Post-mortem MSCT diagnosis of acute pericardial tamponade caused by blunt trauma to the chest in a motor-vehicle collision

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Abstract: A 30-year-old male car driver died after an accident involving a collision with a guardrail barrier on a viaduct. He died before cardiopulmonary resuscitation (CPR) was applied at the accident scene. Autopsy was not permitted due to local culture and family wishes. Multislice computed tomography (MSCT) was used to image the body. The results revealed that death was due to acute pericardial tamponade. A series of rib fractures, and a transverse fracture of the sternum were found. External examination revealed a minor skin abrasion in the middle of the sternum. Reports of MSCT identification of acute pericardial tamponade are rare in cases of motor vehicle collisions. Furthermore, the mechanisms for blunt chest trauma were discussed to explain the injuries.

Key Words: multislice computed tomography (MSCT), pericardial tamponade, sternum fracture, car accident.

A cute pericardial tamponade caused by cardiac rupture most commonly occurs due to collisions between motor vehicles, falls, sporting activities, and is a rare complication from cardiopulmonary resuscitation (CPR) [1–5]. The use of multislice computed tomography (MSCT) scanners is rapidly becoming established in forensic medicine.

The advantage of digital images from CT scans lies in two- and three-dimensional documentation, and in the possibility of reconstructing the events leading to accidents [6, 7]. MSCT also has been used to explore autopsy findings, including fracture systems, air embolism, gross injury to tissues, and drowning [8–10]. However, rare cases of pericardial tamponade with a fractured sternum and ribs have been reported using MSCT-based diagnoses in forensic practice.

We report here a case of pericardial tamponade along with a minor abrasion to chest skin after an unusual car collision with a barrier on a viaduct: the diagnosis was by MSCT. Knowledge of the MSCT findings of pericardial tamponade due to cardiac injury has been accumulating in forensic practice, and we discuss the mechanisms of production of such injuries.

Case history

A 30-old-year car male driver died after a car accident. He was not wearing a seat belt and was traveling at ≈60 km/h. There were no skid marks on the road, and his car veered into a solid guardrail barrier on viaduct. No other resuscitative measures were taken for 60 min until an ambulance arrived, and he was attended to 10-min later. At this time, he was examined by paramedics who found him in respiratory and cardiac arrest. Resuscitation without cardiac massage was applied at the accident scene, but death was pronounced at the scene. The bumper of the car showed severe deformation due to frontal impact (Figure 1A). The right top windshield shattered without bulging. Deployment of an air bag (Figure 1B) and the driver were observed leaning forward to the steering wheel.
The family of the driver did not wish autopsy to be conducted due to local culture and because it was a non-criminal case. Comprehensive health records, information on individual medical history and family medical history were provided by the attending police officer to exclude cardiovascular system diseases (CVDs). All clinical information showed no signs of CVD and other metabolic diseases.

The body was that of a strong young male with a great physique. Two abrasions were under the surface of the chin and on the anterior neck; the diameter was 3 cm (Figure 2A). An abrasion of dimension 3 cm × 0.5 cm was on the skin in the middle of the sternum (Figure 2B). Furthermore, two abrasions were found at the right and left knee. Abrasions or superficial cuts were not observed on the forehead, nose, and face. Thin slivers of windshield glass were not observed on the clothing. No other injury was detected upon external examination. Toxicological examination revealed a alcohol level of 167 mg/100 mL in blood. No other drugs were detected.

Post-mortem MSCT investigation

The entire body was wrapped in an artifact-free body bag and fully scanned using a 40-MSCT system (Definition AS; Siemens Medical Solutions, Erlangen, Germany). Raw data were reconstructed into lung, bone, abdomen and mediastinum window images. All MSCT images were interpreted by two very experienced radiologists in a double-blind fashion based on a consensus of opinion.

MSCT results

Examination of the thoracic cage revealed right fractures of ribs 4–7 in the mid-clavicular line and left fractures of the ribs in the anterior axillary line (Figure 3A). The sternum was fractured transversely at rib 3 and superficial abrasions revealed at the same site (Figure 3A).

MSCT demonstrated pericardial effusion with a CT density consistent with hemorrhage, causing compression of the heart (Figure 4). Furthermore, a large collection of pericardial fluid with attenuation values consistent with hemopericardium was noted.
The pericardial window yielded 500 mL of blood. The pleural space was empty, and hematic fluid was found at the bottom of bilateral thoracic cavities (Figure 4B). CT of the abdomen and thorax did not show signs of injury to viscera. CT of the head and neck did not demonstrate cranio-cerebral injuries, or dislocation or fractures of the cervical spine. CT of the extremities did not reveal injuries.

Axial CT images of the heart and liver demonstrated a dilated inferior vena cava (IVC) and superior vena cava (SVC) approximating to the size of the aorta (Figure 3B and Figure 4B). Imaging at a more caudal level showed bilateral distended renal veins (Figures 3C and D).

Overall the findings were of: (I) blunt injury to the chest and anterior neck; (II) fractures of the
ribs and sternum; (III) pericardial tamponade; and (IV) markedly dilated SVC, IVC, and renal veins.

In this case report, although autopsy was not carried out and we could not confirm the location of rupture in the heart or aorta, we concluded, based on analyses of whole-body CT and complete health records, that the cause of death was acute pericardial tamponade due to blunt trauma to the chest.

Discussion

Chest injuries are responsible for many trauma-based deaths each year. It is estimated that blunt trauma to the heart accounts for 5% of deaths due to blunt trauma [11, 12]. In cases of acute pericardial tamponade due to traffic accidents, the drivers are commonly found dead at the scene and often fail to survive long enough to reach hospital [13, 14].

Few cases of acute pericardial tamponade caused by blunt trauma to the chest have been reported by forensic pathologists by autopsy [15, 16]. Blunt chest trauma probably results in rupture of the ventricles, atria, aorta, coronary arteries and pericardium [2, 17]. The highest prevalence of mortality occurs if there is a ventricular rupture [18]. Ette et al. [19] reported a case of acute pericardial tamponade after a road traffic accident. The driver’s truck was wedged under a bridge. Myocardial laceration on anterior–inferior portion of the right ventricle was found without a tear in the pericardium.

Additional injuries were observed: fracture of the sternum, stable fractures of the ribs, and right-lung contusions with profuse hemothorax in the right thoracic cavity. Machii et al. [20] reported a case of cardiac rupture by penetration of a fractured sternum after CPR. Two tears in the right atrium and a tear in the pericardial sac, each 5 mm in length, were observed. Klintschar et al. [16] described an 84-year-old female who died after active compression–decompression CPR. Autopsy revealed that death was due to myocardial infarction complicated by rupture of the infarcted area, and pericardial tamponade was diagnosed. Several rib fractures as well as transverse fracture of the sternum were observed. In our case, post-mortem CT also revealed accompanying injuries: fractures of the sternum and ribs as well as right hemothorax.

CT is increasingly being utilized in post mortems for the diagnosis of trauma-based injuries and certain diseases. A few cases were also evaluated to make a diagnosis of cardiac and pericardial injuries using CT and ultrasonography for patients in Trauma Center, including CT signs of pericardial tamponade [21–23].

However, CT is rarely used to investigate acute pericardial tamponade in corpses. In our case, post-mortem MSCT findings were analyzed and compared with autopsy findings and radiological results. Localization of the rupture could not be determined because autopsy was not carried out. Abnormalities of the myocardium or valvular disease also could not be determined because histological examination was not undertaken. However, comprehensive health records, and information on the medical history of the victim as well as of the family were collected to exclude CVDs.

Furthermore, the driver was a healthy young male and death was clearly due to a serious collision in a car. MSCT demonstrated hemopericardium causing compression of the heart. CT also demonstrated a dilated SVC, IVC, and bilateral distended renal veins. The post mortem showed similar CT results to those in other cases. Distension of the blood vessels was caused by increased central venous pressure due to increased pericardial pressure after pericardial tamponade [21, 23].

However, these distended veins are also often observed in different causes of death, including heat disease, and drug intoxication. One possible mechanism is that the blood circulation stops. Some authors have described periportal lymphedema and edema of the bowel wall, but these CT results were not found in our case, probably due to the influence of post-mortem changes.

According to the location of external abrasions as well as fractures of the ribs and sternum, we hypothesized the probable course of events. The car veered into a solid guardrail barrier on the viaduct at high speed because the driver was intoxicated with ethanol. The airbag deployed due to significant deceleration and the collision. The driver was propelled forward, and his chest and head hit the deploying airbag and steering wheel because he was not wearing a seatbelt.

Airbag deployment occurs when crash sensors detect an impact equivalent to hitting a solid barrier at 10–15 mph. Most airbag injuries are minor, but fatal injuries ascribed to airbag deployment include dislocations or fractures of the cervical spine, basal skull fractures, and injuries to thoracic and abdominal viscera. With the data available to us, we considered that deployment of the airbag and hitting the steering wheel were probably the dominant reasons for this blunt trauma to the chest.

Two mechanisms for blunt trauma to the chest have been reported to explain the resultant injuries: direct and indirect force to the chest [15, 16, 23, 24].
The direct mechanism is primarily caused by a blow to the anterior chest. In our case, the driver had an abrasion in the middle of the chest, sternal fracture, and rib fractures.

Such a direct blow can suddenly compress the heart, causing ventricle rupture during the end of the diastole when the ventricle is distended with blood. Indirect injury from a blunt force to the abdomen can create increased preload and atrial rupture. Furthermore, the heart can also compress between the sternum and spine, resulting in intense changes in intrathoracic and intracardiac pressure due to sudden deceleration of a motor vehicle [25].

Some authors have reported cardiac rupture due to direct penetration of the myocardium by bony fragments of fractured ribs or the sternum [16, 19, 26, 27]. Based on CT results, pericardial tears were not observed in our case. Hence, we believe the two types of injury mechanisms and deceleration to be the dominant factors in the occurrence of a tear rather than a myocardial contusion.

In conclusion, our case showed four main characteristics of acute pericardial tamponade due to motor-vehicle collision. Firstly, marked hemopericardium caused compression of the heart (CT density was consistent with hemorrhage). Dilated SVC, IVC, and renal veins were similar to the CT results of patients with acute pericardial tamponade, but such dilation is not characteristic for acute pericardial tamponade. Secondly, a fatal injury can occur during a significant collision between motor vehicles with minor external abrasions, but the trauma is caused by direct and indirect injury mechanisms.

Thirdly, ventricular, atrial, and intrapericardial vascular rupture cannot be determined using MSCT if autopsy is not carried out. Lastly, fractures of the sternum and ribs are caused by chest collision with the airbag and steering wheel.

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References