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# Management of Blunt Cardiac Injury

**Bianca Wahlen, MD[1], Ayman El-Menyar, MD[2,3] ***
[1] Department of Anesthesiology, Hamad Medical Corporation, Doha, Qatar
[2] Trauma and Vascular Surgery, clinical research, Hamad Medical Corporation, Doha, Qatar
[3] Weill Cornell Medical College, Doha, Qatar

*Invited State of the Art Trauma Review Article*

***Corresponding Author:**

**AYMAN EL-MENYAR, MD**

Trauma and Vascular Surgery, clinical research, Hamad Medical Corporation, Doha, Qatar
E-mail: *aymanco65@yahoo.com*
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**Abstract**
In some trauma registries, almost half of trauma patients may experience thoracic injuries, which may lead to a wide range of cardiac injuries. Depending on the extent of injury, the mortality rate is relatively high. The diagnostic pathways and management should be structured and, on the one hand, customized to the local availabilities and international guidelines. The initial measures in the trauma room concerning the diagnosis of thoracic injury with suspected cardiac trauma include physical examination, electrocardiogram (ECG), chest x-ray, echocardiogram, and echocardiography with or without CT angiography in some cases. Minor injuries may lead to a wide range of arrhythmias, which are treated like all non-traumatic arrhythmias, including the use of beta-blockers and/or cardioversion. Major injuries with massive bleeding should be managed swiftly for hemodynamic stabilization, insertion of chest tubes, and immediate surgical repair. Depending on the urgency, catheter-based or open, with or without cardiopulmonary bypass, intervention can be performed according to the underlying injury. So far, there are few international guidelines concerning diagnostic pathways and management as each case is unique, and the hospital settings may vary broadly. Despite blunt cardiac injuries not being quite common, they can be missed and fatal. Plenty of articles summarize traumatic cardiac injuries to reach a consensus. Although it could be a challenge in the ED to diagnose cardiac injury, the use of ECG, transthoracic echo, and cardiac biomarkers followed by TEE in unstable or doubtful cases is efficient and cost-effective.

**Keywords:** blunt cardiac contusion, cardiac injury, ECC, TEE, trauma, arrhythmias, cardioversion, beta-blocker

## Introduction

Traumatic blunt cardiac injury is not common; however, misdiagnosis and high mortality are significant concerns (1,2). Motor vehicle crashes with impact at a speed >30 mph with deceleration sheering forces, in addition to direct blows to the chest wall or falls from heights, are the leading causes of cardiac trauma (2). The German Trauma Society Annual Report reported that around 45% of trauma patients may sustain thoracic injuries (3). According to the American Association for the Surgery of Trauma, 20% of the patients dying in motor vehicle collisions had a heart injury, and the same number of patients presenting with blunt thoracic trauma display a cardiac injury in one way or another (4). Considering the

anatomical position, it is evident that the right ventricle and right atrium injuries are the most frequently injured parts of the heart. Injury to the left side of the heart is less frequent, and other regions, like an isolated valve injury, coronary arteries, or septal injuries, are rare. The management of blunt cardiac injury requires a proper understanding of the underlying mechanism of injury, as well as the adequate choice of the various diagnostic tools. A recent meta-analysis, which included 51 studies, revealed that transesophageal echocardiography (TEE) had a specificity of 72% and sensitivity of 87% in picking up cardiac contusion. However, normal electrocardiography (ECG) plus normal cardiac troponin I (cTnI) showed a high sensitivity of 85% to exclude cardiac injuries (5).

**Commotio Cordis and Contusio Cordis**:

Blunt cardiac injuries mostly include commotio cordis and contusio cordis (cardiac contusion). The main difference is the nonexistence of structural damage in patients with commotio cordis, i.e., no morphologic injury to the sternum, ribs, or heart (6,7). Commotio cordis (agitation of the heart) may lead to around one-fifth of sudden cardiac death (SCD) in athletes in the USA. The National Commotio Cordis Registry was established 30 years ago to understand better, improve awareness, and prevent sport-related commotio cordis (6,7). Animal studies in the late 90's suggested the selective activation of the $K^+$ATP channel as the underlying mechanism of cardiac dysrhythmias in patients with commotio cordis (8). Selective Activation of the $K^+$ATP channel is a mechanism by which sudden death is produced by low-energy chest-wall impact. Without structural damage to the heart, the cardiac rhythms may vary in type (atrial fibrillation, ventricular fibrillation (VF), and sudden cardiac death), duration, and severity (9-11). To trigger cardiac arrhythmia, several factors have to be present. The impact has to occur in the right place, at the right point of time, and at a certain velocity. Concerning the location, the mechanical impact has to be located directly over the heart at the anterior chest wall (12). An animal study showed that 9 out of 10 impacts would result in VF only if the impact occurred 30-15 msec before the peak of the T-wave. Four out of 10 impacts during the QRS complex lead to a complete heart block (13). Concerning the velocity, an animal study assessing the effect of the energy of impacts on the occurrence of VF showed that impacts at 20 mph did not induce VF. In contrast, the incidence increases from 7% with 25 mph impacts to 68% with chest impact at 40 mph, and then the probability of occurrence of VF reduces (14).

These rhythm disorders resulting in cardiac arrest should be treated following the ACLS guidelines for cardiac arrest. In the case of VF/VT, immediate defibrillation with high-quality CPR is the only chance for survival (15). Experimental studies investigating the termination of VF after a traumatic event showed a 100% survival rate when the cardioversion was applied within 1 minute from the traumatic event, compared to 46% around 4 minutes after the event (16). A rise in awareness of trauma-related cardiac arrest caused by commotio cordis in athletes led, through education and training, to a considerable increase in the survival rate by almost four times between 2002 and 2013, in slightly more than one decade (17). A similar rise in public responder rates could be observed over time (18,19). VF/VT is the most common rhythm disorder that occurs almost immediately after the traumatic impact and has the highest survival rate when treated within the first minute, which is in nonathletic trauma patients rarely the case. Emergent resuscitation critically needs to be on-time and efficient.

Contusio cordis is structural damage to the heart and may affect any heart structure, including the pericardium, myocardial wall, coronary arteries, papillary muscles, cardiac valves, and great vessels. In general, blunt thoracic trauma may lead to cardiac contusions. As they are scarce, the diagnosis can be easily missed, especially as the symptoms are similar to other co-existing trauma in the thoracic region. They may range from mild to immediate life-threatening (20). Cardiac contusions can result in a new right bundle branch block, dysrhythmias, ventricular or free wall rupture, and valvular insufficiency (21). The diagnosis should be made based on the clinical scenario, troponin values, ECG recording, and echocardiogram.

**Valvular injuries**

Valvular injuries are among the less frequently reported cardiac injuries after blunt trauma, but a post-mortem study by Turan et al. showed that blunt trauma to the chest complicates up to 20 % of major trauma cases and 4% of them, including valvular injuries. The same group reported that due to their anatomical position, aortic and tricuspid valves are more often injured than the pulmonary and mitral valves (22). They assume the underlying cause is the abnormal pressure increase inside the ventricle. At the same time, it is compressed between

the thoracic bony structures during the contraction phase of the ventricle while the valves are still closed. The underlying mechanisms of injury in the mitral and tricuspid valves differ due to their anatomical position. The tricuspid valve is more prone to injuries due to its more anterior position and the stabilizing structures; in the case of the tricuspid valve, the chordae tendinae are weaker than the papillary muscles of the mitral valve (23). In general, due to the given anatomy, the most often injured valve is the aortic valve, followed by the mitral valve, tricuspid valve, and pulmonary valve (24).

The challenge for valvular injuries, especially when incomplete rupture occurs, is the early diagnosis. According to prior reports, the symptoms may be delayed and can occur even weeks or months after the injury, depending on the extent of the injury and the involved valve (25).

TEE is the method of choice for critically ill patients to achieve fast and precise information about heart injury. TEE is less influenced by high positive end-expiratory pressure, the presence of drains and dressing, position, and the patient's physical properties. Studies also showed a change in treatment or diagnosis in up to 70 % of the patients when the initially performed TTE (transthoracic echocardiography) was not satisfying concerning the quality of the images (26). Accordingly, an immediately executed TEE by an experienced team may save valuable time and provide more accurate information, leading, under certain circumstances, to a faster diagnosis and treatment of the critically ill patient. Troponin and electrocardiogram are excellent initial screening tools, but they are not specific to that extent. The surgical treatment of valve injuries varies from valve to valve. Aortic valve replacement is the method of choice, whereas for mitral and tricuspid valves, a replacement is often required, but annuloplasty may be an option depending on the case (21).

**Coronary artery injuries*:***

The main reason for coronary artery injuries is the compression of the heart between the bony structures of the chest. Those injuries are rare and are only accountable for 2-12 % of cardiac injury cases. The left main coronary artery is most often injured at 76%, followed by the right coronary artery at 12% (21). In contrast, left circumflex artery injury is observed very seldom. If not controlled early, the rupture or dissection of the vessels may present with acute myocardial infarction or cardiac tamponade. Some assume that elderly patients with coronary artery disease are more prone to such injuries due to calcifications. The hints for those injuries may be minor, like cardiac arrhythmias, which, if not diagnosed and treated immediately, may lead to death (21,27). Coronary angiography is the method of choice in case of injury or suspected myocardial infarction. The same is valid for CT angiography (20,28).

Nevertheless, the basics, like cardiac enzymes and electrocardiograms, should be obtained, even though troponin is also elevated with other cardiac injuries. The treatment of traumatic coronary artery injury is primarily dependent on the type of injury. An injury leading to cardiac tamponade should be immediately released through pericardiocentesis. Like in non-trauma patients, an occlusion or dissection may need urgent percutaneous coronary intervention or a coronary artery bypass graft (29). The risk-benefit ratio of different options should be carefully considered as potentially necessary anticoagulation in an otherwise severely injured patient may aggravate other injuries.

**Aortic injury**: Thoracic aortic injury may be associated with up to 80% of mortality at the scene (30). Among the aortic injuries that can arrive at the hospital**,** 90% occur at the isthmus of the aorta and 10% at the ascending and diaphragmatic hiatus. However, post-mortem studies show that 20-25% of the deceased patients suffered from injuries to the ascending aorta. The initial step in treating aortic injuries, trauma-related or others, is the use of medications that slow down the heart rate and lower the blood pressure to avoid the aggravation of the life-threatening situation. Beta-blocker is the drug of choice after aortic artery injury (31). Following this, like in any other aortic dissection or rupture, the definitive repair can be either endovascular or open repair.

**Septal defects, free wall ruptures, and blunt pericardial injury:**

The root cause is easily understandable, as shown by anatomy and physiology. The most affected part is the right ventricle, followed by the atrium of the same side of the heart, then the left ventricle, and finally, the left atrium. A traumatic impact during valve closure in the late systole may result more often in atrial injuries. In contrast, a ventricular rupture is more likely when the filling pressure of the ventricles is maximal during the end-diastole (20,21,32). The symptoms are highly dependent on the location of the rupture.

In contrast to free ventricle wall ruptures, areas of the heart with lower pressure, like the septum or atrium, take longer to display the picture of cardiac tamponade. The symptoms range widely, and most of them are unspecific (20,33). In rare cases, the pericardium still covers the myocardial rupture, and there is a chance of developing a pseudoaneurysm (33). Urgent surgical repair is needed for traumatic septal defects and free wall rupture; however, minor, hemodynamically stable septal defects can be treated with primary closure with sutures. Patch closure (bovine pericardial or Dacron patch) is used for large septal defects. Sternotomy has better visualization and exposure than thoracotomy (21).

Blunt pericardial injury is rarely reported (34). Usually, the pericardium ruptures when it is close to either the diaphragm or the pleura. Both areas may result in aggravation of the initial injury by herniation of abdominal organs or parts into the pericardium or part of the pericardium into the pleural space (35). A life-threatening situation may occur when blood or air is collected in the pericardial sac, consecutively leading to an increase in the pressure between the pericardium and myocardium, resulting in cardiac tamponade. Conditions like this can develop even weeks after the incident (36). In general, any major bleeding into the thoracic cavity from aortic- or coronary artery injuries to free wall ruptures of the heart may initially require a chest tube until surgical treatment is possible.

## Conclusion

Despite blunt cardiac injuries not being quite common, can be easily missed and fatal conditions. Plenty of articles summarize traumatic cardiac injury management, however, it is not standardized yet. Although it could be a challenge in the ED to diagnose cardiac injury, the use of ECG, transthoracic echo, and cardiac biomarkers followed by TEE in unstable or doubtful cases is efficient and cost-effective.

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