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ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA MAKALESİ

The Relationship Between Body Mass Index and Abdominal Circumference with Intraabdominal Organ Injury in High Energy Blunt Abdominal Trauma

Yüksek Enerjili Künt Karın Travmalarında Vücut Kitle İndeksi ve Karın Çevresi ile Karın İçi Organ Yaralanması Arasındaki İlişki

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ABSTRACT

Aim: The aim of this study was to determine the impact of body mass index (BMI) and abdominal circumference on intra-abdominal organ injury in high energy blunt trauma patients presenting to the emergency department.

Material and Methods: This prospective, cross-sectional, and analytical study included patients who presented to the Ankara Bilkent City Hospital Emergency Medicine Clinic between June 15, 2022, and December 31, 2022, due to high-energy blunt trauma and underwent contrast-enhanced abdominal computed tomography (CT). Patient demographics, vital signs, height, weight, BMI, mechanism of injury, abdominal injuries, injuries to other systems, abdominal circumference measurements, emergency department outcomes, and laboratory results were recorded in the data collection form. CT images were evaluated by a single radiology specialist, and abdominal circumference and subcutaneous fat tissue thickness were measured.

Results: A total of 374 patients were included in the study. 71.9% of the patients were male (n=269). The average age of the patients was 40 ± 16 years. Intra-abdominal injury was observed most frequently (30.8%) in patients with a BMI <18.5 (p=0.017). Although patients with intra-abdominal injury had lower sagittal abdominal diameter (SAD), transverse external diameter (T-ext), subcutaneous fat (Sc-fat), and BMI averages, these findings were not statistically significant (p=0.321, p=0.666, p=0.172, p=0.595, respectively). Patients admitted to the intensive care unit had lower SAD (20.6 ± 4.0 cm), T-ext (30.7 ± 3.9 cm), Sc-fat (2.0 ± 1.0 cm), and BMI (24.9 ± 4.4 kg/m2) averages (p=0.003, p=0.009, p=0.006, p=0.007, respectively).

Conclusion: Patients with a BMI <18.5 were found to be more susceptible to intra-abdominal injury. Patients with lower abdominal circumference (SAD, T-ext), Sc-fat, and BMI values were more likely to be admitted to the intensive care unit. Therefore, it is important to be cautious regarding abdominal injuries and injuries requiring intensive care admission in underweight and normal-weight patients who have experienced high-energy blunt trauma.

Keywords: High energy, blunt abdominal trauma, body mass index, abdominal circumference, subcutaneous fat thickness, emergency medicine

ÖZ

Amaç: Bu çalışmanın amacı, acil servise başvuran yüksek enerjili künt travma hastalarında vücut kitle indeksi (VKİ) ve karın çevresinin karın içi organ yaralanması üzerindeki etkisini belirlemektir.

Gereç ve Yöntemler: Bu prospektif, kesitsel ve analitik çalışmaya, 15 Haziran 2022 ile 31 Aralık 2022 tarihleri arasında Ankara Bilkent Şehir Hastanesi Acil Tıp Kliniğine yüksek enerjili künt travma nedeniyle başvuran ve kontrastlı abdominal bilgisayarlı tomografi (BT) çekilen hastalar dahil edilmiştir. Hastaların demografik bilgileri, yaşamsal bulguları, boy, kilo, VKİ, yaralanma mekanizması, karın yaralanmaları, diğer sistem yaralanmaları, karın çevresi ölçümleri, acil servis sonlanımı ve laboratuvar sonuçları veri toplama formuna kaydedildi. BT görüntüleri tek bir radyoloji uzmanı tarafından değerlendirildi, karın çevresi ve deri altı yağ dokusu kalınlığı ölçüldü.

Bulgular: Çalışmaya toplam 374 hasta dahil edildi ve %71,9'u (n=269) erkekti. Hastaların yaş ortalaması 40 ± 16 idi. İntraabdominal yaralanma en sık (%30,8) VKİ <18,5 olan hastalarda gözlendi (p=0,017). Karın içi yaralanması olan hastaların sagittal karın çapı (SKÇ), transvers dış çapı (TDÇ), deri altı yağ ve VKİ ortalamaları daha düşük olmasına rağmen, bu bulgular istatistiksel olarak anlamlı değildi (sırasıyla p=0.321, p=0.666, p=0.172, p=0.595). Yoğun bakım ünitesine kabul edilen hastaların SKÇ (20,6 ± 4,0 cm), TDÇ (30,7 ± 3,9 cm), deri altı yağ (2,0 ± 1,0 cm) ve VKİ (24,9 ± 4,4 kg/m2) ortalamaları daha düşüktü (sırasıyla p=0,003, p=0,009, p=0,006, p=0,007).

Sonuç: VKİ <18,5 olan hastalar karın içi yaralanmaya daha yatkın bulundu. Daha düşük karın çevresi (SKÇ, TDÇ), deri altı yağ ve VKİ değerlerine sahip hastaların yoğun bakım ünitesine kabul edilme olasılığı daha yüksekti. Bu nedenle, yüksek enerjili künt travma geçiren zayıf ve normal kilolu hastalarda karın yaralanmaları ve yoğun bakıma yatış gerektiren yaralanmalar konusunda dikkatli olmak önemlidir.

Anahtar Kelimeler: Yüksek enerji, künt karın travması, vücut kitle endeksi, karın çevresi, cilt altı yağ doğu kalınlığı, acil servis

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Introduction

Trauma is the leading cause of death in children and adults under the age of 46 worldwide (1). Each year, more than 5 million people die as a result of trauma (2). Abdominal trauma accounts for approximately 20% of all trauma-related deaths (3). The liver and spleen are the most commonly injured intra-abdominal organs (4). Forces such as compression, stretching, acceleration, and deceleration affect the abdominal cavity and intra-abdominal structures, leading to injuries of the abdominal wall, solid organs, and hollow organs (5). Computed tomography (CT) examinations are almost exclusively used in the diagnosis of abdominal injuries. CT has been shown to be superior to clinical evaluation and diagnostic peritoneal lavage in diagnosing significant abdominal injuries (6). Whole-body CT (head, neck, chest, abdomen, and pelvis) plays a crucial role in determining injury severity and deciding on the sequence of treatment for patients with multiple traumas (6).

The amount of abdominal visceral fat tissue measured by CT is a critical finding related to the risk of metabolic diseases associated with abdominal obesity. Abdominal circumference is one of the methods used to measure the amount of abdominal visceral fat tissue accumulation (7). Body mass index (BMI) is an index that measures body fat based on a person's height and weight. It is calculated by dividing a person's weight in kilograms by the square of their height in meters. Body mass index = weight (kg) / height (m) x height (m). However, due to individual differences, BMI may be insufficient to classify a person as obese or underweight. In certain populations such as athletes and bodybuilders, increased weight due to intensive muscle mass may not be directly associated with the person's health status, rendering BMI calculations inadequate (8).

Obesity is a chronic disease that is becoming increasingly prevalent and a global epidemic. Epidemiological studies have shown an association between high BMI and chronic diseases that negatively impact quality of life, such as cardiovascular diseases, diabetes, malignancies, and chronic kidney disease (9). While numerous studies have demonstrated the relationship between obesity and chronic diseases, there are limited studies on the effect of obesity on trauma patients (10). In this study, we aimed to determine the impact of BMI, abdominal circumference and subcutaneous fat thickness on intra-abdominal organ injury in high-energy blunt trauma patients presenting to the emergency department.

Material and Methods

This study was conducted between June 15, 2022, and December 31, 2022 at the Emergency Medicine Clinic of Ankara Bilkent City Hospital, a tertiary care hospital where all surgical and interventional procedures are available 24/7, serving approximately 470,000 patients annually. The study was approved by the Ankara Bilkent City Hospital Ethics Committee (Approval No: E1-22-2690, dated June 15, 2022). Our study is a prospective, cross-sectional, and analytical study. Patients who met the inclusion criteria during the specified dates were consecutively enrolled. Power analysis was not performed. Patients were enrolled in the study according to the Helsinki Protocol.

Patients aged 18 and older who met the Advanced Trauma Life Support (ATLS) 10 high-energy trauma criteria, who underwent contrast-enhanced abdominal CT, and volunteered to participate in the study were included. Patients with penetrating trauma, a history of laparotomy, diastasis recti, and those for whom e-nabız data were not accessible were excluded from the study.

Patients were evaluated in the red zone of our emergency department by a research assistant with at least two years of emergency medicine training. Patient data including age, gender, vital signs, height, weight, BMI, mechanism of injury, abdominal injuries, other system injuries, abdominal circumference measurements, emergency department outcomes, and laboratory results were recorded on the study form. Height and weight of the patients were obtained from the e-nabız system, an application of the Turkish Ministry of Health, to calculate BMI. For the calculation, the formula Body Mass Index = weight (kg) / height (m) x height (m) was used (11). Patients were classified as underweight (BMI <18.5), normal weight (BMI 18.5-24.9), overweight (BMI 25-29.9), and obese (BMI >30). CT images were evaluated and measurements of abdominal circumference and subcutaneous fat tissue thickness were performed by a single radiology specialist responsible for reading abdominal CT at Ankara Bilkent City Hospital Radiology Clinic.

The technique for measuring abdominal circumference and subcutaneous fat tissue thickness was based on the reference by Daniel et al. (12). The L4-L5 interval on CT images was used, and measurements were made on sagittal abdominal images corresponding to these intervals. Sagittal abdominal diameter (SAD) is the vertical longest anteroposterior length measured in the midline from skin to skin, without considering the umbilical fold. Transverse external diameter (T-ext) is measured horizontally from skin to skin passing through the vena cava and aorta. Subcutaneous fat tissue thickness (Sc-fat) is measured vertically from just beside the umbilical fold to the anterior surface of the abdominal wall (13). An example of abdominal circumference and subcutaneous fat tissue measurement for a patient presenting to our emergency department with motor vehicle accident (MVA) is shown in Figure 1.

The SAD, T-ext, and Sc-fat measurements used in our study were obtained with two devices with 128-detector and 64-detector multi-slice CT scanner systems. (GE Revolution EVO, GE Medical Systems, Milwaukee, WI, USA). Scans were reformatted to a 1.25 mm thickness and analysis was done on a remote workstation (Sarus 3.1, Teknoritma Inc., Ankara, Türkiye PACS Viewer (Teknoritma PACS Viewer, v5, Teknoritma Software, Ankara, Türkiye).

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 20.0 (Armonk, NY). Firstly, demographic data were analyzed, and frequencies of categorical variables were given as sample size and percentage. Pearson's Chi-square test and Fisher's Exact test were used for comparison of categorical data according to appropriateness. Distribution analysis of numerical continuous data was performed using the histogram and Shapiro-Wilk test, and for data not following normal distribution, median and interquartile range were used.

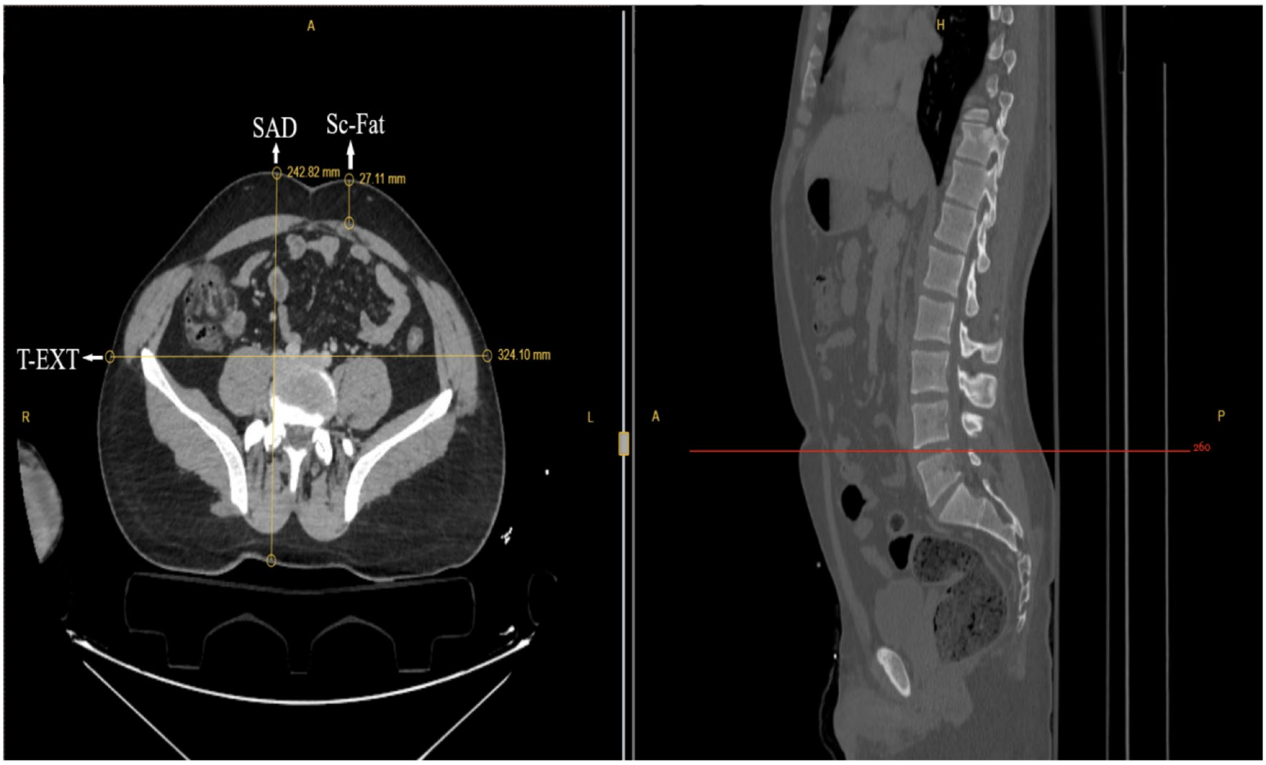

Figure 1. The example of abdominal circumference and subcutaneous fat tissue thickness in a patient admitted to our emergency department and treated for motor vehicle accident
Sc-Fat: subcutaneous fat tissue thickness SAD: sagittal abdominal diameter, T-ext: transverse external diameter

Mann-Whitney U test was used to compare the medians between two independent groups of data not following normal distribution. A p value was used for statistical significance, and a significance level of $p < 0.05$ was considered significant.

Results

A total of 374 patients were included in our study, with 71.9% being male (n=269). The mean age of the patients was 40 ± 16 years. The mean systemic blood pressure was 129±20 mmHg, the mean pulse rate was 87±13 beats per minute and the mean respiratory rate of the patients was 19±5 breaths per minute. Demographic datas and laboratory results of our patients are presented in Table 1. When examining the mechanisms of trauma, it was found that 51.9% of the patients were injured in motor vehicle accidents (n=194), 23% in pedestrian injuries (PI) (n=86), and 25.1% from falls from height (n=94). The mean BMI of the patients was calculated as 26.6. Among the patients, 3.5% had a BMI less than 18.5 (n=13), 39.3% had a BMI between 18.5 and 24.9 (n=147), 33.4% had a BMI between 25 and 29.9 (n=125), and 23.8% had a BMI greater than 30 (n=89). The mean measurements of subcutaneous fat tissue thickness (Sc-fat), sagittal abdominal diameter (SAD), and transverse external diameter (T-ext) were found to be 2.4 ± 1.1 cm, 22.4 ± 4.7 cm, and 32.3 ± 4.6 cm, respectively.

When examining the relationship between laboratory values and the presence of abdominal injury, it was observed that patients with abdominal injury had higher aspartat aminotransferaz (AST), alanin aminotransferaz (ALT), and lipase values compared to those without. These findings were statistically significant ($p < 0.001$ for AST, $p < 0.001$ for ALT, $p < 0.001$ for lipase).

The relationship between the presence of abdominal injury and gender, BMI groups, mechanism of trauma, and patient outcome is presented in Table 2. While intra-abdominal injury was not detected in 92.2% of the patients (n=345), it was found in 7.8% (n=29) of the patients. Head and neck injuries were present in 22.2% (n=83) of the patients, thoracic injuries in 32.1% (n=120), vertebral injuries in 17.1% (n=64), and extremity injuries in 25.7% (n=96). Intra-abdominal injury was more common in patients with a BMI less than 18.5 (p=0.017).

The relationship between BMI, abdominal circumference, subcutaneous fat tissue thickness, and abdominal injury is presented in Table 3. The mean SAD, T-ext, Sc-fat, and BMI were lower in patients with intra-abdominal injuries, but these findings were not statistically significant (p=0.321, p=0.666, p=0.172, p=0.595, respectively).

The relationship between BMI, abdominal circumference, subcutaneous fat tissue thickness, and intensive care unit (ICU) admission is presented in Table 4. A total of 67.1% of the patients were discharged (n=251), 18.7% were admitted to the general ward (n=70), and 14.2% required ICU admission (n=53). There were no fatalities. It was found that patients with intra-abdominal injuries were more likely to require ICU admission ($p<0.001$). Patients who required ICU admission had lower mean SAD, T-ext, Sc-fat, and BMI (p=0.003, p=0.009, p=0.006, p=0.007, respectively).

Variable		n (%) or mean ± SD
Age (year, mean ± SD)		40 ± 16
BMI (kg/m², mean ± SD)		26.6 ± 5.1
Sc-Fat (cm, mean ± SD)		2.4 ±1.1
SAD (cm, mean ± SD)		22.4 ± 4.7
T-ext (cm, mean ± SD)		32.3 ± 4.6
Sex, male (n,%)		269 (71.9)
Vital Signs (mean ± SD)	SBP (mmHg)	129 ± 20
	PR (beat/minute)	87 ± 13
	RR (breaths/minute)	19 ± 5
Laboratory Results (mean ± SD)	Hemoglobin (g/dL)	14.3 ± 1.5
	Hematocrit (%)	43.2 ± 4.3
	Urea (mg/dL)	33 ± 9
	Creatinin (mg/dL)	0.8 ± 0.2
	AST (U/L)	46 ± 52
	ALT (U/L)	39 ± 36
	Amylase (U/L)	64 ± 28
	Lipase (U/L)	38 ± 19
Mechanism (n, %)	MVA	194 (51.9)
	PI	86 (23.0)
	Fall from height	94 (25.1)
BMI group (n, %)	<18,5	13 (3.5)
	18,5-24,9	147 (39.3)
	25-29,9	125 (33.4)
	>=30	89 (23.8)
Abdominal Injury (n, %)		29 (7.8)
Outcome (n, %)	Discharged	251 (67.1)
	Admission	70 (18.7)
	ICU	53 (14.2)
Exitus (n, %)		0 (0)

Table 1. Demographic Data
BMI: Body Mass Index ScFat: Subcutaneous Fat Tissue Thickness SAD: Sagittal Abdominal Diameter Text: Transverse External Diameter PR: Pulse Rate RR: Respiratoryr ate MVA: Motor Vehicle Accident PI: Pedestrian Injury ICU: Intensive Care Unit

Discussion

Trauma is one of the leading causes of mortality worldwide. It is the most common cause of death and disability in individuals under 35 years of age. Particularly, traffic accidents are the predominant mechanism of injury in developing and underdeveloped countries (14). The type and severity of injury vary depending on factors such as the mechanism of injury, deceleration at the time of injury, the use of seat belts, and the effect of airbags.

		Abdominal injury		
		Absent (n,%)	**Present (n,%)**	**P-value**
Sex	Women	99 (94.3)	6 (5.7)	0.357
	Men	246 (91.4)	23(8.6)	
BMI group	<18,5	9 (69.2)	4 (30.8)	0.017
	18,5-24,9	138 (93.9)	9 (6.1)	
	25-29,9	116 (92.8)	9 (7.2)	
	>=30	82 (92.1)	7 (7.9)	
Mechanism	MVA	184 (94.8)	10 (5.2)	0.149
	PI	77 (89.5)	9 (10.5)	
	Fall from height	84 (89.4)	10 (10.6)	
Outcome	Discharged	249 (99.2)	2 (0.8)	<0.001
	Admission	67 (95.7)	3 (4.3)	
	ICU	29 (54.7)	24 (45.3)	

Table 2. The relationship between the presence of abdominal injury and gender, BMI groups, mechanism of trauma, and patient outcome
BMI: Body Mass Index MVA: Motor Vehicle Accident PI: Pedestrian Injury ICU: Intensive Care Unit

Similarly, individual characteristics such as height and weight may also be associated with the severity of injury (15). Our study revealed a higher incidence of abdominal injuries in the underweight BMI group patients.
When trauma patients were examined, it has been observed that men are more exposed to trauma than women both in our country and worldwide. In a study conducted by Liu et al. involving 140,000 patients, 71% of the patients were male, and 29% were female (16). Zhu et al. found that 76% of the patients were male and 24% were female in their study (17). Similarly, Bolandparvaz et al. reported that 73% of the patients were male and 27% were female in their study (18). In our study, a total of 374 patients were included, with 71.9% being male and 28.1% female. Consistent with the literature, our study also found that men are more exposed to trauma compared to women. This may be due to men being engaged in heavier work and being exposed to occupational accidents, the majority of drivers being male, and men being more socially active.
In the study by Zhu et al., the mean age of the patients was 45.6 years (16). Srivastava et al. reported a mean age of 30.6 years for their patients (19). Sierink et al. found a mean age of 42 years among their patients (20), while Jones et al. reported a mean age of 36 years in their study (21). Consistent with the literature, we found the mean age of patients in our study to be 40 ± 16 years.
In the study conducted by Ditillo et al. on blunt trauma patients aged 18 and over, the mean systolic blood pressure (SBP) value was 130 ± 27.3 mmHg, and the mean pulse rate was 91 ± 19 beats per minute (bpm) (22).

	Abdominal injury				
	Absent (%92.2, n=345)		Present (%7.8, n=29)		P-value
	Mean ± SD	Median (%25 - %75)	Mean ± SD	Median (%25 - %75)	
Sc-Fat (cm)	2.5 ± 1.2	2.4 (1.8 - 3.1)	2.2 ± 1.0	2.0 (1.5 - 3.0)	0,172
SAD (cm)	22.5 ± 4.6	22.3 (18.9 - 25.6)	21.5 ± 4.8	20.9 (18.6 - 25.0)	0,321
Text (cm)	32.3 ± 4.6	32.1 (29.2 - 35.2)	31.6 ± 4.4	31.6 (29.2 -34.2)	0,666
BMI (kg/m^2)	26.7 ± 5.0	25.9 (23.4 - 29.4)	25.9 ± 5.6	25.4 (22.1-29.0)	0,595

Table 3. The relationship between BMI, abdominal circumference, and subcutaneous fat thickness with abdominal injury
Sc-Fat: Subcutaneous Fat Tissue Thickness SAD: Sagittal Abdominal Diameter T-ext: Transverse External Diameter BMI: Body Mass Index

	ICU				
	Absent		Present		P-value
	Mean ± SD	Median (%25 - %75)	Mean ± SD	Median (%25 - %75)	
Sc-Fat (cm)	2.5 ± 1.2	2.4(1.8 - 3.2)	2.0 ± 1.0	1.9 (1.4 – 2.9)	0,006
SAD (cm)	22.7 ± 4.7	22.4 (19.1 – 25.8)	20.6 ± 4.0	20.5 (17.6 – 23.4)	0,003
Text (cm)	32.6 ± 4.6	32.2 (29.4 – 35.3)	30.7 ± 3.9	30.7 (27.7 – 33.3)	0,009
BMI (kg/m^2)	26.9 ±5.1	26.2 (23.5 – 30.0)	24.9 ± 4.4	24.7 (22.1- 27.3)	0,007

Table 4. The relationship between BMI, abdominal circumference, and subcutaneous fat thickness with intensive care unit admission
Sc-Fat: Subcutaneous Fat Tissue Thickness SAD: Sagittal Abdominal Diameter T-ext: Transverse External Diameter BMI: Body Mass Index

Alvarez et al., in a study with 200 patients, found that all blunt trauma patients had SBP > 90 mmHg, with 77% of patients having a respiratory rate (RR) of 10-29 breaths per minute (bpm) (23). Bouzat et al. reported in their study of 3260 patients that the mean SBP was 124 mmHg, the mean pulse rate was 90 bpm, and the mean RR was 20 breaths per minute (24). In our study, the mean SBP was 129 ± 20 mmHg, the mean pulse rate was 87 ± 13 bpm, and the RR was 19 ± 5 breaths per minute, which is consistent with the literature.

In the study conducted by Ion et al., the mean Hb was 11.8 ± 2.7 g/dL, mean Hct was 34.9% ± 7.6, with median AST of 59.3 IU/L, median ALT of 48 IU/L, median creatinine of 0.86 mg/dL, and median urea of 35 mg/dL. In this study, ALT, AST, urea, and Hb values were found to be statistically associated with mortality (25). In the study by Musalar et al., the median Hb was 14.2 g/dL, median ALT was 22 IU/L, median AST was 24 IU/L, median amylase was 65 IU/L, and median lipase was 32 IU/L. In this study, Hb, ALT, AST, amylase, and lipase were found to be statistically associated with intra-abdominal injury (26). In our study, the mean Hb was 14.3 ± 1.5 g/dL, with median AST of 32 IU/L, median ALT of 28 IU/L, median amylase of 59 IU/L, and median lipase of 34 IU/L. We found statistically significant differences between AST, ALT, and lipase levels and intra-abdominal injury. These findings are consistent with the literature.

In a study conducted by Choi et al., out of 28,479 blunt trauma patients included in the study, 2.9% had a BMI <18.5, 35.8% had a BMI of 18.5-24.9, 32.4% had a BMI of 25-29.9, and 28.8% had a BMI >30 (27). Our study found that 3.5% of patients had a BMI <18.5, 39.3% had a BMI of 18.5-24.9, 33.4% had a BMI of 25-29.9, and 23.8% had a BMI >30. These findings are consistent with the literature.

In the study by Christensen et al., abdominal injuries were detected in 2.7% of 35,564 patients (28), while Bolandparvaz et al. found abdominal injuries in 8.8% of 47,295 patients (16). In our study, abdominal injuries were detected in 7.8% of patients, which is consistent with the literature.

Boulanger et al. reported that obese trauma patients were more likely to experience thoracic and extremity injuries compared to non-obese patients, but less likely to experience head-neck and abdominal injuries (29). Similarly, Arbabi et al. found that obese patients had more extremity injuries but fewer abdominal injuries (15). In our study, it was observed that the group with a BMI <18.5 was more likely to experience abdominal injuries, which is consistent with the literature.

In the study by Wang et al., an increase in subcutaneous fat thickness in adult blunt trauma patients was found to be associated with a decrease in the severity of abdominal injuries (30). Although our study found lower values of Sc-fat, SAD, and T-ext measurements in patients with abdominal injuries compared to those without, this difference was not statistically significant. However, the assumption that subcutaneous fat thickness may be associated with the severity of abdominal injuries is a common point in both studies.

Conclusion

According to the findings of this study, we observed that patients in the BMI <18.5 group were more prone to abdominal injury as a result of blunt trauma. Additionally, we found that patients presenting to the emergency department due to high-energy blunt trauma with lower abdominal circumference, subcutaneous fat tissue thickness, and BMI were more likely to be admitted to intensive care.

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