Cardiac rupture caused by traffic accident: Case reports and a literature review

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Abstract
The commonest cause of blunt cardiac injuries is from traffic accidents followed by violent falls, sport activities, accidents or a fight but rupture of the heart is rare and lethal. The precise incidence of cardiac injury after a blunt chest trauma is unknown as rates vary greatly in the literature from between 7% and 76% of cases. Autopsy studies have shown that the right ventricle is the most frequently ruptured, followed by the left ventricle, right atrium, intraventricular septum, left atrium and interatrial septum with decreasing frequency. Post-mortem imaging is a rapidly advancing field of post-mortem investigations of trauma victims. The available literature dealing with the comparison of post-mortem computed tomography results with forensic autopsy indicates that conventional autopsy remains superior for the detection of organ and soft tissue injuries in all body regions.

Keywords
Forensic pathology, blunt chest trauma, cardiac rupture, computed tomography post-mortem

Introduction
The most common cause of blunt cardiac injuries is from traffic accidents followed by impacts from violent falls, sport activities, accidents or fights.¹

The review on road safety published by the World Health Organization (WHO) in 2015 providing information from 180 countries indicates that worldwide the total number of road traffic deaths has plateaued at 1.25 million per year.² As reported by Ndiaye et al.,³ injuries most often resulting in death affected the thorax (62% of casualties), the head (49%), the abdomen (10%) and the spine (9%).

Blunt chest trauma may produce great vessel and cardiac injuries, including the pericardium, myocardium, coronary arteries, and cardiac conduction system.⁴ The exact incidence of cardiac injury after blunt chest trauma is unknown as rates reported vary significantly in the literature, ranging from 7% to 76% of cases.⁵

Blunt cardiac injury is most frequently caused by road traffic accidents and results from a direct blow to the chest from a steering wheel or rapid deceleration. The causative force is typically applied to the anterior precordium. Due to its position between the sternum and the thoracic vertebrae, the heart is exposed to any sudden impact on the sternum and to compression of the chest. High-energy blunt traumas (injury severity scores) can lead to different types of cardiac injury such as valve or myocardial contusions and cardiac rupture. These lesions are usually associated with a high mortality rate either by haemorrhagic or arrhythmic complications. Sudden death from a relatively minor contusion follows the disruption of the conduction system.

In traffic accidents, blunt cardiac injury is a common complication of chest trauma, but the rupture of the heart is rare.⁶

Case reports
Case report #1
A 40-year-old Caucasian woman died in a traffic accident; she was in the front passenger seat and was not wearing a seat belt. External examination of the body...
revealed nothing significant. The victim had no particular history of illness including cardiac disease. The legal authorities ordered a complete autopsy to be performed at the Institute of Legal Medicine of Palermo.

**Autopsy findings.** The deceased was a woman of slight build: 163 cm in height and 53 kg in weight. Few contusions (3 × 4 cm) were observed in the right frontal region and in the left parieto-occipital region. There were small ecchymoses over her lower limbs. Subgaleal haemorrhagic infiltration of the right frontal and the left parieto-occipital scalp was found. There were no fractures of the skull. The encephalon revealed diffuse oedema and congestion. Bilateral and multiple rib fractures of the second to the sixteen in the rib anterior arc and of the left clavicle were found. A left haemothorax (1900 cc) partially liquid and clotted, haemopericardium (about 150 cc) and contusion of the left lung acquitted in the pleural cavity were also revealed (Figure 1).

The heart weighed 290 g and its transverse and longitudinal diameters measured 9 cm each. The exam of the heart showed haemorrhagic infiltration of the anterior side of the pericardium with hit transmural laceration on the anterior surface (Figure 2).

After parallel cuts were made perpendicularly to the longitudinal axis, a laceration of the anterior side of the right and left ventricles and of the interventricular septum was observed, a finding of special interest because the traumatic interventricular septum is a rare injury (Figure 3). The necroscopic examination of other organs showed no abnormalities.

**Histological study.** Routine haematoxylin–eosin (HE) staining was performed on all tissue specimens. The lungs showed slight congestion associated with some small intra-alveolar haemorrhages. There were no particular histological findings in the other organs other than slight congestion. The examination of the sites of cardiac rupture did not reveal any myocardial diseases.

**Toxicological analysis.** The blood alcohol and toxicological screening was negative.

**Case report #2**

A 61-year-old man died immediately after a smash-up while stopping his motorcycle. The external examination of the body revealed bruises over the right frontal region and on his chest.

**Post-mortem computed tomography:** **Technique and findings.** The post-mortem (PM) interval between computed tomography (CT) and the medico legal autopsy was 6 h. CT was performed with a 128 slices MDCT scanner (Somatom AS Definition, Siemens). Volume acquisition with thin collimation (1 mm) was performed. Scan parameters were a tube voltage of 120 kVp, with an effective tube current of 120–160
effective mAs, gantry rotation time of 0.5 s, beam pitch of 1.2 and table speed of 46 mm per gantry rotation.

Images were reviewed using Picture Archiving and Communication System (PACS) workstation (Elephant.net suite AGFA HealthCare N.V., Mortsel, Belgium).

During the reading sessions, axial and multiplanar reformatted images were reviewed with a standard window (50 UH) and width level (350 UH), with adjustments made when needed.

PMCT showed a wide haematic pleural effusion due to the direct chest blunt trauma and a laceration of the posterior wall of the right atrium (Figure 4).

**Autopsy findings.** The deceased man was 178 cm in height, 75 kg in weight. A contusion (3×4 cm) was observed in the right frontal region and there were small ecchymoses over the lower limbs. Subgaleal haemorrhagic infiltration of the right frontal scalp was found and integrity of the skull was observed. The encephalon revealed diffuse oedema and congestion. Multiple rib fractures of the second to the nineteenth in the rib anterior arc and of the right clavicle were found. A right haemothorax (1500 cc), haemopericardium (about 100 cc) were also observed.

The heart weighed 350 g; transverse diameters measured 11.5 cm, longitudinal diameters measured 9 cm. Examination of the heart showed haemorrhagic infiltration of the posterior side of the pericardium with hit transmural laceration on the posterior surface of the right atrium (Figure 5).

**Histological study.** Routine HE staining was performed on all tissue specimens. The examination of the sites of cardiac rupture revealed no myocardial disease.

**Discussion and conclusion**

Blunt cardiac injury refers to a lesion sustained from blunt trauma to the heart and one of the most important consequences is myocardial contusion with the most frequent complications being arrhythmias, myocardial rupture, myocardial infarction, followed by valvular or papillary rupture, pericardium or coronary artery lacerations.6–9

Clinically cardiac contusion presents a spectrum of symptoms and signs of varying severity, ranging from precordial pain, dyspnoea, aspecific electrocardiogram (ECG) modifications, increased serum activity of several enzymes, rhythm abnormalities, severe conduction defects and death.10 The absence of a clear definition and gold standard for laboratory testing makes the diagnosis of blunt cardiac injury difficult. Treatment is adapted to the severity of injury and ranges from ECG monitoring to sternotomy with complex surgical repair.

Blunt traumatic rupture of the heart carries a very high mortality rate.11,12 Differences in mortality depend on the location of the injuries with ventricular rupture causing the highest mortality rate. The overall high mortality rate has been attributed to any of the three reasons associated with the injury: bleeding, hypoxia or direct cardiac injury.

Cardiac lacerations due to blunt trauma are almost always described in car accidents; they are rare and usually fatal. Heart lacerations may involve the right and left atria, the right and left ventricles, the atrial septum, the interventricular septum as well as the intrapericardial portion of the superior or inferior vena cava, the pulmonary veins, the atroventricular...
The incidence of cardiac injury after blunt chest trauma in PM studies is reported at between 14% and 25%.\(^\text{15,16}\)

Autopsy studies show that the right ventricle is most frequently ruptured, followed by the left ventricle, right atrium, intraventricular septum, left atrium and interatrial septum in decreasing frequency.\(^\text{16}\)

Possible mechanisms of laceration include a direct blow to the chest, compression of the heart through bidirectional forces between the sternum and the spine during early systole, with the ventricular cavity filled and the atroventricular valves closed, deceleration or rapid rotation with fixation of the great vessels, transmission of high hydraulic venous pressure following compression of the abdomen or extremities and rupture of the myocardium by a fractured rib. In all these injuries, the sudden great pressure applied to the chest seems to be the key factor in determining explosive cardiac laceration, frequently involving the roof of the atria and/or apex of both ventricles. Chamber or valvular rupture is more likely if the impact occurs at end diastole, when the heart is maximally distended with blood. The severity of the lesion depends on the impact velocity and chest compression.

In the reported cases, the cardiac rupture is connected with the violent and direct impact on the chest and the consequences of this violent impact were multiple bilateral fractures of the ribs and cardiac injuries as revealed at autopsy. In case no. 1, there was rupture of the anterior side of both ventricles and a rupture of the interventricular septum; a finding of special interest because the traumatic interventricular septum is a rare injury.

Cardiac rupture may be detectable on post-mortem CT (PMCT).

There is some evidence on digital autopsy and its effectiveness in determining the cause of death caused by blunt trauma.\(^\text{17}\)

While PMCT imaging is better than autopsy in detecting skeletal injuries, organ and soft tissue injuries are often missed by PM imaging whereas, along with other soft tissue and organ injuries, autopsy detects more cardiac and pericardial injuries than radiological investigations.\(^\text{18}\) CT has low sensitivity in detecting cardiac injury. Aghayev et al.\(^\text{19}\) found that two-thirds of these injuries remained undetected with PMCT and PMMRI. Notably, Kasahara et al. reviewed 339 forensic autopsy cases and found that causes of death could be determined based on PMCT findings alone in 7% of the cases, based on suggestive PMCT findings with additional information in 54% and could not be determined in 38%. Among 11 cases of traumatic cardiac rupture, three cases were categorised as diagnosable because rupture sites were clearly found on PMCT. Eight cases of traumatic cardiac rupture were categorised as suggestive, since rupture sites were not evident on PMCT images.\(^\text{20}\)

The available literature which deals with the comparison of PMCT results with forensic autopsy considers that conventional autopsy is better at detecting organ and soft tissue injuries in all body regions.

In conclusion, the possibility of cardiac rupture must be considered with particular attention at post-mortem inspection of victims of a road accident with few traumatic external injuries.

The cases we report underline the importance of a systematic and complete autopsy in all cases of blunt trauma deaths even when the body shows no external injury and that conventional autopsy remains the superior procedure for the detection of organ and soft tissue injuries in all body regions.

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