



Research Article

# Negative Predictive Value of Troponins for the Diagnosis of Occult Cardiac Injuries in Penetrating Trauma

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## Abstract

**Background:** Cardiac trauma is associated with a high mortality rate, but a subset of the patients presents with normal vital signs in the emergency department. Identification of cardiac injuries in these patients can be a challenge. Many investigative modalities have been used to identify penetrating cardiac injury patients. Most of these tests are expensive, specialised and not easily accessible. However, the role of Troponins in penetrating cardiac injury has not been defined. We hypothesised that cardiac troponins have a negative predictive value in penetrating cardiac injuries in those who have normal haemodynamic status and do not have clinical or radiological features on cardiac injury.

**Materials and Methods:** We retrospectively reviewed all patients who presented to the Charlotte Maxeke Academic Hospital trauma unit over 22 months (01 January 2018 to 31 October 2020). Patients were identified using the hospital database. All patients with penetrating trauma to the cardiac zone above 18 years, who were haemodynamically normal and did not have obvious clinical or radiological features suggestive of cardiac injury, were included. The patient's demographics, mechanism of injury, injury severity score, vital signs, investigation findings, troponin levels, final diagnosis, type of operation, length of hospital stay, morbidities and mortalities were recorded. Those with no confirmed injuries were discharged home after minimal 24hr observation and repeat radiological examinations.

**Results:** There was a total of 173 patients identified; 6 were females. The median age was 30 years. Most patients (160/173) had stab wounds. The median Injury Severity Score (ISS) was 12.8. Most patients sustained stab wounds on the left side of the chest (n=90), 52%. Initial ultrasound was positive for pericardial fluid in 10% of patients (n=18). The sensitivity of cardiac troponins was 85.7%, and the specificity was 69.2%. The negative and positive predictor values were 98% and 19.7%, respectively. The mean initial Troponins level was 50 ng/L. The mean repeat troponins were 450 ng/L in those patients with cardiac injuries. The Troponins were significantly different in those with cardiac injuries and those without cardiac injuries. Fourteen patients had a cardiac injury, the right ventricle (3.5%) was the most injured chamber, followed by the left ventricle (2.3%) and Right atrium (0.6%). Two patients sustained myocardial injuries without chamber penetration. The overall mortality rate was 0,6%(n=1). Fifty percent of the patients (n=87) were discharged home from the emergency department, 21.8% were admitted to the ward (n=38), and 15.5% (n=27) were admitted to the Trauma ICU. The average hospital stay was one day for patients with a stab to the precordium.

**Conclusion:** Troponins can be used to evaluate cardiac injuries in haemodynamically normal patients with penetrating chest trauma. Serum Troponins have an excellent negative predictor value (98%). More prospective data is needed to confirm our findings and then extend to clinical practice, especially in resource-limited environments.

## Background

Penetrating cardiac injuries are lethal, with some patients presenting in extremis [1]. However, a subset of patients with penetrating cardiac injuries will present haemodynamically normal and without obvious clinical signs of cardiac involvement [1-3]. These patients have been defined as having occult cardiac injuries [2,3]. Identifying the presence of cardiac injuries in haemodynamically normal patients with proximity injuries can be challenging [1-5]. Clinical signs are unreliable and only present in a few patients with tamponade [4-6]. Ultrasound has been internationally accepted as the screening tool for detecting cardiac trauma but with known limitations [4,5]. The rate of false negatives and positives must be kept in mind when interpreting the results [4,5]. Electrocardiogram (ECG), Chest X-Ray (CXR) and Echocardiogram have also been described in the literature as some of the modalities used to identify occult cardiac injuries [4-7]. ECG changes range from sinus tachycardia to non-specific ST changes [2,6]. The presence of J-waves on ECG signified a significant risk of cardiac injury in a study in Groote Schuur Hospital, Cape Town [2]. Echocardiograms require specialised skills with ranging levels of specificity and sensitivity; it is not always readily available in the Emergency departments [2,7,8]. Chest x-rays also have non-specific features like a straight left heart border and left-sided haemothorax that have been described to try and identify the presence of occult cardiac injuries [2,8]. The diagnosis of occult cardiac injuries needs to be made to prevent secondary haemorrhage, which can occur from 48 hours to 3 weeks [2,9,10]. Failure to identify an occult cardiac injury can also lead to post-traumatic pericarditis, false aneurysms, atrial or ventricular septal defects, ECG abnormalities, valvular defects, and death [9,10].

The usage of Troponins to screen for cardiac injuries has been studied in the setting of blunt cardiac injuries [11]. ECG and Troponins can reliably identify blunt cardiac injuries [12,13]. To our knowledge, there is no conclusive data to support the usage of Troponins as a diagnostic tool in the setting of penetrating cardiac injuries in adults. Only a handful of case reports describe their use [14-16]. Other than trauma emergencies, Troponins have been used to diagnose myocardial ischaemia (MI) in the setting of myocardial infarcts [17,18]. They have been used to diagnose acute MI together with an ECG [17,18]. There are 'Point of care' Troponin tests in the Emergency Department (ED) to facilitate the early identification of myocardial ischaemia [19]. The availability of 'point of care' is even more relevant in middle-income countries like ours, where laboratory services are not always easily accessible, especially after hours. We suspect that troponins could be elevated in significant cardiac injuries. Their relevance may be of value in trauma cases, especially in the absence of hypotension that could cause hypoperfusion of the myocardium. Troponins, if found beneficial as another modality, could assist in minimising the

rate of missed cardiac injuries. Our Trauma unit follows a simple protocol when managing potential cardiac injuries in penetrating chest trauma cases [6]. Those who present with hypotension or have features of distended neck veins, or have muffled heart sounds without tension pneumothorax will be prepared for cardiac surgery. If they already present in cardiac arrest or develop cardiac arrest in casualty, then an Emergency Room Thoracotomy (ERT) would be performed [20]. The emergency department e-FAST is used as standard in our unit, and if there is evidence of haemopericardium, surgery will also be pursued. The CXR features suggestive of cardiac injuries are also used to augment the management algorithm.

However, the challenge still exists with those who do not have the above features of cardiac involvement. We wanted to report on our experience with cardiac enzyme evaluation in these stable patients without obvious features. The study aims to establish the role of serum Troponins in identifying occult cardiac injuries in patients with penetrating chest trauma. We hypothesise that they may have a negative predictor value, especially in resource-limited environments.

## Methods

A retrospective study was conducted at Charlotte Maxeke Academic Hospital trauma unit on all patients who sustained penetrating chest trauma over 22 months (01 January 2018 to 31 October 2020). All patients were identified using the hospital database. We included all patients above the age of 18 years in the study. Patient demographics, mechanism of injury, injury severity score (ISS), vital signs, investigation results, Troponin levels, final diagnosis, type of operation, length of stay, morbidities and mortalities were recorded. The location of the chest injuries was documented in relation to the cardiac box, defined as the area in the chest wall defined by clavicles in the mid-clavicular plane on both sides, from the clavicles to the costal margins.

Serum Troponins were taken in the emergency department on presentation in all patients who presented with proximity injuries to the heart. We used the Elecsys<sup>®</sup> Troponin T high sensitive laboratory assay test by Roche. Troponin levels below 14ng/L were defined as negative, and any troponin level  $\geq 14$ ng/L was defined as positive.

All patients were evaluated for penetrating cardiac injuries using ultrasound, ECG, and troponin levels. Repeated emergency ultrasounds were done in the emergency department, and all patients had a minimum of two radiological chest X-rays.

## Statistical Analysis

Means ( $\pm$ SD) are presented for continuous variables, and frequencies (%) are presented for categorical variables. All analyses were done using STATA version 15. Continuous variables

were first tested for normality using the Shapiro-Wilk test. Fisher’s exact test was used to test the significance of the relationship between categorical variables. Univariate and multivariate analyses were conducted on the data. A p-value of <0,05 was considered statistically significant. Sensitivity, specificity, negative predictive value, and positive predictive value were calculated. Ethics approval was obtained from the University of the Witwatersrand Human Ethics committee and the hospital CEO. Ethics number M180463 was allocated to the study.

## Results

There were 173 patients with penetrating chest injuries in the cardiac zone who had blood taken for troponin levels. The mean age was 30 years, and there were only six female patients. The mechanism of injury was stab wounds in 160 patients and gunshot wounds in 13 patients. Most patients (155/173) presented directly from the scene, and 18 were transferred from other hospitals. The location of the injuries on the chest cavity is outlined in Table 1. Approximately half of the injuries were left to the midline in the cardiac box in 90 patients (52 %). The initial Extended Focused Assessment with Sonography (E-FAST) ultrasound was positive for pericardial fluid in 18 patients (10 %); on repeat E-FAST 14 patients were positive. The sensitivity of cardiac troponins was 85.7%, and the specificity was 69.2%. The negative and positive predictor values were 98.2% and 19.7%, respectively Table 2. The mean initial Troponins level was 50 ng/L in those with cardiac injuries. The mean repeat troponins were 450 ng/L in those patients with cardiac injuries. The Troponins were significantly different in those with cardiac injuries and those without cardiac injuries.

Location of stab (chest)	Number of patients (%)
Right side (cardiac box)	30 (17.34)
Parasternal	48 (27.75)
Left side (cardiac box)	90 (52.02)
Outside cardiac box (cardiac zone)	5 (2.89)

**Table 1:** Location of stab wounds on the chest wall.

Cardiac Troponins	Positive patients	Negative patients
Cardiac injury	12	2
No cardiac injury	49	110
Total	61	112

**Table 2:** Sensitivity and specificity table.

On presentation, the mean systolic and diastolic blood pressure were 124 mmHg and 75 mmHg, respectively. The median

pulse was 91 beats per minute in the emergency department. The mean lactate and Base Excess were 3 mmol/l and minus 4.4 mmol/l. The mean Injury Severity Score and New Injury Severity Score were 12.8 and 13.5. Fourteen patients had cardiac injuries. Most patients sustained injuries to the right ventricle, see Table 3. Other associated injuries in the chest were noted to be lung (59.5 %) and internal mammary arteries (5.4 %). Other injuries to the abdomen were hollow viscus injuries in three patients, the other three patients had solid organ injuries, and one patient had combined hollow viscus and solid organ injuries (Table 4). There was one mortality in the patient population with occult cardiac injury and no mortalities in those without cardiac injuries. The average length of hospital stay was one day in those without cardiac injuries and six days in those with cardiac injuries. Most patients were discharged home from the emergency department (50.3 %), while some were stepped down to our referring hospitals (11.6 %), see Table 5.

Location of heart injury	Number of patients (%)
Right ventricle	6 (3.5 %)
Left ventricle	4 (2.3 %)
Right atrium	1 (0.6%)
Myocardial contusion	2 (1.2 %)
Combined atria and ventricle	1 (0.6 %)

**Table 3:** Location of injuries on the heart.

Other associated injuries	Number of patients (%)
Lung injuries	22 (59.5 %)
Internal mammary artery (IMA)	2 (5.4 %)
Abdomen injuries	7 (18.9%)
Neck injuries	5 (13.5 %)
Head injuries	1 (2.7 %)

**Table 4:** Additional associated injuries.

Disposition	Number of patients (%)
Home	87 (50.3%)
Ward	38 (22 %)
Intensive care unit (ICU)	27 (15.6 %)
Stepped down/Transfer out	20 (11.6 %)

**Table 5:** Disposition of patients from the Emergency Department.

## Discussion

Missing cardiac injuries can result in mortality. It can further result in delayed cardiac tamponade, which has significant mortality (ranging from 17%) and increases hospital stay [2,8,9,16]. Troponins are enzymes released after myocyte necrosis and are used to diagnose myocardial infarction [17,18]. They are further incorporated in the definition of an Acute Coronary Syndrome (ACS) [17]. Outside of the context of ACS, troponin increase reflects myocardial necrosis and provides prognosis information. The prognostic nature of troponins in trauma has been used in head injuries, blunt cardiac injuries, polytrauma and sepsis [21-24]. Troponins and ECG have a negative predictive value of 100% when combined to screen for blunt cardiac injuries [12,13]. There are more unanswered questions about the timing of the test, the type of troponin test to use, and the need for a repeat test.

The role of troponins in blunt cardiac trauma has been well established; however, data on penetrating cardiac injuries is lacking. The rationale would be that some cardiac damage with penetrating injuries can be used to determine who should be referred or admitted in resource-limited environments. The usage of troponins in determining cardiac injuries has not been studied. This is the first study to our knowledge. There have been some case reports which reported the usage of troponins in cardiac injuries [16]. The Subxiphoid window remains the gold standard for the diagnosis of hemopericardium after penetrating cardiac injuries [2]. However, it is invasive and requires general anaesthesia to be performed. The E-FAST is expeditious and non-invasive in assessing fluid around the pericardium [7,8]. Its sensitivity and specificity ranges. It is operator dependent and not always available in resource-limited environments. We suggest that Troponins can be useful in the management of occult cardiac injuries if the basics of clinical evaluation, chest X-ray and Emergency department ultrasound interpretations are adhered to. A normal Troponin would have a good negative predictor value for cardiac injuries. On the other hand, a positive Troponin would warrant further evaluation of the patient. Further evaluation can range from repeat troponins, repeat e-FAST or Echocardiogram.

The role of repeat troponins 24 hours later in the management of occult penetrating cardiac injuries is not well established. We have noted an increase of troponins from baseline troponin to be associated with possible cardiac injuries, and further evaluation with a subxiphoid window is warranted in this group of patients

## Limitations of the Study

This is a retrospective review with its shortcomings; there was a limited number of patients with the target condition. A single-centre study may have unplanned selection bias. No long-term follow-up was available for the study.

## Conclusion

Troponins can be used to evaluate cardiac injuries in haemodynamically normal patients with penetrating chest trauma. It is highly specific for cardiac injuries (98%). More prospective data is needed to confirm our findings and then extend to clinical practice, especially in resource-limited environments.

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