OPEN ACCESS

Journal of Orthopedic Research and Therapy

Nadone HR, et al. J Orthop Res Ther 10: 1391.

www.doi.org/10.29011/2575-8241.001391

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Case Report

Late Deep Implant Infection Following Flail Chest Fixation

Haley R Nadone[1], Dylan Wrye[2], Daniel Gonzales Luna[3], Pierce C Johnson[3], Peter L Althausen[3]*, David C Swanson[3]

[1]University of Nevada, Reno School of Medicine, USA

[2]Reno Orthopedic Center, USA

***Corresponding Author:** Peter L Althausen, Reno Orthopedic Center, 555 North Arlington Avenue, Reno, NV, 89503, USA

Citation: Nadone HR, Wrye D, Luna DG, Johnson PC, Althausen PL, et al. (2025) Late Deep Implant Infection Following Flail Chest Fixation. J Orthop Res Ther 10: 1391. https://doi.org/10.29011/2575-8241.001391

Received Date: 08 July, 2025; **Accepted Date:** 18 July, 2025; **Published Date:** 21 July, 2025

Abstract

Background: Flail chest fixation with modern locking plate technology is a successful means of treatment for unstable injuries. No reports of delayed infection have been presented in the literature. We report on two cases of late infection. **Methods:** A retrospective case-control study was performed at a level II trauma centre on 80 flail chest patients treated with locked plate fixation between January, 2006 and March, 2022. Demographic data was ascertained including age, sex, mechanism of injury, number of fractures, presence of pneumothorax or hemithorax, Operative data was collected such as time to surgery and length of surgery, intensive care length of stay, duration of ventilation, need for tracheostomy, and complications such as hardware irritation, loosening, infection or need for removal. **Results:** Two patients (2.5%) developed late infection. Patients who developed late infection following rib fixation had no statistically significant difference from those who did not other than a longer time to fixation (246.50 ± 122.75 min vs 56.40±53.27 min, $p< 0.001$) and longer duration of intrapleural drainage (16.50 ± 3.54 days vs 7.89 ± 4.83 days, $p = 0.015$). All other demographic, operative, ICU and hospital data were similar among groups. **Conclusions:** Open reduction internal fixation of rib fractures is a well-accepted and effective treatment for patients with flail chest. It has an extremely low complication rate but there is a possibility of late hardware infection requiring removal. Shortening time from injury to OR and decreasing length of intrapleural drainage may reduce the risk of this rare complication.

Keywords: Flail Chest, Rib Fixation

Background

Flail chest fixation with modern locking plate technology has been shown over the last 10 years to be a successful and safe means of treatment for unstable traumatic chest wall injuries [1,2]. Clinical evidence has grown to suggest surgical intervention improves patient outcomes and leads to decreased rates of infection [3,4]. Flail chest injuries treated with surgical fixation have also been found to be cost-effective treatments for these patients [5]. Numerous systematic reviews have shown low incidence of surgical and implant related complications following rib fracture fixation [4-8].

Due to this recent data, there have been increasing rates of surgical fixation for flail chest injuries, highlighting the importance of understanding the long-term prognosis for patients undergoing these procedures [9]. While there are many short-term follow-up studies regarding rib fracture fixation and a few studies showing long-term outcomes, no reports of delayed or late infection have been presented in the literature to date [10-14]. The previous long-term outcome studies report implant irritation leading to implant removal, but report no delayed infections [4,7,8]. In this paper we

present two cases of late hardware infection following flail chest fixation years after the index procedure.

Methods

Following Institutional Review Board (IRB) approval, the trauma database at our Level II trauma center was queried to identify patients treated with operative fixation for flail chest injuries. The electronic medical records (EMR) for all patients who underwent rib fracture fixation between January 2006 and March 2022 were reviewed retrospectively. All patients who underwent surgical fixation of their rib fractures in that timespan were included in this study. Flail chest was defined as fractures of 4 or more ribs fractured at more than 2 sites. Patients with a visible flail segment or lung herniation were included in this study. Only patients with a supplemental O_2 requirement were considered for surgical treatment. Patients underwent surgery as soon as medically cleared. Each surgery was performed in accordance with our institutional protocols as a team approach utilizing a trauma trained general surgeon for thoracotomy and lung intervention as needed and an orthopaedic traumatologist for bone reduction and fixation. Transverse thoracotomy with a muscle sparing approach was performed first by the thoracic surgeon followed by bone fixation by the orthopaedic surgeon. Chest tube or drain placement and closure was done by the thoracic surgeon. Chest tube or drain are removed when chest x-ray is clear, no air leak is present, and output is less than 150mL/day. Sutures or staples are removed 2 weeks post-operatively.

Patient demographic data including age and sex at the time of initial presentation were recorded. In addition, the following patient comorbidity information was collected: BMI, tobacco use history, diabetic status and history of COPD. Other variables obtained were: mechanism of injury, number of rib fractures, level of rib fractures, displacement, flail segment, and concomitant injuries/conditions. Operative measures captured include time to surgery, length of surgery, and number of ribs plated. Hospital admission data collected were hospital length of stay (LOS), intensive care unit (ICU) LOS, ventilation status and duration of intrapleural drainage. Short-term and post-operative complications including ARDS, pneumonia, tracheostomy, hematoma formation, non-union/malunion, superficial wound infection, deep infection, implant irritation and implant removal were also obtained. Patient follow-up was completed in August 2022. Researchers called and emailed each patient who underwent rib fracture fixation during the study period. Patients were asked about their pain status, pain scale and if any additional surgery was performed to treat a rib infection or to remove their rib implants.

Data was analysed by an independent statistician using the statistical software SPSS 25.0. Numerical variables are reported in the form of means and standard deviations and were compared using t-tests. Categorical variables are described in the form of frequencies and percentages and were correlated using Chi-squared tests or Fisher's exact tests. Significance level is set to 0.05.

All methods were performed in accordance with the relevant guidelines and regulations. Informed consent was waived by the IRB as the study was retrospective in nature.

Results

From January 2006 to March 2022, 80 patients were identified as having undergone rib fracture fixation with locked plating for flail chest fixation. Two of these patients (2.5%) were found to have late infection of their implants following their flail chest fixation. The first patient presented 3 years after their initial procedure with complaints of edema and erythema over their surgical incision site located in the left mid-axillary line where the implants were placed. On Gram stain, the patient was found to have a pan-sensitive S. Aureus infection of the left chest wall requiring implant removal in conjunction with an incision and drainage (I&D) of a left chest wall abscess. The second patient presented approximately 7 years later with complaints of purulent drainage from their surgical incision site and prior cultures at an outside institution showing S. Aureus as well. The patient had their rib fracture fixation instrumentation removed and a Gram stain at the time of surgery showed white blood cells (WBCs) with no organisms and no growth on intraoperative cultures. Following hardware removal and a 6-week course of antibiotics recommended by the infectious disease service patients had complete resolution of their symptoms

Average postoperative follow-up time was 108.8 ± 41.3 months for all patients. Table 1 displays the patient demographics which are similar for both cohorts. The average age of all patients was 50.5 years and was 75% male and 25% female, respectively. For those with a delayed infection, the average age was also 50.5 years and was 50% female.

Variable	Late Infection (n = 2)	All Others (n = 78)	p-value
Age (Years)	50.50 ± 2.12	50.51 ± 12.42	0.999
Sex, Female	1 (50%)	19 (24.4%)	0.44
Smoker			
Yes	1 (50%)	17 (21.8%)	0.58
No	1 (50%)	51 (65.4%)	
Former	0 (0%)	10 (12.8%)	
Diabetic	0 (0%)	11 (14.1%)	1
BMI	29.55 ± 1.77	28.71 ± 6.57	0.858
COPD	0 (0%)	2 (2.6%)	1

Numerical variables are reported in the form of means ± standard deviations. Categorical variables are reported in the form of frequencies with the corresponding percentage in parentheses.

Table 1: Patient Characteristics.

Patient's injury characteristics are shown in Table 2. Motor vehicle accidents (MVA) were the prevailing mechanism of injury for the entire cohort (63.8%) but accounted for both mechanisms of injury for the delayed infection patients. Other injury mechanisms include falls, ski accidents and others. The mean number of rib fractures in the delayed infection cohort was 12.5, being bilateral in both (100%) of cases. For the rest of the cohort, the average number of rib fractures were 7.9, occurring bilaterally in 19 (24.4%) of patients. There was one patient with evidence of a sternum fracture. Displacement of the fractures and flail segments were present in both cases of delayed infection. In the entire cohort, 95% of patients had a flail chest segment. 3 (3.8%) patients had an infection prior to their rib fracture fixation but did not present with a delayed infection.

Variable	Late Infection (n = 2)	All Others (n = 78)	p-value
Mechanism of Injury			
MVA	2 (100%)	49 (62.8%)	
Fall	0 (0%)	12 (15.4%)	
Skiing	0 (0%)	12 (15.4%)	
Other	0 (0%)	7 (9.0%)	
Unknown	0 (0%)	1 (1.3%)	
No. of Rib Fractures	12.50 ± 9.192	7.90 ± 2.930	0.608
Bilateral Rib Fractures	2 (100%)	19 (24.4%)	0.066
Sternum Fracture	0 (0%)	1 (1.3%)	1
Displacement	2 (100%)	53 (68.8%)	1
Flail Segment	2 (100%)	74 (94.9%)	1
Pneumothorax	2 (100%)	71 (91%)	1
Hemothorax	2 (100%)	63 (80.8%)	1
Pulmonary Contusion	2 (100%)	60 (76.9%)	1
Infection Prior to Surgery	0 (0%)	3 (3.8%)	1

Numerical variables are reported in the form of means ± standard deviations. Categorical variables are reported in the form of frequencies with the corresponding percentage in parentheses. MVA: Motor Vehicle Accident.

Table 2: Injury Characteristics.

Variable	Late Infection (n = 2)	All Others (n = 78)	p-value
Time to Surgery (Hours)	246.50 ± 122.75	56.40 ± 53.275	< 0.001
Length of Surgery (Minutes)	101 ± 35.36	68.1 ± 34.427	0.186
No. of Ribs Plated	5.0 ± 1.414	4.12 ± 1.184	0.301

Numerical variables are reported in the form of means ± standard deviations. Categorical variables are reported in the form of frequencies with the corresponding percentage in parentheses.

Table 3: Surgical Characteristics.

Table 3 exhibits the surgical characteristics. This data shows that the patients with a delayed infection after their rib fracture fixation had longer times to surgery than those who did not show delayed infections (246.50 vs. 56.40 hours, P = < 0.001). Operative times for all cases averaged 68.94 minutes. The mean number of ribs plated overall was 4.14. Post-operative outcomes (Table 4) were similar for both patient groups. Total LOS for both groups averaged 12.8 days. However, the delayed infection cohort had a longer duration of intrapleural drainage from their chest tubes (16.50 vs. 7.89 days, P = 0.015), had implant irritation (100% vs 0%, P = < 0.001) and subsequently had their rib implants removed (100% vs 0%, P = < 0.001). Average time to implant removal for the delayed infection patients was 59 ± 32.53 months after the initial rib fracture fixation.

Variable	Late Infection (n = 2)	All Others (n = 78)	p-value
Total LOS (Days)	20.50 ± 7.78	14.21 ± 12.12	0.469
Hospital LOS (Days)	7.27 ± 0.91	5.91 ± 4.59	0.469
ICU LOS (Days)	13.77 ± 5.75	8.48 ± 10.07	0.464
Duration of Intrapleural Drainage (Days)	16.50 ± 3.54	33 (42.3%)	0.188
Tracheostomy	0 (0%)	7.89 ± 4.835	0.015
ARDS	2 (100%)	15 (19.2%)	1
Pneumonia	0 (0%)	28 (36.8%)	0.145
Hematoma	0 (0%)	8 (10.7%)	1
Nonunion/Malunion	0 (0%)	3 (3.8%)	1
Superficial Wound Infection	0 (0%)	1 (1.3%)	1
Deep Infection	2 (100%)	3 (3.8%)	1
Implant Irritation	2 (100%)	0 (0%)	< 0.001
Implant Removal	2 (100%)	0 (0%)	< 0.001

Numerical variables are reported in the form of means ± standard deviations. Categorical variables are reported in the form of frequencies with the corresponding percentage in parentheses. LOS: Length of Stay. ICU: Intensive Care Unit. ARDS: Acute Respiratory Distress Syndrome

Table 4: Post-Operative Outcomes.

Discussion

Our study demonstrates similar outcomes to previous studies which indicate that locked plate fixation of rib fractures in patients with flail chest is a safe and effective option. Long-term outcome studies detail implant irritation, palpable implants, and implant removal, but seemingly there have been no reports of delayed or late infection following flail chest fixation [4,7,8]. Delayed and late infections are defined as infections occurring between 2-10 weeks and those greater than 10 weeks out, respectively [15-17]. Both patients in our study had late infections which resolved with hardware removal and antibiotic treatment. This seems to indicate that late infection following rib fixation is a rare but treatable condition.

Although uncommon, infected hardware removal following flail chest fixation is a situation we would like to avoid. Our data indicates that decreasing the time from injury to operative fixation may reduce the risk of infection. Although management of the trauma patient is multifactorial it is imperative that trauma centres have rib fixation protocols in place, trauma trained general and orthopaedic surgeons well versed in internal fixation and operating room availability. Patients should undergo rib fixation as soon as they can be resuscitated and cleared for surgery to decrease the rate of complications, ICU and hospital lengths of stay. The length of intrapleural drainage is also a mitigating factor for infection. Both patients with late infections had hardware infected with skin flora. Extended persistence of drain tubes may be a predisposing factor to such pathogens. It is also possible a localized postoperative fluid collection was missed during routine follow up visits which became infected at a later date. Our data suggests that surgeons need to be vigilant about postoperative management and remove chest tubes as soon as medically safe for patients following fixation.

Conclusion

Open reduction internal fixation of rib fractures is a well-accepted and effective treatment for patients with flail chest. It has an extremely low complication rate but there is a possibility of late hardware infection requiring removal. Shortening time from injury to OR and decreasing length of intrapleural drainage may reduce the risk of this rare complication.

Declarations

Ethics Approval: Study was approved by Renown Regional Medical Center Investigational Review Board.

Consent for Publication: Not Applicable

Availability of Data and Materials: Not Applicable

Competing Interests: The Authors declare that they have no competing interests.

Funding: None

Authors' Contributions

HN gathered and interpreted patient data while being a major contributor in writing the manuscript and table creation. DW gathered patient data and aided in manuscript writing. DGL, PJ, DS, and PA all were major contributors to initial data gathering and were major contributors to writing the manuscript.

Acknowledgements: Lingchen Wang, Statistician

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