# THORACIC TRAUMA GUIDELINE



## 1. Key Messages

The Victorian State Trauma System (VSTS) provides support and retrieval services for critically injured patients requiring definitive care, transfer and management. This thoracic trauma guideline aims to provide evidence-based advice on the initial management and transfer of major trauma patients who present to Victorian health services with thoracic injuries.

This guideline is developed for all clinical staff involved in the care of trauma patients in Victoria. It is intended for use by frontline clinical staff that provide early care for major trauma patients; those working directly at the Major Trauma Services (MTS) as well as those working outside of a MTS.

These guidelines provide the user with accessible resources to provide initial care for critically injured patients with thoracic trauma in an effective and confident manner. The guideline has been assessed utilising the AGREEII methodology for guideline development and is under the auspice of the Trauma System Advisory Committee (TSAC). (1)

### Clinical Emphasis Points:

- Thoracic trauma is a common injury in the multi-trauma patient and a significant cause of mortality and morbidity.
- Thoracic trauma can result in immediately life-threatening injury; such injuries need to be identified, assessed and managed promptly to ensure a positive outcome for the patient.
- Two common reversible causes in traumatic cardiac arrest are found within the thoracic cavity; tension pneumothorax and pericardial tamponade.

- Patients who present with penetrating or blunt thoracic injuries and are pulseless but with myocardial mechanical activity on ultrasound and/or electrical activity may be candidates for resuscitative thoracotomy in the emergency department.
- Non life-threatening injuries can be subsequently addressed in the secondary survey with more in-depth physical examination and monitoring.
- Adequate analgesia is essential to prevent secondary insults due to hypoventilation and assists with coughing and chest physiotherapy.
- Appropriate ventilatory support settings must be considered especially where poor lung compliance and pulmonary contusions are involved.
- Adult Retrieval Victoria (ARV), can facilitate a three-way conversation for advice on patient management with a specialist from a major trauma service. This should be considered early, particularly for patients with:
    - Flail chest
    - Multiple rib fractures
    - Penetrating injury
    - Significant pulmonary contusion
    - Large pneumothorax, or
    - Any critical or life-threatening thoracic injury (see below).
- The presence of thoracic trauma in the paediatric and elderly populations should raise significant concern and must be managed appropriately.

## 2. Rapid Reference Guideline

This page is being held to contain an updated one-page summary of the guideline, intended for real-time clinical access and use.

Please see associated Quick Reference PDF uploaded on sharepoint to review.

# 3. Introduction

Thoracic trauma is responsible for 25% of all trauma deaths and contributes to a further 25%. In Australasia and the UK, 90-95% of all chest trauma is secondary to blunt injury. (2) Motor vehicle crashes account for 70-80% of blunt chest trauma cases. (3) It is important to be aware of the mechanism of injury in chest trauma as blunt and penetrating injuries have different pathophysiology as well as clinical courses.

The initial assessment and management of patients presenting with chest trauma consists of the primary survey with appropriate interventions as per Advanced Trauma Life Support (ATLS)/Early Management of Severe Trauma (EMST) guidelines. Oxygenation should be optimised early, with consideration of ventilatory support for those patients in respiratory failure. In addition, the treating team must consider tension pneumothorax in all patients with signs of shock. (4)

Pulmonary contusions, pneumothorax and haemothorax occur in 30-50% of patients with severe blunt chest trauma. (2) Flail chest injury represents a particularly severe form of chest trauma, and is considered an immediate life threat. Flail chest injury is associated with contusions and haemopneumothorax, and these patients may also experience a degree of mechanical ventilatory failure. A number of factors contribute to morbidity and mortality in patients presenting with thoracic trauma these include failure or delay to perform pleural decompression, delayed or inadequate ventilatory resuscitation, inadequate management of shock, inadequate imaging and insufficient monitoring of arterial blood gases.

Approximately 10% of patients presenting with blunt thoracic trauma and 15 – 30% of patients with penetrating thoracic trauma require surgical intervention. (5) A higher incidence of mortality is associated with penetrating trauma. (2) The majority of patients who do not require surgical intervention can be managed with supportive care and interventions which may include pleural decompression and drainage. (5)

Resuscitative Thoracotomy (RT) in penetrating trauma may be considered for patients who arrive within 10 minutes of becoming pulseless or with evidence of myocardial mechanical activity on ultrasound and/or electrical activity. (6)Other signs of life are respiratory effort or pupillary reaction. Similarly, patients who have sustained blunt chest trauma and display evidence of cardiac tamponade both clinically and on ultrasound examination, who remain severely hypotensive after chest decompression and volume resuscitation may also be candidates for RT.

Adjuncts to the primary survey include chest x-ray (CXR), extended focused assessment using sonography in trauma (eFAST), arterial blood gasses (ABGs), pulse oximetry and electrocardiogram (ECG) monitoring.

Delayed life-threatening complications are detected in the Secondary Survey where further in-depth examination can take place. Initially, hypoxia may be absent in the patient presentation however this may develop as the injuries evolve. Hypoventilation commonly develops due to pain, fatigue from increased work of breathing as well as side effects of opioid analgesia. Ventilatory support in patients with pulmonary contusions and poor lung compliance require ventilation at lower tidal volumes and low inspiratory pressure to reduce barotrauma and secondary lung injury.

Adequate analgesia is essential and many health services have a chest trauma pain management pathway that is followed to ensure analgesia is appropriately titrated. Any patient who is unable to deep breath and cough without pain should be referred to the hospital acute pain service for consideration for patient-controlled analgesia (PCA). Regional analgesia such as serratus anterior plane block (SAPB) or erector spinae block (ESB) should be considered as adjuncts.

Significant chest injury is rare in paediatric trauma, this is primarily due to the compliance of the chest wall which allows for greater deformation of the chest wall before the ribs fracture The mortality in paediatric patients with thoracic trauma is thought to be as high as 30%; death in paediatrics usually occurs soon after the injury whereas an adult with similar injuries tends to survive longer. (7)

The number of total rib fractures, bilateral rib fractures, and rib fractures in more than two areas are associated with increased complications. (8) Rib fractures are some of the most common injuries in the elderly and those >65 years are twice as likely to develop pneumonia. (9, 10). Patients with co-morbidities including prior poor chest wall compliance as well as the elderly are particularly at risk of hypoventilation in the setting of chest trauma and may deteriorate rapidly.

All patients with thoracic trauma must receive a rapid and systematic primary and secondary survey with appropriate interventions as required. The main goals are to detect and recognise potentially life-threatening injuries, stabilise the patient and manage all findings in a timely and appropriate manner. Patients with significant chest injury, including 3 or more rib fractures, flail chest injury or a need for ventilatory support should be transferred to an MTS.

Patients > 65 years of age, with any significant co-morbidities presenting with non-life threatening chest trauma should be treated with high suspicion and consultation with a MTS or Adult Retrieval Victoria (ARV) should be considered early, as often this cohort of patients can be appropriately managed in regional trauma center, which will avoid unnecessary transfers to a major trauma service for definitive care. If in doubt contact and discuss with receiving trauma team/consultant at the MTS or ARV.

# 4. Immediate life-threatening injuries

## Pathophysiology and early management

Immediately life-threatening injuries from thoracic trauma that require immediate interventions are noted below. Interventions to treat these conditions should be familiar to anyone involved in trauma management. These injuries should be identified and treatment initiated during the primary survey. In smaller facilities ARV can assist with identifying injuries and treatment options.

### Tension pneumothorax

Tension pneumothorax occurs when injury to pleural parenchyma creates a one-way valve defect allowing air to enter the pleural space but not leave, resulting in increasing pressure within the pleural cavity. This rise in intra-thoracic pressure impedes ventilation, while the collapsed lung impairs gas exchange, both resulting in tachypnoea and hypoxia. Raised intra-thoracic pressure impedes venous return both from the IVC and SVC, as well as increasing afterload on the heart, resulting in obstructive shock.

The common symptoms and signs of tension pneumothorax include:

- Respiratory distress.
- Agitation with tachypnoea.
- Hypoxia.
- Tachycardia.
- Hypotension.
- Decreased or absent breath sounds on the affected side.
- Hyper-expansion.
- Decreased movement of the affected hemithorax.
- Subcutaneous emphysema.

Distended neck veins may be noted if the patient is not hypovolemic, however examination is usually limited by the cervical collar. Tracheal deviation is a late sign. A patient may be experiencing significant inflow obstruction to the right heart, compounded by hypovolemia before there is noticeable tracheal deviation. Tension pneumothorax may result from blunt or penetrating chest trauma.

**Management:** If tension pneumothorax is suspected, or cannot be excluded in the hypotensive multi-trauma patient who is not responding to volume resuscitation, then chest decompression must be performed without delay.

***Chest decompression in the pre-hospital setting***

Needle Decompression - Needle decompression can be performed at the 2nd intercostal space (ICS) on the mid-clavicular line (MCL) or the 5th intercostal space at the either the mid or anterior axillary line (with the arm in the abducted position). (3) The 5th ICS at the mid or anterior axillary line may not be easily accessible and in such circumstances the 2nd ICS-MCL is used. There are high rates of needles failing to penetrate the pleural cavity at the 2nd ICS-MCL; although this is based on the use of shorter catheters. (11-14) Clinicians should use

their own clinical judgement in choosing the site for needle decompression; considerations should include chest wall thickness, needle catheter size and identification of landmarks on patients anatomy. (11)

Proprietary devices such as the pneumocath or the air release system (ARS) device can be used. If these are unavailable a large bore IV Cannula (14 or 16G) with a 10ml syringe attached can be used, although the length of the needle vs chest wall thickness should be considered. Needle decompression will allow time to transport the patient to a medical facility for definitive decompression and intercostal catheter insertion. Potential pitfalls of needle decompression include kinking of the tube, injury to underlying structure or mispositioning. (11)

Finger Thoracostomy - Unlike needle decompression, finger thoracostomy allows for maximum and reliable release of air and liquid from the pleural cavity. Finger thoracostomy is an invasive procedure, therefore it is a paramount that this is performed under aseptic conditions to avoid secondary infection such as empyema. (15)

*Practical tips for identifying a safe insertion point and performing the procedure:*

1. Identify the mid-humeral point of the adducted arm and mark the underlying skin in the mid-axillary line (this point corresponds to the 4th intercostal space when the arm is abducted)
2. The patient's arm is fully abducted and the skin is prepared with aseptic skin prep.
3. Patient hand breadth from the axilla / hair line
4. If a patient is conscious infiltration of local anaesthetic is required. Additional IV analgesia should be considered.
5. An incision is made through skin, dermis and fascia at the fourth or fifth intercostal space, just anterior to the mid axillary line.
6. The intercostal space is then traversed using a curved forceps via blunt dissection and decompression through the pleura, completed with a sweep with a sterile gloved finger. (16)
7. After successfully completing the procedure, the site should be covered temporarily with a stoma bag/valve bag, commercial chest seal or if this is unavailable a three-way dressing.

**In the case that the patient deteriorates, consideration should be made to re-sweeping the site. (17) .**

***Chest decompression in the emergency department***

If the patient is conscious, and equipment for finger thoracostomy is not immediately at hand, then a needle decompression should be performed at the 5th intercostal space, mid axillary line. (3) This will relieve the intra-thoracic pressure to allow time for formal decompression and insertion of an intercostal catheter (ICC), which should be performed after the needle decompression.

For patients who are either unconscious, or who are in extremis and equipment and clinician is ready, then finger thoracostomy is the treatment of choice for tension pneumothorax. As

previously discussed this procedure is invasive, therefore aseptic technique is paramount. This includes full surgical scrub as well as face masks, gowns and sterile gloves and the area is draped on all four sides, when performed in the emergency department. The technique is the same as described as above.

The sterile insertion of an intercostal catheter connected to an underwater seal drain and administration of IV antibiotics should then follow finger thoracostomy, if there are no other immediate life threats to be addressed.

## Massive Haemothorax

Haemothorax has been consistently defined as an accumulation of blood and fluid in the pleural space that prevents adequate ventilation and compresses the lung; (18) especially when there is >1500mls or 1/3 of the patients' blood volume in the chest cavity. A haemothorax can be caused by a haemorrhage that has originated from the intercostal vasculature, the chest wall, great vessels, mediastinum or internal mammary arteries. (18) Massive haemothorax most commonly occurs after penetrating trauma but can also present after blunt chest trauma. These large accumulations of blood lead to respiratory failure, hypotension and shock.

**Management:** Diagnosis of a haemothorax is usually made via CXR and eFAST in the first instance. Ultrasound has consistently demonstrated to be more sensitive in detecting haemothorax in comparison to a CXR. (19-21) Initial management involves the restoration of circulating blood volume. Damage control resuscitation techniques should be employed until there is definitive control of bleeding. (22) This involves minimal (if any) use of crystalloid, early use of blood products and the rate of infusion being titrated to an adequate (though not normal) systolic blood pressure. Once adequate resuscitation has been performed, the insertion of an intercostal catheter should be performed. This will allow for accurate measurement of blood loss, as well as some tamponade effect on intercostal and parenchymal bleeding when allowing the lung to re-expand against the chest wall. Where >1,500ml is drained, thoracotomy is likely required. Activate the massive transfusion protocol as the patient is likely to require large amounts of blood to restore perfusion. These patients can be extremely challenging, input from trauma and /or cardiothoracic teams would be of benefit to the patient.

### *Chest Tube Insertion*

Re-expanding the lung may tamponade any bleeding vessels, as well as draining a pneumothorax. Insertion site is as described for finger thoracotomy. Once the chest is decompressed via finger thoracotomy under aseptic technique, an ICC is inserted, and is directed posterior and apical. Tube size is important and should be a large bore (28-32Fr) in order to facilitate rapid drainage, prevent air leaks and to allow large blood clots to be removed. Once advanced, ensure fogging and swinging of the tube with expiration and suture in place. Bubbling is a sign of air draining from the pleural space and is normal in the early stages. Persistent bubbling may represent a broncho-pleural fistula. Placement should be confirmed with CXR or CT.

## Cardiac Tamponade

Cardiac tamponade occurs when blood, fluid or air enters the pericardium, restricting cardiac activity and interfering with filling. It primarily results from penetrating trauma however is also possible in cases of severe blunt chest trauma that results in right heart injury. The symptoms and signs evolve and may develop within minutes, or less commonly over the better part of an hour. The classic presentation of Becks Triad (hypotension, raised JVP, muffled heart sounds) may be difficult to identify in the resuscitation bay, particularly where noise makes muffled heart sounds difficult to hear. JVP is particularly difficult to identify in the setting of hypovolaemia, or the presence of a cervical collar in place for spinal immobilisation. A plethoric face and neck that results from inflow obstruction may be noted, although this might be hard for a clinician to note in the first instance; this sign is a distinctive sign in cardiac tamponade and tends to be more pronounced than when it is noted in patients presenting with a tension pneumothorax.

**Management:** The definitive management of pericardial tamponade involves decompression of the pericardial sac and repair of the myocardial defect. The technique used is dependent on the patient's physiology and resources available. Permissive hypotension and minimal volume resuscitation should be employed until decompression is achieved.

***Pericardiocentesis***

Pericardiocentesis involves the insertion of a needle into the pericardium to remove blood / fluid to improve cardiac function and allow adequate ventricular filling. (23) Under ultrasound guidance, a long 18-22g needle attached to a syringe, is inserted into the subxiphoid space and directed towards the left shoulder at a 40-degree angle, with continual aspiration as the needle approaches the right ventricle. Once pericardial fluid is aspirated, the cannula is advanced into the pericardial space and a three-way tap is attached. Note the improvement in output. The patient will require definitive surgery for evaluation and management of the underlying injury.

***Resuscitative Thoracotomy:*** The main aim of resuscitative thoracotomy is to treat pericardial tamponade by decompression of the pericardial sac. While internal cardiac massage can be also performed, this is not a primary indication for performing resuscitative thoracotomy.

If the patient is in refractory shock, and a trained operator e.g. Surgeon or Emergency/Retrieval Physician is available, the patient should undergo a resuscitative thoracotomy. Preferably this should be in performed in theatre (operative thoracotomy) where equipment and theatre-trained staff are available. Although if the patient is in refractory shock (SBP <70), the patient may be deemed too unstable to transfer to the operating theatre. If the patient has lost output, the procedure will need to be performed immediately in the emergency department. Resuscitative thoracotomy should only be performed by appropriately trained and credentialed operators in settings where there is

access to necessary systems and equipment to manage or stabilise myocardial injury or pericardial tamponade.

If there are no surgical services available, nor anyone trained in the procedure of resuscitative thoracotomy and cardiac repair, then the patient should be transferred as a matter of urgency. If the patient is in severe shock (or has lost output), with tamponade confirmed on ultrasound, and all other causes have been eliminated or treated, then a pericardiocentesis can be performed.

## Open pneumothorax

Air will follow the path of least resistance, therefore if an opening in the chest wall is approximately 2/3rd of the diameter of the trachea or greater, air will pass through the chest wall defect with each respiratory effort, rather than down the trachea. Hypoxia and hypercarbia will ensue as ventilation is impaired. (3)

### Management:

***3-sided occlusive dressing***

Promptly closing the opening in the chest with a sterile dressing, occluded on 3 (of four) sides. This will allow air to escape during expiration but not enter during inspiration. The sterile occlusive dressing should be large enough to overlap the wounds edges and then taped securely on 3 sides to provide a flutter type valve effect. As the patient breathes in the dressing prevents air from entering but in expiration allows air to escape. There are some commercial dressings such as Asherman's chest seals which can be utilised.

This should then be followed by the insertion of a chest tube at a site away from the wound. Once the intercostal catheter is in place, then the dressing can be converted to a 4-sided, occlusive dressing. These sorts of wounds will likely require definitive surgical closure.

## Flail Chest & Pulmonary Contusions

Flail chest injury is defined by fractures of 2 or more ribs in continuity, in 2 or more places. This injury results in a segment of the chest wall that is no longer in continuity with the rest of the thoracic cage, causing disruption of its integrity. It may result in paradoxical chest movement where the flail segment moves inwards on inspiration and outwards on expiration. (This is known as a clinical flail, as opposed to a radiological flail which is identified on imaging).

The work of breathing is increased significantly in patients with clinically evident flail chest injury, and they may quickly develop respiratory failure. Flail chest injury is usually the result of a significant energy force applied to the thoracic cage. Flail injury is therefore usually associated with injury to the underlying lung as well as pain leading to hypoxemia, hypercarbia and decreased lung compliance. Patients with flail chest injury and pulmonary

contusions are at particular risk for further complications such as atelectasis, respiratory failure and pneumonia.

**Management**: Flail chest injury represents a severe form of chest trauma and is considered an immediate life-threat. Adequate oxygenation and analgesia, as well as judicious fluid administration is the cornerstone of management. For some patients, simple measures to support respiratory effort and oxygen saturation may be enough. Regional analgesia may assist pain control and help improve oxygenation. ABG's should be performed regularly to monitor ventilation and response to treatment. Non-invasive ventilation (NIV) may assist patients requiring inspiratory support. All patients with flail chest are at risk of respiratory failure and worsening pneumothorax, those on NIV are at even higher risk. All patients who develop respiratory failure should receive intubation and mechanical ventilation early.

**Major tracheobronchial injuries – larynx/ trachea**

Injuries to the larynx, trachea and major bronchi are not common, however they do represent an immediate threat to life. Assessment of airways during the primary survey has a particular focus on airway integrity, and symptoms and signs of upper airway trauma.

Securing the airway is of priority and requires careful intubation. This additionally assists with managing the subsequent complications of Positive Pressure ventilation.

Injury to the intrathoracic trachea and bronchi is usually detected on assessment of breathing- through identification of pneumothorax, tension pneumothorax and subcutaneous emphysema, and the identification of a significant air-leak upon insertion of an intercostal catheter.

For the majority of patients who survive their initial insult, intubation and pleural decompression will be effective temporising measures. These patients often have a large or tensioning pneumothorax with a significant air-leak. They may require two intercostal catheters to allow the affected lung to fully inflate. Trauma that results in major tracheobronchial injury usually results in associated chest injuries, such as multiple fractured ribs including flail, pulmonary contusions and haemothorax / pneumothorax.

***Potentially Life-Threatening Injuries:***

A number of injuries considered potentially or soon to be life threatening, may be detected during the investigations performed as adjuncts to the primary survey, and during the secondary survey. These injuries are:

- Simple pneumothorax
- Diaphragm injury
- Blunt aortic injury
- Oesophageal injury

Simple pneumothorax: Simple pneumothorax results from air collecting between the visceral and parietal pleura as a result of blunt or penetrating trauma. Injury to the pleura disrupts surface tension between the visceral and parietal pleura resulting in lung collapse and altered ventilation/perfusion. (3) A simple pneumothorax or haemothorax can be

managed conservatively with close monitoring, in a situation where the clinician is unsure about continued management ARV can be contacted for advice 24/7.

Diaphragm injury: The diaphragm is a muscle that plays a crucial role in ventilation. Injury can result from penetrating mechanism or in blunt trauma with high intra-abdominal pressures. This injury can result in pulmonary compromise, maldistribution of peritoneal contents into the thorax and may be associated with other significant injuries. Left sided diaphragmatic ruptures are seen more commonly that the right possibly due to protection by the liver. These injuries can be difficult to diagnose initially as chest x-rays can be misinterpreted. (3)

Blunt aortic injury: The thoracic aorta and its branches carry large volumes of blood and can therefore result in rapid exsanguination and death. The relatively fixed nature of these vessels within the thorax make them susceptible to tearing during sudden deceleration forces in trauma. Patients having a mechanism of injury consistent with aortic injury who do not respond to resuscitative measures require rapid diagnosis and preparation for surgical intervention if available.

Oesophageal injury: Oesophageal injuries are more commonly associated with penetrating trauma and may have concomitant injuries to adjacent structures. Evidence of oesophageal injury may be subtle, with an associated delay to diagnosis. These injuries need to be managed by specialist surgical intervention.

*Elderly patients:*

Patients over the age of 65 years are increasingly victims of major trauma. With the projected increase in this population over the coming decades, along with their improved mobility, it is anticipated that numbers will increase further.

Chest trauma represents a significant injury for the older patient due to the physiological changes, pre-existing health conditions, and lower lung capacity. These factors make them more susceptible to increased morbidity and mortality as a result of thoracic trauma. As this cohort reports pain and injury differently to others patient groups, injuries can be overlooked on the initial presentation. Therefore intensive monitoring, robust secondary and tertiary assessments, titrated oxygen therapy, adequate analgesia and early mobilisation should be considered in this patient group.

## 5. Early activation

The presence of significant thoracic trauma needs to be assumed in any patient with a high-energy blunt trauma or penetrating trauma to the torso.

Health services should receive pre-arrival notification for all major trauma patients, including those with thoracic trauma. This information is crucial to supporting how a severely injured patient is managed and can allow for communication to vital members of the response team

as well as time to prepare for the patient's arrival. Notification to the on-call surgeon is recommended for all hypotensive patients, who are either not responding to volume resuscitation, or who have sustained a penetrating chest injury.

The following sequence of actions should take place upon initial notification:

Once notification has been received it is important to:

1. Gather vital information from the notifier using the MIST mnemonic. (24, 25):

| | |
|---|---|
| **M** | Mechanism of injury |
| **I** | Injuries found or suspected |
| **S** | Signs: respiratory rate, pulse, blood pressure, SpO2, GCS or AVPU |
| **T** | Treatment given |

2. Personal protective equipment is vital in the care of trauma patients. Standard precautions with contact and droplet transmission based precautions are standard.
3. Activate the trauma team and available support departments (medical imaging, pathology, blood bank). In small health service settings the available staff will be very limited. Additional staff may be gathered from wards or on call. It may be necessary to utilise the skills of all available resources including emergency response personnel in the initial trauma management.
4. Set up the trauma bay to receive the patient, including equipment checks, documentation, medications and resuscitation equipment. Ensure you have chest trauma equipment immediately available. If sufficient staff are available, a clinician should be prepped and gowned, with equipment open and ready to proceed to rapid chest decompression (finger thoracostomy) if required. Theatres (if available) or retrieval services need to be activated early in the event of a need for surgical intervention.
5. If the patient is hypotensive the massive transfusion protocol should be activated. Hypotension should be considered due to blood loss or tension pneumothorax until proven otherwise. Large-volume blood loss is best managed with blood component resuscitation, and early definitive control of bleeding.
6. Designate roles and specific tasks to staff and maintain an approach based on teamwork. Ensure good communication between all parties involved in managing the trauma. Use closed-loop communication, which ensures accuracy in information shared between response staff. Repeat instructions, make eye contact and provide feedback. Misinterpreted information may lead to adverse events.

If there is no prior notification of the patient, then rapid activation of the trauma team must take place and any required additional resources notified. If it is anticipated that transfer to an MTS will be required, early retrieval activation is essential (phone ARV on 1300 368 661).

Early retrieval activation ensures access to critical care advice and a more effective retrieval response. Early activation and timely critical care transfer improves clinical outcomes for the patient. Even if you are unsure, call the ARV coordinator, who can provide expert guidance and advice over the phone or via tele - or video conference, and establish a connection to an MTS for early notification and ongoing advice.

## 6. Primary Survey

Life threatening chest injuries need to be identified and managed early during the primary survey of major trauma patients. It is vital to actively search for these conditions, as they may not be apparent on initial presentation. Life threatening injuries may evolve over time, therefore it is important to emphasize the need for constant reassessment.

Use a systematic approach based on the ABCDE survey to assess and treat an acutely injured patient. The goal is to manage any life-threatening conditions and identify any emergent concerns.

Clothing should be removed as soon as is possible to gain a thorough view of the patient.

### Airway with cervical spine protection

Assess for airway stability and rapidly assess for major injuries affecting airway patency.

Consider securing the airway with early intubation if there are any signs of:

- Pending airway obstruction: stridor, hoarse voice.
- Decreased level of consciousness.
- Unprotected airway.
- Uncooperative/combative patient leading to distress and risk of further injury.

If the patient is already intubated, document the size and position of the endotracheal tube, including lip level, $ETCO_2$ trace, cuff pressure, grade of view and any intubation difficulty (or Mallampati grade).

Maintain full spinal precautions if indicated - suspect spinal injuries in all poly-trauma patients. Ensure a cervical collar (where appropriate) and in-line stabilisation is maintained until appropriate clinical and/or radiological clearance.

For further detail please refer to the *Primary Survey* section of the Early Trauma Care guideline.

### Breathing and Ventilation

*Identify life threats:*

- Tension pneumothorax
- Massive haemothorax
- Open pneumothorax

- Flail chest & Pulmonary contusions
- Tracheobronchial injury

*Assess the chest - expose:*

- Note respiratory rate / effort / $SpO_2$.
- Look for open wounds / penetrating wounds / tracheal deviation
- Observe any bruising / deformity / abnormal chest movements, eg: Intercostal & / or supraclavicular in-drawing.
- Palpate: Tenderness, crepitus, surgical emphysema.
- Auscultate chest for bilateral air entry, additional noises.

Rapid, shallow ventilation occurs in chest injury as well as developing hypoxia. All patients with chest injuries have a high oxygen demand and therefore supplemental oxygen should be supplied until injury is excluded or effectively managed. Make sure to check the back also as life threatening injuries may be otherwise undetected. Immediately after detection of any life-threatening injuries, interventions need to occur to prevent further deterioration.

*Detecting life threatening injuries:*

- Tachypnoea, decreased or absent air entry to affected side, decreased chest movement, tracheal deviation (late sign) = Tension pneumothorax –> Finger thoracostomy followed by insertion of intercostal catheter.
- Decreased or absent air entry or via eFAST or CXR = Massive Haemothorax ->Chest Tube Insertion
- Open 'sucking wound', decreased air entry = Open pneumothorax - > 3 sided occlusive dressing, intercostal catheter insertion.
- Paradoxical chest movement = Flail Chest & Pulmonary Contusions - >Adequate analgesia / regional block / oxygenation / consider early intubation and ventilation.

A chest x-ray should be performed in the resuscitation bay at the earliest opportunity (and performed with a pelvic x-ray as adjuncts to the primary survey).

## Circulation with haemorrhage control

*Assess circulation and perfusion*

- Pulse – Quality/ rate/ regularity
- Skin – colour / cap refill time / temperature
- BP
- JVP – raised/ flattened.
- Perform eFAST scan looking specifically for evidence of pericardial tamponade or pneumothorax.

*Management:*

- Control bleeding if compressible source
- Obtain IV access – x 2 large bore, take bloods.
- IO access if unable to gain peripheral access.

- Fluid replacement: early administration of blood products. If blood products are unavailable administer Normal Saline 0.9% to maintain permissive hypotension Systolic BP >70 to avoid haemodilution. Consult with ARV for further advice in the poorly perfused/bleeding major trauma patient.
- Continuous clinical monitoring eg: ECG, SpO2, NIBP (consider EtCO2, invasive pressure monitoring, temperature monitoring)

*eFAST:* In experienced hands eFAST has a high sensitivity and specificity. (26) In the hypotensive patient, eFAST should be performed as part of the primary survey. In penetrating trauma to the torso an eFAST should be performed in all cases. In patients who are haemodynamically stable the eFAST may be delayed until the secondary survey if resources do not permit.

## Disability

Assess level of consciousness, as a measure of end-organ oxygenation and perfusion.

- GCS, Pupils, BSL.

## Exposure and environment

By the end of the primary survey the patient should have been fully exposed to ensure no injuries posing an immediate life threat are overlooked. All patients should be exposed appropriately and sequentially, exposing one body region at a time whilst attempting to preserve patient dignity. Prior to exposing a patient, the patient should be informed and consent should be gained.

Trauma patients are prone to hypothermia, so upon completion of the primary survey deliberate measures to prevent this should be taken. Application of external warming devices such as Bair Huggers / warmed blankets are encouraged if the patient is even mildly hypothermic. Hypothermia in the trauma patient is associated with poorer outcomes and linked to deterioration of clotting abilities with increased blood loss. (27)

## Investigations:

- Baseline chest and pelvis x-rays.
- FBC, U&E's, troponin, blood gas, coagulation studies and consider cross match/group and hold.
- 12-lead ECG.

## Analgesia

- Titrated IV narcotic analgesia is the initial approach to pain management in trauma.
- Ongoing pain from chest trauma decreases coughing, leads to shallow hyperventilation, reduced FRC and retention of sputum. This is of particular concern for the elderly trauma patient who is more prone to developing pneumonia.
- Effective pain management may be achieved with the use of paracetamol, non-steroidal anti-inflammatory medicines, opioid analgesia, ketamine, as well as consideration of regional anaesthesia.

- A chest wall block (e.g.: SAPB or ESB) should also be considered in this cohort of patients.

## 7. Secondary survey

The secondary survey is performed as soon as time permits and once the patient has been resuscitated and primary survey issues stabilised. It involves a more thorough head-to-toe examination, and the aim is to detect any injuries that were not detected or managed during the initial assessment and resuscitation. If during the examination or at any time a deterioration is detected, go back and reassess the primary survey using the ABCDE systematic approach. Consider further diagnostic imaging if available and indicated.

### History

Taking an adequate history from the patient, bystanders or emergency personnel related to the events surrounding the injury can assist with understanding the likely extent of the injury and any potential for other injuries.
Use the AMPLE acronym to assist with gathering pertinent information:

**A** **A**llergies
**M** **M**edication
**P** **P**ast medical history including tetanus status
**L** **L**ast meal
**E** **E**vents leading to injury

### Head-to-toe examination

As with all trauma patients a head-to-toe examination is imperative to ensure all injuries are identified and subsequently managed. During this examination, any injuries detected should be accurately documented and any required management should commence concurrently. Management priorities should be ordered, and tasks should be appropriately delegated to ensure efficient and effective care.

For further detail please refer to the *Secondary Survey* of the Early Trauma Care guideline.

## 8. Planning and communication

Clinical staff should initiate contact with ARV early in the patient care pathway or, more importantly as soon as it is identified that the patient meets the major trauma transfer criteria. This is important as the patient may have sustained injuries beyond the reasonable capability of the non-major trauma designated hospital or urgent care service. ARV can be contacted at any time throughout the patient care episode to provide or coordinate clinical advice and consultation.

ARV coordinators can facilitate a multi-party conversations between the referral health service, specialist resources and ARV consultant to discuss the timely management of the

patient.

The decision of when to transfer an unstable patient should ideally be made by the transferring and receiving clinicians in collaboration with the retrieval service. Clear communication is crucial; the transfer of vital information allows receiving clinicians to mobilise necessary resources while the inadvertent omission of such information can delay definitive care. Information should be conveyed in both verbal and written form (via the patient record) and should include the patient's identifying information, relevant medical history, out of hospital management, evaluation and treatment (including procedures performed and imaging obtained). Where possible, imaging obtained should also be electronically transferred to the receiving MTS to aide in decision making and planning.

There are many different types of structured handover. ISBAR & IMIST-AMBO being two of the most common.

- **I**dentification**:** Introduce / identify clinician/self & their role, intro of the patient – age, sex, name.
- **M**echanism of Injury / presenting complaint: Specific explanation of the patients presenting problem and history of presenting complaint.
- **I**njuries / Interventions: Information relating to injuries. Complete top to toe summary. Include what interventions have been performed to help stabilise the patient – e.g. Size 8 ETT
- **S**igns / Symptoms: Looks at the assessment of the patient, requires details of the patient current vital signs and GCS.
- **T**reatments / Trends: Identifies the treatment that was required – e.g. sedation / paralysis & how the patient's condition has changed. Point of transition of responsibility and accountability for patient care.
- **A**llergies: Include what type of reaction
- **M**edication: Patients usual medication
- **B**ackground History: Patients medical history
- **O**ther information: Relevant social information. (28)

It is important that **additional communication** with the ARV coordinator is initiated when there is:

1. Significant deterioration in: conscious state, blood pressure, heart rate, respiratory status, oxygenation
2. Major clinical developments such as significantly abnormal diagnostic tests and new clinical signs.
3. The need for major interventions prior to the retrieval team arriving (for example, intubation or surgery). This will ensure the retrieval team is prepared, the patient receives the appropriate care in transit, and the patient is referred to the correct destination facility.

# 9. Early management

## Airway management

Patients with pulmonary contusions are at high risk for respiratory distress and pneumonia. Methods should be implemented early to improve oxygenation and ventilation. The goal of treatment should focus on re-expansion of the atelectatic regions through appropriate titration of PEEP.

Ventilation strategies should include:

- Low Tidal Volume: (4-8mL/kg)
- Limited plateau pressure <30mmHg
- FiO2 level as low as possible to obtain SaO2 >90%
- Optimal PEEP, incrementally added

## Fluid resuscitation

Undetected bleeding is one of the most preventable causes of death after injury. (29) Therefore, the detection of bleeding is paramount, along side a balanced approach to fluid administration – this should be discussed early when establishing treatment goals.

Resuscitation goals:

- The main goal of blood volume resuscitation in trauma is to preserve vital organ perfusion until bleeding can be controlled.
- Blood pressure goals for penetrating chest trauma or uncontrollable haemorrhage are generally lower than for blunt trauma in the absence of a major head injury.
- Permissive hypotension is acceptable practice until definitive care and surgical intervention can be accessed.
- Tissue perfusion can be assessed in several ways. These include:
    - Skin color- pale, cool, and clammy versus mottled and blue.
    - Capillary refill time
    - Conscious state- decrease conscious state is an indicator of poor cerebral perfusion.
    - Blood gases- acidosis is often mixed in severe chest injury, however increasing base deficit, and increasing lactate are reliable indicators of tissue hypo-perfusion.
    - Urine output – Although this takes time to become evident.
- If possible, all blood/fluid administered to a major trauma patient should be warmed with a fluid warmer.

## Monitor

- HR / RR / BP / $SPO_2$ / GCS / Temperature
- Reassess every 15/60 or more frequently if indicated.
- Fluid Balance Chart – keep an accurate record of input / output.
- Serial Blood Gas assessment of pH, base-deficit and lactate levels provide good monitoring of tissue oxygenation, circulatory status and response to resuscitation.

### Administer

- Tetanus Prophylaxis: updated in the case of significant or contaminated wounds. The tetanus immunoglobulin vaccine should be given to patients who have not received a complete primary immunisation. Even if patients have up-to-date tetanus vaccinations all tetanus-prone wounds must be disinfected and where appropriate, have surgical treatment. (30)
- IV antibiotics: Recommended on insertion of an intercostal catheter and in penetrating trauma.

### Wound Care

In a major trauma patient, early wound closure (pre-transfer) is not a priority (except for bleeding control).

- Remove gross contamination and irrigate the wound.
- Gain haemostasis through pressure and elevation where possible, ensure bleeding has ceased.
- Simple dressings with saline, gauze, combine and moderate compression bandages are generally adequate.
- Suture simple wounds if time allows.

The priorities for further investigation and treatment should now be considered and a plan for definitive care should be established.

## 10. Retrieval and Transfer

ARV can facilitate a multi-party conversation for advice on patient management with an array of specialist services. This should be considered early in the course of patient care, particularly for patients with:

- Flail chest injury;
- Multiple rib fractures;
- Penetrating injury;
- Significant pulmonary contusion;
- Large pneumothorax;
- Any critical or life-threatening thoracic injury.

It is important to note that an exhaustive clinical workup or interventions are not always necessary or appropriate prior to transfer. Stabilisation and ensuring life-threatening problems are addressed, as well as taking measures to prevent deterioration, are essential aspects of early care. Delaying transfer to obtain laboratory results or imaging studies may delay access to definitive treatment. Often such studies must be repeated at the receiving facility regardless.

In partnership with ARV clinicians, interventions to stabilise the patient prior to retrieval personnel arriving should be commenced. ARV will coordinate the retrieval and will evaluate the practical and clinical needs involved in transferring the patient from the referral hospital.

Once retrieval staff arrive, care will be formally transferred to them after a thorough handover is provided. Retrieval staff will assess the patient prior to transfer and may make changes to care plans that ensure the patient is safe during transfer. The use of a transfer checklist can assist in ensuring that important information is not overlooked or omitted.

In specific reference to major thoracic trauma, it is important that the following information is relayed to the receiving hospital as soon as possible, even prior to patient transfer, to facilitate timely intervention on their arrival at the MTS:

- **Suspicion or confirmation of blunt aortic injury**
  It is vital that CT imaging be made available to the treating MTS as soon as practical. This facilitates preparation of the angiography suite at the receiving MTS, as well as allowing consultation with the receiving team regarding blood pressure control.
- **Pericardial fluid or tamponade**
  With prior knowledge that a patient with suspected pericardial tamponade is being transferred, preparations can be made for a cardiac theatre and relevant personnel to be available upon the patient's arrival. Survival in these patients is dependent on time to operative intervention.
- **Massive haemothorax with ongoing bleeding**
  As with pericardial tamponade, the survival of patients with intrathoracic bleeding that requires operative intervention is dependent upon time to theatre.

# 11. Appendix 1: AGREEII Score Sheet – Thoracic Trauma Guideline

**AGREE II Score Sheet: Thoracic trauma guideline**

| Domain | Item | AGREE II Rating | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 *Strongly Disagree* | 2 | 3 | 4 | 5 | 6 | 7 *Strongly Agree* |
| Scope and purpose | 1. The overall objective(s) of the guideline is (are) specifically described. | | | | | | | X |
| | 2. The health question(s) covered by the guideline is (are) specifically described. | | | | | | | X |
| | 3. The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described. | | | | | | | X |
| Stakeholder involvement | 4. The guideline development group includes individuals from all the relevant professional groups. | | | | | | X | |
| | 5. The views and preferences of the target population (patients, public, etc.) have been sought. | | | | | | | X |
| | 6. The target users of the guideline are clearly defined. | | | | | | | X |
| Rigor of development | 7. Systematic methods were used to search for evidence. | | | | | X | | |
| | 8. The criteria for selecting the evidence are clearly described. | | | | | | X | |
| | 9. The strengths and limitations of the body of evidence are clearly described. | | | | | | X | |
| | 10. The methods for formulating the recommendations are clearly described. | | | | | | X | |
| | 11. The health benefits, side effects and risks have been considered in formulating the recommendations. | | | | | | X | |
| | 12. There is an explicit link between the recommendations and the supporting evidence. | | | | | | | X |
| | 13. The guideline has been externally reviewed by experts prior to its publication. | | | | | | | X |
| | 14. A procedure for updating the guideline is provided. | | | | | | | X |
| Clarity of presentation | 15. The recommendations are specific and unambiguous. | | | | | | X | |
| | 16. The different options for management of the condition or health issue are clearly presented. | | | | | | | X |
| | 17. Key recommendations are easily identifiable. | | | | | | | X |

| Domain | Item | AGREE II Rating | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **1** *Strongly Disagree* | **2** | **3** | **4** | **5** | **6** | **7** *Strongly Agree* |
| Applicability | 18. The guideline describes facilitators and barriers to its application. | | | | | | | X |
| | 19. The guideline provides advice and/or tools on how the recommendations can be put into practice. | | | | | | | X |
| | 20. The potential resource implications of applying the recommendations have been considered. | | | | | | | X |
| | 21. The guideline presents monitoring and/ or auditing criteria. | | | | | | | X |
| Editorial independence | 22. The views of the funding body have not influenced the content of the guideline. | | | | | | | X |
| | 23. Competing interests of guideline development group members have been recorded and addressed. | | | | | | | X |
| Overall Guideline Assessment | 1. Rate the overall quality of this guideline. | **1** *Lowest possible quality* | **2** | **3** | **4** | **5** | **6** | **7** *Highest possible quality* |
| Overall Guideline Assessment | 2. I would recommend this guideline for use. | *Yes* | *Yes, with modifications* | | *No* | | | |
| | | X | | | | | | |

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