Clinics of Surgery

Review Article

ISSN: 2638-1451 | Volume 8

Management of Blunt Chest Trauma; Everything you Need to Know - A Review of Literature

Santosh Parsekar[1], Samiksha Arsekar[1], Ella-Marie Filinto-Sequeira[2], Frazer C S Rodrigues[1], Yash Jairam Verenkar[1], Amol Amonkar[1*], and Jude Rodrigues[1]

[1]Department of General Surgery, Goa Medical College, India

[2]Medical Officer, Directorate of Health Services, India

[*]Corresponding author:

Amol Amonkar,
Department of General Surgery, Goa Medical College, India, Tel: +918217447802;
E-mail: amonkaramol@gmail.com

Received: 03 Nov 2022
Accepted: 10 Nov 2022
Published: 15 Nov 2022
J Short Name: COS

Citation:

Amonkar A. Management of Blunt Chest Trauma; Everything you Need to Know - A Review of Literature. Clin Surg. 2022; 8(5): 1-7

Keywords:

Blunt chest trauma; chest trauma; haemothorax; pneumothorax; VATS

Abbreviations:

BCT: Blunt Chest Trauma; MVC: Motor Vehicular Collisions; VATS: Video Assisted Thoracoscopic Surgery; MVA: Motor Vehicular Accidents

1. Abstract

Trauma is the leading cause of death worldwide of which two thirds of the patients have blunt chest trauma with varying severity from a simple rib fracture to flail chest. In this paper we are reviewing the existing literature and the management of blunt chest trauma, throwing light on the critical aspects such as evaluation and treatment. Recent advances of VATS in blunt chest trauma are de-scribed as well, majority of the BCT cases are managed non-operatively with only a handful of cases needing surgical intervention by thoracic surgeons. Younger patients have better prognosis as compared to geriatric patients with the same injuries. We also throw light on the admission criteria for BCT cases, indications of tube thoracostomy and indications of thoracotomy in BCT cases. This particular paper will throw light on the management of blunt chest trauma and its various therapeutic options in detail so as to understand this clinical entity and its implications.

2. Introduction

Trauma is the leading cause of death worldwide, and approximately two thirds of trauma patients have chest trauma with varying severity from a simple rib fracture to penetrating injury of the heart or tracheobronchial disruption. [1-4].

Blunt chest trauma is most common with 90% incidence, of which less than 10% require surgical intervention of any kind. [1,2]. Etiology of chest trauma is broadly categorised by mechanism into blunt or penetrating trauma. The most common cause of blunt chest trauma is motor vehicular collisions which account for up to 80% of injuries. Other causes include falls, vehicles striking pedestrians, acts of violence and blast injuries.

The majority of penetrating trauma is due to gunshots and stabbing [1, 2].

2.1. Pathophysiology and Anatomical considerations

2.1.1. Chest Wall: The major components of the chest wall are the rib-cage, costal cartilage and intercostal musculature [1,2]. Blood supply and innervation to the chest wall are through neurovascular bundles com-prising of an intercostal artery, vein and nerve that course at the inferior border of each rib [1,2,4]. Deep to the rib cage is the parietal pleura which makes up the inner lining of the chest wall [1,2,6,7]. It receives somatic innervation from the intercostal nerves and therefore transmits pain [1,2]. A layer of visceral pleura covers the intrathoracic structures [1,2,5]. A potential space is thus formed be-tween the parietal and visceral layers, called the pleural space, which normally contains a small vol-ume of hypotonic fluid approximately 0.3 ml/kg which undergoes constant turnover at the rate of 0.15 ml/kg per hour [1,5]. The pleural fluid is produced by the parietal pleura itself and reabsorbed by pleural lymphatics [1]. When lymphatic reabsorption is overwhelmed, pleural effusion occurs [1,2,6].

The chest wall serves two main purposes; firstly, it serves to facilitate respiration via contraction of the diaphragm and intercostal muscles. This drives inspiration by increasing the intrathoracic volume, thus decreasing intrathoracic pressure, allowing the passive flow of air into the lungs. The re-verse occurs during expiration - the diaphragm and intercostals return to their relaxed positions resulting in an increase in intrathoracic pressure which forces air out of the lungs [1,10].

The chest wall also protects the intrathoracic structures from external injury [1,11]. The sternum and clavicle provide additional structural support to the anterior thorax, they are dense bones that serve as points of attachment for the pectoralis major & minor muscles and therefore require significant force to fracture [1,3,4]. Similarly, the scapulas overlie the superior aspect of the posterior chest wall and provide an additional protective barrier to trauma [1,19].

The mediastinum comprises of the heart, thoracic aorta, trachea and oesophagus and is anatomical-ly located in the centre of the chest between the right and left hemi-thoraces [1,3]. It is bordered by the sternum anteriorly, vertebral column posteriorly, and parietal pleura & lungs bilaterally, and ex-tends from the thoracic inlet superiority to the diaphragm inferiorly [1,3]. The most common isolated mediastinal injury in blunt trauma is an injury to the aorta, which can range in severity from an inti-mal laceration to complete aortic transection [1,21].

2.2. Pathophysiology of Injury

Morbidity and mortality associated with thoracic injury is due to disruption of respiration, circulation, or both [1,4].

Respiratory compromise an occur due to direct injury to airway or lungs as is the case with pulmonary contusions or from interference in the mechanics of breathing as with rib fractures [1,19]. The common outcome is the development of ventilation-perfusion mismatch and decreased pulmonary compliance. This then results in hypoventilation and hypoxia which may necessitate intubation [1,24].

Circulatory compromise occurs in the setting of significant blood loss, decreased venous return, or direct cardiac injury [1,2,3,4]. Intrathoracic bleeding most commonly manifests as haemothorax in both blunt & penetrating trauma and a massive haemothorax can lead to to hypotension and haemodynamic shock [1,2,3,9].

3. Review of Literature

3.1. Management of Blunt Chest Trauma

The initial evaluation of a blunt chest trauma patient is based on the ATLS protocol, which begins with an assessment of the patient's breathing & circulation during the primary survey [1,3].

The most critical injuries to be identified and treated in the thoracic region during the primary survey are [1,17]:

- Airway Obstruction
- Tension pneumothorax
- Open pneumothorax
- Flail chest and pulmonary contusion
- Massive haemothorax
- Cardiac tamponade

Secondary survey is done for potentially life-threatening chest injuries such as [1,12]:

- Tracheobronchial tree injury
- Simple pneumothorax
- Pulmonary contusion
- Haemothorax
- Blunt cardiac injury
- Traumatic aortic disruption
- Blunt oesophageal rupture
- Traumatic diaphragmatic injury

These injuries usually require immediate intervention such as intubation, needle decompression, tube thoracostomy, or pericardiocentesis. They should be resolved as they are discovered [1,23].

All blunt chest trauma patients must be managed in accordance with ATLS algorithms [3]:

- A (Airway with c-spine protection) - Is the patient speaking in full sentences?
- B (Breathing and Ventilation) - Is the breathing laboured? Are symmetrical breath sounds present bilaterally?
- C (Circulation with haemorrhage control) - Are pulses present and symmetric? How does the patient's skin appear? (cold & clammy or warm & well perfused)
- D (Disability) - What is the GCS score? Are they moving all extremities?
- E (Exposure/ Environment control) - Completely expose the patient. Is rectal tone present? Is there any gross bleeding per rectum?

3.2. Initial Interventions [1,11]

- IV - 2 large bore needles (minimum 18 gauge), antecubital intravenous.
- O2 - Nasal cannula/ face mask.
- Monitor - Put the patient on a cardiac monitor.

It is important to note that if there is any deficiency noticed during the primary survey, the problem must be addressed immediately to stabilise the patient without proceeding further [1,3,13].

If the primary survey is intact, the adjunct to the primary survey includes any of the following as necessary - EKG, ABG, chest X-ray, pelvic X-ray, Urinary catheterisation, FAST exam and/or DPL [1,2,5].

Next, a secondary survey must be performed which includes a complete history and physical examination. This is to be done after the primary survey, and after any intervention performed if any, in response to any anomaly in the primary survey [1,2,4] (Figure 1-3).

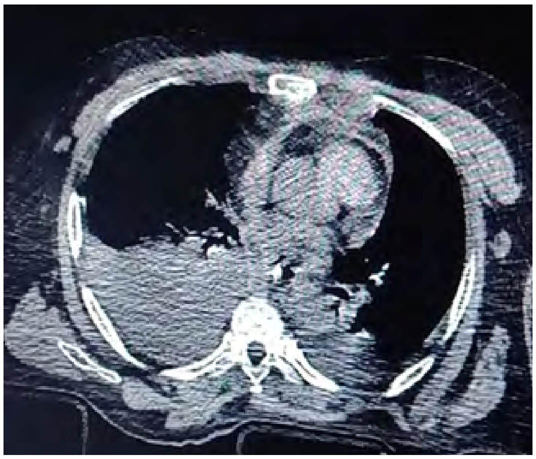

Figure 1: CT Thorax showing a haemothorax

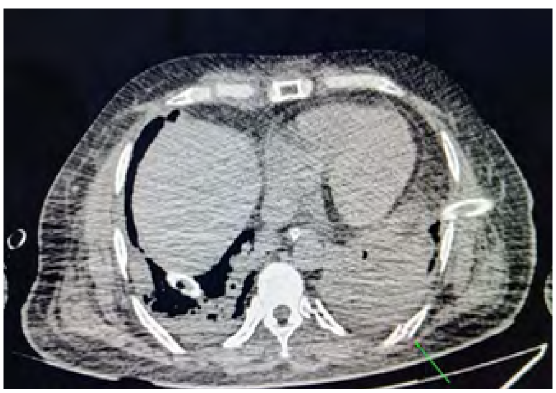

Figure 2: CT Thorax showing rib fractures

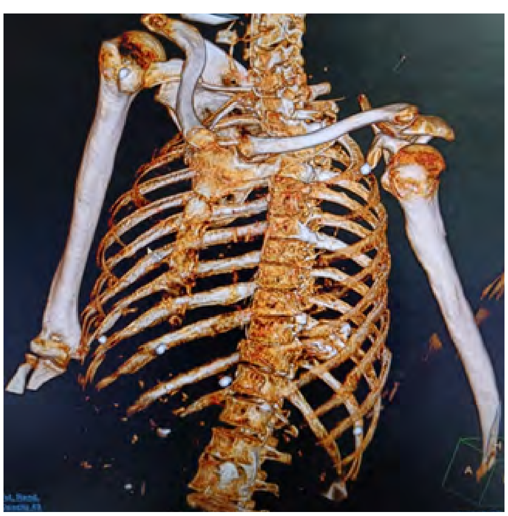

Figure 3: CT Thorax 3D reconstruction view showing multiple fracture ribs

3.3. Evaluation

3.3.1. Chest X-ray: Most thoracic injuries can be evaluated by physical exam and chest X-ray. A chest X-ray is fast, easy to obtain, inexpensive and often readily accessible [1,2]. Any patient who undergoes an intervention in the trauma bay should have a repeat chest X-ray performed to ensure the adequacy of the procedure [1,3]. An initial chest X-ray is recommended in any patient who presents with blunt chest trauma, but is not mandatory if the trauma is minor and the patient is not manifesting any physical signs to suggest underlying injury [1,2,3]. As per the NEXUS chest decision rules, patients <60 years who do not have any chest pain or tenderness, no distracting injuries or intoxication and whose mechanism did not involve rapid deceleration do not need a routine chest X-ray [1,3,15]. All criteria being met, there is a low likelihood of a clinically significant intrathoracic injury, with a negative predictive value of 99%. However, if the patient meets any individual criterion, chest X-ray should be performed. Conversely, physical exam alone has not been shown to have adequate diagnostic sensitivity, particularly for pneumothorax [1,2,3,15].

3.3.2. Ultrasound: Sonographic evaluation of the abdomen and thorax using the Focussed assessment with sonography in trauma (FAST) is vital in the initial phase of the trauma assessment [1,2,29]. As per ATLS guidelines it is ideally performed during the circulatory evaluation of the primary survey to allow for the rapid detection of any pathological fluid collection in the pericardial, intraperitoneal or intrathoracic spaces [1,2,29]. Haemothorax can be identified using the standard flank views where the most dependent portions of the pleural spaces can be imaged [1,30]. The extended FAST (e-FAST) exam employs additional chest views to evaluate for pneumothorax [1,30]. The linear ultrasound transducer probe (5-10 MHz) is utilised as opposed to the standard curvilinear probe (2.5-5 MHz) as the higher frequency enhances visualisation of the pleural space [1,2,29]. The examination typically be-gins in the third or fourth intercostal space in the midclavicular line and evaluation is based on the presence or absence of the parietal and visceral pleurae sliding past each other termed as lung sliding. Absent lung sliding suggests the presence of pneumothorax [1,2,8]. Several signs have also been described to aid in the diagnosis, most importantly the lung point sign, where both lung sliding and the absence of lung sliding are visualised in the same sonographic window [2,3,7]. The lung point sign has a sensitivity of over 66% and is 100% specific for pneumothorax [1,2,8].

3.3.3. CT Thorax: The use of CT scans in the evaluation of trauma patients has significantly increased. Compared to chest x-rays, CT thorax has a greater sensitivity for detecting a pneumothorax or haemothorax and also allows evaluation of the rib cage, the mediastinum, the lung parenchyma & the aorta [1,3,14]. The decision to obtain a CT thorax should be based on physical findings, mechanism of injury and clinical judgement. Patients who are haemodynamically stable with a normal chest x-ray and no sternal, thoracic spinal or scapular tenderness are unlikely to have a significant intrathoracic injury to warrant a CT thorax as shown by NEXUS [1,2,16]. Scanning based on mechanism remains controversial. However, recent studies have also reported a substantial number of patients, up to 19% with significant underlying injury despite having no clinical symptoms or abnormal findings on chest x-ray [1,3,28]. High risk mechanisms include high energy deceleration MVC over 30 mph with frontal or lateral impact, MVC with injection, falls over 7.62 m (25 feet) and direct chest impact [1,4,18]. There-fore the current recommendations are to obtain CT imaging in symptomatic patients and those presenting after high-risk mechanism regardless of symptomatology or chest x-ray findings [1,4,18]. Patients with symptoms concerning for underlying tracheobronchial, oesophageal or vascular injury or those with symptoms that cannot be adequately explained by chest x-ray require CT scanning for further investigation [1,2,27].

3.3.4. Oesophagography, Oesophageoscopy & Bronchoscopy: An oesophageal injury is often difficult to diagnose because it lacks specific symptoms [1,2,25]. It is rare in blunt chest trauma and typically occurs in the settings of severe polytrauma which further complicates the diagnosis [1,3,25]. When present, patients may have cervical subcutaneous emphysema, neck haematoma or bloody aspirate from a gastric tube, none of which are specific [1,3,25]. A chest x-ray may demonstrate pneumo mediastinum or pleural effusion prompting CT, but definitive diagnosis requires oesophageogram or endoscopy [1,2,10]. Water soluble oesophageogram it performed first followed by barium oesophageogram if suspicion remains. Endoscopy is generally less favoured in the acute setting due to fear of exacerbating an existing injury [1,2,10]. A tracheobronchial injury is rare in blunt chest trauma, present in less than 1% of patients and is seen in injuries with severe high-risk mechanisms [1,3,5]. Injuries usually occur within 1 cm of the carina and is more common in the right main stem bronchus as it is less flexible [1,3,5]. In penetrating trauma, an oesophageal injury is often associated with concomitant trickle injury due to proximity, and these patients require workup for both [1,3,4]. Patients with persistent pneumothorax after tube thoracostomy, a large air leak, difficulty ventilating and those with transmediastinal penetrating trauma should all undergo expeditious flexible bronchoscopy [1,4,22].

3.4. Management

Life-threatening injuries diagnosed during the initial trauma evaluation require prompt intervention [1,3]. The most common injuries due to thoracic trauma are pneumothorax and haemothorax which are definitively managed in 80% of cases with tube thoracostomy [1,3,26]. The size of the chest tube used is a clinical decision based on the pathology seen on the chest x-ray [1,3,4]. If both pneumo-thorax and haemothorax are present, a size 28 Fr or 32 Fr chest tube is usually considered as this will facilitate the evacuation of both air and blood while minimising the chance of the tube obstructing due to clot [1,3]. If no effusion is present, small bore catheters are appropriate, although many trauma clinicians will still opt for formal chest tubes instead [1,3]. Occult pneumothorax is a pneumo-thorax that is seen on CT but not on chest x-ray [1,2,8]. They are incidentally found in 2% to 10% of trauma patients who undergo chest CT scan [1,2,8].

Patients can be observed if the pneumothorax is less than 8 mm however occult pneumothorax is associated with a 5 to 10% risk of expansion and should be closely monitored [1,2]. Patients whose pneumothorax expand or those who become symptomatic warrant tube thoracostomy [1,2]

3.5. Admission Criteria for a Case of Blunt Chest Trauma [1,3,19]

1. Age >65 years

2. Patients who are unable to maintain an oxygen saturation of 92% or have an incentive spirometer volume of <15 ml/kg

3. All patients with 3 or more rib fractures

4. Patients with pulmonary complications such as contusions, pneumonia etc.

5. Pneumothorax, haemothorax

6. Flail segment

7. Patients with < 3 rib fractures which are displaced fractures at risk of pulmonary complications

8. Pre-existing pulmonary disease

Chest wall injuries are common In blunt chest trauma and the majority of cases are treated non-operatively [1,4,7]. Most of the BCT cases are seen in the setting of motor vehicular accidents especially when patients are seat belted or sustain frontal impact to the steering wheel [2,3]. Rib fractures are found in up to 10% of all trauma patients and 30% of patients presenting with chest trauma [1,3,19]. Sternal fractures and scapular fractures are less common, accounting for 8% and 3.5% respectively of BCT patients [1,3,19]. Rib fractures are diagnosed clinically or radiologically an initial chest x-ray [1,24]. Patients will complain of pain and dyspnoea on physical examination and may be found to have tenderness, crepitus, or diminished breath sounds [1,3,24]. Patient with less than 3 rib fractures and no associated Injuries are appropriate candidates for outpatient management with oral analgesics, however, Management should be on the case to case basis [1,3,19]. Pain management begins with standing acetaminophen and NSAIDS with opioids administered as needed [1,4]. Demand only Patient Controlled Analgesia (PCA) with opioids is effective when pain is more severe, but patients should be transitioned to oral narcotics as they clinically improve [1,3]. In patients with multiple or displaced rib fractures and those with pain refractory to pharmacologic management, regional anaesthesia techniques are employed [1,4]. These include placement of epidural catheters, paravertebral blocks and intercostal nerve blocks [1,4]. The EAST trauma guidelines advocate for the use of epidural anaesthesia in patients with more than 3 rib fractures, or patients with less than 3 rib fractures but who are more than 65 years old, or who have a significant history of cardiopulmo-nary disease [1,3,19]. Compared to other forms of analgesia, a continuous epidural infusion has shown to re-duce the need for mechanical ventilation, length of intensive care unit stay, or mortality [1,4]. Paravertebral catheters administer a local anaesthetic to the paravertebral space and have comparable efficacy to epidural catheter but with a lower rate of causing sys-temic hypotension [2,3]. Surgical rib fixation is reserved for pa-tients in whom adequate analgesia cannot be achieved due to frac-ture severity and those with impending respiratory failure [1,3,19]. Ideally to be performed within 48 to 72 hours of injury [1,3,19].

3.5.1. Role of Pain Control in BCT: Pain control significantly affects mortality and morbidity in patients with blunt chest trauma [1,2]. Pain leads to splints which worsen or prevent healing. In many cases it can lead to pneumonia [2,3]. Early analgesia should be considered to decrease splinting. In the acute setting push doses of short acting narcotics should be used. Other pain control op-tions include intrapleural blocks, epidural an-aesthesia, transder-mal patches, and intravenous patient controlled analgesia (PCA) [2,3]. Non-narcotic transdermal patches are safe pain management options for many patients [1,2]. It should be considered for pa-tients with persistent chest wall pain despite lack of confirmed rib fractures, the patient being discharged or as an adjunct while ad-mitted [1,2].

3.5.2. Role of Antibiotics: Prophylactic antibiotics for tube thora-costomy for BCT did not reduce the incidence of empyema or pneumonia when placed with sterile technique [3,4]. Antibiotics play a significant role in pulmonary contusions secondary to BCT [3,4].

3.5.3. Role of Surgical Management of Rib Fractures: Open Reduction and Internal Fixation (ORIF) have shown to decrease mortality in patients with flail chest, shorten the duration of me-chanical ventilation, reduce hospital stay and reduce intensive care length of stay [1,4].

3.5.4. Role of Supportive Care: Supportive care such as postural drainage, chest physiotherapy, incentive Spirometry, suctioning, encouraging coughing and deep breathing help to prevent atelec-tasis [1,3]. Prone positioning of the patient with contusion reduces the stress on the diaphragm and positioning of the contused lung in a non-dependent position helps to recruit alveoli [1,3]. Non-in-vasive ventilation can cause gastric dis-tension and aspiration es-pecially if the level of consciousness is impaired [1,4]. If positive pressure ventilation fails, invasive ventilation is required [1,3]. Large tidal volume can have adverse effects hence use of Low tidal volume is suggested [2,4]. Patients with severe hypoxia and poor response to other therapies can benefit from nitric oxide. Diuretics can be used in a contusion to reduce pulmonary venous resistance and pulmonary capillary hydrostatic pressure [2,4]. If fluid therapy is re-quired to maintain euvolaemia, measuring pulmonary artery pressure is recommended to avoid pulmonary oedema [2,4].

Flail chest occurs when three or more contiguous ribs are fractured in at least two locations. This leads to the paradoxical movement of the flail segment during respiration [1,3,9]. This injury itself is usually not the cause of respiratory compromise [1,3,9]. Respira-tory failure in these patients typically results from the underlying presence of a pulmonary contusion [1,3,9]. Pulmonary contusions them-selves usually progress over the first 12 to 24 hours post in-jury, in which time worsening of hypoventilation & hypoxaemia May necessitate intubation [1,3]. Initial chest x-ray usually under-estimates the degree to which the lung parenchyma is damaged and patients with primary pulmonary contusion should therefore be admitted and serially monitored for signs of impending decom-pensation [2,3,10].

Tension pneumothorax is the presumed diagnosis when patients present with chest trauma, respira-tory distress and hypotension [1,4,23]. A physical exam will also demonstrate specific clinical signs such as tracheal deviation away from the affected side, de-creased or absent breath sounds on the affected side, and subcuta-neous emphysema [1,3]. If recognised in the field, immediate de-compression using a 14-gauge needle placed in the 2nd intercostal space in the mid clavicular line is indicated [1,3,23]. It should be noted that recent data suggests that needle decompression through the 5th intercostal space in the anterior axillary line correlates with a lower chance of failure (16.7%). Once in the emergency depart-ment, patients who have undergone a needle decompression in the field must then undergo immediate tube thoracostomy for defini-tive management [1,2,17].

Massive haemathorax is defined as greater than 1500ml of blood in the adult population [1,3]. In BCT it is most commonly due to multiple rib fractures with associated lacerated intercostal arteries, however bleeding can also be due to lung parenchymal laceration in which case there is usually an associated air leak [2,3,12]. Re-gardless of the aetiology, massive haemathorax is an indication of operative intervention, but the patient's condition should first be stabilised with tube thoracostomy to facilitate lung re-expansion [2,3,12].

3.6. When Should the Thoracic Surgeon Definitely be Involved? [1,4,7]

According to the ATLS guidelines this is recommended as follows:

1. Blood loss over the chest tube >1500ml initially or >200ml/hr over 2-4 hours
2. Haemoptysis
3. Massive subcutaneous emphysema
4. Important air leakage over the chest tube
5. Uncertain images on the chest x-ray or CT thorax
6. Penetrating chest trauma

3.7. Indicators for an Immediate Thoracic Surgical Intervention: [1,4,7]

1. Blood loss >1500ml initially or >200ml/hour over 2-4 hours
2. Endobronchial blood loss; massive contusion with significant impairment of mechanical ventilation
3. Tracheobronchial tree injury (air leakage/ haemothorax)
4. Injury of the heart or large vessels (Blood loss/ pericardial tamponade)

Anterolateral thoracostomy in the 4th-6th intercostal space is usually recommended, although in 20% of patients it is insufficient to visualise all lesions and must be modified [2]. Clamshell (transverse sternotomy and bilateral anterolateral thoracostomy) will permit better exposition of thoracic organs [2]. The necessity for emergency room thoracotomy is extremely rare, anterolateral thoracotomy will permit a potentially life-saving measure (clamping of a great vessel) in an extreme situation before proceeding to the operating theatre [3].

3.8. Role of VATS in BCT [1,3,18]

The role of minimal invasive surgery in management of chest trauma should not be under or over estimated. The amount of randomised prospective data for Video-Assisted Thoracoscopic Surgery (VATS) management in chest trauma patient is very sparse.

VATS as a procedure for pleural space management:

In the non-critical, non-massive transfusion patients, in haemodynamically unstable patients with severe chest wall or cardiac vessel injury and massive blood transfusion there is no role for VATS.

Indications for VATS in chest trauma:

1. Penetrating injury with little blood loss in a stable patient
2. Persistent haemothorax
3. Empyema
4. Persistent air leakage
5. Suspicion of diaphragmatic rupture

4. Discussion

Trauma is the leading cause of death worldwide. Approximately two third of these patients have blunt chest trauma with varying severity from a simple rib fracture to flail chest. Blunt chest trauma is most common with 90% incidence, of which less than 10% require surgical intervention of any kind. Thoracic surgeons are usually not part of the trauma team in most hospitals. The objective of this review article is to throw light on the management of blunt chest trauma cases – multiple rib fractures, flail chest, haemathorax, pneumothorax, and the role of thoracic surgeons in blunt chest trauma. Recent advances in minimal invasive surgery in chest trauma are gaining scope in today's world. Geriatric patients have higher mortality compared to younger patients with the same injuries. Elderly patients with a single rib fracture have twice the mortality as their younger counterparts with the same injury. Mortality increases by 19% for each additional rib fracture and the risk of pneumonia by 27%. Chest trauma is a common problem encountered by the emergency department, blunt chest trauma is best managed by a multidisciplinary team that consists of general surgeons, nurse practitioners, anaesthesiologists, thoracic surgeons, ICU nurses, and cardiac surgeons. Depending on the extent of injury, the outcomes of chest trauma vary from isolated rib fractures where the prognosis is good, to aortic disruption where the prognosis is poor. The highest morbidity following chest trauma is seen in very young and very old patients.

5. Conclusion

Blunt chest trauma is a common clinical entity ranging from a simple rib fracture to flail chest. Blunt chest trauma is best managed by a multidisciplinary team which consists of general surgeons, nurse practitioners, anaesthesiologist, ICU specialists, physiotherapists and thoracic surgeons, however the main role is played by the general surgeons. In the management, thoracic surgeons are usually not involved as a part of the trauma team because surgical intervention in the management of blunt chest trauma is rare except in severely injured patients. The objective of this article is to review literature on various aspects in the management of blunt chest trauma.

Younger patients have better prognoses as compared to geriatric patients with the same injuries.

A majority of the BCT cases are managed nonoperatively or conservatively with only a handful of cases which need surgical intervention by thoracic surgeons.

References

1. Jain A, Waseem M. Chest trauma. Stat pearls. 2022; 1-15.
2. Edgecombe L, Sigmon DF, Galuska MA, Angus LD. Thoracic trauma. 2022; 1-14.
3. Ludwig C, Koryllos Aris J. Management of chest trauma. Thorax Dis. 2017; 9 (Suppl 3): S172-S177.
4. Nadir N, Stuempfig N. Saem. 2019; 1-10
5. Seamon MJ, Haut ER, Van Arendonk K, Barbosa RR, Chiu WC, Dente CJ, et al. An evidence-based approach to patient selection for emergency department thoracotomy: A practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg. 2015; 79(1): 159-73.
6. Miserocchi G. Physiology and pathophysiology of pleural fluid turnover. Eur Respir J. 1997; 10(1): 219-25.
7. Meredith JW, Hoth JJ. Thoracic trauma: when and how to intervene. Surg Clin North Am. 2007; 87(1): 95-118.
8. Lichtenstein DA, Mezière G, Lascols N, Biderman P, Courret JP, Gepner A, et al. Ultrasound diagnosis of occult pneumothorax. Crit Care Med. 2005; 33(6): 1231-8.
9. DiGiacomo JC, Angus LDG. Thoracotomy in the emergency department for resuscitation of the mor-tally injured. Chin J Traumatol. 2017; 20(3): 141-146.

10. Goodman M, Lewis J, Guitron J, Reed M, Pritts T, Starnes S. Video-assisted thoracoscopic surgery for acute thoracic trauma. J Emerg Trauma Shock. 2013; 6(2): 106-9.

11. Dyer DS, Moore EE, Ilke DN, McIntyre RC, Bernstein SM, Durham JD, et al. Thoracic aortic injury: how pre-dictive is mechanism and is chest computed tomography a reliable screening tool? A prospective study of 1,561 patients. J Trauma. 2000; 48(4): 673-82.

12. Galvagno SM, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Pain management for blunt thoracic trauma: A joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. J Trauma Acute Care Surg. 2016; 81(5): 936-51.

13. Sirmali M, Türüt H, Topçu S, Gülhan E, Yazici U, Kaya S, et al. A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. Eur J Cardiothorac Surg. 2003; 24(1): 133-8.

14. Salim A, Sangthong B, Martin M, Brown C, Plurad D, Demetriades D. Whole body imaging in blunt multisystem trauma patients without obvious signs of injury: results of a prospective study. Arch Surg. 2006; 141(5): 468-73.

15. Rodriguez RM, Anglin D, Langdorf MI, Baumann BM, Hendey GW, Bradley RN, et al. NEXUS chest: validation of a decision instrument for selective chest imaging in blunt trauma. JAMA Surg. 2013; 148(10): 940-6.

16. Rodriguez RM, Langdorf MI, Nishijima D, Baumann BM, Hendey GW, Medak AJ, et al. Derivation and validation of two decision instruments for selective chest CT in blunt trauma: a multicenter prospective observational study (NEXUS Chest CT). PLoS Med. 2015; 12(10): e1001883.

17. Champion HR, Copes WS, Sacco WJ, Lawnick MM, Keast SL, Bain LW, et al. The Major Trauma Outcome Study: establishing national norms for trauma care. J Trauma. 1990; 30(11): 1356-65.

18. Moore FO, Goslar PW, Coimbra R, Velmahos G, Brown CV, Coopwood TB, et al. Blunt traumatic occult pneumothorax: is observation safe? --results of a prospective, AAST multicenter study. J Trauma. 2011; 70(5): 1019-23.

19. Brasel KJ, Moore EE, Albrecht RA, deMoya M, Schreiber M, Karmy-Jones R, et al. Western Trauma Association Critical Decisions in Trauma: Manage-ment of rib fractures. J Trauma Acute Care Surg. 2017; 82(1): 200-3.

20. Inaba K, Ives C, McClure K, Branco BC, Eckstein M, Shatz D, et al. Radiologic evaluation of alternative sites for needle decompression of tension pneumothorax. Arch Surg. 2012; 147(9): 813-8

21. Tang GL, Tehrani HY, Usman A, Katariya K, Otero C, Perez E, Eskandari MK. Reduced mortality, paraplegia, and stroke with stent graft repair of blunt aortic transections: a modern meta-analysis. J Vasc Surg. 2008; 47(3): 671-5.

22. Rhee PM, Acosta J, Bridgeman A, Wang D, Jordan M, Rich N. Survival after emergency department thoracotomy: review of published data from the past 25 years. J Am Coll Surg. 2000; 190(3): 288-98.

23. Clark GC, Schecter WP, Trunkey DD. Variables affecting outcome in blunt chest trauma: flail chest vs. pulmonary contusion. J Trauma. 1988; 28(3): 298-304.

24. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma. 1994; 37(6): 975-9.

25. Veysi VT, Nikolaou VS, Paliobeis C, Efstathopoulos N, Giannoudis PV. Prevalence of chest trauma, associated injuries and mortality: a level I trauma centre experience. Int Orthop. 2009; 33(5): 1425-33.

26. LoCicero J, Mattox KL. Epidemiology of chest trauma. Surg Clin North Am. 1989; 69(1): 15-9.

27. Ekpe EE, Eyo C. Determinants of mortality in chest trauma patients. Niger J Surg. 2014; 20(1): 30-4.

28. Davis JS, Satahoo SS, Butler FK, Dermer H, Naranjo D, Julien K, et al. An analysis of prehospital deaths: Who can we save? J Trauma Acute Care Surg. 2014; 77(2): 213-8.

29. Ebrahimi A, Yousefifard M, Mohammad Kazemi H, Rasouli HR, Asady H, Moghadas Jafari A, et al. Diagnostic Accuracy of Chest Ultrasonography versus Chest Radiography for Identification of Pneumothorax: A Systematic Review and Meta-Analysis. Tanaffos. 2014; 13(4): 29-40.

30. Nagarsheth K, Kurek S. Ultrasound detection of pneumothorax compared with chest X-ray and computed tomography scan. Am Surg. 2011; 77(4): 480-4.