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Blunt traumatic rupture of the pericardium with cardiac herniation: two cases diagnosed using computed tomography

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Abstract Traumatic ruptures of the pericardium with cardiac herniation are infrequent, and their radiological pattern little familiar, so that they are often missed preoperatively. Few reports have emphasised the use of a CT scan as a tool for diagnosis and CT scan signs have not been well documented. We report on two cases of traumatic herniation of the heart for which a CT scan brought a major contribution for diagnosis. We describe the presence of an empty pericardial sac on CT slices which allowed us to diagnose the cardiac herniation. These observations demonstrate that CT scans can contribute to the diagnosis of pericardial rupture with cardiac herniation.

Key words Trauma · Pericardium · Heart · Hernia · CT

Introduction

Pericardial ruptures from blunt chest trauma, with or without cardiac herniation, are rare observations but are found in up to 3 % of patients in autopsy series [1]. The first observations were provided by Morel-Lavallee in 1864 [2]. Since that time, except three series of large trauma centres [3, 4, 5], only case reports have been published. Pericardial ruptures follow a severe blunt chest injury. Their mechanism is similar to that of traumatic aortic ruptures (i.e. frontal and vertical deceleration or violent thoracic crush) and dominated by motor vehicle accidents. The pericardial rupture may occur on the pleuropericardium or diaphragmatic pericardium [4, 6]. The pericardial tear may be isolated or complicated by cardiac herniation. Pericardial injuries can be extremely difficult to diagnose, particularly if there is no protrusion of the heart. As yet, there is no consensus on the best means of diagnosis, and CT scan signs have rarely been described [5, 7, 8, 9, 10]. We report on two cases of traumatic rupture of the pericardium with cardiac herniation, one on the left side and the other on the right side, for which a CT scan allowed us to make the diagnosis.

Case reports

Case 1

A 78-year-old man arrived at the emergency department of our hospital after a serious traffic accident (head-on car collision). Initial lesions included head trauma with loss of consciousness and chest trauma with respiratory failure. The haemodynamic condition of this patient was unstable despite a blood transfusion and amine pressive therapy. The chest X-ray (Fig. 1a) showed broken ribs on the right side (fifth, sixth, seventh), fracture of the sternum and the left clavicle, a left apical cuff and subcutaneous emphysema. The heart was enlarged and shifted to the left with a right

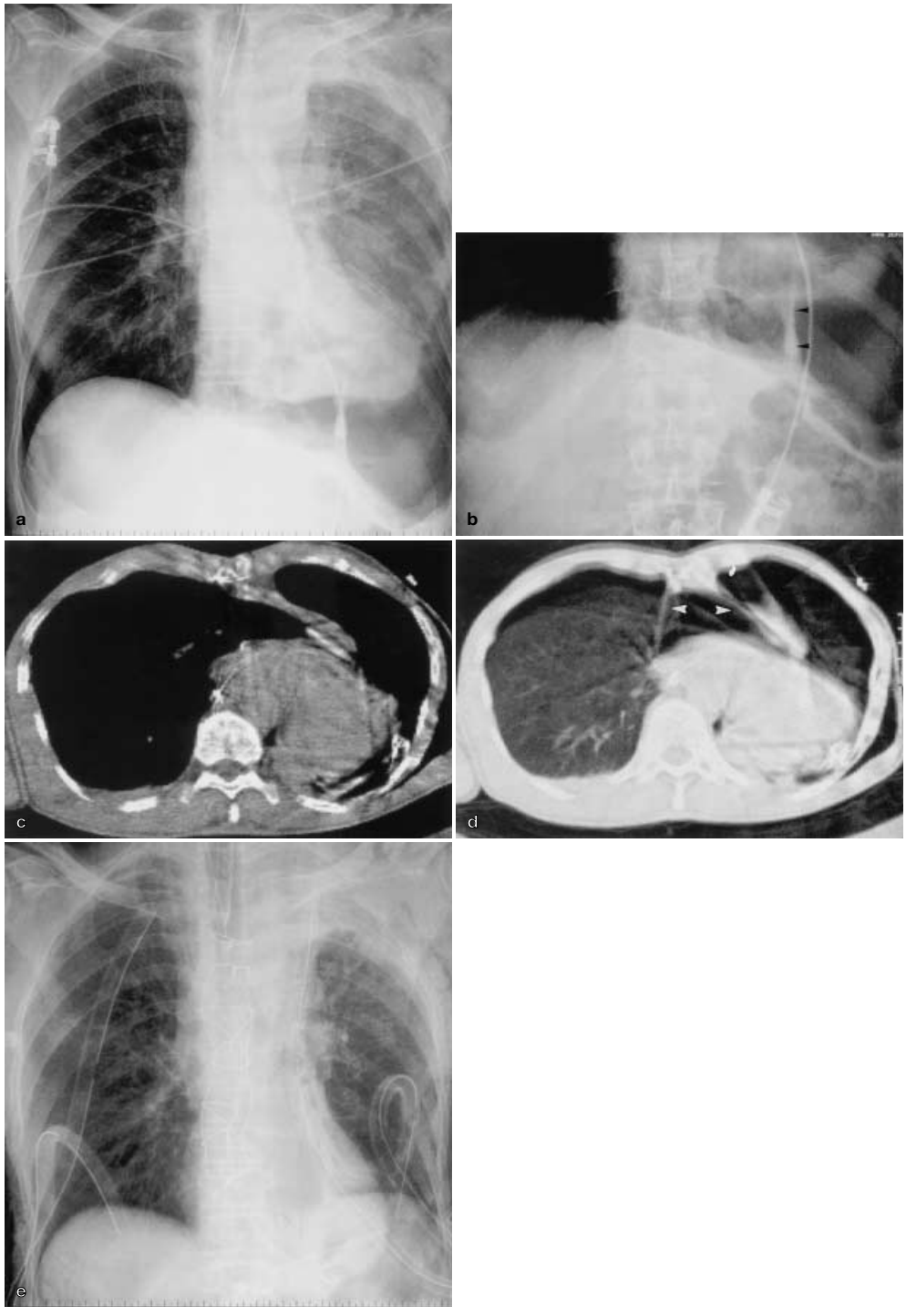

Fig. 1 a–e A 78-year-old man who was involved in a head-on car collision. **a** Antero-posterior chest X-ray. The heart is shifted to the left, with a right border projected on the spine and a double left contour. An air collection underlines the inferior side of the heart. Such a collection can correspond to a pneumopericardium, a pneumomediastinium (but there was no other sign of air in the mediastinum and in the pericardial sac) or to a pneumothorax around a dislocated heart. **b** Cone view on the left diaphragm. The air collection visible on the inferior side of the heart is separated by a dense vertical line corresponding to the left pleuropericardium *(arrowheads)*. **c** Axial CT scan (8 mm thick), window level: 20 HU, width 450 HU. The heart is dislocated in the left hemithorax, turning around the descending aorta. The left pericardium is draping the heart on its anterior side. **d** Axial CT scan (8 mm thick). Window level: 600 HU; width 1600 HU. The pericardial sac *(arrowheads)* is underlined by a bilateral pneumothorax. It is empty and the heart is dislocated in the left hemithorax. **e** Postoperative chest X-ray control. The heart is situated medially in the thorax, with a regular shape of the left inferior arc. Two pleural and two mediastinal drains are inserted

border projected on the spine and a double left contour. An air collection was noted between the inferior side of the heart and the diaphragm. This collection was separated by a dense vertical line (Fig. 1b). As this collection underlined the inferior side of the heart, it could correspond to a pneumopericardium or a pneumomediastinium, but there were no other signs of air collection in the pericardium on the chest X-ray that could confirm the latter hypothesis. Abdominal US was normal. Despite an unstable haemodynamic condition, the patient was examined by CT. A CT scan of the head revealed a left temporal haemorrhagic contusion. The CT scan of the chest was performed using a Somatom DRH (Siemens, Erlangen, Germany) with slice-to-slice acquisition, slice thickness 10 mm, 125 kV and 125 mA, without opacification. The examination showed a bilateral pneumothorax and a dislocation of

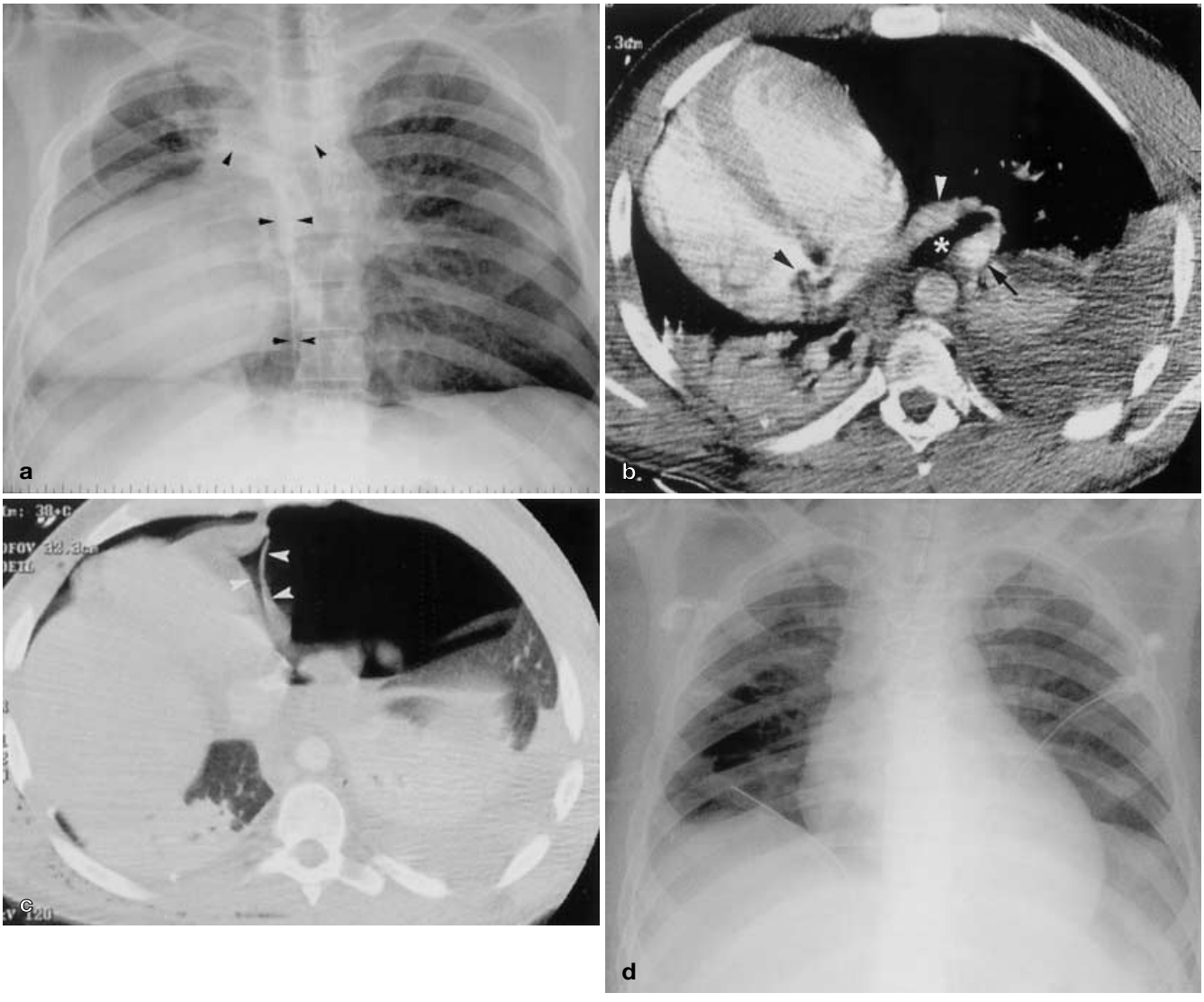

Fig. 2 a–d A 36-year-old man who had a severe ski accident. **a** Antero-posterior chest X-ray. Right-sided heart without patent abnormality of cardiac contour but the left border is located in the right hemithorax. The border of the descending aorta cannot be seen. A long medial vertical line *(arrowheads)* is seen. The upper part is thick and corresponds to the anterior mediastinal line and the lower part is thin and corresponds to the left pleuropericardium. There are no signs of pneumomediastinium or pleuropericardium. **b** Axial enhanced CT scan (3 mm thick). Window level: 58 HU; width 394 HU. The heart is dislocated in the right hemithorax, and right cardiac chambers are located posteriorly to the left ones. A spur is seen on the posterior wall of the right atria *(black arrowhead)*, related to a bending of this wall. The left bronchus *(asterisk)*, the left superior pulmonary vein *(white arrowhead)* and the left pulmonary artery *(black arrow)* are located anterior to the descending aorta. The right inferior lobe is collapsed and a left pleural effusion is visible. **c** Axial CT scan (3 mm thick) at the level of the right diaphragm and inferior vena cava. Window level: –400 HU; width 1600 HU. The pericardial sac is visible *(white arrowheads)* as a triangular cavity underlined by the bilateral pneumothorax. **d** Postoperative chest X-ray control. Normal cardiac shadow

the heart in the posterior part of the left thoracic cavity (Fig. 1c,d). A translucent round cavity, which was thought to be the pericardial sac, was seen in place of the heart, with two lateral leafs underlined by the bilateral pneumothorax (Fig. 1d). The pneumopericardium and the pneumothorax accounted for the air collection at the inferior side of the heart found on the chest X-ray. The vertical dense line separating this collection was related to the left pleuropericardium. The examination was performed without enhancement; thus, the morphology of cardiac chambers could not be analysed. As the diagnosis of traumatic cardiac herniation was prompted and the patient's hemodynamic status was bad, he was taken to the operative room. Thoracotomy confirmed a lateral tear of the pleuropericardium and dislocation of the heart in the left hemithorax. The phrenic nerve was respected. There was no myocardial contusion or cardiac rupture. The heart was replaced in its normal site and the tear was sutured. Postoperatively, the patient recovered to a stable haemodynamic status. The chest X-ray was then normal (Fig. 1e). He died 24 h later because of brain damage.

Case 2

A 36-year-old man was admitted to our hospital following a severe skiing accident (a 100-m fall onto a rocky slope). Physical examination revealed paraplegia. Despite the seriousness of the accident, there were no signs of circulatory or respiratory failure. An anterior chest X-ray (Fig. 2a) showed the cardiac mass totally displaced within the right thoracic cavity, uncovering the dorsal spine. A vertical line slightly curved to the left seemed to correspond in its upper part to the anterior mediastinal line, but was prolonged down, up to a few centimetres above the diaphragm. The descending aorta could not be localised on the right or the left side of the dorsal spine. The fourth, fifth and sixth posterior arcs of right ribs were broken as well as the fifth and sixth vertebra. A diagnosis of traumatic cardiac herniation was considered but was questionable because of the patient's good haemodynamic status. Abdominal US showed that the liver was on the right side, the spleen on the left side and there was no peritoneal effusion; thus, a total situs inversus could be eliminated but the hypothesis of a right-sided heart remained possible. Transthoracic echocardiography was not useful because of bilateral pneumothorax. Trans-oesophageal echocardiography did not find any sign of pericardial tear, cardiac herniation, myocardial contusion or pericardial effusion. The morphology of the cardiac chambers was normal except for a spur on the posterior wall of the right atria. The preserved haemodynamic condition allowed the realisation of a helical CT scan. It was performed with a General Electric Hi-Speed (GE Medical Systems, Milwaukee, Wis.), slice thickness 3 mm, 2:1 pitch, 0.8 s per rotation, at 120 kV and 150 mA, with and without contrast enhancement. This CT examination confirmed the bilateral pneumothorax and showed a right lung contusion with small hemothorax (Fig. 2b,c). The heart was displaced to the right, the aortic cross was on the left side and right cardiac chambers were located posterior to the left ones. The branch of the pulmonary artery that crossed over the bronchus was located on the left (Fig. 2b). These findings suggested the hypothesis of a right cardiac herniation rather than a congenital abnormality. The pulmonary veins were draped around the anterior side of the descending aorta and remained patent. The inferior vena cava was deviated to the right but was not strangulated. The spur that was found on trans-oesophageal echocardiography corresponded to a bending of the posterior wall of the right atrium and was related to a twist of the heart around an axis constituted by the two vena cava. On slices at the level of the heart ventricles, a triangular cavity that underlined the right border of the anterior mediastinal line corresponded to the empty and collapsed pericardial sac (Fig. 2c). The CT scan demonstrated that the vertical dense line in the middle of the chest film corresponded to the anterior mediastinal line in its superior part and to the left pleuropericardium in its inferior part. According to the CT signs, the diagnosis of cardiac herniation was assumed. The patient was taken to the operating room where he underwent a thoracotomy. It confirmed that the heart was dislocated from its pericardium which was torn from superior vena cava to diaphragm. The tear was vertical, 15 cm long, and located just behind the phrenic nerve, which had been preserved. There was no myocardial contusion or cardiac rupture. The heart was replaced in the pericardium and the tear was sutured. The right phrenic nerve was separated from the pericardium but was respected. The postoperative course was good in despite right phrenic palsy and the postoperative chest film was normal (Fig. 2d).

Discussion

In a review of the literature, Clark et al. [4] reported in 142 traumatic ruptures of the pericardium. The left pleuropericardium was injured in 71 (50%), the right pleuropericardium in 24 (17%), the diaphragmatic pericardium in 39 (27%) and the superior mediastinal pericardium in 6 cases (4%). A cardiac herniation was found in 31 of left and 5 of right pleuropericardial defects, and in 4 diaphragmatic tears of the pericardium. Since 1987, we have noted in the literature 44 additional cases of pericardial ruptures, 26 of the 44 being complicated with cardiac herniation.

In ruptured diaphragmatic pericardium, abdominal protrusion of viscera in the pericardial sac may occur, but cardiac herniation is rare. In ruptured pleuropericardium, the tear is most often located along the phrenic nerve and, when the tear is large enough, the heart may be dislocated. Dislocation of the heart results in a torsion along an axis made by the inferior vena cava and the great vessels with strangulation of the heart. It may incarcerate the myocardium or strangulate a coronary artery [7]. Other cardiac injuries may be associated with ruptures of pleuropericardium such as myocardial contusion [8] and chamber ruptures [5].

Clinical signs of cardiac herniation include loud heart sounds, splashing murmur as described by Morel-Lavallee [1], deviation of apex beats and signs of elevated right venous pressures (jugular vein distension). Electrocardiogram may show axis deviation or rotation, T-wave inversion or an acute bundle branch block.

Dealing with a patient who presents cardiovascular failure without evidence of haemorrhage, a chest X-ray may suggest a cardiac herniation if there is (a) a shift of the heart to the left with or without a double contour of the inferior left arc, (b) a displacement of the heart to the right, or (c) signs of pneumopericardium, with or without pneumothorax. Both of our cases presented a shift of the heart, the first one to the left with a right border projected on the spine, and the second one in the right hemithorax with a left border underlined by the air of the right lung. There was no sign that could explain this shift, i.e. compressive pneumothorax or haemothorax, air trapping in the lung or atelectasis. Thus, this sign constituted a valuable piece of information and clearly a warning signal. None of our cases presented usual signs of pneumopericardium, but in the first case the air collection underlying the heart was related in its medial part to a pneumopericardium and in the external part to a pneumothorax that underlined a dislocated heart. This latter aetiology of a collection that underlined the inferior side of the heart should be kept in mind.

Only a few authors [5, 7, 8, 9, 10] have reported on the use of chest CT. In their articles, the main sign of cardiac herniation is a dislocation of the heart in the left hemithorax. Thomas et al. [7] described a pericardial

flap and an external solution of continuity of the pericardial sac as an additional sign of pericardial rupture. In our two cases, a dislocation of the heart was visible on CT slices, but the most important diagnostic sign was the demonstration of an empty pericardial sac on CT images, especially in the second patient in whom differential diagnosis of congenital abnormality could be discussed. Furthermore, the presence of an empty pericardial sac which was filled with air made the pleuropericardium visible on chest film, and CT examination allowed us to understand these unusual signs. In the first patient, the left pleuropericardium was visible as a vertical line that separated the air collection at the inferior side of the heart, and in the second patient, the left pleuropericardium which was underlined by air accounted for the continuation of the anterior mediastinal line down to the diaphragm.

In the second patient, the displacement of the heart to the right side suggested the diagnosis of right cardiac herniation, but there was no other sign of dislocation (i.e. pneumopericardium) on chest X-ray that could help us to assess this hypothesis. Furthermore, this patient had a preserved haemodynamic status and this rare occurrence in cardiac dislocations made the diagnosis more difficult. Surprisingly, haemodynamic conditions were preserved in the five right cardiac herniations discussed in Clark et al.'s article [4]. However, in our review of the literature we found four additional right traumatic cardiac herniations [5, 11, 12, 13] and none of them were haemodynamically well tolerated. Only 2 of 32 cases that we reviewed had a stable haemodynamic status. In these 2 cases (left traumatic herniations of the heart), diagnosis and subsequent surgery were delayed up to 14 days and 2 months.

Surgical repair consists of repositioning the heart and then suturing the tear or performing a pericardiotomy. The latter technique entails a risk of post-pericardiotomy syndrome [7]. The final outcome of patients with traumatic cardiac herniation that has been repaired depends on associated injuries, and the mortality rate remains high (up to 40%) in this population of severely injured patients [3, 5].

In these observations of traumatic cardiac herniations, CT appeared to be a valuable diagnostic tool. It demonstrated direct signs of cardiac herniation: dislocation of the heart and presence of an empty pericardial sac. Furthermore, it allowed us to understand unusual signs of cardiac herniation on chest films, such as dense lines, due to the visibility of the pleuropericardium. The systematic use of CT in the investigation of traumatic pathology should improve the diagnosis of these traumatic cardiac herniations.

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