Hungarian Air Ambulance Nonprofit, Ltd.[1], Department of Emergency Medicine, Semmelweis University, Budapest, Hungary[2], Department of Anesthesiology and Intensive Care, Medical Centre Hungarian Defence Forces[3], Department of Anesthesiology and Intensive Therapy, Semmelweis University, Budapest, Hungary[4], Department of Trauma and Chest Surgery, Petz Aladar County Teaching Hospital, Gyor, Hungary[5]

Emergency thoracostomy as a safe and effective intervention in prehospital trauma

A five year experience from the Hungarian Air Ambulance

Laszlo HETZMAN[1, 2], Akos SOTI[1, 2], Peter TEMESVARI[1], Attila EROSS[3], Andras PETROCZY[1, 4], Andras CSEKO[4], David SUTORI[1, 5]

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ABSTRACT

Traumatic tension pneumothorax is one of the most frequent causes of early mortality among the severely injured. Different methods are recommended for chest decompression. The aim of this study is to examine whether emergency thoracostomy can improve the real 30-day survival compared to the expected Revised Trauma Score (RTS) based survival, the Return of Spontaneous Circulation (ROSC) rate in Traumatic Cardiac Arrest (TCA), reduce the occurrence of tension pneumothorax (tPTX) and to determine the complication rate of the intervention.

Keywords: ***Emergency medical services; Hemothorax; Pneumothorax; Thoracostomy; Trauma Scores;***

BACKGROUND

Traumatic tension pneumothorax is one of the most frequent causes of early mortality of the severely injured (12, 25). Different methods are recommended for chest decompression such as needle decompression, small bore catheters (≤14Fr), emergency thoracostomy and different size intercostals drains. The reported effectiveness and complication rates of the methods are vastly different (2, 3, 5–11, 14, 22, 26, 28). The Hungarian Air Ambulance (HAA) is the HEMS (Helicopter Emergency Medical Service) provider in Hungary (population: 9.9 million, area: 93.000 km2), which operates from seven air bases. Prior to 2011, the HAA's pleural decompression policy included only needle decompression and small bore catheter use (≤14Fr). In 2011, a new standard operating procedure (SOP) was introduced based on London's Air Ambulance's (LAA) model. Emergency thoracostomy was introduced according to well defined indication criteria as standard treatment for mechanically/positive pressure ventilated patients requiring chest decompression (2, 16, 18).

Professional support was provided by the original authors. Training courses were organized, of which, following an admissions test, additional theoretical and skill stations practice in which hands-on training was carried out. Manikins, porcine thoraces/animal models and rib cages were used at skill stations to represent the anatomy and to demonstrate the technique. Emergency thoracostomy technique training was implemented through complex simulations in combination with non-technical skills, while applying different stress factors. Cadaver laboratory practices completed the training program.

METHODS AND PATIENTS

HAA's chest decompression procedure

Emergency thoracostomy corresponds to the Advanced Trauma Life Support (ATLS) chest decompression procedure with the exception of inserting a chest drain into the thoracostomy cavity (1). The main theoretical reasons for this omission are the prehospital inserted drain can create a false impression of security (may become clogged, kinked and/or mispositioned) and provides a colonization surface for microbes. Additionally, there is no need for a Heimlich valve or suction, since simple thoracostomy is exclusively used with positive pressure ventilation.

In the case of traumatic cardiac arrests (TCA), simple bilateral thoracostomy is an absolute indication to exclude tension pneumothorax (tPTX) as a potentially reversible cause of cardiac arrest (4H-4T). It is performed prior to the initiation of chest compressions (19).

In consideration of patients with cardiac output, emergency thoracostomy should be performed following or parallel to the initiation of positive pressure ventilation (24). Thoracostomy is implemented on the more suspicious/injured side first. If the intervention proves ineffective or deterioration occurs, the procedure is carried out on the other side as well. In the case of chest injuries, the following signs raise the suspicion of tPTX and these are to be checked during the ABCD assessment and following the initiation of positive pressure ventilation:

- Hemodynamic instability (hypotension, tachycardia or bradycardia)
- Surgical emphysema
- Bony crepitus, signs of rib fracture
- Flail chest
- Multiple rib fractures
- Severe asymmetry in breath sounds (after checking tube position and depth)
- Unilateral wheezing in breath sounds
- Sucking chest wound
- Hypoxia

Suspected or confirmed pneumothorax (PTX) of a non-ventilated patient with stable hemodynamics without imminent signs of deterioration is not an indication for the procedure.

Technique of the HAA's emergency thoracostomy

A 4 cm skin incision is made in the safety triangle (marked by the pectoralis major and the latissimus dorsi muscle and the 5th rib) in the 4th intercostals space anterior to the mid-axillary line. It is followed with a blunt

dissection of subcutaneous tissues using Spencer Wells forceps to extend into the intercostal space. The pleural space is opened by a closed Spencer Wells while observing the air hiss and thoracic bleeding. Subsequently, the intercostal muscles are detached from the upper edge of the lower rib by moving the Spencer Wells in a ventro-dorsal direction in the thoracic cavity. A finger is inserted in the thoracic cavity, in which the position and the degree of the lung expansion is examined. If any deterioration reoccurs, the thoracostomy cavity can be reopened again through re-fingering. If multiple re-tensioning occurs, a sterile endotracheal tube or chest drain may be inserted in the thoracostomy cavity.

PATIENTS

All missions (2693) were reviewed in our retrospective database analysis between 1 August 2009 and 31 October 2014. All intubated and ventilated chest trauma patients were enrolled, whom met the indication criteria for HAA's chest decompression procedure. Patients with traumatic cardiac arrest (TCA) whose chest trauma could not be clearly ruled out were also included. Non-intubated patients and patients with injuries incompatible with life were excluded. The Revised Trauma Score (RTS) was calculated in all cases. RTS based expected 30-day survival rate was calculated accordingly to the original RTS method (4).

Patients were categorized in to two groups. Group A was defined as chest trauma patients treated with no thoracic intervention, only needle decompression, small bore catheter or thoracostomy from 1 August 2009 through 31 May 2011. Group B included patients treated with emergency thoracostomy from 1 June 2011 through 1 June 2014. Additional subgroups were created in both A and B groups regarding patients with cardiac output and Traumatic Cardiac Arrest (TCA).

There were 897 cases in group A, of which, 45 cases fulfilled the selection criteria (age 46 – 15 to 78); male/female 32/13). 39/45 cases were traffic accident injuries and 6/45 suffered other trauma mechanisms. There were no penetrating injuries in this group. 29/45 patients had maintained cardiac output (RTS 5.874±1.686) and 16/45 were in TCA. In consideration of patients with cardiac output, among 24/29 cases, there was no intervention carried out, in 2/29 cases, needle decompression was performed and in 3/29 cases, a small bore catheter was inserted. In the TCA subgroup, no prehospital chest decompression was performed in 3/16 cases. In 7/16 cases, needle decompression was performed, in 1/16 cases, a small bore catheter was used, in 4/16 cases, thoracostomy was performed and in 1/16 cases along with chest drain insertion. 63 of the total 1796 cases were included in group B (age 44 (2 to 78); male/female 49/14). 47/63 cases were the result of traffic accidents, 14/63 were other trauma and 2 patients suffered penetrating injuries. 33/63 cases were patients with cardiac output (RTS 4.495±1.851) and 30/63 were in TCA. Among those patients with cardiac output, thoracostomy was performed in 28/33 cases and in 5/33 cases along with chest drain insertion. In the TCA subgroup, thoracostomy was performed in 29/30 cases and in 1/30 case along with chest drain insertion (*Table 1–2*).

Complications were also reviewed and their potential relationships to interventions. In the event of traumatic cardiac arrest, temporary and permanent (lasting at least until hospital turnover) returns of spontaneous circulation (ROSC) were evaluated. In the hospital follow-up, tPTX presence upon admission, 30 day survival rates and any prehospital chest intervention related complications were reviewed (12, 20, 21). Fisher-Irwin test and the Chi-square test were performed in which the significance level was $p<0.05$.

The primary endpoint was:

1. Comparison of real and expected (RTS based) 30-day survival rate among patients with maintained cardiac output in group A and B

The secondary endpoints were:

2. Presence of tPTX upon hospital admission in group A and B
3. ROSC in TCA subgroups of group A and B
4. Prehospital chest intervention related complications documented while hospitalized

Table 1 *Patient demografics and mechanism of injury*

	Group A (01/08/2009 to 31/05/2011)		Group B (01/06/2011 to 31/10/2014)	
Total cases	897		1796	
Total involved	45	5.0%	63	3.6%
Maintained cardiac output	29	3.2%	33	1.8%
TCA	16	1.8%	30	1.7%
Avg age involved	46 (15 to 78)		44 (2 to 78)	
Total male/female	32/13		49/14	
RTS (avg±SD)	5.874 (±1.686)		4.495 (±1.851)	
Mechanism				
Traffic Accident	39	86.7%	47	74.6%
Penetrating injury	0	0.0%	2	3.2%
Other trauma	6	13.3%	14	22.2%

Table 2 *Traumatic cardiac arrests (TCA)*

Interventions				
None	3	18.8%	0	0.0%
Needle	7	43.8%	0	0.0%
Smallborecatheter	1	6.3%	0	0.0%
Thoracostomy	4	25.0%	29	96.7%
Thoracostomy + Drain	1	6.3%	1	3.3%
ROSC	1	6.3%	7	23.3%
ROSC with hospital admission	0	0.0%	5	16.7%
30-day survival	0	0.0%	1	3.3%

RESULTS

Indication criteria distributions are presented in *Table 3*.

1. Comparison of group A and B in 30-day survival rate among patients with cardiac output

In group A, 19 of 26 patients (73.08%) survived up to thirty days following hospital admission. Based on the average of calculated RTS, the expected survival in this group was 90%. In group B, 20 of 30 patients (66.67%) survived up to thirty days following hospital admission. The expected survival was 70.7% based on the RTS. No significant difference was observed in survival rates between the two treatment protocol groups ($p=0.41$). There was a significant difference in calculated RTS expected survival rates between the two groups ($p<0.05$).

2. Presence of tPTX upon hospital admission

In group A, tPTX was confirmed upon admission in 3/26 cases (11.54%). Out of these 3 cases, two cases involved needle decompression and in one case, no chest intervention was performed. In group, B tPTX was confirmed in 0/30 cases. There was a significant difference between the two groups ($p<0.05$).

3. Difference in ROSC between group A and B

In group A, temporary ROSC was registered in one case, however, the patient expired on the scene. There was no survival at hospital admission 0/16 (0%). In group B, 7/30 (23.3%) ROSC were registered. Maintained ROSC was witnessed in 2/30 (6.7%) cases, of whom eventually expired on the scene, 5/30 (16.7%) patients survived up through hospital admission and we registered 1/30 (3.3%) patient who survived thirty days following admission. There was a significant difference between the two groups ($p<0.05$).

4. Prehospital chest intervention related complications documented while hospitalized

There was no prehospital chest intervention related complication documented in any of the groups.

Table 3 *Indications and interventions in patients with cardiac output*

	Group A n=29		Group B n=33	
Indications				
Hypoxia	21	72.4%	20	60.6%
Hypotension	9	31.0%	15	45.4%
Severe asymmetry in breath sounds	3	10.3%	17	51.5%
Surgical emphysema	11	37.9%	19	57.6%
Flail chest / multiple rib fracture	12	41.4%	13	39.4%
Unilateral wheezing	0	0.0%	15	45.4%
Interventions				
None	24	82.7%	0	0.0%
Needle	2	6.9%	0	0.0%
Small bore catheter	3	10.3%	0	0.0%
Thoracostomy	0	0.0%	28	84.9%
Thoracostomy + Drain	0	0.0%	5	15.2%

DISCUSSION

In examining the primary endpoint, we could observe there was no significant difference in survival rates between the two groups. The all-survival rate compared to the RTS based expected survival rate was worse in group A. Based on RTS expected survival rates, patients in group B experienced more serious injuries. In conclusion, emergency thoracostomy can improve the chance of survival, however, due to multifactorial injuries, no clear correlation is seen.

Prehospital chest injury treatment focuses on space management, which aims at decompression and prevention of tPTX. Despite of the needle decompression in two cases, tPTX was confirmed upon hospital admission. While implementing emergency thoracostomy, no tPTX was registered. This may be due to the various chest decompression methods (15, 17, 27).

Interestingly, tPTX is a common cause of TCA and the second most preventable cause of trauma death in the prehospital setting (23). The elevated intrathoracic pressure caused by tPTX leads to the compromise of the circulatory system, prevents lung expansion and subsequently leads to a peri-arrest or arrest situation. Survivors were registered only with the use of emergency thoracostomy. The 16.7% prehospital ROSC rate in group B correlates with published literature data (13). Among those patients who expired while hospitalized, the cause of death was not associated with chest injury. There were

no prehospital chest intervention-related complications documented. In light of the data, this implies emergency thoracostomy is a safe procedure.

CONCLUSION

Emergency thoracostomy during the prehospital phase offers a safe and simple alternative for preventing or treating tPTX in the prehospital setup regarding ventilated trauma patients. Thoracostomy with the right indications is recommended as standard practice for every service when treating severely injured patients.

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Corresponding author:
Laszlo Hetzman
E-mail: laszlohetzman@yahoo.com