Prehospital Chest Tube Thoracostomy:

Effective Treatment or Additional Trauma?

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Abstract

Background The use of prehospital chest tube thoracostomy (TT) remains controversial because of presumed increased complication risks. This study analyzed infectious complication rates for physician-performed prehospital and emergency department (ED) TT.

Methods Over a 40-month period, all consecutive trauma patients with TT performed by the flight physician at the accident scene were compared with all patients with TT performed in the emergency department. Bacterial cultures, blood samples, and thoracic radiographs were reviewed for TT-related infections.

Results Twenty-two patients received prehospital TTs and 101 patients received ED TTs. Infected hemithoraces related to TTs were found in 9% of those performed in the prehospital setting and 12% of ED-performed TTs (not significant).

Conclusion The prehospital chest tube thoracostomy is a safe and lifesaving intervention, providing added value to prehospital trauma care when performed by a qualified physician. The infection rate for prehospital TT does not differ from ED TT.

Introduction

Management of trauma patients has been subject to many changes during recent years. To achieve a higher standard of care, further standardization was implemented. Nowadays, trauma patients all over the world are assessed and treated either in accordance with the Advanced Trauma Life Support–based protocol for physicians as set forth by the American College of Surgeons or according to the Pre-Hospital Trauma Life Support system in the case of ambulance nurses in the field[1].

Alterations and additions to assessment and treatment of trauma patients have been effectuated both clinically and at the accident site. In The Netherlands, one of these additions to trauma care for severely injured patients in the prehospital phase is the introduction of the helicopter mobile medical team, a physician-staffed Helicopter Emergency Medical Service (HEMS). One of the benefits is the fact that a highly trained surgeon or anesthesiologist can perform procedures, such as administration of analgesics and general anesthetics and insertion of a tube thoracostomy (TT), that ambulance nurses are not allowed to execute. Although the beneficiary influence on survival of the Helicopter Mobile Medical Team has been established, little is known about the benefits or disadvantages achieved by the use of the separate interventions in the prehospital phase of trauma care[2, 3].

The subject of this study is the treatment of pneumoand/ or hemothoraces by the use of TT, which is the initial treatment of choice for significant pneumothorax, massive hemothorax, and hemopneumothorax[1]. TT has become a standard procedure in emergency departments, whereas in the prehospital phase, its use remains controversial. Some authors have proposed that the use of TT in the prehospital phase reduces mortality and is a safe and effective tool with low associated morbidity[4, 5]. Schmidt et al. also stated that the risk for infections does not increase simply because of environmental factors, whereas others consider intrapleural and

wound infections to be more likely when chest tubes are placed in less sterile environments, such as accident scenes[5-7].

The primary objective of this study was to compare the infectious complication rate between emergency department (ED) and prehospital TT. Secondary objectives are the assessment of misplacements and analysis of TT indications.

Patients and Methods

The setting was the Erasmus MC University Medical Center Rotterdam (EMC), a Level I trauma center and teaching hospital with more than 1,200 beds. ED resuscitation of trauma victims is a multidisciplinary Advanced Trauma Life Support–based effort. Direct patient care is provided by residents in surgery, anesthesiology, and emergency medicine. Extended trauma care at the accident site can be provided by physician-staffed HEMS. These physicians are well-trained anesthesiologists or trauma surgeons.

Over a 40-month period, all consecutive trauma patients that were given a chest tube either by the Rotterdam HEMS or in the ED and subsequently admitted to the EMC were prospectively enrolled in this study. Patients who received a chest tube in another hospital or who died within 48 hours directly after trauma were excluded, after it was confirmed that none of these patients died as a result, directly or indirectly, of chest tube placement. Patients were subdivided into two groups: those who had a TT placed in the prehospital setting and those who had a TT placed in the ED. All TTs were performed by blunt dissection of the subcutis and intercostal muscles, after incision of the skin at the fourth or fifth intercostal space, anterior to the midaxillary line. The pleura was opened using a blunt instrument. No trocars were used because of the increased risk for iatrogenic complications[8].

Empyema-like intrapleural infections are related to chest tube placement, but pulmonary infections can arise through a large number of paths.7 Therefore, primary outcome was defined as empyema-like intrathoracic infections or an infected tube insertion site (extrathoracic). These were diagnosed by the diagnostic triad of positive infection parameters in the blood, suspicious chest radiograph, and positive bacteriologic culture. Blood samples were taken at days 7 and 14 after TT, and infectious parameters were deemed positive when two values of C-reactive protein greater than 30 mg/L, erythrocyte sedimentation rate greater than 30 mm/h, or white blood cell count greater than 10×10^9/L were found. All bacteriologic cultures from thoracic fluid or the tube insertion site were analyzed for microbiologic infection by the department of microbiology and the presence of infectious agents was determined. Subsequently, all chest radiographs were reviewed by a senior radiologist. Misplacements were defined as chest tubes placed outside of the pleural cavity. Patient demographics and type of injury were prospectively entered, as was TT indication, clinical course, and outcome, The Injury Severity Score was calculated[9].

Statistical Analysis

Statistical analysis was performed retrospectively for the purpose of this study. All calculations regarding TT-related infections and complications pertained to the number of drained hemithoraces instead of patients. All data were collected in a Microsoft Access 97 database and analyzed using the SPSS version 10.0 software. Analysis was performed using Student's t, Fisher's exact, and Mann-Whitney tests, and means are given ± SD with a 95% confidence interval.

Results

From October 2000 until February 2004, a total of 203 patients (Fig. 1) received TTs in either the prehospital setting or the ED of the EMC. Seven patients received TTs in other hospitals and 47 patients died within 48 hours after admission. All 54 were excluded. The resulting 149 patients, receiving 194 chest tubes placed in 169 hemithoraces (129 unilateral, 20 bilateral), were admitted to the EMC, and enrolled into this study. The mean Injury Severity Score for included patients was 23.3, ranging from 9 to 54. The patient population was then categorized into two groups: 29 patients with chest tubes (in 32 hemithoraces) placed in the prehospital setting, and 120 patients with chest tubes placed in the ED (in 137 hemithoraces) (Table 1). Two patients received TTs in the prehospital setting and, on arrival to the ED, received another chest tube contralaterally. They were analyzed in both the prehospital and ED groups, with the corresponding hemithorax.

Indications for TT

The indications for TT of the included patients in both groups are listed in Table 1. Overall, the main indication for the use of TT was a clinically significant (i.e., desaturation of the patient below 95% SaO_2) pneumothorax (84 of 169), for both the prehospital (12 of 32) and the ED (72 of 137) situations. The relative number of pneumothoraces was larger in the ED ($p=0.13$), whereas decompressed tension pneumothoraces were in the prehospital setting more often considered as an indication for TT (11 of 32) compared with the ED group (10 of 137) ($p<0.0001$). For penetrating trauma, the main TT indication was the presence of a hemothorax. With blunt trauma, more TTs were performed for pneumothorax in the ED (44 of 64) than in the prehospital setting (12 of 28) ($p=0.04$).

A total of seven needle decompressions were performed in the patient population that received prehospital TT (22%). In the ED population, 10 needle decompressions were documented (7%), of which 6 had been performed in the prehospital setting.

Infectious Complications

In 39 instances, antibiotics were given before TT was performed; 2 of 29 times in TTs performed in the prehospital setting and 37 of 120 times in those performed in the ED (p=0.008). None of these patients developed complications. Related to chest tube insertion, a total of 19 infected hemithoraces did develop, 3 in the prehospital group and 16 in the ED group (Table 2): 2 local infections at tube insertion site, 8 true empyemas, and 9 empyema-like intrathoracic infections. Associated with chest tube insertion, empyema will typically culture gram-positive Staphylococcus aureus[10, 11]. When looking at S. aureus–related infections only, data showed a total of 1 of 32 prehospital and 12 of 137 infections (p=0.47). One patient from the ED group developed bilateral empyema from infection with S. aureus. The main indication for TT placement in the group with infectious complications was pneumothorax (8 of 19), followed by hemothorax (6 of 19).

Another 49 patients from the entire population had laboratory infection parameters that were considered positive but did not have positive cultures of fluid from drain exits or pleural fluid. Two of these patients did have fluid collections that were suspected of having empyema thoraces, but when drained fluid was cultured, no microorganisms were found.

Tube Malpositioning

In total, none of the TTs performed in the prehospital setting and 2 of the ED-performed TTs (2 of 162) needed replacement after being diagnosed as malpositioned. One was found to be

placed intrahepatically, causing an undrained hemithorax that led to empyema thoraces in both hemithoraces. One ED-placed chest tube was positioned subcutaneously.

Intensive Care Unit and Hospital Stays

The mean stay of patients in hospital, in the intensive care unit (ICU), and the duration of drainage (primary TT) are shown in Table 3. Duration of drainage was longer for patients that received ED TT than prehospital TT, with 4.3 and 4.1 days, respectively (p=0.663). Conversely, mean ICU and total hospital stay was longer for patients that had TTS performed in the prehospital setting. Mean hospital stay was longer for patients that developed infectious complications (p<0.0001, Mann-Whitney).

Discussion

Performance of tube thoracostomy is often the definitive treatment for severe thoracic injury and may be a lifesaving intervention in the initial care for severely injured patients. Indications are well defined[1], but in many prehospital programs, TT is not included in the therapeutic arsenal because of assumed added risks of complications[12]. By comparing complication rates between TTs performed in the prehospital setting and those performed in the ED, this study intended to determine the possible added risk of using TT by physicians in the field and to compare outcome to the literature. Emphasis must be placed on the fact that the Dutch HEMS is physician-staffed, where other studies comparing complications between emergency departments and the field are based on flight nurse–staffed HEMSs[13-16]. Potential causes for thoracic empyema include iatrogenic infection of the thoracic pleural cavity during chest tube placement. A total of 19 infected hemithoraces did develop, 3 after prehospital TT and 16 after ED TTs, which did not differ significantly (p=1.0). When

associated with chest tube insertion, empyema will typically culture gram-positive S. aureus[11, 17]. The current study showed 1 of 32 prehospital and 11 of 137 ED infections (p=0.47) resulting from S. aureus, with an overall empyema incidence of 4%. Studies analyzing clinically placed TTs showed similar incidences. Millikan et al. found a 2.4% incidence of empyema[7] and, more recently, Deneuville found an incidence of 2%[18]. One study pertaining to TTs performed in the prehospital setting by physician-staffed HEMS found no intrapleural infections after emergent TT in the field in 63 patients[5], which does not correspond to our results, showing an infection rate of 9% in TTs performed in the prehospital setting. In 47 cases (32%), antibiotics were given before TT placement. Although prophylactic administration of antibiot-ics is part of both TT protocols and its benefits in prevention of empyema has been established[19], there seems to be either a suboptimal protocol adherence or a problem with its registration. In the ED, the prophylactic administration of antibiotics (37%) was documented significantly more often then in the prehospital setting (10%) (p=0.008).

A secondary outcome measure was tube malpositioning. When computed tomographic scanning is used, tube malpositioning can be found in up to 26% of performed TTs.19 This study showed only two cases (1%) of tube malpositioning. However, because radiography, which only detects a small percentage of tube malpositioning[20], is the standard for establishing TT position, improperly placed chest tubes may have been overlooked. For the same reason, retained hemothorax, which is a well-defined risk factor in the cause of infectious complications such as empyema thoraces[10, 21], cannot be diagnosed with high sensitivity either.

The main indication for TT placement, in concordance with others[5], was a clinically significant pneumothorax. Significantly more tension pneumothoraces were diagnosed and treated in the prehospital setting than in the ED. A possible explanation lies in the urgent nature of the tension pneumothorax and the subsequent need for immediate treatment in the

prehospital setting by needle decompression as a lifesaving intervention. This does mean, however, that these patients are given a TT in the emergency department for a simple pneumothorax, because the tension component has been cleared.

An interphysician discrepancy may exist. Flight physicians for the Dutch HEMS are surgeons or anesthesiologists who received extensive additional training in prehospital trauma care. Physicians performing TTs in the ED of the EMC, a teaching hospital, are most often first- or second-year residents in surgery, supervised by an attending trauma surgeon. Insufficient experience of individuals involved in trauma care is, to some extent, a reason for significant morbidity and extended hospital stay resulting from TT[18]. More malpositioned tubes did in fact occur when the lesser experienced physician in the ED performed TT, though not significantly. Length of stay in the hospital and ICU did not significantly differ either. To what extent infectious complications as defined here can be linked to physician inexperience remains unclear. Many other factors surrounding individual cases confound this comparison. Duration of drainage has been shown not to correlate with the development of empyema[10]. Our results showed no difference in duration of drainage or in incidence of infectious complications between the TTs performed in the prehospital setting and those performed in the ED.

In conclusion, the results of this study show that the rate of infectious complications did not differ for TTs performed in the prehospital setting and those performed in the ED. Neither did the main indication for placement of a chest tube (i.e., pneumothorax). Reduction of the incidence of chest tube-related complications may be obtained by additional training of physicians and better protocol adherence to antibiotic strategies. In light of current findings, the authors state that prehospital use of tube thoracostomy by qualified professionals does not introduce additional risk of complications compared with the in-hospital situation and

therefore is a lifesaving and valuable addition to prehospital care for the severely injured patient.

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Table 1. General characteristics, TT indications and complications for both the prehospital and ED study groups

		Overall		Blunt trauma		Penetrating trauma	
		PH (n= 29)	ED (n= 120)	PH (n= 28)	ED (n= 64)	PH (n= 1)	ED (n= 56)
General							
	Male	22	101	21	50	1	51
	Mean age (years ± SD)	38.0 (±18.0)	36.1 (± 15.4)	38.8 (±17.8)	42.2 (±17.2)	16 [a]	29.7 (±9.7)
	Mean ISS	29.3 (±11.7)	22.1 (± 10.4)	30.0 (±11.2)	26.3 (± 9.9)	9 [a]	16.6 (±8.1)
	Hemithoraces (n= 169)	32	137	31	73	1	64
	Drains (n= 194)	32	162	31	86	1	76
Indications (per hemithorax)							
	Tension pneumothorax	11/32	10/137†	11/31	6/73		5/64
	Flail chest	2/32	6/137	2/31	6/73		
	Hemothorax	7/32	48/137	6/31	17/73	1/1	31/64
	Pneumothorax	12/32	72/137	12/31	44/73‡		28/64
Complications (per hemithorax)							
	Infections	3/32	16/137	3/3	14/137		2/64
	Malpositioning	0	2/162		2/86		

Data are given for the entire population and then subdivided into penetrating and blunt trauma groups.
[a] Values cannot be called mean; TT= Tube Thoracostomy; PH= Pre-hospital; ED= Emergency Department; ISS®= Injury Severity Score; †=p<0.0001, Mann Whitney test; ‡= p<0.05, Mann Whitney test.

Table 2. Overview of data concerning patients with positive laboratory infection parameters and bacterial cultures

Pt	Group	Indication	Gender	Age (yrs)	ISS	Hosp (days)	ICU (days)	Trauma	Causative agent	Radiological Diagnosis	Treatment
1	PH	Ptx	m	29	17	25	19	B	Staph Aureus, E. Coli	Wound infection	AB
2	PH	Htx	f	24	41	114	29	B	Pseudomonas aer	Pleural fluid	AB
3	PH	FC	m	25	38	19	14	B	Klebsiella pneum	Pleural fluid	AB
4	ED	TPtx	m	31	25	20	1	P	S. Aureus	Empyema Thoraces (CT)	Thoracotomy + AB
5	ED	TPtx	m	65	34	21	1	B	S. Aureus, Pseudomonas aer	Pleural fluid	AB
6	ED	Htx	m	21	19	25	1	P	Hafnia alvei, Serratia marc	Empyema Thoraces	Thoracotomy
7	ED	Htx	m	54	34	92	15	B	S. Species, Pseudomonas aer	Pleural fluid	AB
8	ED	Htx	m	18	25	40	18	B	S. Aureus	Empyema Thoraces	Thoracotomy
9	ED	Htx	m	68	22	34	/	B	S. Aureus	Empyema Thoraces	Thoracotomy
10	ED	Htx	m	50	26	14	/	B	S. Aureus	Pleural fluid	AB
11	ED	FC	f	75	29	105	30	B	B. cereus	Pleural fluid	Drainage
12	ED	FC	m	65	45	74	31	B	S. Aureus	Empyema Thoraces	Thoracotomy
13	ED	Ptx	f	31	25	22	1	B	S. Species	Pleural fluid	Drainage
14	ED	Ptx	m	65	29	7	2	B	S. Aureus	Abscess rib	AB
15	ED	Ptx	m	42	10	24	9	B	S. Aureus	Empyema Thoraces bilateral, intrahepatic chest tube	Thoracotomy + AB
16	ED	Ptx	f	63	41	108	38	B	S. Aureus	Abscess entry wound + thoracic wall	Incision and drainage
17	ED	Ptx	m	37	27	19	3	B	S. Aureus	Empyema Thoraces	TT + AB
18	ED	Ptx	m	33	34	25	13	B	S. Aureus	Pleural fluid	AB

Pt=patients; ED= Emergency Department, PH= prehospital; TPtx= tension pneumothorax, Ptx= pneumothorax, Htx= hemothorax, FC = flail chest; ISS® = Injury Severity Score; Hosp stay = length of hospital admission (days); ICU= Intensive Care Unit admission (days); Trauma, B=blunt, P=penetrating. AB= AntiBiotics.

Table 3. Mean hospital and ICU stays in days, and duration of chest tube drainage, for prehospital and ED performed TT groups

	Prehospital n= 29 patients, 32 hemithoraces	ED n= 120 patients, 137 hemithoraces
Hospital stay (days)	21,5 (± 23,3)	19,1 (± 21,9)
ICU stay (days)	8,3 (± 10,3)	5,7 (± 11,2)
Drainage time (days)	4,1 (± 3,3)	4,3 (± 2,9)

ED: Emergency Department, ICU: Intensive Care Unit.

Figure 1. Flowchart of included patient population. The number of infections is depicted per moment of TT performance (at the accident site or in the Emergency Department)