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RESEARCH ARTICLE **OPEN ACCESS**

Investigation of Cardiac Injuries, Including Contusions, in Patients with Blunt Chest Trauma

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Abstract:

Introduction: Blunt cardiac injury (BCI) is a critical yet underdiagnosed condition in patients with blunt chest trauma, often leading to significant morbidity and mortality. Despite its clinical importance, there is a lack of standardized diagnostic criteria, making early identification and management challenging. This study aimed to investigate the incidence, associated factors, and outcomes of BCI in patients with blunt chest trauma, addressing a significant research gap in trauma care.

Methods: This retrospective observational study included 180 patients with blunt chest trauma from 2020 to 2021. Data on age, sex, cause of trauma (*e.g.*, car accidents, motorcycle accidents, falls), and clinical outcomes were collected. BCI was diagnosed based on elevated troponin levels, echocardiographic findings, or CT imaging. Injury Severity Scores (ISS), length of hospital stay, and mortality rates were also recorded.

Results: Among 180 patients, BCI was diagnosed in 13.3% (n=24). There was no significant difference in age, sex, or mechanism of trauma between patients with and without BCI. Motorcycle accidents were the most common cause of BCI (66.7%). Patients with BCI had significantly higher mortality rates (20.8% *vs*. 7.1%, P<0.01) and higher ISS scores (35.37 *vs*. 32.14, P<0.05) compared with those without BCI. Pulmonary contusion was significantly more prevalent in BCI patients (70.8% *vs*. 39.7%, P<0.01).

Discussion: BCI in patients with blunt chest trauma is associated with higher mortality, greater injury severity, and an increased incidence of pulmonary contusion.

Conclusion: These findings underscore the need for early and accurate diagnosis of BCI using troponin levels and imaging, as well as tailored management strategies to improve outcomes.

Keywords: Cardiac contusion, blunt chest trauma, BCI, mortality, trauma.

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1. INTRODUCTION

Blunt chest trauma is a diagnostic and therapeutic clinical challenge, often accompanied by significant cardiac injury [1]. If not identified and treated promptly,

serious complications or even death due to myocardial rupture may occur [2].

In cases of cardiac injury, there can be an elevation in cardiac enzymes, electrocardiographic abnormalities, and impaired contractile function [3]. These clinical manifestations often overlap with those seen in acute myocardial infarction, making accurate diagnosis a complex task [4].

Blunt Cardiac Injury (BCI) refers to a spectrum of cardiac injuries resulting from non-penetrating chest trauma, including myocardial contusion, valve rupture, and other structural or functional impairments [5]. The term 'cardiac contusion' specifically describes myocardial hemorrhage, necrosis, and edema, often confirmed through histopathological examination during surgery or post-mortem [6]. Clinically, BCI is the preferred term as it encompasses a broader range of injuries caused by blunt trauma [7].

BCI often occurs as a result of severe blunt trauma, most commonly associated with motor vehicle accidents (51%), followed by pedestrian collisions with motor vehicles (35%), motorcycle accidents (9%), and falls from heights (6%) [8]. Diagnosing BCI can be challenging due to the absence of a universally accepted gold-standard diagnostic test, and this challenge is heightened when dealing with polytrauma patients [9, 10].

The reported incidence of cardiac injuries following blunt thoracic trauma varies from 8% to 76%, largely due to the lack of standardized diagnostic criteria [11]. Diagnostic methods for assessing cardiac trauma include a range of techniques, among which cardiac computed tomography (CT) plays a significant role in providing valuable insights into cardiac injuries [12, 13]. Other common diagnostic methods for BCI include clinical findings or surgery, electrocardiogram (ECG), cardiac troponin I or T, and cardiac imaging, such as transthoracic echocardiography (TTE) or transesophageal echocardiography (TOE) [14]. Screening for BCI often involves obtaining serum troponin levels and an Electrocardiogram (ECG) for patients diagnosed with a sternal fracture [15]. A combination of these methods may be necessary for accurate diagnosis [16]. Cardiac troponin levels are increasingly used as a diagnostic tool for patients suspected of having BCI [17].

Given the limited existing studies on cardiac trauma in Iran, particularly in the context of blunt chest trauma, this study was conducted to address the critical gap in local data [18]. By investigating cardiac injuries and contusions in patients with blunt chest trauma, we aim to expand upon the diagnostic findings and background knowledge available in this area [19]. Diagnosing blunt cardiac injury remains challenging due to the lack of established diagnostic criteria [20, 21]. To address this, we examined factors associated with BCI using data from the Japan Trauma Data Bank (JTDB) in a multicenter observational study [22].

2. METHODS

In this retrospective observational study, the medical records of 180 patients with blunt chest trauma who were hospitalized were obtained. Ethical approval was obtained from the Ethics Committee of Alborz University of Medical Sciences (code: 1400.151.IR.ABZUMS.REC) for the period from 2020 to 2021.

The inclusion criteria for this study were patients aged ≥18 years with blunt chest trauma, either isolated or combined with other injuries. Patients with prior cardiac conditions were not explicitly excluded. However, the diagnosis of BCI was based on acute findings (*e.g.*, elevated troponin levels, ECG abnormalities, or echocardiographic evidence) that were directly attributable to the traumatic event, minimizing the potential confounding effect of pre-existing cardiac conditions.

The severity of the injuries was calculated using the Injury Severity Score (ISS) online at https://www.mdcalc.com/injury-severity-score-iss.

The diagnosis of BCI was confirmed using a combination of serum troponin levels (T or I) above the 99th percentile, measured within 12 hours of trauma, along with at least one of the following criteria:

1. Clinical findings indicative of pericardial rupture, heart herniation, or central tendon rupture.

2. Hypotension requiring inotropic support, not explained by other types of shock.

3. ECG abnormalities consistent with diffuse heart damage.

4. Transthoracic echocardiography findings indicative of non-penetrating cardiac injury.

All patients included in the study were screened with troponin testing and ECG. Echocardiography was performed selectively based on clinical suspicion or abnormal findings in troponin levels or ECG. This approach was chosen to balance diagnostic accuracy with resource utilization.

2.1. Sample Size Estimation

The sample size was estimated to be 180 individuals based on similar studies [5], considering a confidence interval of 95%, an error coefficient of 0.05, and a power of 80%, using the sample size determination formula (1) [5].

$$n = (Z1-\alpha/2 \times \delta)2 \mid d\ [5] \quad (1)$$

n=numbers, Z1-a2 = standard deviation, ð= Frequency variation, d= mean error

2.2. Data Analysis

Statistical analysis was performed using SPSS v24 (IBM, Chicago, IL). Qualitative data were compared using the Chi-square and Fisher's exact tests, while quantitative data were analyzed using the independent t-test and the Mann-Whitney test. A 2-sided p-value of less than 0.05 was considered statistically significant.

2.3. Diagnostic Imaging

Pulmonary contusions were diagnosed using chest X-rays and/or CT scans, with findings such as patchy consolidation, ground-glass opacities, and hemorrhage confirming the diagnosis.

3. RESULTS

In the present study, a total of 180 patients with non-penetrating chest trauma were examined. The mean age of the patients was 40.9 years (standard deviation, SD=12.3), and the minimum, maximum, and median ages were 18, 79, and 39 years old, respectively. Among the patient population, 138 individuals (76.7%) were males, and 42 patients (23.3%) were females.

Regarding the cause of trauma, out of 180 patients, 120 patients (66.7%) were involved in motorcycle accidents, 37 patients (20.6%) experienced car accidents, 16 patients (8.9%) fell from a height, and 7 patients (3.9%) sustained trauma from other causes (Table 1).

In terms of diagnosis, a total of 24 patients (13.3%) were identified as having BCI. The mean age of patients did not exhibit significant differences based on BCI diagnosis. Patients' sex frequency was compared based on the BCI diagnosis, which did not show a statistically significant difference between them using the Fisher exact test.

The severity of trauma mechanism was compared between patients with and without BCI diagnosis, and there was no significant difference in Fisher's exact test between the two groups. Furthermore, the average length of hospital stay did not exhibit a significant difference based on BCI diagnosis.

Patients with BCI exhibited a significantly higher mean ISS compared with those without BCI (Table 1; p=0.027). The mean ISS for patients without BCI was 32.1 (SD=5.4), whereas for patients with BCI, it was 35.4 (SD=5.4) (Table 1).

When evaluating the mortality rate, patients diagnosed with BCI (20.8%) exhibited a significantly (p=0.044) higher mortality rate than those without BCI (7.1%) as determined by Fisher's exact test (Table 1).

Additionally, the comparison of findings accompanying the patients based on BCI diagnosis in (Table 2) revealed a statistically significant difference only in the case of pulmonary contusion. Thus, the incidence of pulmonary contusion was found to be significantly higher in patients with BCI (70.8%) than in those without BCI (39.7%) (p=0.007).

Table 1. Comparison of patient characteristics based on blunt cardiac injury (BCI) diagnosis, including mean age, gender frequency, trauma mechanism frequency, mean hospital stay duration, mean injury severity score (ISS), and frequency of death.

Variable				
BCI	**No**	**Yes**	**Statistical test**	**p**
Age (yr)	40.6 ± 13.0	43.2 ± 13.8	Independent-t	0.320
ISS	32.14 (5.42)	35.37 (5.43)	Mann-Whitney	0.027
	Number (%)			
Male	122 (78.2%)	16 (66.7%)	Fisher’s exact	0.298
Female	**34(21.8%)**	**8(33.3%)**		
Cause				
Car accident	33 (22.1%)	4 (16.7%)	Fisher’s exact	0.974
Motorcycle accident	103 (66%)	17 (70.8%)		
Fall from a height	14 (9%)	2 (8.3%)		
Other	6 (3.8%)	1 (4.2%)		
Duration of hospital stay (days)	11.1 (2.0)	11.9 (2.4)	Mann-Whitney	0.108
Death				
No	145 (92.9%)	19 (72.9%)	Fisher’s exact	0.04
Yes	11 (7.1%)	5 (20.8%)		

Table 2. Comparison of the frequency of death in patients according to the diagnosis of BCI.

Findings	Diagnostic Aids	BCI Number (%)		Statistical test	P
		No	Yes		
Pulmonary contusion	Chest X-ray, CT scan	62 (39.7%)	17 (70.8)	Fisher’s exact	0.007
Rib fracture	Chest X-ray	44 (28.2%)	8 (33.3%)	Fisher’s exact	0.632
Flail chest	Chest X-ray, CT scan	10 (6.4%)	4 (16.7%)	Fisher’s exact	0.097
Sternal fracture	Chest X-ray	3 (1.9%)	2 (8.3%)	Fisher’s exact	0.133
Troponin T (TAT)	Troponin T measurement	8 (5.1%)	8 (5.1%)	Fisher’s exact	0.625

4. DISCUSSION

The primary objective of the present study was to investigate the incidence of cardiac injuries, including cardiac contusion, in patients with blunt chest trauma. Our findings revealed a 13.3% incidence of BCI, consistent with previous studies reporting rates ranging from 8% to 76%. This variability underscores the lack of standardized diagnostic criteria and highlights the need for harmonized protocols.

These findings are consistent with a study by Gao *et al.* [23], which reported an 18.3% incidence of BCI in a single-center study. Conversely, Gregorian *et al.* [24] reported a much lower prevalence (0.3%), likely due to differences in diagnostic criteria and sample size limitations. Skinner *et al.* [5] found a 50% incidence, further illustrating the wide variability in BCI diagnosis across studies.

The present study identified motorcycle accidents as the predominant cause of trauma among BCI patients, contrasting with prior research where motor vehicle accidents and pedestrian collisions were more common [25]. This discrepancy may reflect regional differences, such as higher motorcycle usage in our study population [1, 26]. Future studies should explore these variations to better understand the epidemiology of BCI.

Interestingly, we found no significant association between BCI and rib or sternal fractures, a finding consistent with the results of a study by Skinner *et al.* [5], but inconsistent with those of Gregorian *et al.* [24], who reported a strong link between BCI and sternal fractures. This inconsistency may be due to our study's limited sample size. Therefore, larger, multicenter studies are needed to clarify these relationships.

The higher ISS and mortality rates in BCI patients compared with non-BCI patients align with findings from studies by Skinner *et al.* [4] and Gao *et al.* [23], suggesting that BCI is associated with a poorer prognosis. These findings underscore the need for early diagnosis and intervention in blunt chest trauma cases.

While our study did not explicitly address troponin screening, the clinical implications of such screening warrant further investigation. Troponin levels could serve as a valuable diagnostic tool for identifying BCI in high-risk patients, potentially improving outcomes [27-29].

In the study by Ahmadinejad *et al.*, a significant association was reported between cardiac injury and sternal fracture displacement greater than 5 cm [30]. In the present study, sternal fracture displacement was more common in patients with cardiac injury than in those without, although this difference was not statistically significant. This could be due to the limited sample size in the present study and the low incidence of sternal fractures. Therefore, multicenter studies in this area are recommended.

However, this limitation was mitigated through a comprehensive review of patients' electronic medical records, ensuring the accuracy and reliability of the data collected.

Future research should evaluate the efficacy of routine troponin screening in blunt chest trauma cases.

CONCLUSION

The findings of the present study indicate that non-penetrating cardiac injury (NCI) in patients with blunt chest trauma is associated with higher mortality rates and more severe injuries. The most common accompanying finding in these patients was pulmonary contusion, highlighting the need for further research to explore this association in greater detail.

A significant limitation of this study was the reliance on hospital records rather than direct patient access. The findings reported in this study underscore the importance of early diagnosis and management of NCI in blunt chest trauma patients to improve outcomes. Further studies are recommended to validate these findings and explore additional factors influencing mortality and injury severity in this patient population.

AUTHORS' CONTRIBUTIONS

The authors confirm their contribution to the paper as follows: draft manuscript: SM and MA; conceptualization: MA; validation: YA and AS; investigation: IA; data curation: AS. All authors reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

BCI	=	Blunt cardiac injury
ISS	=	Injury Severity Score
CT	=	Computed tomography
TTE	=	Transthoracic echocardiography
TOE	=	Transesophageal echocardiography
ECG	=	Electrocardiogram
CI	=	Confidence interval
NCI	=	Non-penetrating cardiac injury
JTDB	=	Japan Trauma Data Bank

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the ethics committee of Alborz University of Medical Sciences (code: 1400.151.IR.ABZUMS.REC).

HUMAN AND ANIMAL RIGHTS

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from each participant.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

All relevant data and materials are provided within the manuscript.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

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