



Pre-hospital and in-hospital thoracostomy: indications and complications

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ABSTRACT

INTRODUCTION Pleural drainage with chest tube insertion for thoracic trauma is a common and often life-saving technique. Although considered a simple procedure, complication rates have been reported to be 2–25%. We conducted a prospective cohort observational study of emergency pleural drainage procedures to validate the indications for pre-hospital thoracostomy and to identify complications from both pre- and in-hospital thoracostomies.

PATIENTS AND METHODS Data were collected over a 7-month period on all patients receiving either pre-hospital thoracostomy or emergency department tube thoracostomy. Outcome measures were appropriate indications, errors in tube placement and subsequent complications.

RESULTS Ninety-one chest tubes were placed into 52 patients. Sixty-five thoracostomies were performed in the field without chest tube placement. Twenty-six procedures were performed following emergency department identification of thoracic injury. Of the 65 pre-hospital thoracostomies, 40 (61%) were for appropriate indications of suspected tension pneumothorax or a low output state. The overall complication rate was 14% of which 9% were classified as major and three patients required surgical intervention. Twenty-eight (31%) chest tubes were poorly positioned and 15 (17%) of these required repositioning.

CONCLUSIONS Pleural drainage techniques may be complicated and have the potential to cause life-threatening injury. Pre-hospital thoracostomies have the same potential risks as in-hospital procedures and attention must be paid to insertion techniques under difficult scene conditions. In-hospital chest tube placement complication rates remain uncomfortably high, and attention must be placed on training and assessment of staff in this basic procedure.

KEYWORDS

Trauma – Thoracostomy – Chest injury

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Pleural drainage with chest tube insertion for thoracic trauma is a common and often life-saving manoeuvre.^{1,2} Although viewed as a simple, minor procedure, it is often performed sub-optimally and has reported complication rates of 2–25%.^{3–6} Classical management of tension pneumothorax in the pre-hospital arena is needle decompression,⁷ but this is an inexact technique that may be ineffective and potentially dangerous.^{8–11} Some advanced emergency medical services use a formal thoracostomy, with^{11,12} or without¹⁵ chest tube insertion. While this procedure has been reported as safe^{11,12} and more effective than needle decompression,¹⁴ its associated morbidity is not well described.

We conducted a prospective cohort study of all emergency pleural drainage procedures for trauma. The primary aims of the study were to assess the indications for pre-hospital thoracostomy and identify complications associated

with both pre-hospital and in-hospital pleural drainage procedures.

Patients and Methods

The Royal London Hospital is a 675-bed university trauma centre and incorporates the London Helicopter Emergency Medical Service (HEMS), a dedicated trauma aeromedical service staffed by a combined physician and paramedic crew trained in advanced pre-hospital care.

The trauma centre has defined indications for pre-hospital thoracostomy as detailed in Table 1. The procedure is performed with a similar technique to that for standard chest tube insertion. The thoracostomy is sited in the fourth or fifth intercostal space anterior to the mid axillary line and the pleural space is entered with blunt dissection. If the patient is receiving positive-pressure ventilation, no inter-

Table 1 Indications for pre-hospital thoracostomy*Absolute indications*

- Traumatic arrest
- Low output state of unknown cause
- Tension pneumothorax as diagnosed by
 - Hypoxia
 - Hypotension
 - Absent breath sounds
 - Tracheal shift

Relative indications

- Positive pressure ventilation (PPV) + chest signs localised to a hemithorax
 - Reduced air entry
 - Surgical emphysema
 - Unilateral wheeze
 - Bony crepitations (rib fractures)
- Hypoxia or hypotension + chest signs localised to a hemithorax

No indication

- Simple pneumothorax
- Unilateral chest signs without PPV, hypoxia or hypotension

costal chest tube is placed prior to emergency department arrival.¹⁵ All thoracostomies are performed by the pre-hospital physicians who are emergency department consultants or in their final year of training in emergency medicine.

In the emergency department, resuscitation is based upon the Advanced Trauma Life Support (ATLS) guidelines. A chest radiograph is taken immediately on arrival in most trauma patients.⁷ All pre-hospital thoracostomies have chest tubes placed regardless of clinical status or radiographic results, and these are placed through the existing thoracostomy site. Patients without pre-hospital thoracostomy who require pleural drainage have chest tubes inserted as described in the ATLS course manual, with post-placement radiograph.⁷ Chest tubes are ideally placed anteriorly and posterior placement is acceptable only for isolated haemothorax. The physicians placing the tubes are commonly ATLS-certified junior surgical trainees, and have variable levels of experience in their insertion. Prophylactic antibiotics are not administered for chest tube placement.

Data were collected prospectively over a 7-month period on all patients requiring either pre-hospital thoracostomy or emergency department tube thoracostomy. Details collected included mechanism of injury, the indications for pleural drainage, insertion techniques and the confirmed thoracic injury (from chest radiograph or computed tomography).

Outcome measures were appropriate indications, errors in tube placement and all documented complications. Chest tubes were defined as being well-positioned if all of the drainage holes were within the pleural cavity, not abutting the mediastinum and whether it was appropriately placed anteriorly or posteriorly (if available from computed tomography imaging). Complications were defined as either major or minor. Major complications constituted any life-threatening conditions as a result of thoracostomy or chest tube insertion. Minor complications constituted non-life-threatening conditions. Patients were followed up daily until removal of chest tube.

Results

Ninety-one chest tubes were inserted into 52 patients. The median age was 29 years (inter-quartile range, 22–39 years), 44 (85%) patients were male and 12 (25%) had penetrating injuries. Sixty-five thoracostomies were performed on 35 patients in the pre-hospital phase of their care. In the emergency department, 17 patients received 26 tube thoracostomies as primary procedures following identification of thoracic injury.

Of the 65 pre-hospital thoracostomies, 30 (46%) had absolute indications, 16 (25%) had relative indications and 19 (29%) thoracostomies had no clear indication. Of the 26 tube thoracostomies performed in the emergency department, 4 were for tension pneumothorax, 14 for simple pneumothorax or haemothorax, 3 for reduced air entry on clinical examination and 5 for non-functioning existing tubes. Twenty-eight chest tubes (31%) were poorly positioned and 15 (17%) of these required repositioning (Table 2).

There were nine deaths, none related directly to thoracostomy. Overall complication rate was 14% (Table 3). There were 8 major complications (9%), all occurring in patients receiving pre-hospital thoracostomy. Thoracostomy was required for one empyema and two haemothoraces. There was one large haematoma with active haemorrhage from a scapular artery laceration requiring operative ligation. Four

Table 2 Chest tube placement

Well positioned	48 (53%)
Poor position	28 (31%)
<i>Inappropriately posterior</i>	7
<i>Lung parenchyma/fissure</i>	7
<i>Too far/kinked</i>	12
<i>Partially in pleural cavity</i>	1
<i>Not in pleural cavity</i>	1
Unknown	15
Repositioned	15 (17%)

Table 3 Complications

MAJOR

Massive haemothoraces	2
Empyema	1
Scapular artery haemorrhage	1
Non-relieved tension pneumothoraces	4

MINOR

Thoracostomies for reduced AE due to R main bronchus intubation	2
Lung contusion	1
Right thoracostomy for isolated left chest stabbing	1
Thoracostomy not through pleura	1

pre-hospital thoracostomies (6%) were well sited and initially effective but the pneumothorax had re-tensioned on arrival in the emergency department.

There were five minor complications including one lung contusion from chest tube insertion after an apparently unnecessary thoracostomy. Two thoracostomies were performed for decreased air entry on the left, but the tracheal tube was subsequently found to be in the right main bronchus. There was one right-sided thoracostomy for an isolated left-sided chest stabbing, and one thoracostomy failed to penetrate the pleura. There were 22 potentially unnecessarily placed chest tubes (19 thoracostomies without documented indication, and three chest tubes re-sited for incorrectly placed tubes). There were no cases of drain site cellulitis or abscess.

Discussion

Field diagnosis of tension pneumothorax is difficult and classical signs of decreased air entry, hyper-resonance, and tracheal shift may be absent. Tension pneumothorax may present purely as a low output state or traumatic arrest without obvious haemorrhage. Although no life-threatening chest injuries were missed in our study, we identified 22 (24%) pre-hospital thoracostomies that were potentially unnecessary. This is similar to an earlier study from Hanover which reported a 24% rate of non-therapeutic pre-hospital chest tube placement.¹²

The risk:benefit ratio is clearly in favour of pre-hospital thoracostomy for the absolute indications given in Table 1, as these patients are either *in extremis* or have a clear diagnosis. Intervention in the relative indication group is more difficult to justify. The rationale for intervention in this group is primarily to avoid development of a tension pneumothorax during transport given the difficulties in assess-

ing patients in a helicopter or moving ambulance. However, the non-zero rate of major complications would suggest that this may not be a suitable indication for intervention without a clear diagnosis, especially in an urban setting with short transit times. This relative indication group would be appropriately studied in a randomised, controlled trial. A recent study has shown that ED thoracic ultrasound can have a sensitivity of 92% of detecting pneumothorax in trauma patients.¹⁵ With the availability of light-weight, portable ultrasound machines, accurate diagnosis might be possible in the pre-hospital setting.

All pre-hospital thoracostomies had chest tubes placed in the emergency department, regardless of clinical and radiological findings. It is debatable whether the 'stable' patient with no pleural collection requires formal chest tube placement following thoracostomy and these thoracostomies could probably be closed primarily in the emergency department.

This study confirms that pleural drainage procedures in injured patients are not without risk. We show an overall complication rate of 14%, a 9% rate of major complications and no deaths were attributable to the thoracostomy procedure. Although 70% of the thoracostomies were performed in the field with the inherent difficulties of poor access, light and sterility, our complication rate is consistent with the published literature of 2–25%.^{3–6,16} Major complications appeared to be related to field insertion technique and this may be due to difficulties with unusual patient and physician positioning.

The incidence of infective complications was particularly low in this series, with one empyema and no wound site complications. A recent study of pre-hospital chest tube insertion had a high empyema rate of 9% (and 12% for in-hospital procedures).¹⁶ It is possible that avoiding tube insertion until emergency department arrival reduces the incidence of empyema although the Hanover study reported no infections (or indeed any significant complications) in 76 pre-hospital chest tubes.¹²

We found that 31% of chest tubes placed in the emergency department were positioned suboptimally and 17% required repositioning. This is consistent with published data¹⁷ and suggests the need for formal training and assessment beyond that provided by an ATLS course prior to junior staff being allowed to insert tubes unsupervised.

Conclusions

Pleural drainage techniques are not uncomplicated and have the potential to cause life-threatening injury. Pre-hospital thoracostomies are relatively safe but have the same potential problems as intercostal chest tubes and attention must be paid to insertion technique under difficult scene conditions. Pre-hospital diagnosis of tension

pneumothorax remains difficult and there is a trade-off between missing an easily treated clinically significant injury and performing an unnecessary procedure with its attendant complications. Intervention should be reserved for patients with unexplained hypotension or obvious clinical signs of a tension pneumothorax. In-hospital complication and tube misplacement rates remain uncomfortably high and attention must be placed on training and assessment of staff in this basic procedure.

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