

Practice Makes Perfect: The Evolution of Blunt Chest Trauma

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Thoracic trauma is the second most common injury in the United States and is associated with significant morbidity and mortality.^{1,2} Fractured ribs are the most common thoracic injury and can occur due to a variety of mechanisms ranging from motor vehicle collisions to falls from standing, particularly in the elderly. Historically, the clinical significance of rib fractures was underestimated by clinicians. Over the last few decades the dangers of rib fractures have become more widely known and treatment has improved.^{2,3,4} The Rhode Island Trauma Center (RITC) at Rhode Island Hospital is the busiest level 1 trauma center in New England and admits nearly 4,000 injured patients each year, 25% of whom have sustained fractured ribs. RITC employs an evidence-based, multi-modal rib fracture protocol that is continually updated and has achieved excellent outcomes.¹

A review of the National Trauma Data Bank for patients with rib fractures revealed complications in 13% of patients and a mortality rate of 10%.² Complications from rib fractures include atelectasis, hemo- and pneumo-thoraces, pneumonia, Acute Respiratory Distress Syndrome, pulmonary embolus, and empyema.² Additionally, as the number of rib fractures increases, the risk of significant complications also increases.^{2,3} Much of the morbidity of rib fractures is commonly due to poor pain control leading to ineffective pulmonary toilet resulting in atelectasis, pneumonia, and respiratory failure. Multiple institutions have shown improved outcomes when treatment protocols are implemented for patients with rib fractures.^{5,6} Elderly patients are a particularly vulnerable population when it comes to complications related to rib fractures.^{3,4} In fact, one study has shown that the increase in morbidity begins as early as the age of forty-five.⁴

Rib fractures results in poor pulmonary function due to a combination of both severe pain and pulmonary toilet as well as altered pulmonary mechanics. In most bone fractures, stabilization to minimize movement results in dramatic improvement in pain and facilitates faster healing and recovery. However, in rib fracture cases, the fractures are difficult to stabilize, resulting in pain from rib movement with each breath. Coughing and sneezing can induce incapacitating pain. Due to the pain, patients are predisposed to the complications previously mentioned. In addition to the pain-related complications, the effects of rib fractures on the mechanical function of the chest can contribute to

morbidity. Flail chest occurs as the result of multiple adjacent ribs fractured in two or more places. The flail segment behaves as an independent island of chest wall and moves paradoxically in relation to the rest of the chest wall. Clinically the flail segment appears to collapse inward with respiration as the rest of the chest expands outward. This can result in a rapidly progressive respiratory failure. Consequently, management of rib fractures and flail chest focuses on controlling pain and improving pulmonary mechanics, but there is a high incidence of respiratory failure requiring mechanical ventilation. This type of respiratory failure is not readily reversible, and many elderly patients, and their families opt for comfort measures rather than intubation, tracheostomy and long-term custodial care.

RIB FRACTURE PROTOCOL

The rib fracture protocol at RITC employs a multi-disciplinary approach to managing patients with rib fractures. The core tenets of the protocol focus on pain control, pulmonary toilet, and restoring normal pulmonary mechanics, with fracture stabilization a newer addition to our treatment regimen. The protocol depends on all members of the treatment team, including, nursing, respiratory therapy, physical and occupational therapy, and physicians as well as the patient their family and friends.

PAIN MANAGEMENT

Adequate pain control has been recognized as a vital component of rib fracture management for decades, but recently newer methods of pain control have emerged to improve outcomes in patients with rib fractures. The goal of therapy is to achieve the greatest degree of pain control with the least risk of side effects. Combination therapies utilizing several different agents are preferred in order to minimize the adverse effects of large doses of narcotics.

All trauma patients with rib fractures are initially treated with acetaminophen and ibuprofen unless contraindicated. These medications provide adequate relief for some patients and have a relatively low-risk side-effect profile. Ideally, these agents are dosed on an alternating regimen in order to provide better continuous relief. Administration of ketorolac has been shown to decrease ventilator days and

frequency of pneumonia and recent evidence indicates that the previously used doses may be cut in half without a degradation in their pain relieving properties. Unfortunately, many elderly patients have diminished glomerular filtration rates as a normal part of aging, despite a “normal” serum creatinine level, thus NSAIDs are frequently contraindicated in this population. Topical lidocaine patches have been advocated for rib fracture pain, but data regarding these patches is equivocal.^{8,9} In our practice, we have seen benefit in some patients with a low side-effect profile when the 5% strength patches are used, but this benefit is often lost at lower concentrations.

Typically, patients admitted with rib fractures need more potent pain medications added to their regimen, and opioids play an important role in controlling this pain. Narcotic pain medicines provide good pain control in many patients but carry the risk for complications due to respiratory depression or dependency. At RITC we carefully create a treatment plan for patients requiring narcotics to minimize prolonged narcotic use and we have been able to manage most patients without too much difficulty.

Regional anesthetics and catheter-based pain control has been used for decades in many areas of medicine, especially obstetrical care, but have been under-utilized in patients with rib fractures. Epidural catheters have been shown to improve outcomes in multiple studies^{2,3,10} and catheter-based therapy has been recommended by a joint practice management guideline from the Eastern Association for the Surgery of Trauma and the Trauma Anesthesiology Society.¹¹ Despite evidence demonstrating improved outcomes with epidural catheters, many providers are reluctant to place catheters due to perceived risks or contraindications in injured patients (spinal fractures, coagulopathy).

For patients with contraindications to epidural catheters, newer, less invasive catheter-based technologies have proven effective and safe for improving rib fracture pain. We have begun using erector spinae blocks (ESB) placed by the anesthesia team with excellent success controlling pain. The catheter for an ESB is placed outside the vertebral column, which decreases the risk of nerve injury and epidural hematomas. Additionally, these catheters can be placed in patients with spinal fractures and/or in patients with coagulopathy or who have recently taken anticoagulants. Multiple studies have now shown improved outcomes in patients with rib fractures following placement of erector spinae blocks.^{12,13}

PULMONARY HYGIENE

In addition to good pain control, pulmonary hygiene is paramount in avoiding complications due to rib fractures. All patients admitted to the RITC with rib fractures are assessed with the rib fracture protocol and treated with an aggressive regimen of incentive spirometry and early mobilization when possible. Patients are tested on their maximal inspired volume upon admission and followed throughout their

hospital course to assess for worsening pulmonary function. An initial low incentive spirometry volume may predict eventual respiratory compromise and need for positive pressure ventilation.¹⁵ Brown et al. demonstrated the feasibility and utility of a nurse-driven protocol to use Incentive spirometry to predict impending respiratory compromise.¹⁴ The rib fracture protocol also facilitates early mobilization by nursing through multidisciplinary rounds and frequent communication between nursing and the trauma team. Any patients with mobility concerns are then referred early for a physical therapy evaluation.

RIB STABILIZATION

Although fixation of rib fractures is not a new therapy, there has been a renewed interest in operatively stabilizing ribs over the last decade as new technology and risk stratified data has shown improved outcomes in some patients following rib open reduction internal fixation (ORIF). The stabilization of the rib fractures is believed to reduce the pain associated with movement of the fractured ribs. Multiple studies have shown improved pulmonary function tests, shortened hospital and ICU lengths of stays, and decreased ventilator days with surgical fixation of rib fractures.¹⁶ Majercik et al demonstrated high patient satisfaction with surgical rib stabilization and 90% of patients were able to return to the same work as prior to their injuries.¹⁷

We use a rib scoring system to predict patients at risk for morbidity and consider rib fixation in high-risk patients. Patients with significant blunt thoracic trauma have 3D reconstruction of the rib cage performed utilizing the data obtained during their initial CT scan to facilitate characterization of the rib fractures. Patients with any of the following are considered for surgical rib stabilization: flail chest, 30% loss of thoracic volume, and aligned fractures in 3 or more consecutive ribs or severe displacement of rib fractures. Additionally, patients with symptomatic fractures refractory to multi-modal pain control efforts or chronic pain from poorly healed fractures or non-unions may be considered for rib ORIF.

Patients undergoing rib stabilization generally receive an epidural prior to surgery. We then proceed with a muscle-sparing chest wall incision over the ribs to be plated. Through this incision the fractured ribs are exposed and realigned. In the case of volume loss, the internally displaced ribs are elevated to restore the chest wall volume. Titanium plates are then used to span the fracture and fixate the fractured rib in the proper anatomic position. A video-assisted thorascopic evaluation of the pleural space is performed at the completion of the case to evacuate any hemothorax and facilitate proper chest tube placement.

In our series of patients, most people have had significant improvement in their pain scores and pulmonary function early after surgery with a very low complication rate. Patients are out of bed on postoperative day one and the chest tube is usually removed within two days.

RIB FRACTURES IN THE GERIATRIC POPULATION

Rib fractures in older patients carry a significantly worse outcome than in younger patients. Patients aged 65 years and older experience significantly higher rates of pneumonia and have higher rates of mortality especially when their fractures are refractory to multi-modal pain control efforts.^{3,17} A meta-analysis revealed an odds ratio for mortality of 1.98 for patients 65 years and older.¹⁸ There are likely multiple reasons for this increase in mortality, including, comorbid medical conditions, reduced physiologic reserve, and a narrow therapeutic window for treatments for rib fractures.

In order to improve outcomes in our geriatric patients, the RITC initiated a geriatric rib fracture protocol in 2009. Patients aged 65 and older with 2 or more rib fractures were admitted to the trauma ICU where our nurses focus on aggressive pain control, assessment of pulmonary function via incentive spirometry monitoring, physical therapy and optimizing nutrition. The inspiratory volume achieved on the incentive spirometer was followed and if the patient is not able to achieve 10-15 ml/kg on the spirometer or has an inadequate cough, prompt anesthesia consultation is obtained for consideration of an epidural or ESB. Patient outcomes were evaluated before and after the introduction of the protocol. The patients were similar in age and injury severity before and after the protocol. After initiation of the protocol, the rib fracture patients were more likely to be admitted to the ICU (64.4% vs 24.8%, $p<0.01$). Patients admitted after creation of the protocol had a shorter ICU length of stay (5.5 vs 8 days), fewer patients required mechanical ventilation (5.5 vs 8 days), and the mortality was significantly lower in the protocol group (9% vs 24%; $p=0.01$).

CONCLUSION

Thoracic trauma and rib fractures are common injuries that can result in significant morbidity and mortality. The Rhode Island Trauma Center cares for hundreds of patients each year with rib fractures. Through a constantly evolving protocol of multi-modal pain control, intensive nursing care, and operative rib stabilization, we have been able to restore health and function to many Rhode Island residents.

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