Surgical rib fixation as an alternative method of treatment for multiple rib fractures: an audit of results compared with traditional medical management

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Background: Rib fractures are a common cause of morbidity and chronic pain, delaying return to normal activities. Reports suggest that surgical fixation improves acute and long-term outcomes.

Method: A single centre retrospective review of multiple rib fractures, comparing the outcomes of cases managed using surgical fixation with cases managed only with best medical therapy (BMT) over 2 years.

Results: Thirty-five patients with rib fractures were admitted over the study period. The most common causes of rib fractures were motorcycle crashes (34.2%) and falls (31.4%). Fourteen patients had surgery. There were no differences between the two groups regarding the number of fractured ribs, injury severity score (ISS), ICU or hospital length of stay. The median numeric pain visual analogue scale (VAS) on admission was eight points for non-ventilated patients. In the surgical group the median VAS significantly fell to a median of 2 points in the first 24 hours after surgery (p = 0.04). Only two out of 25 major complications were directly attributable to the surgery for rib fixation. Patients managed without surgery needed significantly longer time to return to normal activities compared to those who had surgery (median 7 weeks versus 3 weeks, p = 0.03).

Conclusions: Our preliminary results suggest that rib fixation should be considered a treatment alternative in patients with multiple rib fractures.

Keywords: rib fractures, surgical fixation, flail chest, trauma

Introduction

Rib fractures are common and causations are multifactorial; they are a recognised marker for severity of injury and a significant cause of in-hospital morbidity, chronic pain, and delays in return to normal activities.1,3 The number of ribs fractured, presence of flail segment, patient age, associated lung trauma and extra thoracic injuries, especially traumatic brain injury are predictors of outcome.1-10

The current standard of care for rib fractures is non-operative and is based on several key components. These include appropriate oxygenation, management of respiratory failure with mechanical ventilation, lung re-expansion techniques, appropriate management of pain, removal of secretions and aggressive chest physiotherapy.1-10

Unfortunately, non-operative management addresses only the pathophysiological component of this problem, while the mechanical and anatomical problems (actual fractures) are usually overlooked and treated with options that are not designed to facilitate bone consolidation.

The impact of rib fractures on prolonged disability is usually greater than traditionally expected; chronic pain is considered to be present in 22% of cases (could be as high as 59%) and some form of disability in 53% of cases 6 months after injury.10-22

Attempts to provide rigidity to the chest wall in the event of fractures is not a new proposition, multiple techniques have been used along the years to achieve stability with variable success.

Efforts to advance the surgical fixation of flail chest and multiple rib fractures to the level of standard of care have not met the expectations or received the approval of many surgeons, mostly due to lack of appropriate evidence and familiarity with the procedures.11

Evidence in favour of surgical stabilisation of rib fractures has been limited by the quality of the studies as with other trauma related issues,11-20 however, the accumulated evidence both from randomised clinical trials and from the systematic reviews and metaanalysis consistently favours rib fixation over medical management.1,12-26

This mounting experience points to significant advantages such as the reduced incidence of pneumonia and respiratory failure, shorter ventilation time, shorter ICU and hospital stay with minimal complications as well as faster return to productive life, all of which result in improved quality adjusted life-years and costs.1,12-26
At our institution, all patients with rib fractures were admitted to a trauma ICU ward and offered the standard of care as per protocol of the unit, including intravenous analgesia; oxygen, nebulised bronchodilators as needed, mechanical ventilation when indicated, management of associated injuries and active physiotherapy. A computed tomography scan (CT) of the chest was obtained and three-dimensional (3-D) volume reconstructions performed to evaluate the thoracic skeleton and assess indication for surgery.

As per unit protocol, a follow-up visit was scheduled at two weeks interval after discharge in all cases to clinically assess pain level, physical and pulmonary function and obtain chest radiographies to exclude residual pulmonary problems and in the surgical cases to evaluate the fracture site and implant complications. Once the patients re-incorporated to normal activities, they were considered discharged and advised to return for consultation if a problem or concern arose.

Only patients who have three or more rib fractures, or a flail chest with severe pain, as assessed by numeric visual analogue scale (VAS) higher than 6 points, fracture displacement, pulmonary contusion or inability to tolerate physiotherapy are considered for fixation at our institution.

The aim of study was to compare outcomes between subjects with multiple ribs fractures who received surgical rib fixation, and those who only received best medical therapy (BMT).

Method
Retrospective study from 1 July 2015 to 31 August 2017 (a 25-month period).

Inclusion criteria
All trauma patients presenting with multiple fractured ribs at a level 2 private trauma centre in Johannesburg.

Exclusion criteria
Subjects < 18 years of age, incomplete clinical data, associated severe traumatic brain injury (GCS < 8), major spinal injuries, those with predominantly posterior fractures not amenable to surgical options, and those who have mild symptoms and are able to participate fully in physiotherapy care.

Data collected
The following information was extracted from clinical notes and entered on a Microsoft Excel Spreadsheet (Microsoft Corp, Redmond, WA): Demographic data (age and sex), mechanism of injury, patterns and number of rib fractures, associated injuries noted, physiological factors (revised trauma score, injury severity score, new injury severity score, probability of survival), medical treatment offered, surgical treatment offered, time to surgery, ICU length of stay, hospital length of stay, in-hospital mortality, procedure related complications, time to return to work or normal activities, pain assessment on admission, after surgery and during outpatient review, and radiological findings during outpatient review.

The surgical procedure to fix the ribs was performed using a muscle sparing thoracic incision (Figure 1). The ribs were stabilised using titanium plates and screws (RibFix Blu™, Zimmer Biomet, Jacksonville, USA); an effort was always made to provide stability for all accessible fractures.

Figure 1: A typical example of multiple rib fractures and three plated fractures

Fractures in ribs one, three, ten, eleven and twelve or fractures less than 3 cm from the costo-vertebral or sternocostal joints were not fixed. The flail segments were either bridged with a long plate spanning the two fractures or using two individual plates.

Data analysis
Descriptive statistics were used to summarise the data. Statistical difference between comparable groups was assessed using Student’s t-test for continuous variables, \( p < 0.05 \) was considered to be statistically significant.

Results
During the study period, 35 patients were admitted with a diagnosis of rib fractures alone or as part of polytrauma. The patients were mostly males with a median age of 44 years (range 16–68) (Table I).

The most common causes for rib fractures in our series were motorcycle crashes (34.2%) and falls (31.4%), closely followed by motor vehicle collisions. More than
Sixty per cent of the cases were considered severe trauma (ISS > 16), the median ISS was 21 (4–75). For the patients treated with BMT, the median ISS was 24 (4–75) versus ISS 21 (16–75) for those offered surgery (Table 2).

There was no major difference regarding affected side (15 right – 19 left), and only one patient had bilateral fractures. Seventy-seven per cent (77.1%) of the patients had three or more fractures (median 6; range 3–7) including nine flail chests (25.7%). The most common associated injuries were pulmonary contusion in 27 cases (77.1%), followed by haemopneumothorax in 24 cases (68.5%). Other associated injuries included clavicular fracture, upper and lower limb fractures, ruptured spleen and mild TBI, among others.

Numeric visual pain scale (VAS) assessments were administered to all conscious patients; overall the median VAS pain on admission for non-ventilated patients was 8 points (range 6–10), operated patients who were not ventilated demonstrated significant immediate postoperative reduction of the pain scales to a median of 2 out of 10 (range 1–4) (Figure 2). Twelve of the fourteen patients (85.7%) had the surgery performed in the first seven days following injury (median 4 days, range 2–14).

Twenty-five major complications were recorded, 13 in the surgery group and 12 in the BMT group. The most common complication was pneumonia in 23% of cases (4 in each group); other complications included cardiovascular failure, severe sepsis and acute kidney injury requiring renal replacement therapy. Complications related to the ORIF procedure were recorded in only 2 of 14 patients operated (Table 3).

ICU and hospital stay were similar for patients operated or managed with BMT (6.5 and 8.5 days, respectively). The median time to return to normal productive life was 3 weeks for the surgical patients (ranging between 2–16 weeks) versus 7 weeks for the BMT group (range 3–52 weeks) (Table 4).

Discussion

The idea of stabilising fractured ribs to reduce pain, complications and facilitate healing is not new. In 1926, Jones first described the application of traction to the sternum to treat flail chest. Others soon followed with a myriad of different methods including traction, direct wiring of ribs and metal implants, unfortunately, surgical stabilisation did not become the standard of care, as mechanical ventilation was considered satisfactory for the treatment of the associated pulmonary contusion and to provide stability to the chest wall.

Over the years, multiple publications have demonstrated a clear reduction in the need for opioid analgesia, incidence of pneumonia, shorter ventilation times and ICU stay and generally, a better outcome when surgery was offered over BMT. Unfortunately, in South Africa, not all patients have access to all of the BMT strategies, including options in advanced pain management.

Our series showed similar results between the two groups regarding ISS, number of fractures, pain VAS on admission, ICU and hospital length of stay and complications; the
main difference observed was the time necessary to return to normal activities (median 7 weeks for medical therapy versus 3 weeks for surgical cases \( p = 0.03 \)) and an obvious reduction of pain VAS in the postoperative period \( p = 0.04 \).

Despite the clear advantage of mechanical ventilation to treat the respiratory failure associated with multiple rib fractures, the use of positive end-expiratory pressure (PEEP) does not achieve complete stability of the thoracic skeleton, which impacts the consolidation of the fracture site. Adequate analgesia, chest physiotherapy and early skeletal (rib) fixation seems to prevent complications, as stated in several recent studies.12,15-17,19,21

**Study limitations**
A single centre study with a small sample size having potential selection bias and lack of power. The retrospective nature opens it up to the usual limitations of such studies. The pain VAS is subjective and results may not be accurate.

**Conclusion**
There were no significant immediate differences between the ICU length of stay and complications in the BMT group and the surgical group. The postoperative pain VAS was significantly reduced in the surgical group. There was also a significant trend to earlier return to normal activities in the surgical group.

Based on the results of our study and the available evidence, we conclude that rib fixation should be offered to all patients that fit the criteria for surgery.

**Conflict of interest**
The authors declare no conflict of interest.

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**Ethical approval**
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