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Acil Servise Ateşli Silah Yaralanması Nedeniyle Başvuran Hastalarda Bilgisayarlı Tomografide Saptanan Patolojik Bulguların Prognostik Rolünün Belirlenmesi

Determining the Prognostic Role of Pathological Findings Detected on Computed Tomography in Patients Presenting to the Emergency Department Due to Firearm İnjuries

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ÖZ

Giriş: Ateşli silah yaralanmaları (ASY), dünya genelinde travmaya bağlı ölümlerin ikinci en yaygın nedenidir. Bilgisayarlı tomografi (BT), ASY dahil olmak üzere travma hastalarının değerlendirilmesinde tercih edilen görüntüleme yöntemidir. BT'de saptanan patolojik bulguların belirlenmesi ve prognostik değerlerinin değerlendirilmesi, klinik yönetimi yönlendirmede yardımcı olabilir. Bu çalışmanın amacı, ASY nedeniyle acil servise başvuran hastalarda BT bulgularının prognostik önemini araştırmaktır.

Yöntem: Bu retrospektif gözlemsel çalışma, üçüncü basamak bir hastanenin acil servisine ASY nedeniyle başvuran hastaları kapsamaktadır. BT görüntülemesi yapılmayan, 18 yaş altı olan, ateşli silah dışı travması bulunan, eksik verisi olan veya takibi sağlanamayan hastalar çalışma dışı bırakıldı. Demografik veriler, yaralanma özellikleri, acil servise başvuru şekli, laboratuvar parametreleri ve BT bulguları kaydedildi. Hastane yatışı, yoğun bakım ünitesi (YBÜ) yatışı, cerrahi müdahale ve hastane içi mortalite gibi klinik sonuçlar değerlendirildi. BT bulguları ile bu klinik sonuçlar arasındaki ilişkiler uygun istatistiksel yöntemlerle analiz edildi.

Bulgular: Lojistik regresyon analizi sonucunda, BT bulgularından intrakraniyal hemoraji (OR: 348,41; p < 0,001), hemotoraks (OR: 66,94; p = 0,011) ve pnömoperiton (OR: 24,06; p = 0,022), hastane içi mortalitenin bağımsız belirleyicileri olarak saptandı. Pnömoperiton, ekstremite kemik kırığı ve ekstremite arteriyel yaralanmaları cerrahi müdahaleyi öngörürken; kafatası kırığı, pnömoperiton ve ekstremite arteriyel yaralanmaları YBÜ yatışını öngördü.

Sonuç: BT'de saptanan patolojik bulgular özellikle pnömoperiton, intrakraniyal hemoraji ve hemotoraks, ASY hastalarında güçlü prognostik göstergelerdir. Bu bulgulara yönelik farkındalık, klinisyenlerin risk sınıflaması yapmasına ve cerrahi ya da yoğun bakım müdahaleleri için zamanında karar vermesine katkı sağlayabilir.

Anahtar Kelimeler: ateşli silah, tomografi, acil servis, hastane içi mortalite, prognoz

ABSTRACT

Objective: Firearm injuries (FI) are the second leading cause of trauma-related deaths worldwide. Computed tomography (CT) is the preferred imaging modality for assessing trauma patients, including those with FI. Identifying pathological findings on CT and evaluating their prognostic value may help guide clinical management. This study aimed to investigate the prognostic significance of CT findings in patients presenting to the emergency department (ED) due to FI.

Method: This retrospective observational study included patients who presented to the ED of a tertiary hospital with FI. Patients without CT imaging, those under 18 years, with non-firearm trauma, missing data, or unavailable follow-up were excluded. Demographic data, injury characteristics, mode of ED presentation, laboratory parameters, and CT findings were recorded. Clinical outcomes including hospital admission, intensive care unit (ICU) admission, surgical intervention, and in-hospital mortality were assessed. Associations between CT findings and these outcomes were analyzed using appropriate statistical methods.

Results: Logistic regression analysis was performed to identify CT findings independently associated with these clinical outcomes. Intracranial hemorrhage (OR 348.41, p < 0.001), hemothorax (OR 66.94, p = 0.011), and pneumoperitoneum (OR 24.06, p = 0.022) were independent predictors of in-hospital mortality. Pneumoperitoneum, extremity bone fracture, and extremity arterial injury predicted surgical intervention, while skull fracture, pneumoperitoneum, and extremity arterial injury predicted ICU admission.

Conclusion: Pathological CT findings, particularly pneumoperitoneum, intracranial hemorrhage, and hemothorax are strong prognostic indicators in FI patients. Awareness of these findings can aid clinicians in risk stratification and guide timely decisions for surgical management and intensive care.

Keywords: firearm, tomography, emergency service, hospital mortality, prognosis

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INTRODUCTION

Firearm injuries (FI) are the second most common cause of trauma-related deaths worldwide (1). In the United States, there are approximately 90,000 emergency department visits annually due to nonfatal firearm injuries (2). Among patients presenting to the emergency department following FI, extremity injuries are the most frequently observed, followed by thoracoabdominal and cranial injuries (3).

While surgical intervention is the primary approach in the management of clinically unstable patients, various imaging modalities are utilized in the evaluation of stable patients (4). Computed tomography (CT) is the preferred imaging modality in the emergency assessment of trauma patients, including those with FI (5). It plays a particularly important role in the evaluation of clinically stable patients, in identifying those who may be managed non-operatively, and in their subsequent monitoring (4). The assessment and analysis of pathological CT findings obtained in these patients, and the determination of their relationship with clinical outcomes, may provide valuable guidance to clinicians in patient management.

The aim of this study is to identify pathological findings detected on CT imaging and evaluate their prognostic value in patients presenting to the emergency department following firearm injuries.

MATERIALS AND METHODS

This study was designed as a retrospective observational study. It was conducted on patients who presented to the emergency department of a tertiary care hospital due to FI between January 1, 2022, and December 31, 2024. This study was approved by the local ethics committee on March 12, 2025 (decision number=2025-42).

All patients from all age groups who presented to the emergency department following FI were included in the study. Patients were excluded if no CT imaging was obtained during their emergency department evaluation, if they were under the age of 18, had concomitant non-firearm-related trauma, had missing data, or could not be followed up.

In this study, patients who presented to the emergency department due to FI were identified by an emergency medicine specialist through a review of the hospital information management system. For each patient, the following data were recorded: age, demographic characteristics, anatomical site(s) of injury, mode of presentation to the emergency department (self-presented or via ambulance), laboratory tests ordered in the emergency department (White blood cell [WBC], Neutrophil, Lymphocyte, Hemoglobin, Hematocrit, Platelet, Albumin, Blood Ure Nitrogen [BUN], Ure, Creatinine, glomerular filtration rate [GFR], Sodium, Potassium, Calcium, International Normalized Ratio [INR]).

CT images obtained in the emergency department and the corresponding pathological findings were analyzed and recorded by a radiologist with 10 years of professional experience. In addition, data on hospital admission status (ward or intensive care unit [ICU]) were documented by another emergency medicine specialist. Using the hospital database, in-hospital mortality and whether the patient underwent surgical intervention were also determined.

Subsequently, a statistical analysis was conducted to compare patients' age, demographic characteristics, injury sites, mode of presentation to the emergency department, laboratory tests ordered in the emergency department, and pathological findings on CT imaging, with respect to their hospital admission status, in-hospital mortality, and whether they underwent surgical intervention.

Statistical Analysis

Data was analyzed using the open-source statistical software Jamovi version 1.6.21. Descriptive statistics were used to characterize the patient cohort. The normality of distribution for continuous variables was assessed using the Shapiro–Wilk test and histograms. Since the data did not follow a normal distribution, categorical variables were expressed as percentages, and continuous variables were presented as medians with interquartile ranges (IQRs). For comparisons between two groups, chi-squared or Fisher's exact tests were used for categorical variables, and the Mann–Whitney U test was applied for continuous variables. In comparisons among more than two groups, chi-squared or Fisher's exact tests were again used for categorical variables, while Kruskal–Wallis test was used for continuous variables due to non-normal distribution. For post hoc analysis of continuous variables, the Dwass–Steel–Critchlow–Fligner test was employed, while for categorical variables, chi-squared post hoc tests with Bonferroni correction were applied. To identify variables associated with in-hospital mortality, ICU admission, and surgical intervention, logistic regression analyses were performed. In the multivariate logistic regression model, a stepwise method was used to eliminate confounding and non-significant variables to obtain the most parsimonious model. A p-value of <0.05 was considered statistically significant for all analyses.

RESULTS

In our study, a total of 342 patients with FI presented to the emergency department during the specified study period. Of these, 90 patients who did not meet the inclusion criteria were excluded. As a result, 252 patients were included in the final analysis (Figure 1).

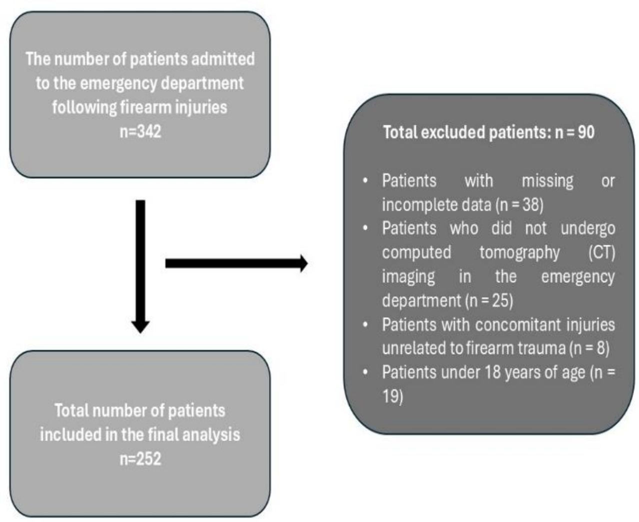

Figure 1. Flowchart of study design

The median age of the included patients was 29 years (IQR: 24–44), and 93.7% (n = 236) were male. The majority of patients (84.9%, n = 214) were transported to the emergency department by ambulance. The most frequently observed injury site was the lower extremity (69%, n = 174), followed by the upper extremity (20.2%, n = 51) and the abdomen (14.7%, n = 37). On CT imaging performed in the emergency department, the most common pathological finding was muscle and soft tissue injury (95.6%, n = 241), followed by extremity bone fractures (32.9%, n = 83), extremity arterial injuries (9.5%, n = 24), and pneumoperitoneum (8.7%, n = 22). Further details are presented in Table 1.

Among the patients included in our study, 112 were discharged from the emergency department, 72 were admitted to inpatient wards, and 65 were admitted to the ICU. Mortality in the emergency department was observed in 3 patients. Head (n = 17, p = 0.008), thoracic (n = 18, p < 0.001), abdominal (n = 22, p < 0.001), and back injuries (n = 11, p = 0.016) were identified as the injury locations most significantly associated with ICU admission. In contrast, lower extremity injuries (n = 90, p < 0.001) were the most common injury pattern among patients discharged from the emergency department. In the ICU group, WBC count (median 13.4 x10³/µL [0.6–18.5], p < 0.001), lymphocyte count (median 3.60 x10³/µL [2.72–4.69], p = 0.023), sodium (median 139 mmol/L [137–140], p = 0.040), and INR (median 1.05 [1.01–1.15], p < 0.001) were significantly higher, whereas hemoglobin (median 13.7 g/dL [12.4–15.7], p < 0.001), hematocrit (median 39.2% [36.3–44.7], p < 0.001), albumin (median 39 g/L [35–42], p < 0.001), and calcium (median 8.8 mg/dL [8.4–9.3], p < 0.001) were significantly lower. Further details are presented in Table 2.

Table 1. Descriptive Analysis of Study Population

	Total (n=252)		**Total (n=252)**
Age, year, median (IQR 25-75)	29 (24-44)	**Pathological findings on CT, n (%)**	
Sex, n (%)		Skull fracture	12 (4.8)
Male	236 (93.7)	Intracranial hemorrhage	11 (4.4)
Female	16 (6.3)	Orbital injury	5 (2)
Mode of ED presentation, n (%)		Maxillofacial injury	9 (3.6)
Self-presented	38 (15.1)	Cervical spine injury	1 (0.4)
Ambulance	214 (84.9)	Thoracal spine injury	2 (0.8)
Region of Injury, n (%)		Lumbar spine fracture	4 (1.6)
Head	36 (14.3)	Rib fracture	14 (5.6)
Neck	11 (4.4)	Pneumothorax	13 (5.2)
Vertebra	6 (2.4)	Hemothorax	15 (6)
Thorax	32 (12.7)	Cardiac injury	0 (0)
Abdomen	37 (14.7)	Scapular fracture	5 (2)
Back	23 (9.1)	Splenic injury	5 (2)
Genital	7 (2.8)	Hepatic injury	6 (2.4)
Upper Extremity	51 (20.2)	Renal injury	7 (2.8)
Lower Extremity	174 (69.0)	Urinary bladder injury	0 (0)
Laboratory Parameter, median (IQR 25-75)		Hollow viscus injury	15 (6)
WBC (10³/µL)	11.8 (9.55-14.9)	Pneumoperitoneum	22 (8.7)
Neutrophil (10³/µL)	6.95 (5.35-10.7)	Testicular or penile injury	7 (2.8)
Lymphocyte (10³/µL)	3.08 (2.01-4.29)	Pelvic fracture	7 (2.8)
Hemoglobin (g/dL)	14.6 (13.2-15.7)	Extremity bone fracture	83 (32.9)
Hematocrit (%)	42.5 (38.7-45.4)	Extremity arterial injury	24 (9.5)
Platelet (10³/µL)	252 (220-299)	Extremity venous injury	6 (2.4)
Albumin (g/L)	42 (39-45)	Muscle and soft tissue injury	241 (95.6)
BUN (mg/dL)	14 (12-17)		
Ure (mg/dL)	30 (25-36)		
Creatinine (mg/dL)	0.9 (0.7-1)		
GFR (mL/min/1,73m²)	111 (97-125)		
Sodium (mmol/L)	138 (136-140)		
Potassium (mmol/L)	3.94 (3.70-4.23)		
Calcium (mg/dL)	9.4 (8.8-9.7)		
INR	1.02 (0.96-1.07)		

ED=Emergency Department, WBC= White blood cell, BUN= Blood Ure Nitrogen, GFR= glomerular filtration rate, INR= International Normalized Ratio CT= Computer Tomography

Table 2. Comparison Of Demographic Characteristics, Region of Injury, and Laboratory Findings According to Patients' Discharge and Hospitalization Status

	Discharge (n=112)	Ward (n=72)	ICU (n=65)	p value
Age, year, median (IQR 25-75)	28 (24-39.5)	30 (24.8-44.8)	33 (25-47)	0.213
Sex, n (%)				
Male	106 (94.6)	67 (93.1)	61 (93.8)	0.942[a]
Female	6 (5.4)	5 (6.9)	4 (6.2)	
Mode of ED presentation, n (%)				
Self-presented	27 (24.1)	9 (12.5)	2 (3.1)	**<0.001[b**]**
Ambulance	85 (75.9)	63 (87.5)	63 (96.9)	
Region of Injury, n (%)				
Head	12 (10.7)	7 (9.7)	17 (26.2)	**0.008[b**]**
Neck	4 (3.6)	2 (2.8)	5 (7.7)	0.358[a]
Vertebra	3 (2.7)	1 (1.4)	2 (3.1)	0.878[a]
Thorax	6 (5.4)	6 (8.3)	18 (27.7)	**<0.001[b**]**
Abdomen	4 (3.6)	10 (13.9)	22 (33.8)	**<0.001[b**]**
Back	6 (5.4)	4 (5.6)	11 (16.9)	**0.016[b**]**
Genital	1 (0.9)	5 (6.9)	1 (1.5)	**0.048[a**]**
Upper Extremity	23 (20.5)	14 (19.4)	14 (21.5)	0.955[b]
Lower Extremity	90 (80.4)	51 (70.8)	33 (50.8)	**<0.001[b**]**
Laboratory Parameter, median (IQR 25-75)				
WBC ($10^3/\mu L$)	10.7 (8.66-13.5)	12.8 (9.91-14.8)	13.4 (10.6-18.5)	**<0.001***
Neutrophil ($10^3/\mu L$)	6.41 (5.13-8.67)	7.97 (5.57-10.9)	7.27 (5.9-12.8)	**0.008***
Lymphocyte ($10^3/\mu L$)	2.76 (1.98-3.83)	2.91 (1.96-4.32)	3.60 (2.72-4.69)	**0.023***
Hemoglobin (g/dL)	15.0 (14.1-16.0)	14.4 (13.4-15.5)	13.7 (12.4-15.2)	**<0.001***
Hematocrit **(%)**	43.9 (40.7-46.6)	42.3 (38.5-44.9)	39.2 (36.3-44.7)	**<0.001***
Platelet ($10^3/\mu L$)	247 (207-289)	261 (228-302)	247 (227-316)	0.111
Albumin (g/L)	43 (41.8-46)	43 (39-45)	39 (35-42)	**<0.001***
BUN (mg/dL)	14 (12-17)	14 (12-16)	13 (10-17)	0.245
Ure (mg/dL)	30 (26-37)	30 (25-34)	29 (21-36)	0.341
Creatinine (mg/dL)	0.9 (0.7-1)	0.81 (0.7-0.9)	0.8 (0.7-1)	0.549
GFR (mL/min/1,73m²)	113 (99-125)	109 (97.8-125)	112 (93-127)	0.479
Sodium (mmol/L)	138 (136-140)	137 (136-138)	139 (137-140)	**0.040***
Potassium (mmol/L)	3.98 (3.73-4.25)	3.94 (3.69-4.24)	3.80 (3.63-4.15)	0.101
Calcium (mg/dL)	9.6 (9.2-9.8)	9.3 (8.8-9.7)	8.8 (8.4-9.3)	**<0.001***
INR	1.02 (0.94-1.05)	1.0 (0.96-1.05)	1.05 (1.01-1.15)	**<0.001***

[a] According to fisher exact test results, [b] According to qi-square test results, ED=Emergency Department, WBC= White blood cell, BUN= Blood Ure Nitrogen, GFH= glomerular filtration rate, -Three cases resulted in mortality in the emergency department
* According to Post-hoc Dwass-Steel-Critchlow-Fligner test results
WBC= ward-discharge (p=0.009); ward-ICU (p=0.381); discharge-ICU (p<0.001)
Neutrophil = ward-discharge (p=0.050); ward-ICU (p=0.730); discharge-ICU (p=0.019)
Lymphocyte = ward-discharge (p=0.894); ward-ICU (p=0.187); discharge-ICU (p=0.012)
Hemoglobin = ward-discharge (p=0.076); ward-ICU (p=0.046); discharge-ICU (p<0.001)
Hematocrit = ward-discharge (p=0.053); ward-ICU (p=0.133); discharge-ICU (p<0.001)
Albumin= ward-discharge (p=0.204); ward-ICU (p<0.001); discharge-ICU (p<0.001)
Sodium= ward-discharge (p=0.213); ward-ICU (p=0.034); discharge-ICU (p=0.481)
Calcium= ward-discharge (p=0.007); ward-ICU (p=0.002); discharge-ICU (p<0.001)
INR= ward-discharge (p=0.945); ward-ICU (p<0.001); discharge-ICU (p<0.001)
** According to Post-hoc qi-square test results (with Bonferroni correction)
Mode of ED presentation= ward-discharge (p=0.165); ward-ICU (p=0.129); discharge-ICU (p<0.001)
Head= ward-discharge (p=0.829); ward-ICU (p=0.036); discharge-ICU (p=0.021)
Thorax= ward-discharge (p=0.425); ward-ICU (p=0.009); discharge-ICU (p<0.001)
Abdomen= ward-discharge (p=0.030); ward-ICU (p=0.018); discharge-ICU (p<0.001)
Back= ward-discharge (p=0.954); ward-ICU (p=0.099); discharge-ICU (p=0.036)
Genital= ward-discharge (p=0.105); ward-ICU (p=0.212); discharge-ICU (p=1.000)
Lower extremity= ward-discharge (p=0.136); ward-ICU (p=0.048); discharge-ICU (p<0.001)

Regarding CT findings, the following pathologies were significantly associated with ICU admission: skull fracture (n = 11, 16.9%, p < 0.001), intracranial hemorrhage (n = 11, 16.9%, p < 0.001), lumbar spine fracture (n = 3, 4.6%, p = 0.017), rib fracture (n = 10, 15.4%, p < 0.001), pneumothorax (n = 10, 15.4%, p < 0.001), hemothorax (n = 11, 16.9%, p < 0.001), scapular fracture (n = 5, 7.7%, p = 0.001), splenic injury (n = 4, 6.2%, p = 0.004), hepatic injury (n = 5, 7.7%, p = 0.001), renal injury (n = 6, 9.2%, p < 0.001), hollow viscus injury (n = 13, 20%, p < 0.001), pneumoperitoneum (n = 19, 29.2%, p < 0.001), pelvic fracture (n = 7, 10.8%, p < 0.001), and extremity arterial injury (n = 17, 26.2%, p < 0.001). Testicular or penile injury (n = 5, 6.9%, p = 0.048) and extremity bone fractures (n = 39, 54.2%, p < 0.001) were significantly associated with ward admission. Further details are presented in Table 3.

Table 3. Comparison of Pathological Findings Detected on Computed Tomography According to Patients' Discharge and Hospitalization Status

Pathological findings on CT, n (%)	Discharge (n=112)	Ward (n=72)	ICU (n=65)	p value
Skull fracture	0 (0)	1 (1.4)	11 (16.9)	**<0.001[a]**
Intracranial hemorrhage	0 (0)	(0)	11 (16.9)	**<0.001[a]**
Orbital injury	0 (0)	3 (4.2)	2 (3.1)	0.074[a]
Maxillofacial injury	1 (0.9)	4 (5.6)	4 (6.2)	0.078[a]
Cervical spine injury	0 (0)	0 (0)	1 (1.5)	0.261[a]
Thoracal spine injury	0 (0)	0 (0)	1 (1.5)	0.261[a]
Lumbar spine fracture	0 (0)	0 (0)	3 (4.6)	**0.017[a]**
Rib fracture	1 (0.9)	2 (2.8)	10 (15.4)	**<0.001[a]**
Pneumothorax	0 (0)	1 (1.4)	10 (15.4)	**<0.001[a]**
Hemothorax	0 (0)	2 (2.8)	11 (16.9)	**<0.001[a]**
Cardiac injury	0 (0)	0 (0)	0 (0)	-
Scapular fracture	0 (0)	0 (0)	5 (7.7)	**0.001[a]**
Splenic injury	0 (0)	0 (0)	4 (6.2)	**0.004[a]**
Hepatic injury	0 (0)	0 (0)	5 (7.7)	**0.001[a]**
Renal injury	0 (0)	0 (0)	6 (9.2)	**<0.001[a]**
Urinary bladder injury	0 (0)	0 (0)	0 (0)	-
Hollow viscus injury	0 (0)	1 (1.4)	13 (20)	**<0.001[a]**
Pneumoperitoneum	0 (0)	1 (1.4)	19 (29.2)	**<0.001[b]**
Testicular or penile injury	1 (0.9)	5 (6.9)	1 (1.5)	**0.048[a]**
Pelvic fracture	0 (0)	0 (0)	7 (10.8)	**<0.001[a]**
Extremity bone fracture	22 (19.6)	39 (54.2)	22 (33.8)	**<0.001[b]**
Extremity arterial injury	0 (0)	7 (9.7)	17 (26.2)	**<0.001[b]**
Extremity venous injury	0 (0)	3 (4.2)	3 (4.6)	**0.042[a]**
Muscle and soft tissue injury	110 (98.2)	69 (95.8)	60 (92.3)	0.155[b]

[a] According to fisher exact test results, [b] According to qi-square test results, CT= Computer Tomography, ICU= Intensive Care Unit
-Three cases resulted in mortality in the emergency department
According to Post-hoc qi-square or fisher exact test results (with Bonferroni correction);
Skull fracture= ward-discharge (p=0.391); ward-ICU (p=0.003); discharge-ICU (p<0.001)
Intracranial hemorrhage= ward-discharge (-); ward-ICU (p<0.001); discharge-ICU (p<0.001)
Lumbar spine fracture= ward-discharge (p=1.000); ward-ICU (p=0.312); discharge-ICU (p=0.144)
Rib fracture= ward-discharge (p=0.562); ward-ICU (p=0.027); discharge-ICU (p<0.001)
Pneumothorax= ward-discharge (p=0.391); ward-ICU (p=0.009); discharge-ICU (p<0.001)
Hemothorax= ward-discharge (p=0.152); ward-ICU (p=0.015); discharge-ICU (p<0.001)
Scapular fracture= ward-discharge (-); ward-ICU (p=0.066); discharge-ICU (p=0.018)
Splenic injury= ward-discharge (p=1.000); ward-ICU (p=0.144); discharge-ICU (p=0.054)
Hepatic injury= ward-discharge (p=1.000); ward-ICU (p=0.066); discharge-ICU (p=0.018)
Renal injury= ward-discharge (p=1.000); ward-ICU (p=0.030); discharge-ICU (p=0.006)
Hollow viscus injury= ward-discharge (p=0.391); ward-ICU (p<0.001); discharge-ICU (p<0.001)
Pneumoperitoneum= ward-discharge (p=0.391); ward-ICU (p<0.001); discharge-ICU (p<0.001)
Testicular or penile injury= ward-discharge (p=0.105); ward-ICU (p=0.636); discharge-ICU (p=1.000)
Pelvic fracture= ward-discharge (-); ward-ICU (p=0.015); discharge-ICU (p<0.001)
Extremity bone fracture= ward-discharge (p<0.001); ward-ICU (p=0.051); discharge-ICU (p=0.105)
Extremity arterial injury= ward-discharge (p=0.003); ward-ICU (p=0.036); discharge-ICU (p<0.001)
Extremity venous injury= ward-discharge (p=0.174); ward-ICU (p=1.000); discharge-ICU (p=0.144)

Among the patients who presented to the emergency department following FI, 98 patients underwent surgical intervention, and in-hospital mortality occurred in 9 patients. When the injury sites of patients who underwent surgical intervention were analyzed, abdominal injuries were found to be significantly associated with surgical need (n = 26, 26.5%, p < 0.001). On the other hand, the presence of head (n = 5, 55.6%, p = 0.004), thoracic (n = 5, 55.6%, p = 0.002), and back injuries (n = 3, 33.3%, p = 0.039) was significantly associated with in-hospital mortality. In terms of laboratory findings, patients who required surgical intervention had significantly higher values of WBC (median 13.1 x10³/μL [10.0–17.3], p < 0.001), neutrophil count (median 7.70 x10³/μL [5.83–12.8], p = 0.004), platelet count (median 260 x10³/μL [230–312], p = 0.039), and INR (median 1.03 [0.99–1.09], p = 0.001), whereas hemoglobin (median 14.0 g/dL [12.7–15.5], p < 0.001), hematocrit (median 41.0 % [37.5–44.7], p < 0.001), albumin (median 40 g/L [38–44], p < 0.001), urea (median 29.5 mg/dL [22.0–34.0], p = 0.048), potassium (median 3.84 mmol/L [3.59–4.16], p = 0.015), and calcium (median 8.90 mg/dL [8.50–9.50], p < 0.001) levels were significantly lower. When examining the association between laboratory findings and in-hospital mortality, creatinine (median 1.0 mg/dL [1.0–1.2], p < 0.001) and INR (median 1.20 [1.14–1.28], p = 0.001) were significantly higher among non-survivors, while hemoglobin (median 12.2 g/dL [9.60–12.7], p = 0.002), hematocrit (median 36.1% [30.3–38.4], p = 0.002), albumin (median 33 g/L [30–38], p < 0.001), GFR (median 89 mL/min/1,73m² [59–101], p = 0.003), and calcium (median 8.4 mg/dL [8.0–8.8], p = 0.003) were significantly lower. Further details are provided in Table 4.

Table 4. Comparison of Demographic Characteristics, Region of Injury, and Laboratory Findings According to Patients' Surgical Intervention and in-Hospital Mortality Status

	Surgical intervention			In-hospital mortality		
	No (n=154)	Yes (n=98)	p value	No (n=243)	Yes (n=9)	p value
Age, year, median (IQR 25-75)	29 (24-43)	31 (25-46)	0.402[a]	29 (24-43.5)	37 (25-46)	0.446[a]
Sex, n (%)						
Male	144 (93.5)	92 (93.9)	0.906[b]	228 (93.8)	8 (88.9)	0.451[a]
Female	10 (6.5)	6 (6.1)		15 (6.2)	1 (11.1)	
Mode of ED presentation, n (%)						
Self-presented	30 (19.5)	8 (8.2)	**0.014[b]**	38 (15.6)	0 (0)	0.363[c]
Ambulance	124 (80.5)	90 (91.8)		205 (84.4)	9 (100)	
Region of Injury, n (%)						
Head	25 (16.2)	11 (11.2)	0.268[b]	31 (12.8)	5 (55.6)	**0.004[c]**
Neck	9 (5.8)	2 (2.0)	0.150[b]	9 (3.7)	2 (22.2)	0.053[c]
Vertebra	6 (3.9)	0 (0)	0.084[c]	6 (2.5)	0 (0)	1.000[c]
Thorax	15 (9.7)	17 (17.3)	0.077[b]	27 (11.1)	5 (55.6)	**0.002[c]**
Abdomen	11 (7.1)	26 (26.5)	**<0.001[b]**	34 (14.0)	3 (33.3)	0.131[c]
Back	13 (8.4)	10 (10.2)	0.658[b]	20 (8.2)	3 (33.3)	**0.039[c]**
Genital	3 (1.9)	4 (4.1)	0.315[c]	7 (2.9)	0 (0)	1.000[c]
Upper Extremity	31 (20.1)	20 (20.4)	0.957[b]	50 (20.6)	1 (11.1)	0.691[c]
Lower Extremity	111 (72.1)	63 (64.3)	0.192[b]	173 (71.2)	1 (11.1)	**<0.001[c]**
Laboratory Parameter, median (IQR 25-75)						
WBC (10³/μL)	10.9 (9.18-14.1)	13.1 (10.0-17.3)	**<0.001[a]**	11.8 (9.57-14.8)	20.1 (5.90-27.3)	0.324[a]
Neutrophil (10³/μL)	6.68 (5.25-9.27)	7.70 (5.83-12.8)	**0.004[a]**	6.92 (5.37-10.5)	12.7 (2.20-19.3)	0.475[a]
Lymphocyte (10³/μL)	2.83 (1.99-3.94)	3.45 (2.04-4.61)	0.074[a]	2.98 (2.01-4.28)	3.51 (3.09-4.96)	0.399[a]
Hemoglobin (g/dL)	15.0 (13.8-15.8)	14.0 (12.7-15.5)	**<0.001[a]**	14.7 (13.4-15.7)	12.2 (9.60-12.7)	**0.002[a]**
Hematocrit (%)	43.2 (40.3-45.8)	41.0 (37.5-44.7)	**<0.001[a]**	42.7 (39.0-45.4)	36.1 (30.3-38.4)	**0.002[a]**
Platelet (10³/μL)	250 (208-293)	260 (230-312)	**0.039[a]**	255 (220-299)	224 (132-237)	0.087[a]
Albumin (g/L)	43 (41-45)	40 (38-44)	**<0.001[a]**	43 (39-45)	33 (30-38)	**<0.001[a]**
BUN (mg/dL)	14 (12-17)	14 (10-16)	**0.032[a]**	14 (12-17)	15 (13-22)	0.160[a]
Ure (mg/dL)	30.0 (26.0-36.8)	29.5 (22.0-34.0)	**0.048[a]**	30 (25-36)	33 (27-46)	0.174[a]
Creatinine (mg/dL)	0.9 (0.7-1.0)	0.8 (0.7-1.0)	0.388[a]	0.9 (0.7-1.0)	1.0 (1.0-1.2)	**<0.001[a]**
GFR (mL/min/1,73m²)	111 (98-125)	111 (95.3-126)	0.874[a]	112 (98-126)	89 (59-101)	**0.003[a]**
Sodium (mmol/L)	138 (136-139)	138 (136-140)	0.895[a]	138 (136-140)	139 (137-140)	0.132[a]
Potassium (mmol/L)	3.99 (3.73-4.25)	3.84 (3.59-4.16)	**0.015[a]**	3.93 (3.70-4.22)	4.34 (3.93-4.83)	0.139[a]
Calcium (mg/dL)	9.50 (9.10-9.78)	8.90 (8.50-9.50)	**<0.001[a]**	9.4 (8.8-9.7)	8.4 (8.0-8.8)	**0.003[a]**
INR	1.02 (0.95-1.07)	1.03 (0.99-1.09)	**0.011[a]**	1.02 (0.96-1.07)	1.20 (1.14-1.28)	**0.001[a]**

[a] According to Mann-Whitney U test results, [b] According to qi-square test results, [c] according to fisher exacts test results, ED=Emergency Department, WBC= White blood cell, BUN= Blood Ure Nitrogen, GFH= glomerular filtration rate

When evaluating the relationship between pathological CT findings and the need for surgical intervention, the presence of pneumothorax (n = 9, 9.2%, p = 0.021), hemothorax (n = 10, 10.2%, p = 0.023), hepatic injury (n = 5, 5.1%, p = 0.034), renal injury (n = 6, 6.1%, p = 0.015), hollow viscus injury (n = 14, 14.3%, p < 0.001), pneumoperitoneum (n = 18, 20.4%, p < 0.001), pelvic fracture (n = 7, 7.1%, p < 0.001), extremity bone fracture (n = 55, 56.1%, p < 0.001), extremity arterial injury (n = 22, 22.4%, p < 0.001), and extremity venous injury (n = 5, 5.1%, p = 0.034) were found to be significantly associated with the need for surgical intervention. Regarding the association between pathological CT findings and in-hospital mortality, the presence of skull fracture (n = 5, 55.6%, p < 0.001), intracranial hemorrhage (n = 5, 55.6%, p < 0.001), rib fracture (n = 3, 33.3%, p = 0.009), pneumothorax (n = 5, 55.6%, p < 0.001), hemothorax (n = 5, 55.6%, p < 0.001), and pneumoperitoneum (n = 4, 44.4%, p = 0.004) were significantly associated with mortality. Further details are presented in Table 5.

When pathological CT findings were evaluated using logistic regression analysis, the presence of intracranial hemorrhage (OR 348.41 [95% CI: 2.86–8.84], p < 0.001), hemothorax (OR 66.94 [95% CI: 0.96–7.45], p = 0.011), and pneumoperitoneum (OR 24.06 [95% CI: 0.454–5.91], p = 0.022) were identified as independent predictors of in-hospital mortality. In predicting the need for surgical intervention, pneumoperitoneum (OR 30.55 [95% CI: 1.11–5.73], p = 0.004), extremity bone fracture (OR 10.13 [95% CI: 1.61–3.02], p < 0.001), and extremity arterial injury (OR 30.69 [95% CI: 1.85–5.00], p < 0.001) were found to be independent predictors. In predicting ICU admission, skull fracture (OR 106.83 [95% CI: 2.53–6.81], p < 0.001), pneumoperitoneum (OR 193.55 [95% CI: 3.17–7.36], p < 0.001), and extremity arterial injury (OR 28.18 [95% CI: 2.30–4.38], p < 0.001) emerged as independent predictors. Further details are provided in Table 6.

Table 5. Comparison of Pathological Findings Detected on Computed Tomography According to patients' Surgical Intervention and in-Hospital Mortality Status

Pathological findings on CT, n (%)	Surgical intervention			In-hospital mortality		
	No (n=154)	Yes (n=98)	p value	No (n=243)	Yes (n=9)	p value
Skull fracture	7 (4.5)	5 (5.1)	1.000[a]	7 (2.9)	5 (55.6)	**<0.001[a]**
Intracranial hemorrhage	7 (4.5)	4 (4.1)	1.000[a]	6 (2.5)	5 (55.6)	**<0.001[a]**
Orbital injury	1 (0.6)	4 (4.1)	0.077[a]	4 (1.6)	1 (11.1)	0.168[a]
Maxillofacial injury	5 (3.2)	4 (4.1)	0.739[a]	8 (3.3)	1 (11.1)	0.283[a]
Cervical spine injury	1 (0.6)	0 (0)	1.000[a]	1 (0.4)	0 (0)	1.000[a]
Thoracal spine injury	1 (0.6)	1 (1.0)	1.000[a]	1 (0.4)	1 (11.1)	0.070[a]
Lumbar spine fracture	1 (0.6)	3 (3.1)	0.302[a]	3 (1.2)	1 (11.1)	0.136[a]
Rib fracture	6 (3.9)	8 (8.2)	0.149[b]	11 (4.5)	3 (33.3)	**0.009[a]**
Pneumothorax	4 (2.6)	9 (9.2)	**0.021[b]**	8 (3.3)	5 (55.6)	**<0.001[a]**
Hemothorax	5 (3.2)	10 (10.2)	**0.023[b]**	10 (4.1)	5 (55.6)	**<0.001[a]**
Cardiac injury	0 (0.0)	0 (0.0)	-	0 (0.0)	0 (0.0)	-
Scapular fracture	1 (0.6)	4 (4.1)	0.077[a]	4 (1.6)	1 (11.1)	0.168[a]
Splenic injury	1 (0.6)	4 (4.1)	0.077[a]	4 (1.6)	1 (11.1)	0.168[a]
Hepatic injury	1 (0.6)	5 (5.1)	**0.034[a]**	5 (2.1)	1 (11.1)	0.198[a]
Renal injury	1 (0.6)	6 (6.1)	**0.015[a]**	6 (2.5)	1 (11.1)	0.227[a]
Urinary bladder injury	0 (0)	0 (0)	-	0 (0)	0 (0)	-
Hollow viscus injury	1 (0.6)	14 (14.3)	**<0.001[b]**	13 (5.3)	2 (22.2)	0.093[a]
Pneumoperitoneum	2 (1.3)	18 (20.4)	**<0.001[b]**	18 (7.4)	4 (44.4)	**0.004[a]**
Testicular or penile injury	3 (1.9)	4 (4.1)	0.436[a]	7 (2.9)	0 (0)	1.000[a]
Pelvic fracture	0 (0)	7 (7.1)	**0.001[a]**	6 (2.5)	1 (11.1)	0.227[a]
Extremity bone fracture	28 (18.2)	55 (56.1)	**<0.001[b]**	82 (33.7)	1 (11.1)	0.279[a]
Extremity arterial injury	2 (1.3)	22 (22.4)	**<0.001[b]**	24 (9.9)	0 (0)	1.000[a]
Extremity venous injury	1 (0.6)	5 (5.1)	**0.034[a]**	6 (2.5)	0 (0)	1.000[a]
Muscle and soft tissue injury	147 (95.5)	94 (95.9)	0.861[b]	234 (96.3)	7 (77.8)	0.053[a]

[a] According to fisher exacts test results, [b] According to qi-square test results

Table 6. Evaluation of the Association Between Pathological Computed Tomography Findings and Intensive Care Unit Admission, Surgical Intervention, and in-Hospital Mortality Using Binary Logistic Regression Analysis				
	Univariate Analysis		Multivariate Analysis	
	OR (%95 CI)	P value	OR (%95 CI)	P value
In-hospital mortality				
Intracranial hemorrhage	49.38 (2.36-5.44)	<0.001	348.41 (2.86-8.84)	<0.001
Skull fracture	42.14 (2.23-5.26)	<0.001		
Thoracal spine injury	30.25 (0.55-6.27)	0.019		
Rib fracture	10.55 (0.84-3.87)	0.002		
Pneumothorax	36.72 (2.11-5.09)	<0.001		
Hemothorax	29.13 (1.91-4.83)	<0.001	66.94 (0.96-7.45)	0.011
Pneumoperitoneum	10.00 (0.90-3.70)	0.001	24.06 (0.454-5.91)	0.022
Surgical intervention				
Pneumothorax	3.79 (0.13-2.54)	0.030		
Hemothorax	3.39 (0.11-2.33)	0.031		
Renal injury	9.98 (0.17-4.43)	0.035		
Hollow viscus injury	25.5 (1.19-5.29)	0.002		
Pneumoperitoneum	19.48 (1.49-4.45)	<0.001	30.55 (1.11-5.73)	0.004
Extremity bone fracture	5.76 (1.18-2.32)	<0.001	10.13 (1.61-3.02)	<0.001
Extremity arterial injury	22.0 (1.62-4.56)	<0.001	30.69 (1.85-5.00)	<0.001
Intensive Care Unit				
Skull fracture	37.28 (1.55-5.68)	<0.001	106.83 (2.53-6.81)	<0.001
Rib fracture	10.97 (1.07-3.72)	<0.001		
Pneumothorax	33.27 (1.43-5.58)	<0.001		
Hemothorax	18.54 (1.58-4.46)	<0.001		
Hollow viscus injury	45.75 (1.77-5.88)	<0.001		
Pneumoperitoneum	75.59 (2.29-6.36)	<0.001	193.55 (3.17-7.36)	<0.001
Extremity arterial injury	8.96 (1.26-3.13)	<0.001	28.18 (2.30 -4.38)	<0.001

Intensive Care Unit; qi-square= 137, $p < 0.001$, Nagelkerke $R^2 = 0.620$
Surgical intervention; qi-square= 121, $p < 0.001$, Nagelkerke $R^2 = 0.518$
In-hospital mortality; qi-square= 46.4, $p < 0.001$, Nagelkerke $R^2 = 0.634$
OR= Odds ratio, CI= Confidence Interval

DISCUSSION

In this study, among patients presenting to the emergency department with FI, extremity injuries were the most frequently observed, whereas back, head, and thoracic injuries were the most strongly associated with in-hospital mortality. Among the pathological findings detected on CT imaging, pneumoperitoneum was identified as the most significant finding associated with all three outcomes: in-hospital mortality, ICU admission, and the need for surgical intervention. Additionally, intracranial hemorrhage and hemothorax were other key findings associated with mortality, while skull fractures and extremity arterial injuries were strongly associated with ICU admission.

Extremity injuries were the most frequent injuries observed in FI cases, thoracoabdominal injuries rank second in frequency (3). In line with the literature, our study found extremity injuries to be the most common, followed by abdominal injuries.

The ability to predict patient prognosis based on CT findings can substantially enhance clinical decision-making and management in both the emergency department and subsequent care phases. In particular, CT plays a crucial role in determining the prognosis and management of patients who are clinically stable at presentation. The findings obtained from CT are essential in guiding decisions regarding hospital admission vs. discharge, as well as operative vs. non-operative management (76–11). Identifying which specific injuries are associated with increased mortality and surgical intervention needs can undoubtedly support more meticulous monitoring and management of such patients in overcrowded emergency departments (12).

Pneumoperitoneum is one of the most frequently observed findings following abdominal FI (13). In a study investigating the effectiveness of non-operative management in patients with FI, the presence of pneumoperitoneum on CT was found to be closely associated with failure of non-operative follow-up (14). In our study, the detection of pneumoperitoneum on CT imaging in patients with FI was significantly associated with in-hospital mortality, ICU admission, and the need for surgical intervention. Given this association with higher mortality, patients presenting to the emergency department with abdominal FI and pneumoperitoneum detected on CT should be promptly evaluated for surgical management.

Another CT finding that was strongly associated with mortality in our study was intracranial hemorrhage. In a previous study conducted in an intensive care setting, intracranial injuries and hemorrhages were identified as the most critical factors contributing to mortality in FI patients. Similarly, 57.5% of patients who died in the ICU in that study were reported to have intracranial hemorrhage, consistent with the findings of our study (15).

In addition, hemothorax was also found to be significantly associated with in-hospital mortality in our cohort. Hemothorax occurs in approximately 60% of patients with thoracic trauma and is responsible for an estimated 15–30% of trauma-related deaths (16). In another study, hemothorax was detected in 77.5% of patients who presented with penetrating thoracic trauma (17). Furthermore, increased hemothorax volume has been associated with longer ICU stays (16). In our study, the presence of hemothorax was identified as an independent predictor of in-hospital mortality, and it was also significantly associated with both ICU admission and the need for surgical intervention.

When further evaluating the results of our study, several laboratory parameters were found to be statistically associated with ICU admission, the need for surgical intervention, and in-hospital mortality. However, despite statistical significance, none of these parameters reached a level of clinical significance. Therefore, based on the findings of our study, relying solely on laboratory values to guide decisions regarding surgical intervention or ICU admission does not appear to be appropriate.

Limitations of the Study

Our study has several limitations. First, it was designed as a retrospective study, and therefore inherently carries the typical limitations associated with retrospective designs. Another important limitation is that only patients who underwent CT imaging were included in the study. As a result, the included cohort consisted of patients who were clinically stable enough to undergo CT scanning. Consequently, the findings of this study do not provide information about patients who were too unstable to receive CT imaging.

CONCLUSION

In conclusion, among patients presenting to the emergency department following FI, the pathological CT findings most strongly associated with in-hospital mortality were pneumoperitoneum, intracranial hemorrhage, and hemothorax. Clinicians should be aware of the prognostic significance of CT findings when managing patients with FI in the emergency setting and should incorporate these findings into their decision-making processes for patient management and follow-up.

Ethics Committee Approval: This study was approved by the Research Ethics Committee of the Faculty of Medicine at Hitit University on March 12, 2025 (decision number=2025-42).

Author Contributions: Concept: SG and YY, Design: SG, AÖ and ATK, Supervision: SG, SK and YY, Resources: ATK, AÖ and SK, Materials: AÖ and EK, Data Collection and/or Processing: SG, AÖ, EK and ATK, Analysis and/or Interpretation: SG and EK, Literature Search: SG, AÖ, ATK and SK, Writing Manuscript: SG and YY, Critical Review: SG, AÖ, EK, ATK, SK and YY

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REFERENCES

1. Naghavi M, Marczak LB, Kutz M, Shackelford KA, Arora M, Miller-Petrie M, et al. Global Mortality From Firearms, 1990-2016. JAMA. 2018;320:792-814.
2. Hartman HA, Seewald LA, Stallworth P, Lee DB, Zimmerman MA, Ehrlich PF, et al. Firearm possession among emergency department youth and young adults: A latent class analysis. Prev Med. 2025;190:108183.
3. Özkan A, Ferhatlar E, Algin A. Firearm violence and the 'reopening phenomenon' in Turkey. Injury. 2024;55:111962.
4. Naeem M, Hoegger MJ, Petraglia FW 3rd, Ballard DH, Zulfiqar M, Patlas MN, et al. CT of Penetrating Abdominopelvic Trauma. Radiographics. 2021;41:1064-81.
5. Gopireddy DR, Kee-Sampson JW, Vulasala SSR, Stein R, Kumar S, Virarkar M. Imaging of penetrating vascular trauma of the body and extremities secondary to ballistic and stab wounds. J Clin Imaging Sci. 2023;13:1.
6. Pinto A, Russo A, Reginelli A, Iacobellis F, Di Serafino M, Giovine S, et al. Gunshot Wounds: Ballistics and Imaging Findings. Semin Ultrasound CT MR. 2019;40:25-35.
7. Mansor S, Bendardaf R, Issa Y, Moftah M. The impact of urgent computed tomography angiography for gunshot wounds in extremities with concomitant vascular injuries on diagnosis and postoperative outcomes. Vascular. 2018;26:600-7.
8. Singh N, Hardcastle TC. Selective non operative management of gunshot wounds to the abdomen: a collective review. Int Emerg Nurs. 2015;23:22-31.
9. Melo EL, de Menezes MR, Cerri GG. Abdominal gunshot wounds: multi-detector-row CT findings compared with laparotomy: a prospective study. Emerg Radiol. 2012;19:35-41.
10. Jeffery AJ, Rutty GN, Robinson C, Morgan B. Computed tomography of projectile injuries. Clin Radiol. 2008;63:1160-6.
11. Mansour A, Badillo-Goicoechea E, Alvarado-Dyer R, Pasternak O, Nguyen HTN, Fakhri F, et al. Brain Imaging Features in Patients with Gunshot Wounds to the Head. J Neurotrauma. 2025;42:689-99.
12. Dilip M, Su H, Zhang W, Meng L, Tuffuor K, Pham L, et al. Load leveling as a strategy to enhance emergency department throughput. Am J Emerg Med. 2025;98:207-12.
13. Martin MJ, Brown CVR, Shatz DV, Alam H, Brasel K, Hauser CJ, et al. Evaluation and management of abdominal gunshot wounds: A Western Trauma Association critical decisions algorithm. J Trauma Acute Care Surg. 2019;87:1220-7.

14. Obadiel YA, Albrashi A, Allahabi N, Sharafaddeen M, Ahmed F. Outcomes of Nonoperative Management of Penetrating Abdominal Trauma Injury: A Retrospective Study. Cureus. 2024;16:e58599.

15. Rougerie L, Charbit J, Mezzarobba M, Leone M, Duclos G, Meaudre E, et al. Epidemiology of civilian's gunshot wound injuries admitted to intensive care unit: A retrospective, multi-center study. Injury. 2024;55:111735. doi: 10.1016/j.injury.2024.111735.

16. Kithuka CM, Ntola VC, Sibanda W. An audit of traumatic haemothoraces in a regional hospital in KwaZulu-Natal, South Africa. S Afr J Surg. 2023;61(3):12-6. doi: 10.36303/sajs.3986

17. de Melo ASA, Moreira LBM, Pessoa FMC, Saint-Martin N, Ancilotti Filho R, Souza AS Jr, et al. Tomographic aspects of penetrating thoracic trauma: injuries from firearms and other weapons. Radiol Bras. 2017;50:372-7. doi: 10.1590/0100-3984.2016.0167.