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Failure rate of prehospital chest decompression after severe thoracic trauma

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ABSTRACT

Introduction: Chest decompression can be performed by different techniques, like needle thoracocentesis (NT), lateral thoracostomy (LT), or tube thoracostomy (TT).
The aim of this study was to report the incidence of prehospital chest decompression and to analyse the effectiveness of these techniques.
Material and methods: In this retrospective case series study, all medical records of adult trauma patients undergoing prehospital chest decompression and admitted to the resuscitation area of a level-1 trauma center between 2009 and 2015 were reviewed and analysed. Only descriptive statistics were applied.
Results: In a 6-year period 24 of 2261 (1.1%) trauma patients had prehospital chest decompression. Seventeen patients had NT, six patients TT, one patient NT as well as TT, and no patients had LT.
Prehospital successful release of a tension pneumothorax was reported by the paramedics in 83% (5/6) with TT, whereas NT was effective in 18% only (3/17). In five CT scans all thoracocentesis needles were either removed or extrapleural, one patient had a tension pneumothorax, and two patients had no pneumothorax. No NT or TT related complications were reported during hospitalization.
Conclusion: Prehospital NT or TT is infrequently attempted in trauma patients. Especially NT is associated with a high failure rate of more than 80%, potentially due to an inadequate ratio between chest wall thickness and catheter length as previously published as well as a possible different pathophysiological cause of respiratory distress. Therefore, TT may be considered already in the prehospital setting to retain sufficient pleural decompression upon admission.

1. Introduction

Chest decompression is an infrequent, life-saving procedure in trauma patients suffering from a tension pneumothorax. It occurs infrequently in trauma patients and interferes with cardiorespiratory function [1]. Therefore, rapid evaluation and urgent treatment by needle thoracocentesis (NT), lateral thoracostomy (LT), or tube thoracostomy (TT) is required in order to restore hemodynamic function and to improve respiration [1-3]. Needle thoracocentesis and TT were proved safe [4-6] and equally successful in the animal model [7]. Depending on the emergency medicine system, most commonly only designated emergency physicians are capable and allowed to perform TT, whereas NT may also be performed by skilled and educated paramedics.

Needle thoracocentesis is fast, simply applied, and used most commonly in the prehospital setting or during resuscitation [8]. The overall incidence of complications of NT is low [4,9]. According to leading trauma guidelines (Advanced Trauma Life Support®, Prehospital Trauma Life Support®) a needle or venous catheter should be inserted in the 2nd intercostal space (ICS) mid-clavicular line [2]. However, the reported success rate has a wide range varying from 5% to 96% [3,10-13]. One of the failure reasons is the insufficient length of standard needles and catheters for the 2nd ICS to reach the intrapleural space. Hence, some authors recommend the 5th ICS mid-axillar line for NT due to the smaller chest wall thickness in this area [14-18].

Tube thoracostomy ensures maximal pleural cavity evacuation and lung re-expansion [1,3]. The procedure entails a thoracostomy preferably in the 4th or 5th ICS mid-axillary line (Bulau) or the 2nd ICS midclavicular line (Monaldi), without any differences in the occurrence of misplacement or complications between both positions in trauma patients [19]. Complications related to TT, such as damage to the thoracic wall, the lungs, to abdominal or mediastinal organs, are less common since the use of trocars has been abandoned in favor of blunt dissection [1]. However, in the prehospital setting TT is blamed to increase resuscitation time and infection rate. While data on prolongation of the prehospital resuscitation time is incongruent [20,21], higher infection rate due to TT was not observed so far [5,21,22].

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Lateral thoracostomy is performed by blunt dissection and digital decompression through the pleura in the 4th ICS mid-axillar line and may be considered as an alternative in mechanical ventilated patients [23]. As decompression of the pleural space is the primary goal during resuscitation of the hemodynamically instable patient with suspected hemato- or pneumothorax, insertion of a chest tube is optional [3].

The aim of this study was to report the incidence of prehospital chest decompression, to analyse the effectiveness of the used techniques and to show the consecutive diagnostic thoracic findings and further treatment in the resuscitation area.

2. Material and methods

Data analysis was started after obtaining approval of the local ethics committee (Kantonale Ethikkommission Zurich, Switzerland, KEK-ZH-No: 2011-0382, PB_2016_01888).

2.1. Study design and participants

In this retrospective single-center case series study all adult trauma patients admitted to the resuscitation area of the University Hospital Zurich between 2009 and 2015 were included. Patients treated with attempted chest decompression in the prehospital setting underwent detailed analysis.

2.2. Setting

The University Hospital Zurich (USZ) is one of twelve level-1 trauma centers in Switzerland. In the Swiss emergency medicine system, most commonly a team of two registered paramedics, with a 3-year advanced federal diploma of higher education, treat a patient on the scene and transport the patient to the trauma center. In case of life threatening emergencies like severe trauma, a designated emergency physician, skilled and trained in advanced airway management, resuscitation and application of TT and NT is brought in parallel and in addition to the prehospital scene of action. Tube thoracostomy may only be performed by the designated emergency physician, whereas paramedics may perform NT. Later, in the resuscitation area of the hospital, a standardized clinical approach according to leading trauma concepts (Advanced Trauma Life Support®, European Trauma Course® and Definitive Surgical Trauma Care®) is provided. A chest X-ray and an ultrasound of the abdomen are taken in case of an acute problem in the primary survey. To diagnose and evaluate most relevant injuries, a primary whole-body-CT-scan is performed as soon as the patient is stable or stabilized. The trauma staff includes at least one senior and one junior anaesthetist, one senior and one junior trauma surgeon and anesthesia as well as scrub nurses.

2.3. Variables and data collection

All medical records of the included patients were reviewed. The ICD 10 GM (International Classification of Diseases, 10th-Revision, German Modification [24,25]) codes were used to identify (thoracic) injuries and the CHOP codes (catalogue of the Swiss Surgery Classification System [26]) for procedures. The data was encoded by professional medical coders.

Paramedic records of all patients undergoing prehospital chest decompression were reviewed. Number and location of prehospital chest interventions were extracted from these records. Prehospital chest decompressions were most commonly documented as NT and/or TT only, without information about catheter gauge and length. The treatment was defined as successful if any prehospital improvement in clinical (improved breath sounds or decreased dyspnoea if not intubated) and/or vital signs (improvement in systolic blood pressure, heart rate or oxygen saturation) was reported by paramedics or emergency physicians.

All chest X-rays and computed tomogram (CT) scans at admission were reviewed by the authors to analyse placement, location, and effect of the chest tubes or needles (catheters) and to identify the presence of rib fractures, lung contusions, hemato- or pneumothoraces.

2.4. Statistical analyses

Only descriptive statistic was applied to analyse data. Categorical data were reported in absolute numbers (n) and percent (%), numerical data as mean and standard deviation (±SD). All statistical analyses were performed by IBM SPSS Statistics 22 (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Cohort

In a 6-year period, 24 of 2261 (1.1%) trauma patients admitted to the resuscitation area obtained prehospital chest decompression (Table 1).

The mean injury severity score was 37 ± 23. Pneumothorax was the leading traumatic finding, although it was not present in all patients undergoing prehospital chest decompression (Table 2). Other frequent injuries were rib fractures, flail chest, lung contusions and hematothoraces, while injuries of great vessels, of the bronchi or the diaphragm were less common. Two patients had only superficial thoracic injuries.

3.2. Prehospital needle thoracocentesis (NT)

Seventeen patients were treated with NT prior to arrival to the hospital (Fig. 1). All NT were performed at the 2nd ICS mid-clavicular line. Only three patients (18%) were - according to paramedic reports - successfully decompressed, although in all of these three patients, the needles were removed before admission or extrapleural in the primary CT scan (Fig. 2). Two of those patients received a TT in the resuscitation area to decompress a simple pneumothorax, while the third patient had no remaining pneumothorax and underwent no further treatment.

The majority (8 patients, 57%) of the unsuccessfully treated patients immediately received a TT in the resuscitation area at admission, before performing any X-ray or CT scan. An initial CT scan was performed in two patients, one requiring a TT directly afterwards due to a tension pneumothorax while the thoracocentesis needle was extrapleural. The other patient had no pneumothorax, although the needle was placed improperly, and needed no further TT after admission. In four patients, a chest X-ray was the first imaging method. Two of them had a tension hematothorax requiring an emergency department thoracotomy in the resuscitation area, one had a hematothorax requiring an urgent

Table 1
Overview.

		$n = 24$
Age, mean (±SD), years	43	(±22)
Sex male	19	79%
Body mass index, mean (±SD), ($n = 18$)	25.2	(±3.1)
Blunt trauma	20	83%
Penetrating trauma	4	17%
Prehospital endotracheal intubation	20	83%
Prehospital cardiopulmonary resuscitation	3	13%
Prehospital needle thoracocentesis (NT)	17	71%
Prehospital chest tube thoracostomy (TT)	6	25%
Prehospital needle & chest tube	1	4%
ISS, mean (±SD)	37	(±23)
1-day mortality	6	25%
In-hospital mortality	11	46%
Length of hospital stay, mean (±SD), days	15	(±14)
Late complications related to TT or NT	0	

Data reported as frequency with percentage or mean (±SD).
ISS, Injury Severity Score.
SD, Standard Deviation.

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