Management of Traumatic Rib Fractures

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KEY POINTS

- Rib fractures are common sequelae of chest wall trauma.
- Five or more rib fractures are associated with poorer clinical outcomes.
- Mortality significantly increases (approximately 30%) when flail chest occurs.
- Novel fascial plane blocks such as erector spinae blocks are increasingly used for analgesia.

INTRODUCTION

Rib fractures are common injuries worldwide, often occurring in the context of trauma. These usually occur as a consequence of blunt force trauma to the chest wall, such as that seen in road traffic accidents or falls from a height. However, there are increasing numbers of presentations with injuries following relatively innocuous mechanisms (eg, low-level falls) in older populations. This had led to more focus on so-called 'silver trauma' (trauma in older people) to improve trauma care in older patients with increased comorbidities and reduced physiological reserve.

Younger patients with isolated rib fractures generally manage with simple analgesia and are less likely to develop serious complications. In contrast, older patients and those with significant comorbidities are at much greater risk of developing respiratory complications such as atelectasis, pneumonia, and subsequent respiratory failure. Individuals with multiple displaced rib fractures and those with a 'flail' segment have a significantly increased morbidity and mortality. In these higher risk groups, a coordinated multimodal approach to management with a focus on optimal analgesia and respiratory support is vital to ensuring good outcomes.

ANATOMY

The chest wall is made up of 12 pairs of ribs. Each of these ribs articulates posteriorly with the vertebral column. There is a direct articulation between the first 7 ribs anteriorly with the sternum (Figure 1). Below this level the ribs are either attached to the sternum by costal cartilage (ribs 8 to 10) or termed 'floating ribs' (ribs 11 and 12), with no anterior articulations.

There is a neurovascular bundle which runs inferior to the corresponding rib and includes the intercostal artery, vein, and nerves.

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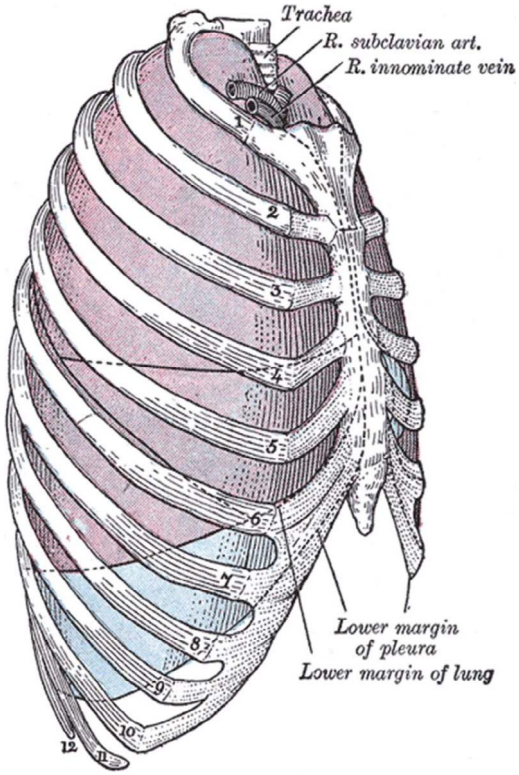

Figure 1. Lateral view of the thorax showing anterior articulations of the ribs. Reproduced from Bartleby.com; *Gray's Anatomy*, plate 966 (public domain) CC BY 3.0.

MECHANISM OF INJURY

Direct trauma to the chest wall is the most common cause of rib fractures. This may be due to high-impact trauma such as that seen in road traffic accidents or falls from height. A significant proportion of patients with major trauma will have an associated chest wall injury. With a growing elderly population, however, there are increasing numbers of elderly patients sustaining rib fractures following a simple fall from standing.

The posterolateral angle of the rib is structurally the weakest point. The pattern of injury, however, will often be determined by the site of impact and the degree of force applied.

It is important to note that due to the relative elasticity of tissues in young children, a significant force is required to result in rib fracture. This makes this clinical presentation rare in this age group and when it occurs, nonaccidental injury must be considered.

Less commonly, rib fractures can occur due to repeated coughing (stress fracture) or due to underlying malignancy (pathological fractures). The focus of this article, however, will be on rib fractures due to direct trauma.

COMPLICATIONS

Complications associated with traumatic rib injuries include

- pneumothorax,
- haemothorax,
- pneumonia,
- pulmonary contusion, and
- injury to major vessels and intra-abdominal organs.

The pattern of rib injury is important when considering the associated complications as summarised in Table 1.

The most important sequela of significant chest wall injury is worsening respiratory failure. The likelihood of patients with multiple rib fractures developing an associated pneumonia is high. This can further exacerbate problems with oxygenation and ventilation associated with the initial chest trauma (atelectasis, contusion). Severe pneumonia leading to respiratory failure is a major cause of death in this patient population.

Pattern of Injury	Clinical Significance
Fracture to first 2 ribs	Less common, indicates high-impact injury; associated with higher morbidity/mortality (potential injury to major vessels)
Displaced fractures	Risk of laceration to lung parenchyma; associated haemothorax/pneumothorax
Lower right ribs	Risk of hepatic injury
Lower left ribs	Risk of splenic injury

Table 1. Common Patterns of Rib Trauma and Clinical Significance

FLAIL CHEST

Flail chest is defined as fracture of 3 or more ribs in more than one place, often as a result of high-impact, blunt trauma (Figure 2). This results in a segment of the chest wall which is no longer in continuity with the rest. Consequently, the mechanical movement of the chest wall during normal ventilation is lost.

Clinically this can be seen as 'paradoxical' chest wall movement with inward movement of the flail segment with inspiration, due to negative intrathoracic pressure as the rib cage moves upward and outward. The opposite is seen during expiration, with outward movement of the unstable flail segment. This can significantly impair the mechanics of ventilation, leading to increased work of breathing and deteriorating respiratory function.

Flail chest is thought to occur in approximately 10% of all chest wall injuries, with associated mortality of greater than 30%.[1] These patients are much more likely to require intubation and ventilatory support and require early input from critical care.

ASSESSMENT

Patients with rib fractures require careful assessment to exclude any associated life-threatening injuries. This would normally be carried out in a structured Advanced Trauma Life Support–style approach by a hospital trauma team.

Identification of rib fractures may be difficult in patients with a reduced conscious level due to a head injury or in those with other painful distracting injuries. In patients with isolated injuries, localised pain to the chest wall, particularly with deep inspiration and associated tenderness or deformity, would raise suspicion of underlying rib fractures.

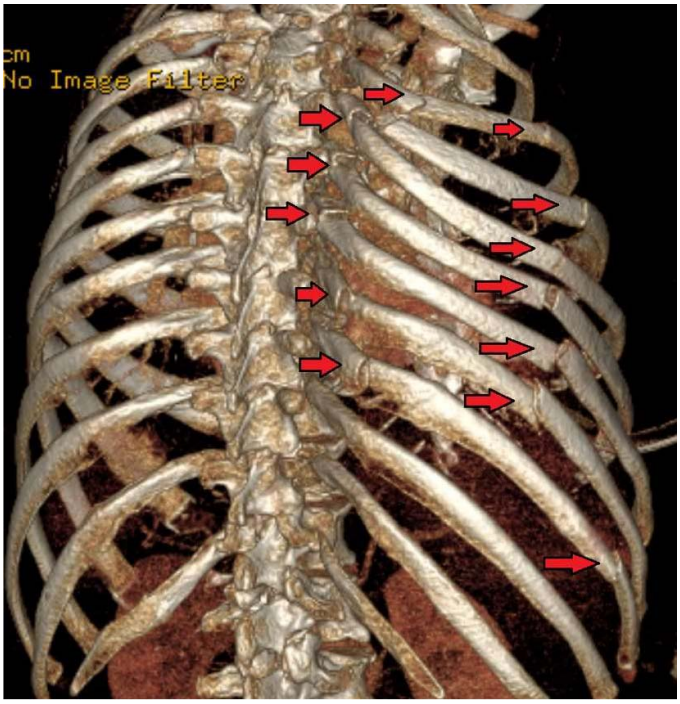

Figure 2. Three-dimensional reconstruction from a CT scan showing a flail chest (arrows mark the rib fractures). Reproduced from https://en.wikipedia.org/wiki/Flail_chest (image author: James Heilman MD) CC BY-SA 4.0.

The absence of breath sounds on the affected side or developing surgical emphysema may indicate the presence of an underlying pneumothorax. A tension pneumothorax could develop as a result of displaced rib fractures; this may need immediate needle decompression to prevent cardiovascular collapse.

An anteroposterior chest film performed as part of an initial primary survey of trauma patients may identify rib fractures, particularly if significantly displaced. This can usually be obtained with minimal delay in the emergency department and can help initial decision making in the context of major trauma. However, undisplaced rib fractures are often undetected on plain films, which may lead the clinician to underestimate the extent of the chest wall injury. This may lead to inappropriate disposition and missed opportunity for aggressive early management.

As availability of this resource increases, the imaging modality of choice for chest wall injury is a computed tomography (CT) scan of the thorax. This may be performed as part of a trauma scan (CT of head, neck, thorax, abdomen, and pelvis) in the context of major trauma. The primary indication is to identify any serious internal thoracic injuries, but it will also facilitate the early diagnosis of the number and degree of displacement of rib fractures. These can be converted into 3-dimensional reconstructions of the chest wall to demonstrate the nature of complex chest wall injuries.

MANAGEMENT

Risk Stratification

Isolated rib fractures in younger patients with little comorbidity rarely require admission to hospital. These patients may be suitable for discharge home from the emergency department with appropriate analgesia.

Age and number of rib fractures are the main factors which have been shown to increase the likelihood of complications and thus require admission to hospital.[2] This has led to the development of scoring systems to help stratify patients into risk categories to determine appropriate level of inpatient care. One such example, developed by Easter, is the rib fracture score[3]:

$$\text{Rib fracture score} = (\text{breaks} \times \text{sides}) + \text{age factor}.$$

Although questions have been raised as to the validity of this scoring system, it remains a useful tool in triaging patients to appropriate levels of analgesia and supporting decision making with regard to need for high-dependency care.[4] An adaption of this scoring tool used to guide pain management in patients with rib fractures is shown in Figure 3.[5]

At our institution, clinical factors taken into account when risk scoring patients

- age (+1 for each 10 years over age 10),
- rib fractures (+3 for each individual fracture),
- chronic lung disease (+5 if present),
- anticoagulant or antiplatelet therapy (+4 if present), and
- oxygen saturation in air (+2 for each 5% decrease below 95%).

Patients scoring 20 or more on the rib fracture score at our institution are referred to critical care for more aggressive management and consideration of regional anaesthetic techniques for analgesia in view of an increased risk of pulmonary complications.

A large retrospective review of older patients (over 65 years) with blunt chest trauma showed that having 5 or more rib fractures was a significant predictor of poorer outcomes, including an increased duration of hospital stay and the likelihood of admission to critical care.[6]

The significant pain associated with rib fractures results in reduced coughing and shallow breathing. This predisposes patients to complications such as atelectasis and pneumonia. Optimising pain control through a multimodal approach, in order to facilitate deep breathing and effective coughing to clear secretions, is the mainstay of treatment for these patients.

Pharmacological

Simple Analgesics

Regular paracetamol and nonsteroidal anti-inflammatories (used with caution in elderly, due to the risk of renal impairment) should be prescribed unless contraindicated.

Opioids

In the acute setting, patients are likely to need titrated doses of intravenous morphine or similar opioids to control pain, particularly if there are other associated injuries. If the pain is reasonably well controlled, consider prescribing an oral morphine equivalent for breakthrough pain.

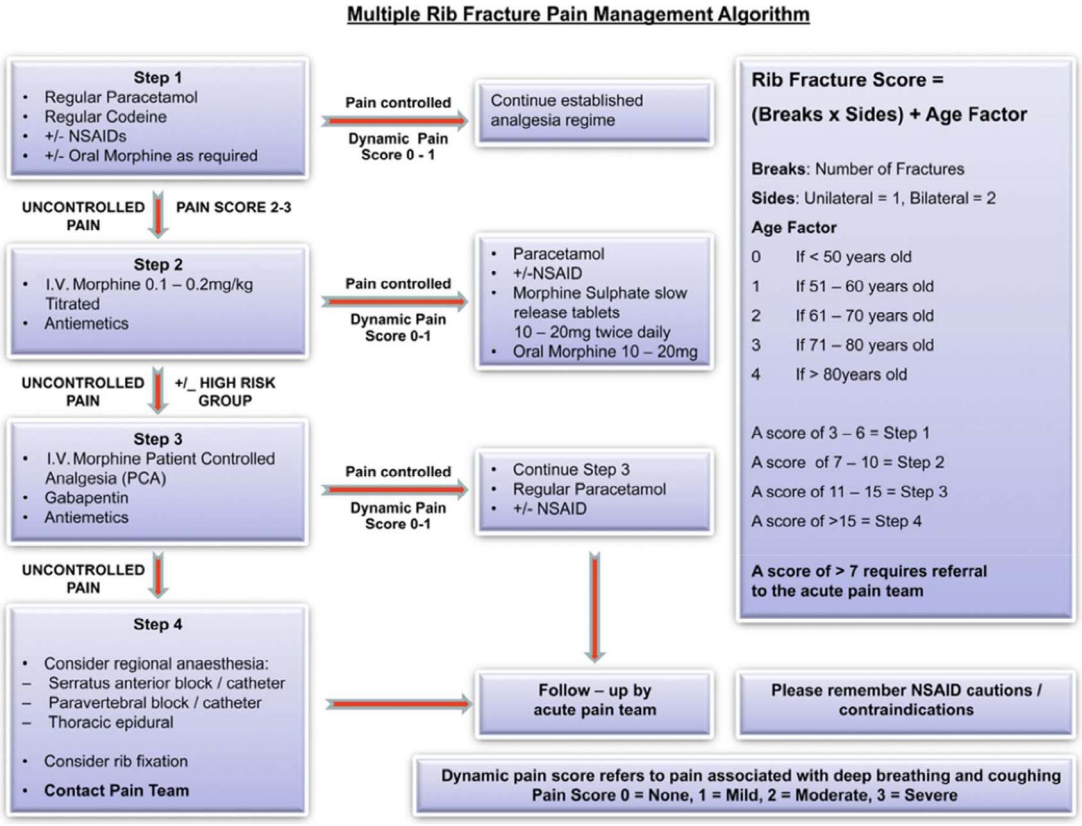

Figure 3. Multiple rib fracture pain management algorithm. Reproduced with permission.[5]

In patients with moderate to severe pain, intravenous patient-controlled analgesia should be considered to allow regular small boluses of opioid to be delivered on demand. The protocol can be altered to allow a larger bolus dose or a background infusion if necessary.

Despite their efficacy in terms of pain relief, these medications may not be well tolerated due to common side effects such as nausea and vomiting (ensure appropriate antiemetics are prescribed as required). In elderly patients, additional side effects, such as drowsiness and confusion, may limit the effectiveness of a patient-controlled analgesia.

Nonopioid Analgesics

Intravenous ketamine may be a useful adjunct in the initial management of patients with chest wall trauma. Gabapentinoids such as gabapentin or pregabalin can have opioid-sparing effects as part of a longer-term analgesic regimen in this patient group.

Regional Analgesia

Although pharmacological treatment will be adequate for a large proportion of patients, regular review of pain control is an essential part of management in patients with rib fractures. Patients unable to deep breathe or cough despite the above measures should be considered for regional anaesthetic techniques to optimise their pain control.

There are a number of techniques available depending on the extent of the fractures and local policy but randomised trials comparing outcomes between these options are limited. A detailed description of each technique is beyond the scope of this article but a brief summary of each with relative benefits and drawbacks is outlined in Table 2.

A recent editorial in *Anaesthesia* discusses the relative lack of high-quality studies supporting the use of some of these interventions.[7] Despite limited evidence of efficacy or safety, there is rising popularity and acceptance for the use of fascial plane blocks (eg, erector spinae plane block) within this context. The authors also suggest that it may become the new gold standard for management of pain caused by rib fractures. In our institution, erector spinae plane block with catheter insertion is now the preferred regional anaesthetic technique for patients with multiple rib fractures.

Regional Technique	Clinical Application	Benefits	Drawbacks
Thoracic epidural	Neuraxial technique; traditional approach but decreasing popularity Continuous infusion via epidural catheter	Bilateral analgesia Established technique Superior pain relief[8]	Contraindicated in coagulopathy Requires expertise to manage safely Side effects: hypotension, urinary retention, motor weakness
Thoracic paravertebral block	Used to provide unilateral analgesia (covers posterior fractures) May be single shot or bolus or continuous infusion via catheter	Effective unilateral analgesia Established technique Reduced hypotension compared to epidural	Relatively contraindicated in coagulopathy Technically challenging procedure (catheter) Side effects: pneumothorax, inadvertent epidural spread
Intercostal nerve blocks	Relies upon multiple injections at level of fractured ribs	Relatively simple technique	Limited duration as single shot Risk of pneumothorax High systemic absorption of local anaesthetic (risk of toxicity)
Erector spinae plane block	Fascial plane block Used to provide unilateral analgesia (covers posterior fractures) May be single shot or bolus or continuous infusion via catheter	Relatively easy block to perform Considered safer in coagulopathy than epidural/ paravertebral block Reduced hypotension compared to epidural	Variable spread of local anaesthetic Requires ultrasound to aid insertion Limited good-quality evidence base; novel approach
Serratus plane block	Fascial plane block Used to provide unilateral analgesia (covers anterior fractures) May be single shot or bolus or continuous infusion via catheter	Relatively easy block to perform Considered safer in coagulopathy than epidural/ paravertebral block Reduced hypotension compared to epidural	Not suitable for posterior rib fractures Variable spread of local anaesthetic Requires ultrasound to aid insertion Limited good-quality evidence base; novel approach

Table 2. Summary of Regional Anaesthetic Techniques for Management of Traumatic Rib Fractures

Supportive

Nonpharmacological measures that may reduce the likelihood of intubation are predominantly based around chest physiotherapy. Strategies include

- incentive spirometry and
- pulmonary toilet to clear secretions.

The effectiveness of chest physiotherapy, however, is dependent on the patient having adequate analgesia.

Chest drain insertion to treat any associated pneumothorax or haemothorax should be considered.

Patients must be closely monitored for evidence of respiratory fatigue due to the relative inefficiency of ventilation when significant chest injuries are present. Those with an increasing oxygen requirement, worsening tachypnoea, and increasing $Paco_2$ should be considered for intubation and invasive ventilation. Patients not suitable for treatment escalation may be trialled on noninvasive ventilation or humidified high-flow nasal oxygen as an appropriate ceiling of care.

The likelihood of requiring intubation and ventilatory support is markedly increased in patients with flail chests. A large retrospective review of patients with blunt thoracic trauma found 59% of this subgroup will require mechanical ventilation during their admission.[9]

Although patients with rib fractures are at risk of developing pneumonia, antibiotics should be not prescribed routinely.

Surgical

The vast majority of patients with rib fractures can be managed with a combination of the measures outlined above. However, a small proportion may benefit from undergoing surgical fixation of rib fractures. Some studies have shown that operative intervention in this group of patients can reduce length of critical care admission, facilitate weaning from mechanical ventilation, and improve overall mortality.[10] The cost-effectiveness of reducing critical care length of stay may see an increase in surgical intervention in this patient population in the future.

SUMMARY

- Rib fractures are commonly encountered injuries in blunt chest trauma.
- The number of ribs fractured and age are predictors of complications.
- Respiratory failure is the major complication (atelectasis, pneumonia, pulmonary contusion).
- There is a high likelihood of patients requiring intubation and ventilation if they have a flail segment.
- Multimodal analgesia and regional anaesthetic techniques are the mainstays of treatment.

REFERENCES

1. Nirula R, Diaz JJ Jr, Trunkey DD, et al. Rib fracture repair: indications, technical issues, and future directions. *World J Surg*. 2009;33(1):14-22.
2. Flagel B, Luchette F, Reed R et al. Half-a-dozen ribs: the break-point for mortality. *Surgery*. 2005;138(4):717-725.
3. Easter A. Management of patients with multiple rib fractures. *Am J Crit Care*. 2001;10(5):320-329.
4. Maxwell C, Mion L, Dietrich M, et al. Hospitalised injured older adults; clinical utility of a rib fracture scoring system. *J Trauma Nurs*. 2012;19(3):168-174.
5. May L, Patil S. Rib fracture management. *BJA Education*. 2016;16(1):26-32.
6. Shulzhenko N, Zens T, Beems M, et al. Number of rib fractures thresholds independently predicts worse outcomes in older patients with blunt trauma. *Surgery*. 2017;161(4):1083-1089.
7. El-Boghdadly K, Wiles M. Regional anaesthesia for rib fractures: too many choices, too little evidence. *Anaesthesia*. 2019;74(5):564-568.
8. Peek J, Smeeing DPJ, Hietbrink F, et al. Comparison of analgesic interventions for traumatic rib fractures: a systematic review and meta-analysis. *Eur J Trauma Emerg Surg*. 2019;45(4):597-622.
9. Gage A, Rivara F, Wang J. The effect of epidural placement in patients after blunt thoracic trauma. *J Trauma Acute Care Surg*. 2014;76(1):39-45.
10. Pressley C, Fry W, Philp A, et al. Predicting outcome of patients with chest wall injury. *Am J Surg*. 2012;204(6):910-914.