Long-term patient outcomes after surgical stabilization of rib fractures


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Abstract

BACKGROUND: Rib fractures are common, and can be disabling. Recently, there has been increased interest in surgical stabilization of rib fractures (SSRF). It is difficult to define long-term benefits of the procedure. This is a descriptive study of patient outcomes after SSRF.

METHODS: SSRF patients between April 2010 and August 2012 at a Level I trauma center were identified. Data were collected from the medical records. A telephone survey asking about pain, satisfaction, and employment was administered to patients after hospital discharge.

RESULTS: One hundred-one patients met inclusion criteria. Fifty (50%) patients completed the survey. Indications for SSRF included flail chest, displaced fractures, pain, and inability to wean from mechanical ventilation. Pain was gone at 5.4 ± 1.1 weeks post discharge. Satisfaction with SSRF on a scale of 1 to 10 was 9.2 ± 2. Ninety percent of employed patients returned to the same work at 8.5 ± 1.2 weeks.

CONCLUSIONS: SSRF patients are satisfied and are able to return to normal activity with few limitations. A prospective study using modern rib fixation technology is needed to further define benefits.

Rib fractures are painful and potentially disabling. According to the National Center for Health Statistics, over 300,000 patients with rib fractures were seen in U.S. emergency departments (EDs) in 2009.1 Rib fractures occur in at least 10% of patients who are admitted to trauma centers.2 Up to 50% of these patients, particularly those with complicated rib injuries such as flail chest, will experience chronic pain or chest wall deformity. Over 30% will have some long-term disability, and often do not return to full-time employment.3,4 This results in social and economic costs, both to the U.S. healthcare system and to individuals in the form of lost productivity, and decreased quality of life (QOL).

Recently, interest in the surgical stabilization of rib fractures (SSRF) has increased dramatically. Despite this, it is not considered the standard of care, even for patients with flail chest or significantly displaced fractures.5,6 There are many reasons for this, but a lack of data is cited as a principal factor.7 Most of the published literature that exists centers on in-hospital outcomes, such as ventilator days, intensive care unit (ICU) length of stay (LOS), need for tracheostomy, incidence of pneumonia, and death.8 Currently, the only study published that looks specifically at long-term outcomes and QOL after SSRF in patients treated in North American trauma centers is a Markov decision model designed to compare cost-effectiveness of nonoperative management versus SSRF of flail chest.9
Methods

We performed a retrospective telephone survey of patients who had SSRF between April 2010 and August 2012 at Intermountain Medical Center in Murray, Utah. All patients who had SSRF performed after incurring rib fractures and who were at least 6 months out from hospital discharge were considered eligible. A medical record review for demographic, injury, hospital, and surgical data was also performed for all patients. This study was performed with approval from Intermountain Healthcare’s Institutional Review Board.

All patients had a chest computed tomography scan with 3-dimensional reconstruction performed within 24 hours of admission to better define their rib injury. Flail chest was radiographically defined as 3 or more ribs fractured in 2 or more sites. “Clinical” flail chest was defined as visible paradoxical motion of the chest wall with respiration. “Significant fracture displacement” and “chest wall deformity” were determined from review of the medical records.

All patients had standard therapy for severe chest trauma from the time that they arrived in the ED. This included intravenous, oral, and/or epidural analgesia, and aggressive chest physiotherapy. Endotracheal intubation was performed and mechanical ventilation was initiated when indicated for hypoxia or hypercarbia, altered mental status, or severe brain injury. No patient underwent obligatory mechanical ventilation for the purpose of chest wall stabilization.

The decision to perform SSRF and at what time interval was at the discretion of the attending surgeon. The criteria used to determine whether a patient was a candidate for surgery included radiographic or clinical flail chest, fracture displacement, chest wall deformity, pain, and inability to wean from mechanical ventilation. All operations were performed under general anesthesia, without single lung ventilation. The decision to place an epidural catheter was made jointly between the operating surgeon and anesthesiologist. The fractures were exposed via a lateral thoracic incision, the location, size, and orientation of which varied depending on the location of the fractures. A muscle sparing approach was used. The fractured ribs were exposed individually. Minimal periosteal elevation was performed. After reduction, ribs were stabilized with “MatrixRIB,” (DePuy Synthes, West Chester, PA) a rib-specific locking plate and screw system. At least 3 locking screws were placed on each side of the fracture line. All fractures considered to be displaced enough to benefit from plating were fixed. In patients with flail chest, 2 plates were sometimes used instead of 1 large plate if the fractured areas on the same rib were far enough apart. Fractures that were significantly posterior or inaccessible because of position under the scapula were not plated.

The pleural cavity was entered via a small stab incision and irrigated to evacuate hemothorax. A 19Fr round, fully fluted Blake drain (Ethicon, Somerville, NJ) was placed in the pleural cavity in lieu of a standard chest tube. The pleural cavity was never widely opened. The wound was closed in layers, and a second closed suction drain was placed in the subcutaneous tissues. Patients were transferred to the ICU or the trauma ward as deemed appropriate. There was no mandatory ICU admission.

Using the medical record, we located a telephone number and mailing address for each patient. If 2 attempts at telephone contact were unsuccessful, a letter was sent via U.S. mail inviting the patient to contact us. Upon telephone contact, the patient gave verbal consent to participate in the survey. The postoperative survey was generated specifically for this study, and asked patients to recall their postdischarge pain, narcotic use, and chest wall stability, as well as how satisfied they were with their overall outcome. The next section of the survey asked patients to describe their ability to work or strenuous activity since their hospital discharge, and how this compared with their preinjury employment/activity.

Continuous variables are reported as mean (standard error of the mean) if normally distributed, and median (interquartile range) if not normally distributed. Categorical variables are reported as counts and percentages. Student t tests and Fisher’s exact test analysis were used to compare groups as appropriate.

Results

In the study time period, 975 patients were admitted to the trauma service with rib fractures. One hundred-one (10%) patients had SSRF and met study criteria. Fifty (50%) patients were successfully contacted, completed the survey, and are included in this analysis. Patient demographics and injury data of all 101 eligible patients, as well as the 50 patients who completed the survey are outlined and compared in Table 1. There was no difference in age, sex, ISS, chest AIS, number of ribs fractured, or mechanism of injury between the eligible group and those who were surveyed.

The indications for surgery were multifactorial in many cases, and are listed in Table 2. The most common reason for surgical intervention was flail chest. There was no difference between the eligible and surveyed group with regard to indications. Fifteen (30%) surveyed patients were admitted from the ED to the trauma ward, 32 (64%) to the ICU, and 3 (6%) went directly to the operating room for exploratory laparotomy to address other injuries. Fifteen surveyed patients (30%) required mechanical ventilation before SSRF. Six of these had a concomitant traumatic brain injury, and were
patients stated that they still have pain from their ribs. Six of them said that the pain is minimal or intermittent, however, and does not interfere with daily activities. Two complained of chronic pain, and continued to require narcotics to manage this pain. Both of these patients also had clavicle and shoulder girdle injuries, however, which may make the delineation of pain attributable to ribs difficult. The 48 patients who were not requiring narcotics at the time of survey said that they were able to discontinue pain medications at 4.7 ± 1 weeks after hospital discharge. Seven (14%) patients did not use any narcotics after discharge. Patients who no longer have pain said that their rib pain was completely gone at 5.4 ± 1 weeks post-discharge. Forty-one (82%) patients said that they remember feeling at least “somewhat better” immediately after their surgery. Forty-three (86%) patients said that their chest wall looks and feels normal.

On a scale of 1 to 10, with 1 being not satisfied at all, and 10 being very satisfied, patients rated their experience with SSRF and the results of the procedure as 9.2 ± .2. Patients were very polarized on this issue, however, with 48 giving a rating of 8, 9, or 10, and 2 (the 2 with chronic pain issues) giving a rating of 2. Forty-seven (94%) patients said that they would recommend SSRF to a friend or family member with a similar injury.

Thirty-four patients were employed full-time before their rib fractures. The rest were either retired (11), students working part-time (2), or already permanently disabled (3). Of the patients who were employed, 33 of 36 (92%) patients returned to work at the same job that they did preinjury. One other patient returned to his job, but had some change in duties. Mean time to get back to full-time work was 7.9 ± 1.0 weeks. Forty-six (92%) patients said that they had no significant limitations in any part of their lives.

### Comments

This observational study demonstrates that patients who have SSRF are able to wean off of narcotics in a reasonable amount of time, have low rates of chest wall deformity and/or chronic pain, and are very satisfied with the procedure. Furthermore, they return to work, school, or other meaningful activities in a reasonable amount of time, and are able to participate in those activities without significant limitations. As we have gained more institutional experience with SSRF, our results indicate a trend toward offering it earlier in the hospital stay to patients with these injury patterns.

The indications for SSRF have been heavily debated in the surgical literature, without resolution. The 2012 Eastern Association for the Surgery of Trauma practice

### Table 1

<table>
<thead>
<tr>
<th>Demographic and injury information</th>
<th>Eligible patients (n = 101)</th>
<th>Surveyed patients (n = 50)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>57 ± 2</td>
<td>57 ± 2</td>
<td>.95</td>
</tr>
<tr>
<td>Male (%)</td>
<td>79 (78%)</td>
<td>37 (74%)</td>
<td>.68</td>
</tr>
<tr>
<td>ISS</td>
<td>21 ± 1.1</td>
<td>22 ± 1.7</td>
<td>.41</td>
</tr>
<tr>
<td>Chest AIS</td>
<td>3.4 ± .1</td>
<td>3.4 ± .1</td>
<td>.88</td>
</tr>
<tr>
<td># ribs fractured</td>
<td>6.3 ± .2</td>
<td>6.3 ± .3</td>
<td>.97</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Indications for surgery*</th>
<th>Eligible patients (n = 101)</th>
<th>Surveyed patients (n = 50)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flail chest</td>
<td>64 (63%)</td>
<td>35 (70%)</td>
<td>.47</td>
</tr>
<tr>
<td>Fracture displacement</td>
<td>23 (23%)</td>
<td>10 (20%)</td>
<td>.83</td>
</tr>
<tr>
<td>Intractable pain</td>
<td>37 (37%)</td>
<td>20 (40%)</td>
<td>.72</td>
</tr>
<tr>
<td>Inability to wean from mechanical ventilation</td>
<td>10 (10%)</td>
<td>6 (12%)</td>
<td>.78</td>
</tr>
</tbody>
</table>

*Percentages add up to <100% because some patients had more than one recorded indication for surgery.

intubated upon arrival to the ED for decreased level of consciousness. One was hypotensive from intra-abdominal bleeding upon arrival, and was intubated in the ED and taken to the OR for emergent laparotomy.

SSRF was performed on post-injury day 3.4 ± .5. This number trended lower later in the study. In the last 12 months of the study period, surgery was performed on post-injury day 2.1 ± .5, as compared to day 4.0 ± 1.1 in the first 17 months (P = .06). Number of ribs plated was 4.2 ± .2. In some cases, 1 rib was treated with more than 1 plate. Thirty-eight (76%) patients were admitted to the ICU postoperatively. Median postop ICU LOS was 1 (Interquartile range [IQR] 0 to 3) day. Total hospital LOS postoperatively was 8 (IQR 6 to 11) days. Inhospital complications included pneumonia (5), deep venous thrombosis (4), and surgical site infection (2). Thirty-four (68%) patients were discharged to home, 8 (16%) to rehab, and 8 (16%) to a skilled nursing facility. Postdischarge complications included 1 readmission for a recurrent/retained hemothorax, and 1 patient who had his plates removed at 1 year postinjury for chronic pain of uncertain etiology.

The time from hospital discharge to administration of the telephone survey was 16 ± 1 months. Eight (16%) of the patients who were employed, 33 of 36 (92%) patients returned to work at the same job that they did preinjury. One other patient returned to his job, but had some change in duties. Mean time to get back to full-time work was 7.9 ± 1.0 weeks. Forty-six (92%) patients said that they had no significant limitations in any part of their lives.
management guideline for pulmonary contusion and flail chest cites SSRF as a Level III recommendation, and states that "this modality may be considered in cases of severe flail chest failing to wean from the ventilator..." and further, that "the patient subgroup that would benefit from early 'prophylactic' fracture fixation has not been identified."6

There are currently 3 randomized trials, none from North America, that compare patients who have their rib fractures treated with SSRF to those who have conventional, nonoperative treatment.10–12 In all of these trials, the need for mechanical ventilation and flail chest were requirements to be included in the study. Their findings included decreased length of mechanical ventilation, ICU stay, incidence of pneumonia, and need for tracheostomy, as well as lower overall medical expenses (in the case of Tanaka) for the surgically managed group. Clearly, these authors studied a different population than this study. Furthermore, all used surgical instrumentation that was structurally different from the MatrixRIB system used in our patients, making an "apples to apples" comparison impossible. At Intermountain Medical Center, we use slightly different, perhaps more liberal, indications for SSRF. In our patient population, only 21 (42%) patients ever required mechanical ventilation, and 10 (20%) patients were never in the ICU at all. We have a very active patient population in Utah, who are often anxious to get back to strenuous work or leisure activities. We have found that for patients with significantly displaced ribs, flail chest, or pain not controlled by conventional measures, SSRF has gotten them back to their preinjury level of functioning quickly. This study confirms this.

The evidence looking at long-term benefits of SSRF is scarce. A recent meta-analysis3 comparing SSRF with nonoperative management of flail chest did not discuss any postdischarge outcome variables. Tanaka10 and Masco12 did look at postoperative QOL indices as part of their trials. Tanaka found that patients who had SSRF were more likely to return to a high-activity job, while Masco failed to demonstrate a difference in QOL outcomes at 6 months postdischarge. Granetzny11 assessed pulmonary function at 2 months postdischarge, and found that the surgically managed group had a less restrictive pattern than those treated nonoperatively. The only study that addresses differences in pain levels between surgically and nonsurgically managed patients is a retrospective study that looked at total inpatient narcotics requirements.13 The authors in that study found no difference in the amount of narcotics administered during the hospital stay, nor any difference in ventilator days, pneumonia, hospital, or ICU LOS.

There are 2 studies examining long-term outcomes and QOL in patients who have undergone SSRF.14,15 Both are retrospective. The most recent study, from the United Kingdom, consists of 10 patients. The fractures were treated with 2 different rib-specific systems. The authors administered a questionnaire post-surgery, and found that most patients had no pain, were satisfied with the surgery, and reported a good or excellent QOL. They did not report on the ability to return to employment. Our results corroborate these findings. The other QOL study, by Campbell et al, was a series of 32 patients in Australia. A thoracoscopic surgical technique and a biodegradable "mesh" construct were used to stabilize the rib fractures. These authors found, via questionnaire, that long-term pain levels were low, and that half of all patients could do all of the activities that they did before their injury. Fifty-five percent of patients returned to work. Only 15% did not return to work because of sequelae from their injuries. Although our results appear similar, it is difficult to compare our patients with theirs, as the operative technique/stabilization method was vastly different than the system we used.

Recently, Bhatnagar et al16 published a Markov transition state model of the long-term socioeconomic benefits and cost-effectiveness of SSRF versus "standard of care" (SOC) nonoperative management. The authors used the National Trauma Data Bank to determine incidence of various outcomes associated with having rib fractures. They determined that if SSRF patients had a 0% improvement in QOL compared to SOC patients, SSRF cost about $5,000 less per incremental QOL unit. If SSRF patients had a postinjury QOL that was 15% higher than SOC patients, the difference in cost per incremental QOL unit between the groups was over $10,000, favoring SSRF. Based on our data, we would argue that the QOL difference between SSRF and SOC patients may be <15%. This would make SSRF even more cost-effective over the long term than reported.

Our study has several limitations. First is the retrospective nature. We relied on patients' memories to tell us when they were able to discontinue narcotics and when they returned to work and/or strenuous activities. Second is the lack of a comparative, nonoperatively managed group. Although we do not consider performing SSRF on all of our rib fracture patients, most who meet operative criteria (clinical flail, significant displacement, intractable pain, failure to wean from mechanical ventilation) are offered surgery. Thus, it is challenging for us to find a true case-control group to perform a meaningful comparative study.

In conclusion, SSRF is an effective modality for patients with rib fractures who have flail chest, significantly displaced fractures, or intractable pain. There appear to be long-term clinical and, perhaps, socioeconomic benefits to performing the procedure. A prospective study that uses modern rib fixation technology and examines short- and long-term outcomes is needed to further define these benefits.

References