



Review

Pitfalls associated with open reduction and internal fixation of fractured ribs

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ABSTRACT

Rib fracture is exceedingly common and remains a leading cause of death in patients with chest injury. Probability of death increases by 19% with each broken rib, and the probability of death increases further with age. Treatment is centered on pain control and early mobilization to provide adequate pulmonary hygiene. Multimodality interventions, such as incentive spirometry, postural changes, and coughing, are pivotal in minimizing the risk of pneumonia and death. Recently, many studies have found mortality benefit to operation fixation (ORIF) of ribs in select patients. However, this procedure remains underutilized partly due to lack of familiarity with its technique and pitfalls by trauma surgeons, in particular. Whereas there are publications on operative technique, there are no studies describing pitfalls associated with this procedure. The purpose of this paper is to describe pitfalls on the technical aspects of ORIF of the ribs based on the medical literature where possible and based on our experience in instances where peer reviewed evidence is lacking. The paper is not meant to serve as a protocol for managing rib fractures.

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Introduction

Rib fractures are present in approximately 10% of injured patients and flail chest is present in 3–5% of injured patients who arrive at a trauma center [1,2]. Mortality following chest wall

injury is directly related to patient age [3] and number of ribs fractured [4,5], and can be as high as 35%. In addition to pulmonary contusion with resultant hypoxemia, pain due to severe injury to the chest wall itself can lead to hypoventilation and ineffective coughing with resultant atelectasis and bronchial plugging. This decreased air exchange, in turn, can lead to pneumonia, adult respiratory distress syndrome (ARDS), and respiratory failure. Whereas the odds ratio of death increases by 19% and the risk of pneumonia increases by 27% with each fractured rib, the odds of

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death decreases by 40% with adequate pain control [3]. Thus, adequate pain control and early mobilization form the cornerstones of the management of rib fractures, particularly severe fractures such as flail chest.

The Eastern Association for the Surgery of Trauma practice management guidelines for the treatment of flail chest support the use of open reduction and internal fixation (ORIF) of fractured ribs in patients who cannot be liberated from mechanical ventilation despite use of a multimodality pain regimen which includes regional analgesia [6]. In this select cohort, ORIF of fractured ribs has been shown to have significant benefit in reducing the duration of mechanical ventilation, need for tracheostomy tube placement, pneumonia, death, and long-term pain with resultant earlier return to work and an improvement in lifestyle [7–13]. Furthermore, this approach has also been found to be cost-effective, even after accounting for the higher upfront cost of operation [14,15].

Despite the above noted recommendation and studies, a survey study of trauma, orthopedic, and thoracic surgeons found that whereas upwards of 80% of surgeons felt that ORIF of the ribs is indicated in selected patients, only 26% had actually performed the procedure [16]. The authors suggested that barriers to operative repair of fractured ribs included a lack of expertise, particularly amongst trauma surgeons, and a lack of published literature on pitfalls associated with this procedure. The purpose of this paper is to describe the operative technique and pitfalls associated with ORIF of fractured ribs. The manuscript will not discuss operative repair of sternal fractures. The paper is not meant to serve as a protocol for managing rib fractures.

Patient selection

The majority of patients with fractured ribs will not require operative intervention. The purpose of ORIF of fractured ribs in the vast majority of patients is pain control to allow for coughing and deep breathing so as to avoid the need for mechanical ventilation. Because ORIF of the ribs is one of many treatment modalities whose aim is to alleviate pain following rib injury, it should be reserved for those who fail medical management. Currently, there are no absolute indications for ORIF of the ribs. Table 1 lists commonly used non-surgical modalities for the treatment of chest wall injury, and Table 2 lists the relative indications and contraindications to ORIF of ribs. Less common indication for ORIF of rib fractures in the acute setting is the stoved-in chest in combination with severe flail chest or a traumatic thoracic hernia. In these instances, the structural integrity of the chest wall has been compromised and the goal is to re-establish the functional structure of the thoracic cavity.

- Pitfall: The probability that respiratory failure is a result of inherent chest wall instability or deformity in the absence of severe pain is very low [17]. Very rarely, patients may present in a delayed fashion with a restrictive respiratory disorder due to malunion of a large number of severely displaced, fractured ribs. This can result in a fused rib cage where the ribs no longer move and the thoracic cavity does not expand during the respiratory cycle. In this instance, pre-operative pulmonary function testing should be used to quantify the severity of the respiratory

Table 1
Non-surgical modalities for control of pain following chest wall injury.

- Regional analgesia, including epidural or paravertebral catheters, with continuous and/or patient controlled infusion of local anesthetic [6]
- Ketamine infusion
- Lidocaine infusion (intravenous, continuous route)
- Non-steroidal anti-inflammatory agents
- Paracetamol
- Parenteral or enteral opioids

Table 2
Indications and contraindications for ORIF of rib fractures.

Relative Indications	Contraindications
Pain refractory to medical management	Respiratory failure due to a cause other than chest wall injury/pain
Respiratory failure due to chest wall instability	Severe pulmonary contusion
Chest wall deformity with visibly distracted rib fractures	Severe concomitant injury(ies) that necessitate intubation (e.g. brain injury)
Impaired pulmonary function tests due to chest wall deformity	Patients with physiologic compromise who would not tolerate nor benefit from surgery
Non-union or malunion of rib fractures	

ORIF = open reduction, internal fixation.

impairment resulting from the chest wall as opposed to other, parenchymal based pathology.

- Pitfall: Because the goal of ORIF is to alleviate pain, it is imperative that the cause of respiratory failure be pain related rather than parenchymal pathology, most commonly severe pulmonary contusion or pneumonia. A study of over 400 patients found no benefit to ORIF of the rib in patients with severe pulmonary contusion [13]. Rarely, patients may present in a delayed fashion with pain due to nonunion of a large number of severely displaced, fractured ribs [18]. Although ORIF of the rib may be beneficial, the cause of the pain must be localized to the nonunionized fractures. Fig. 1 shows an example of a practice management guideline for ORIF of the ribs.
- Pitfall: When needed, the timing to ORIF should be shortly after arrival to the trauma center, ideally within 2–3 days, although there are no studies upon which to firmly recommend a specific time [19]. The goal of ORIF of the rib is to minimize the risk of pneumonia by decreasing the need for mechanical ventilation and allowing for adequate pulmonary hygiene. As such, if the patient is able to withstand operation, it is logical to assume that the earlier the operation is performed, the better.

Imaging and localization of fractures

Plain x-ray lacks sufficient sensitivity to adequately diagnose all rib fractures. Two-dimensional (2D) chest CT scan is the imaging modality of choice both as a means to diagnose rib fractures as well as to determine their characteristics [25]. Some centers use 3D imaging of the chest wall to assess the nature and location of the fracture. A study comparing 2D and 3D CT imaging for rib fractures found that 2D imaging is superior for identifying the presence of a fracture and 3D imaging may be superior for operative planning [26].

- Pitfall: Localizing a fracture site based on CT imaging can be difficult if the patient is positioned differently on the operating room table than he/she was in the CT scanner. This is particularly important if the scapula is used as a landmark because abduction of the arm, often needed if the patient is positioned in a decubitus or prone position, will rotate the scapula and change the distance between its tip and a particular fracture site. Use of a fixed point, such as the spine, is more useful for posterior fractures, but is difficult with lateral or anterior fractures due to the curvature of the ribs and inability to measure a straight line. The sternum may offer a better fixed landmark from which to measure the distance to anterior rib fractures based on the CT scan. When possible, manual palpation of the chest wall for instability or crepitus can serve as an effective means of determining where to place the incision.

Thoracoscopy (VATS) can be used as a means to both assess the exact location of fractures and to evacuate hemothorax. This may be very beneficial in planning for the site(s) of incisions.

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