1. Key Messages

The Victorian State Trauma System provides support and retrieval services for critically injured patients requiring definitive care, transfer and management. This thoracic trauma guideline provides 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 Service (MTS) as well as those working outside of a MTS. These thoracic management guidelines provide up-to-date information for frontline healthcare clinicians.

These guidelines provide the user with accessible resources to effectively and confidently provide early care for critically injured thoracic patients. The guideline has been assessed utilising the AGREEII methodology for guideline development and is under the auspice of the Victoria State Trauma Committee (VSTC).¹

Clinical Emphasis Points:
- Thoracic trauma is a common injury in the multi-trauma patient and a significant cause of mortality. Life threatening injuries need to be addressed promptly to ensure a positive outcome for the patient.
- Thoracic trauma can result in immediately life-threatening injury, as well as delayed morbidity and mortality.
- Early recognition with prompt diagnosis and treatment of thoracic trauma is essential to prevent both early and delayed morbidity and mortality.
- Suboptimal initial management of thoracic trauma can be associated with significant complications and morbidity.
- Life threatening injuries identified in the primary survey need to be addressed before moving on to the secondary survey.
- Patients who present with penetrating or blunt thoracic injuries and are pulseless but with myocardial electrical activity may be candidates for resuscitative thoracotomy in the emergency department.
- Delayed life threatening injuries can be addressed in the secondary survey with more in-depth physical examination and monitoring.
- Appropriate ventilatory support settings must be considered especially where poor lung compliance and pulmonary contusions are involved.
- Adequate analgesia is essential to prevent secondary insults due to hypoventilation and assists with coughing and chest physiotherapy.
- 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 in the course of patient care, 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.
Victorian State Trauma System Guideline
Thoracic Trauma

Make early contact with ARV for advice from the major trauma services and to initiate retrieval.

Early Activation
- Gather vital information
- Activate Trauma Team
- Designate roles
- Set up to receive patient
- Ensure safety using PPE

Primary Survey

Airway / C-spine
- Rapidly assess airway stability & for major injuries affecting patency
- Be prepared for a difficult intubation
- Maintain full spinal precautions

Breathing
- Identify any life threats & treat immediately
- Assess RR, work of breathing, SpO2 & symmetry
- Oxygen therapy to maintain SpO2 between 94-96%
- ETCO2 monitoring if intubated

Circulation
- Insert x2 large bore IV canulas
- IO access if required
- Assess HR / BP / JVP / Cap refill
- Initial management of hypovolaemia - crystalloids fluids, 20mL/kg, then consider blood products

Disability
- Assess conscious level - AVPU
- Check pupils
- Test BSL

Exposure / Environment
- Fully expose and inspect patient
- Prevent heat loss
- Log roll

Adjuncts
- FAST scan
- Analgesia
- X-ray: Chest, Pelvis
- Bloods - FBE, X-match, U&E, Lactate, ABG, Troponin
- 12 lead ECG
- Orogastric tube if intubated
- AMPLE mnemonic

Key Points

Life threatening injuries:
- Tension pneumothorax
  - Hypoventilation, tachypnoea, decreased or absent air entry to affected side, decreased chest movement, tracheal deviation (late sign)
  - Immediate finger thoracostomy, then reassess. An intercostal catheter can be performed later.
- Massive haemorrhage
  - Dullness to percuss, decreased or absent air entry
  - Insertion of intercostal catheter
- Open pneumothorax
  - Open "winking wound", decreased air entry
  - 3 sided occlusive dressing followed by insertion of intercostal catheter
- Flail chest & Pulmonary contusions
  - Paradoxic chest movement
  - Adequate analgesia / oxygenation / consider early intubation and ventilation.

Resuscitative thoracotomy:
Patients who present with penetrating or blunt thoracic injuries and are pulseless but with myocardial electrical activity may be candidates for resuscitative thoracotomy. This can be done in the emergency department with trained clinicians and appropriate equipment.

Management Considerations

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 secretions. This is of particular concern for the elderly trauma patient who is more prone to developing pneumonia leading to increased morbidity and mortality. Consideration should be given towards intercostal or epidural anaesthesia and / or patient controlled analgesia (PCA's).

Does patient meet potential major trauma criteria for intra-hospital transfer?

- Manage cervical spine using NEXUS criteria
- Perform secondary survey
- Monitor closely
- Observe in facility for at least 4 hours
- Provide required care, discharge and follow up as necessary

Patient meets potential major trauma criteria?

- Perform complete trauma evaluation
- Monitor vital signs closely
- Observe in facility
- Seek advice from ARV coordinators regarding treatment options
- Provide required care
- Involve other medical specialties as required
- Contact ARV if deterioration in patients condition occurs

Notify ARV immediately if Aortic Injury, Pericardial Fluid, Tamponade or Massive Haemorrhage

ARV Adult Retrieval Victoria

1300 36 86 61 Statewide
24 hours

28/07/2017 | Version 1.0 | Not applicable to Paediatric patients | Contact us: Trauma.Victoria@ambulance.vic.gov.au
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 ATLS/EMST guidelines. Of particular note, 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.\(^3\) Flail chest injury represents a particularly severe form of chest trauma, and is considered an immediate threat to life. Not only is it associated with contusions and haemopneumothorax, many patients also experience a degree of mechanical ventilatory failure. Delayed or inadequate ventilatory resuscitation, inadequate management of shock, insufficient monitoring of arterial blood gases and delay or failure to perform decompression or drainage as well as inadequate imaging remain identifiable problems that contribute to morbidity and mortality in all patients with chest injury.\(^2\)

Penetrating thoracic injuries represent 10% of cases and are more likely than blunt injury to require operative intervention. The majority of the remainder will require supportive care which may include pleural decompression and drainage.

Resuscitative Thoracotomy (RT) in penetrating trauma may be considered for patients who arrive pulseless but with electrical activity. 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.

Delayed life threatening complications are detected in the Secondary Survey where further in depth examination can take place. Adjuncts to the primary survey include CXR, ABG’s, pulse oximetry and ECG monitoring. Hypoxia may be absent early in the presentation however may develop as the injuries evolve. Hypoventilation commonly develops due to pain, fatigue from increased work of breathing as well as side effects of opiate analgesia. Ventilatory support in patients with pulmonary contusions and poor lung compliance requires ventilation at lower tidal volumes and low inspiratory pressure in order to reduce barotrauma and secondary lung injury.

Adequate analgesia is essential and many departments 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 or locoregional analgesia.

Significant chest injury is rare in paediatric trauma. Death usually occurs soon after the injury in a child, whereas an adult with similar injuries tends to survive longer. This is primarily due to the compliance of the chest wall which allows for greater deformation of the chest wall before the ribs fracture. Major internal injuries may occur without any external chest wall injury.5

Rib fractures are some of the most common injuries in the elderly and those >65 years are twice as likely to develop pneumonia (Morely E, 2016) 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 recognise and treat life threatening injuries in the emergency setting, stabilise the patient and detect potentially life threatening injuries in the secondary survey. Patients with significant chest injury, including 3 or more rib fractures, flail chest injury, a need for ventilator support, patients > 65 years of age and with any significant co-morbidities should be transferred to a major trauma service for definitive care.

4. Immediately 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 also impedes venous return both from the IVC and SVC, as well as increasing afterload on the heart. Obstructive shock soon develops.

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 field (Needle decompression & Finger thoracostomy)**

Needle decompression is performed preferably at the 5th intercostal space, mid axillary line (with the arm in the abducted position). This location may not be easily accessible, and in such circumstances the 2nd intercostal space, mid axillary line is used. A large bore IV Cannula (14 or 16G) with a 10ml syringe attached is inserted, and air is drawn. Alternatively a pneumocath can be used. 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 or malpositioning. Unlike needle decompression, finger thoracostomy allows for maximum release of air and liquid from the pleural cavity. It may be appropriate to proceed to finger thoracostomy in the field, particularly if evacuation is to be delayed. Finger thoracostomy is an invasive procedure, so every effort should be made to perform this under aseptic conditions. The patient’s arm is fully abducted and the skin is prepared with aseptic skin prep. An incision is made through skin, dermis and fascia at the fourth or fifth intercostal space, just anterior to the mid axillary line. (Prior infiltration of local anaesthetic is required if the patient is conscious). 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. The site is then covered with a three way dressing, or a valve-bag. Re-sweeping of the site can also be performed if the patient deteriorates.

**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. This will relieve the intra-thoracic pressure to allow time for formal decompression and insertion of an intercostal catheter (ICC), which should be performed immediately 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. Finger thoracostomy is an invasive procedure, so every effort should be made to perform this under aseptic conditions. This includes full surgical scrub as well as face masks, gowns and sterile gloves when performed in the emergency department. The patient’s arm is fully abducted, skin is prepared with aseptic skin prep from midline to bed, and axilla to costal margin. The area is draped on all four sides. The procedure is then performed, as described...
above. In most emergency departments, finger thoracostomy can be performed just as quickly as needle decompression which only has a 42.5% success rate.\(^8\)

The sterile insertion of an intercostal catheter connected to an underwater seal drain should then immediately follow finger thoracostomy.

**Massive Haemothorax**

Accumulation of blood and fluid in the hemithorax prevents adequate ventilation and compresses the lung, especially when there is >1500mLs or 1/3 the patient’s blood volume in the chest cavity. It most commonly occurs after penetrating trauma but can also be present in blunt trauma. Bleeding can be due to injury from the lungs, major vessels, intercostal vessels or the heart. These large accumulations of blood lead to respiratory failure, hypotension and shock.

**Management:** Initial management involves the restoration of circulating blood volume and the insertion of a chest drain. Large bore IV cannulas or intraosseous access if unable should obtained and volume resuscitation commenced. Damage control resuscitation techniques should be employed until there is definitive control of bleeding. 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. The insertion of an intercostal catheter will allow for accurate measurement of blood loss, as well as some tamponade effect when allowing the lung to re-expand against the chest wall. This will have some effect on intercostal bleeding and parenchymal bleeding. 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.

**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 thoracostomy 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 of the tube with expiration and suture in place. Placement should be confirmed with CXR. Auto transfusion could be considered in some circumstances if capabilities exist.

**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 ED, particularly where noise makes muffled heart sounds difficult to hear, or in the setting of hypovolaemia where a raised JVP may not be present. What is often seen is the plethoric face and neck that results from inflow obstruction. This tends to be more pronounced than when seen in tension pneumothorax, and is a distinctive sign.

**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.

If the patient is in shock, and a surgeon is available, the patient should undergo a resuscitative thoracotomy. Preferably this should be in theatre (operative thoracotomy) if time allows, however if the patient loses output it will need to be performed in the emergency department.

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.

**Resuscitative Thoracotomy:**

The aims of resuscitative thoracotomy are to treat pericardial tamponade by decompression of the pericardial sac and temporary or definitive repair of the myocardial defect. While internal cardiac massage can be also performed, this is not a primary indication for performing resuscitative thoracotomy. Ideally it should be performed in the operating room where equipment and theatre-trained nursing staff are available. If the patient has lost output however, it should be performed immediately in the emergency department.

Resuscitative thoracotomy should only be performed by appropriately trained and credentialed medical practitioners in settings where there is access to necessary systems and equipment to manage or stabilise myocardial injury or pericardial tamponade.

**Pericardiocentesis**

Pericardiocentesis involves the insertion of a needle into the pericardium to remove blood / fluid in order to improve cardiac function and allow adequate ventricular filling. 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 3 way tap is attached. Note the improvement in output. The patient will require definitive surgery for evaluation and management of the underlying injury.

**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.

**Management:** involves 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 in inspiration. 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.

**3-sided occlusive dressing**

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 pre-made dressings such as Asherman’s chest seals which can be utilised.

**Flail Chest & Pulmonary Contusions**

Spontaneous breathing relies on the ability to create negative pressure within the thorax. Flail chest injury is defined by fractures of 2 or more ribs in continuity, in 2 or more locations. 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 defined 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 threat to life. 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. Epidural analgesia may assist pain control and help improve oxygenation. ABG’s should be performed regularly to monitor ventilation and response to treatment. Non-invasive positive pressure ventilation (NIPPV) may assist breathing by overcoming the need to create negative pressure during inspiration (Morely E, 2016). Patients who develop early respiratory failure however require immediate mechanical ventilation.

**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. Injury to the intrathoracic trachea and bronchi is 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. It may also be suggested on chest x-ray when completing the adjuncts to the primary survey.

While the definitive management of intrathoracic airways injuries is challenging, and requires specialist input, the early management follows EMST/ATLS principles. For the majority of patients who initially survive, chest decompression will suffice. 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 in the pre-hospital setting, 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.

Diaphragm injury: The diaphragm is a muscle that plays a crucial role in ventilation. Injury can result from penetrating mechanism or blunt trauma from high intra-abdominal pressures. This injury can result in pulmonary compromise and complications to peritoneal contents 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.

Blunt aortic injury: The thoracic aorta and its branches carry large volumes of blood and can therefore result in fast massive exsanguination and death. Due to the relatively fixed nature of these vessels make them susceptible to sudden decelerative 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, but delay in diagnosis can result in associated sepsis. 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 conditions and lower lung capacity. These factors make them more susceptible to increased morbidity and mortality as a result of thoracic trauma.
5. Early activation

The presence of significant thoracic trauma needs to be assumed in a multi-trauma patient, particularly when the mechanism of injury is due to a high-energy blunt trauma. Emergency medical services should notify the receiving hospital that a trauma patient with thoracic injuries is on the way. This information may be crucial to 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 the department 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:

1. Gather vital information from the notifier using the MIST mnemonic:¹⁰
   - M Mechanism of injury
   - I Injuries found or suspected
   - S Signs: respiratory rate, pulse, blood pressure, SpO2, GCS or AVPU
   - T Treatment given

2. Ensure all staff involved in patient care are wearing gloves, aprons and eye protection. Personal protective equipment is vital in the care of trauma patients.

3. Activate the trauma team and available support departments (medical imaging, pathology). In small health service settings this may only consist of a clinician and a nurse. 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 at the ready. 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 need to be activated early in the event of surgical intervention.

5. If the patient is hypotensive the massive transfusion protocol should be activated. Hypotension should be considered due to blood loss 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 request must take place and any 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 videoconference, and link to an MTS for early notification and further advice.

6. Primary Survey

Life threatening chest injuries need to be recognised and addressed early during the primary survey of major trauma patients. It is vital to actively search these conditions out as they may not be apparent on initial presentation. Life threatening injuries 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 cut off as soon as is possible in order 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 further risk of injury.

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

Note ETCO2 trace.

Maintain full spinal precautions if indicated - suspect spinal injuries in all poly-trauma patients. Ensure a cervical collar and in-line immobilisation is maintained throughout patient care.

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 / SpO2.
- Look for open / penetrating wounds / tracheal deviation / plethoric facies.
Observe any bruising / deformity / abnormal chest movements: Intercostal & / or supraclavicular in-drawing.

- Palpate – hyporesonance (fluid), hyperresonance (air), 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 ruled out. Make sure to check the back also as life threatening wounds may be otherwise undetected. Immediately after detection of any life threatening injuries, interventions need to occur in order to prevent further deterioration.

**Detecting life threatening injuries:**

- Hyperresonance, 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.
  - Dullness to percuss, decreased or absent air entry => 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 / oxygenation / consider early intubation and ventilation.

A mobile 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 – carotid, femoral or radial?
- Skin – colour / cap refill time / temperature.
- BP.
- JVP – raised/ flattened.
- Look for plethoric facies.
- Perform FAST scan looking specifically for evidence of pericardial tamponade or pneumothorax.

**Management:**

- 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 available, alternatively isotonic crystalloid solution e.g. 0.9% Saline 20ml/kg.
- Continuous cardiac monitoring.
- Control bleeding if compressible source.

**FAST:** In the hypotensive patient, FAST should be performed as part of the primary survey. FAST is more accurate than physical examination for detecting the presence of pericardial or intraperitoneal bleeding.
For hemodynamically normal patients, FAST can be performed as an adjunct to the primary survey.

**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 so as to ensure no injuries posing an immediate life threat are missed.
Trauma patients are prone to hypothermia, so upon completion of the primary survey 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. Consideration must be given to the patient’s age, gender and culture when exposing them for a trauma examination. Exposure may need to be done sequentially, uncovering one body region at a time to maintain patient dignity.

**Investigations:**
- Baseline portable chest and pelvis x-rays.
- FBC, U&E’s, troponin, ABG, X-Match, Coagulation studies.
- 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 leading to increased morbidity and mortality. Effective pain management may be achieved with the use of paracetamol, non-steroidal anti-inflammatory drugs, tramadol, opioid analgesia as well as consideration of intercostal nerve blocks, likely managed in the MTS.

7. Secondary survey
The secondary survey is performed if time permits once the patient has been resuscitated and stabilised. It involves a more thorough head-to-toe examination, and the aim is to detect any delayed 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 of the events surrounding the injury can assist with understanding the extent of the injury and any
possible other injuries. Use the AMPLE acronym to assist with gathering pertinent information:
A Allergies
M Medication
P Past medical history including tetanus status
L Last meal
E Events leading to injury

**Head-to-toe examination**
During this examination, any injuries detected should be accurately documented and any required treatment should occur, such as covering wounds, managing non-life-threatening bleeding and splinting of fractures.

**Head and face:**
- Face: examine & palpate for lacerations, depressions, swelling, bruising to mastoid / peri-orbital region
- Ears: CSF, blood, blood behind tympanic membrane, hearing
- Eyes: foreign body, Sub conjunctival haemorrhage, hyphaema, contact lenses, test eye movements / vision
- Nose: Deformities, bleeding, nasal septal haematoma, CSF leak
- Mouth: Lacerations, swelling, broken or loose teeth
- Jaw: pain or trismus

**Neck**
Assume cervical spine injury until excluded, re-apply collar after examination. Examine:
- Trachea (midline or deviated).
- Upper airways- look for evidence of local trauma to the bruising, haematoma, crepitus, open wounds, subcutaneous emphysema.
- Veins: distended / flattened.
- Oesophagus: poorly localised chest pain, and almost always in association with major chest and/or abdominal trauma.

**Chest:**
- Reassess: auscultate breath and heart sounds.
- Palpate clavicle / ribs / apply gentle sternal compression.
- Note any percussion abnormality, lack of breath sounds, wheezing or crepitations.

**Back:**
- Log roll the patient while maintaining in-line stabilisation.
-Inspect the entire length of the back noting any deformity, bruising and lacerations.
- Palpate for any tenderness or steps, including the posterior ribs, and thoraco-lumbar spine.

**Abdomen:**
- Palpate for areas of tenderness including flank, note any guarding.
- Look for any bruising, lacerations or penetrating injuries.
• Check the pelvis - apply a binder if fracture suspected.
• Auscultate bowel sounds.

**Limbs**

• Inspect all limbs for bruising, lacerations, deformities, wounds.
• Palpate for bony and soft-tissue tenderness, check movements, stability and muscular power.
• Assess distal colour, warmth, movement, sensation and capillary refill.
• Complete sensory and motor function, especially in suspected spinal injury.

8. Planning and communication

Front line 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 clinical skill set of the hospital or urgent care service. ARV can be contacted at any time throughout the patient care episode to offer or coordinate clinical advice and consultation. ARV coordinators can facilitate a three-way conversation between the referral health service, specialist resources and ARV consultant to discuss the best, 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 transmission 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, pre-hospital management, evaluation and treatment (including procedures performed and imaging obtained).

There are many different types of structured handover. ISBAR & IMIST-AMBO being two of the most common. ARV recommends using the IRMIST model of clinical handover:

• Identification: Introduce / identify clinician/self & their role, intro of the patient – age, sex, name
• Retrieval: Reason for retrieval, from which referrer.
• Mechanism of Injury / presenting complaint: Specific explanation of the patient’s presenting problem and history of presenting complaint.
• Injuries / 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
• Signs / Symptoms: Looks at the assessment of the patient, requires details of the patient current vital signs and GCS.
• Treatments / 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.
Allergies: Include what type of reaction
Medication: Patients usual medication
Background History: Patients medical history
Other information: Relevant social information

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 en route and the patient is referred to the correct facility.

9. Early management

Airway management
Patients with pulmonary contusions are at high risk for respiratory distress and pneumonia. Methods should be implemented early on in the course of treatment to improve oxygenation and ventilation. The goal of treatment should focus on re-expansion of the atelectatic regions through high 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 (Morely E, 2016)

Fluid resuscitation
Avoidance of hypovolaemia in trauma is a cornerstone of management. A balanced approach to fluid replacement is important, especially in establishing early treatment goals.

Resuscitation goals:

- The main goal of blood volume resuscitation in trauma is to preserve vital organ perfusion until bleeding can be controlled.
- In immediate trauma care aim for a blood pressure greater than 90 mmHg systolic or a shock index less than 1 (HR/SBP).
- 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. (SBP values less than 90 mmHg may be acceptable if cerebral perfusion is maintained).
- Tissue perfusion can be assessed in a number of ways. These include:
  - Skin color: pale and peripherally shut down versus mottled and blue.
  - Prolonged capillary refilling time.
o Decreased conscious state- poor cerebral perfusion.
o Arterial blood gases- acidosis is often mixed in severe chest injury, however increasing base deficit and increasing lactate are reliable indicators of tissue hypo-perfusion.
o Decreased urine output 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 / SPO2 / GCS.
- Reassess every 15/60 or more frequently if indicated.
- Fluid Balance Chart – keep an accurate record of input / output.
- Serial BG 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. Tetanus immunoglobulin should be given to patients who have not received a complete primary immunisation.\textsuperscript{16}
- 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.
- 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 may now be considered and a plan for definitive care established.

10. Retrieval and Transfer
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 in the course of patient care, particularly for patients with:
- Flail chest.
- Multiple rib fractures.
- Penetrating injury.
- Significant pulmonary contusion.
- Large pneumothorax, or
- Any critical or life-threatening thoracic injury.
It is important to note that an exhaustive clinical workup and intervention is not always necessary or appropriate prior to transfer. Stabilisation and ensuring life-threatening problems are addressed, as well as taking measures to prevent deterioration en-route, 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 liaison 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 on scene, be prepared to give a thorough handover. Retrieval staff will assess the patient prior to transfer and may make changes to care in order to ensure the patient is safe during transfer.

The use of a transfer checklist can help to ensure that important information is not omitted and the patient is packaged accordingly.

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, so as 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. If possible, images should be shared via the ‘Hub and Spoke’ system. This facilitates preparation of the angiography suite at the receiving MTS, as well as allowing consultation with the receiving team regarding blood pressure control en route.

- **Pericardial fluid or tamponade:**
  With prior knowledge that a patient with suspected pericardial tamponade is en route, 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: AGREE II Score Sheet – Thoracic Trauma Guideline

<table>
<thead>
<tr>
<th>Item</th>
<th>AGREE II Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The overall objectives of the guideline are clearly described.</td>
<td>X</td>
</tr>
<tr>
<td>2. The health questions covered by the guideline are clearly specified and described.</td>
<td>X</td>
</tr>
<tr>
<td>3. The population(s) and settings to which the guideline is intended to apply are clearly specified.</td>
<td>X</td>
</tr>
<tr>
<td>4. The guideline development group includes individuals from at least three of the following: professional groups, patients/public, etc.</td>
<td>X</td>
</tr>
<tr>
<td>5. The views and preferences of the target population/patients, public, etc., have been sought.</td>
<td>X</td>
</tr>
<tr>
<td>6. The target users of the guideline are clearly identified.</td>
<td>X</td>
</tr>
<tr>
<td>7. Systematic methods were used to search for evidence.</td>
<td>X</td>
</tr>
<tr>
<td>8. The criteria for selecting the evidence are clearly described.</td>
<td>X</td>
</tr>
<tr>
<td>9. The strengths and limitations of the body of evidence are clearly described.</td>
<td>X</td>
</tr>
<tr>
<td>10. The methods for formulating the recommendations are clearly described.</td>
<td>X</td>
</tr>
<tr>
<td>11. The health benefits, side effects, and risks have been considered in formulating the recommendations.</td>
<td>X</td>
</tr>
<tr>
<td>12. There is an explicit link between the recommendations and the supporting evidence.</td>
<td>X</td>
</tr>
<tr>
<td>13. A process for revising the guideline has been established.</td>
<td>X</td>
</tr>
<tr>
<td>14. A protocol for updating the guideline has been established.</td>
<td>X</td>
</tr>
<tr>
<td>15. The recommendations are specific and unambiguous.</td>
<td>X</td>
</tr>
<tr>
<td>16. The different options for management of the condition or health issue are clearly presented.</td>
<td>X</td>
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<tr>
<td>17. Key recommendations are easily interpretable.</td>
<td>X</td>
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<tr>
<td>Domain</td>
<td>Item</td>
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<td>------------------------</td>
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<tr>
<td>Applicability</td>
<td>18. The guideline describes facilitators and barriers to its application.</td>
</tr>
<tr>
<td></td>
<td>19. The guideline provides advice and/or tools on how the recommendations can be put into practice.</td>
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<td></td>
<td>20. The potential resource implications of applying the recommendations have been considered.</td>
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<td></td>
<td>21. The guideline presents monitoring and/or auditing criteria.</td>
</tr>
<tr>
<td>Editorial independence</td>
<td>22. The views of the funding body have not influenced the content of the guideline.</td>
</tr>
<tr>
<td></td>
<td>23. Competing interests of guideline development group members have been recorded and addressed.</td>
</tr>
<tr>
<td>Overall Guideline Assessment</td>
<td>1. Rate the overall quality of this guideline.</td>
</tr>
<tr>
<td></td>
<td>2. I would recommend this guideline for use.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
12. References


accidental or exposure hypothermia in adult major trauma patients. *International Journal of Nursing Practice*, 308-318.


