ORIGINAL ARTICLE

Attention: Cardiac contusion

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ABSTRACT

BACKGROUND: The objective of the study is to investigate diagnostic and clinical processes performed for cardiac contusion in patients with blunt thoracic trauma.

METHODS: This study was conducted retrospectively on 65 patients admitted with isolated blunt thoracic trauma to the Emergency Medicine Department. The CT images, the cardiac enzyme levels, the periodic 4-h follow-up electrocardiography (ECGs) in the emergency department, and the results of echocardiography, performed at admission and when required according to the clinical status, were investigated. The 1-h and 4-h high-sensitivity troponin I levels were studied, and values above 0.04 ng/ml were considered as positive.

RESULTS: Sixty-five patients with isolated thoracic trauma were included in the study, 23 (35.38%) had pulmonary and cardiac contusions both. In 23 (35.38%) patients, pulmonary contusion had been present, and cardiac contusion had not been identified at the initial evaluation. However, during clinical follow-up, troponin became positive, dysrhythmia developed, and the trauma affected the heart in four of these patients. In six (9.24%) patients, cardiac contusion was identified without pulmonary contusion. In 13 (20%) patients, no cardiac or pulmonary contusion was identified. troponin elevation was detected in 10 patients without a diagnosis of cardiac contusion who had a pulmonary contusion, hemothorax, and/or pneumothorax at the time of hospital admission and then with normal troponin levels at 4-h control. We found that there was a statistical agreement between cardiac contusion and troponin-ECG results at 4th h.

CONCLUSION: We advise that all blunt thoracic trauma patients should be screened for cardiac contusion by continuous ECG monitoring and troponin levels.

Keywords: Cardiac contusion; dysrhythmia; trauma; troponin.

INTRODUCTION

Blunt thoracic injuries can occur because of traffic accidents, falling from high places, occupational accidents, and crush injuries of the thoracic wall. Injuries of the heart, large vessels, and esophagus can occur besides pulmonary and thoracic wall injuries with the effect of direct compression of the chest wall. A cardiac injury can occur because of direct trauma of the fractured bones, compression between the sternum and vertebral column, opposite forces of acceleration origin, and hydraulic impact.[1]

Thoracic trauma is responsible for approximately 25% of trauma-related death.[2,3] Studies have shown that the rate of blunt cardiac injury varied between 20% and 76% in blunt thoracic trauma.[2,4,5] Cardiac contusion was identified with a rate of 16% in autopsy studies conducted in sudden deaths following blunt thoracic trauma and with a rate of 76% in clinical studies.[6]

No definitive, gold standard test for diagnosing cardiac contusion is present in emergency departments. Physical examination, serum troponin level, chest radiography, computed tomographic (CT) imaging, cardiac scintigraphy, radionuclide angiography, electrocardiography (ECG), and echocardiography (ECHO) are the methods used for diagnosis.[7] However, a cardiac contusion is a difficult-to-diagnose clinical condition. Unfortunately, neither a diagnostic test with high specificity and sensitivity nor a consensus on this subject is present. Troponin positivity could be seen with various traumatic con-

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ditions, by this way cardiac contusion may be misdiagnosed or underestimated. In our cases, we excluded multitrauma patients and investigated only isolated thoracic trauma patients without any other trauma components to show the effect of serial cardiac enzyme measurements together with ECG and ECHO. The aim of our study was to investigate diagnostic and clinical processes performed for cardiac contusion in patients with blunt thoracic trauma.

MATERIALS AND METHODS

This study was conducted retrospectively on 65 patients admitted with isolated blunt thoracic trauma to the Emergency Medicine Department of a tertiary university hospital between January 1st, 2017, and January 1st, 2018. Data were retrieved from the Hospital Automation System and the patient charts. Ethic approval was obtained from the university ethics committee (Accept number: 21/02/2020//20.478.486).

Patients aged over 18 years who had only thoracic trauma without any multitrauma component, in whom CT imaging was performed, and cardiac enzyme level was investigated, were included in the study. Patients admitted with multiple trauma, penetrating thoracic trauma, and cardiac disorder history was excluded from the study. In patients with multiple admissions, only the first admission was evaluated. The CT images of the patients in the Hospital Automation System, the cardiac enzyme levels, the periodic 4-h follow-up ECGs in the Emergency Department, and the results of ECHO, performed at admission and when required according to the clinical status, were investigated. The 0-h and 4-h high-sensitivity troponin I levels were studied, and values above 0.04 ng/ml were considered as positive.

Number Cruncher Statistics System 2007 (Kaysville, Utah, USA) program was used for statistical analysis. Descriptive methods (mean, standard deviation, median, frequency, rate, minimum, maximum) were used when evaluating the study values. Quantitative assessment normal distribution compatibility was tested by the Shapiro-Wilk test and graphical evaluations. Pearson Chi-Square test, Fisher's Full test, and Mc Nemar fit test were used for comparison in the qualitative map. Significance $p<0.05$ evaluation was evaluated.

RESULTS

Sixty-five isolated blunt thoracic trauma patients, in whom CT imaging and ECG were performed, and cardiac enzyme level was investigated, were included in the study. Multi-trauma (1897 patients), penetrating thoracic trauma (407 patients), and patients with known cardiac comorbidities (38 patients) were excluded from the study. All patients were followed-up with non-invasive cardiac monitoring in the emergency department. Fifteen (23.1%) of 65 patients were female, and 50 (76.9%) were male. The mean age was 40.18±17.68 years (Table 1).

Of 65 patients with isolated thoracic trauma included in the study, 8 (12.30%) were admitted for non-vehicle traffic accident, 21 (33.20%) for in-vehicle traffic accident, 3 (3.7%) for falling down from the height, and 33 (50.8%) for compression-crushing. We observed 13 pneumothorax, nine hemothorax, 19 hemopneumothorax, 46 rib fractures, and 25 sternal fractures.

Both cardiac and pulmonary contusions were observed in 23 patients. (35.38%) In 23 (35.38%) patients, pulmonary contusion had been present, and cardiac contusion had not been identified at the initial evaluation. However, during clinical follow-up, troponin became positive, dysrhythmia developed, and the trauma affected the heart in four of these patients. In six (9.24%) patients, cardiac contusion was identified without pulmonary contusion. In 13 (20%) patients, no cardiac or pulmonary contusion was identified (Table 2).

There was no significant association between pulmonary contusion and cardiac contusion ($p>0.05$). There was no significant association between sternal fracture, anterior rib fracture, sternal + anterior rib fracture, and cardiac contusion ($p>0.05$).

Table 1. Distribution of descriptive properties

	n (%)
Age[year)	
Min-Max (Median)	18–88 (40)
Mean±Standard deviation	40.18±17.68
Gender	
Female	15 (23.1)
Male	50 (76.9)
Cardiac contusion	29 (44.6)
Pulmonary contusion	46 (70.8)
Rib fracture	46 (70.8)
Sternal fracture	25 (38.5)
Anterior rib fracture	3 (4.6)
Hemothorax	9 (13.8)
Pneumothorax	13 (20.0)
Hemopneumothorax	19 (29.2)
Troponin at 0 hour (+)	29 (44.6)
Troponin at 4th hour (+)	23 (35.4)
Electrocardiography 0. hour (+)	29 (44.6)
Electrocardiography 4. hour (+)	23 (35.4)
Echocardiography (+)	10 (15.4)
Evaluation result	
Service follow-up	22 (33.8)
Intensive care follow-up	23 (35.4)
Discharge	20 (30.8)

Table 2. Cardiac contusion related traumatic conditions

	Cardiac contusion (-) (n=36)	Cardiac contusion (+) (n=29)	
Pulmonary contusion			
No	13 (68.4)	6 (31.6)	[a]0.174
Yes	23 (50.0)	23 (50.0)	
Sternal fracture			
No	23 (57.5)	17 (42.5)	[a]0.664
Yes	13 (52.0)	12 (48.0)	
Anterior rib fracture			
No	35 (56.5)	27 (43.5)	[b]0.582
Yes	1 (33.3)	2 (66.7)	
Sternal+Anterior rib fracture			
No	36 (57.1)	27 (42.9)	[b]0.195
Yes	0 (0)	2 (100)	

[a]Pearson Chi-Square Test; [b]Fisher's Exact Test.

During the clinical follow-up of 23 patients, cardiac rhythm abnormalities were detected in four patients with a pulmonary contusion in whom troponin value was negative at admission, and no ECG finding was present. In the ECG taken because of dysrhythmia, sinus tachycardia was present. An increased level of 4-h high-sensitive troponin I was also identified. In two of these patients, increased echogenicity around the right ventricle and a pericardial effusion varying between 1 cm and 1.5 cm in thickness were discovered in the ECHO investigation. In three of these four patients, isolated sternal fracture and pulmonary contusion were present. The remaining one patient had hemopneumothorax, fractures of the left anterior ribs, and pulmonary contusion. The other 19 patients were clinically followed-up with non-invasive cardiac monitoring. Twelve patients in whom the serial high-sensitive troponin values were below 0.04 ng/ml. and abnormalities of neither ECG nor ECHO findings were present were hospitalized for follow-up, and seven patients with only minimal pulmonary contusion and/or a single non-displaced rib fracture were discharged to follow-up with treatment advice.

During clinical follow-up of 23 patients with pulmonary contusion and an increased admission high-sensitive troponin I level, it was observed that the elevation of 4-h high-sensitive troponin I continued in 13 patients, whereas in ten patients it became negative. ECHO revealed minimal pericardial fluid around the posterior wall in five patients. In the ECG investigation of 13 patients with a cardiac contusion, premature ventricular contractions were identified in six patients, and supraventricular tachycardia in seven patients. No abnormal ECG finding was present in ten patients.

Persisting elevation of the 4-h high-sensitive troponin level, and with signs in ECG revealing that the heart was affected following blunt thoracic trauma were thought to have cardiac contusion, and all were admitted to the intensive care unit for follow-up of cardiac dysrhythmia and contusion. During the intensive care follow-up, ST-segment elevation was detected in two patients. Angiography revealed stenosis of coronary arteries in two patients, and the stent was placed. During the intensive care follow-up of these two patients, cardiac arrest developed, followed by death.

In one patient, the ECHO performed after the development of hypotension, tachycardia, and cardiogenic shock revealed a pericardial fluid collection with a width of 2.7 cm together

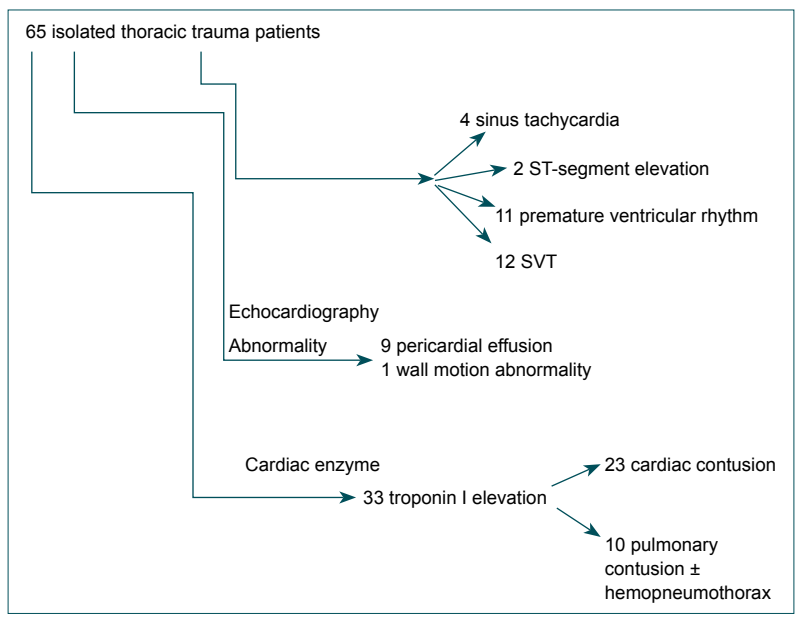

Figure 1. Troponin elevation, ECG changes and echocardiography findings in cardiac contusion.

Table 3. Correlation between troponin results and cardiac contusion

		Cardiac contusion (-)	Cardiac contusion (+)	Total	ᶜp
Troponin 4th hour	Cardiac contusion (-)	32 (49.2)	10 (15.4)	42 (64.6)	0.180
	Cardiac contusion(+)	4 (6.2)	19 (29.2)	23 (35.4)	
	Total	36 (55.4)	29 (44.6)	65 (100)	
	Sensitivity	65.52			
	Specificity	88.89			
	Positive predictive value	82.61			
	Negative predictive value	76.19			
	Accuracy	78.46			

ᶜMcNemar Test.

Table 4. Correlation between troponin results and cardiac contusion

		Cardiac contusion (-)	Cardiac contusion (+)	Total	ᶜp
EKG 4th hour	Cardiac contusion (-)	32 (49.2)	10 (15.4)	42 (64.6)	0.180
	Cardiac contusion(+)	4 (6.2)	19 (29.2)	23 (35.4)	
	Total	36 (55.4)	29 (44.6)	65 (100)	
	Sensitivity	65.52			
	Specificity	88.89			
	Positive predictive value	82.61			
	Negative predictive value	76.19			
	Accuracy	78.46			

ᶜMcNemar Test. ECG: Electrocardiography.

with diastolic collapse during hospitalization in the intensive care unit. Emergency pericardiocentesis was performed with the diagnosis of cardiac tamponade; however, death due occurred to cardiogenic shock during the follow-up of the patient. Ten of 13 patients followed up for cardiac contusion and thoracic trauma were discharged after cardiac troponin value became negative, no dysrhythmia like the initially detected one was present in serial ECGs, and the follow-up ECHO revealed no wall motion abnormality and regression of existing pericardial effusion.

When chest CT images of six patients with a cardiac contusion but without pulmonary contusion were investigated, it was found that a sternal fracture was present in five patients, in two of whom the sternal fracture was accompanied by left anterior rib fractures. In all patients, the high-sensitive troponin I value was above 0.04. In one patient, ECG revealed ST-segment elevation, and ECHO identified a wall motion abnormality and the ejection fraction of 30. The patient was considered as encountering myocardial infarction following isolated thoracic trauma. The patient died because of suddenly developing cardiac arrest. The ECG revealed premature ventricular beats–supraventricular tachycardia in the other five patients. Regarding the high-sensitive troponin I level, 2–2.5 fold increases were determined when 4-h values were compared to the initial values. Serial ECG follow-up showed that previously determined ECG abnormalities continued. ECHO revealed increased echogenicity around the right ventricle together with a pericardial fluid collection reaching a width of almost 1 cm in two of these five patients. These patients were admitted to the intensive care unit for follow-up with the diagnosis of cardiac contusion following isolated thoracic trauma.

Among 13 patients in whom neither a pulmonary nor a cardiac pathology were determined, a sternal fracture and a non-displaced fracture of a single rib were identified in seven patients and an isolated non-displaced fracture of a single rib in six patients.

Cardiac contusion was detected in 23 of the 65 patients who were included in our study; four patients died. We observed cardiac contusion in 44.9% (n=29) of patients at 0 h and 35.4% (n=23) of patients at 4th h with ECG and Troponin. ECG abnormalities in 23 patients were sinus tachycardia (four patients), ST-segment elevation (two patient), premature ventricular rhythm (11 patients), and supraventricular tachycardia (12 patients). We determined ECHO abnormality in

15.4% (n=10) of patients. We found that there was an agreement between cardiac contusion and troponin-ECG results at 4th h without statistical significance (p=0.180; p>0.05). In addition, troponin elevation was detected in 10 patients without a diagnosis of cardiac contusion who had a pulmonary contusion, hemothorax and/or pneumothorax at the time of hospital admission and then with normal troponin levels at 4-h control (Fig. 1, Tables 3 and 4).

DISCUSSION

The cardiac contusion is a critical traumatic condition that does not have clear criteria for diagnosis but leads to death when not considered by the clinician as a possibility.

Traffic accidents, falls, and compression between two objects are the most frequent causes of blunt thoracic trauma. The mechanisms of a cardiac contusion are compression of the heart between sternum and spine, deceleration injury, and direct injury of broken ribs or sternum.[8,9] The incidence of blunt cardiac injury is about 20–76% in blunt thoracic trauma patients.[2,4] Cardiac contusion was detected in 16% of cases, which was proven by autopsy studies.[6]

The incidence of sternal fracture accounts for 0.45–8% of traumatic emergencies.[10,11] In a study, the blunt cardiac injury was detected in about 3.6% of patients which involved approximately 23,000 trauma cases.[12] Myocardial contusion is an essential complication of sternal fracture which is diagnosed in 8% to 10% of patients.[13]

Our study included 65 isolated thoracic trauma patients (3.42%) in 1897 trauma patients. We determined cardiac contusion in 35.38% of thoracic trauma patients. Our ratio of cardiac contusion is higher than in other studies. The cause of a higher ratio is related to a special group of patients which included only thoracic trauma.

We evaluated 65 isolated thoracic trauma patients without multi-trauma components. When we looked at the literature, most of the studies which are interested in cardiac contusion usually have multi-trauma patients. The sternal fracture was detected in 25 (38.46%) of 65 isolated thoracic trauma patients. The higher rate of sternal fracture in our study is because of only the involvement of thoracic trauma patients with a few cases without multi-trauma. We observed 23 cardiac contusion patients associated with 15 sternal fractures. We think thoracic trauma which affects, especially the anterior thoracic wall may cause cardiac injury.

Although there are many studies about cardiac contusion, there is no gold standard for diagnosis in trauma patients admitted to emergency service.[8,9,14,15]

It was shown that cardiac contusion could be identified by using creatine kinase and creatine kinase-MB in 19% of patients, troponin in 15–24%, transthoracic ECHO in 3–26%, transesophageal echocardiogram in 27–56%, and by ECG in 29–56% of patients.[4,16]

Troponin positivity was seen with cardiac, hepatic, and pelvic injuries; higher injury severity score and age, and positive Troponin T was found in 18% of the patients without cardiac involvement.[2] There is no consensus, a specific diagnostic tool or a test regarding traumatic cardiac contusion. In this study, isolated thoracic trauma patients were examined. In this way, other trauma components that could cause troponin elevation were excluded from the study. Thus, the diagnostic value of troponin in cardiac contusion was tried to be revealed by excluding other possible causes. We detected false-positive troponin elevation in 10 pulmonary contusion, hemothorax, and pneumothorax patients without cardiac contusion. The most important diagnostic point was the troponin at the 4th h control. Troponin level elevation has continued in the cardiac contusion patients, while turned to normal level in the others. This indicates that troponin should be measured in thoracic trauma patient at regular intervals.

Especially in multi-trauma patients, the possibility of cardiac contusion may be forgotten in cases requiring immediate intervention at the time of admission to the hospital. Clinical features of cardiac contusion provoke suspicion. In the literature, some algorithms are advised for blunt cardiac injury patients which include that in patients who are normotensive, in sinus rhythm, and who have normal electrocardiographic findings, no further evaluation is needed.[17] We think the most effective and vital condition for diagnosing cardiac contusion is the suspicion of the doctor who performs trauma evaluation and then the subsequent cardiac tests.

According to the renewed Eastern Association for the Surgery of Trauma practice management guideline; the guide, based on the literature, provided some advice for blunt cardiac injury. ECG should be performed on all patients in whom BCI is suspected with Level I evidence and in patients with a normal ECG result and normal troponin I level, blunt cardiac injury is ruled out with Level 2 evidence.[18] In addition to the trauma guideline, we advise that ECG and troponin I should be examined in all thoracic trauma patients at the first admission time to hospital and then repeated at 4 h intervals to rule out cardiac contusion.

The most important point of our article is that clinicians should be alert for cardiac injury in trauma patients, especially for thoracic ones. It is very difficult to decide whether acute coronary syndrome or cardiac contusion.[19] We advise screening thoracic trauma patients for cardiac injury. The patient's clinical changes, changes in ECG pattern, progressively increase troponin level alert the clinicians to make a different approach.

Looking at the results of our study, we suggest that multi-trauma patients should be assessed by physical exam-

ination findings, cardiac enzymes, ECG, and ECHO at the first admission time to hospital and then followed by repeated intervals of physical examination and laboratory tests. We diagnosed four cardiac contusion patients with normal electrocardiographic and echocardiographic findings at the time of hospital admission who had troponin elevation and electrocardiographic abnormalities approximately after 4 h. We think that this study will contribute to the future trauma guidelines as a suggestion of repeated evaluation of troponin, ECG and ECHO not only in the first application but also in the follow-up period for all multi-trauma patients, mainly including thoracic trauma.

We did not use any of trauma scores in this study. It was the most important limitation of our study. Trauma scores are generally used to determine the severity of multitrauma. We wanted to show the effectiveness of troponin and ECG in the diagnosis of the cardiac contusion. We tried to exclude all other possibilities that could cause troponin positivity. The other limitation of our study was our few number of cases. We evaluated only thoracic trauma patients. In daily clinical situations, we usually encounter multitrauma patients. For this reason, it was very difficult to evaluate the patients with only thoracic trauma without any multitrauma component.

We could not detect any statistical significance between cardiac contusion and troponin- ECG results, but we found an agreement between them. These results were achieved with a limited number of patients. If the number of cases can be increased in future studies, statistically significant results can be obtained.

Conclusion

Thoracic trauma is a significant risk factor for cardiac contusion. We advise that all blunt thoracic trauma patients should be screened for cardiac contusion by continuous ECG monitoring and troponin levels at 4-h intervals for at least 2 times.

Ethics Committee Approval: This study was approved by the Manisa Celal Bayar University Faculty of Medicine Ethics Committee (Date: 21.02.2020, Decision No: 21/02/2020//20.478.486).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Dikkat: Kardiyak kontüzyon

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AMAÇ: İzole künt toraks travmasında kardiyak kontüzyonlu hastaların tanı ve klinik sürecini ortaya koymaktır.
GEREÇ VE YÖNTEM: Bu çalışma, acil tıp bölümüne izole künt toraks travması sonrası gelen 65 hasta üzerinde geriye dönük olarak gerçekleştirildi. Tomografi görüntüleri, kardiyak enzim düzeyleri, periyodik dört saatlik EKG ve başvuru sırasında ve gerektiğinde klinik duruma göre yapılan ekokardiyografi sonuçları incelendi. Bir saatlik ve dört saatlik yüksek hassasiyetli troponin I seviyeleri çalışıldı ve 0.04 ng/ml'nin üzerindeki değerler pozitif olarak kabul edildi.
BULGULAR: Çalışmaya alınan, toraks travması geçiren 65 hastanın 23'ünde (%35.38) hem pulmoner hem de kardiyak kontüzyon vardı. Yirmi üç hastada (%35.38) pulmoner kontüzyon mevcuttu ve ilk değerlendirmede kardiyak kontüzyon tespit edilmedi. Bununla birlikte, klinik takip sırasında troponin pozitifleşmesi- aritmi gelişti ve bu hastaların dördünde travmaya bağlı kardiyak etkilenme görüldü. Altı hastada (%9.24) pulmoner kontüzyon olmadan kardiyak kontüzyon saptandı. On üç (%20) hastada kardiyak veya pulmoner kontüzyon saptanmadı. Hastaneye yatış sırasında pulmoner kontüzyon, hemotoraks ve/veya pnömotoraks olan ve ardından dört saatlik kontrolde troponin seviyeleri normal olan 10 hastada kardiyak kontüzyon tanısı olmadan troponin yüksekliği saptandı. Sonuçlar değerlendirildiğinde, dördüncü saat sonuçlarında kardiyak kontüzyon ile troponin-EKG arasında istatistiksel uyum tespit edildi
TARTIŞMA: Tüm künt toraks travması geçiren hastalarda EKG ve troponin düzeylerinin takibi ile kardiyak kontüzyon açısından taranmaları öneriyoruz.
Anahtar sözcükler: Disritmi; kardiyak kontüzyon; travma; troponin.

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