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THE DECISIVE ROLE OF SHOCK INDEX IN FLUID THERAPY IN HEMORRHAGIC TRAUMA CASES IN EMS: A RETROSPECTIVE STUDY

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ABSTRACT

Objective: The study aimed to evaluate the determining role of the shock index (SI) in initiating fluid therapy in trauma patients with active bleeding in out-of-hospital emergency care.

Material and Methods: Trauma patients aged 18 years and older with active bleeding who were brought to the emergency department of a university hospital between 01.07.2010 and 01.07.2020 were scanned. A total of 3367 patients' files were scanned, and 587 of them who met the inclusion criteria were included in the study. The patients' shock indexes (SI) were calculated based on the first measured vital signs in the EMS ambulance. The SPSS was used for statistical analysis. The chi-square test was used to determine the relationship between the independent and dependent variables. The results were evaluated at a confidence interval of 95%, and p <0,05 was accepted as statistically significant.

Results: It was found that >500 mL IV crystalloid fluid was administered to 76,7% of the patients at out-of-hospital, 66,4% (n=390) had hemorrhagic shock according to the out-of-hospital SI, 60,3% had a systolic blood pressure of >90 mmHg at the first measurement. Out-of-hospital SI averages of those who died in the hospital were higher than those who were discharged. It was found that among the patients who did not have shock according to the SI, those who received out-of-hospital IV fluids had a higher hospital death rate.

Conclusion: SI can be used as a tool for out-of-hospital trauma patient identification and mortality assessment. SI can be used as a predictive tool in determining the need for out-of-hospital fluid therapy.

Keywords: Prehospital Emergency Health Services, Trauma, Shock Index, IV Fluid Therapy

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EMS'DE HEMORAJİK TRAVMA OLGULARINDA ŞOK İNDEXİNİN SIVI TEDAVİSİNDE BELİRLEYİCİ ROLÜ: RETROSPEKTİF BİR ÇALIŞMA

ÖZ

Amaç: Çalışmanın amacı, hastane öncesi acil bakımda aktif kanaması olan travma hastalarına sıvı tedavisi başlamada, şok indeksinin (SI) belirleyici rolünün değerlendirilmesidir.

Gereç ve Yöntemler: Bir üniversite hastanesi acil servisine 01.07.2010-01.07.2020 tarihleri arasında, acil yardım ambulansları ile getirilen 18 yaş ve üzeri, aktif kanaması olan travma hastaları taranmıştır. Toplam 3367 hasta dosyası taranmış, araştırmaya alınma kriterlerine uyan 587 hasta çalışmaya dahil edilmiştir. Hastaların şok indeksleri (SI) EMS ambulansında ilk ölçülen vital bulguları esas alınarak hesaplanmıştır. Bağımsız ve bağımlı değişkenler arasındaki ilişkinin belirlenmesinde ki-kare testi kullanılmıştır. Sonuçlar %95 güven aralığında değerlendirilmiştir ve $p<0.05$ istatistiksel olarak anlamlı kabul edilmiştir.

Bulgular: Hastaların, %76.7'sine hastane öncesinde >500 mL IV kristaloid sıvı uygulandığı, %66.4'ünde hastane öncesi SI'a göre hemorajik şok olduğu, %60.3'ünün ilk ölçülen sistolik kan basıncının>90 mmHg olduğu bulunmuştur. Hastanede ex olanların hastane öncesi SI ortalamaları taburcu olanlarınkinden daha yüksektir. SI'a göre şok olmayan hastalardan hastane öncesi IV sıvı uygulananlarda, hastanede ex olma durumunun daha yüksek olduğu bulunmuştur.

Sonuç: SI hastane öncesi travmalı hastanın tanımlanmasında ve mortalite değerlendirmesinde bir araç olarak kullanılabilir. Hastane öncesi sıvı tedavisi ihtiyacının belirlenmesinde SI belirleyici bir araç olarak kullanılabilir.

Anahtar Kelimeler: Hastane Öncesi Acil Sağlık Hizmetleri, Travma, Şok İndeksi, IV Sıvı Tedavisi

INTRODUCTION

Although trauma is one of the most important social health problems worldwide, it constitutes approximately 10% of the total patient burden (Ramesh et al., 2019). Pfeifer et al., (2019) examined 19 studies in their systematic literature review study and found rates ranging from 14.6% to 47.6% regarding the mortality rate of patients with out-of-hospital trauma (Pfeifer et al., 2019). This makes the traumatized patient more important in EMS and encourages new recommendations and studies to reduce mortality (Bores et al., 2018). To reduce mortality, it is important to perform effective triage in EMS, identify trauma severity, and decide on treatment options quickly. One of the important tools that can be used for rapid evaluation of the patient is stated as SI. SI is a tool used in EMS and emergency care to determine the severity of trauma and detect shock (Montoya et al., 2015). While the standard SI, which is found by dividing the heart rate per minute by the systolic blood pressure, is kept up to date, there are also modified

shock indices determined by considering the trauma mechanism and developing complications (Kim et al., 2021).

Hemorrhage in trauma cases in EMS is one of the most important issues for emergency care, and bleeding is responsible for approximately 40% of trauma-related deaths that occur within 24 hours (Chen et al., 2020; Kauvar et al., 2006; Neeki et al., 2018). Fluid resuscitation in trauma patients with active bleeding has been one of the important topics in the literature for many years, and it is widely accepted to wait until the limit of hypotension (90 mmHg for out-of-hospital) to start fluid therapy today (Kudo et al., 2017). The relationship between starting fluid therapy at the right time and mortality in trauma cases in EMS necessitates a more careful evaluation of additional tools that can assist the EMS staff in making a decision. From these perspectives, it is an important question whether the SI, which is extremely easy to calculate and has been known for years, can be used effectively in deciding to initiate fluid resuscitation in EMS patients with trauma.

The aim is to evaluate if the SI may play the decisive role for fluid therapy of trauma cases with active bleeding in EMS. With the known effect of fluid therapy on mortality in trauma patients, the study is considered important to be able to develop new recommendations in EMS, where the trauma-related mortality rate is very high.

The question of this research is;

what is the relationship between initiating IV fluid therapy in traumatic shock patients, and death?

1. MATERIAL AND METHOD

Trauma patients aged 18 years and older with active bleeding who were brought to the emergency department of a university hospital by ambulances between 01.07.2010 and 01.07.2020 and registered in the Electronic Document Management System were scanned. Variables which used in our study were age, gender, vital signs, trauma mechanism, initiation of IV fluid therapy before the hospital. A total of 3,367 patient files were evaluated , and 587 patients of them who met the inclusion criteria were included in the study. Patients were divided into 2 groups as those who received more than 500 cc of fluid at out-of-hospital period and those who received less than 500 cc of fluid. We accepted that the patients who were started on fluids were prediagnosed as shock.Patients under the age of 18 with minor trauma and without active bleeding were excluded from the study. The SI calculations of the patients were based on

the first measured vital signs in the EMS ambulance (SI = Heart Rate (heart rate/minute)/Systolic Blood Pressure (mmHg).

SI is the ratio of heart rate to systolic blood pressure, which may be easily calculated in the field (Pandit et al., 2014). Dividing heart rate by systolic blood pressure (SBP) is suggested as a marker that can be used to predict the severity of hypovolemic shock (Liu et al., 2012). It is a physiological value that can guide EMS and emergency care to determine the severity of trauma and also detect early hemorrhagic shock (Montoya et al., 2015). The normal SI values in adults are between 0.5 and 0.7. A SI $\geq$ 0.9 indicates higher priority in triage and is consistent with higher hospitalization rates. SI $\geq$ 1.0 is associated with significantly worse outcomes in patients with acute circulatory failure (Berger et al., 2013). It is stated that SI is a better predictor than systolic blood pressure in patients with hemorrhage (Birkhahn et al., 2005).

Statistical Analysis

The SPSS (IBM SPSS Statistics version 22.0; SPSS Inc., Chicago, IL) was used for statistical analysis. In the analysis of data, the descriptive information about the patients included in the study was given as numbers, percentages, distribution, and mean values. The chi-square test was used to determine the relationship between the independent and dependent variables. The results were evaluated at a confidence interval of 95%, and $p < 0.05$ was accepted as statistically significant.

Ethical considerations

This study was conducted in adherence to the Declaration of Helsinki. Ethics committee approval for the study was obtained from the Ethics Committee of the University (Ethics Committee approval number; 20-10-T/38. The study was planned and implemented following this approval. Institutional guidelines for retrospective studies acclaimed by the institutional review board were the baseline for the study.

2. RESULTS

Demographic and clinical characteristics of the patients

When the distribution of the patients according to their demographic and clinical characteristics was examined, it was determined that 82.8% (n=486) of our patients were male, 76.7% (n=450) received >500 mL IV crystalloid fluid in EMS, 66.4% had shock according to EMS SI value, 60.3% (n=354) had systolic blood pressure >90 mmHg at first measured in EMS, and 86.9% (n=510) of patients discharged from hospital (Table 1). In addition, the mean age of the patients

was 41.75 ± 16.42, the mean EMS SI score was 1.23 ±.48, and the hospital SI mean score was .85±.49 (Table 1).

In patients with the systolic blood pressure of >90 mmHg at first measured out-of-hospital, 65.3% of them were recieved >500 mL of IV fluids (Table 1).

Table 1. Demographic and clinical characteristics of the patients (n=587)

Variables	**n**	**%**
Gender		
Male	486	82.8
Female	101	17.2
Intravenous fluid administration in EMS > 500 mL		
Yes	450	76.7
No	137	23.3
Presence of shock according to SI in EMS		
Having a shock	390	66.4
Shock nonexistent	197	33.6
Systolic blood pressure in EMS		
90 mmHg and above	354	60.3
89 mmHg and below	233	39.7
Mean arterial pressure (MAP)		
64 ve altı	358	61.0
65 ve üstü	229	39.0
IV fluid administration status in patients with systolic blood pressure > 90 in EMS		
Applied	231	65.3
Not applied	123	34.7
Patient outcome		
EX	77	13.1
Being discharged	510	86.9
	X±sd	**Min/max**
Age	41.75 ± 16.42	min = 18, max = 98
Mean SI in EMS	1.23±.48	min = 0, max = 6.11
Mean SI in hospital	.85±.49	min = 0, max = 7

Out-of-hospital IV fluid initiation status and out-of-hospital and hospital SIs of the patients

SI values of patients who were started on out-of-hospital fluid were higher than those who were not started, as expected. This was statistically significant (t=4.217, p=.000). Hospital shock index scores were also significally higher (t=2.815, p=.000) (Table 2). On the contrary, it was also statistically significant as expected (Table 3).

Table 2. Investigation of out-of-hospital IV fluid initiation status and out-of-hospital and hospital SIs of the patients (N=587)

Variables	Out-of-hospital SI		Hospital SI	
Patients' out-of-hospital IV fluid initiation status				
IV fluid started	1.28±.47	t=4.332 p=.000*	.88±.54	t =2.892 p=.000*
IV fluid not started	1.07±.51		.74±.21	

Table 3. Initiation of IV fluids and examination of out-of-hospital and in-hospital SIs in patients with shock on EMS according to SI (N=390)

Variables	out-of-hospital SI		Hospital SI	
İnitiation of IV fluids in patients with out-of-hospital shock				
Yes (n=305)	1.48±.40	t=4.217	.95±.58	t=2.815
No (n=85)	1.25±.57	p=.000*	.77±.23	p=.000*

The general outcome of patients with SBP 90 mmHg and above

It was significally determined that 8.7% of the patients with SBP 90 mmHg and above who were started out-of-hospital IV fluids and 2.4% of those who were not started ended up with exitus. (Table 4).

Table 4. Evaluation of the general outcome of patients with SBP 90 and above/ MAP 65 and above (N=354)

	Variables	Patient outcome				
	Out-of-hospital IV fluid initiation					
		EX n	%	Being discharged n	%	
SBP 90 and above	Yes	20	8.7	211	91.3	X^2=5.110 P=.024*
	No	3	2.4	120	97.6	
MAP 65 and above	Yes	9	6.8	124	93.2	X^2=5.110 P=.090
	No	2	2.1	94	97.4	

According to the shock index, fluid onset status and mortality in patients without out-of-hospital shock

Based on our results 24.1% of the patients received out-of-hospital IV fluids and 3.8% of those who did not recieve out-of-hospital IV fluids in patients without shock according to SI ended up with exitus . According to the shock index, a statistically significant difference is found between the fluid onset status and the outcome in patients who do not have a out-of-hospital shock (Table 5).

Table 5. According to the shock index, fluid onset status and mortality status in patients without out-of-hospital shock

Variables	**Outcome**				
Out-of-hospital IV fluid initiation status					
	EX		Being discharge		
	n	%	n	%	
Yes	35	24.1	110	75.9	X^2=10.331 P=.001*
No	2	3.8	50	96.2	

3. DISCUSSION

Massive hemorrhage is the leading cause of out-of-hospital death in severely injured trauma patients and is responsible for nearly half of all deaths occurring within the first 24 hours after injury (Kauvar et al., 2006; Schroll et al., 2018). Fluid transfusion protocols have been designed in traumatized patients and have been associated with increased survival (J. W. Cannon et al., 2017; Duchesne et al., 2010). The optimal approach in the out-of-hospital care of trauma patients is controversial. While previous studies have fallen short of demonstrating the definitive benefit or harm associated with IV fluid use, controversy remains (Hampton et al., 2013; Stiell et al., 2008; Yaghoubian et al., 2007). It is stated that out-of-hospital intravenous fluid administration in trauma patients will reduce mortality, especially in major injuries and in rural regions where the out-of-hospital transport time is long (Hampton et al., 2013; Murad et al., 2012; Ramesh et al., 2019). However, there is high evidence that high-volume fluid resuscitation may cause dilution coagulopathy, increase bleeding and mortality, cause resuscitation damage, and gastrointestinal and cardiac complications. For this reason, it is recommended not to initiate fluid resuscitation until the limit of permissible hypotension while stopping bleeding and transferring as quickly as possible in trauma patients with out-of-hospital active bleeding (Kudo et al., 2017; Paravar et al., 2014; Tran et al., 2018).

Clinical decisions are made according to hemodynamic parameters in the out-of-hospital area and the emergency department. Trauma mechanisms or patients' physical examinations are not defined as effective methods for predicting the need for fluid resuscitation or survival in traumatized individuals. The literature shows that the uncertainty between the out-of-hospital fluid volumes and mortality is still preserved. Various scoring systems have been developed to determine the need for transfusion. SI emerges as an important identification method of hemorrhagic shock, especially in the early stages of bleeding (Birkhahn et al., 2005; Mutschler et al., 2013). SI is an easy-to-use clinical tool to rapidly identify patients at risk of hemodynamic decompensation and is a simple scoring system used to determine the need for fluid resuscitation, especially in trauma patients with suspected hemorrhagic shock. In a study by Schroll et al. (2018), SI was shown as a distinctive scoring method in predicting the need for transfusion in the out-of-hospital environment (Schroll et al., 2018). The feature of the shock index that does not take into account the trauma mechanism of the patient, demographic characteristics of the patients, especially age, acquired diseases, and additional complications in the patient have also been criticized in the literature. Modified shock indices including different conditions and additional complications have also emerged (Bourque et al., 2013; Erol et al., 2021; Schroll et al., 2018; Shangguan et al., 2015).

There are very limited studies on the use of SI in EMS. However, although out-of-hospital SI is associated with mortality rates in various studies, the high mortality rates in trauma patients and the variety of complications related to the trauma mechanism limit the predictive value of SI. Bourque, et al. (2013) showed that various modified shock indices and standard SI have mortality sensitivity in the patient population with GI bleeding when compared with traditional vital signs (Bourque et al., 2013). In their study, Cannon et al. (2009) reported that high SI was associated with higher mortality rates in all trauma patients, and it was stated that the increase in SI until transfer from EMS to the emergency room indicates higher mortality (Cannon et al., 2009). Björkman et al. (2020), in their out-of-hospital study, showed a gradual increase in mortality in all age groups with the increase in SI in patients without major additional medical problems (Björkman et al., 2021). Kim et al. (2021) found a relationship between delta shock index in the out-of-hospital area and in-hospital mortality in the trunk and extremity trauma patients (Kim et al., 2021). In this study, mortality was higher in patients with high SI in all trauma types and age groups.

In this study, a positive and weak significance was found between out-of-hospital and hospital SIs. A significant difference was found between IV fluid administration and out-of-hospital and hospital shock index scores in EMS. In the case of initiation of IV fluid in a patient in shock

according to SI in EMS, patients' hospital SI decreased, and patient survival was found to increase. However, in patients with systolic blood pressure >90 mmHg and a low SI score, fluid initiation appears to be a factor that increases mortality. Geeraedts et al. (2015) found a linear relationship between IV fluid volume in EMS and shock index upon arrival at the emergency department and showed that IV fluid resuscitation was associated with a reduction in SI and thus a reversal of shock (Geeraedts et al., 2015). The study by Dula et al. (2002) stated that the systolic blood pressures of the patients who were started on fluid resuscitation in EMS increased in the emergency department, and the patient's survival increased significantly (Dula et al., 2002). Hampton et al. (2013) found in their study that EMS IV fluid administration was associated with increased survival in trauma patients (Hampton et al., 2013). However, many studies have shown the association of fluid resuscitation with high mortality in out-of-hospital care(Haut et al., 2011; Sampalis et al., 1997). Although there are studies that link the success of fluid resuscitation to hypotensive resuscitation (Dutton et al., 2002; Morrison et al., 2011), there are also studies showing that there is no positive or negative relationship between fluid administration and mortality in EMS (Bores et al., 2018; Katayama et al., 2022).

CONCLUSION

SI can be used as a tool for out-of-hospital traumatized patient identification and mortality assessment. Our study does not provide general evidence for fluid resuscitation in out-of-hospital trauma patients. A relationship was found between fluid therapy and mortality in this study, but this situation needs to be supported by experimental studies and it is recommended that new studies be conducted on this subject.

Limitation

Our data could not differentiate patients with traumatic brain injury. Chronic diseases, drugs used by the patients, and complications due to trauma were not evaluated. Besides, patients are not given any blood stopper drug such as tranexamic acid at both hospital and out-of-hospital. As these conditions can have an impact on hemodynamic stability, they may have a significant impact on the results of this study.

Author Contribution

Study Design AE, SÖ, SG; Data Collection SÖ, AE, SG; Data Analysis SÖ, SG, AE; Study Supervision AE, SG, SÖ, YAA, AFK; Manuscript Writing SÖ, AE, SG, YAA, AFK; Critical Revisions for Important Intellectual Content SÖ, AE, SG, AFK, YAA.

Conflict of Interest

There is no conflict of interest between the authors.

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