



ORIGINAL ARTICLE

Improved Outcomes after Surgical Stabilization of Rib Fractures in Patients with Polytrauma and Associated Chest Wall Fractures

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Abstract

Introduction: Non-operative management of rib fractures can lead to significant morbidity such as chronic pain, and dyspnea. Up to 40% may also fail to return to work. Over the last decade rib fixation has made resurgence and there are emerging data supporting early fixation in patients that fail aggressive pain control even in non-flail segments. We describe our early experience with early rib fixation in a small cohort of patients with severe chest wall injury.

Methods: After IRB approval, all patients who underwent surgical fixation of rib fractures were queried from the trauma database at our Level II Trauma center from 9/2014 to 9/2015. Inclusion criteria included flail segments or significant displacement with associated refractory pain and impaired oxygen exchange or ventilation. A total of $n = 23$ patients were analyzed for demographic data including age, gender, ISS, and chest AIS. The number of rib fractures plated, concomitant chest wall fractures, HLOS, ICU LOS, vent days and day of surgery were also analyzed. All patients underwent rib fixation through minimally invasive incisions and using DePuy Synthes MatrixRib plating system.

Results: Males ($n = 20$) were the majority and age was 55 ± 13.5 yrs. (range 22-86). Most patients, 83% had significant chest wall destruction including concomitant scapula, sternal and clavicle fractures. The ISS was 24.7 ± 17.8 (range 9-75). Chest AIS was 3.5 ± 0.8 (range 3-6). Total LOS 10.32 ± 3.7 , ICU LOS 1.26 ± 2.28 , vent days 0.28 ± 0.75 . Average day to fixation was 3 ± 1.21 . The number of ribs repaired was 4.9 ± 2.2 . None of the patients required mechanical ventilation postoperatively. At two weeks clinic follow up to 68% of patients reported no pain and were off narcotics. Two patients developed pneumonia prior to fixation and there were no deaths in this series.

Conclusions: We report our preliminary experience with early rib fixation in a small cohort of patients with severe chest wall injuries. All of the patients tolerated the procedure and early outcomes were favorable, even at the extremes of age. More long-term data is needed to assess the efficacy of early rib fixation.

Introduction

Multiple rib fractures occur in approximately 10% of patients involved in polytrauma, mainly due to blunt mechanisms of injury. Non-operative management of rib fractures can lead to significant morbidity such as chronic pain, and dyspnea and up to 40% of patients may also fail to return to work [1-3]. Over the last decade rib fixation has made resurgence and there are emerging data supporting early fixation in patients that fail aggressive pain control even in non-flail segments. Though there remains to be no standard approach to the patient with rib fractures, some agreed upon indications for surgical fixation have been flail chest, inability to wean from the ventilator, mobile ribs refractory to conventional pain management, and chest wall deformity or non-union [4,5]. These indications traditionally have relied upon patients failing aggressive pulmonary hygiene and pain control by presenting with limited pulmonary function. The problem with this approach is that as previously stated, non-operative management of rib fractures may lead to significant chronic morbidity, and thus there has been the development surgical approaches that use less morbid minimally invasive incisions, allowing for the expansion of surgical indications for rib fixation beyond patient with loss of physiologic reserve [6]. We present our preliminary experience with early rib fixation based on a well-defined chest wall injury protocol, with expanded indications for rib fixations beyond flail segments.

Methods

Institutional board approval was obtained to re-

view all patients who underwent surgical fixation of rib fractures were queried from the trauma database at our Level II Trauma center from 9/2014 to 9/2015. Patient demographics were recorded, including injury patterns based on type of chest wall injury, injury severity scores (ISS), and chest abbreviated injury scores (chest AIS). Pre-operative evaluation including protocol based indications for surgical fixations will be described, characteristics of surgical approaches will be described and outcomes including length of stays (LOS), ventilator days, nosocomial infections, and narcotic requirements at follow up.

Chest wall injury and rib fixation protocol characteristics

All patients admitted with the diagnoses of rib fractures including flail segments or fractures with significant displacement (more than 1 cortical rib diameter), are assessed for pain control, impaired oxygen exchange, or impaired ventilation. Pain management is through a multidisciplinary team comprised of a trauma surgeon, pharmacologist and anesthesia pain specialist. Multimodality pain control is attempted with narcotics, lidocaine patches, non-steroidal inflammatory agents and muscle relaxants. Patients are also offered pain catheters or epidural catheters either at the time of injury for severe chest all injuries are within 24 hours if the aforementioned methods are ineffective for pain control. Pain scores are based on a visual analog score or a numeric scoring system. Pain scores greater than 6 are considered for operative management.

Pulmonary function is evaluated with objective measures including oxygen saturations and ventilation based on ABG's when indicated. Tidal volumes on incentive spirometry are also recorded at the time of presentation and at 24 hours. Volumes less than 750 ml with adequate pain control are considered high-risk and surgical rib fixation is offered. In patients managed with mechanical ventilation, vital capacities, negative inspiratory force are used to assess readiness for extubation and the potential need for surgical fixation. Pain medication requirements in patients on ventilators are also evaluated and pain scores are used to assess surgical fixation candidates as well.

Operative techniques

Preoperative high-resolution 64 slice Computed tomography (CT) scans of the chest are obtained with three-dimensional reconstructions for operative planning. The operative technique includes intubation with single lumen endotracheal intubation with positive end expiratory pressures of 8 cm H₂O used throughout the case for airway expansion. A minimally invasive technique using a 12 cm muscle-sparing incision is performed. The incision was chosen based on location of fractures. Incision included paraspinous or subscapular for posterior fractures with entry into the auscultato-

ry triangle in order to elevate trapezius and latissimus dorsi muscles without division. Lateral fractures were approached via a longitudinal incision medial to the latissimus dorsi muscle and anterior fractures were approached through an inframammary incision. If multiple fracture sites were present, the surgeon adjusted the incision as necessary. All fractures were exposed and plated using the DePuy Synthes MatrixRib plating system. Pleural washout and thoracostomy tube placement are performed in all cases. Intercostal nerve blocks are also performed at all levels of fracture. Selective bronchoscopy for aggressive pulmonary hygiene is also performed prior to completion of the procedures in patients with severe atelectasis or presumed pneumonia prior to surgical rib fixation. Postoperative pain regimen included oral pain medication and muscle relaxants. Patients who A total of n = 23 patients were analyzed for demographic data including age, gender, ISS, and chest AIS. The number of rib fractures plated, concomitant chest wall fractures, HLOS, ICU LOS, vent days and day of surgery were analyzed.

Results

During the study period our Level II trauma center admitted 2424 patients. The blunt mechanisms comprised 80%, and penetrating mechanisms were 20%. There was a total of n = 59 admissions for primary management of rib fractures. The majority of the patients were admitted to unmonitored beds, n = 40. Admission to a monitored bed was required for n = 19 patients.

The study cohort comprised n = 23 patients that required surgical rib fixation based on the aforementioned clinical criteria. Males (n = 20) were the majority and age was 55 ± 13.5 yrs. (range 22-86). Elderly patients comprised 25% of the cohort. Most patients, 83% had significant chest wall destruction including concomitant scapula, sternal and clavicle fractures. The ISS was 24.7 ± 17.8 (range 9-75). Chest AIS was 3.5 ± 0.8 (range 3-6).

Average day to fixation was 3 ± 1.21. The number of ribs repaired was 4.9 ± 2.2. In the majority of cases ribs 4-9 were repaired. There was n = 2 cases in which the third ribs were repaired. The operative time was 120 minutes ± 40 and estimated blood loss was 50 ± 23. A minority of patients (n = 4) had moderate to severe atelectasis requiring therapeutic bronchoscopy prior to extubation. Video assisted thoracoscopic decortication was not required in this series. There were no peri-operative complications.

There was n = 6 patients that required mechanical ventilation prior to surgery and non-invasive ventilation was required in n = 2 patients postoperatively while in the recovery area. The hospital length of stay was 10 ± 3 days and ICU LOS 2 ± 1 days. At two weeks clinic follow up 68% of patients reported no pain and were off narcotics. Long-term follow-up was not obtained in this study. There was n = 1 patient that required read-

Table 1: Patient characteristics/outcomes.

Age/Gender	Mechanisms	ISS/Chest AIS
55 ± 13.5 yrs	Blunt 80%	ISS 24.7 ± 17.8
Males, n = 20		
Female, n = 3	Penetrating 20%	Chest AIS - 3.5 ± 0.8
OR Time	HLOS	Complications
# of ribs ORIF	ICU LOS	
120 min ± 40	10 ± 3 days	Pneumonia - n = 2
4.9 ± 2.2 ribs ORIF	2 ± 1 days	PE - n = 1

mission within 30 days for a pulmonary embolism. That patient was fully anticoagulated and was discharged to home stable. Two patients developed pneumonia prior to fixation and there were no deaths in this series (Table 1).

Discussion

The management of rib fractures and flail chest has evolved over the past decade. There has been an increase in the interest to surgically repair rib fractures after severe chest wall trauma. Standardized approaches are still lacking and the importance of defining clinical indications and incorporating surgical rib fixation into practice has sparked the development of practice guidelines and algorithms to encourage a standardized approach to be taken for patients with chest injury. Some common themes and indications for rib fixation include; 3 or more rib fractures with displacement of more than 1 rib cortical diameter, flail segment, worsening pulmonary status, mechanical ventilation, uncontrolled pain, lung impalement and pulmonary herniation [6,7].

As in many other trauma centers, we have an established protocol to manage patients with rib fractures, that involves aggressive pulmonary hygiene, and multimodality pain control. Objective evidence of pulmonary function based on incentive spirometry volumes, oxygenation and pain control is followed and surgical fixation is offered to patients who fail any of those measures. Data continues to emerge evaluating multimodality pain control for the management of chest wall injuries, and it is unclear that pain control alone is associated with favorable outcomes as there are mixed results with some studies suggestive benefits of multimodality pain regimens, and others showing no benefit [8-11]. The expansion of surgical repair beyond the traditional indications including flail chest, perhaps enriches the protocol based outcomes, particularly with the use of muscle sparing smaller incisions. Our data supports early surgical intervention and despite the limitations of our study design, being retrospective and underpowered, the results suggest that early surgical fixation is safe and many patients don't require long term narcotic use for chronic pain. The avoidance of long-term and high narcotic requirements may have obvious benefits including avoiding addiction.

Age influences the potential morbidity and mortality associated with rib fractures. It has been shown that pa-

tients over 65 years of age tend to have longer hospital lengths of stay, ICU stays and ventilator days when compared to younger patients and pneumonia occurs more frequently in the elderly population after chest trauma [12]. There has been data to show a linear relationship to number of rib fractures with increased mortality and pneumonia rates in this group as well. There is a large amount of literature which focuses on outcomes in elderly patients who have sustained trauma and if treated early and aggressively can be rescued even in the extremes of cases [13,14]. In our cohort of patients age had negligible impact on the decision to provide operative repair in this series, as 25% of the study cohort was over the age of 65. The elderly patients in this series all tolerated surgery, there were no deaths or significant complications. Similarly, in a recent study comparing outcomes in the elderly in patients managed with surgery vs. medical management, there was a significant improvement in mortality and respiratory function in the surgery group [15]. Thus, the traditional attitude that elderly patients don't tolerate rib fractures and are at risk for high morbidity and mortality, seems to be challenged with an emerging surgical approach.

Study Limitations

We recognize the limitations of this study based on the small sample size and retrospective observational design. There are no long-term follow-up data beyond thirty-day readmission data. The promising results are not based on comparison with controls which would strengthen the conclusions.

Conclusions

We report our preliminary experience with early rib fixation in a small cohort of patients with severe chest wall injuries. All of the patients tolerated the procedure and early outcomes were favorable, even at the extremes of age. More long-term data is needed to assess the efficacy of early rib fixation, particularly related to the impact on long-term morbidity and cost.

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