Tension pneumothorax in unsuccessful cardiopulmonary resuscitation

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Abstract: Background. A well-known complication of cardiopulmonary resuscitation (CPR) and a potentially reversible cause of cardiac arrest (CA) is tension pneumothorax (TP). In TP external cardiac massage is ineffective because increased intrathoracic pressures hamper passive diastolic filling of the heart.

Case Reports. As forensic practice reveals repeated cases of unsuccessful CPR with co-existing TP, we exemplarily describe 4 cases of unsuccessful CPR from different origins with TP, which prevented CPR from positive outcome. Why should a forensic pathologist be aware of this? Not only complications of medical therapies are of medico-legal relevance, but also omission of procedures. Autopsy cases with TP after CPR should be discussed regarding medical malpractice. Bilateral chest decompression before termination of CPR must be considered in all patients with CA and blunt chest trauma, i.e. external cardiac massage.

Key Words: cardiopulmonary resuscitation, tension pneumothorax, chest trauma, chest decompression, autopsy.

Tension pneumothorax (TP) is a reversible cause of cardiac arrest (CA) and the leading cause of preventable traumatic death [1]. Reversal of CA-inducing causes is crucial, and fundamental differences in successful management of CA from internal or traumatic origin have been described including a pre-hospital algorithm for traumatic cardiopulmonary resuscitation (CPR) [2].

Transitions between CA from reversible internal causes and traumatic reversible causes are fluent as external cardiac massage (ECM) is in fact a repeated blunt chest trauma with rib serial fractures and flail chest and thus may cause TP [3,4]. Experience from forensic and emergency medicine routine reveals repeated cases of CPR failure due to TP. We present 4 cases of CA from either internal or traumatic origin and unsuccessful CPR with TP, in which chest decompression was considered life-saving or at least beneficial.

Case 1 – penetrating chest trauma
A 40-year-old man was stabbed in the right hemithorax (Fig. 1a). The man was able to call the emergency service, but was found lifeless when rescue personnel arrived on scene 20 min later. CPR was performed for > 20 min without chest decompression despite subcutaneous emphysema. Death was certified on the scene of the incident. At autopsy, only a superficial laceration of the right lung without relevant hemothorax was present (Fig. 1b). Cause of death was TP. In this case, from a medico-legal point of view, chest decompression would have been life-saving in this young and healthy man.

Case 2 – blunt chest trauma
A 66-year-old woman was rolled over by a truck and sustained blunt torso trauma. CPR by rescue service was performed for > 30 min,
but without chest decompression despite massive subcutaneous emphysema. At autopsy, absence of severe external injuries was found, but massive internal injuries (i.e. myocardial and pulmonic lacerations, comminuted ribcage) with TP, hemothorax and subcutaneous tissue emphysema by artificial ventilation. Cause of death was polytrauma. With regard to the massive injury pattern, chest decompression would not have been life-saving in this case.

**Discussion**

TP is caused by a link between the pleural cavity and atmosphere with valve effect, so that – either during

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**Case 3 – chronic obstructive lung disease (COPD)**

A 62-year-old woman with COPD Grade GOLD IV was admitted to hospital due to inflammatory exacerbation. In hospital, she was endotracheally intubated and ventilated due to progredient respiratory insufficiency, and five minutes later, CA occurred. CPR was performed for > 45 min, but no chest decompression was performed despite massive subcutaneous emphysema. At autopsy, we found TP caused by a ruptured emphysematous bubble during artificial ventilation, serial rib fractures, and COPD Grade GOLD IV with inflammatory exacerbation. Cause of death was TP. In this case, from a medico-legal point of view, survival with chest decompression could not be affirmed due to severe pre-existing pulmonary disease.

**Case 4 – pneumonia**

A 69-year-old man suffered from apoplexy. Due to bilateral pneumonia with progredient respiratory insufficiency, artificial ventilation was necessary. CA occurred in hospital during routine tube change, and CPR was performed for > 30 min. Despite subcutaneous emphysema, chest decompression was not performed. At autopsy TP was present (Fig 2), also bilateral pneumonia and apoplexy. Cause of death was bilateral pneumonia. TP was caused by fractured ribs and subsequent ventilation during CPR. In this case with CA from bilateral pneumonia, from a medico-legal point of view, survival with chest decompression could not be stated.
self-reliant inspiration (case 1) or artificial ventilation (cases 2-4) – air infuses the pleural space, becomes entrapped, and accumulates. CA occurs through pressure-induced shifting of mediastinal structures and heart to the contralateral (healthy) side. At autopsy, TP is characterized by (mostly generalized) skin emphysema and increased upper venous congestion, collapsed lungs and depression of the diaphragm, accompanied by pneumomediastinum and pneumopericardium. Entrance of air into the pleural cavity is possible through lung tissue injury with (case 1) or without (cases 2-4) external chest trauma.

Our 4 cases strongly support the necessity for a structured approach to the exclusion of potential reversible causes of CA (hypoxemia, hypovolemia, hypo/hyperkalemia, hypothermia, pericardial tamponade, intoxication, thromboembolism, TP – also known by the acronym “4H and 4T”) and ventilation problems during CPR, e.g. “DOPES” (dislocation, obstruction, pneumothorax, equipment, stomach). TP is an important differential diagnosis in CPR, and pleural decompression prior to termination of CPR demonstrated a survival benefit [5]: ECM is ineffective with co-existing TP as increased intrathoracic pressures hamper passive diastolic myocardial filling, and return of spontaneous circulation (ROSC) cannot occur as long as the pleural cavity is not decompressed. In the pre-hospital situation (case 1+2), exclusion of TP must focus on subcutaneous emphysema as pathognomic sign and auscultation (extenuated / absent respiratory sounds, hypersonorous percussion of the affected hemithorax). Upper venous congestion is an unreliable sign of TP with co-existing hemorrhagic shock. Chest X-ray is mandatory in hospitalized patients (cases 3-4), even during CPR.

Chest decompression drains, mini-thoracotomy, or thoracic puncture pressure relief before terminating CPR must be practically included in management regimes for CA. There is nothing to lose, but all at stake.

Why should a forensic pathologist be aware of this? Not only complications of medical therapies are of medico-legal relevance, but also omission of procedures [3,4]. Autopsy cases with TP after CPR should be discussed regarding malpractice. Bilateral chest decompression before termination of CPR must be considered in all patients with CA and blunt chest trauma, i.e. ECM.

References