

CASE REPORT

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Sudden death from myocardial contusion following an isolated blunt force trauma to the chest

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Abstract Cardiac contusion is a common concomitant injury in blunt, non-penetrating chest trauma and is mostly a benign disorder which remains undiagnosed. In the case presented, a young man sustained a single blunt trauma to the chest from falling pieces of a wooden wheel and died at the scene. Among other findings, the autopsy revealed a circumscribed detachment of the coronary arteries on the anterior side of the heart. The most unusual findings were lacerations of the vessel wall layers in these areas which could already be seen at the autopsy and were proven by histological examination.

Keywords Heart · Contusions · Non-penetrating wounds · Histology · Fatality

Introduction

Although blunt traumas of the heart have been known for hundreds of years, Urbach (1922) was one of the first to provide a detailed systematical overview [1]. Since 1935, when Beck [2] described the phenomenon of cardiac contusions, many articles concentrated on the pathology, diagnosis and treatment of non-penetrating traumatic injuries of the heart.

Due to its anatomic position between the sternum and the thoracic vertebrae, the heart is exposed to any sudden impact on the sternum and to compression forces applied to the chest. Cardiac injuries range from concussion to major disruption, of which the least severe is the cardiac concussion or commotio cordis. Compared to contusions, concussions are characterised by a lack of myocardial cel-

lular damage and cardiac concussion causes functional damage while cardiac contusion is structural damage. However, both concussion and contusion may be caused by similar mechanisms.

Cardiac contusion is a concomitant injury in blunt chest trauma and frequently suspected in patients with non-penetrating injuries of the chest. Most patients with a diagnosed cardiac contusion have been injured in traffic accidents [3, 4, 5, 6] and have either recovered successfully or died from other injuries. In contrast, no sudden death from an isolated, single cardiac contusion with the absence of further injuries has been reported so far.

Case history

A 28-year-old farmer was found lying in a rural building and had been previously carrying bales of straw up the barn floor. His mother, who was working outside in the garden, suddenly heard a dull thud and noticed that one of the bales had fallen down. She found her son lying on the floor and called the police. On arrival of the emergency physician the man showed respiratory and cardiac arrest and after 40 min of unsuccessful resuscitation death was declared.

Police investigations revealed that the man had used a self-constructed straw bale-lifting machine consisting of an electric motor, with a wooden wheel fixed to it, driving a tackle block by a 3-m-long leather belt. The wooden wheel was originally situated at a height of 1.3 m but when the man was found, the wooden wheel was broken into pieces. The belt was found next to the man at a distance of 1.5 m from the electric motor.

Autopsy findings

The body was that of a male 178 cm in height and the external examination of the body revealed a 3.6-cm laceration on the left side of the forehead. A few isolated subcorneal and subconjunctival petechiae were observed and a rectangular skin abrasion over the sternum measuring 18 cm in the longitudinal body axis and 10.4 cm in width.

The internal examination revealed haemorrhages in the pectoral muscles corresponding to the skin abrasion with 50 ml of a sanguinous fluid in the right pleural space and 20 ml in the pericardium. The lungs showed a haemorrhagic edema, the lung tissue small lacerations measuring up to 3 cm. The weight of the heart was 380 g, the heart muscle was relaxed. Subepicardial haemor-

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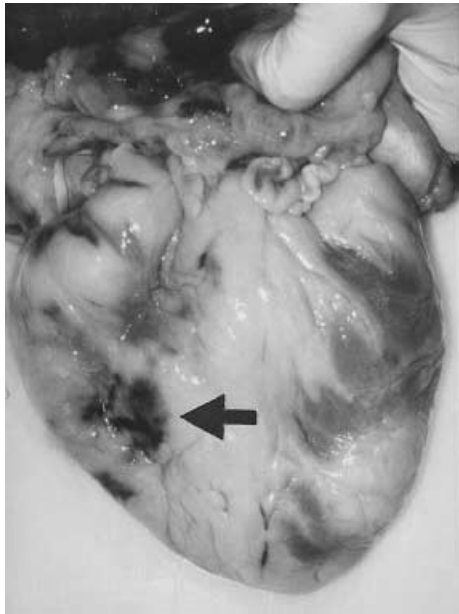


Fig.1 Anterior side of the heart with subepicardial haemorrhage (arrow)

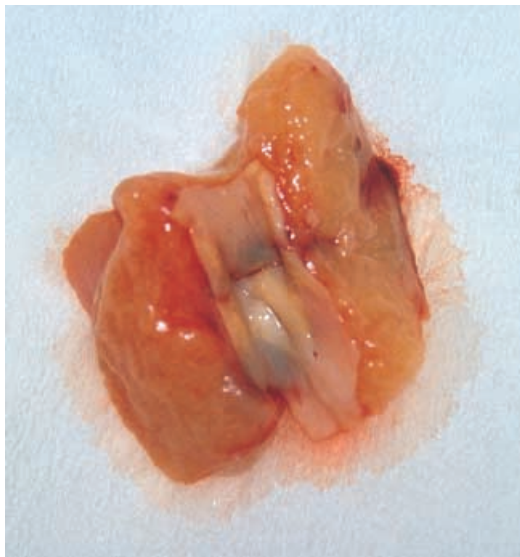


Fig.2 An incomplete circular rupture and haemorrhages between the media and adventitia can be seen by dissection of the right coronary artery

rhaging was visible on the anterior and posterior side of the heart (Fig. 1). Small lacerations of the papillary muscles in the right ventricle were observed. Both the left and the right coronary artery were detached from the adjoining tissues. The detachment of the right coronary artery was 4 cm in length and originated adjacent to the origin of that vessel. The branches of the left coronary artery were detached next to their common origin and the detachment was 2 cm long. All of the detached vessels showed small lacerations of up to 2 mm in length across the vessel walls (Fig. 2) but did not lead to considerable obliteration of the vessel. Even the macroscopic examination revealed an unusual dissection of the coronary vessels.

Ribs 2–5 on the right and 2–3 on the left were fractured in the midclavicular line showing only sparse haemorrhages to the adjoining tissues. No abnormalities of the other internal organs were found.

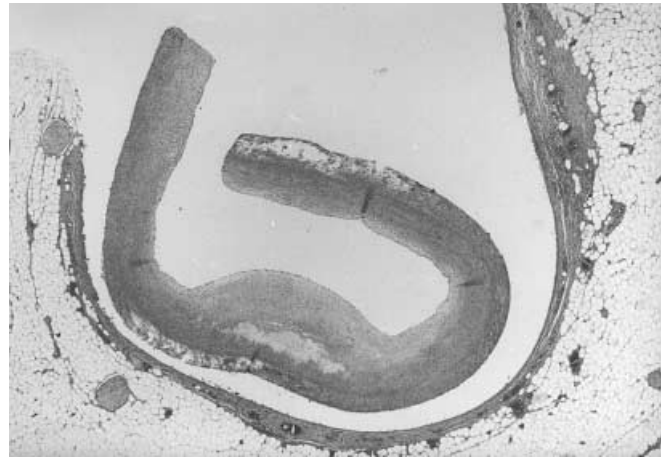


Fig.3 Right coronary artery with dissection of the layers (HE, 40 ×)

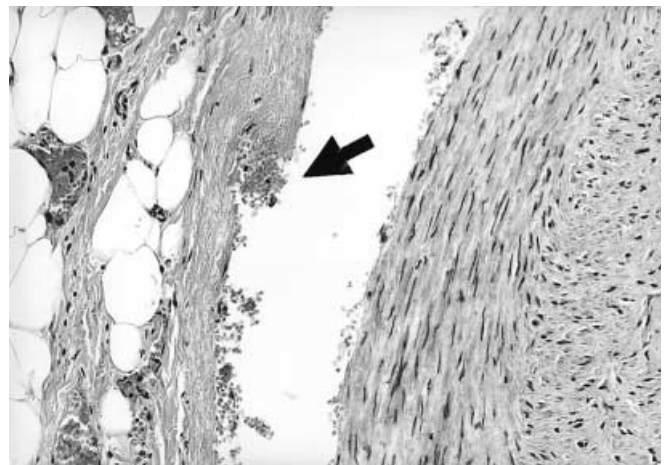


Fig.4 Detail from Fig.3. Traumatic dissection of the layers with erythrocytes between adventitia and media (arrow, HE, 400 ×)



Fig.5 Reconstruction of the accident

Histological findings

The histological examination of the coronary arteries showed a detachment of subepicardial vessels (Aa. coronariae) from the fatty tissue (Fig. 3) and the resulting space was filled with erythrocytes.

In some areas, coronary vessels showed intimal and medial tears but there were no signs of thrombosis.

A traumatic rupture was found between the adventitia and the media with accumulation of erythrocytes (Fig. 4). The vessel wall was free of pre-existing disorders such as medionecrosis.

The anatomical structure of the myocardium and the small vessels was normal. However, in the area of contusion, isolated foci of haemorrhages could be found between the muscle fibres and in the epicardial fatty tissue. The extravasated erythrocytes were not accompanied by any cellular reaction such as leukocyte demarcation. There were no signs of myocarditis. Apart from intramuscular haemorrhages, reactions of cardiomyocytes, such as contraction band necrosis, fatty degeneration and sarcoplasmic vacuoles, were absent.

Further investigations

The investigation of the wooden wheel revealed that it had been constructed of single boards and originally had a diameter of 42 cm and a width of 9.85 cm. The shape of the broken piece corresponded exactly with the abrasion marks on the body (Fig. 5) so that the chest trauma must have been caused by parts flying off the broken wheel.

Discussion

Cardiac contusions are said to be the most common injury in blunt, non-penetrating chest traumas [7, 8, 9] and according to the literature, the incidence of cardiac contusions after blunt chest traumas is 7–27% and the mortality is less than 15% [4, 5, 6, 10, 11]. Although it often remains undiagnosed, it is a benign disorder in most patients [2, 12, 13] and furthermore, cardiac contusions are common injuries in children [14, 15].

Cardiac contusions usually result from acute heart compression between the sternum and the spine due to increased intrathoracic pressure, i.e. transmitted from a blow to the chest, as in the case presented. In the pre-seat belt era, cardiac contusions of drivers were known as a result of frontal collision accidents and referred to as the steering wheel injury [2]. In contrast, there was a recent report of an isolated coronary artery dissection in a driver who had been involved in a head-on collision he had been wearing a seat belt and the airbag had inflated [16]. Other causes of cardiac contusions include falls, fist blows, hoof blows, kicks, crushing, explosions and even cardiac massage [1, 17].

Experiments with rabbits have shown that the impact severity (whether a concussion, contusion or a rupture of the heart occurs) depends on the impact velocity and chest compression [18] and as it is a distinct pathology entity cardiac contusion can be identified grossly and histologically at autopsy.

The clinical signs of cardiac contusions are similar to those of an infarction including increased serum activity of several enzymes [7, 19], ECG alterations or cardiac arrhythmia [20]. Arrhythmia occurs as a result of abnormal perfusion patterns, aberrant conduction by damaged myocardial cells or vagal-sympathetic reflexes. Interestingly, the subjective complaints are also similar as most patients with a cardiac contusion report chest pain and angina-like

symptoms which are not relieved by coronary vasodilating drugs [21]. In 1954, Burchell [22] expressed his clinical impression regarding injuries of this type in a couplet:

“And always with a heart contusion
Arise both doubt and much confusion”.

Clinical studies report a much higher frequency of severe post-traumatic heart disorders than experimental studies with animals [23]. This was explained by pre-existing degenerative alterations of the heart and/or coronary vessels resulting in more extensive haemorrhaging or post-traumatic coronary thrombosis.

The right ventricular wall is the area most vulnerable to contusions from blunt chest traumas. Due to higher pressures and thickness on the left heart wall, the risk of a damage of the aortic and mitral valves is much higher than for the valves on the right side [13]. On the other hand, there are reports about lesions of the tricuspid valve following blunt chest trauma [24]. In addition, we show that the coronary arteries also can be part of traumatic injuries. According to the literature, lacerations of the coronary arteries are a very rare complication in myocardial contusions. Only 10 patients out of 546 autopsies of patients with blunt chest trauma showed coronary artery lacerations [25]. Recently, aneurysms of the branch arteries of the left anterior descending coronary artery following a right chest wall contusion have been reported in a 5-year-old child who had been the victim of a high-speed motor vehicle crash [26].

Arrhythmia or an inappropriate low cardiac output is frequently found in patients with cardiac contusion [27]. Recent studies in rabbits revealed that myocardial contusion has direct arrhythmogenic effects. A high contusion kinetic energy was found to result in increased arrhythmia seriousness [28].

In the case presented, only small lacerations across the coronary artery wall were present. In our opinion, these tears were too small to cause any relevant obliteration of the vessel. Aside from potential artefacts because of resuscitation, pathology findings were absent in the case presented. We assume that death occurred as a result of arrhythmia, perhaps in combination with low cardiac output.

The massive blunt force was applied to the sternum, and the skin abrasions were in correspondence with the localisation of cardiopulmonary resuscitation (CPR). Therefore, the effect of resuscitation can not be estimated exactly. However, as the histological examination revealed only isolated foci of haemorrhages in the area of contusion without cellular reaction and haemorrhaging in the adjoining soft tissue of the fractured ribs was very sparse, the trauma had been survived only for a very short time. The blunt force trauma in the case presented had a high energy level and a hard pulse. Reports from the literature indicate that this type of trauma seems to be more likely to cause coronary artery dissections or aneurysms [16, 25, 26]. In contrast, CPR shows a lower energy level and a more softer pulse. Typical injuries following CPR include serial rib fractures and/or fractures of the sternum (especially in elderly patients) leading to contusion or impale-

ment of the lungs, disruption of the stomach or the diaphragm [29] or even major disruption of the heart wall due to dislocation of sharp-edged bone fragments [30], but CPR has not been described as a cause of severe coronary artery dissection

Lethal cardiac contusions are very rare [3, 4] and in most cases not only a single blunt chest trauma but multiple injuries like major fractures or ruptured viscera are sustained and the fatal outcome is usually caused by these latter injuries. Death from a cardiac contusion, however, usually occurs several days or weeks after the trauma as a result of coronary thrombosis or even a delayed heart rupture after 44 days [12].

In contrast to myocardial infarction, the transition from normal to damaged myocardial tissue is more abrupt in cardiac contusion. However, histological changes are often similar including leucocyte infiltration, myocardial cell necrosis, absorption of haemorrhage, healing by scar formation, sarcoplasmatic vacuoles and contraction banding associated with diffusion of calmodulin [31, 32, 33, 34, 35]. It is an interesting fact that changes from myocardial trauma were found to be detectable much earlier than those from ischemic damage. The most significant changes were found in the centre of the contusion [32]. In the case presented, even these early reactions of cardiomyocytes were absent. In our opinion, this follows from the very short survival time after the trauma which is demonstrated by the sparse haemorrhages to the adjoining tissues in the injured parts of the body and the internal organs. However, a recent study reported that in two cases of myocardial contusion, contraction band necrosis was not detectable although the trauma had been survived for several days [36]. For the early detection of myocardial damage, immunohistochemical markers are a useful tool [35].

As cardiac contusions are primarily survived, clinicians must be aware of late complications, i.e. disorders of blood flow and coronary thrombosis. From the legal point of view, a causal connection between thoracic trauma and late cardiac complications must be taken into consideration.

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