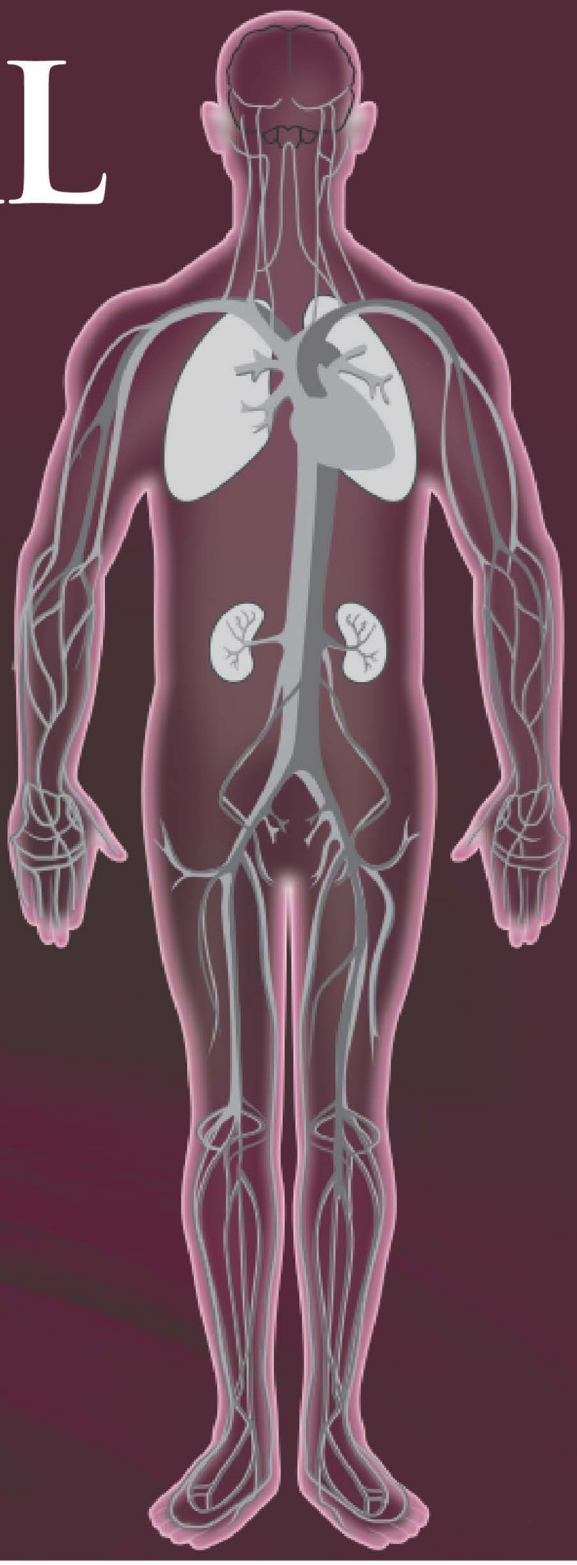
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Critical Care Update 2017



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3

CHAPTER

Blunt Chest Trauma

Mahesh Nirmalan, James Hanison

INTRODUCTION

Blunt chest trauma is a leading cause of hospital admissions and mortality worldwide. It represents between half and two-thirds of all chest trauma patients and the most common mechanism of injury is road traffic accident.[1,2] The victims of blunt chest trauma are mostly younger males and the observed mortality rates may vary considerably ranging between 6 and 45%. This wide variation in the reported mortality figures reflects the differences in the initial impact, severity of injuries, effectiveness in prehospital care, and subsequent definitive medical treatment in emergency departments. In general, the evolution of signs and symptoms shows a very consistent pattern, reflecting the physiological consequences of the initial bony/soft tissue injuries and the (predictable) onset of secondary pulmonary complications, if these injuries are managed ineffectively or inadequately in the early stages. Therefore, the early management of blunt chest trauma has drawn considerable interest in recent years.

PATTERNS OF INJURY

Rib Fractures

Rib fractures are the most common injuries sustained following blunt chest.[2] It is estimated that approximately 10% of all trauma patients may sustain one or more rib fractures as part of their initial injury.[3] Rib fractures may be associated with considerable pain, which renders breathing and coughing difficult and/or ineffective. They may also be associated with direct injury to the lung parenchyma causing contusions on the lung surface or frank hematomas within and around the lungs. These changes may impair ventilation or cause an increase in shunting, ventilation/perfusion mismatch, and/or dead-space ventilation. All of the above mechanisms may cause respiratory failure—characterized by hypoxemia, hypercarbia, labored breathing, and ineffective sputum clearance. Rib fractures also frequently lead to delayed morbidity as a result of atelectasis and nosocomial infections that occur within collapsed or poorly ventilated alveolar units. These delayed complications are usually attributed to ineffective clearance of secretions associated with poor/ineffective cough and inadequate chest expansion during tidal breathing. As a result, approximately 6–10% of patients develop pneumonia and in 4% or so the infections are severe enough to cause death.[4] The National Patient Safety Agency in the United Kingdom has identified these patients as "at-risk patients" to highlight the need for early recognition and careful monitoring within a high-care environment, where effective analgesia, physiotherapy, and controlled mobilization may be achieved in order to minimize the onset of these complications.[5]

In this context, some scoring systems have been developed, so that at-risk groups may be identified early and triaged to a high-care environment. Easter et al. developed a simple scoring system to assess the likelihood of developing complications following rib fracture[6] where the total score was calculated on the basis of the number of fractures, whether or not the injury was unilateral or bilateral with an additional factor assigned to age, reflecting the fact that elderly patients were more prone to respiratory complications after injury.

Easter's rib fracture score = (breaks × sides) + age factor

The allocated age factor was:

- Less than 50 years = 0
- 51–60 years = 1
- 61–70 years = 2
- 71–80 years = 3
- More than 80 years = 4.

It was suggested that patients with a higher score had a greater propensity to develop pulmonary complications and, therefore, greater length of stay in the hospital. The validity of this scoring system was evaluated by Maxwell et al. who found that, although higher scores were associated with a greater length of stay in intensive care unit (ICU) and hospital, the correlation between the variables was moderate-to-weak. Furthermore, the clinical usefulness of the score to guide

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TABLE 1 **Chest wall trauma scoring system**

Age (years) • <45—1 point • 45–65—2 points • >65—3 points	*Number of rib fractures* • <3 breaks—1 point • 3–5 breaks—2 points • >5breaks—3 points
Pulmonary contusion • None—0 points • Mild—1 point • Severe—2 points • Bilateral—3 points	*Bilateral rib fractures* • Unilateral fractures—0 points • Bilateral fractures—2 points
Total score: _____	

decision making, such as discharge to the ward or home, was also limited.[7]

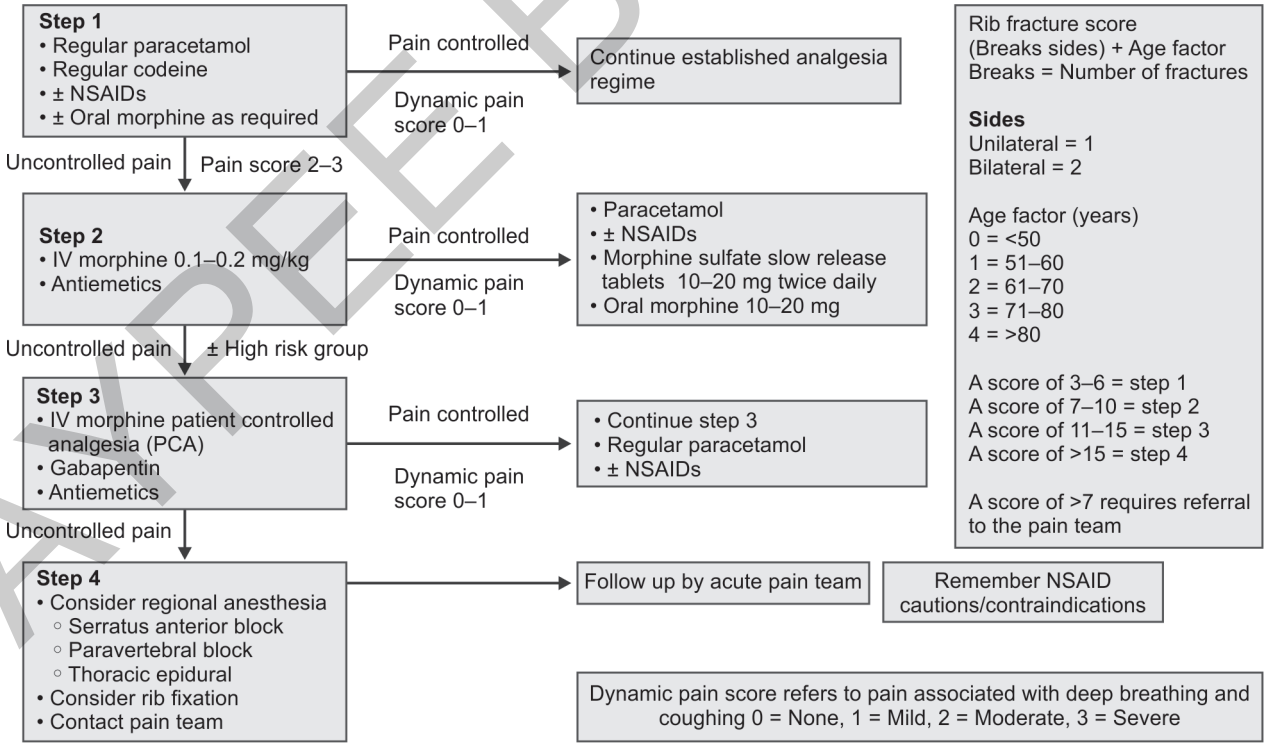
Pressley et al. developed a more elaborate scoring system based on the number of fractures, age and the severity of lung contusions and this system is shown in table 1. This study found that patients with a cumulative score of >7 had a mortality of 14.3% compared to patients with scores of ≤6 who had a mortality of 4.2%. They also found that patients with lower scores were less likely to be mechanically ventilated, less likely to be admitted to ICU and had a shorter length of stay in hospital.[8]

It is clear that both scoring systems are based on several arbitrary criteria and, hence, will lack sensitivity and specificity when it comes to predicting clinical outcome in individual patients. Nevertheless, the usage of such systems will help to have a systematic approach to routine management of patients with rib fractures. This systematic approach is particularly useful to standardize the provision of analgesia and to set thresholds for the introduction of regional analgesic techniques at the early stages.

Analgesia for Rib Fracture

Several analgesia options are available including intravenous opioids (usually with a patient-controlled analgesia), nonnarcotic analgesics, and regional anesthetic techniques. May et al. have incorporated the Easter rib fracture score into an algorithm to guide the intensity of the multimodal analgesic regimen according to risk factors (Flowchart 1).[9]

Clinical trials suggest that effective thoracic epidural analgesia decreases the duration of mechanical ventilation, incidence of nosocomial pneumonia, and improves pulmonary function following rib fractures as compared to parenteral opioids alone.[10,11] However, to date no mortality benefits have been demonstrated and this has led to a poor uptake of epidural blocks even in larger trauma centers. It must, however, be emphasized that in these patient groups the clinical trajectories determining death or survival are "sensitively dependent" on several factors that cannot be controlled for in clinical trials. Consequently, the absence of



IV, intravenous; NSAID, nonsteroidal anti-inflammatory drug.

FLOWCHART 1: Multimodal analgesic regimen for rib fracture

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"mortality benefits" must not be used as an argument to deny patients a treatment modality, such as epidural analgesia, that has been shown to have several short-term benefits including better quality of analgesia, reduced incidence of nosocomial infections, and decreased need for mechanical ventilation.[12] These short-term benefits are important and valid endpoints when it comes to assessing the effectiveness of thoracic epidural analgesia. Many patients may have contraindications to epidural analgesia, such as coagulopathy, and in such patients there is a need to consider other regional anesthetic techniques such as paravertebral blocks and serratus plane block. Both these techniques are amenable to continuous local anesthetic infusion via indwelling catheters, but require skilled personnel and appropriate equipment to provide them. Paravertebral block has been demonstrated as noninferior to epidural analgesia in terms of efficacy and preservation of pulmonary outcomes.[13] Serratus plane block was first described in 2013 and as such has not entered common practice yet.[14] Intrapleural and intercostal regional anesthetic techniques are, however, not recommended due to inferior safety and efficacy profiles.[9]

Overall, having a protocol-driven approach to analgesia, using a dedicated team whose members have a specialized interest in regional analgesic techniques and an objective scoring system to guide decision making is to be strongly recommended in the management of patients with multiple rib fractures.

Rib Fixation

Over the past few years, surgical plating technology has improved to the point of making surgical fixation of fractured ribs a viable option. There is increasing evidence that this is an appropriate treatment in selected patient groups. Marasco et al. evaluated the effect of surgical rib fixation for patients who were ventilator dependent with flail segment rib fractures. They found that surgical rib fixation reduced the length of stay on ICU and reduced the requirement for noninvasive ventilation (NIV) postextubation.[15] Tanaka et al. also evaluated surgical rib fixation in ventilator-dependent patients and found a shorter duration of mechanical ventilation, shorter ICU stay, and improved pulmonary function tests at 12 months.[16]

The rib fixation technology has been assessed by the National Institute for Health and Care Excellence (NICE) in the United Kingdom and they assert that rib fixation technology is safe and current evidence suggests benefit in selected patient groups. The NICE guidelines suggest that careful patient selection should be made by critical care specialists, chest physicians, and thoracic surgeons with appropriate experience.[17] In particular, patients with more than four rib fractures, flail segments, and >45 years of age are currently considered suitable candidates for surgical rib fixation even though with greater experience and development of safer surgical techniques this list may expand in the future.

Injuries to Intrathoracic Viscera

The most common presentation following blunt thoracic trauma is a bony fracture of the thorax. However, many mechanisms of injury contain a considerable transfer of energy to the patient and injures to the heart, lungs, and associated structures must always be considered. Indeed, Shorr et al. noted that almost 25% of patients presenting with blunt chest trauma may have injuries to intrathoracic viscera in the absence of bony fractures.[18] A high index of clinical suspicion coupled with trauma series computed tomography (CT) scan imaging is essential, if these intrathoracic injuries are not to be missed in the early stages.

Hemothorax

Hemothorax is the second most common injury after rib fractures following blunt chest trauma.[2] There is a wide spectrum of severity of hemothorax with some representing massive and persistent blood loss and some being more minor. Recent guidance suggests that all hemothoraces should be considered for insertion of an intercostal drain and if >1,500 mL of blood is drained then surgical exploration should be considered.[19] They also suggest that persistent hemothorax following drain or a persistent air leak should trigger early surgical exploration in preference to repeated intercostal drain insertion.[17]

Pneumothorax

Pneumothorax is a frequent and serious complication following chest trauma. The intrapleural air can arise from laceration of the lung parenchyma by fractured ribs or by disruption of lung parenchyma by the forces and pressures generated at the time of the injury. Although the current British Thoracic Society guidelines for the management of spontaneous pneumothoraces suggest that some low-risk patients may be suitable for observation or needle aspiration,[20] the situation is different in trauma patients. Due to the dynamic and evolving nature of lung injury in the context of trauma, insertion of an intercostal drain should be considered in all trauma patients who have a pneumothorax at the time of initial presentation. While it is accepted practice to insert an intercostal drain for pneumothoraces that are large enough to be visible on chest X-ray (CXR), the correct approach for patients in whom a small pneumothorax is detected on a trauma series CT scan alone remains uncertain. It is recommended that such "occult" pneumothoraces may be considered for conservative management, unless they receive positive pressure ventilation.[21]

Pulmonary Contusion

Pulmonary contusion is a relatively frequent complication following blunt chest trauma. Pulmonary injury triggers an

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inflammatory cascade that results in pulmonary infiltrates, reduced compliance, pulmonary hypertension, and impaired gas exchange. Pulmonary contusion in isolation does not carry a large risk of death with one study finding 100% survival after isolated pulmonary contusion.[22] However, the appropriate fluid management strategy in patients with significant lung contusion remains controversial. The current evidence suggests that patients with pulmonary contusion should not be subjected to excessive fluid restriction. On the contrary they should be resuscitated as necessary with isotonic crystalloid (or colloid solution—depending on the overall hemodynamic picture) to achieve adequate tissue perfusion soon after injury. Once the usual resuscitation endpoints have been achieved, further fluid administration (usually in pursuit of an ambitious/erroneous level of urine output figure) should be meticulously avoided. Invasive hemodynamic monitoring techniques may aid in optimizing hemodynamic status while avoiding excessive fluid administration.

Patients with lung contusion and in need of respiratory support should be supported using a step-ladder approach involving positive end-expiratory pressure/continuous positive airway pressure, NIV, and mechanical ventilation using low-tidal volumes. In practical terms, the approach that should be adopted is no different to those with suspected acute lung injury and all attempts, including effective analgesia using regional techniques and minimal use of opiates/sedation should be employed to facilitate early weaning/extubation. Steroids, prophylactic antibiotics, or repeated bronchoalveolar lavages have no role in the management of lung contusions.

Diaphragmatic Rupture

Diaphragmatic injury is less frequent in blunt trauma as opposed to penetrating trauma, but is still present in 1–7% of cases. The left hemidiaphragm is most frequently affected with herniation of abdominal viscera into the thorax. Right hemidiaphragm rupture may be associated with major vessel disruption and associated high-morbidity risk. Bilateral rupture is rare.[23] Computed tomography imaging remains the modality of choice to detect diaphragmatic injuries. Chest X-ray has a low sensitivity, particularly in right-sided injuries where the liver may prevent herniation of abdominal viscera into the thorax.[24] Repair of diaphragmatic injury requires surgical treatment. Approach via laparotomy is most frequently performed, but thoracoscopic or combined approaches are also performed. Laparoscopic repair is also feasible.[25]

Tracheobronchial Injury

Tracheobronchial injuries are an infrequent complication following blunt chest trauma. One study found that injuries occur most frequently to the bronchi within 2 cm of the carina with right-sided injuries being more frequent, but left-sided injuries have better outcomes.[26] Another study found equal distribution of injuries throughout the trachea, carina, and bronchus.[27] Mortality is <10%.[24,25]

Myocardial Contusion

Myocardial contusion is found to be present in approximately 10–20% of all admissions with blunt chest trauma. Abnormalities include ECG changes, elevated serum troponin, and regional wall motion abnormalities on echocardiography.[28] Although this seems to be a relatively frequently occurring event, the potential for long-term harm seems low.[29]

Disruption of the Aorta

Injury to the thoracic aorta is an uncommon presentation following blunt chest trauma, but represents a significant risk of mortality. It is estimated to be present in <0.5% of cases. However, it has been demonstrated in approximately one-third of patients who die before arrival in hospital following road traffic accident.[30] The majority of patients, who do survive to hospital, have injuries that are located at the aortic isthmus. False aneurysm, dissection, and intimal tear may occur with false aneurysm being most frequent. In such patients, the presence of aortic injuries usually signify a high velocity injury and consequently as many as one-third of cases will die within 4 hours of hospital attendance, usually associated with multiple visceral injuries.

The Eastern Association for the Surgery of Trauma has made several recommendations for the investigation and management of aortic injury. They recommend contrast CT over the traditional aortic angiography, as the preferred method of imaging and endovascular repair in preference to open repair. They also recommend delayed repair over immediate repair as this planned approach is associated with reduced mortality.[31] The Society for Vascular Surgery recommend endovascular repair for management of traumatic thoracic aortic injury as it is associated with reduced mortality, reduced renal injury, reduced cord ischemia, and reduced infection rates.[32]

Cardiac Tamponade

Cardiac tamponade is most commonly associated with penetrating chest trauma.[33] It can also occur following blunt trauma, and when it does, the prognosis is grave. One case series found that all cases presenting with cardiac lacerations and tamponade in the context of blunt trauma died despite intervention.[18] Emergency thoracotomy is rarely indicated in blunt thoracic trauma with chances of survival being very low following this intervention.[34]

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IMAGING MODALITIES

Computed Tomography

A review of trauma patients in Australia following blunt thoracic trauma found that CT was significantly more sensitive at detecting rib, sternum, and vertebral fractures as compared to CXR. It was also significantly more sensitive at detecting pneumothorax, hemopneumothorax, and lung contusion.[35] It was, however, noted that positive CT findings—not present on the conventional CXR, altered management in only 6% of patients following blunt chest trauma as the majority of small pneumothoraces and lung contusions did not require any specific interventions.[36] Patients with chest wall tenderness, reduced air entry, or abnormal respiratory effort were more likely to have additional findings detected on CT following a plain CXR.

The number of patients presenting with trauma is large and it is, therefore, necessary to select patients who should be subjected to CT scans. Current guidelines recommend that all patients who have sustained major trauma and multiple injuries should receive a CT scan from vertex of head to mid-thigh (the trauma CT).[37] Therefore, all patients with major multiple injuries will receive a CT. The decision, therefore, remains about which patients who have sustained isolated and minor chest injuries would benefit from a CT scan. Repeated clinical review and repeated observation of clinical signs of impending respiratory failure remain key to decision making in this context.

Lung Ultrasound

Ultrasonography of the chest has been increasing in popularity over the last two decades due to the increased availability, safety, and the potential for repeated bedside use. Protocolized scanning regimes have been developed such as the Bedside Lung Ultrasonography in Emergency (BLUE) protocol[38] for patients in critical care and the extended Focused Assessment with Sonography for Trauma (FAST) scan, which is specifically designed for use in trauma.[39] Thoracic ultrasound has a comparable specificity and a superior sensitivity compared to plain CXR.

Ultrasonography is a well-established modality of assessment in trauma patients with FAST scans routinely taught in Advanced Trauma Life Support (ATLS) courses. The inclusion of thoracic ultrasound is a sensible and feasible extension of this approach and may have the added benefit of detecting pneumothoraces not detected on plain CXR. Though not superior to CT, it may provide results more rapidly at the bedside.

Echocardiography

Both transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) have been assessed in the context of blunt chest trauma. Karalis et al. found that TTE-provided suboptimal views in one in five patients with blunt chest trauma, whereas TEE was optimal in those. They found 30% of patients displayed myocardial contusions and this was predictive of developing cardiac complications, although only 4% of patients in total actually required treatment for cardiac complications.[40] Charillo et al. found that TTE was only possible in 38% of cases compared to 98% with TEE. They noted that TEE demonstrated 93% sensitivity in detecting aortic rupture.[41] Transesophageal echocardiography has been demonstrated to have a superior sensitivity and equal specificity to helical chest CT in the detection of traumatic arterial injuries after blunt chest trauma. Transesophageal echocardiography also appears to be more sensitive at detecting myocardial contusions compared to CT.[42]

Echocardiography appears to have a useful role in detecting arterial ruptures following blunt chest injury, at least as effectively as CT scan and TEE is more likely to provide consistently useful images in most patients. Echocardiography is more effective than CT at detecting myocardial injury although only a small proportion of these patients will go on to require treatment for cardiological complications.

SCORING SYSTEMS

Scoring systems, specific for rib fractures, have already been alluded to. A number of more generic scoring systems have also been developed to evaluate patients following blunt chest trauma of any kind (including all patients regardless of injury sustained). These scoring systems include the Pulmonary Contusion Score[43] and the Thoracic Trauma Severity Score (Table 2).[44]

TABLE 2 **Thoracic Trauma Severity Score**

Age (years) • <30—0 points • 30–41—1 point • 42–54—2 points • 55–70—3 points • >70—5 points	*PaO_2 to FiO_2 ratio (mmHg/dL)* • >400—0 points • 301–400—1 point • 201–300—2 points • 150–200—3 points <150—5 points
Pulmonary contusion • None—0 points • 1 lobe unilateral—1 point • 1 lobe bilateral—2 points • 2 lobes unilateral—3 points • <2 lobes bilateral—4 points • >2 lobes bilateral—5 points	*Pleural involvement* • None—0 points • Pneumothorax—1 point • Unilateral hemothorax—2 points • Bilateral hemothorax—3 points • Tension pneumothorax—5 points
Rib fractures • None—0 points • 1–3—1 point • 3–6 unilateral—2 points • >3 bilateral—3 points • Flail chest—5 points	Total score: _____

PaO_2, partial pressure arterial oxygen; FiO_2, fraction of inspired oxygen.

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Mommsen et al. evaluated a number of scoring systems and compared them against established trauma scoring systems and found that the Thoracic Trauma Severity Score had superior sensitivity and specificity for predicting multiple organ dysfunction syndrome, acute respiratory distress syndrome (ARDS) and mortality.[45]

LONG-TERM OUTCOME

Prolonged pulmonary morbidity, after the acute stages of the illness has revolved, has been reported in patients who sustained blunt chest trauma. Leone et al. found that patients had reduced exercise tolerance, altered pulmonary function tests and reduced quality of life at 6 months and 1 year on follow-up.[46] Whether this is a distinct disease entity or the sequelae of acute lung injury/ARDS itself remains to be elucidated.

CONCLUSION

Blunt chest trauma is a significant cause of morbidity and mortality and mainly affects young people. From the point of view of the general intensivists, the key management priorities should be focused around:

- Provision of effective analgesia using a standardized analgesic ladder guided by one of the objective rib fracture scoring systems within a high-care area where close hemodynamic monitoring is feasible
- Hemodynamic optimization using isotonic solutions and the avoidance of fluid over prescription once resuscitation targets have been achieved
- Step-ladder approach to respiratory support, including early weaning from mechanical ventilation
- Correct identification of patients who may benefit from surgical rib-fixation
- Complete and early characterization of nonbony/visceral injuries using appropriate imaging modalities.

The imaging modality of choice is the trauma CT, even though echocardiography and other ultrasound-based techniques are used increasingly. Scoring systems have a role in predicting outcome but should be used judiciously when determining the clinical trajectory in any individual patient.

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