Cardiac Trauma

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10.1 Background

Patients victim of trauma with blunt cardiac injury (BCI) aren't uncommon even if the exact incidence is unknown. Subtler cases of BCI are often misdiagnosed, frequently overshadowed by concomitant consequences of the trauma, while severe injuries can cause the patient's death. Indeed, cardiac injury includes a spectrum of pathology ranging from clinically silent, transient arrhythmias to deadly cardiac wall rupture [1]. The cardiac contusion is the most frequent possibility and the management of that is still debated [2, 3]. Actually, in patients with traumatic injuries cardiac contusions might remain hidden.

However, laboratory data as troponin release have been observed far from the occurrence of the chest trauma [4]. After cardiac injury, arrhythmias, cardiac wall motion abnormalities, cardiac failure, cardiogenic shock, septum, papillary muscles or valves rupture can occur and great attention to these clinical signs should be paid to these patients [5, 6]. Due to their anterior position, right ventricle (RV) and right atrium (RA) are most frequently involved, whereas left-sided lesions are less frequent. On the contrary, lesion of septum, coronary arteries, and valve injuries rarely occur [7].

Pericardium or myocardium laceration and/or coronary artery or vein lesions frequently result in life-threatening hemopericardium and cardiac tamponade. The prompt diagnosis and treatment (pericardiocentesis and/or surgical repair of the lesion) are crucial.

Evaluation of trauma patients with suspected cardiac injury can be complex and include electrocardiography (ECG), measurement of cardiac biomarkers, and imaging examinations. ECG and cardiac biomarkers are useful screening tools for injury, while echocardiography is allowing to evaluate function and anatomic abnormalities.

The patient may not notice or be capable of reporting chest trauma. If the injury occurs in the hospital (e.g., perforation of a cardiac chamber by catheters) in a conscious patient, the individual often complains of severe chest discomfort.

The occurrence of hemopericardium, with or without clinical signs of hemodynamic impairment,

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could be the main sign of cardiac injury. The multislice spiral computed tomography (MSCT), with administration of intravenous iodinated contrast material, can detect a spectrum of complications related to the trauma [8]. The careful assessment of patients with cardiac trauma, with or without penetrating injuries, is a challenging and time-critical issue. Clinical data and imaging findings provide complementary information necessary for an accurate diagnosis, therapeutic planning, and prognosis also in hemodynamically stable patients. In addition to transthoracic and transesophageal echocardiography, chest radiography and computed tomography (CT), other available modalities such as nuclear medicine, and magnetic resonance imaging (MRI) may play a role in selected cases [9].

10.2 Definitions, Diagnosis, and Treatments

BCI historically refers to a broadly defined group of injuries typically occurring after a rapid deceleration or a direct blow to the chest. BCI has been associated with valvular or myocardial dysfunction leading to heart failure, dysrhythmias, free wall rupture causing pericardial effusion and tamponade, and, rarely, coronary artery damage leading to acute myocardial infarction (AMI).

Myocardial rupture, contusion, and laceration account for almost 90% of deaths secondary to non-penetrating cardiac trauma [1]. Penetrating cardiac trauma is characterized by high mortality rate and those who survive to hospital discharge still have an overall mortality approaching 80% [10]. Evaluation for cardiac trauma should be mandatory for patients with anterior chest wall injury.

10.2.1 Definition

BCIs, based on specific injuries, will be addressed:

Myocardial contusion, extremely variable in severity, is usually caused by blunt chest trauma (car or motorcycle accidents) or chest compression during cardiopulmonary resuscitation (CPR) maneuvers. Palpitations, arrhythmias, or unexplained tachycardia or hypotension may occur. Some patients develop conduction abnormalities. Normal troponin I or T assay in combination with an ECG are exclusion criteria for cardiac injury/damage and the patient can be safely discharged [11].

Cardiac camera ruptures are usually associated with quick death. Sometimes, in case of limited wall damage, such as in case of trauma involving the atrium, the junction with vena cava, or the right ventricle, the clinical presentation can be characterized by hemopericardium (Fig. 10.1). In these cases, a timely diagnosis is crucial. Both ultrasound and CT examination can provide useful information leading to emergent surgery.

Similar to the previous conditions, *valve injuries*, such as leaflet rupture, rapidly lead to a clinical

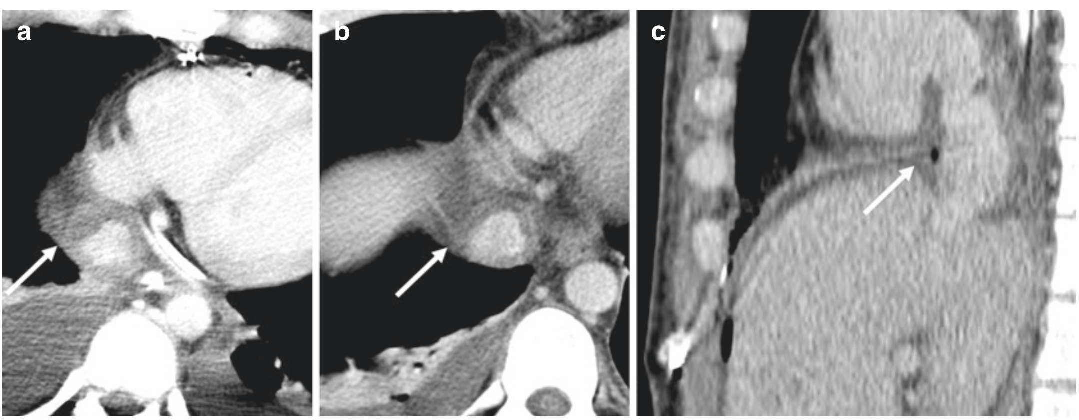

Fig. 10.1 Traumatic inferior cava disconnection. Contrast enhanced MSCT—post-surgical control after 1 day (**a**) and after 1 week (**b**, **c**). In (**a**) (*arrow*) is still present a hematoma; in (**b**, **c**) the hematoma decreased (*arrow*)

scenario of heart failure (rapidly evolving respiratory insufficiency due to pulmonary edema, pulmonary crackles, and hemodynamic instability) [12].

Septal rupture can cause delayed heart failure. It is important to understand if septal defect (SD) is a preexisting situation or it is caused by trauma. Acquired ventricular SD could be associated with a third heart sound, a loud systolic murmur, and signs of left or right ventricular failure. Finally, *commotio cordis* is characterized by sudden death following a blunt chest impact in patients without preexisting or traumatic structural heart diseases. Common situations of commotio cordis are those that occur during sport activities [13]. Although the pathophysiology is unclear, the temporal correlation between the trauma and the death keeps the ventricular fibrillation the most likelihood etiopathogenesis [13].

10.2.2 Diagnosis

In multiple trauma, the chest trauma is considered to cause up to 25% of the causes of death. Therefore, chest trauma should always be taken into serious consideration even in the absence of external signs or specific symptoms. The dynamics of the event is also important in the stratification of the risk of damage (impact on steering, airbags, etc.) [14]. Cardiac involvement should be suspected in patients with significant chest injury or polytrauma referring palpitations, ore suffering of arrhythmias, presenting new cardiac murmur, or unexplained tachycardia or hypotension. ECG ST segment might change by mimicking myocardial ischemia after cardiac trauma. The most common conduction abnormalities include atrial fibrillation, bundle branch block (mostly right), unexplained sinus tachycardia, and single or multiple ventricular ectopic beats. Cardiac biomarkers (i.e., troponin, CPK-MB) are useful tools for the screening of blunt cardiac injury. If cardiac biomarkers and ECG are within normal limits and there are no arrhythmias, blunt cardiac injury can be excluded. Rarely, chest trauma can cause a coronary artery damage causing myocardial infarction (Fig. 10.2). In addition, in approximately 20% of patients with penetrating lesions of the heart, and in patients with non-penetrating trauma, a delayed form of pericarditis, similar in character and natural history to those occurring after AMI, can occur [15]. In these cases, the medical history before chest trauma is of major importance in diagnosing the cardiac disease.

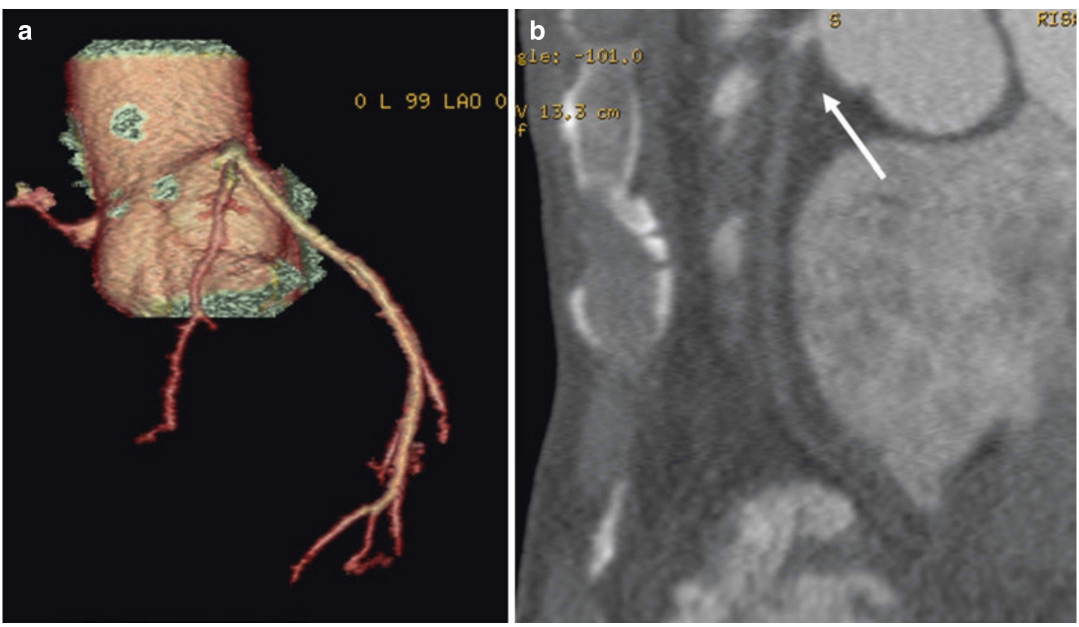

Fig. 10.2 Post-traumatic right coronary occlusion. (**a**) VRT reconstruction and (**b**) MIP reconstruction

Nuclear medicine. Until now, the role of nuclear medicine (including PET using 18F-2-fluoro-2-deoxy-D-glucose) has not well established in the setting of blunt thoracic trauma [16]. In selected cases, the same nuclear medicine techniques that are successfully used to diagnose myocardial ischemia have been attempted in evaluating trauma patients.

Angiography. Angiography, although not specifically indicated, can visualize or suspect some of the mechanical consequences of a chest trauma such as pericardial effusion, ventricular septal defects (VSDs), fistulae, and ventricular or aortic aneurysms [17].

Echocardiography. Ultrasound techniques, in the setting of trauma, has gained wide acceptance in the form of the Focused Assessment with Sonography for Trauma (FAST), in which echography is used to detect free fluid in the pericardium [16].

Echocardiography usually performed during the early phases of resuscitation can show wall motion abnormalities, pericardial fluid, or chamber or valvular rupture.

In addition, regurgitant valvular lesions, aortic-atrial or ventricular fistulae, and VSDs can produce left ventricular dilatation or hypercontractility at the echocardiographic examination. Valvular regurgitation and shunt flow can be detected and quantified by means of the Doppler evaluation. Myocardial contusion and MI result in regional hypokinesis or akinesis [2].

Chest X-ray (*CXR*): CXR continues to be an appropriate primary screening modality in thoracic trauma assessment, as noted in "ACR Appropriateness Criteria Blunt Chest Trauma" [16]. Antero-Posterior (AP) chest radiography is essential to quickly exclude rough displacement of lines and tubes that could be difficult to detect in the setting of polytrauma. Although AP chest radiographs are often of pore quality in case of polytrauma, they still are considered essentials. Signs include cardiomegaly secondary to hemopericardium or pericardial effusion; signs of left ventricular failure (vascular redistribution, interstitial or alveolar edema, pleural effusion) secondary to myocardial contusion, ventricular aneurysm, valvular disruption, intracardiac fistula, or VSD; and mediastinal widening secondary to aortic disruption and tracheal deviation. In addition, chest X-ray can easily investigate the occurrence of further findings, such as fractured ribs, hemo/pneumothorax, or pulmonary infiltrates in patients with trauma. However, it is widely known that AP chest radiography has lower accuracy for blunt traumatic injuries than CT and the use of this as the only diagnosis tool in trauma does not seem appropriate [16].

CT how and when. CT represents a gold standard modality in polytrauma. Contrast enhanced chest CT is known as a reliable modality for the investigation of thoracic trauma [16]. A cardiac injury can be present in patients with high kinetic energy trauma associated with sternum or rib fractures, lung contusions, pneumothorax, and vascular lesions. Although CT clearly allows detailed evaluations of trauma patients, the use of ionizing radiation have raised some safety concerns related to the extensive use of CT. In fact, ionizing radiation derived from medical use has increased, and the use of CT should be limited to the necessity [18]. There are conflicting data on whether routine chest CT is necessary in the setting of blunt trauma so far.

Depending on CT available apparatus, a collimation of 0.6 mm is recommended. The radiation dose should be kept as lower as possible, especially by applying dose reduction software wherever available. Nevertheless, the use of 120 KV and 300 mA is currently considered appropriate. Intravenous administration of contrast medium is imperative for imaging polytrauma patients. Usually, pre- and post-contrast imaging is performed in arterial phase (as not to miss any injury of the major vessels) and in venous phase. In case of suspected bleeding, a delayed acquisition at 5 min is highly recommended, taking into account patient's hemodynamic stability. Optimal opacification may be obtained with injection of 100–140 mL of iodinated contrast medium (preferable high concentration) at a flow rate of 3–4 mL/s followed by a saline flush injection. Importantly, pericardial effusion must be considered a red flag sign (Fig. 10.3). ECG gating for thoracic trauma is quite controversial as it provides a high diagnostic

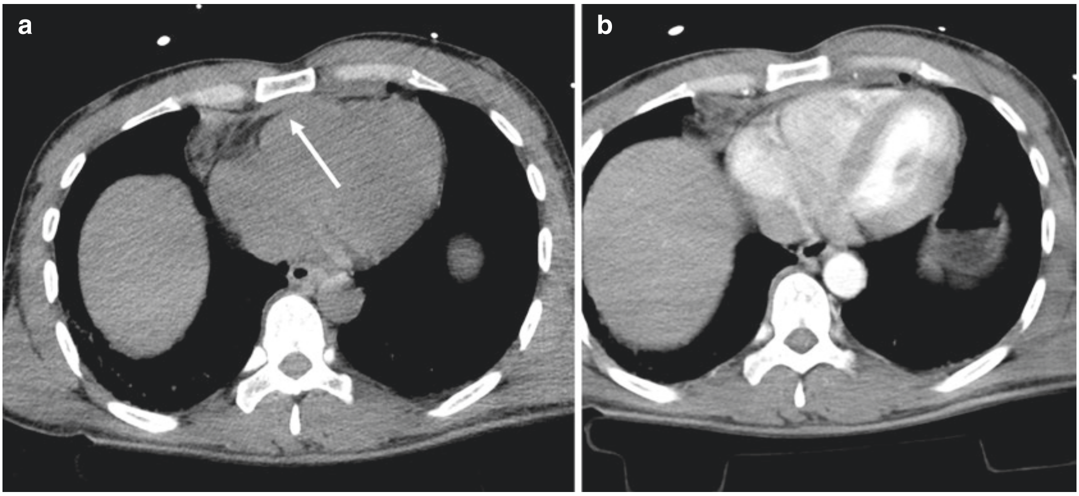

Fig. 10.3 (**a**) Non-contrast enhanced CT shows a hyperdense pericardial effusion; this must be a warning sign (*arrow*). The CT study may require the completion of a gated exam. (**b**) Contrast enhanced MSCT doesn't show any change in the pericardial effusion

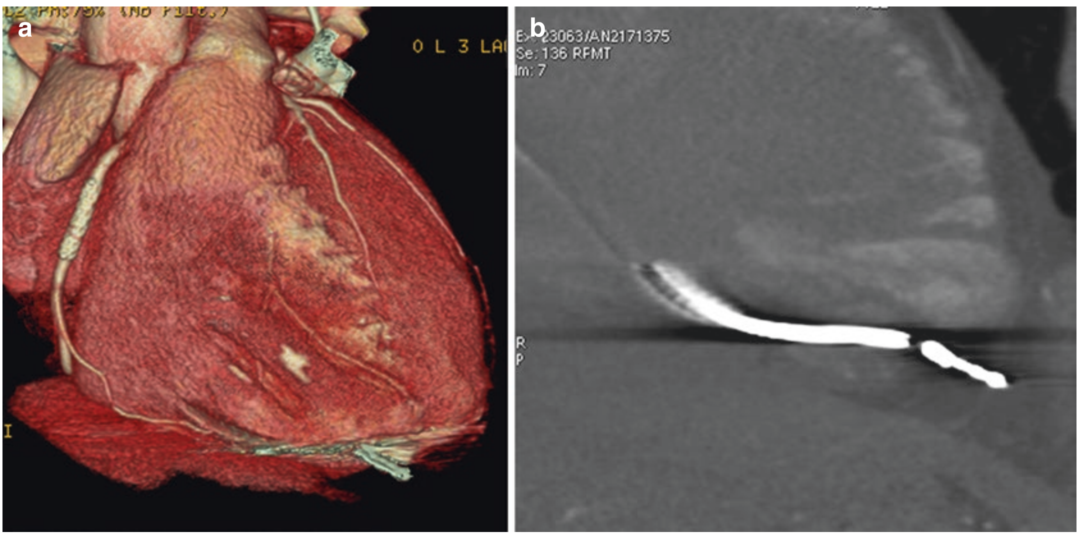

Fig. 10.4 Myocardial laceration caused by cardiac catheter. Gated cardiac CT acquisition. (**a**) VRT reconstruction shows the catheter end that goes beyond the myocardial wall. (**b**) MIP reconstruction

quality for vascular structures (aortic, coronary, or cardiac injury) but may reduce the quality of bone and lung injury. Given the fact that retrospective ECG gating compared with prospective ECG gating increases the radiation dose significantly, and that polytrauma patients may have an unstable heart rate higher than 80 beats/min, one should weigh the use of ECG gating carefully so as not to lose valuable time [14]. When a cardiac trauma or great vessels heart connection injury are suspected in stable patients, a gated CT examination could be useful after the initial CT as extending. A gated cardiac CT can be useful also in a suspect of iatrogenic cardiac trauma as post-surgery or vascular procedures (Fig. 10.4).

Post-mortem computed tomography is now an emerging method which is employed in forensic medicine before autopsy for "violent" death [19].

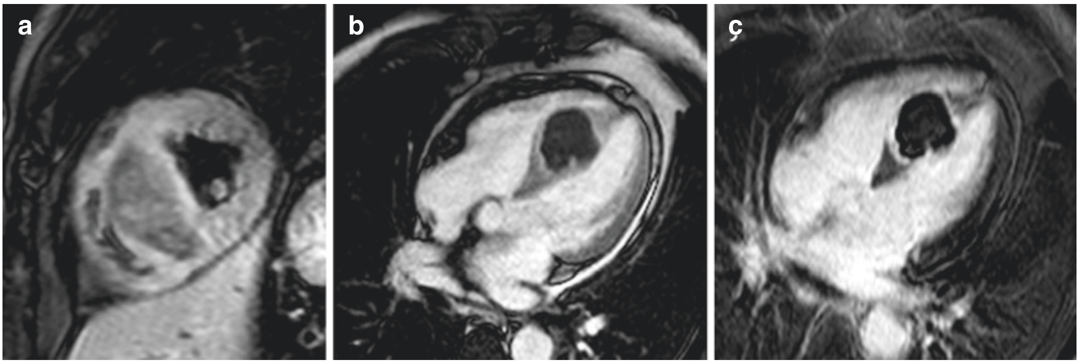

Fig. 10.5 Septal post-traumatic hematoma after cardiac catheterization. (**a**) T2w SPAIR short axis acquisition shows a septal thickening with the presence of focal well-circumscribed hypointense lesion. (**b**, **c**) Post-contrast cine bTFE and PSIR images show septal non-enhanced core

MRI: how and when. MRI is not widely used in the trauma setting since, differently to radiography, ultrasound, and CT, a rapid image acquisition is not possible with MRI. In addition, cardiac assessment is usually performed with breath-hold sequences which imply a cooperation frequently impossible in trauma patients.

Moreover, in emergency, the patient's past medical history, often unknown, could hide a dangerous contraindication to MRI examination. But, in conditions of clinical stability, MRI can be used to solve any residual doubt. The cine images can highlight areas of hypokinesia and also to assess the possible presence of myocardial or pericardial tearing. T1 w and T2 w sequences could underline the presence of pericardial effusion (and eventually blood content) as well as the presence of myocardial edema [16].

The assessment of perfusion and late gadolinium enhancement (LGE) may reveal ischemic injury or the presence of complications such as post-traumatic pericarditis.

Also, MRI in special cases helps to characterize possible injury as the presence of intramyocardial or pericardial hematoma (Fig. 10.5) [9].

10.2.3 Treatment

Patients with myocardial contusion causing conduction abnormalities require cardiac monitoring for 24 h due to the risk for sudden major arrhythmias. Treatment is mainly supportive (e.g., treatment of symptomatic arrhythmias or heart failure) and a further therapy is seldom needed. In severe injury, medical therapy (as volume loading) could be necessary awaiting surgical treatment. But, medical therapy could be enough, as in case of cardiac contusion, resembling that of non-Q wave myocardial infarction. Heart failure usually can be managed with conventional treatments, including vasodilators, diuretics, and inotropes.

In case of myocardial or valvular damages, surgical repair could be indicated, and in such cases, valve reconstruction is commonly successful. Fistulae and significant septal defects usually must be surgically repaired since spontaneous recover does not usually occur. Patients with commotio cordis are treated for their arrhythmias (e.g., resuscitation with CPR and defibrillation followed by in-hospital observation). Post-traumatic pericarditis treatments are similar to those that follow an infarction. Transient or permanent conduction disturbances may require temporary or permanent transvenous pacing. Laceration or rupture of a coronary vessel, a cardiac chamber, or the aorta requires urgent surgical repair. A coronary artery bypass could be necessary.

Key Points

- In case of chest trauma, the occurrence of palpitations, arrhythmias, new cardiac murmur, or unexplained tachycardia and/or hypotension could suggest blunt cardiac injury.

- ECG and cardiac biomarkers are useful tools for screening. Echocardiography is a simple and promptly available method to evaluate cardiac function and anatomic abnormalities.
- Chest radiography and chest CT or computed tomography angiography (CTA) are complementary first-line imaging modalities in the evaluation of patients with blunt trauma. Whether the combination of clinical conditions and mechanism of injury suggest a low probability of damage, a chest radiograph could be enough as first line of investigation.
- Transthoracic echocardiography is always indicated when cardiac injury is suspected.
- Cardiac CTA, cardiac MRI, and transesophageal echocardiography may be useful additional tools in selected cases

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