EVIDENCE SERIES

An evidence review of diagnosis and treatment of traumatic pneumothorax

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Contents

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Summary of findings

Chest trauma with a resulting traumatic pneumothorax is a common occurrence. This review explores the current evidence and best practice.

Note: this document is not a clinical guidance document. It provides evidence on clinical practice relating to the questions it sets out to answer.

Diagnosis of traumatic pneumothorax

- Thoracic computerised axial tomography (CT) is considered the gold standard for diagnosing traumatic pneumothoraces.[1]
- Chest ultrasound is portable, safe and provides a fast alternative for traumatic pneumothorax detection, if thoracic CT is unavailable.[2-5]
- Ultrasound detection of pneumothorax may also be used for diagnosis. Ultrasound has a better diagnostic performance than chest radiography and comparable with thoracic CT.[2-5]

Initial management of traumatic pneumothorax

Oxygen therapy

- This review has found insufficient evidence that a high concentration of oxygen improves the resolution of traumatic pneumothoraces.
- Oxygen delivery is best used to maintain adequate oxygen saturation.[6]

Needle decompression

- Needle decompression may be warranted as a temporising measure for a patient presenting with tension pneumothorax. Care must be taken to monitor the patient for repeat tension pneumothorax or failure of this intervention.[7]
- Longer catheters (greater than 4.5cm) appear to improve success and 6.4cm catheters are successful in the majority of patients.[8]

Which patients require intervention?

The occult pneumothorax

Occult pneumothoraces can usually be safely managed with close observation alone.[9]

The occult pneumothorax with intermittent positive-pressure ventilation

There is increasing evidence that an occult traumatic pneumothorax can be safely observed, even in patients requiring short-term positive pressure ventilation (PPV).[10]

Stable patient with pneumothorax

The evidence suggests that most stable patients (i.e. with no respiratory distress, hypoxia or haemodynamic compromise) with traumatic pneumothorax can be safely managed without a chest drain. However, around 10% of patients will subsequently require a chest drain.[11]

Selection of catheter size for tube thoracostomy

Limited available evidence suggests that chest tube size does not impact on clinical outcome, including no difference in the efficacy of drainage; rate of complications including retained haemothorax; need for additional tube drainage; or invasive procedures.[12-15]

Finger versus tube thoracostomy

- For patients with chest trauma who are not spontaneously breathing, finger thoracostomy is associated with improved clinical status.[16]
- Finger thoracostomy appears safe to perform in the prehospital environment, when performed by physician-staffed Helicopter Emergency Medical Service (HEMS) crew.[17-19]

Use of antibiotics

- Evidence supports the use of prophylactic antibiotics in patients requiring a chest drain after penetrating trauma, or after a prehospital finger thoracostomy.[20]
- No definitive evidence is available supporting the use of antibiotics following blunt chest trauma. This should remain under the discretion of the treating physician.[17, 21]

Introduction

What is a traumatic pneumothorax?

A traumatic pneumothorax occurs when air enters between the chest wall and lungs due to a traumatic mechanism. This can be penetrating, such as a knife or bullet wound, or due to blunt forces to the chest wall.[22] This evidence review reveals, best practice care for a person experiencing traumatic pneumothorax requires close observation, and potentially lifesaving interventions by senior medical personnel.

Aim

This evidence review aims to provide the current evidence relating to the diagnosis and treatment of traumatic pneumothorax. It is not a clinical guidance document; rather, it provides available evidence about clinical practice.

The management of spontaneous pneumothoraces usually follows standard clinical pathways. This evidence review aims to address variation that may exist in the management of traumatic pneumothorax, focusing on the prehospital and hospital environments.

This review is divided into the following:

- Diagnosis of traumatic pneumothorax
- Initial management of traumatic pneumothorax:
  - Oxygen therapy
  - Needle decompression
- Which patients with a traumatic pneumothorax require intervention?
  - The occult pneumothorax
  - Stable patients with pneumothorax
- Does chest tube size matter?
- Prehospital decompression and complications following procedures

Alert

Any traumatic pneumothorax causing physiological derangements, such as hypoxia or haemodynamic compromise, will require rapid assessment and likely interventions (such as thoracostomy), especially if tension pneumothorax is suspected.

Who is this document for?

This document is designed to present the latest evidence for staff involved in acute trauma care, including (but not limited to) clinicians in major and regional trauma services, rural clinicians, prehospital clinicians, and their governing authorities, who manage thoracic trauma resulting in pneumothorax. It is specifically focused on NSW conditions but could be applied to other jurisdictions and contexts.

Search methods

An initial scan was done capturing literature from 1967 to 2019 using *BestBets*, *Medline* and *PubMed*.

To more systematically review the literature, an additional search was undertaken using *Embase, Medline* and *PubMed* databases. Two search strategies were used:

Search strategies

1. ***Embase and Medline*** – terms traumatic and pneumothorax.ab. were used, limited to systematic reviews and in English language only. No time range.
2. ***PubMed*** – the following terms were used; (("trauma"[Title] OR "traumatic"[Title] OR "injury"[Title]) AND "pneumothorax"[Title]) AND (review [Filter] OR systematic review [Filter]) Filters: Review, Systematic Review, Humans, English. No time range.

Both searches yielded a total of 58 articles. After screening out references already cited and irrelevant articles related to the subject matter, only three articles where added. These three articles were added to supporting evidence in the reference tables, with no further changes made to this document.

Diagnosis of traumatic pneumothorax

Thoracic CT remains the gold standard in the diagnosis of traumatic pneumothorax. However, widespread use of thoracic CTs have led to overdiagnosis of clinically insignificant occult pneumothoraces (see below section for guidance on the management of occult pneumothoraces).[10]

The upright chest radiograph remains the primary diagnostic study in the acute evaluation of traumatic pneumothorax. However, most trauma patients are kept supine and increasing evidence has shown chest X-ray alone has poor sensitivity for ruling out pneumothoraces.

There is increasing evidence for the use of bedside ultrasound in detection of traumatic pneumothoraces. We have evaluated its evidence for use in trauma patients.

Evidence (refer to Table 1)

Chest CT is the gold standard to detect thoracic trauma, including traumatic pneumothoraces. CT has a higher sensitivity than chest radiography in traumatic pneumothorax detection, particularly in trauma patients lying in the supine position.[1] Routine use of chest CT should be strongly considered in patients with high mechanism, abnormal chest radiography, altered mental status, distracting injuries or clinically suspected thoracic injuries.[23]

Disadvantages of chest CT are that it:

- exposes patients to higher levels of radiation
- requires patients to be stable for transport
- adds additional time to reaching a diagnosis.

As radiation exposure continues to increase in trauma patients, it is important that more directed imaging of the chest is considered.[24]

In pneumothoraces, air is contained between the parietal and visceral pleura, preventing visualisation of deeper structures. Therefore, the diagnosis of pneumothorax by ultrasound requires observation of five clinical signs, which are most sensitive when used in combination.[2-5]

Five clinical signs for diagnosis of a pneumothorax by ultrasound

- **Absence of lung slide:** the absence of a lung slide is a sensitive predictor of a pneumothorax. However, further signs are required as other conditions can also cause absence of lung slide.[2, 3]
- **A-line sign:** A-lines are horizontal linear artefacts below the pleural line and occur in both normal lungs and pneumothoraces. The A-line sign is when A-lines are present with the absence of ULC (ultrasound lung comets), also known as B-lines.[2, 3, 5]
- **Absence of ULCs:** ULCs are absent in pneumothoraces and hold a negative predictive value of 100%. The absence of ULCs occurs due to contrasting adjacent acoustic impedance between tissue or fluid and air within the lungs.[2-4]
- **Absence of lung pulse:** the lung pulse is a vertical movement of the pleural line due to transmission of ventricular contractions through consolidated lung to the pleura. The lung pulse is therefore absent in a pneumothorax.[2, 3]
- **Presence of the lung point:** the lung point is seen at the tip of the pneumothorax where the lung again adheres to the parietal pleura. Recognition of the lung point has a positive predictive value of 100% and can demonstrate the extent of the pneumothorax. However, it has

a low sensitivity because, with large pneumothoraces a lung point may not be seen on the anterior chest.[2-4]

Conclusion

Current evidence suggests that chest ultrasound is portable, safe and provides a fast alternative for traumatic pneumothorax detection. When these five clinical signs are used, a pneumothorax can be accurately detected at the bedside. Ultrasound detection of pneumothorax has a better diagnostic performance than chest radiography and is comparable with thoracic CT.[4] Table 1 summarises the evidence for the use of lung ultrasound in detecting pneumothoraces.

Initial management of traumatic pneumothorax

Oxygen therapy

The use of supplemental oxygen may contribute to the management of traumatic pneumothorax, whether large, small or occult. This is based mostly on the theory that oxygen 'washes out' the nitrogen in the pleural space.[25]

Given oxygen is absorbed faster into the blood than nitrogen, the resolution of the pneumothorax is expedited during supplemental oxygen administration. While this is supported by some research, there is increasing acknowledgement of oxygen as a drug with associated complications and contraindications that should also be considered.

Complications associated with high-flow oxygen appear to be dose-dependent.

Complications include:

- reduced respiratory drive, in patients with severe chronic obstructive pulmonary disease (COPD)
- resorption atelectasis
- pulmonary fibrosis
- alveolar haemorrhage
- pulmonary oedema
- various drug and disease interactions
- the cost of admission to hospital.[26-30]

Evidence (refer to Table 2)

The evidence for the benefit of supplemental oxygen in humans with pneumothorax is primarily from small studies of patients with spontaneous, non-traumatic pneumothorax.[31, 32] These studies have not been replicated since their publication more than 30 years ago. Despite this lack of evidence, this practice is used for spontaneous pneumothorax and often for traumatic pneumothorax.

There are a number of studies in rabbit models that demonstrated an enriched oxygen environment hastens the resolution of experimentally created traumatic pneumothorax.[33-36] Despite the lack of evidence for the benefit in traumatic pneumothorax in humans, this practice is often recommended and can be found in many published guidelines.[25]

Guidance

The Eastern Association for the Surgery of Trauma (EAST) *Guidelines on the management of traumatic pneumothorax* makes no specific mention of the use of oxygen for small (or occult) traumatic pneumothorax, but recommends careful observation (non-invasive monitoring and management) of these patients. It is accepted and recommended practice to conservatively manage occult pneumothorax in this way, usually in an inpatient setting.[37]

An article by Sharma et al. states that:

> "It is recommended that a hospitalised patient with any type of pneumothorax who is not subjected to aspiration or tube thoracostomy should be treated with supplemental oxygen at high concentration."[25]

Conclusion

- There is insufficient evidence that high concentrations of oxygen improve the resolution of traumatic pneumothorax in humans. Further study is required.
- Evidence suggests that traumatic pneumothorax is often one part of a multisystem trauma and treatment should not be considered in isolation of other injuries. Supplemental oxygen should be strongly considered in the setting of hypoxemia, especially with haemorrhagic shock.[25]
- Considering known complications with high oxygen administration, current evidence suggests titrating inspired oxygen to maintain adequate oxygen saturation.[26-30]

Needle decompression

Needle decompression to alleviate tension pneumothorax is widely taught as a life-saving procedure. Traditional teaching is to use the second intercostal space in the mid-clavicular line (MCL). In recent years, there has been increasing concern regarding failure rates and complications using this approach.[38]

The issues

- The needle often doesn't reach the pleural cavity, especially in obese patients.[38, 39]
- Difficult to do in the military context (i.e. soldier with body armour).[38]
- Needle placement (second intercostal space (ICS) MCL) is rarely achieved.[38]

An alternative location of using the fifth ICS anterior or mid-axillary line (MAL) has been proposed.[40]

This may be difficult in the prehospital environment, due to the catheter kinking once the patient is packaged into transport with their arms down.

Evidence (refer to Table 3)

Anatomical location for needle placement

A recent systematic review and meta-analysis by Laan et al. sought to compare the results of research comparing the three main locations proposed for needle decompression.[41] The main issue identified with needle decompression at ICS2-MCL is that the failure rate is high because the chest wall is relatively thicker in this area.[41] Additionally, insertion of a needle at ICS2-MCL may increase the rate of iatrogenic injury to the lung.[42]

Two alternative lateral chest sites have been studied — anterior axillary line (ICS4/5-AAL) and mid-axillary line (ICS4/5-MAL) — both in the fourth or fifth intercostal space (fourth/fifth are grouped together because of insufficient evidence to differentiate them).

Laan et al. found average failure rates of 38% with ICS2-MCL; 31% at ICS4/5-MAL and 13% at ICS4/5-AAL with a 5cm angiocatheter.[39] From this high-quality meta-analysis, ICS4/5-AAL appears to be far superior to the other two locations studied, although more research needs to be done to determine the appropriate angiocatheter length at this alternative location.

Special considerations need to be made in the prehospital medicine, where placement at ICS4/5-AAL may complicate patient packaging.

Needle length

Recommended length of angiocatheter ranges from 5 to 8cm. Outside of this optimal needle length, shorter needle use is associated with higher failure rate and longer needle use is associated with increased incidence of adverse events, which can be serious.[7]

Chest wall thickness and subsequent success of needle decompression appear to be variable based on factors such as patient body build and gender.[39, 43, 44] Furthermore, chest thickness appears to vary by location.[45]

For these reasons, some authors conclude that needle length selection should be left to provider discretion, based on patient characteristics.[39, 44]

A 2015 meta-analysis found needle length of at least 6.44cm was required to penetrate the pleura, at ICS2-MCL, in 95% of patients, and the average chest wall thickness was 4.19cm at this location.[8]

Safety precautions

Caution should be exercised when considering needle decompression where there is no tension pneumothorax, as its use in this situation could precipitate iatrogenic pneumothorax and other serious complications.[46]

In the prehospital environment, diagnosis of tension pneumothorax includes physical signs and ultrasound confirmation of pneumothorax, plus respiratory compromise and/or circulatory compromise. Distended neck veins and tracheal deviation are very late and unreliable signs of tension pneumothorax.[47]

Care must be taken to train providers in the correct technique, including the use of simulation and guided practice.

When performed at ICS4-AAL, there is radiographic evidence that needle insertion perpendicular to the chest wall is associated with better success and lower complication rates.[40]

Conclusion

- Needle decompression may be warranted as a temporising measure for a patient presenting with tension pneumothorax. Care must be taken to monitor the patient for repeat tension pneumothorax and any rare iatrogenic complications.[7]
- The fourth/fifth intercostal space, anterior axillary line is associated with the highest success rate when compared with the second intercostal space, MCL and fourth/fifth intercostal space, MAL. The needle should be inserted perpendicular to the chest wall to avoid injury.[8]
- Longer catheters (greater than 4.5cm) appear to improve success, with 6.4cm catheters successful in the majority of patients. More research is needed to determine success rates and complications associated with different needle lengths in different locations. Providers should be aware of special populations, such as obese patients, who may have increased chest wall thickness.[48]

Which patients with a traumatic pneumothorax require intervention?

The occult pneumothorax

Definition

An occult pneumothorax refers to a pneumothorax seen on CT but not apparent on supine plain radiography.[49]

Introduction

Due to the increased use of CT scans over the past few decades, there has been increased detection of pneumothorax, which had not previously been detected by chest X-rays. There has been debate among clinicians as to how this injury is managed, especially if the patient is placed on PPV.[50]

Evidence (refer to Table 4)

A BestBETs (Best evidence topics) review, published in 2006, summarised the evidence from 1991 to 2000 on whether tube thoracostomy was indicated in trauma patients who have an occult pneumothorax discovered on CT scanning.[51] The results of the studies were varied and were of mixed evidence levels, ranging from retrospective reviews to prospective randomised controlled trials (RCTs). However, the study numbers were low in nearly all (n=11-44). Overall, it was suggested that small occult pneumothoraces could be safely observed with no further interventions.

Since this time there have been a small number of publications reviewing this topic:

- A retrospective review of the data from 1994 to 2003 showed; out of 1,881 blunt trauma patients, 68 (3.6%) had an occult pneumothorax, with 35 having a tube thoracostomy and 33 being monitored.
  - No incidence of progression of pneumothorax or tension pneumothorax in the observation group (despite 48% having PPV).
  - The hospital length of stay (LOS) was lower in the observed group.[52]
- A prospective, observational study at 16 trauma centres over two years reviewed 569 occult pneumothoraces; 21% had tube thoracostomy and 79% observed. Only 6% of patients failed observation.
  - None suffered any complication due to delayed tube thoracostomy.
  - Hospital and intensive care unit (ICU) LOS was significantly longer in tube thoracostomy group.
  - A regression analysis showed that mean occult pneumothorax size 7mm, PPV, occult pneumothorax progression (pneumothorax subsequently identified on follow-up chest X-ray), respiratory distress, and the presence of a haemothorax in patients as independent factors associated with failure of observation.[46]
- Prospective RCT over four to six years in three trauma centres (n=90), randomised to either tube thoracostomy or observation.
  - Primary endpoint was 'respiratory distress' (i.e. acute change from a 'stable' baseline requiring an urgent placement of a chest drain). Changes include an acute increase by 0.2 in the fraction of inspired oxygen; requirement for pharmacologic paralysis to improve ventilator synchrony; requirement for manual bag mask or prone ventilation; or documentation of an adverse respiratory event in the medical record.[53]
  - No difference in outcome, ICU or hospital LOS or mortality.
  - Only one patient in observed group (2%) developed tension pneumothorax while undergoing sustained PPV under six hours of admission.

  - 20% in the observation group had a tube thoracostomy for other reasons (e.g. pneumothorax progression or pleural fluid).
  - The size of the occult pneumothorax did not affect the failure of the observation group.
  - There were no complications in the observed group versus 15% of patients with tube thoracostomy suffering a complication.
- A retrospective review of a database over two years and 83 patients identified 42% had tube thoracostomy and 58% observed.[9]
  - Patients with a tube had significantly longer hospital LOS compared with observed groups.
  - Only four (8.3%) patients required a tube thoracostomy in the observed group.
  - 20% of the tube thoracostomy group suffered a complication (wound infection at the area surrounding the chest tube, haemothorax, pleural effusion, empyema, expanding pneumothorax and subsequent requirement of tube thoracostomy); whereas 8.3% suffered complications in the observation group.

Guidelines and recommendations

1. The EAST *Practice management guidelines for management of hemothorax and occult pneumothorax*, published in 2011, states:

> "Occult pneumothorax, those not seen on chest radiograph, may be observed in a stable patient regardless of positive pressure ventilation (Level 3)."[10]

Conclusion

Current evidence suggests:

- patients with occult pneumothoraces can be safely managed with close observation alone[9]
- patients with deterioration on chest X-ray, respiratory distress, and possibly sustained PPV or pneumothorax progression, may be more likely to fail observation and require tube thoracostomy.[46, 53]

Occult pneumothorax and positive pressure ventilation

Traditionally, patients on PPV with a pneumothorax have received an intercostal catheter (ICC) due to the plausible theory of pressure-driven increase in pneumothorax size and resultant tension pneumothorax. There is currently insufficient research to support this recommendation in the treatment of occult pneumothorax.

Evidence (refer to Table 5)

- A 1992 study reports retrospective review of 26 patients with occult pneumothorax. Two died from brain injury and were excluded. Eleven received immediate ICC and 13 were observed. Numbers from outcomes not reported, just the conclusion that observation was safe.[54]
- In an RCT (n=40) patients with an occult pneumothorax were randomised to observation or ICC. Most experienced blunt trauma, except for one patient in each group. There was no statistically significant difference in hospital or ICU LOS. Fifteen patients in the observation group and 12 in the ICC group underwent PPV. In the observation group, five patients had progression of pneumothorax and three developed tension pneumothorax on PPV.[55]

- In 1999, Brasel et al. conducted a RCT of trauma patients in two centres in the United States. Nine patients in each group required PPV at some point. There was no progression of pneumothorax or tension pneumothorax in the observation group, regardless of PPV. Of interest, the article describes:

> "Ventilatory strategies generally used during the study included tidal volumes of 8-10mL/kg, limited positive end-expiratory pressure, and peak pressure limits of 40 to 50cmH2O."[56]

- In 2009, a Canadian RCT (Ouellet et al.) examined traumatic pneumothoraces, randomised to ICC or observation. Two major centres were used. Only patients requiring PPV were recruited. A total of 24 patients were enrolled. Thirteen patients were initially treated conservatively. Four of these later needed non-urgent ICC placement for fluid or worsening pneumothorax. There was no progression to tension pneumothorax. Hospital LOS, ICU LOS and mortality were all the same across the two groups.[57]
- In 2009, Wilson et al. conducted a retrospective review of the Nova Scotia trauma registry in Canada. It identified 1,881 blunt trauma patients; 68 with occult pneumothorax. Thirty-three were managed without ICC and 16 were managed with PPV at some stage. There was no difference in outcomes compared with 35 occult pneumothorax patients having been treated with ICC.[52]
- A literature review on the management of traumatic occult pneumothorax reviewed 411 articles and selected three randomised trials. The study from Enderson was identified as an outlier in revealing progression on occult pneumothoraces.[49, 55-57] A retrospective study of occult pneumothoraces in a trauma cohort found that no patients with an occult pneumothorax on chest X-ray and observed on intermitted positive pressure ventilation (IPPV) in the emergency department had pneumothorax progression.[58]
- A further RCT (n=90) assigned patients with occult pneumothorax to either tube thoracostomy (n=40) or clinical observation (n=50) with the following results:

> "No difference in mortality, intensive care unit (ICU) stay, ventilator time or total hospital LOS between groups. In those observed, 20% required subsequent pleural drainage (40% pneumothorax progression, 60% pleural fluid and 20% other)."[53]

- An observational study of 602 traumatic pneumothoraces by the Trauma Audit and Research Network (TARN), based in the United Kingdom, demonstrated no difference between the hazard ratio for failure between conservatively-managed PPV patients and non-ventilated patients.[11]

Guidelines and recommendations

EAST guidelines

- *Practice management guidelines for the management of haemothorax and occult pneumothorax* states:
  - Occult pneumothorax, not seen on chest radiograph, may be observed in a stable patient, regardless of PPV (Level 3).
  - Scoring systems are not accurate in predicting which patients will need a tube thoracostomy for occult pneumothorax (Level 3).[10]

Conclusion

There is increasing evidence that occult traumatic pneumothorax can be safely observed, even in patients requiring short-term PPV. Prerequisites are that patients are haemodynamically stable, with no respiratory compromise.[10, 55-58]

Risk factors for progression to ICC include prolonged PPV and large associated haemothorax.[52]

Stable patient with pneumothorax

Can stable patients with traumatic pneumothoraces be treated safely and effectively without a chest drain? The evidence is derived from a BestBets review done in 2008 reviewing the evidence from 1950 to 2008 and a large study published in 2018.[11]

Evidence (refer to Table 6)

A total of 525 unique papers were identified from *Medline* and *Embase*. Three were relevant. No prospective RCTs were found comparing observation or catheter aspiration with thoracostomy in traumatic pneumothorax. The pooled results from these studies demonstrate less than 9% of patients required chest drain insertion for radiological progression; none required a chest drain for clinical deterioration. The available evidence indicates that conservative treatment can be undertaken.

Conclusion

Although the available evidence is limited, current evidence suggests that stable patients with traumatic pneumothorax can be safely and effectively treated without chest drain insertion, with 10% of patients subsequently requiring chest drain insertion.[11] Patients with larger pneumothoraces (>35mm) are more likely to need pleural drainage.

Selection of catheter size for tube thoracostomy

The theory behind chest drain insertion is that haemothorax requires a large bore drain (36-40Fr) to be able to remove clotted blood. However, larger drains may be associated with increasing patient pain. Further evidence for optimal tube size is required

Evidence (refer to Table 7)

- A retrospective review of patients who received either large (36-40Fr) and small (28-32Fr) chest drains for:
  - complications: pneumonia, empyema, retained haemothorax and unresolved pneumothorax
  - initial drain output
  - duration of tube
  - pain score one hour after insertion.[13]

  Conclusion: There were no difference in any of the outcomes. This was regardless of whether patients had a pneumothorax or haemothorax.

- A RCT comparing 20 patients with 14Fr pigtail versus 20 patients with 28Fr chest tube for traumatic pneumothorax studied:
  - tube-site pain after tube insertion (days 0, 1 and 2) and total intravenous pain medication usage
  - success rate of pneumothorax resolution and tube insertion-related complications.[14]

  Conclusion: The group found that chest wall pain between the groups were the same, but tube-site pain was statistically different at Day 0, 1 and 2, with the pigtails causing less pain. There was no statistical difference in analgesia use (although trended lower in pigtail) with no difference in reported complications (n=1 in each group).

- Retrospective analysis of complications in small (8-16Fr) versus large (32-40Fr). Small drains were placed under image guidance (CT or USS), and large drains were placed by residents.[15]

  Conclusion: No difference between large or small intercostal drains.

- A retrospective review completed by Tanizaki compared patients who had a chest tube placed with either a small (20-22Fr) or large (28Fr) within two hours of arrival to hospital following trauma. The two groups were well matched, although the large tube group had longer ICU LOS.[59]

  Conclusion: Complication (empyema, retained haemothorax, additional tube insertion, thoracotomy) rate was the same for the two groups using a small or large chest tube.

- Bauman recently published the group's experience of using pigtail catheters over a seven-year period. This included patients with either a haemothorax or haemopneumothorax. There were some differences between the groups, with pigtails being inserted more often in elderly, blunt trauma patients and in a delayed setting.[12]

  Conclusion: Comparing patients with pigtail catheters (14Fr) to patients who had a large tube thoracotomy (32-40Fr), there were similar outcomes in relation to failure rate (incompletely drained that required second intervention) and tube-related complications.

Guidelines and recommendations

West Yorkshire Trauma Network, UK, 2020

- *Management of Chest Wall Trauma in Adults* states:

  > "A 28fr chest drain is sufficient in most situations. In the trauma situation, small bore Seldinger drains should be avoided unless there is a specific indication after discussion with an appropriate specialist team."[60]

Vanderbilt, 2012

- *Hemothorax Guidelines* suggest pigtail or large bore chest tube with a range of 14-32F.[61]

EAST guidelines

- 2011 *Practice management guidelines for management of haemothorax and occult pneumothorax*.
  - No mention on chest tube size but should be done by tube cut-down technique.
  - Attempt of initial drainage of haemothorax should be with a tube thoracostomy (Level 3).[10]

Conclusion

- Current practice and guidelines suggest patients with traumatic haemothorax are best managed with a 'large bore' tube thoracostomy (i.e. >28Fr).
- Some evidence is emerging to suggest that using smaller tubes via Seldinger technique (pigtail catheters) are likely to be equivalent and cause less complications.

Finger versus tube thoracostomy

Simple finger thoracostomy is a feasible prehospital intervention that appears to effectively treat a pneumothorax in patients undergoing PPV. There is a low level of evidence about the complications associated with this practice.

Evidence (refer to Table 8)

- The first description of simple thoracostomy in the prehospital setting by Helicopter Emergency Medical Service (HEMS) was described by Deakin et al. in 1995, in their publication *Simple thoracostomy avoids chest drain insertion in prehospital trauma*:
  - All 45 patients had immediate clinical resolution.
  - 100% of patients had initial chest X-ray showing very minor residual pneumothorax.
  - No patients had evidence of infection attributable to the thoracostomy site or subsequent chest drain insertion.
  - In the 216 patients who received tube thoracostomy at the roadside, "wound infection/sepsis requiring antibiotic treatment was reported at <5%, with no further breakdown of numbers."[16]
- A four-year review of prehospital simple thoracostomies performed by a physician-paramedic HEMS team, showed opaque reporting of complications as 'no immediate complications'. No data was presented on infectious or other downstream complications. There is only reference to the difficulty separating simple thoracostomy complications from complications arising from the insertion of a chest tube in emergency department or operating theatre.[18]
- Similarly, in an Italian HEMS service with anaesthetist and two nurses as medical crew, reportedly no infectious complications were detected, and no immediate anatomical or haemorrhagic complications were found.[19]
- In 2008, Aylwin et al. published a comprehensive look at simple thoracostomies, both in and out of hospital. There were 65 prehospital simple thoracostomies. Only about 61% were done for appropriate indications.
  - There were eight major complications, all in the prehospital cohort:
    - One empyema
    - Two massive haemothoraces
    - One scapular artery haemorrhage
    - Four non-relieved tension pneumothoraces
  - One thoracostomy did not penetrate the pleura.
  - There were no wound site infections noted.[17]

Conclusion

Finger thoracostomy in patients with chest trauma, not spontaneously breathing, is associated with improved clinical status and appears safe to perform in the prehospital environment when performed by physician-staffed retrieval teams.[18, 19]

Complications are poorly investigated and reported. Higher level studies such as Aylwin et al.[17] indicate a significant rate of serious complications, but infective complications are relatively rare. There is some indication the procedure is over-utilised. There is insufficient data on complications with finger thoracostomies.

Use of antibiotics

There is conflicting evidence on the use of prophylactic antibiotics after the treatment of a pneumothorax with closed tube thoracostomy.

Evidence (refer to Table 9)

There is evidence to show a reduction in empyema and infection rates when prophylactic antibiotics were administered to patients requiring a closed tube thoracostomy for penetrating trauma.[20]

There is no consensus for the use of prophylactic antibiotics in patients requiring a tube thoracostomy in the absence of penetrating trauma. Meta-analysis has suggested the use of antibiotics,[62] but several studies have suggested that routine use of antibiotics for blunt trauma does not significantly reduce the risk of empyema or wound infections.[17, 21]

Guidance

In 2017, the Royal College of Surgeons of Edinburgh published *Prehospital management of life-threatening chest injuries: a consensus statement*:

- No hard evidence for prophylactic antibiotics for prehospital thoracostomy. Studies exist looking at hospital tube thoracostomy.
- The British Thoracic Society guidelines recommend antibiotics should be considered for trauma patients, especially penetrating trauma, requiring chest drains.
- Consensus opinion was that prophylactic antibiotics should be considered for prehospital thoracostomy, especially in cases of penetrating chest trauma, or with transport times >3 hours.
- Consensus view was to use prehospital inserted thoracostomy for chest drain insertion and cover with antibiotics, rather than increasing morbidity with a second incision. However, in the case of penetrating trauma chest trauma, intercostal drains should not be inserted into the wound.[63]

Conclusion

- Evidence supports the use of prophylactic antibiotics in patients requiring a chest drain after penetrating trauma.
- No definitive evidence for the use of antibiotics following blunt chest trauma. This remains under the physicians' discretion.

Conclusion

This evidence review challenges some classic teachings on the management of traumatic pneumothorax, such as all traumatic pneumothoraces require a large chest drain and all patients undergoing IPPV with a pneumothorax require a chest drain. These teachings may not be consistent with current evidence.

Other evidence advocates a more conservative approach, such as patients with occult or asymptomatic small traumatic pneumothoraces, can be safely managed with close observation alone.

Conflict of interest and declarations

Trauma Innovation Committee members and NSW Institute of Trauma and Injury Management staff have declared they have no affiliations, conflicting or financial interests associated with the subject matter mentioned in this document.

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Glossary

AAL	Anterior axilliary line
A-Line	Horizontal artifactual repetitions of the pleural line displayed at regular interval
BET	Best evidence topic
COPD	Chronic obstructive pulmonary disease
CT	Computer tomography
CXR	Chest X-ray
EAST	Eastern Association for the Surgery of Trauma
HEMS	Helicopter Emergency Medical Service
ICC	Intercostal catheter
ICS	Intercostal space
IPPV	Invasive positive pressure ventilation
ITIM	Institute of Trauma and Injury Management
IV	Intravenous
LOS	Length of stay
MAL	Mid-axilliary line
MCL	Mid-clavicular line
NIV	Non-invasive ventilation
OPTX	Occult pneumothorax
OT	Operating theatre
PPV	Positive pressure ventilation
PTX	Pneumothorax
RCT	Randomised controlled trial
TARN	Trauma Audit and Research Network
TIC	Trauma Innovation Committee
ULC	Ultrasound lung comets

Evidence tables

Table 1: Evidence table – studies assessing lung ultrasound in the diagnosis of pneumothoraces

Study reference	Patient number	Sensitivity	Specificity	Gold standard
Xirouchaki et al. 2011[64]	42	USS vs. CXR 75% vs. 0%	USS vs. CXR 93% vs. 99%	CT
Nagarsheth et al. 2011[6]	79	USS vs. CXR 81% vs. 31%	USS vs. CXR 100% vs. 100%	CT
Sartori et al. 2007[65]	285	USS vs. CXR 100% vs. 87%	USS vs. CXR 100% vs.100%	No
Zhang et al. 2006[66]	135	USS vs. CXR 86% vs. 27%	USS vs. CXR 97% vs 100%	CT and chest drain
Chung et al. 2005[67]	97	USS vs. CXR 80% vs. 47%	USS vs. CXR 94% vs. 94%	CT
Blaivas. 2012[68]	176	USS vs. CXR 98% vs. 75%	USS vs. CXR 99% vs. 100%	No
Lichtenstein et al. 2005[69]	200	USS 95%	USS 94%	CT
Kirkpatrick et al. 2004[70]	225	USS vs. CXR 48% vs. 20%	USS vs. CXR 98 vs. 99%	No
Knudtson et al. 2004[71]	328	USS 92%	USS 99%	CXR
Vafaei et al. 2016[72]	55	USS vs. CXR 84% vs. 67%	USS vs. CXR 98% vs. 93%	CT
Soult et al. 2015[24]	345	USS vs. CXR 40% vs. 24%	USS vs. CXR 99% vs. 100%	CT
Helland et al. 2016[73]	49	USS 68%	USS 98%	CT
Staub et al. 2018[74]	17 studies	USS 95%	USS 95%	CT
Alrajhi et al. 2012[75]	1,048	USS vs. CXR 90.9% vs. 52.2%	USS vs. CXR 98.2% vs. 99.4%	CT
Chan et al. 2017[76]	410	USS vs. CXR 91% vs. 47%	USS vs. CXR 99% vs. 100%	CT

Table 2: Evidence table – oxygen therapy

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results	Study weaknesses
Panjwani. 2017[77]	4 patients with small pneumothorax: 2 iatrogenic, 1 traumatic, 1 primary spontaneous	Case series, very low	Lung re-expansion	In patients with small pneumothorax, supplemental oxygen therapy and observation may be sufficient for resolution.	Case series, small sample, observational, no control group.
Chadha et al. 1983[32]	8 patients with pneumothorax: 3 iatrogenic and 5 spontaneous	Case series, very low	Resolution rate	In patients with small pneumothorax, supplemental oxygen increased the rate of resolution. Patients with larger pneumothorax required chest tube insertion.	Case series, small n, observational, no control group, old study.
Northfield. 1971[31]	22 patients with spontaneous pneumothorax: 12 breathing room air, 10 given supplemental oxygen	Retrospective control arm, prospective treatment arm, low	Primary- mean rate of absorption of gas Secondary included time to complete re-expansion	Oxygen therapy consistently increased mean rate of absorption. Oxygen therapy appeared to decrease time to complete re-expansion.	Small n, indirect primary endpoint, old study.

Table 3: Evidence table – needle decompression

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results
Stevens et al. 2009[78]	Data from 110 patients were analysed, measuring chest wall depth at the second intercostal space, midclavicular line on CT scans	Retrospective case review	The mean chest wall depth on the right was 4.5cm (+/- 1.5cm) and on the left was 4.1cm (+/- 1.4cm). 55 of 110 patients had at least one side of the chest wall measuring greater than 4.4cm.	The standard 4.4cm angiocatheter is likely to be unsuccessful in 50% (95% confidence interval. This equates to 40.7-59.3%) of trauma patients on the basis of body size.

Table 3: Evidence table – needle decompression (cont.)

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results
Inaba et al. 2012[13]	30 patients were randomly chosen for each BMI quartile, patients inclusion in the study was on the basis of their BMI	Retrospective case review	The mean difference in chest wall thickness between the second ICS at the MCL and the fifth ICS at the AAL was 12.9mm (95% CI, 11.0-14.8; P<0.001) on the right and 13.4mm (95% CI, 11.4-15.3; P<0.001) on the left.	Needle thoracostomy decompression would be expected to fail in 42.5% of cases at the second ICS in the MCL compared with 16.7% at the fifth ICS in the AAL. The chest wall thickness at the fifth ICS AAL was 1.3cm thinner on average and may be a preferred location for needle thoracostomy decompression.
Schroeder et al. 2013[79]	201 patients' chest wall thicknesses were measured at the second ICS, (MCL and the fifth ICS,) AAL	Retrospective case review	The average chest wall thickness in the overall cohort was 4.08cm at the second ICS/MCL and 4.55 cm at the fifth ICS/AAL.	29% of the overall had a chest wall thickness greater than 4.5cm at the second ICS/MCL and 45% had a chest wall thickness greater than 4.5cm at the fifth ICS/AAL.
Inaba et al. 2011[80]	20 randomly selected unpreserved adult cadavers were evaluated. A total of 14 male and 6 female cadavers were studied	Prospective observational study	Overall, 100% of needles placed in the fifth intercostal space and 57.5% of the needles placed in the second ICS entered the chest cavity.	On average, the chest wall was 1cm thinner at the fifth ICS and may improve successful needle placement.
Inaba et al. 2015[40]	A total of 25 US Navy Hospital corpsmen underwent a standardised training session followed by inserted 100 14-gauge angiocatheter needles into 25 'fresh' cadavers	Prospective observational study	Time to decompression did not differ between the second and fifth ICS. Accuracy was superior at the fifth ICS, with a misplacement rate of only 22.0% versus 82.0% at the second ICS.	The fifth ICS AAL can be localised and decompressed with a higher degree of accuracy than the traditional second ICS MCL.
Carter. 2013[39]	91 patient records reviewed that had CT of the chest and measured the chest wall depth at the second intercostal space bilaterally	Retrospective case review	46mm needles would only be successful in 52.7%, 51mm has a success rate of 64.8%. A 64mm needle would be successful in 79% percent of our patient population.	Use of longer length needles for needle thoracostomy is essential given the extent of the nation's adult obesity population.

Table 4: Evidence table - patients who require a traumatic pneumothorax require intervention

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results	Study weaknesses
Wilson et al. 2009[52]	68 occult pneumothoraces: 35 received tube thoracostomy, 33 managed conservatively	Retrospective case review	Hospital LOS	Hospital LOS was significantly longer for patients receiving tube thoracostomy compared to those who didn't (10 vs. 7 days p=<0.01). 48% of patients in the observation group underwent PPV. None had progression of pneumothorax.	Retrospective review so significant patient selection biases. No mention of monitoring of progression or how long PPV occurred for.
Moore et al. 2011[46]	569 occult pneumothoraces: 121 received tube thoracostomy, 448 managed conservatively	Prospective multicentre observational study	Failure of observation	Only 6% of patients in observation group required tube thoracostomy. Pneumothorax progression, respiratory distress, and the presence of a haemothorax in patients as independent factors associated with failure of observation. Hospital and ICU LOS were significantly longer in tube thoracostomy group.	Observational study only. Significant patient selection bias remains. Study only analyses patients who failed observation and not the tube thoracostomy group.
Kirkpatrick et al. 2013[53]	90 patients with occult pneumothoraces: 40 randomised to tube thoracostomy, 50 randomised to observation only	Prospective multicentre RCT	Composite outcome of respiratory distress	Risk of respiratory distress was similar between the observation and tube thoracostomy groups (relative risk, 0.71; 95% confidence interval, 0.40,1.27).	No blinding to intervention (although unavoidable).
			Mortality and LOS	There was no difference in mortality or ICU LOC, ventilator or hospital days between groups.	
			Complications	There were no complications in the observed group vs. 15% of patients with tube thoracostomy suffering a complication.	

Table 4: Evidence table - patients who require a traumatic pneumothorax require intervention (cont.)

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results	Study weaknesses
Zhang et al. 2016[9]	83 occult pneumothoraces: 35 received tube thoracostomy, 48 managed conservatively	Retrospective case review	Mortality and LOS	Patients who received tube thoracostomy had longer hospital stays compared to the observation group (13 vs. 5.5 days, p=0.008). There was no difference in mortality (5.7 vs. 2.1%, p=0.57).	Retrospective review so significant patient selection biases. Limited details surrounding complication definition and surveillance.
			Complication rate	20% of the tube thoracostomy group suffered a complication, whereas none suffered complications in the observation group.	

Table 5: Evidence table - assessing occult pneumothorax and positive pressure ventilation

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results	Study weaknesses
Enderson et al. 1993[55]	Adult patients with OPTX in a major trauma centre	RCT	40 patients enrolled, 19 for ICC and 21 for observation. 8 of 21 in the observation group had progression of PTX requiring ICC on PPV. 3 developed pneumothorax.	8 of 21 had progressive pneumothorax on PPV, 3 of which developed tension pneumothorax.	Small study from 1993, with results differing from other similar trials.
Brasel el al. 1999[56]	Prospective trauma patients in single US centre with blunt trauma and OPTX	RCT	Total of 44 patients. 9 patients in each group received PPV. No difference in complication rate.	No progression in observed cohort to ICC in patients with PTX and PPV.	Small study with only 18 patients total receiving PPV.
Wilson et al. 2009[52]	Consecutive trauma patients with pneumothorax 1997 to 2003. 1,881 patients screened. 307 pneumothoraces, 68 of which were occult pneumothorax.	Retrospective registry review	29 patients with occult pneumothorax received ICC and PPV. 16 patients with pneumothorax had PPV without ICC.	There was no difference in outcomes other than shorter LOS in the group that did not have ICC placed. Injury severity between the two groups was the same.	Retrospective review, with unexplained time since last patient in 2003 and time of publication in 2009. Small numbers of patients that demonstrate the comparison of interest.
Oullet et al. 2009[57]	Trauma patients with OPTX on CT that also required PPV 2006-2008.	RCT from two centres	24 patients enrolled. 15 observed and 9 with ICC at time of diagnosis.	4 observed patients needed subsequent ICC non-urgently. There was no difference in mortality, LOS in ICU or hospital or respiratory distress.	Small study with unequal study group sizes.
Yadav et al. 2010[49]	Trauma patients with pneumothorax without haemodynamic instability. 411 article abstracts were reviewed. 3 RCTs were identified and included.	Literature review	The three RCTs included were Oullet[54], Enderson[52] and Brasel.[53]	No significant difference between observation and tube thoracostomy in regards to progression of occult pneumothorax, risk of pneumonia, or LOS in hospital or ICU.	Small numbers of patients included.

Table 5: Evidence table - assessing occult pneumothorax and positive pressure ventilation (cont.)

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results	Study weaknesses
Lee et al. 2012[50]	Consecutive ED trauma patients with occult pneumothorax identified on CT.	Retrospective trauma registry review. Prime purpose to look at anatomical site of the OPTX, but outcomes reported.	8 patients with OPTX without ICC were managed with mechanical ventilation for the purpose of surgery. None progressed to needing ICC.	8 patients with known OPTX received PPV with no progression of pneumothorax.	Retrospective study that was primarily aimed at describing site and associated severity of OPTX in trauma. Outcomes from PPV only incidentally reported.
Kirkpatrick et al. 2013[53]	Adult trauma patients with occult pneumothorax requiring PPV. Recruited from 4 major Canadian centres.	RCT	90 patients recruited, 40 for ICC and 50 for observation. 15% of patients with initial ICC had complications from ICC. Of the observation group 20% required eventual drainage, from progressive pneumothorax, fluid or 'other'. Patients with short-term PPV for operations had few complications compared to sustained PPC for ICU.	Only 10% of patients with pneumothorax on PPV required ICC when initially observed. Large haemothorax identified as main risk factor in conservative management.	Mixed group of PPV, from long-term ICU to short-term for single operation only.
Walker et al. 2018[11]	Adult trauma patients from TARN database. April 2012 to December 2016.	Retrospective review of trauma database	602 patients with traumatic pneumothorax were reviewed. Mean ISS 26. 277 were observed without ICC. Only 10% required subsequent tube insertion. Of this, 62 patients were on PPV, and only 10% of these required ICC. Only the presence of large haemothorax was associated with likelihood of failure of conservative treatment.	Only 10% of patients with pneumothorax on PPV required ICC when initially observed. Large haemothorax identified as main risk factor in conservative management.	Retrospective review. Few patients at 62 with PPV treatment.

Table 6: Evidence table - stable patient with pneumothorax

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results	Study weaknesses
Eddine et al. 2019[81]	336 patients with traumatic pneumothorax	Observational study	Outcome depending on pneumothorax size – cut off 35mm	41% of patients with pneumothorax >35mm required pleural drain compared to 9% with <35mm.	Not RCT.
Walker et al. 2018[11]	602 TARN patients	Observational study	Progression to intervention	Mean ISS 26 46% treat conservatively including patients requiring PPV 10% required subsequent ICC.	Not RCT but large cohort.
Knottenbelt et al. 1990[82]	333 patients with pure unilateral PTX, lung border less than 1.5cm from chest wall at third rib, not requiring IPPV, no underlying lung disease treated expectantly studied	Case series/ prospective observational study of new protocol	Progression to chest drainage Clinical deterioration	8.8% (6/333) required chest drain for radiological progression. No clinical deterioration in group treated expectantly.	No control group. Rates of complications at follow-up not divided into groups treated expectantly or by thoracostomy. Majority of patients with penetrating wounds, may not be reflective of other populations.
Johnson et al. 1996[83]	53 patients with a diagnosis of traumatic PTX found on department database, 29 managed expectantly, 24 by thoracostomy, 49 post blunt trauma, 4 penetrating trauma	Retrospective case note review	Progression to chest drain Clinical deterioration	7% (2/29) required chest drain for asymptomatic radiographic progression. No clinical deterioration in group treated expectantly.	Retrospective. No control group. No protocol for choice of treatment - at physician discretion. Length of follow-up not specified.

Table 6: Evidence table - stable patient with pneumothorax (cont.)

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results	Study weaknesses
Obeid et al. 1985[84]	34 patients simple traumatic PTX, haemodynamically stable, no other clinically significant injury, no underlying lung disease treated by catheter aspiration or thoracostomy. 4 post blunt trauma, 21 intravenous (IV) drug injection, 9 penetrating trauma patients matched to control patients treated with thoracostomy prior to study.	Prospective trial of aspiration	Progression to chest drain Clinical deterioration	6% (1/17) required chest drain for failure of aspiration. No clinical deterioration in group treated by aspiration.	Small numbers. Not randomised. Control group not studied prospectively. High incidence of IV drug use as aetiology – may not be reflective of other populations.

Table 7: Evidence table - selection of catheter size for tube thoracostomy

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results	Study weaknesses
Inaba et al. 2012[13]	353 chest tubes. 186 small (28-32Fr) and 167 large (33-40Fr) placed in 293 patients	Prospective analysis	Complication rate	No statistically significant difference in tube-related complications. Pneumonia (4.9% vs. 4.6%; adj. p=0.282), empyema (4.2% vs. 4.6%; adj. p=0.766), or retained haemothorax (11.8% vs. 10.7%; adj. p=0.981), comparing small versus large chest tubes.	Not an RCT. Patient selection biases.
Kulvatunyou et al. 2014[14]	40 patients randomised to 28Fr tube thoracostomy or 14Fr pigtail drain for simple traumatic pneumothorax	Randomised trial	Pain scores	Patients with a pigtail catheter had significantly lower tube-site pain scores than those with a chest tube. Pain scores were lower in pigtail compared to drain at baseline after tube insertion (3.2(0.6) vs. 7.7(0.6); p<0.001), on day 1 (1.9(0.5) vs. 6.2(0.7); p<0.001) and day 2 (2.1(1.1) vs. 5.5(1.0); p=0.040). The decreased use of pain medication associated with pigtail catheter was not significantly different. The duration of tube insertion, success rate and insertion-related complications were all similar in the two groups.	Small study numbers with only 20 patients in each arm. Using pain as an outcome measure can lead to subjective biases from the research group. Only simple pneumothorax. Unclear if this would apply to haemothorax also.
Rivera et al. 2009[15]	202 non-emergent tube thoracostomies. 131 small tubes (8-16Fr) compared to 71 large tubes (32-40Fr)	Retrospective review	Complication rate	The overall complication rate was similar between small catheter tube thoracostomy and nonemergent large catheter tube thoracostomy (25.2% vs. 29.6%, p=NS). Rates of haemothoraces were low for small tubes versus large tube (6.1% vs. 4.2%, p=NS) and rates of residual/ recurrent pneumothoraces were not significantly different (8% vs. 14%, p=NS). The rate of occurrence of fibrothorax, however, was significantly lower for small tube compared with large tube (0% vs 4.2%, p < 0.05).	Retrospective review so significant patient selection bias. Comparison only made in non-emergent tubes, therefore unclear application to usual trauma chest drains placed.

Table 7: Evidence table - selection of catheter size for tube thoracostomy (cont.)

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results	Study weaknesses
Tanazaki et al. 2017[59]	124 tube thoracostomies placed within 2 hours of hospital arrival. 68 small tubes (20-22Fr) and 56 large (28Fr).	Retrospective review	Complication rate	There was no significant difference of tube-related complications. No difference in empyema (small: 1/68 vs. large: 1/56; p=1.000) or retained hemothorax (small: 2/68 vs. large: 2/56; p=1.000), the need for additional tube placement (small: 2/68 vs. large: 4/56; p=0.408) or thoracotomy (small: 2/68 vs. large: 1/56; p=1.000).	Retrospective review so patient selection bias. Definition of 'large tube' of 28Fr not consistent with previous studies.
Bauman et al. 2018[12]	496 trauma patients for haemothorax or haemopneumothorax. 307 by large chest tube (32-40Fr) and 189 pigtail (14Fr).	Retrospective review	Complication rate	Insertion-related complications: chest drain 14 (5%) vs. pigtail 17 (8.5%) p=0.11.	Retrospective review. Patient selection bias.
			Failure rate	Failure rate: Chest drain 73 (24%) vs. pigtail 39 (21%) p=0.39.	
			Initial tube output	Initial output (mL), median (IQR) chest drain 300 (150, 500) vs. pigtail 425 (200, 800) p<0.001.	

Table 8: Evidence table - complications from simple ('finger') thoracostomy

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results
Deakin et al. 1995[16]	45 patients who were treated with simple thoracostomy rather than tube thoracostomy	Case study	Simple thoracostomy appears to have important advantages over conventional techniques.	Simple thoracostomy warrants further clinical evaluation.
Chester et al. 2016[18]	126 patients with a total of 236 thoracostomies (87% were bilateral). Between 1 April 2010 and 31 March 2014.	Retrospective review	No immediate complications were recorded on the database.	
Massarutti et al. 2006[19]	55 consecutive patients with suspected pneumothorax. 4 were bilateral, with total 59 thoracostomies.	Case series	72% survived to hospital discharge.	Treatment of traumatic pneumothorax by simple thoracostomy without chest tube insertion is a safe and effective technique.
Aylwin et al. 2008[17]	91 chest tubes were placed into 52 patients. 65 thoracostomies were performed in the field without chest tube placement. 26 procedures were performed following emergency department identification of thoracic injury.	Prospective analysis	65 prehospital simple thoracostomies. Only about 61% were done for appropriate indications. There were eight major complications, all in the prehospital cohort.	

Table 9: Evidence table - use of antibiotics in managing traumatic pneumothorax

Study reference	Patient group	Study type and level of evidence	Outcomes	Key results
Bosman et al. 2012[20]	Review of RCT 11 articles, including 1,241 chest drains	Meta-analysis	Patients who received antibiotics had almost three times lower risk of empyema.	Antibiotic prophylaxis reduced infection after chest drain insertion in penetrating trauma.
Sanabria et al. 2006[21]	Review of meta-analysis comparing antibiotics vs placebo in isolated chest trauma in five trials	Meta-analysis	Significant reduction in the risk of empyema and pneumonia for patients who received antibiotics (three trials included blunt trauma, of which did not evaluate the outcomes by injury mechanism).	Recommends the use of antibiotics in isolated blunt trauma to reduce the rate of empyema and pneumonia.
Aylwin et al. 2008[17]	Study looking at 91 chest drains (65 prehospital thoracostomies and 26 in hospital)	Prospective study	No patients were given prophylactic antibiotics for chest drain, there was empyema and no wound site infections.	No suggestions about prophylaxis but suggested that avoiding tube insertion until the ED.
Heydari et al. 2014[62]	RCT looking at patients with blunt chest trauma receiving chest drains, 112 chest drains	RCT	Treatment group receiving antibiotics had two patients with pneumonia, placebo group had four patients with pneumonia and one empyema.	Study concluded that prophylactic antibiotics should not be given as did not significantly reduce the incidence of pneumonia or empyema.

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