% confidence interval (CI) =0.612, 0.809, p<0.001], for the RV/LV ratio was 0.777 (95% CI=0.686, 0.868, p<0.001), and for sPESI was 0.676 (95% CI =0.579, 0.774, p=0.002). When comparing the performance of CAR, RV/LV ratio, and sPESI in predicting ICU admission using the DeLong test, no statistically significant difference was found (p=0.147).

Table 1. Descriptive characteristics of patients based on mortality and admission status

	ICU-ward admission status			30-day mortality			180-day mortality		
	Ward (n=68)	ICU (n=43)	p value	Survive (n=104)	Non-survive (n=7)	p value	Survive (n=94)	Non-survive (n=17)	p value
Age, median (IQR 25-75)	60 (43-72.25)	71 (62-82.5)	<0.001	65 (46.75-77)	63 (62-72)	0.653	62.5 (46-73)	77 (62-88)	0.003
Sex (n, %)									
Male	26 (38.2%)	21 (48.8%)	0.271	43 (41.3%)	4 (57.1%)	0.454*	39 (41.5%)	8 (47.1%)	0.669
Female	42 (61.8%)	22 (51.2%)		61 (58.7%)	3 (42.9%)		55 (58.5%)	9 (52.9%)	
Comorbidities (n, %)									
COPD	16 (23.5%)	12 (27.9%)	0.605	26 (25%)	2 (28.6%)	1,000*	22 (23.4%)	6 (35.3%)	0.363*
DM	17 (25%)	12 (27.9%)	0.734	29 (27.9%)	0 (0%)	0.187*	21 (22.3%)	8 (47.1%)	0.068*
HT	37 (54.4%)	30 (69.8%)	0.107	64 (61.5%)	3 (42.9%)	0.432*	54 (57.4%)	13 (76.5%)	0.182*
CHF	11 (16.7%)	5 (11.6%)	0.506	15 (14.4%)	1 (14.3%)	1.000*	13 (13.8%)	3 (17.6%)	0.709*
CAD	19 (27.6%)	17 (39.5%)	0.204	34 (32.7%)	2 (28.6%)	1.000*	30 (31.9%)	6 (35.3%)	0.784
Ca	12 (17.6%)	6 (14.0%)	0.607	16 (15.4%)	2 (28.6%)	0.317*	9 (9.6%)	9 (52.9%)	<0.001

*According to Fisher's exact test results.

A p value of <0.05 was considered statistically significant.

ICU: Intensive care unit, IQR: Interquartile range, COPD: Chronic obstructive pulmonary disease, DM: Diabetes mellitus, HT: Hypertension, CHF: Congestive heart failure, CAD: Coroner arterial disease, Ca: Cancer

The AUC value for CAR in predicting 180-day mortality was 0.782 (95% CI =0.672, 0.892, p<0.001), while the AUC value for sPESI was 0.593 (95% CI =0.460, 0.726, p=0.224). When comparing the performance of CAR and sPESI in predicting 180-day mortality using the DeLong test the performance of CAR was found to be significantly superior (AUC difference =0.189, 95% CI =0.048, 0.330, p=0.008).

The cut-off value of CAR for predicting 180-day mortality was calculated as 0.754 according to the Youden index. When the CAR ratio was ≥0.754, the sensitivity for predicting 180-day mortality was 70.59%, specificity was 71.28%, PLR was 2.46, NLR was 0.41, PPV was 30.77%, and NPV was 93.06%. For high-risk patients (sPESI ≥1) in predicting 180-day mortality, the sensitivity of sPESI was 94.12%, specificity was 24.47%, PLR was 1.25, NLR was 0.24, PPV was 18.39%, and NPV was 95.83%.

Discussion

This study is significant because it is the first to compare the performance of sPESI and CAR in predicting mortality in PE patients. It underscores the importance of an elevated CAR in predicting 180-day mortality in PE patients. Additionally, an increased CAR was associated with ICU admissions. However, no association was found with 30-day mortality. While an sPESI score above 1 was linked to ICU admission, no relationship was observed with 30-day and 180-day mortality.

Various scoring systems are utilized to predict mortality in PE patients, with PESI and sPESI being two such systems [14]. Although sPESI may categorize patients with a low mortality risk as higher risk, it is preferred in emergency departments due to having fewer parameters, ease of use, and efficacy in predicting

Table 2. Laboratory parameters of patients based on mortality and admission status

Laboratory parameters, median (IQR 25-75)	ICU-ward admission status			30-day mortality			180-day mortality		
	Ward (n=68)	ICU (n=43)	p-value	Survive (n=104)	Non-survive (n=7)	p-value	Survive (n=94)	Non-survive (n=17)	p-value
Hemoglobin (g/dL)	12.75 (11.55-14.32)	13.1 (12.15-14.25)	0.517	12.9 (11.7-14.3)	11.2 (10.15-14.6)	0.524	12.95 (11.9-14.37)	12.3 (10.7-13.6)	0.126
Hematocrit (%)	38.2 (36.17-41.97)	40.7 (36.3-43.25)	0.333	39.3 (36.37-24.5)	36.3 (32.7-44.65)	0.743	39.6 (36.42-42.72)	39 (33-40.7)	0.142
MCV (fL)	85.3 (79.87-89.17)	87.3 (81.7-91.15)	0.230	86.5 (81.32-90.5)	74.8 (71.85-86.05)	0.030	86.75 (81.4-90.7)	84.8 (77.4-88.1)	0.161
Neutrophil (10^9/L)	6.06 (4.59-7.64)	7.14 (4.93-8.77)	0.042	6.36 (4.59-7.88)	9.34 (5.92-10.84)	0.089	6.06 (4.49-7.84)	7.87 (6.42-9.34)	0.010
Lymphocyte (10^9/L)	1.9 (1.5-2.7)	1.6 (1.18-2.27)	0.181	1.76 (1.35-2.46)	1.37 (1.31-2.12)	0.369	1.87 (1.47-2.72)	1.13 (0.66-1.9)	0.004
Platelet (10^9/L)	234.5 (197-294.75)	218 (177.5-278)	0.254	229.5 (193.75-282.5)	242 (216.5-302)	0.430	223.5 (193.25-279.5)	250 (227-320)	0.152
Glucose (mg/dL)	110 (100-137.25)	129 (112-167.5)	0.029	115.5 (101-153.25)	140 122-162)	0.267	114 (100.25-137.75)	165 (140-200)	<0.001
Creatinine (mg/dL)	0.8 (0.6-0.92)	0.9 (0.75-1.1)	0.003	0.8 (0.7-1)	0.8 (0.7-0.95)	0.888	0.8 (0.7-1)	0.8 (0.7-1	0.729
GFR (mL/min./1.7)	95.5 (75.5-109.5)	73 (55.5-97)	<0.001	90 (67-107.25)	94 (67-98)	0.889	91.5 (70-107.75)	78 (56-96)	0.151
Sodium (mmol/L)	138 (136.75-140)	137 (135.5-138)	0.014	138 (136-139)	137 (134-137.5)	0.206	138 (136-139.75)	137 (136-138)	0.233
Potassium (mmol/L)	4.25 (4-4.4)	4.31 (3.8-4.56)	0.552	4.3 (4-4.5)	3.87 (3.6-4.45)	0.269	4.26 (4-4.5)	4.3 (3.87-4.43)	0.679
Albumin (g/L)	40 (38-42)	37 (33-40)	0.002	40 (36-42)	36 (34.5-40)	0.401	40 (37-42)	33 (31-37)	<0.001
CRP (mg/L)	14.7 (6.64-29.47)	28.5 (18.25-46.1)	<0.001	21 (8.2-36.3)	25.7 (16.95-54.55)	0.294	18.25 (7.18-32.22)	37 (25.7-56.9)	0.001
Troponin-I (ng/L)	100 (100-107)	327 (100-1025)	<0.001	100 (100-324.25)	227.5 (100-364)	0.636	100 (100-333)	107 (100-258)	0.895

A p-value of <0.05 was considered statistically significant.

ICU: Intensive care unit, IQR: Interquartile range, CRP: C-reactive protein, GFR: Glomerular filtration rate, MCV: Mean corpuscular volume, min.: Minimum

Table 3. The relationship between CAR, RV/LV ratio, sPESI, and thrombolytic therapy with patient hospitalization and mortality

Indices	ICU-ward admission status			
	Ward (n=68)	ICU (n=43)	95% CI	p value
CAR, median (IQR 25-75)	0.38 (0.16-0.74)	0.77 (0.47-1.47)	-0.539, -0.164	<0.001
RV/LV, median (IQR 25-75)	0.91 (0.8-1.04)	1.19 (1.06-1.51)	-0.423, -0.201	<0.001
sPESI (>0, high-risk) (n,%)	44 (64.7%)	43 (100%)	0.378, 0.588[b]	<0.001[a]
Thrombolytic therapy (n,%)	0 (0%)	19 (44.2%)	0.649, 0.829[b]	<0.001
	30-day mortality			
	Survive (n=104)	Non-survive (n=7)	95% CI	p value
CAR, median (IQR 25-75)	0.54 (0.21-1.01)	0.65 (0.49-1.39)	-0.841, 0.224	0.300
RV/LV, median (IQR 25-75)	1.03 (0.85-1.28)	0.90 (0.86-0.91)	-0.037, 0.339	0.147
sPESI (>0, high-risk) (n,%)	81 (77.9%)	6 (85.7%)	-0.068, 0.123[b]	1.000[a]
Thrombolytic therapy (n,%)	17 (16.3%)	2 (28.6%)	-0.094, 0.196[b]	0.406
	180-day mortality			
	Survive (n=94)	Non-survive (n=17)	95% CI	p value
CAR, median (IQR 25-75)	0.47 (0.17-0.84)	1.05 (0.65-1.87)	-1.05, -0.427	<0.001
RV/LV, median (IQR 25-75)	0.99 (0.83-1.22)	1.07 (0.91-1.34)	-0.292, 0.80	0.304
sPESI (>0, high-risk) (n,%)	71 (75.5%)	16 (94.1%)	0.028, 0.256[b]	0.114[a]
Thrombolytic therapy (n,%)	18 (19.1%)	1 (5.9%)	-0.248, 0.005[b]	0.181

[a]According to Fisher's exact test results.

[b]Difference in proportions.

A p-value of <0.05 was considered statistically significant.

ICU: Intensive care unit, CAR: C-reactive protein/albumin ratio, RV/LV: The ratio of the right ventricle to the left ventricle, sPESI: Simplified pulmonary embolism severity index, IQR: Interquartile range, CI: Confidence intervals

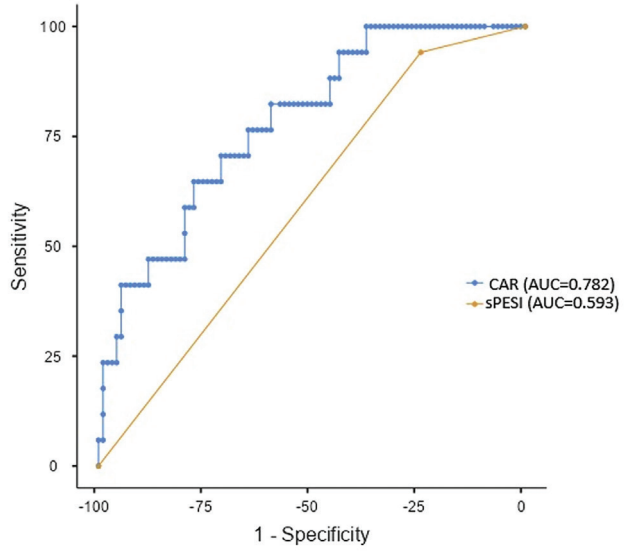

Figure 2. Receiver operating characteristic curve analysis; the performance of CAR and sPESI in predicting 180-day mortality

sPESI: Simplified pulmonary embolism severity index, CAR: C-reactive protein/albumin ratio, AUC: Area under the curve

30-day mortality [4]. Alongside these scoring systems, various laboratory parameters are also being investigated to predict mortality risk in PE patients [15]. The CAR is a novel indicator of inflammation being studied in PE patients [11,12]. CAR includes both CRP and albumin; increased CRP or decreased albumin correlates with an elevated CAR [10]. A recent study concluded that an elevated CAR is closely associated with venous thromboembolism, particularly in middle-aged and older adults. This association was attributed to the increased risk of thrombosis resulting from heightened inflammation, with the CAR being recognized as a reliable marker of systemic inflammatory response [16].

In a study by Norton et al. [10], increased CRP and decreased albumin levels were associated with 180-day mortality in PE patients. Another study suggested that an elevated CAR could be used to determine the prognosis of PE patients [11]. Similarly, in a study conducted by Artac et al. [17], the CAR was found to be closely associated with both early- and late-term mortality in patients with PE. In another study, Özcan et al. [12] found that an increased CAR was associated with 180-day mortality in PE patients. They compared CAR with PESI and concluded that an elevated CAR was superior to PESI in predicting 180-day mortality [12]. In our study, considering the applicability in emergency departments, we used sPESI instead of PESI. We examined the performance of the CAR ratio and sPESI in predicting 180-day mortality and found CAR to be superior to sPESI. Additionally, in our study, the CAR ratio was

higher in patients admitted to the ICU, indicating that CAR may be effective in identifying high-risk patients.

Several studies have evaluated the association between the CAR and short-term mortality in patients with PE [11,17,18]. In a study by Hocanlı and Tanriverdi [11], CAR was identified as an independent predictor of in-hospital mortality among PE patients. Similarly, Artac et al. [17] reported that CAR was closely associated with early mortality in this patient population. Another study found a significant relationship between CAR and mortality [18]. In our study, we aimed to investigate the prognostic value of CAR in predicting 30-day mortality in patients with PE. However, unlike the aforementioned studies, our findings did not demonstrate a statistically significant association. This discrepancy may be attributed to the retrospective, single-center design of our study and the relatively small sample size. Additionally, the number of patients who experienced mortality within 30-days was notably low, which may have limited the statistical power of our analysis. Further large-scale, multicenter prospective studies are needed to clarify this issue. Moreover, in our study, we did not identify a significant association between the sPESI score and 30-day mortality.

Study Limitations

Our study has several limitations. Firstly, it was designed retrospectively. In our study, data from the hospital database were inaccessible or incomplete for nearly 60% of the patients, which led to a reduced study population. Additionally, the number of patients who experienced 30-day mortality was less than 10% of the total population, which may have resulted in insufficient dataregarding 30-day mortality. Furthermore, these data are based on a single measurement, and repeated measurements may not accurately reflect the relationship between changes in CAR over time and mortality. Another limitation of our study is that the number of patients initially evaluated was higher than the final study population due to the application of detailed exclusion criteria. This may have led to selection bias in our study. Moreover, in our study, mortality was defined as death due to any non-traumatic cause. However, the causes of death were not specified in our dataset, which may have influenced the overall mortality outcomes by including deaths from unrelated causes. Nonetheless, in patients who have experienced a major risk factor such as PE, the contribution of PE to mortality cannot be entirely ruled out.

Additionally, due to the retrospective nature of our study, complete data for all parameters were not available, and therefore, an assessment based on the PESI score could not be performed. Although this represents a significant limitation, the sPESI score remains valuable due to its greater practicality in emergency settings. Our study is the first to evaluate this aspect. Future research may enhance the literature by comparing sPESI and PESI scores concurrently. Lastly, we only included hospitalized patients; therefore, our study results do not include information about low-risk PE patients who were deemed suitable for outpatient treatment.

Conclusion

In conclusion, this study demonstrates that an increased CAR is associated with 180-day mortality and ICU admissions in PE patients. Furthermore, we found that CAR had a higher prognostic value than the sPESI score in predicting 180-day mortality. These findings suggest that CAR may serve as a valuable prognostic marker for late-term mortality in PE patients. However, similar results were not observed for predicting 30-day mortality. Nevertheless, the current study is of particular value as it is the first to compare CAR with the sPESI score in this context. Future research should focus on reevaluating these findings in prospective, large-scale, multicenter cohorts and further investigating the prognostic utility of CAR in this patient population.

Ethics

Ethics Committee Approval: This study was approved by the local Hitit University Faculty of Medicine Clinical Research Local Ethics Committee (decision number: 2023-05, date: 12.01.2023).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

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

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ORIGINAL RESEARCH

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Factors that Extend the Operative Time in Laparoscopic Cholecystectomy

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Abstract

Objective: The research aims to identify preoperative factors that prolong surgical time in laparoscopic cholecystectomy (LC) before the procedure and to inform patient and surgeon selection decisions.

Materials and Methods: Retrospective cross-sectional review of surgical records was conducted involving 400 LC cases. The patients who had LC are divided into two groups. An operative time of up to 90 minutes was classified as Group I, while a duration exceeding 90 minutes was categorized as Group II. The parameters compared for operative time of surgery are; gender, age, medical co-morbidity, single or multiple stones, previous surgery, gallbladder wall thickness, history of endoscopic retrograde cholangio pancreatography (ERCP) and endoscopic sphincterotomy (ES), laparoscopy performed by a resident or specialist, white blood cell count, and presence of adhesions in the sac site.

Results: When patients who had ERCP and/or ES prior to LC in Group I and Group II were compared, preoperative ERCP/ES was associated with prolonged operative time [odds ratio (OR): 2.48; 95% confidence interval (CI): 1.3-4.58; p=0.03]. Additionally, trainee-led procedures increased operative time (OR: 1.85; 95% CI: 1.18-2.88; p=0.02). As a result of statistical analyses, the surgeon's experience (assistant or specialist) and preoperative ERCP or ES were identified as two key determinants contributing to the extended duration of LC.

Conclusion: Preoperative estimation of prolonged operative time before LC facilitates improved surgical, anesthetic, and staffing planning. Preoperative ERCP/ES, (p=0.03) and surgeon inexperience (p=0.05) independently prolonged the operative time (OR: 2.48 and 1.85, respectively). Prioritizing experienced surgeons for such cases optimizes OR scheduling.

Keywords: Laparoscopic cholecystectomy, operative time, ERCP, endoscopic sphincterotomy

INTRODUCTION

Acute cholecystitis (AC) and biliary obstruction by stones constitute a large percentage of patients presenting to the emergency department with epigastric and right upper quadrant pain. Severe episodic pain localized to these areas is characteristically seen in AC. Physical examination reveals tenderness and rebound in the right upper quadrant. The Tokyo Guide is widely used in the diagnosis and treatment of AC in emergency departments. Grade I (mild) and Grade II (moderate) AC: If the Charlson Comorbidity Index (CCI) and the American Society of Anesthesiologists-Physical Status Classification Score (ASA-PS) indicate that the patient can withstand surgery, laparoscopic cholecystectomy (LC) should ideally be performed soon after onset. While early LC is advocated for AC (Tokyo Guidelines), prolonged operative times remain a barrier to efficient OR management. Identifying preoperative predictors of surgical complexity is critical for resource allocation.

LC is a minimally invasive surgical procedure that has become one of the preferred approaches in the treatment of gallbladder stones. Beneficial features encompass reduced postoperative discomfort, a decreased length of hospital stay, quicker resumption of work life, and favorable cosmetic outcomes [1-5]. Technical difficulties encountered during laparoscopy and

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the level of training of the surgeon can extend the duration of LC. Prediction can detect cases with extended durations to maintain patient load balance, achieve patient and surgeon satisfaction, and facilitate efficient operating room (OR) management [3].

Predicting the operative time can be helpful for the surgeon who will perform the laparoscopy. With the highlights of this information, better planning of surgical discipline and anesthesia can be achieved. [1,6] In addition, informing the patient about the possibility of prolonged duration or conversion to open cholecystectomy will be valuable to prepare for potential outcomes.

The success of laparoscopic surgery depends on appropriate patient selection, technical equipment, and the experience of the physician performing the laparoscopy. Severe coagulopathy contraindicates laparoscopy. Other absolute contraindications are "frozen abdomen", intestinal obstruction with severe abdominal distension, hemorrhagic shock, severe cardiac dysfunction, and other coexisting diseases requiring laparotomy [7].

This study aims to identify parameters that can assist in predicting operative time prior to surgery and guide surgical planning based on the data found to be significant. For this purpose, variables influencing the surgical time in LC were evaluated based on patient-related, diagnostic, and surgical factors. According according to Tokyo Guidelines, patients without comorbidities who present to the emergency department with AC may undergo LC without delay.

Materials and Methods

Study Design and Collecting Patients' Data

The records of 400 LC cases (60% of cases from the emergency department), who underwent cholecystectomy in a tertiary care training and research hospital, were reviewed retrospectively. Ethics committee approval was not obtained for the study because there was no requirement for ethics committee approval for retrospective studies conducted for graduation thesis purposes without any intervention on the patient before the Regulation on Clinical Research published in the Official Gazette No. 28617 dated 13 April 2013. Patients with prior known coagulopathy, body mass index (BMI) greater than 35, pregnancy, portal hypertension, sepsis, were excluded from a study. Surgical interventions that were initiated laparoscopically and converted to open surgery (n=47) were also excluded to isolate factors affecting purely laparoscopic operative time. Operative time was defined based on the interval from skin incision to skin closure. The patients were categorized into two groups: Group I, with an operative time of 90 minutes or less, and Group II, with an operative time exceeding 90 minutes. The factors that were predicted to prolong the operative time before surgery in patients of these groups were recorded, evaluated, and compared. In this analysis, the determinant factors influencing surgical duration include age, gender, medical co-morbidity (e.g., diabetes, hypertension, cardiovascular disease), single or multiple gallstones, previous surgery, gallbladder wall thickness (≤3 mm or >3 mm), presence of preoperative endoscopic retrograde cholangio pancreatography (ERCP) and endoscopic sphincterotomy (ES), performing the operation by a specialist or a resident (under the supervision of a specialist), and the white blood cell (WBC) count. In addition, the adhesion status of the gallbladder anatomic location observed during surgery and its effects on the operative time were investigated.

Statistical Analysis

Statistical analysis was performed using the SPSS program (SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. Chicago, SPSS Inc.). According to these results, p values less than 0.05

Table 1. Patient demographic data

Parameters	Grup-I	Grup-II	Total
Female	223	98	321
Male	50	29	79
No history of surgery	234	102	336
History of surgery present	39	25	64
Single stone	109	41	150
Multiple stones	164	86	250
Wall thickness <3mm	250	118	368
Wall thickness >3mm	23	9	32
No adhesions	231	97	328
Adhesions present	42	30	72
No comorbidities	181	80	261
Comorbidities present	92	47	139

were found to be significant. In the statistical analysis, a chi-square test was used for attribute variables, and a Mann-Whitney U test was used for continuous variables. Logistic regression analysis was used to evaluate the factors increasing the operative time.

Results

Four hundred LC cases were included in the study. Descriptive demographics are shown in Table 1. Preoperative ERCP and ES applications and the performance of the surgery by specialists or a resident (under the supervision of a specialist) were found to be effective among the predicted factors for prolonging the operative time. It was determined that 50 of 400 patients underwent ERCP and/or ES. In 248 of 350 patients who did not undergo ERCP and/or ES, the operative time was found to be less than 90 minutes, while in 102 patients, it was over 90 minutes (Figure 1) (Table 2).

ERCP and ES were carried out in 9.2% of LC cases in Group I and 19.7% of cases in Group II. A comparison of patients who underwent ERCP and/or ES in Group I and Group II revealed a significant difference in the operative time extension (p=0.03).

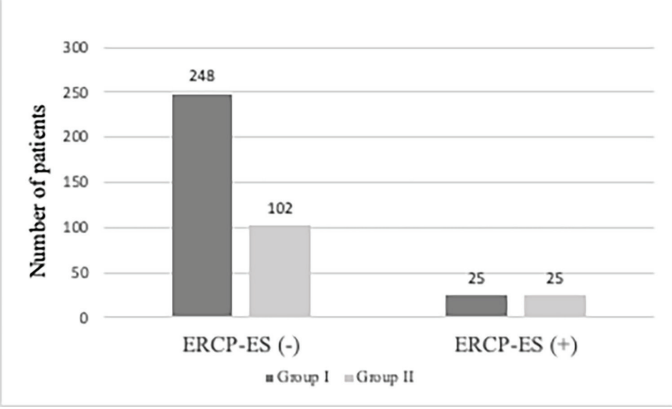

Figure 1. Distribution of patients with and without ERCP and ES in Group-I and Group-II

ERCP: Endoscopic retrograde cholangio pancreatography, ES: Endoscopic sphincterotomy

The risk coefficient was 2.48 (1.3-4.58). Correct discrimination was determined to be 68%.

Eighty of the 273 (29.3%) LC operations in Group-I were performed by residents (under the supervision of a specialist) at the beginning of the learning curve, and 193 (70.7%) of them were performed by specialists. While residents were present in 53 (41.7%) cases in Group-II, specialists were found in 74 (58.3%) cases (Table 2). The logistic regression analysis revealed a statistically significant variation in operative time between residents and specialists within the groups. The risk coefficient is 1.85, and the confidence interval is 1.18-2.88 (85%).

Among the factors analyzed for their potential influence on operative duration, the mean age was 52.5 years in with the 273 patients whose LC lasted less than 90 minutes (Group I), and 51.6 years in with the 127 patients with operative times exceeding 90 minutes (Group II). There was no statistically significant difference. Similarly, mean WBC counts were 6600/10³ µL in Group I and 8700/10³ µL in Group II, with no significant difference observed. In terms of gender distribution, 81.7% (n=223) of Group I and 77.2% (n=98) of Group II were female, while 18.3% (n=50) and 22.8% (n=29), respectively, were male. Gender did not significantly affect operative duration.

Regarding comorbidities, 66.3% (n=181) of Group I and 62.9% (n=80) of Group II had no associated medical conditions, with no significant difference between groups. Similarly, previous surgical history was absent in 85.7% (n=234) of Group I and 81% (n=102) of Group II, showing no significant association with operative time. A single gallbladder stone was detected in 39.9% (n=109) of Group I and 32.3% (n=41) of Group II, while multiple stones, were observed in 60.1% (n=164) and 67.7% (n=86), respectively. The number of stones had no significant effect on operative duration. Gallbladder wall thickness was ≤3 mm in 91.6% (n=250) of Group I and 92.9% (n=118) of Group II, and >3 mm in 8.4% (n=23) of Group I and 7.1% (n=9) of Group II, respectively, with no statistically significant difference observed. Intraoperative adhesions at the gallbladder site were absent in 84.6% (n=231) of Group I and 77% (n=97) of Group

Table 2. Number of patients with and without ERCP/ES and specialists/residents in groups

Groups	ERCP and/or ES (-)	ERCP and/or ES (+)	Total
Group-I	248	25	273
Group-II	102	25	127
	Resident	**Specialist**	**Total**
Group-I	80	193	273
Group-II	53	74	127
Total	133	267	400

ERCP: Endoscopic retrograde cholangio pancreatography, ES: Endoscopic sphincterotomy

II, and present in 15.4% (n=42) and 23% (n=30), respectively. Adhesion presence was not significantly associated with prolonged operative time.

Discussion

Cholecystitis, gallstone-related pancreatitis, cholangitis and biliary colic are the main reasons for emergency department visits related to hepatobiliary system LC is still the first choice for the treatment of symptomatic and some asymptomatic gallstones [1]. Recently, robotic cholecystectomy has emerged as an alternative to the laparoscopic approach. However, despite its advantages, challenges such as insufficient availability of a qualified surgical workforce and the absence of clear clinical superiority have limited its adoption as a primary method [2] LC has the advantages of less post-surgery pain, short hospital stay, faster recovery period, earlier return to work, and better cosmetic results [1-5]. The Tokyo Guide is widely used in the diagnosis and treatment of AC in emergency departments.

Grade I (mild) and Grade II (moderate) AC: If the CCI and ASA-PS indicate that the patient can withstand surgery, LC should ideally be performed soon after onset. Therefore, LC is important in the management of patients diagnosed with AC in the emergency department. It is also recommended that LC be performed for AC instead of open cholecystectomy (level of evidence 2A) [8].

Although there is little difference in operative time between laparoscopic and open surgery, laparoscopy may take longer if difficulties are experienced in the operation. Predicting the operative duration in elective laparoscopic surgery is meaningful for achieving high efficiency in scheduling [3].

The prolongation of operative duration is likely attributable to multiple factors. Patient factors like gender, age, BMI, ASA score, and abnormal liver function tests (LFT) are significant indicators of challenging procedures, characterized by an operative time exceeding 60 minutes [4]. Unfortunately, except for age and gender, other demographic factors were not included in this study. There would be more comprehensive outcomes if those factors could be studied. Two important factors affecting the duration of laparoscopic surgery were found. These factors are: ERCP and/or ES existence before surgery and the experience of the surgeon performing the surgery. ERCP, with or without ES, is broadly recognized as the standard diagnostic and therapeutic method for patients with common bile duct (CBD) stones [4]. Using ERCP, CBD stone removal is successful in approximately 97% of cases. LC following ERCP is an established treatment approach for gallstone disease with CBD stones. The conversion rate of LC after ERCP is higher compared to elective LC for uncomplicated cholelithiasis [5]. A plausible explanation for this could be that ERCP induces cholangitis, resulting in inflammation and adhesions around the extrahepatic biliary tree, thereby complicating the laparoscopic procedure [6]. According to the results, the risk coefficient increased by 2.4 in the presence of ERCP and/or ES before the surgery, while the risk coefficient increased by 1.8 when the resident performed the surgery (under the supervision of a specialist). Moreover, understanding reliable indicators of challenging LC would aid in developing an appropriate treatment plan and optimizing resource allocation to better anticipate difficult cases [3]. The laparoscopic approach to difficult cholecystectomy is technically more challenging than open cholecystectomy and it requires a qualified surgeon. In this study, no significant difference was found in the effect of age, gender, thickness of the gallbladder wall, and the presence of single or multiple stones on the duration of surgery.

Bharamgoudar et al. [9] developed a scoring tool (CholeS dataset) designed to predict the likelihood of a LC lasting more than 90 minutes based on pre-operative patient factors. This tool has undergone successful external validation using a separate dataset and has demonstrated strong predictive accuracy. The findings revealed that the proportion of operations exceeding 90 minutes significantly increases from 5.8% in low-scoring individuals to 41.4% in high-scoring individuals. Contrary to Bharamgoudar et al.'s [9] scoring system (CholeS), adhesions did not affect operative time in our cohort, possibly due to low rates of upper abdominal surgeries.

The standard approach for managing concomitant cholelithiasis and choledocholithiasis involves either a one-stage or two-stage procedure. This typically consists of LC combined with CBD exploration during the operation, or LC alongside preoperative, postoperative, or even intraoperative ERCP cholangio pancreatography with ES (ERCP-ES) for stone removal. The most commonly used method worldwide is preoperative ERCP-ES with stone extraction, followed by LC, ideally performed the following day [10].

Ahn et al. [11] reported that preoperative ERCP is a significant contributor to the complexity of LC. Therefore, it is recommended that experienced surgeons perform LC following preoperative ERCP. As the level of surgical difficulty does not vary based on the timing of cholecystectomy after ERCP, there is no justification for delaying LC after the procedure. da Costa et al. [12] also stated that surgeons should anticipate a challenging cholecystectomy following mild gallstone pancreatitis, particularly in cases involving males, previous sphincterotomy, and delayed cholecystectomy.

In this study, it was determined that ERCP and/or ES before surgery could be an important independent factor prolonging the operative time, together with technical difficulties. This situation may be related to the increased prevalence of acute biliary pancreatitis in patients undergoing ES. It was also found that previous surgical operations did not affect the

operative time. The effect of the presence of adhesions at the gallbladder's anatomical location on the operative duration was investigated in our study, and it was determined that it could not be an important factor in prolonging the operative time. Compared to patients with a history of lower abdominal surgery or no prior abdominal surgeries, those who had undergone previous upper abdominal surgery experienced longer operative times and higher complication rates [13].

While some series suggest that LC is a more difficult operation for men, and the rate of conversion to open cholecystectomy is high, it is stated that this is not the case in other series. In this study, it was determined that there was no statistically significant difference between male and female patients, which would extend the operative time. In addition, Stoica et al. [14] also found a good correlation between total leukocyte count, fibrinogen, and difficult LC.

Yuzbasioglu et al. [15] declared that the grading of AC is necessary for not only defining the severity of AC, but also planning early or elective cholecystectomy. Patients were classified into three stages namely mild, moderate, and severe, according to the severity of AC using the Tokyo Guidelines [8,15,16]. Procalcitonin level could also discriminate grade III from grade I-II with 72.4% sensitivity and 90.06% specificity. Although no grading was made regarding the AC stages in the study, the potential relationship between this grading and surgical time can be investigated in subsequent studies.

Complications and conversion rates of LC depend on the experience of the surgeon and the difficulty of surgical intervention. There is a relationship between surgical difficulty and the experience of surgeons. The study suggests that LC of patients who underwent ERCP and/or ES before surgery would be more appropriate in terms of operative time and surgical outcomes. In addition, predicting which LCs may prolong the operative time and be converted into open surgery can be useful to inform the patient about these possibilities.

There is a learning curve for LC that includes operative time, rate of conversion to open surgery, and complication rates. Laparoscopic surgery has a long learning curve and Pietra Lombardi et al. [17] reported that approximately 25 LCs should be performed in order to gain enough experience. Therefore, patients should be carefully selected to minimize the complications that may arise at the beginning of the learning curve. Preoperative estimation of a long operation time is very useful for patients and surgeons who are scheduled for LC. As it provides better planning of surgery and anesthesia in every aspect, the choice of surgeon (specialist or assistant) could be made according to this foresight.

Study Limitations

This study was limited by the availability of all patient factors and lack of information on surgeon experience. There is no exact information about how long LC is performed after emergency room admission. BMI and ASA scores were not analyzed but may affect operative difficulty. Operative time variability due to unmeasured factors (e.g., equipment availability) cannot be excluded.

Conclusion

Predicting the operative time for LC operations will facilitate the selection of surgeons and patients, as well as help in programming OR scheduling. The existence of ERCP and/or ES before LC and at the beginning of the learning curve, residents are important factors that may prolong the operative time. It may be preferable for LC operations to be performed by surgeons with more experience, especially in patients who have previously had ERCP and/or ES. In addition, patient-specific factors including increased BMI, increased age, male sex, increased ASA, and abnormal LFT are also significant predictors of prolonged LC operative time and may be indicators of increased procedural difficulty. In addition to these results, although traditional approaches have adopted the idea that patients should first receive antibiotic treatment in AC cases and then undergo elective LC after the acute condition has subsided, current approaches, as explained in the Tokyo 18 guideline, report that Grade I and Grade II AC cases presenting to the emergency department can also undergo LC without any loss of time. Future studies may be conducted to evaluate both approaches.

Ethics

Ethics Committee Approval: Ethics committee approval was not obtained for the study because there was no requirement for ethics committee approval for retrospective studies conducted for graduation thesis purposes without any intervention on the patient before the Regulation on Clinical Research published in the Official Gazette No. 28617 dated 13 April 2013.

Informed Consent: Retrospective study.

Footnotes

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ORIGINAL RESEARCH

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Comparative Predictive Value of the Harmless Acute Pancreatitis Score, Ranson Score, and Neutrophil-to-Lymphocyte Ratio for Mortality Prediction in Patients with Acute Pancreatitis Presenting to the Emergency Department

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Abstract

Objective: Early risk stratification in acute pancreatitis (AP) is essential for guiding clinical decisions in the emergency department (ED). This study aimed to compare the clinical utility of three accessible indicators—Harmless acute pancreatitis score (HAPS), Ranson score, and neutrophil-to-lymphocyte ratio (NLR)—in predicting in-hospital mortality.

Materials and Methods: This retrospective cohort study included 347 adult patients (≥18 years) diagnosed with non-traumatic AP between January 2020 and January 2024 at a tertiary care ED. The diagnosis was established using the American College of Gastroenterology criteria. HAPS, Ranson score (based on admission data), and NLR were calculated at initial presentation. Patients with chronic pancreatitis, traumatic etiology, malignancy-related AP, or incomplete data were excluded. Predictive performance for in-hospital mortality was evaluated using receiver operating characteristic analysis and compared using the DeLong test.

Results: In-hospital mortality occurred in 35 patients (10.1%). HAPS showed a sensitivity of 82.9%, specificity of 64.7%, and a negative predictive value (NPV) of 97.1%. Ranson score had a sensitivity of 68.6%, specificity of 72.8%, and NPV of 95.4%. NLR ≥4.9 yielded a sensitivity of 82.9%, specificity of 59.9%, and NPV of 96.9%. Area under the curve (AUC) values were 0.757 [95% confidence interval (CI): 0.708-0.801] for HAPS, 0.755 (95% CI: 0.706-0.799) for Ranson, and 0.642 (95% CI: 0.589-0.692) for NLR. No significant difference was observed between HAPS and Ranson (p=0.956), while comparisons involving NLR approached statistical significance.

Conclusion: HAPS and Ranson scores demonstrated comparable and superior performance in predicting in-hospital mortality in patients with AP. Due to its simplicity and excellent NPV, HAPS may be particularly useful as a bedside exclusion tool in the emergency setting.

Keywords: Acute pancreatitis, mortality prediction, emergency department, risk stratification, Harmless acute pancreatitis score

Introduction

Acute pancreatitis (AP) is a common gastrointestinal emergency characterized by the sudden onset of pancreatic inflammation, typically presenting with upper abdominal pain [1]. Although the majority of cases are mild and self-limiting, approximately 15-20% may progress to persistent organ failure, which significantly increases the risk of mortality. Due to this clinical heterogeneity, accurate risk stratification in the early phase of emergency department (ED) presentation is of paramount importance for guiding triage decisions, determining the appropriate level of care, and ensuring the efficient allocation of medical resources [2].

Several clinical scoring systems have been developed to predict the severity of AP [3]. Tools such as the Ranson score, APACHE

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II, and BISAP are commonly used in clinical practice. However, many of these systems rely on time-dependent laboratory parameters or require complex calculations, which may limit their practicality in ED settings where rapid decision-making is essential [3].

In this context, models based on simple, rapidly applicable, and easily accessible parameters have gained prominence. The Harmless acute pancreatitis score (HAPS) is a bedside risk stratification tool designed to identify patients unlikely to develop severe disease, utilizing only three fundamental clinical variables [4]. Although the Ranson score is based on a broader set of parameters, it remains one of the most widely used and validated classical scoring systems for AP in the literature [5]. On the other hand, the neutrophil-to-lymphocyte ratio (NLR), derived from complete blood count parameters, is considered a biomarker reflecting systemic inflammation [6]. In recent years, it has emerged as a prognostic indicator in numerous critical illnesses, including AP [6].

Although various studies have explored the prognostic utility of these parameters in patients with AP, the comparative performance of HAPS, the Ranson score, and NLR in predicting in-hospital mortality during the early phase of ED presentation has not been clearly established in the literature [4-6]. The aim of this study is to comparatively evaluate the predictive value of the HAPS, Ranson score, and NLR in forecasting in-hospital mortality among patients presenting to the ED with AP, and to elucidate their potential roles in early risk stratification.

Materials and Methods

Study Design and Participants

A retrospective cohort was used in this study. The research was conducted on patients diagnosed with AP in the adult Emergency Department of University of Health Sciences Türkiye, Haydarpaşa Numune Training and Research Hospital, a tertiary university-affiliated hospital, between January 1, 2020, and January 1, 2024. Eligible cases were identified through the hospital information management system using the International Classification of Diseases, 10th Revision codes. To minimize selection bias, all consecutive patients who met the inclusion criteria were enrolled in the study.

The diagnosis of AP was established based on the guidelines of the American College of Gastroenterology (ACG), requiring the presence of at least two of the following criteria: (i) acute-onset, characteristic upper abdominal pain; (ii) serum amylase or lipase levels at least three times the upper limit of normal; (iii) imaging findings consistent with AP on contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI).

Inclusion Criteria

- Adults aged 18 years and older
- Diagnosis of AP according to ACG criteria
- Presence of contrast-enhanced CT or MRI findings supporting the diagnosis
- Availability of complete data for HAPS, Ranson score, and NLR

Exclusion Criteria

- Patients under the age of 18
- Cases of pancreatitis secondary to trauma
- Known history of chronic pancreatitis
- Secondary pancreatitis due to malignancy or postoperative causes
- Missing laboratory data or absence of imaging confirming the diagnosis

Data Collection Process

Demographic characteristics, presenting complaints, vital signs, laboratory results, and radiological imaging data of the patients were retrospectively retrieved from the hospital information system. All measurements were based on data obtained at the time of ED admission.

Variables and Measurements

HAPS was calculated based on the hematocrit level, serum creatinine concentration, and the presence or absence of peritoneal signs on physical examination at presentation. The Ranson score was calculated based on admission parameters. The NLR was derived from the complete blood count performed at the time of presentation. Mortality was defined as death occurring at any time during the hospital stay.

Ethical Approval

The study was approved by the University of Health Sciences Türkiye, Haydarpaşa Numune Training and Research Hospital, Clinical Research Ethics Committee (approval number: HNEAH-GOAEK/KK/2025/92, date: 22.07.2025). All procedures were conducted in accordance with the ethical standards of the 2013 revised version of the Declaration of Helsinki and relevant national ethical guidelines. Since the data were analyzed retrospectively and anonymized, individual informed consent was not required.

Statistical Analysis

All statistical analyses were conducted using SPSS (version 25.0; IBM Corp., Armonk, NY, USA) and MedCalc (version 14.8.1; MedCalc Software Ltd., Ostend, Belgium). The distribution of continuous variables was assessed using the Kolmogorov-Smirnov test. Non-normally distributed data were presented as medians with interquartile ranges, while categorical variables

were summarized as frequencies and percentages (%). Differences between two groups were analyzed using the Mann-Whitney U test for continuous variables and the chi-square (χ^2) test for categorical variables. The discriminatory power of the HAPS, Ranson score, and NLR in predicting mortality was evaluated using receiver operating characteristic (ROC) curve analysis. The area under the curve (AUC) was calculated for each of these variables. Differences between ROC curves were compared using the DeLong test. Optimal cut-off values were determined according to Youden's index (J). A p-value of <0.05 was considered statistically significant in all analyses.

Results

A total of 347 patients who met the predefined inclusion and exclusion criteria were included in the study. The mean age of the study population was 64.5±14.2 years. Of the patients, 28.2% (n=98) were male and 71.8% (n=249) were female. The in-hospital mortality rate was 10.1% (n=35). Analyses were conducted by comparing the demographic, clinical, and laboratory characteristics between survivors and non-survivors.

Comparative analyses revealed statistically significant differences in several clinical and laboratory parameters between patients who survived and those who died during hospitalization. According to the Mann-Whitney U test, systolic blood pressure (122.0 mmHg vs. 136.0 mmHg, p<0.001) and diastolic blood pressure (78.0 mmHg vs. 82.0 mmHg, p=0.001) were significantly lower in the non-survivors group. In contrast, heart rate (88 vs. 77 beats/min, p=0.003) and respiratory rate (17 vs. 16 breaths/min, p=0.028) were significantly higher in non-survivors.

Moreover, white blood cell count (p=0.034), aspartate aminotransferase (p=0.013), lactate dehydrogenase (p<0.001), neutrophil count (p=0.001), NLR (p=0.006), and serum creatinine levels (p<0.001) were all significantly elevated in the non-survivor group. No statistically significant differences were observed between the groups in terms of body temperature, oxygen saturation, hemoglobin, hematocrit, platelet count, lymphocyte count, or glucose levels (p>0.05) (Table 1).

In the analysis of categorical variables, the presence of impaired mental status was significantly associated with increased mortality (85.7% vs. 1.6%, p<0.001). Among comorbid conditions, congestive heart failure (p=0.007), cerebrovascular disease (p=0.002), chronic renal failure (p=0.002), and chronic kidney disease (p=0.032) were significantly associated with in-hospital mortality. No statistically significant association was observed between mortality and other comorbidities such as diabetes mellitus, hypertension, coronary artery disease, or malignancy (p>0.05) (Table 2).

Regarding outcome parameters, both the need for intensive

Table 1. Comparison of clinical and laboratory parameters between survivors and non-survivors

Parameter	Survivors [median (25-75)]	Non-survivors [median (25-75)]
Age, years	64.00 (56.00-71.00)	67.00 (62.00-73.00)
Systolic blood pressure (mmHg)	136.00 (127.00-152.00)	122.00 (95.00-138.00)
Diastolic blood pressure (mmHg)	82.00 (75.00-89.00)	78.00 (63.00-83.00)
Pulse (beats/min)	77.00 (71.00-84.00)	88.00 (72.50-104.00)
Body temperature (°C)	36.50 (36.30-36.80)	36.50 (36.15-37.25)
Peripheral O_2 saturation (%)	96.00 (95.00-98.00)	96.00 (92.00-97.50)
Respiratory rate (breaths/min)	16.00 (14.00-18.00)	17.00 (15.00-20.00)
White blood cells (10^3/µL)	10.40 (8.47-13.60)	12.10 (10.45-14.10)
AST (U/L)	37.50 (27.00-60.25)	54.00 (28.00-399.00)
Glucose (mg/dL)	106.00 (90.00-134.25)	84.00 (67.50-146.50)
LDH (U/L)	251.50 (187.00-328.25)	446.00 (264.00-596.00)
Hemoglobin (g/dL)	13.80 (12.50-14.90)	13.50 (12.05-14.75)
Hematocrit (%)	41.40 (37.50-44.70)	40.50 (36.15-44.25)
Platelets (10^3/µL)	241.00 (177.75-279.25)	237.00 (176.50-246.50)
Neutrophils (10^3/µL)	6.35 (4.70-9.22)	8.80 (8.20-10.45)
Lymphocytes (10^3/µL)	1.60 (1.20-2.20)	1.50 (1.30-2.25)
Neutrophil/lymphocyte ratio	4.13 (2.60-6.64)	6.13 (5.42-7.03)
Creatinine (mg/dL)	0.80 (0.66-1.00)	1.11 (0.75-1.41)

AST: Aspartate aminotransferase, LDH: Lactate dehydrogenase

care unit (ICU) admission (94.3% vs. 6.1%, p<0.001) and the requirement for mechanical ventilation (94.3% vs. 1.0%, p<0.001) were strongly associated with mortality.

The predictive performance of the three scoring systems for in-hospital mortality was compared using ROC curve analysis.

The AUC was calculated as 0.757 [95% CI: 0.708-0.801] for the HAPS, 0.755 [95% confidence interval (CI): 0.706-0.799] for the Ranson score, and 0.642 (5% CI: 0.589-0.692) for the NLR. In terms of diagnostic accuracy, the highest sensitivity (82.9%) was observed for both HAPS (+) and NLR (cut-off >4.9), while the highest specificity (72.8%) was noted with the Ranson score (cut-off >1). The highest negative predictive value (NPV) was achieved by HAPS at 97.1%.

Pairwise comparisons of the ROC curves were performed using the DeLong test. No statistically significant difference was observed between HAPS and the Ranson score (AUC difference =0.002, 95% CI: -0.070 to 0.074, p=0.957). The comparison between HAPS and NLR showed an AUC difference of 0.115 (95% CI: -0.006 to 0.236, p=0.063), while the difference between Ranson and NLR was 0.113 (95% CI: -0.013 to 0.238, p=0.078). Although the latter two comparisons indicated a numerical trend toward better performance of HAPS and Ranson over NLR, these did not reach statistical significance.

The ROC curve analysis comparing the predictive performance of HAPS, Ranson score, and NLR is shown in Figure 1.The cut-off based diagnostic performance metrics of HAPS, NLR, and Ranson scores are summarized in Table 3.

Table 2. Clinical characteristics and outcomes according to survival status (n, %)

Variable	Survivors, n (%)	Non-survivors, n (%)	p-value
Demographics			
Gender (male)	90 (28.8%)	8 (22.9%)	0.554*
Impaired mental status	5 (1.6%)	30 (85.7%)	<0.001#
Etiology of pancreatitis			
Biliary	119 (38.1%)	11 (31.4%)	0.468*
Drug-induced	6 (1.9%)	0 (0.0%)	>0.99#
Alcoholic	11 (3.5%)	0 (0.0%)	0.611#
Idiopathic	138 (44.2%)	14 (40.0%)	0.720*
Hyperlipidemia (etiology)	37 (11.9%)	5 (14.3%)	0.593*
Malignancy (etiology)	2 (0.6%)	0 (0.0%)	>0.99#
Comorbidities			
Diabetes mellitus	80 (25.6%)	9 (25.7%)	>0.99#
Hypertension	120 (38.5%)	16 (45.7%)	>0.99*
Coronary artery disease	38 (12.2%)	2 (5.7%)	0.466*
Congestive heart failure	13 (4.2%)	6 (17.1%)	0.401*
Chronic pulmonary disease	20 (6.4%)	0 (0.0%)	0.007*
Arrhythmia	21 (6.7%)	2 (5.7%)	0.242#
Cerebrovascular disease	6 (1.9%)	5 (14.3%)	>0.99#
Chronic renal failure	20 (6.4%)	0 (0.0%)	0.002*
Chronic kidney disease	14 (4.5%)	5 (14.3%)	0.242#
Malignancy (comorbidity)	18 (5.8%)	0 (0.0%)	0.032*
Radiological findings			
Pancreatic edema	18 (5.8%)	0 (0.0%)	0.235#
Peripancreatic fluid collection	14 (4.5%)	0 (0.0%)	0.376#
Pancreatic necrosis	5 (1.6%)	0 (0.0%)	>0.99#
Outcomes			
ICU admission	19 (6.1%)	33 (94.3%)	<0.001*
Mechanical ventilation	3 (1.0%)	33 (94.3%)	<0.001*

*Chi-square test was used.
#Fisher's exact test was used.
ICU: Intensive care unit

Table 3. Comparison of cut-off based diagnostic metrics for HAPS, NLR, and Ranson scores in predicting mortality

Score	Criterion	Youden index J	Sens.	Spec.	PLR	NLR	PPV	NPV
HAPS	>0	0.476	82.86	64.74	2.35	0.26	20.9	97.1
NLR	>4.9	0.427	82.86	59.94	2.07	0.29	18.8	96.9
Ranson	>1	0.413	68.57	72.76	2.52	0.43	22.0	95.4

HAPS >0 indicates the presence of at least one adverse parameter (hematocrit ≥43% in men or ≥39.6% in women, serum creatinine >2 mg/dL, or presence of peritoneal signs), meaning that the patient does not fulfill the criteria for harmless acute pancreatitis.

Sens.: Sensitivity, Spec.: Specificity, PLR: Positive likelihood ratio, NLR: Negative likelihood ratio, PPV: Positive predictive value, NPV: Negative predictive value

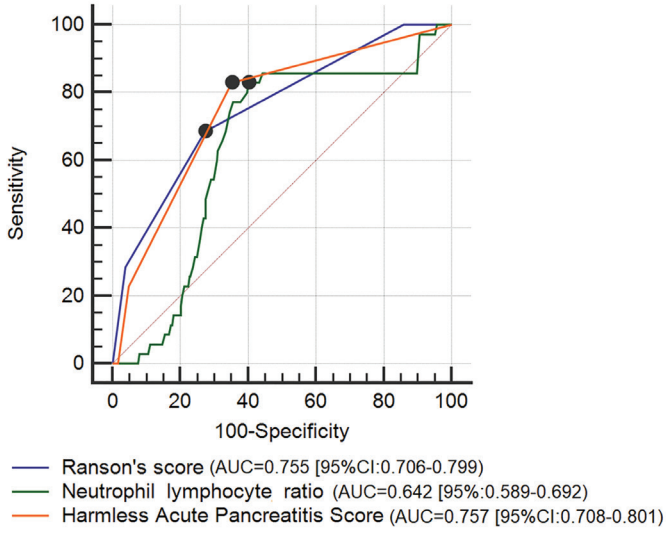

Figure 1. Comparison of ROC curves for prognostic scores in predicting 30-day mortality in acute pancreatitis

AUC: Area under the curve, ROC: Receiver operating characteristic

Discussion

This study aimed to evaluate and compare the diagnostic performance of the HAPS, Ranson score, and NLR in predicting in-hospital mortality among patients presenting to the ED with AP. The findings demonstrated that both HAPS and the Ranson score exhibited strong and comparable discriminatory performance, whereas NLR showed a lower predictive accuracy in comparison to these two scoring systems.

When examining the area under the ROC, AUC, the HAPS (AUC: 0.757) and the Ranson score (AUC: 0.755) demonstrated comparable levels of diagnostic accuracy. Both scores exhibited moderate-to-high discriminatory power. This finding is consistent with previous studies. For instance, in a study by Lankisch et al. [4] the HAPS was reported to have high sensitivity in ruling out severe AP, highlighting its utility in avoiding unnecessary hospitalizations. The Ranson score, on the other hand, has been widely used since its initial validation studies and is still regarded as a reliable tool for predicting various systemic complications in AP [5-7].

In this study, the NLR demonstrated a lower discriminatory power, compared to HAPS and the Ranson score, with an AUC of 0.642—approaching statistical significance without reaching it. This result suggests that inflammatory biomarkers may have limited utility in predicting mortality when used in isolation. Although previous research has proposed that NLR may be valuable in the prognostication of AP, the specificity (59.94%), and positive predictive value (18.8%) observed in this study indicate its relatively low positive predictive accuracy [6]. In the study conducted by Aykan et al. [8] patients with AP classified as severe according to the HAPS score had significantly higher mean NLR values compared to those with mild or moderate disease. The authors reported that elevated NLR levels were independent predictors of disease severity in AP, based on the HAPS classification. NLR has been reported to exhibit stronger predictive performance in systemic inflammatory conditions such as sepsis and COVID-19, but it may not be sufficient on its own in diseases with heterogeneous etiopathogenesis, such as AP [6,9].

In the comparative analysis using the DeLong test, no statistically significant difference was found between HAPS and the Ranson score (p=0.956), supporting the notion that both scoring systems offer a similar level of discriminatory performance. One major advantage of HAPS is its simplicity, as it relies on only three parameters readily available at the time of admission, making it a rapid and feasible tool in the emergency setting. Given the increasing patient burden and overcrowding in EDs, the availability of a simple and rapid risk stratification tool, such as HAPS, is particularly valuable for optimizing triage decisions and resource allocation [10]. This feature renders HAPS particularly practical in time-constrained environments. In contrast, the Ranson score includes parameters that require up to 48 hours of follow-up, making it more applicable to hospitalized patients [11]. Nonetheless in this study, even the modified version of the Ranson score calculated solely from admission parameters demonstrated comparable predictive performance with HAPS.

One of the most noteworthy findings of this study is the high NPV of the HAPS score (97.1%). This indicates that patients with low HAPS scores are at very low risk of in-hospital mortality, supporting the utility of HAPS as a reliable rule-out tool. The study by Maisonneuve et al. [12] states that the HAPS score accurately identifies non-severe cases of AP that do not require

ICU admission and facilitates the selection of patients who may be discharged after a short stay in a general ward or even managed at home [12]. Such a result highlights the potential role of HAPS in contributing to strategies aimed at reducing unnecessary hospital admissions in ED settings.

Study Limitations

This study has several limitations. First, its single-center and retrospective design may restrict the generalizability of the findings. Second, the calculations of HAPS and Ranson scores were based exclusively on admission data; notably, the classic 48-hour follow-up parameters required for the full Ranson score were not included. Moreover, the divergence from the conventional cut-off value for the Ranson score should be acknowledged as a limitation in terms of external validity.

Despite these limitations, the study has important strengths, including an adequate sample size, a comprehensive evaluation of independent variables, and methodological rigor, particularly through the use of the DeLong test for ROC curve comparisons.

Conclusion

This study demonstrated that both the HAPS and the Ranson score are strong and comparable predictive tools for estimating in-hospital mortality among patients presenting to the ED with AP, whereas the NLR exhibited relatively weaker diagnostic performance. In clinical decision-making processes, the HAPS score stands out due to its rapid applicability and high rule-out capacity. Future research should focus on validating these scoring systems through prospective, multicenter studies, ideally incorporating biomarker-based predictive models.

Ethics

Ethics Committee Approval: The study was approved by the University of Health Sciences Türkiye, Haydarpaşa Numune Training and Research Hospital, Clinical Research Ethics Committee (approval number: HNEAH-GOAEK/KK/2025/92, date: 22.07.2025).

Informed Consent: Since the data were analyzed retrospectively and anonymized, individual informed consent was not required.

Footnotes

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

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ORIGINAL RESEARCH

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Evaluation of Urine Culture Results and Antibiotic Resistance Patterns in the Emergency Department Between 2020 and 2023

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Abstract

Objective: Urinary tract infections (UTIs) are one of the most common infectious diseases encountered in emergency departments (EDs), and increasing antimicrobial resistance has become a significant challenge in managing these infections. This study evaluated the antibiotic resistance patterns of pathogens isolated from urine cultures obtained from patients presenting to the ED between 2020 and 2023 and investigated the changes in resistance rates over time.

Materials and Methods: This was a retrospective, single-center study. Urine culture and antibiogram results of patients aged 18 years who presented with a preliminary diagnosis of UTI between January 1, 2020, and December 31, 2023, were reviewed. Data were collected from electronic patient records, and pathogens isolated in cultures were analyzed according to antibiotic susceptibility.

Results: A total of 978 patients who had urine cultures requested were included in the study. Growth was detected in 258 (26.4%) patients. The median age of patients with positive cultures was 55.5 years (interquartile range: 35-74.25), and 69.8% were female. The most frequently isolated pathogen was *Escherichia coli* (61.6%), followed by *Klebsiella pneumoniae* (19%). Ampicillin (38%), ceftriaxone (32.9%), ciprofloxacin (28.3%), and trimethoprim-sulfamethoxazole (TMP/SMX) (24.4%) had the highest resistance rates. Resistance to antibiotics such as meropenem, amikacin, and gentamicin was also lower. An increase in resistance rates was observed for amoxicillin-clavulanate, ampicillin, and TMP/SMX between 2020 and 2023.

Conclusion: Our study shows that the UTI pathogens most commonly isolated from patients presenting to the ED exhibit increasing resistance rates to widely used antibiotics. These findings highlight the need for empirical antibiotic therapy to be guided by local resistance patterns and regularly updated. Continuous monitoring of local antibiogram data is crucial for reducing antibiotic resistance and improving patient outcomes.

Keywords: Urinary tract infections, emergency department, antibiotic resistance, *Escherichia coli*, *Klebsiella pneumoniae*, urine cultures

Introduction

Urinary tract infections (UTIs) are one of the most commonly encountered infectious diseases in emergency departments (EDs), accounting for 25% of all infectious diseases, making them the second most prevalent cause [1,2]. UTIs are classified based on their clinical characteristics into uncomplicated and complicated infections. Complicated UTIs involve factors that increase the risk of treatment failure and recurrence, such as underlying anatomical or functional abnormalities, immunosuppression, comorbidities, and resistant microorganisms. Therefore, urine cultures play a critical role in complicated UTIs; culture results guide the selection of appropriate antibiotics, helping to prevent treatment failures and the development of severe complications, such as urosepsis [3,4]. Delays in obtaining culture results in the ED often lead clinicians to rely on previous culture results or empirical treatment, which can sometimes result in the unnecessary use of broad-spectrum antibiotics. Although empirical antibiotic therapy can expedite the treatment process, especially when culture results are not promptly available, the effectiveness of antibiotics administered in this manner is influenced by

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regional antibiotic resistance patterns. Increasing antibiotic resistance leads to treatment failure and hospital admissions and places significant economic burden on the healthcare system. Therefore, determining the most appropriate antibiotics for treating UTIs and basing treatment decisions on up-to-date antibiogram data are essential for improving patient outcomes and preventing antibiotic resistance [3,5]. The aim of this study was to examine the urine culture and antibiogram results obtained from patients presenting to the ED and to investigate the changes in antibiotic susceptibility of the isolated pathogens between 2020 and 2023. By providing updated data to the literature, this study aims to contribute to the optimization of antimicrobial treatment strategies.

Materials and Methods

Study Design

This retrospective study was conducted in an ED with an annual average of 385,000 patient visits. The local ethics committee approved the study at University of Health Sciences Türkiye Ankara Atatürk Sanatoryum Training and Research Hospital, Scientific studies Ethics Committee (approval number: 2024-BÇEK/125, date: 31.07.2024). Data were collected from electronic health records and patient files.

Data Collection

Data were collected from electronic medical records and patient files. A retrospective chart review was performed by two emergency physicians, each with at least 3 years of experience. This review included both the clinical and demographic details of the patients. In cases in which there were differences in the evaluations made by the two physicians, the lead investigator reviewed the cases and provided the final decision.

Study Population

The study included patients aged 18 and over who had urine cultures with a preliminary diagnosis of UTI between January 1, 2020, and December 31, 2023, in the Emergency Department of University of Health Sciences Türkiye Ankara Atatürk Sanatoryum Training and Research Hospital. Only patients with complete data and positive pathogen growth in their urine cultures were included, whereas those with suspected contamination based on culture results were excluded.

The demographic data, chronic diseases, and urine culture results of the included patients were recorded. The microorganisms isolated from the urine cultures were classified, and the antibiogram results were analyzed in two groups based on susceptibility and resistance. Additionally, the antibiotic resistance profiles of frequently isolated pathogens were evaluated by year, and changing resistance patterns were analyzed.

Statistical Analysis

All data collected and recorded in the study form were analyzed using IBM SPSS 20.0 statistical software (Chicago, IL, USA). The normality of the distribution of categorical and continuous numerical variables was assessed using the Shapiro-Wilk test. Descriptive statistics for categorical and continuous numerical variables are presented as median [(interquartile range (IQR): 25-75] and frequencies and percentages for categorical variables. Categorical variables were evaluated using the chi-square test, whereas continuous variables were assessed using the Mann-Whitney U test. A critical alpha value of 5% was considered for all statistical analyses, and the hypotheses were tested in a two-tailed manner.

Results

Urine cultures were requested for 978 patients in the ED between 2020 and 2023. Bacterial growth was detected in 258 patients (26.4%) (Figure 1). The median age of patients with positive urine cultures was found to be 55.5 years (IQR: 35-74.25). Among the patients with growth, 69.8% were female, 18.2% had a diagnosis of diabetes mellitus, and 2.3% were pregnant. Polymicrobial growth was observed in 6 patients. The most commonly encountered microorganism in urine cultures was *Escherichia coli (E. coli)* at 61.6%, followed by *Klebsiella pneumoniae (K. pneumoniae)* at 19%. The pathogens identified

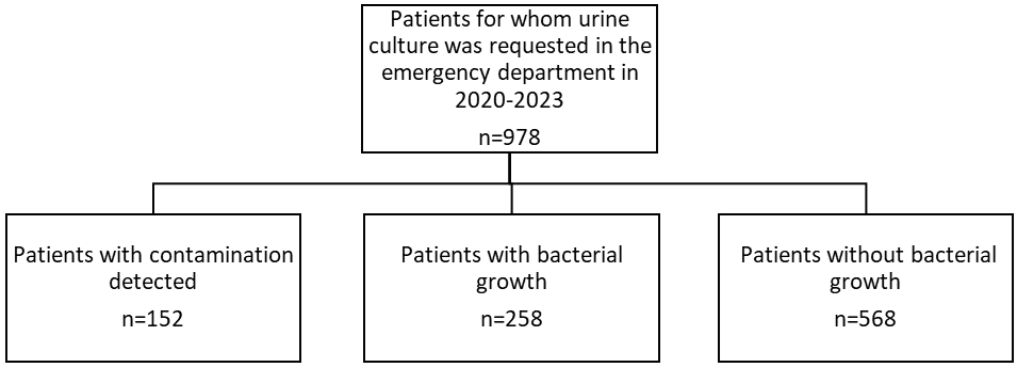

Figure 1. Flowchart of the patients

in the urine cultures are presented in Table 1. When examining all positive samples, the antibiotic resistance rates were found to be 38% for ampicillin, 32.9% for ceftriaxone, 28.3% for ciprofloxacin, and 24.4% for trimethoprim-sulfamethoxazole (TMP/SMX). The antibiotics with lower resistance rates were meropenem (10.5%), amikacin (7%), and gentamicin (7%) (Figure 2, Table 2). Among the 158 patients with *E. coli* growth, 51 (32.1%) were found to be susceptible to all tested agents. The antibiotic to which the isolated *E. coli* strains exhibited the highest resistance was ampicillin (38.4%), whereas the antibiotics with the lowest resistance rates were ofloxacin and ertapenem, both with a resistance rate of 0.6%. An increase in resistance rates over the years was observed for amoxicillin/clavulanate, ampicillin, and trimethoprim/sulfamethoxazole. The changes in the antibiotic resistance of *E. coli* strains over time are presented in Table 3. The antibiotic to which the isolated *K. pneumoniae* strains exhibited the highest resistance was ampicillin (55.1%), whereas the antibiotics with the lowest resistance rates were gentamicin (16.3%) and ertapenem (10.2%). An increase in resistance to gentamicin was observed over time. The changes in the antibiotic resistance of *K. pneumoniae* strains over time are presented in Table 4.

Table 1. Pathogens identified in urine cultures

Isolated microorganism	n (%)
Escherichia coli	159 (61.6)
Klebsiella pneumoniae	49 (19)
Enterococcus fecalis (Group D)	11 (4.3)
Enterobacter cloacae	10 (3.9)
Pseudomonas aeruginosa	9 (3.5)
Streptococcus agalactiae (Group B)	9 (3.5)
Staphylococcus aureus	5 (1.9)
Candida albicans	5 (1.9)
Proteus mirabilis	3 (1.2)
Klebsiella oxytoca	2 (0.8)
Acinetobacter baumannii	1 (0.4)
Citrobacter freundii	1 (0.4)
Streptococcus dysgalactiae (Group C/Group G)	1 (0.4)

A single patient may have multiple isolated pathogens

Discussion

This study aimed to provide a contemporary perspective on the management of UTIs in the ED by examining the changes in urine culture results and antibiotic resistance patterns over time among patients who presented to the ED between 2020 and 2023. In our study, growth was detected in approximately one-quarter (26.4%) of patients who underwent urine culture in the ED. The most frequently encountered pathogen among the isolated microorganisms was *E. coli*, consistent with previous studies. This finding supports the notion that *E. coli* is the dominant pathogen in community-acquired UTIs [1,6,7]. The second most commonly isolated pathogen was *K. pneumoniae*, which is consistent with findings reported in other studies in the literature [1,7,8]. In our country, patients often present to EDs for initial evaluation of

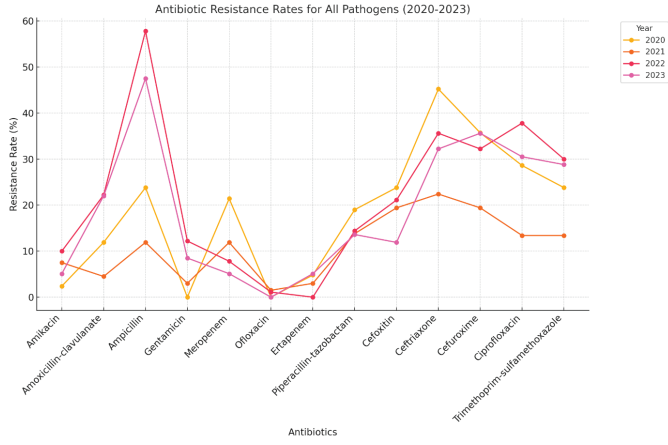

Figure 2. Antibiotic resistance rates for all pathogens between 2020 and 2023

Table 2. Antibiotic resistance rates for all pathogens between 2020 and 2023

Antibiotics, n (%)	2020	2021	2022	2023	Total
Amikacin	1 (2.4)	5 (7.5)	9 (10)	3 (5.1)	18 (7)
Amoxicillin-clavulanate	5 (11.9)	3 (4.5)	20 (22.2)	13 (22)	41 (15.9)
Ampicillin	10 (23.8)	8 (11.9)	52 (57.8)	28 (47.5)	98 (38)
Gentamicin	0 (0)	2 (3)	11 (12.2)	5 (8.5)	18 (7)
Meropenem	9 (21.4)	8 (11.9)	7 (7.8)	3 (5.1)	27 (10.5)
Ofloxacin	0 (0)	1 (1.5)	1 (1.1)	0 (0)	2 (0.8)
Ertapenem	2 (4.8)	2 (3)	0 (0)	3 (5.1)	7 (2.7)
Piperacillin-tazobactam	8 (19)	9 (13.8)	13 (14.4)	8 (13.6)	38 (14.7)
Cefoxitin	10 (23.8)	13 (19.4)	19 (21.1)	7 (11.9)	49 (19)
Ceftriaxone	19 (45.2)	15 (22.4)	32 (35.6)	19 (32.2)	85 (32.9)
Cefuroxime	15 (35.7)	13 (19.4)	29 (32.2)	21 (35.6)	78 (30.2)
Ciprofloxacin	12 (28.6)	9 (13.4)	34 (37.8)	18 (30.5)	73 (28.3)
Trimethoprim-sulfamethoxazole	10 (23.8)	9 (13.4)	27 (30)	17 (28.8)	63 (24.4)

Table 3. Antibiotic resistance rates for *E. coli* between 2020 and 2023 (n=159)

Antibiotics, n (%)	2020	2021	2022	2023	Total	p
Amikacin	0 (0)	0 (0)	3 (5.3)	0 (0)	3 (1.9)	0.140
Amoxicillin-clavulanate	1 (4)	2 (5.6)	12 (21.1)	10 (24.4)	25 (15.7)	0.030
Ampicillin	3 (12)	4 (11.1)	33 (57.9)	21 (51.2)	61 (38.4)	0.001
Gentamicin	0 (0)	0 (0)	5 (8.8)	2 (4.9)	7 (4.4)	0.144
Meropenem	3 (12)	4 (11.1)	2 (3.5)	0 (0)	9 (5.7)	0.077
Ofloxacin	0 (0)	0 (0)	1 (1.8)	0 (0)	1 (0.6)	0.615
Ertapenem	0 (0)	1 (2.8)	0 (0)	0 (0)	1 (0.6)	0.329
Piperacillin-tazobactam	5 (20)	5 (13.9)	6 (10.5)	5 (12.2)	21 (13.2)	0.702
Cefoxitin	6 (24)	9 (25)	9 (15.8)	3 (7.3)	27 (17)	0.152
Ceftriaxone	10 (40)	10 (27.8)	19 (33.3)	15 (36.6)	54 (34)	0.764
Cefuroxime	8 (32)	10 (27.8)	15 (26.3)	17 (41.5)	50 (31.4)	0.418
Ciprofloxacin	6 (24)	6 (16.7)	21 (36.8)	13 (31.7)	46 (28.9)	0.186
Trimethoprim-sulfamethoxazole	4 (16)	2 (5.6)	14 (24.6)	12 (29.3)	32 (20.1)	0.049

E. coli: Escherichia coli

Table 4. Antibiotic resistance rates for *Klebsiella pneumoniae* between 2020 and 2023 (n=49)

Antibiotics, n (%)	2020	2021	2022	2023	Total	p
Amikacin	1 (12.5)	5 (33.3)	7 (33.3)	3 (60)	16 (32.7)	0.364
Amoxicillin-clavulanate	2 (25)	1 (6.7)	8 (38.1)	3 (60)	14 (28.6)	0.074
Ampicillin	4 (50)	3 (20)	15 (71.4)	5 (100)	27 (55.1)	0.003
Gentamicin	0 (0)	0 (0)	5 (23.8)	3 (60)	8 (16.3)	0.006
Meropenem	5 (62.5)	2 (13.3)	5 (23.8)	3 (60)	15 (30.6)	0.038
Ertapenem	1 (12.5)	1 (6.7)	0 (0)	3 (60)	5 (10.2)	0.001
Piperacillin-tazobactam	2 (25)	3 (20)	7 (33.3)	3 (60)	15 (30.6)	0.389
Cefoxitin	3 (37.5)	3 (20)	8 (38.1)	3 (60)	17 (34.7)	0.395
Ceftriaxone	6 (75)	5 (33.3)	11 (52.4)	4 (80)	26 (53.1)	0.148
Cefuroxime	5 (62.5)	3 (20)	11 (52.4)	4 (80)	23 (46.9)	0.055
Ciprofloxacin	4 (50)	3 (20)	9 (42.9)	2 (40)	18 (36.7)	0.428
Trimethoprim-sulfamethoxazole	4 (50)	5 (33.3)	10 (47.6)	3 (60)	22 (44.9)	0.701

their complaints and face social barriers to accessing outpatient clinics. This situation frequently leads to the implementation of empirical antibiotic therapy without urine culture, which can result in antibiotic resistance or treatment failure. Urine culture is therefore requested in the ED for accurate diagnosis and treatment management. In a study conducted in the ED, the rate of urine culture requests for complicated UTIs was reported to be 70.2%, resulting in a treatment change rate of 4.6% [8]. Studies in EDs have reported growth rates in urine cultures of 33.5%, 11.6%, 28.1%, 35%, and 51.2%, respectively [9-13]. This rate was found to be 26.4%. Although the rates of culture requests and positive results may vary across clinics, the positivity rates of cultures were significantly high. These differences can be explained by various factors, such as patient profile, physicians' approaches to laboratory utilization, the functioning of the laboratory, and the hospital's operational system.

The most common pathogen responsible for UTIs is typically *E. coli* International studies have reported that the proportion of *E. coli* in urine cultures ranges from 50% to 85% [2,5,8,14]. In our country, this rate varies between 35% and 80% [1,3,6,7,10,11]. In our study, the frequency of *E. coli* was found to be 61.6%. The second most frequently observed microorganism was *K. pneumoniae* (19%), which is consistent with other data in the literature [7,12,14,15]. In our study, particularly high resistance rates were observed against commonly used antibiotics such as ampicillin, ceftriaxone, ciprofloxacin, and TMP/SMX. Resistance to ampicillin was found to be as high as 38%, which may be a result of the widespread production of beta-lactamases in *E. coli* and *K. pneumoniae* strains [16]. In a study conducted in Türkiye in 2012, the antibiotic with the lowest resistance observed against *E. coli* strains was meropenem (0%), whereas the highest resistance was found with ampicillin-sulbactam (36.8%) [1]. Another study reported that the most resistant

antibiotic for isolated *E. coli* strains was ampicillin (64.7%), with the most sensitive being imipenem/meropenem at a resistance rate of 2.5% [7]. A 2006 study found resistance rates of 64%, 48%, 47.1%, and 40.4% against ampicillin, ciprofloxacin, levofloxacin, and TMP/SMX, respectively [12]. In our study, the most resistant antibiotic for isolated *E. coli* strains was ampicillin (38.4%), whereas the most sensitive antibiotics were ofloxacin and ertapenem, both of which had a resistance rate of 0.6%. Resistance to ciprofloxacin was found to be 28.9%, TMP/SMX resistance was 20.1%, and meropenem resistance was 5.7%. Additionally, between 2020 and 2023, an increase in resistance rates to amoxicillin/clavulanic acid, ampicillin, and TMP/SMX was observed among *E. coli* strains. However, when examining studies from previous years, particularly between 2006 and 2012, it is notable that resistance rates for ampicillin, ciprofloxacin, and TMP/SMX were approximately twice as high. This trend may be attributed to the success of rational antibiotic use practices implemented over the years. In our study, the antibiotic resistance rates of the isolated *K. pneumoniae* strains were consistent with previous research [7,17]. High resistance rates were particularly recorded against commonly used antibiotics such as ampicillin, ceftriaxone, TMP/SMX, and ciprofloxacin. A previous study reported resistance rates of 64.7% for amoxicillin-clavulanate, 58.5% for ciprofloxacin, and 57.2% for ceftriaxone in *K. pneumoniae* strains [7]. In our study, gentamicin (16.3%) and ertapenem (10.2%) were identified as the most sensitive antibiotics. This finding is consistent with other studies that identified aminoglycosides and carbapenems as the most effective agents [7]. However, the annual increase in gentamicin resistance highlights the need for careful use of this antibiotic and emphasizes the importance of considering alternative treatment options. It is crucial for each country to have its own epidemiological data, as it enables physicians to be aware of current antibiotic resistance rates in their regions and to adjust treatments and prophylaxis accordingly. In addition, it should not be overlooked that every empirically initiated treatment must be reviewed based on the antimicrobial susceptibility profile. This strategy plays a significant role in reducing resistance rates and enhancing treatment success.

Study Limitations

The study was retrospective and conducted at a single center. The data obtained only included urine cultures from patients admitted to the ED and did not include those treated in outpatient clinics or other clinical settings. Furthermore, more detailed information regarding the patients' clinical courses, the antibiotics used, and the outcomes of these treatments could not be evaluated within the scope of the study. Additionally, changes in antibiotic resistance rates could not be fully analyzed in relation to hospital policies, trends in antibiotic usage, and variations in patient profiles.

Conclusion

In our study, we found that *E. coli* and *K. pneumoniae* are frequently isolated pathogens that exhibit high resistance rates to commonly used antibiotics. The increase in antibiotic resistance highlights the need for careful consideration in the selection of empirical treatments and underscores the critical role of susceptibility testing in the treatment process. Given that resistance rates can vary over time, it is crucial to regularly monitor antibiotic resistance profiles at each center and update treatment strategies accordingly.

Ethics

Ethics Committee Approval: The local ethics committee approved the study at University of Health Sciences Türkiye Ankara Atatürk Sanatoryum Training and Research Hospital, Scientific studies Ethics Committee (approval number: 2024-BÇEK/125, date: 31.07.2024).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

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

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REVIEW

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Effectiveness of Tabletop Exercise Training in Triage for Medical Personnel: A Systematic Review

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Abstract

Mass casualty incidents require a rapid and coordinated response from medical personnel, where triage is a critical skill. Tabletop exercise training has emerged as an innovative method to enhance triage skills by providing a safe, risk-free environment for scenario-based practice. This systematic review aims to evaluate the effectiveness of tabletop exercise training in improving triage skills among medical personnel. A comprehensive literature search was conducted in March 2024 across the following databases: ScienceDirect, PubMed, Wiley Online Library, and Cochrane. The search strategy included combinations of the following terms:

- "Tabletop exercise" AND "triage"
- "Tabletop simulation" AND "emergency preparedness"
- "Triage training" OR "disaster drill"
- "Medical personnel" AND and "simulation-based learning"

Boolean operators and or were used to refine the search results. Inclusion criteria covered studies published between 2014 and 2024 involving medical personnel trained in triage. The primary outcomes measured included improvements in triage accuracy, response time, decision-making, and teamwork. Out of 178 articles identified, 10 studies met the inclusion criteria. Findings indicate that tabletop exercises (TTX) significantly improve triage accuracy, reduce response times, and foster better teamwork and communication among healthcare providers. TTX are an effective training method for enhancing triage skills in medical personnel and should be integrated into regular training programs to improve preparedness for real-world emergencies.

Keywords: Tabletop exercise, triage training, medical personnel, systematic review, emergency preparedness

Introduction

Mass casualty incidents (MCIs), such as major accidents, terrorist attacks, or natural disasters, can result in a high number of casualties, necessitating a rapid and coordinated response from medical personnel. Triage, the process of classifying patients based on the severity of their injuries and their need for care, is one of the most crucial skills in emergency situations [1]. Without adequate triage skills, medical personnel risk making decisions that could have fatal consequences for both patients and the healthcare system as a whole. Therefore, effective training in triage is essential to ensure that medical personnel can provide appropriate and efficient care in stressful environments [2].

Tabletop exercise training has emerged as an innovative and effective method for improving triage skills. These exercises allow participants to engage in realistic simulation scenarios,

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where they can develop strategies, collaborate with teams, and refine their decision-making skills without real risk [3]. Research indicates that tabletop exercises (TTX) not only enhance triage knowledge and skills but also strengthen teamwork and communication among medical personnel. By employing a simulation-based approach, TTX can better prepare medical personnel for complex and dynamic emergency situations [4].

This systematic review aims to evaluate the effectiveness of TTX in triage training for medical personnel by collecting and analyzing data from relevant studies. By assessing the results of various studies, we hope to gain a deeper understanding of the impact of TTX on improving triage skills, response time, and accuracy in patient management. The findings of this review are expected to provide valuable insights for the development of more effective triage training programs, ultimately enhancing the preparedness and response of medical personnel in dealing with mass disaster incidents in the future.

Materials and Methods

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The study population includes medical personnel who participated in triage training using TTX. The effectiveness of tabletop exercise training in improving triage skills was examined, with comparisons made to other triage training approaches. The primary outcomes measured include improvements in triage skills, decision-making accuracy, response times, and teamwork among medical personnel. A comprehensive literature search was conducted in March 2024 across four major databases: ScienceDirect, PubMed, Wiley Library Online, and Cochrane. The search used a combination of keywords, including “tabletop exercise”, “triage training”, “medical personnel”, and “effectiveness”. Boolean operators such as “AND”, “OR”, and “NOT” were applied to refine search results and maximize relevant article retrieval. Inclusion and exclusion criteria were defined using the framework patient/population, concept, and context. Inclusion criteria required studies involving medical personnel undergoing tabletop exercise-based triage training, published between 2014 and 2024, in English, and classified as research articles. Exclusion criteria included: studies not using TTX, articles published more than 10 years ago, non-English publications, and non-research materials (e.g., books, videos, conference proceedings). The initial search yielded 178 articles. After removing duplicates (76 articles), the remaining 102 articles were screened by title and abstract, resulting in 34 articles (Figure 1).

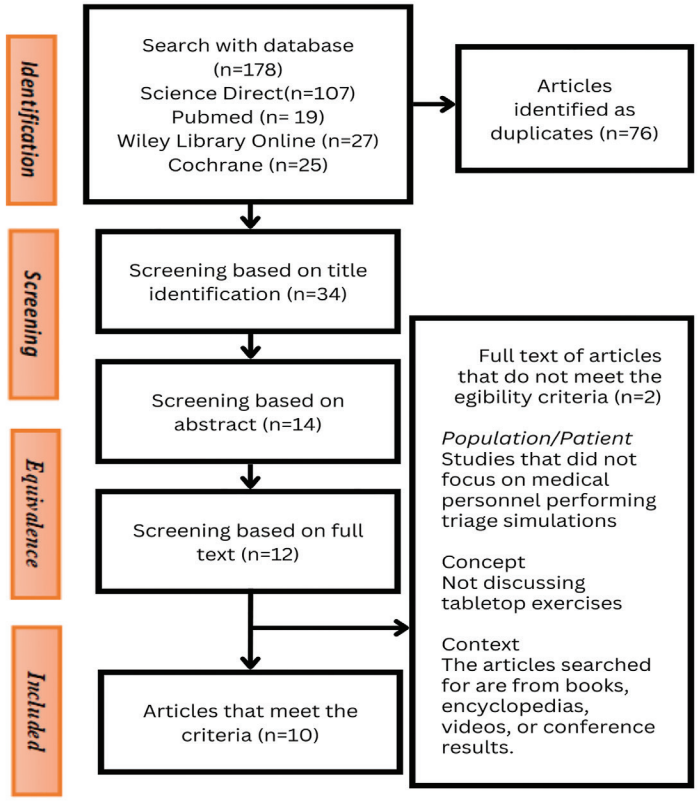

Figure 1. Flowchart of systematic review with process using PRISMA statistical analysis

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Data extracted from the included studies were synthesized and analyzed in a descriptive manner. A narrative synthesis approach was used to summarize improvements in triage accuracy, response times, decision-making, and teamwork. When applicable, percentage improvements and confidence intervals were reported. The quality of included studies was assessed using the Joanna Briggs Institute (JBI) critical appraisal tool. Statistical pooling or meta-analysis was not performed due to heterogeneity in study designs, interventions, and outcome measures. Full-text reviews narrowed the selection to 10 eligible studies that met all inclusion criteria. The PRISMA flowchart outlines this selection process; article eligibility was assessed based on study design, sample size, intervention details, and outcome measures (Table 1).

Results

Data extraction was performed using a standardized form to collect information on study characteristics (author, year, location, sample size, and design), intervention details, key findings, and conclusions. The results were synthesized to provide a comprehensive evaluation of the impact of TTX on triage training outcomes, highlighting both qualitative and quantitative evidence from the selected studies (Table 2).

Triage is a fundamental component of emergency response, particularly in MCIs where patient needs must be rapidly prioritized. Effective triage can significantly impact patient outcomes, reducing mortality rates and optimizing resource allocation. Research over the past decade has demonstrated that training methods directly influence the accuracy and speed of triage decision-making, with TTX emerging as a highly effective approach to skill development.

TTX provide a safe, controlled environment where medical personnel can simulate emergency scenarios without real-world consequences. Studies show that this training method enhances decision-making skills, improves knowledge retention, and boosts confidence in triage situations. For example, a 2021 study by Sena et al. [5] found that TTX improved both response times and triage accuracy among emergency medicine residents, with participants reporting greater preparedness for real-life emergencies.

Research indicates that TTX enhance cognitive processing under pressure, allowing participants to practice prioritizing patients based on injury severity. A study revealed a 20% improvement in triage accuracy after just one hour of tabletop training. Furthermore, these exercises reinforce the simple triage and rapid treatment and sort, assess, lifesaving interventions, treatment/transport methodologies, ensuring participants can swiftly apply evidence-based practices (Table 3).

Effective triage is a team effort, requiring clear communication and collaboration among healthcare providers. Several studies emphasize the role of TTX in fostering teamwork. The study demonstrated that healthcare teams participating in collaborative TTX showed improved coordination, with reduced errors during triage simulations. While immediate post-training improvements are well-documented, research also suggests long-term benefits. Medical students who participated in TTX retained triage knowledge and skills six months post-training. However, ongoing refresher exercises may be necessary to maintain competency over time.

The quality appraisal of the included studies was conducted using the JBI checklist, which comprises nine critical appraisal questions addressing the methodological soundness of the research. These include clarity of objectives, appropriateness of inclusion criteria, methodological validity, study design adequacy, data collection methods, rigor in data analysis, ethical consideration, and alignment between results and conclusions.

As summarized in Table 4, all ten studies included in this review demonstrated high methodological quality, with total scores ranging from 8/9 to 9/9. Three studies—Nabi et al. [6], Sena et al. [5], and Lee and Franc. [7]—achieved a perfect score (9/9), indicating exceptional rigor. Most studies showed strong alignment in research objectives, methodology, and results, although a few lacked explicit ethical statements or coherence in their conclusions.

This uniform quality across studies supports the credibility of findings and strengthens the evidence for recommending TTX in improving triage accuracy, response efficiency, and interprofessional collaboration in emergency settings.

Table 1. Population, concept, context of article effectiveness of tabletop exercise training in triage for medical personnel: a systematic review

Patient/population	Medical officer conducting triage training	Medical personnel who do not undergo training and do not use tabletop exercises
Concept	Tabletop exercises	Does not explain tabletop exercise
Context	1. Triage Training 2. Research publications less than the last 10 years (2014-2024) 3. Publication using English language 4. The article type is a research article	The articles searched for are from books, encyclopedias, videos, or conference results.

Discussion

The findings from this systematic review highlight the significant impact of TTX on improving triage skills, response times, and teamwork among medical personnel [8]. However, while the benefits are clear, several factors must be considered to ensure the long-term effectiveness of this training method [9].

Triage Skills Enhancement: Long-Term Retention and Sustainability

TTX has been shown to improve triage accuracy and decision-making under pressure. Participants consistently demonstrated better patient prioritization and faster classification during simulated MCIs [10]. However, some studies suggest that these skills may degrade over time without regular refresher training [7]. To address this, incorporating periodic TTX sessions into ongoing education programs could help sustain these improvements [11].

Balancing Speed and Accuracy in Triage

One of the standout benefits of TTX is its ability to accelerate response times. In emergency situations, faster triage can save lives- but speed should not come at the cost of accuracy [12]. Some studies reported that instances where participants, focusing on rapid assessment, made more frequent errors in patient classification [13]. This highlights the need for exercises that emphasize both speed and precision, along with strategies for mitigating cognitive overload [5].

Teamwork and Communication: The Double-Edged Sword

TTX strengthens teamwork by promoting communication and collaboration in a low-stakes environment [6]. Better coordination leads to more efficient triage and patient management [14]. However, poor team dynamics or conflicts, even during training, can hinder learning outcomes. Addressing this, requires structured debriefing sessions, where teams reflect on their performance and work through interpersonal challenges [15].

Accessibility and Resource Limitations

While TTX is a cost-effective training option, access to this method may still be limited in certain healthcare settings, especially in resource-constrained regions [16]. Some facilities might lack trained facilitators or appropriate materials to run the exercises effectively [17]. Policymakers and healthcare institutions should explore ways to standardize and distribute TTX materials, possibly through digital platforms, to bridge this gap [18].

Training Policy and Institutional Support

The review also suggests that integrating TTX into institutional training policies can enhance disaster preparedness at a systemic level [19]. However, policy changes can face resistance from stakeholders due to logistical challenges, staffing constraints, or financial limitations [20]. Demonstrating the long-term benefits of TTX, including potential cost savings from better disaster management, could help garner support for widespread implementation [21].

Table 2. Resume article effectiveness of tabletop exercise training in triage for medical personnel: a systematic review

Author	Country	Time	Place	Design	Retrieval data
Aslan et al. [3] 2021	Türkiye	2021	Gümüşhane province	Observational study	Survey and questionnaire
Chiang et al. [17] 2020	Taiwan	2020	Military hospital	Cross-sectional design	Pre-post test and observation
Castro Delgado et al. [9] 2023	Spain	2023	Oviedo University	Pre-post test design	Survey and test results
Davis et al. [22]	USA	2016-2017	Gulf-Coast region	Quantitative pre-post test design	Evaluation form
Farhadloo et al. [8] 2018	Iran	2018	Qom	Semi-experimental study	Test and simulation outcomes
Nabi et al. [6] 2022	Iran	2022	Isfahan province	Prospective pre-post intervention	Performance assessment
Sena et al. [5] 2021	USA	2021	New York	Pre-post test design	Likert Scale Questionnaire
Sultan et al. [4] 2023	Saudi Arabia	2023	Various healthcare facilities	Mixed-method (observation & interview)	CSCATTT instrument results
Khan [19] 2018	Qatar	2018	Hamad General Hospital	Randomized control trial	Accuracy and time-to-triage data
Lee and Franc [7] 2015	Canada	2015	University of Alberta, Royal Alexandra Hospital	Prospective observational cohort	Computer-based simulation

CSCATTT: Cardiac surgery competency assessment tool for the theatre team

Conclusion

The findings of this review show that TTX can significantly enhance triage skills, reduce response times, and improve accuracy in MCIs. Integrating TTX into clinical practice can better prepare medical personnel for real-world emergencies, minimizing triage errors and optimizing resource allocation during crises. Regularly incorporating TTX into training programs, facilitating post-exercise team debriefings, and leveraging digital platforms for wider access can sustain skill development and preparedness. On a policy level, adopting TTX as a mandatory component of emergency training, with national guidelines on training frequency, facilitator qualifications, and evaluation metrics, could standardize

Table 3. Characteristics of subjects in 10 articles included in the systematic review

Author	Sample	Age range	Men	Woman	Improved knowledge/skills (%)
Aslan et al. [3]	140 PH-staff (EMTs, paramedics)	22-50 years	70	70	75%
Chiang et al. [17]	161 nurses	25-55 years	40	121	80%
Castro Delgado et al. [9]	135 medical students	21-25 years	60	75	85%
Davis et al. [22] 2020	391 nursing students	20-30 years	100	291	78%
Farhadloo et al. [8]	70 nursing students	18-30 years	35	35	88%
Nabi et al. [6]	70 emergency personnel	25-45 years	45	25	82%
Sena et al. [5]	18 emergency medicine residents	26-35 years	12	6	90%
Sultan et al. [4]	100 healthcare workers	23-50 years	55	45	87%
Khan [19]	106 ED staff (doctors, nurses)	24-55 years	52	54	90%
Lee and Franc [7]	108 physicians and nurses	28-60 years	60	48	70%

Table 4. Quality assessment of included articles (Joanna Briggs Institute)

No	Author(s), Year	Clarity of objectives	Inclusion criteria	Validity of method	Study design	Data collection	Analysis	Ethics	Conclusion alignment	Total score	Quality category
1	Aslan et al. [3] 2021	✔	✔	✔	✔	✔	✔	✗	✔	8/9	Good quality
2	Chiang et al. [17] 2020	✔	✔	✔	✔	✔	✔	✗	✔	8/9	Good quality
3	Castro Delgado et al. [9] 2023	✔	✔	✔	✔	✔	✔	✔	✔	9/9	Good quality
4	Davis et al. [22] 2020	✔	✔	✔	✔	✔	✔	✗	✔	8/9	Good quality
5	Farhadloo et al. [8] 2018	✔	✔	✔	✔	✔	✔	✗	✔	8/9	Good quality
6	Nabi et al. [6] 2022	✔	✔	✔	✔	✔	✔	✔	✔	9/9	Good quality
7	Sena et al. [5] 2021	✔	✔	✔	✔	✔	✔	✔	✔	9/9	Good quality
8	Sultan et al. [4] 2023	✔	✔	✔	✔	✔	✔	✔	✗	8/9	Good quality
9	Khan [19] 2018	✔	✔	✔	✔	✔	✔	✔	✗	8/9	Good quality
10	Lee and Franc [7] 2015	✔	✔	✔	✔	✔	✔	✔	✔	9/9	Good quality

and strengthen disaster readiness. Despite strong evidence supporting TTX, gaps remain in understanding long-term skill retention, emphasizing the need for longitudinal studies to assess how well triage competency is maintained over time. Future research should explore comparisons between TTX and other training methods, investigate cost-effectiveness, and develop hybrid models that combine TTX with hands-on simulations for more immersive learning. Additionally, studying psychological factors like stress management and cognitive resilience could further refine training approaches, ensuring medical personnel are not only technically skilled but also mentally prepared to make critical decisions in high-pressure situations.

Footnotes

Authorship Contributions

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

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

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REVIEW

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The Stabilization Protocol: A Mini Review on Evidence-based Traumatic Stabilization

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Abstract

Standard spinal immobilization traditionally involving a spinal board and cervical collar, has long been the prehospital standard of care for trauma patients. However, recent studies highlight potential adverse effects, including pain and respiratory impairment. A narrative mini-review was conducted using Medline, Web of Science, Scopus, and Google Scholar. Nine articles published in the last five years were selected, comprising observational studies, literature reviews, and expert consensus documents. The S.T.A.B.I.L.E. protocol emerged as a structured, evidence-based decision-making model for prehospital spinal management. Integrated within the Airway, Breathing, Circulation, Disability, Exposure framework, it supports emergency medical services personnel in assessing whether to apply and, if so, how to apply spinal motion restriction, considering clinical and logistical variables. Compared to traditional protocols such as NEXUS and the Canadian C-Spine Rule, S.T.A.B.I.L.E. emphasizes a broader clinical context-such as respiratory status, hemodynamic stability, and environmental conditions-providing a more pragmatic and patient-centered approach. The protocol may enhance patient safety, reduce unnecessary immobilization, and support clinical decision-making. While the S.T.A.B.I.L.E. protocol represents a promising alternative to traditional immobilization practices, further clinical validation is needed to confirm its efficacy and facilitate its adoption in prehospital trauma care.

Keywords: Trauma, emergency medical services, spinal cord, immobilization, spinal motion restriction

Introduction

For a long time, conventional spinal immobilization (SI), which includes the use of a spinal board and cervical collar, has been considered the standard procedure for protecting traumatized patients in the pre-hospital environment. However, recent investigations have questioned the efficacy and safety of this approach, highlighting potential risks and complications associated with it [1]. In particular, prolonged use of the spinal board can induce pain, pressure sores, and respiratory difficulties [2]. As a result, the need has arisen to develop alternative evidence-based strategies for managing trauma patients.

SI in the pre-hospital setting has represented a standardized practice since the 1960s [2,3]. Its application is determined during the scene and patient assessment, particularly in the presence of suspected head or spinal trauma, altered mental status, or neurological deficits [2,4]. The goal of SI is to prevent or minimize secondary spinal cord injury caused by potential spinal column injuries.

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The SI technique involves the use of a spinal board, cervical collar, head fixation devices, and strapping systems. The spinal board serves both as an immobilization device and a support for patient transport. The material of this device must be shock-resistant and easily sanitizable [4]. The strapping system ensures the patient is secured to the board, while the cervical collar prevents flexion, extension, or rotation of the neck. Head fixation devices are used to limit rotational movements of the head. Overall, the system should not obstruct the performance of cardiopulmonary resuscitation maneuvers and must allow for the implementation of advanced rescue procedures.

Despite the widespread use of the spinal board in SI, its actual effectiveness remains largely unproven. In recent years, doubts have arisen regarding the utility of this practice due to the increasing number of adverse effects associated with it [2,3].

An emerging alternative technique is spinal motion restriction (SMR) [5]. This technique involves maintaining the patient's body alignment on the ambulance stretcher using a cervical collar and securing straps. In this context, at the trauma scene, the spinal board is used solely as a tool for extrication and transfer of the patient, to be removed from the ambulance stretcher or as soon as possible [6].

To assist professionals in applying the most effective and safe protocol, decision-support tools such as the NEXUS and the Canadian C-Spine Rule have been developed. These tools, initially used to determine the need for diagnostic investigations, are now essential for operational decisions in emergency care.

Häske [7] developed a "traffic light" system to assist emergency medical services (EMS) in selecting patients for immobilization. This method provides immediate visual guidance to assess the risk level and the need for SI, optimizing resource management and patient safety.

The objective of this article is to conduct a mini-review on the topic and then present the S.T.A.B.I.L.E. protocol, a decision-making strategy aimed at guiding EMS personnel in managing trauma patients. It evaluates the effectiveness of spinal board techniques compared to alternative methods, mainly SMR, and explores the main limitations of its use.

Ethical Considerations

This study did not require approval from an ethics committee as it is a proposal of a clinical decision-making protocol based on a narrative literature review. The S.T.A.B.I.L.E. protocol has not yet been applied or tested in clinical practice.

This study did not undergo ethical committee review as it is a proposal for a clinical decision-making protocol, based on secondary data and literature analysis. The S.T.A.B.I.L.E. protocol has not yet been applied or tested in clinical practice.

Methodology

A mini-review was conducted using the Medline, Web of Science, Science Direct, and Google Scholar databases between February and March 2024. Keywords included: out-of-hospital, EMS, trauma, spinal cord, SI, SMR, pain, and radiological tests, combined using Boolean operators.

Inclusion Criteria: Peer-reviewed articles published in English or Italian in the last five years, focusing on pre-hospital SI strategies. **Exclusion Criteria:** studies not involving EMS contexts, pediatric-specific research, and opinion pieces lacking scientific backing. Various study types were considered, including observational research, systematic reviews, and narrative reviews (Table 1). The selection process involved title/abstract screening and full-text analysis. No formal risk of bias assessment was conducted. Ethical approval was not required, as this study did not involve human participants or primary data collection.

This narrative literature analysis was carried out to explore the scientific evidence related to the assessment and treatment of trauma patients in the pre-hospital setting. The primary goal was to identify key parameters for an accurate evaluation and develop a standardized protocol to guide clinical decisions. From this analysis, the S.T.A.B.I.L.E. protocol emerged.

Table 1. Summary of reviewed studies

Study	Design	Main findings	Limitations
Sundstrøm et al. [2] (2014)	Critical review	Limited evidence for collar use in trauma	Non-systematic
Hauswald et al. [3] (1998)	Observational study	No neurological benefit from immobilization	Small sample
Kwan and Bunn [4] (2005)	Systematic review	Risks may outweigh benefits in some cases	Inconsistent quality of studies
Dixon et al. [5] (2014)	Biomechanical study	Spinal boards increase biomechanical stress	Simulated setting
Connor et al. [6] (2013)	Consensus statement	Initial agreement on reduced immobilization	Expert opinion
Häske et al. [7] (2022)	Descriptive model	Traffic light system aids EMS decisions	Lacks validation
Walters et al. [8] (2013)	Guidelines	Supports targeted cervical immobilization	Broad scope
Haut et al. [9] (2010)	Retrospective study	Spinal immobilization may harm in penetrating trauma	Limited generalizability
Righi et al. [1] (2024)	Narrative review	Emerging model S.T.A.B.I.L.E. could be safer	Conceptual only

EMS: Emergency medical services

The S.T.A.B.I.L.E. protocol (Figure 1) integrates with the systematic Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach used in the primary assessment of trauma patients. After an initial quick look, to determine the most appropriate operational strategy, "Scoop and Run" or "Stay and Play", it would be advisable to sequentially apply the stages of the S.T.A.B.I.L.E. protocol.

A PRISMA flow diagram (Figure 2), summarizing article selection is recommended for future iterations to enhance transparency.

This step-by-step approach allows for the identification of specific conditions that may influence the decision to proceed with SI, ensuring a complete and accurate assessment of the patient.

Description of The S.T.A.B.I.L.E. Protocol

The S.T.A.B.I.L.E. protocol involves a detailed assessment through the following phases, aligned with the ABCDE sequence:

A) Airway-Airway Management: Cervical immobilization is not recommended when the airway is compromised or at risk, as it could hinder life-saving interventions needed to ensure airway patency [2].

B) Breathing-Respiration: In cases of thoracic trauma, such as pneumothorax or rib fractures, or severe respiratory failure, SI may exacerbate respiratory compromise and is therefore discouraged [4].

C) Circulation-Circulation: Conditions such as cardiac arrest, traumatic brain injury with increased intracranial pressure, or signs of hypotension (mean arterial pressure <70 mmHg) represent contraindications to SI, as it could interfere with resuscitation efforts or worsen hemodynamic instability [5].

D) Disability-Disability/Neurological Status: SI is recommended for unconscious patients [Glasgow Coma Scale (GCS) <8] or those with evident neurological deficits resulting from trauma. Conversely, in conscious patients (GCS >8) without neurological deficits, immobilization should be avoided, and the patient should be instructed to limit movement, unless other specific indications exist [6].

E) Exposure-Exposure and Other Factors: SI is discouraged in patients with a body mass index greater than 25, due to the increased risk of skin injuries, in cases where transportation is expected to exceed 30 minutes, due to the heightened risk of pain and complications associated with prolonged immobilization, and when the body temperature exceeds 37 °C, due to the risk of

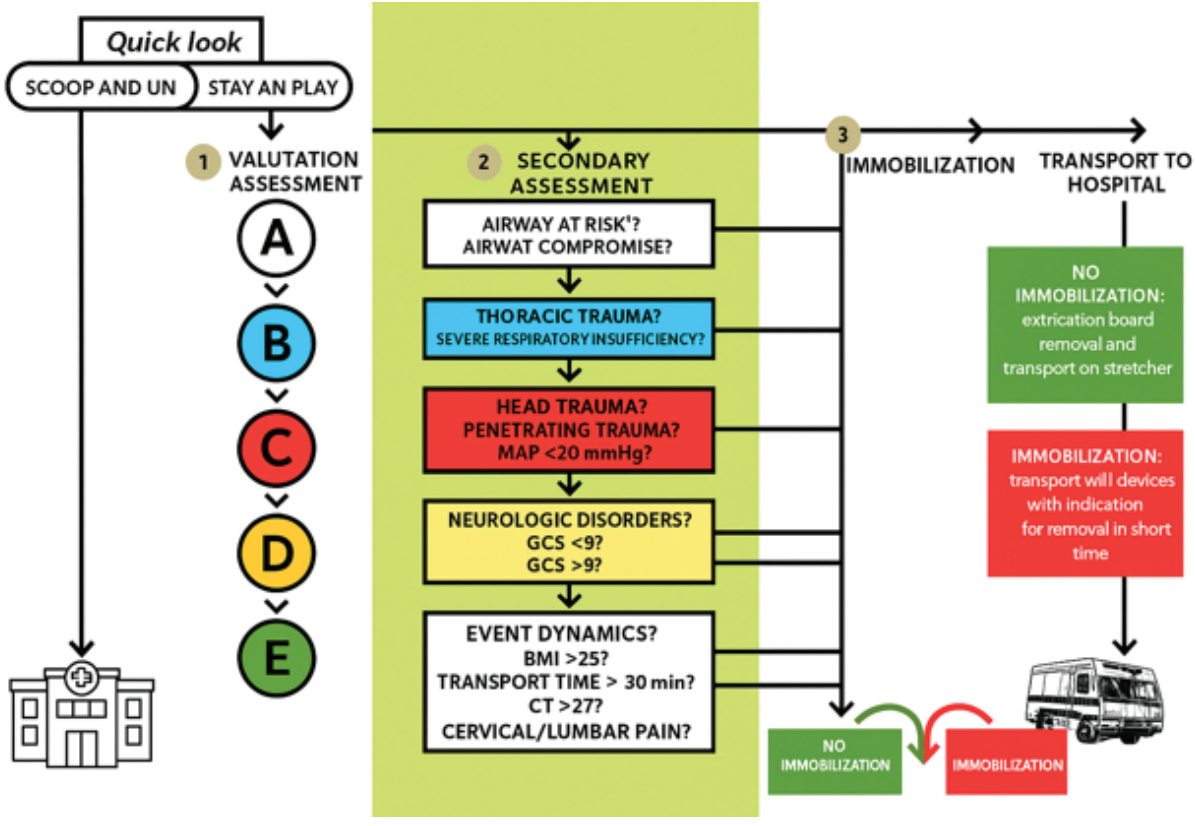

Figure 1. The S.T.A.B.I.L.E. protocol-evidence-based traumatic

GCS: Glasgow Coma Scale, BMI: Body mass index, CT: Computed tomograhphy

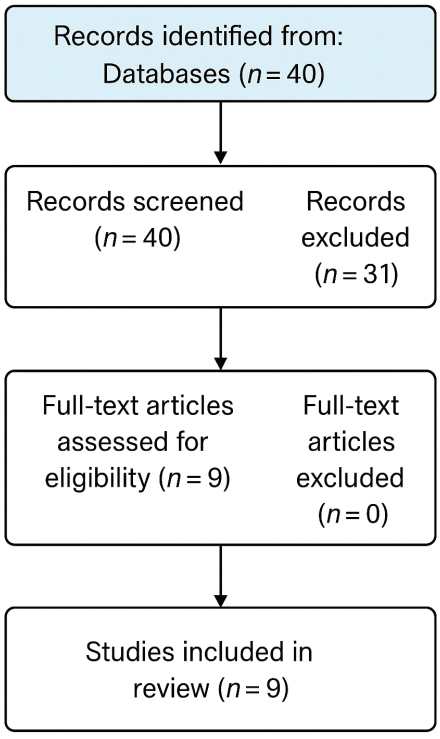

Figure 2. PRISMA flow diagram

exacerbating thermal stress. However, immobilization becomes necessary in the presence of cervical or lumbar pain upon the arrival of rescue teams or in cases of high-energy trauma events [7].

Transfer and Transport Methods

After determining the need for SI or not, the following steps are taken:

• **Absence of Complete Immobilization:** If complete immobilization is not deemed necessary, the spinal board can be used to transfer the patient onto the stretcher and then removed. Transport to the emergency department is preferably conducted using a vacuum mattress or the standard stretcher mattress, ensuring greater comfort and reducing the risk of complications [8].

• **Presence of Complete Immobilization:** If complete SI has been performed (including the spinal board, cervical collar, fixation systems such as the "spider", and head blocks), the spinal board may be maintained during transport. However, it is essential to remove it as soon as possible upon arrival at the ED, after ruling out any spinal injuries, to prevent complications associated with prolonged immobilization [9].

This review highlights the evolution of prehospital SI strategies and the emergence of more tailored approaches such as S.T.A.B.I.L.E. Unlike prior protocols (e.g., NEXUS, Canadian C-Spine Rule), which focus primarily on ruling out cervical spine injury, S.T.A.B.I.L.E. integrates clinical, physiological, and operational considerations into a comprehensive framework. By addressing the limitations of traditional immobilization-particularly in cases with altered airway, respiratory distress, or prolonged transport-the protocol offers a nuanced guide aligned with the realities of emergency care.

Discussion

The S.T.A.B.I.L.E. protocol presents a structured, decision-oriented model that complements existing literature on SI. Compared to previous reviews focused on the NEXUS criteria or the Canadian C-Spine Rule, S.T.A.B.I.L.E. adds value by aligning immobilization decisions with the ABCDE trauma assessment framework, ensuring a more integrated clinical response. While NEXUS and Canadian rules focus on ruling out cervical spine injury through clinical signs, S.T.A.B.I.L.E. emphasizes operational practicality in prehospital settings. Furthermore, protocols like the Immo Traffic Light System provide color-coded guidance but do not account for patient-specific physiological conditions as clearly as S.T.A.B.I.L.E. does. The integration of hemodynamic parameters, thermal status, transport duration, and body habitus makes S.T.A.B.I.L.E. a more holistic tool in complex trauma care. However, its clinical utility remains to be validated through prospective trials. Comparison with established systems highlights its promise, but also underlines the need for harmonization with global trauma guidelines. Limitations of this review include its narrative nature, potential selection bias, and lack of a formal quality assessment of included studies.

…of this protocol and significantly improve trauma patient outcomes.

Conclusion

In conclusion, emerging scientific literature highlights the S.T.A.B.I.L.E. protocol as a potentially promising, evidence-based approach for the optimal management of trauma patients in pre-hospital settings. It's clear and systematic decision-making sequence could offer advantages over standard immobilization, contributing to the overall safety of the patient.

However, it is crucial to recognize that although the theoretical evidence is encouraging, the practical application of the S.T.A.B.I.L.E. protocol requires careful consideration. Its implementation should be guided by standardized clinical protocols and supported by adequate training for healthcare personnel involved in pre-hospital emergency care.

Further research and clinical studies are encouraged to more thoroughly evaluate the effectiveness, feasibility, and safety of the S.T.A.B.I.L.E. protocol in real-world contexts, as well as to

identify and address any barriers to its implementation. Only through an integrated approach, combining scientific evidence with prudent clinical practice and experience-based decision-making, will it be possible to fully harness the potential.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.V.R., S.R., H.G., Concept: M.R., L.R., Design: C.R.I., L.R., Data Collection or Processing: M.V.R., S.R., H.G., L.R., Analysis or Interpretation: M.V.R., S.R., H.G., M.R., L.R., Literature Search: M.V.R., S.R., H.G., L.R., Writing: M.V.R., S.R., H.G., C.R.I., L.R.

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