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REVIEW

Pleural decompression and drainage during trauma reception and resuscitation

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Summary   This review examines pleural decompression and drainage during initial hospital adult trauma reception and resuscitation, when it is indicated for haemo-dynamically unstable patients with signs of pneumothorax or haemothorax. The relevant historical background, techniques, complications and current controversies are highlighted.
   Key findings of this review are that:

1. Needle thoracocentesis is an unreliable means of decompressing the chest of an unstable patient and should only be used as a technique of last resort.
2. Blunt dissection and digital decompression through the pleura is the essential first step for pleural decompression, as decompression of the pleural space is a primary goal during reception of the haemodynamically unstable patient with a haemothorax or pneumothorax. Drainage and insertion of a chest tube is a secondary priority.
3. Techniques to prevent tube thoracostomy (TT) complications include aseptic technique, avoidance of trocars, digital exploration of the insertion site and guidance of the tube posteriorly and superiorly during insertion.
4. Whenever possible, blunt thoracic trauma patients should undergo definitive CT imaging after TT to check for appropriate tube position.
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Introduction

Pleural decompression is an intervention commonly employed during the pre-hospital, emergency department, intra-operative, peri-operative, intensive care and ward stages of trauma care. Although similar principles for pleural decompression are common to all stages, physiologic states, co-morbidities and diagnostic factors create differing priorities and techniques.

This review examines pleural decompression and drainage during initial hospital adult trauma reception and resuscitation. The relevant historical background, indications, techniques, complications and current controversies are highlighted Table 1.

Current incidence

Current estimates of thoracic trauma suggest an incidence of 12 persons per million of population per day. Thoracic injuries are primarily responsible for 25% of all trauma deaths and contribute to a further 25% of deaths.[24]

Approximately 33% of thoracic injuries require hospital admission.[55] However, over 85% of patients with thoracic trauma do not require thoracic surgery and thoracotomy is indicated in only

Table 1 Key points for pleural decompression in trauma

Needle decompression should only be used a technique of last resort
Digital decompression is the essential first step
Chest tube insertion is a secondary priority
Complications will be reduced with aseptic technique, avoidance of trocars, digital exploration of the insertion site and guidance of the tube during insertion

5—10% of patients sustaining major blunt thoracic injury.[14,26] Most thoracic trauma is adequately managed with simple lifesaving manoeuvres including supplemental oxygenation, tube thoracostomy, mechanical ventilation when indicated and circulatory support.[24] Prospectively gathered trauma registry data indicates that tube thoracostomy is required in 25% of patients presenting with major trauma.[32]

The majority of trauma patients requiring chest decompression have it performed during the initial phase of reception at the receiving hospital.[32]

History of pleural decompression for trauma

Pleural decompression and drainage for trauma is a relatively recent therapy. During the mid 19th Century combat mortality rates for thoracic trauma were reported as high as 80%.[6,51] The management of thoracic trauma was conservative and expectant. Medical interventions recommended for chest injuries were limited to wound closure and rest.

Two common causes of death from thoracic trauma were initial blood loss and subsequent empyema. The management of empyema was directed towards the avoidance of active treatment. In the late 19th century the concept of continual pleural drainage was promoted.[33] Following the Franco-Prussian War of 1870—71 the German technique of pleural drainage was associated with a reduction in the development of empyema.[60]

An aggressive surgical approach aimed at reducing the incidence of empyema was modified after the report of the US Army's Empyema Commission in World War 1 (1914—19). The Empyema Commission's recommendations changed the treatment of empyema from early and sometimes prompt open treatment, to repeated aspirations followed by

closed drainage. This was associated with a rapid fall in mortality from sepsis from 60—80% to less than 15%.[51]

At the commencement of World War 2 (1939—45) chest decompression and drainage had become the preferred approach for empyema.[20] In addition, earlier access to surgical care at forward battlefield casualty receiving stations gave medical staff the opportunity to observe and develop treatments for traumatic tension pneumothorax, a condition that was rarely seen in civilian life at this time. Needle decompression was used for tension pneumothorax secondary to penetrating thoracic injury, with the needle connected to rubber tubing and the end of tubing placed underwater to effect a one way valve. In 1944 Fuld described a modification of this, using components of an intravenous transfusion set to make the valve. Fuld recommended early decompression at regimental aid posts prior to transport[28] (Figure 1).

However, the principle means of pleural drainage employed in hospitals was closed-tube drainage of the chest with an underwater seal. By the end of WW2 this had become the standard treatment for pneumothorax and haemothorax.[51]

Since WW2 the increase in road traffic has been the major contributor to the increase in civilian trauma.[62,63] The majority of civilian thoracic trauma is blunt in nature and associated with other body system injuries. A single system approach to care has been replaced by techniques appropriate for severely injured road crash patients who have
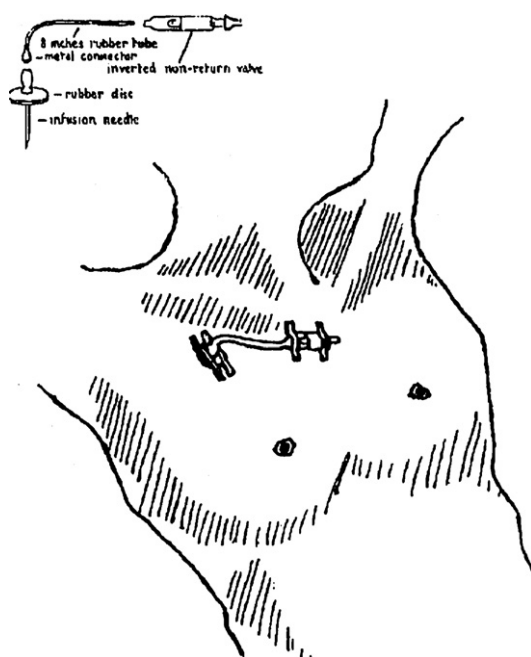

Fig. 1 From Fuld H, 1944 Simple device for control of tension pneumothorax.

multi-system injuries. Also, the widespread use of positive pressure ventilation in the field has increased the numbers of thoracic trauma patients that reach hospital alive.[9] Positive pressure ventilation, whilst improving oxygenation, has potentially deleterious effects including rapid development of tension pneumothorax, pneumopericardium with tamponade and systemic gas emboli. Improved imaging, ready access to CT scanning and concerns regarding the cost/benefit of some procedures has prompted a re-examination of the evidence basis for interventions in thoracic trauma.[4] Current interventions commonly employed for pleural decompression and drainage during trauma reception and resuscitation are needle thoracocentesis (NT) and tube thoracostomy (TT).

Needle thoracocentesis and tube thoracostomy

Much of the literature related to the initial diagnosis and management of pleural decompression is uncontrolled or based on expert opinion alone. Recommendations for pleural decompression and drainage during trauma resuscitation can be made based on the available literature, although some controversies remain including:

1. Is needle thoracocentesis (NT) during trauma reception and resuscitation a useful and reliable technique? What are the dangers associated with NT?
2. What is the best technique for pleural decompression of haemodynamically unstable patients during trauma reception?
3. Where is a tube thoracostomy best positioned? What is the most appropriate way to check correct tube positioning?
4. When is pleural decompression most appropriately performed during trauma reception?

Is needle thoracocentesis during trauma reception and resuscitation a useful and reliable technique? What are the dangers associated with NT?

Needle decompression of the chest is taught as a 'life-saving' procedure for patients in extremis with circulatory collapse secondary to tension pneumothorax.[2] However, there is no evidence that needle thoracocentesis is a reliable or useful procedure for hospital trauma reception. Recent studies demonstrate significant failure rates associated with needle thoracostomy and the related technique of small gauge catheter-over-needle insertion.[15,32]

Failure to decompress a tension pneumothorax using needle thoracocentesis is well recognised in
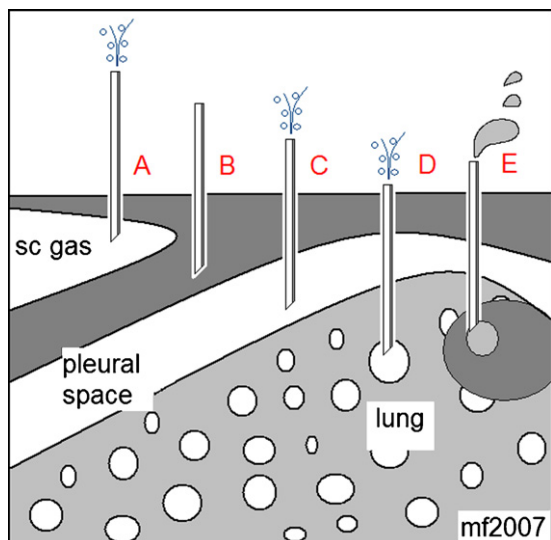
Fig. 2 Possible positions of needle thoracocentesis (NT): (A) False positive—as needle decompresses sub-cutaneous emphysema. (B) False negative—as needle does not reach pleural space. (C) Correct position of NT with decompression of tension pneumothorax. (D) False positive—with needle intrapulmonary in bulla or bronchial tree. If the tension pneumothorax is loculated due to pulmonary adhesions and missed by NT a false-negative result may occur with intra-pulmonary placement. (E) True negative—with needle in a major vessel or the heart. This may be mis-interpreted as a false positive for haemothorax. Only C will decompress a tension pneumothorax. A, B, D and E have all been associated with failure to decompress the pleural space and fatal outcomes.

the literature.[37,49] NT for patients with cardiovascular collapse is an unreliable technique with significant false positives and negatives, which will contribute to death if unrecognised (Figure 2).[49]

Potential outcomes of attempted NT include:

A. False positive as needle decompresses sub-cutaneous emphysema:

   Without penetrating the pleural space the needle decompresses sub-cutaneous gas, causing a release of gas and the impression that the pleural space has been decompressed.

B. False negative as needle does not reach pleural space:

   Failure to reach and decompress the pleural space is the major argument against the use of NT.[7] Although initial studies using ultrasound determination of chest wall thickness seemed to indicate that needle lengths of 4.5 cm would be sufficient to reach the pleural space in most patients,[7,47] more recent studies of trauma patients undergoing chest CT scan indicate that a catheter length of less than 5 cm would fail to reach the pleural space 18—33% of the time.[30,38,45]
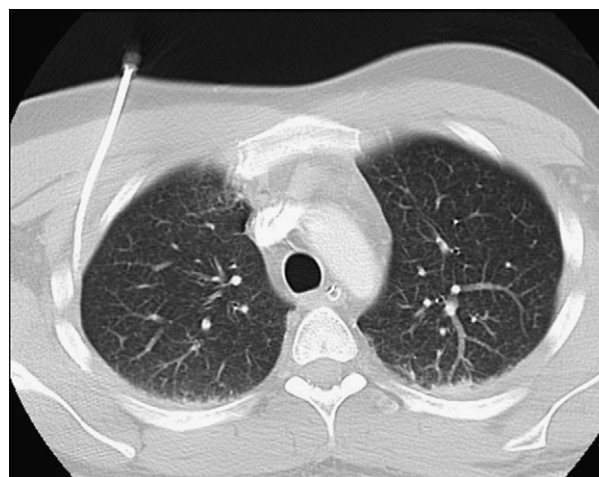

Fig. 3 Extrapleural placement of catheter-over-needle thoracocentesis. The catheter length is adequate but is extrapleural. There is no pneumothorax.

Increasing needle length to reduce this possibility does not guarantee effective pleural decompression. Also, CT studies indicating the correct requirements for needle length only result in successful decompression if the needle is inserted in the anatomically correct location. Extra pleural and intra-axillary placement may still occur using needles of greater than 5 cm in length and will cause a false negative result[32] (Figures 3 and 4). Also, intrapulmonary and intracardiac placement is more likely with longer needles (Figure 5).

NT using a lateral approach in the mid axillary line has been suggested as potentially more
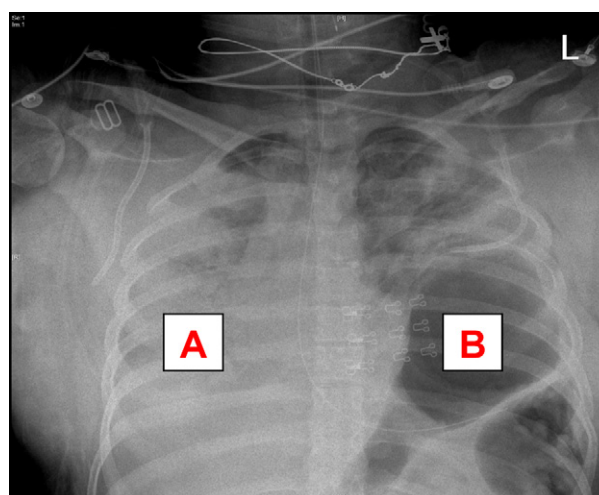

Fig. 4 Incorrectly placed right catheter-over-needle thoracocentesis. The Pneumocath™ on the right (A) is in the mid-clavicular line but is extra-pleural within the right axilla. There is a ruptured left hemi diaphragm with associated mediastinal shift and a left intra-pleural Pneumocath™ (B). The patient is intubated.
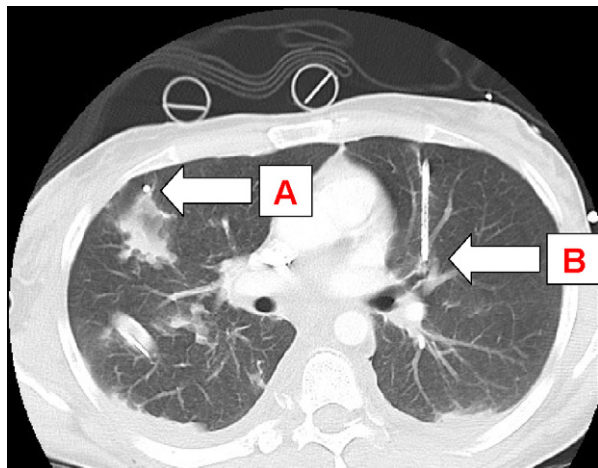
Fig. 5 False positive needle decompression of chest. Bilateral Pneumocath[TM] cannulae post-needle decompression of the chest can be seen on this chest CT. The associated Heimlich valves can be seen taped to the anterior chest wall. A right chest tube is visible. The right Pneumocath[TM] is intrapulmonary with associated haemorrhage (A). The left Pneumocath[TM] is intrapulmonary with the tip in the bronchial tree with an associated ongoing air leak creating a false positive finding (B).

efficacious [54] but there is little evidence to support this approach. Lateral chest wall thickness when measured on CT scanning has been reported as greater that that anteriorly, with an increased likelihood of NT failure.[38] Furthermore, all of the complications of needle decompression outlined in Figure 2 still apply.

C. Correct positioning with decompression of tension pneumothorax:

Decompression of a true tension pneumothorax may still be difficult to identify, as the tension pneumothorax is initially a clinical diagnosis with associated inaccuracies. Attempting to determine the physiological significance of a possible tension pneumothorax in the haemodynamically unstable patient with multiple injuries is also problematic. NT attempts may create a pneumothorax or haemothorax by mechanisms D and E illustrated in Figure 2, confounding subsequent attempts to determine the primary pathology. In a prospective case series from California, 108 (1.7%) of 6241 major trauma patients underwent prehospital NT. Only 5% of these patients demonstrated an objective improvement in their clinical signs.[19]

D. False positive with needle intrapulmonary in bulla or bronchial tree:

Decompressing intrapulmonary gas may give the impression of successful pleural decompression with potentially dire consequence (Figure 5).

E. True negative with needle in major vessel or heart:

Cardiac or pulmonary artery injury is a possible complication of needle decompression, particularly in the setting of mediastinal shift associated with tension pneumothorax or massive haemothorax.[10,54]

Locating the ideal anatomical position to perform NT is problematic. Fuld's original diagram (Figure 1) indicates a needle placed at or just lateral to the nipple line in the midclavicular line. Although the second intercostal space in the mid-clavicular line has been promulgated as the recommended location for NT, a more medial placement is seen when prospectively studied.[25] Infrequent users identify the vertical line half-way between the mid-sternum and lateral thoracic wall (rather than the more lateral mid clavicular line) as the preferred site for NT (Figure 6). Also, patients may arrive on cross-sectionally convex spine boards, which displace the shoulders and clavicles anteromedial thus increasing the likelihood of medial misplacement. A NT insertion point medial to the midclavicular line is more likely to be associated with vascular injury and haemorrhage, particularly the internal mammary artery medially, subclavian vessels superiorly and pulmonary trunk and heart inferiorly.[10,54,61]

By definition, NT is performed on haemodynamically unstable patients who are usually ventilated. Needle thoracocentesis is (at best and only when
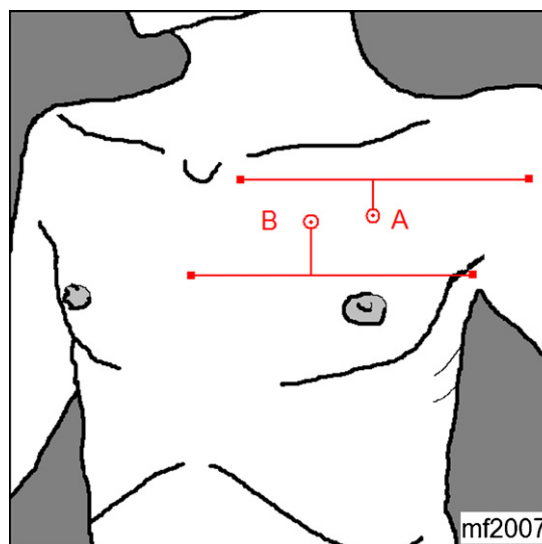

Fig. 6 Incorrect identification of the mid-clavicular line may result in needle decompression that is too medial, with increased risk of vascular and cardiac injury. The recommended insertion point (A) in the second intercostal space in the midclavicular line is more lateral to the point commonly identified, which is half-way between the midline and the lateral chest wall (B).

successful) a temporising procedure which may delay formal pleural decompression and drainage. Incorrect needle placement, by failing to decompress the affected pleural space — or by causing a major vessel or heart injury — will confound an already critical situation and increase the likelihood of death.

Recent reviews have emphasised that NT may be ineffective, yet have indeterminate conclusions regarding whether it is a procedure that should be recommended [15,40,59] reserving it as a technique of 'last resort'.

However, there is no evidence that NT is a reliable means of pleural decompression. The technique should be avoided during hospital trauma reception and resuscitation and used only as a technique of last resort. Blunt dissection and digital decompression should be the technique of first choice.

What is the best technique for pleural decompression of haemodynamically unstable patients during trauma reception?

Decompression of the pleural space is a primary goal during reception of the haemodynamically unstable patient with a haemothorax or pneumothorax. Lateral thoracostomy alone (without tube insertion) is an effective method for rapid chest decompression with a high success rate.[17,32] Insertion of a tube to allow continuing drainage of gas or blood (with or without suction assisting) is a secondary priority.

The recommended technique of pleural decompression follows the ATLS guidelines.[2] The arm on the affected side is abducted and the patient's skin is prepared with povidine iodine or equivalent solution. In conscious patients local anaesthetic should be infiltrated sub-cutaneously and through the intercostal space along the intended track. The fourth or fifth intercostal space is identified and a skin incision is made obliquely in the mid-axillary line. Blunt dissection using a curved clamp through to the pleural space over the superior aspect of the rib is performed, followed by digital identification of the pleural space. Any tension is decompressed once the pleural space is breached. Insertion of a sterile gloved finger through the parietal pleura and into the pleural space identifies the pleural space. This digital technique verifies that the pleural space has been breached and allows the operator to feel for lung, diaphragm and on occasion stomach (e.g. diaphragmatic rupture) and heart (e.g. mediastinal displacement, cardiomegaly, pericardial rupture with cardiac herniation), or the presence of pleural adhesions.

False positives can occur. Decompression of sub-cutaneous gas during blunt dissection may give the impression of pleural decompression, but this will be identified with subsequent digital inspection. The space between the scapula and the adjacent ribs can create confusion in morbidly obese patients.

However, blunt dissection and finger decompression appears to be a reliable and safe procedure and is the recommended procedure prior to chest tube insertion. Once successfully performed it reduces the urgency of the situation and allows time for the subsequent placement of a chest tube.

Tube thoracostomy

Insertion of an intrapleural tube via thoracostomy is a fundamental skill in trauma resuscitation. Lateral placement in the fourth or fifth intercostal space anterior to the mid-axillary line is considered optimal.[2,39] A 28-Fr or 32-Fr catheter without trocar is introduced in a postero-superior direction through the intercostal space and advanced without force into the pleural space. The correctly placed tube should fog. When connected to an underwater seal drain the water level should swing with inspiration/expiration. The underwater seal drainage (UWSD) system should be self-contained, with reservoir, suction regulation chamber and positive pressure pop-off valve. Wall suction (-20 cm H20) may be applied to the UWSD when necessary. The tube should be secured to the skin with a heavy, braided suture.[32] It is important to direct the tube in the desired direction, the track through the sub-cutaneous tissues should already be heading superiorly. Tubes that are placed superiorly have a reduced likelihood of intrafissural placement. A superiorly directed tube can easily flick down to a more inferiorly directed position if the skin suture forces it that way and care should be taking when suturing.

A variety of dressings may be used. One described technique is to apply two transparent, self adhesive, semi-permeable dressings in a bi-folding manner to allow inspection of the wound and to form a sealed mesentery around the base of the tube to prevent dislodgement.[32]

A low complication rate using this technique during the resuscitation of major trauma patients has been reported.[32] There is, nevertheless, a significant morbidity reported in association with tube thoracostomies.[18] Tube malposition is common and has been reported to be as high as 20%.[35] There are numerous reports of incorrect placement [53] and damage to intra-thoracic and intra-abdominal structures (Figure 7).[49]

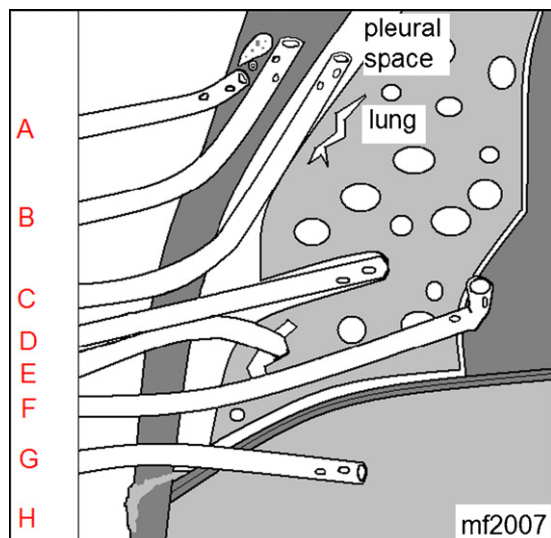Possible positions and complications of tube thoracostomy include:

Fig. 7 Possible positions and complications of tube thoracostomy (TT): (A) Trauma to the intercostal neurovascular bundle. (B) Extrapleural placement. (C) Correct position in pleural space. (D) Intrafissural placement. (E) Intrapulmonary placement. (F) Mediastinal impingement or penetration. (G) Trans-diaphragmatic placement. (H) Infection.

A. Trauma to the intercostal neurovascular bundle:
Although reported occasionally, the risk of this will be minimised by blunt dissection directly over the rib, avoiding the inferior aspect of the rib and the neurovascular bundle. It may be characterised by bright blood in the tube associated with the development of haemothorax and should prompt thoracic surgical review.

B. Extrapleural placement:
The chest tube may be inserted outside of the rib cage, or the tip of the tube may be in the pleural space but one or more side-holes may in an extra-pleural position (Figure 8). In both situations, the drainage of air or fluids from the pleural space is ineffective. With insertion outside the rib cage the pleural space is not drained, although if the side-holes are near the skin surface bubbling may still be seen if any sub-atmospheric pressure is applied through the UWSD. If extrapleural the tube should be replaced and an intrapleural drain inserted.

C. Correct position in pleural space:
When the tube thoracostomy is correctly positioned the post-insertion images should be checked to show that the tube is straight without kinks and directed at the apex of the lung posteriorly. All side holes should be within the pleural space and the quantity of air or fluid should be diminished in comparison to pre-insertion X-ray images. The fluid levels in the drainage
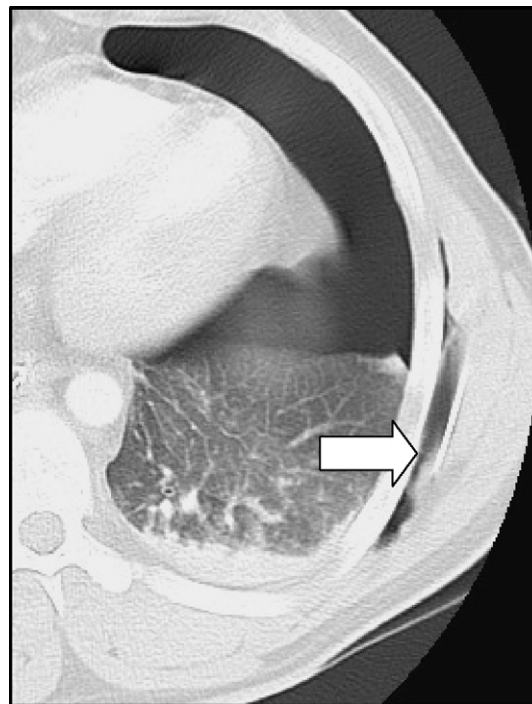

Fig. 8 False positive as chest tube decompresses subcutaneous emphysema. There is a left pneumothorax. The tube thoracostomy has been placed extrapleural in subcutaneous gas, creating a false positive with associated failure to decompress the pleural space.

container should be monitored to confirm continued drainage. Before connection of suction the fluid level in the underwater seal should be seen to move up with inspiration and down with expiration confirming intra-pleural position of the tube.

D. Intrafissural placement:
Placement of the chest tube in the interlobar fissure is a recognised complication of tube thoracostomy. With the arm abducted the surface anatomy of the pulmonary fissure is adjacent to the recommended site of thoracostomy and chest tube insertion. Not surprisingly this has been described as the commonest placement problem using the lateral approach.[35] Operators should be aware of this and aim to digitally guide the tube superiorly and posteriorly rather than medially. If the tube is not swinging or draining it will require replacement.

E. Intrapulmonary placement:
Pulmonary and associated visceral pleural tears are commonly associated with air leaks and pneumothoraces. Chest tubes inserted on the affected side run the risk of intrapulmonary placement though these tears (Figure 9). Intrapulmonary placement is associated with a large, ongoing air leak and may be identified on CT imaging. If intrapulmonary placement has
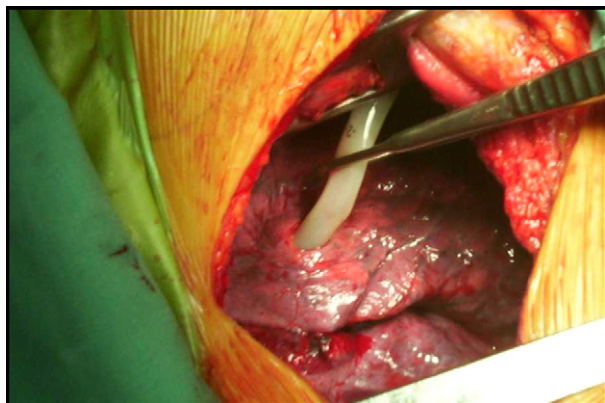
Fig. 9 Intrapulmonary placement of tube thoracostomy. Picture courtesy of Mr Adrian Pick.

Fig. 10 An autopsy photograph of a chest tube which has been inserted through the heart leading to death. The tube was inserted with the use of a trocar. Picture courtesy of Mr Ian Civil.

occurred the tube requires removal and replacement with careful attention to digital palpation of the pleural space.

Digital decompression of the pleural space identifies that no adhesions are present and will cause the lung to fall away. The use of a large chest tube 28Fr or greater will also decrease the likelihood of intrapleural insertion.[27] Blunt dissection and insertion of a finger with 360° rotation is a pre-requisite of all tube thoracostomies. If adhesions are felt the insertion site should be re-located.

F. Mediastinal impingement or penetration:

Medial placement of the chest tube against the heart, coronary arteries and great vessels has been reported. If post-insertion massive blood loss through the tube or imaging appearance suggests intravascular placement the tube should be clamped and left in situ until urgent thoracic surgical control can be achieved.

Inferior vena caval injury,[22] cardiac perforation[16] and pulmonary artery injury[57] have been described. These can be minimised by avoiding use of trocars, lateral rather than medial placement and by digitally guiding the tube in a superior and posterior direction. If resistance to placement is felt the tube should not be forcibly advanced. The use of chest tube trocars is contraindicated during trauma reception because of the likelihood of serious injury due to the accidental and uncontrolled advancement of the trocar[36] (Figure 10).

G. Trans-diaphragmatic or intra-bowel placement:

Haemo-pneumothoraces are associated with rib and pulmonary injury as well as diaphragmatic tears.[64] Trans-diaphragmatic tube placement is more likely if an ipsilateral diaphragmatic tear is present. Digital palpation through the thoracostomy site may allow detection of a diaphragmati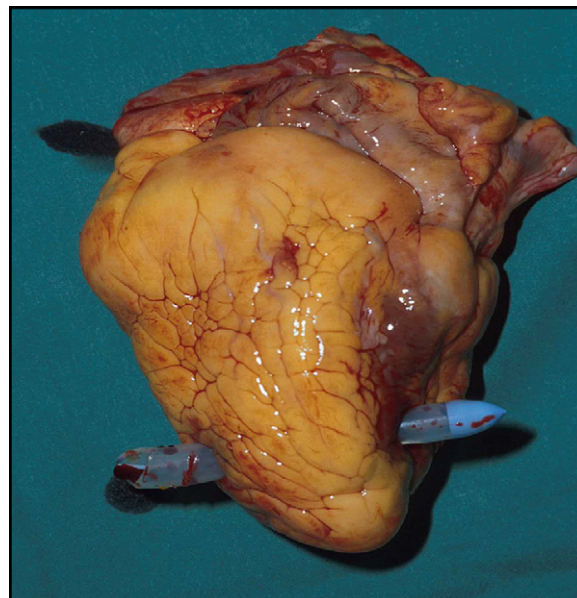c tear, as well as detecting associated intrathoracic bowel and (occasionally) spleen. In 2001 digital examination through left sided thoraco-abdominal stab wounds had a sensitivity of 96% and positive predictive value of 91% for lesions of the left hemi diaphragm, which was considered better than the helical CT scanning available at that time.[52] Newer, multi-detector CT scanners with higher definition sagittal and coronal reformations are expected to improve diagnostic sensitivity of diaphragmatic injury. Correct interspace selection, digital exploration prior to tube insertion and careful postero-superior tube placement should reduce the incidence of transdiaphragmatic placement or bowel perforation during tube thoracostomy. If bowel or bile contents appear in the tube any applied suction should be turned off, the tube left in situ and surgical attention sought.

H. Infection:

Emergency Department insertion of thoracostomy tubes has been shown to be safe, effective and associated with a lower complication rate than inpatient ward insertion.[12] There appears to be no difference between complication rates for tubes inserted in ED compared to the operating theatre.

However, conformity with universal precautions and sterile technique is essential during tube thoracostomy. Wide area skin preparation with chlorhexidine in alcohol or povidine iodine and extensive

large sized sterile draping provides an aseptic field.[43] Placement of the instrument tray close to the thoracic incision alongside the operator's dominant hand reduces hand to incision site distance and contamination opportunity. Sharing of instrument trays with other invasive procedure operators increases the likelihood of contamination and 'sharps' injuries and should be avoided.[56] Particular care must be taken to control patient pain and avoid patient interference with and contamination of the procedural field. The operator should be aware that a frequent source of contamination occurs when the non-sterile drainage system is connected to the chest tube before skin suturing is completed.[44]

Unlike central line placement during trauma patient reception and resuscitation, tube thoracostomies are usually not replaced in the post-resuscitative period. The tube thoracostomy is only removed when air or fluid drainage decreases to acceptable levels over the days after placement. The duration of tube placement makes empyema avoidance critical. In some trauma centres there is a reported incidence of empyema of 14% of all tube thoracostomies[11,18,23,48] Contamination during insertion appears to be a major cause. In one study using video-audit of 50 tube thoracostomies during trauma patient reception and resuscitation, all 50 tube thoracostomies demonstrated contamination before, during or after insertion.[44]

Simple techniques as outlined above can avoid the morbidity associated with empyema. Training with use of real patient care video-clips showing non-optimal and ideal tube thoracostomy in emergency circumstances may be used to reduce empyema.[1]

Many studies have examined the role of prophylactic antibiotics at the time of chest tube insertion and in the following 24 h. There is conflicting evidence to support this practice with some studies showing no benefit[46] and others demonstrating a small difference in infection rates in patients receiving prophylactic first generation cephalosporins.[8,31,42]

Where is tube thoracostomy best positioned? What is the most appropriate way to check correct tube positioning?

Malpositioning may result in inadequate drainage of air and fluid with an associated increase in morbidity. The most immediate way to check whether the chest tube is satisfactorily positioned and functioning is to check the movement of the underwater seal (or equivalent) during respiration and review the post-insertion chest X-ray. Using a supine chest X-ray alone to determine satisfactory chest tube

position is unreliable. An effectively functioning drain should not be immediately repositioned solely because of its radiographic position.[36]

CT scans are more sensitive and specific than plain radiography for detection of pneumothorax, pulmonary laceration and chest tube position, and are the current 'gold standard'.[29,41] Although the indications for thoracic CT scanning for trauma continue to evolve, blunt thoracic trauma patients should undergo definitive CT imaging after TT (particularly in the setting of mechanical ventilation) whenever possible.[58]

When is pleural decompression most appropriately performed during trauma reception?

Due to the complications described above it is valid to question the indications for pleural decompression during trauma patient reception and resuscitation. Pleural decompression is beneficial for patients with haemodynamic or respiratory compromise with coinciding pneumothorax or haemothorax and for mechanically ventilated patients with pneumothorax.[3] The latter includes patients with planned surgical procedures who will undergo positive pressure ventilation in the Operating Room.

There is also evidence of benefit from decompression of occult pneumothorax (e.g. detected by CT scan but difficult to visualise on X-ray) in patients who are ventilated, due to the likelihood that positive pressure ventilation of such patients will cause tension pneumothorax.[21] However, occult pneumothorax in spontaneously breathing, stable patients can be treated expectantly with serial examination and X-ray[13,50] even if moderately sized.[61]

A small number of patients will die because of untreated tension pneumothorax, particularly in the setting of positive pressure ventilation. In a comprehensive review Leigh-Smith and Harris noted that the dominant physiological feature during decompensation from tension pneumothorax in the non-ventilated population was progressive respiratory failure with death from respiratory — not cardiovascular — arrest.[40] This was in contrast to a more rapid deterioration and early reduction in cardiac output expected and observed in ventilated patients.[5]

Tension pneumothorax may develop rapidly on initiation of positive pressure ventilation during reception and resuscitation. Loss of cardiac output/trauma arrest during the primary survey of a ventilated adult trauma patient is an indication for immediate pleural decompression. Tracheal deviation is not a reliable sign[34] and the absence of breath

sounds may be misleading. Therefore, bilateral decompression of the pleural spaces is indicated when the cause of loss of cardiac output or cardiac arrest is unclear.

The trauma team should completely expose the chest, look for asymmetrical chest movements and palpate for sub-cutaneous emphysema. Although auscultation as a discriminator for tension pneumothorax diagnosis has been shown to unreliable in mechanically ventilated patients, diminished breath sounds in either axilla may indicate ipsilateral tension pneumothorax or haemothorax. Listening in the mid axillary line allows breath sounds to be heard over all lobes of the lungs, as this is the point on the surface anatomy at which all three lung lobes

(2 on left) intersect. In the setting of hypotension (SBP $<$ 100 mmHg) or hypoxia (SpO$_2$ $\leq$ 90) the affected hemithorax should undergo pleural decompression. Palpable sub-cutaneous emphysema in either axilla coupled with circulatory compromise should also prompt pleural decompression on the affected side.

The Victorian Major Trauma Services have developed a scalable and exportable, computer-prompted, algorithm system for real-time use with major trauma patients. The development of computer assisted prompts to aid decision making during trauma reception required mapping clinical decision-making into a binary format. Using the best available evidence (which has been outlined in the
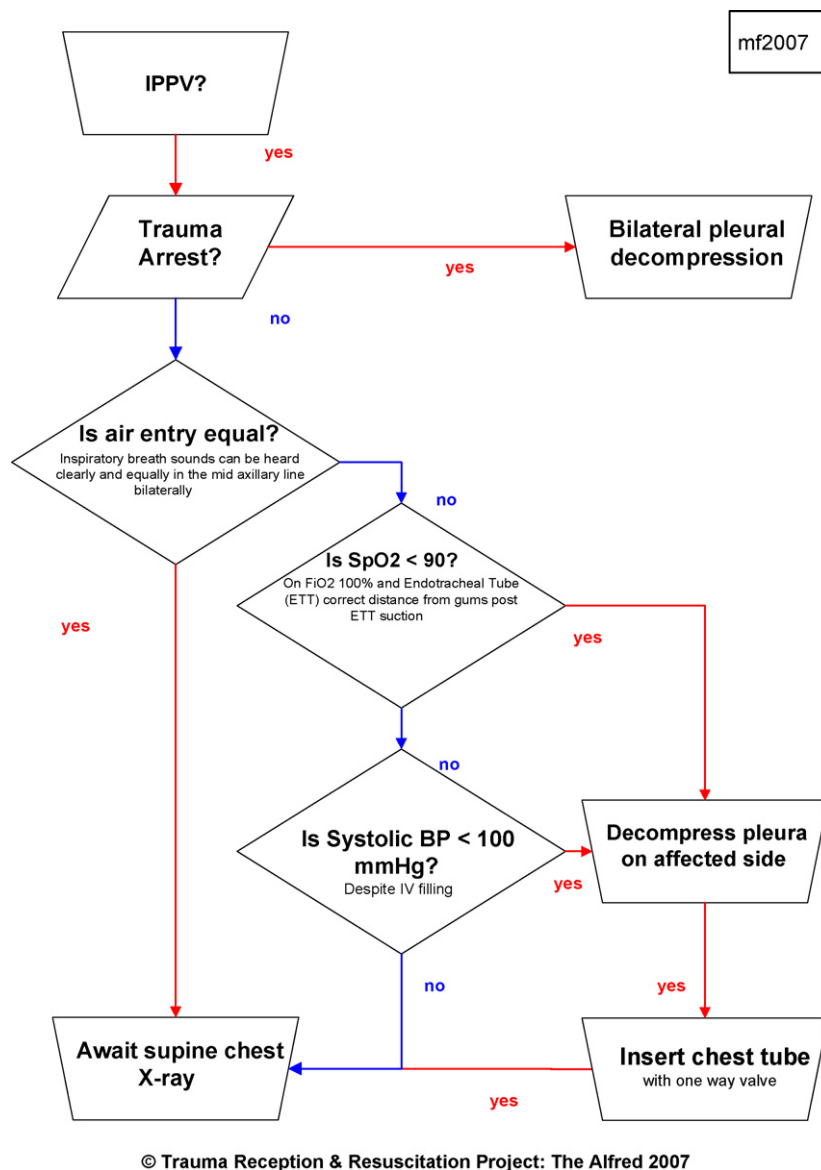

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Fig. 11 initial binary decision tree for pleural decompression. ©Trauma Reception & Resuscitation Project: The Alfred 2007.

previous discussion) a binary decision tree for 'pleural decompression' has been developed and is illustrated in Figure 11.

Pleural decompression is an emergency procedure which is often performed badly. The purpose of this review is to improve performance, by encouraging clinicians to adopt a clear decision path, employ a safe technique, be cognisant of the indications and be aware of pitfalls.

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