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Comparison of In-Hospital Outcomes of Surgical Stabilization of Rib Fractures with Nonsurgical Management: A Multicenter, Prospective, Cohort Study

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ABSTRACT

Background: Evidence for the efficacy of surgical stabilization of rib fractures in patients with rib fractures is controversial. **Objective:** We aim to compare the clinical outcomes of surgical rib fixation for rib fracture with non-operative treatment. **Methods:** Our institutional database from three general hospitals (Viet Duc Hospital, Viet Tiep Friendship Hospital & Cho Ray Hospital) was queried to identify patients with flail chest treated with locked plate fixation between December 2021 and February 2023. A medical record review for demographic, injury, hospital, and surgical data was also retrospectively performed for all patients. Characteristics and outcomes of the patients receiving the surgical rib fixation for rib fracture were compared with those without surgery. **Results:** A total of 166 patients with thoracic trauma were included. The majority of patients were male, and the age range was from 18 to 80 years old, with a mean age of 51.6 years. 52 (31.3%) underwent surgical stabilization of rib fractures (SSRF). The highest combined injuries were limb injuries, followed by traumatic brain injury, and maxillofacial trauma. While 1 patient died in the non-surgical group, there was no significant difference in the mortality between the two groups. The surgical group had a slightly shorter hospital stay than the non-surgical group (8.6 days vs. 10.0 days, p-value: 0.038). SSRF group tended toward a lower incidence of pneumonia compared to the non-surgical group (SSRF: 3.8% vs. non-surgical: 7%), but this difference was not statistically significant (p-value: 0.426). SSRF group also had a lower incidence of tracheostomy than the non-operative group (SSRF: 0% vs. non-surgical: 1.8%, p-value: 0.337). **Conclusion:** Operative fixation of a rib fracture in trauma patients resulted in a lower incidence of pneumonia, fewer days of mechanical ventilation, and a shorter hospital stay compared to non-operative treatment group.

Keywords: Rib fracture, surgical stabilization of rib fractures, SSRF, rib fixation.

1. BACKGROUND

Chest wall injury is common following blunt trauma, and rib fractures are the most common of these injuries (1). Mortality rates after rib fractures are approximately 10%, with a higher rate observed among the elderly trauma patient (2). Rib fractures resulting from chest wall trauma are often accompanied by internal thoracic injuries including pulmonary pathology. Pain caused by rib fractures can lead to inadequate ventilation and ineffective clearance of secretions, which can lead to atelectasis. As a consequence, there is a high risk of superinfection, which can lead to pneumonia and prolonged mechanical ventilation (1).

There are two controversial methods of treating rib fractures: non-operative, conservative management and surgical stabilization of rib fractures. Non-operative management, which involves pulmonary toilet, pain control, and selective ventilatory support, is the standard treatment for these injuries at most institutions. The application of operative intervention for rib fractures is controversial. However, several reports indicate that patients undergoing open reduction internal fixation (ORIF) of flail chest injuries or multiple rib fractures require a shorter duration of ventilator support, are less likely to develop infections and septicemia, and are less likely to require tracheostomy compared to

Variables	Nonoperative N = 114 Count (% of total)	Operative N = 52 Count (% of total)	Total N = 166 Count (% of total)	p-value
Age (years)				0.687
Mean (SD)	51.90 (14.49)	50.96 (12.62)	51.61 (13.90)	
Min, Max	18.0, 80.0	19.0, 76.0	18.0, 80.0	
Sex				0.015
Male	94 (82.5%)	34 (65,4%)	128 (77,1%)	
Female	20 (17.5%)	18 (34,6%)	38 (22,9%)	
Glasgow comma score				0.037
Mean (SD)	14.63 (1.19)	14.98 (0.14)	14.74 (1.00)	
Min, Max	4.0, 15.0	14.0, 15.0	4.0, 15.0	
Injury Severity Score (ISS)				0.130
Mean (SD)	11.19 (6.30)	13.11 (8.43)	11.79 (7.06)	
Min, Max	3.0, 38.0	5.0, 45.0	3.0, 45.0	
Mechanism of injury				0.587
Traffic accident	73 (64.0%)	37 (71.2%)	110 (66.3%)	
Labor accident	15 (13.2%)	5 (9.6%)	20 (12.0%)	
High fall	11 (9.6%)	2 (3.8%)	13 (7.8%)	
Crushed	2 (1.8%)	2 (3.8%)	4 (2.4%)	
Household accident	13 (11.4%)	6 (11.5%)	19 (11.4%)	
Combine injuries				
Traumatic brain injury	21 (18.4%)	6 (11.5%)	27 (16.3%)	0.265
Maxillofacial trauma	21 (18.4%)	5 (9.6%)	26 (15.7%)	0.148
Spinal cord injury	7 (6.1%)	4 (7.7%)	11 (6.6%)	0.709
Abdominal trauma	11 (9.6%)	8 (15.4%)	19 (11.4%)	0.282
Limb injury	39 (34.2%)	11 (21.2%)	50 (30.1%)	0.089

Table 1. Baseline characteristics between the operative and non-operative groups

those managed non-operatively. Despite the great benefits of surgical stabilization of rib fractures, this practice is still not widespread National Trauma Data Bank (NTDB) data indicate that less than 1% of patients with flail chest undergo this operation (3). There are numerous reasons for this discrepancy, but may be grouped broadly into lack of evidence-based indications for SSRF, lack of familiarity with the operation, and lack of specialty ownership for the care of rib fracture patients.

Over the past few years, the practice of surgical stabilization of rib fractures (SSRF) for the treatment of severe chest wall injuries has increased exponentially, but surgeons have not been able to take advantage of rib fixation in trauma patients (4). The explanation for this is that there are currently few generally accepted indications for rib fixation and there is much controversy about its effectiveness in patients with thoracic trauma (5). The primary goals of rib fixation are to reduce mechanical ventilation time and improve respiratory function by improving lung mechanics, reducing pain, and preventing pulmonary complications associated with severe chest wall deformities. The authors contend that the current literature regarding the benefits of surgical rib fixation is based on three randomized controlled trials, numerous prospective studies, and several retrospective studies. Nevertheless, the outcomes following rib fixation have not been thoroughly assessed (6-8). In addition, the majority of studies on rib fixation surgery have been carried out in developed countries. As a result, there is a necessity for a study that examines the implementation of this procedure in resource-limited settings.

2. OBJECTIVE

Herein, the study aims to compare the clinical outcomes of surgical rib fixation for rib fracture with non-operative treatment.

3. MATERIAL AND METHODS

Study setting

This study was a prospective cohort study conducted from December 2021 to February 2023 at three centers located in three different cities: Viet Duc University Hospital (Hanoi City), Viet Tiep General Hospital (Hai Phong City) and Cho Ray Hospital (Ho Chi Minh City). These three centers were identified based on a professional relationship between investigators, data collection over similar periods, comparable indications for SSRF, volume of cases, and perioperative management protocols, and a relatively limited number of surgeons performing the operation and caring for the patients in the intensive care unit (ICU). At each study center, data sharing agreements were established between the primary study center and each satellite center.

Patients

All adult patients (18 years of age or older) who are admitted to participating hospitals and have confirmed thoracic or multiple rib fractures following blunt thoracic trauma on computerized tomography (CT) scan were enrolled in the study. We divided the patients into two groups: one group underwent rib fixation surgery, while the other group did not undergo rib fixation surgery. We excluded patients with non-traumatic rib fractures, with rib fractures resulting from cardiopulmonary resuscitation, and thoracic injuries involving broken ribs.

Operative treatment

Variables	Nonoperative N = 114 Count (% of total)	Operative N = 52 Count (% of total)	Total N = 166 Count (% of total)	p-value
Number of ribs fractured				0.095
Mean (SD)	7.48 (3.43)	6.52 (3.44)	7.18 (3.45)	
Min, Max	2, 18	2, 17	2, 18	
Flail chest	6 (5.3)	6 (11.5)	12 (7.2)	0.148
Sternum fracture	6 (5.3)	3 (5.8)	9 (5.4)	0.894
Pneumothorax	62 (54.4)	26 (50.0)	88 (53.0)	0.599
Hemothorax	102 (89.5)	41 (78.8)	143 (86.1)	0.066
Hemopneumothorax	36 (31.6)	15 (28.8)	51 (30.7)	0.723
Pulmonary contusion	39 (34.2)	10 (19.2)	49 (29.5)	0.050

Table 2. CT imaging characteristics between the operative and non-operative groups.

Variables	Nonoperative N = 114 Count (% of total)	Operative N = 52 Count (% of total)	Total N = 166 Count (% of total)	p-value
ICU length of stay				<0.001
Mean (SD)	0.09 (0.60)	1.08 (2.34)	0.40 (1.47)	
Min, Max	0, 5	0, 11	0, 11	
Hospital length of stay				0.038
Mean (SD)	10.09 (4.84)	8.67 (4.56)	9.64 (4.78)	
Min, Max	3, 27	2, 21	2, 27	
Ventilator days				0.912
Mean (SD)	0.12 (0.70)	0.10 (0.31)	0.11 (0.64)	
Min, Max	0, 5	0, 1	0, 5	
Mechanical ventilation	4 (3.5)	2 (3.8)	6 (3.6)	0.914
Tracheostomy	2 (1.8)	0 (0.0)	2 (1.2)	0.337
30-day mortality	1 (1.1)	0 (0.0)	1 (0.9)	0.631
Hospital Complications				
Pneumonia	8 (7.0)	2 (3.8)	10 (6.0)	0.426
Empyema	5 (4.4)	1 (1.9)	6 (3.6)	0.430
Hemothorax	2 (1.8)	1 (1.9)	3 (1.8)	0.940
Pleural Thickening	1 (0.9)	0 (0.0)	1 (0.6)	0.498
Overall complication rate	8 (7.0)	3 (5.8)	11 (6.6)	0.764

Table 3. Comparisons of the outcomes between the operative and non-operative groups.

Indications for surgery were ≥ 1 of the following: a) flail chest, b) three or more bicortically displaced fractures, c) failure of narcotics or epidural pain catheter, d) Failure to wean from ventilator, and e) Chest wall deformity/defect.

Nonoperative treatment

Nonoperative treatment consisted of adequate pain management, supportive mechanical ventilation when indicated and physiotherapy for breathing exercises according to standard national guidelines.

Variables

The patient's baseline characteristics included age, gender, injury severity score, Glasgow comma score, mechanism of injury and combined injuries.

Primary outcome was considered to be hospital length of stay and pneumonia rate. Secondary outcome was number of days in ICU, need for tracheostomy, in-hospital complication rate, mechanical ventilation rate and mortality.

Statistical analysis

Data were analyzed using the Stata® 15 (StataCorp LLC, College Station, TX, USA). Normality of continuous data was checked using the Shapiro–Wilk test, and homogeneity of variance across groups was determined using the Levene's test. Baseline characteristics were presented as mean and standard deviation (SD) for continuous variables and frequency and percentage for categorical variables. In the crude analysis, the difference between operative group and nonoperative group were compared using a Mann–Whitney U test (continuous data) or a Chi-squared test (categorical data).

4. RESULTS

A total of 166 patients were included in final analysis. Of these, 52 (31.3%) underwent SSRF. Flail chest was diagnosed in 4.6% patients. The baseline characteristics in the study population are described in Table 1. The SSRF group was younger than the control group (mean age: 50.9 years vs. 51.9 years; p <0.001), less likely to be functionally dependent (0.1% vs. 10.8%; p <0.001), more likely to be treated at a Level I trauma center (52.1% vs. 43.0%, p <0.001), and less likely to have been treated at a nonteaching hospital (11.5% vs. 15.5%, p = 0.01). The highest combined injuries are limb injuries, followed by traumatic brain injury, and maxillofacial trauma. There were no significant differences between the two groups with regard to age, ISS score, and mechanism of injury (Table 1).

Flail chest was diagnosed in 12 (7.2%) patients. The SSRF group had a higher proportion of patients diagnosed with flail chest compared to the non-operative group (11.5% vs. 5.3%, p >0.05). There was no significant difference in CT imaging characteristics between two groups (p >0.05) (Table 2).

One patient died in the non-operative group. Operative group had a shorter mean duration of hospitalization com-

pared to nonoperative group (8.6 days vs. 10.0 days, p = 0.038). There was not significant diference in the number of days on a ventilator between the SSRF and non-operative groups (Table 1). SSRF patients tended toward a lower pneumonia rate than the non-operative group (SSRF 3.8% vs. non-surgical 7%) (p = 0.426). SSRF group also had a lower tracheostomy rate than the non-operative group (SSRF 0% vs. non-operative 1.8%, p = 0.337) (Table 3).

5. DISCUSSION

To the best of our knowledge, this is the first prospective cohort study conducted in Vietnam to compare surgical rib stabilization with conventional management. Our findings demonstrated that patients who underwent surgery had better clinical outcomes, including a shorter hospital stay, lower rates of pneumonia and tracheostomy. These results suggest that surgical management of chest trauma patients may lead to improved short-term outcomes when compared to a conservative approach.

There has been a rapid increase in the number of single-center studies evaluating outcomes after rib stabilizing surgery in the past 10 years, and most studies also show the effectiveness of internal rib fixation in reducing need for mechanical ventilation and length of hospital stays in the surgical group. In a US National Trauma Data Bank review that included more than 600,000 patients with rib fractures, surgical fixation of the rib fracture reduced mortality. In the first randomized study for flail chest treatment, Tanaka, who stabilizes flail chest with Judet struts, showed that the surgically treated group demonstrated a significantly shorter ventilator duration and hospital length of stay, along with lower incidence of pneumonia (6). In a second prospective study conducted by Granetzny et al., patients who received surgical treatment had a significant reduction in ventilation days, as well as shorter hospital and ICU stays compared to the conservatively treated group (7). Leinicke et al. conducted a meta-analysis, which included two of the three randomized controlled trials mentioned, and concluded that operative fixation of flail chest provides several benefits based on nine studies (9).

In relation to the duration of hospitalization, the SSRF procedure exhibited significant advantages by decreasing the length of hospital stay in comparison to the non-operative group. These findings align with numerous prior studies. A recent meta-analysis, which included data from four studies comprising 400 patients, reported a mean reduction of 4 days in inpatient hospital stay for patients who underwent surgical treatment. In a randomized controlled trial, Granetzny observed a mean reduction of 11.4 days in hospital stay for surgically treated patients (7).

Our study revealed that patients who underwent SSRF were less likely to develop pneumonia in comparison to the non-operative group. This finding is strongly supported by previous research. Sarah et al. demonstrated a significantly lower incidence of pneumonia in patients who received surgical treatment (24% compared to 39% in the usual care group) (10). Meta-analysis showed that rib fixation resulted in a significant reduction of pneumonia compared to non-operative treatment with a risk ratio of 0.59.

Our study findings were consistent with previous research, which showed that rib fusion was associated with a lower risk of tracheostomy compared to the non-operative group. Slobogean et al. reported an odds ratio OR = 0.12 for tracheostomy for patients treated surgically compared with patients treated non-surgically (12). In the case series by Althausen et al., surgical intervention reduced the need for tracheostomy from 39% in nonoperative patients to 13.6% in patients treated with rib surgery (13). Ahmed et al. demonstrated similar results, with 11% of patients treated surgically requiring tracheostomy, compared with 37% of patients treated without surgery (14). Reducing the need for tracheostomy not only helps to avoid a secondary surgical procedure but also helps to avoid associated complications.

The strengths of our study include its prospective, multicenter cohort design. However, certain limitations should be acknowledged. Firstly, the short duration of follow-up may have impacted the number of reported complications. Secondly, due to the inconsistent timing and frequency of follow-up appointments, as well as patients receiving reexaminations at hospitals closer to their homes, follow-up data for discharged patients was not available. Thirdly, the majority of patients included in the study had sustained multi-trauma injuries, which may have led to variation in outcome measures between groups, despite comparable ISS scores. Future randomized, prospective studies with longer follow-up periods are needed to quantify the long-term outcomes and benefits of SSRF compared to non-operative management.

6. CONCLUSION

SSRF may offer certain in-hospital outcome benefits when compared with nonoperative management. Operative fixation of a rib fracture in trauma patients resulted in a lower incidence of pneumonia, fewer days of mechanical ventilation, and a shorter hospital stay compared to non-operative treatment group.

- **Ethical statement:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from the patients for publication of this report and any accompanying data. This study was approved by the Institutional Review Board of Hanoi Medical University (No. 504/GCN-HĐĐĐNCYSHSĐH-ĐHYHN).
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