

# Rib Fractures: New Trend and Techniques in Fixation

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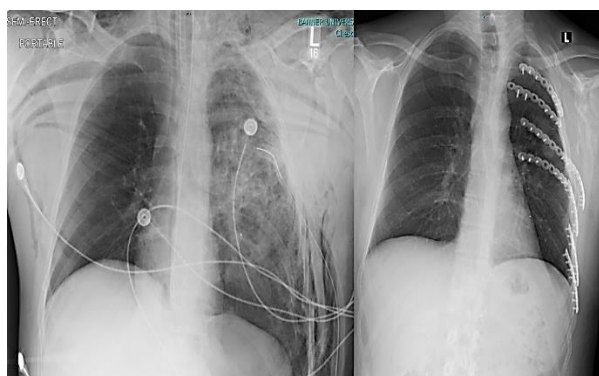
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## Background

Isolated rib fractures are common injuries that are routinely treated non-operatively with good outcomes. However, in the setting of high-energy trauma to the thorax, a patient may sustain multiple rib fractures, with a flail chest or unstable chest wall. A flail chest injury is defined as a fracture of 3 or more consecutive ribs, in two or more locations, which can create an unstable segment (1, 2).

Patients with flail chest injuries have high rates of morbidity and mortality (1). Pain, decreased thoracic volume, and inability to clear secretions can negatively impact ventilation and respiration, which can render patients in need of invasive mechanical ventilation. Prolonged mechanical ventilation is associated with an increased risk of pneumonia, sepsis, tracheostomy, and increased health care costs (2-5). A review of the National Trauma Databank revealed poor outcomes in patients with flail chest injuries, with mechanical ventilation needed in 59%, admission to the intensive care unit (ICU) in 82%, tracheostomy in 21%, pneumonia in 21%, sepsis in 14%, and 16% rate of mortality (1).

Historically, flail chest injuries were routinely treated non-operatively. However, in the last two decades, there has been an increased interest in surgical fixation of these injuries (6) (Figure 1). Multiple retrospective and non-randomized studies have reported improved outcomes and lower complications with surgery, such as a lower rate of mechanical ventilation, ICU stay, pneumonia, tracheostomy, pain, and time off work (5, 7-10).



**Figure 1.** Multiple left-sided rib fractures and a flail chest treated with surgical fixation

However, these studies have been fraught with the lack of a control group, outdated modes of treatment, and

small sample sizes. Up until recently, there have been limited high-quality prospective studies looking at the benefits of operative compared to nonoperative management. This study aimed to present new trends and techniques in the fixation of rib fractures.

**Latest Evidence from a Recent Randomized Controlled Trial (RCT):** A recently presented multi-centered RCT reported on the outcomes of surgery and non-operative treatment for the treatment of patients with unstable chest wall injuries. This was an RCT conducted at 15 sites across Canada and the United States, with a total of 207 patients enrolled (11). Patients were randomized to (i) non-operative treatment (n = 99), which involved mechanical ventilation as needed, pain management, and chest physiotherapy, and (ii) operative treatment (n = 108), which included all treatments in the non-operative group, as well as surgical fixation of the chest wall within four days of injury.

Inclusion criteria were age between 16-85 years and the presence of a flail chest, or severe deformity of the chest wall with multiple displaced rib fractures. Exclusion criteria included severe pulmonary contusion or head injury, anatomic location of fractures not amenable to surgical fixation (ribs 1, 2, fractures adjacent to the spine, fractures involving floating ribs), patient not medically optimized to undergo surgery, and surgical fixation > 4 days from time of injury (as prolonged delay to surgery can increase the negative effects of prolonged mechanical ventilation and risk of ventilator-associated pneumonia).

The primary outcome in this study was the number of ventilator-free days (VFDs) in the first 28 days after injury, which is a composite outcome assessing the length of time on mechanical ventilation as well as mortality. This is an outcome routinely used in acute respiratory distress studies. A higher number is better: if no mechanical ventilation is needed, the patient has a VFD of 28, and in case of mortality or ventilation > 28 days, the patient receives a VFD of 0. Secondary outcomes included length of time in the ICU, hospital length of stay, rates of pneumonia, sepsis, tracheostomy, mortality, and surgical complications.

Of the 207 patients randomized, the mean age was 53 years, with a mean number of 10 fractured ribs. Forty-three percent were on mechanical ventilation at the time of randomization, and 78% were admitted to the ICU.

Results demonstrated that overall, there was minimal difference in VFD between the surgical (22.7 days) and non-operative (20.6 days) groups (P = 0.089). There was also no difference in ICU and hospital length of stay, or complications (pneumonia, sepsis, tracheostomy).

However, mortality was significantly lower in the surgical group (0%) compared to the non-operative group (6%) ( $P = 0.01$ ).

When looking at the subgroup analysis of patients who were on mechanical ventilation at the time of randomization, surgery seemed to provide a benefit compared to non-operative treatment. In this subgroup, surgery was associated with higher VFD (16.4 vs. 13.6,  $P = 0.04$ ), and there was a shorter hospital length of stay (hazard ratio: 1.36,  $P = 0.02$ ). Complications were similar between the two treatment groups. In contrast, the subgroup of patients who were not on mechanical ventilation did not have an improvement in any of the outcomes (VFD, ICU length of stay, complications, etc.) with surgery, compared to non-operative treatment.

The results of this study are different from some of the prior lower-quality studies. The results suggest that surgical treatment of flail chest injuries does not provide as much benefit as previously reported regarding decreasing the risk of pneumonia and sepsis. Mortality was lower with surgery (which may be due to unrelated causes), and there was a potential benefit in lowering time on mechanical ventilation and hospital length of stay (in the ventilated subgroup only). Surgical treatment of non-ventilated patients does not seem to provide any benefit in the outcomes assessed.

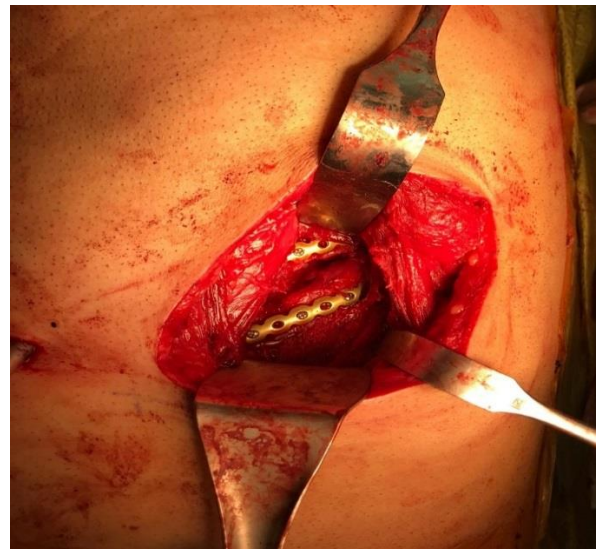
**Surgical Planning:** Given the anatomy of the rib cage, when multiple ribs are fractured, they break across a similar location. It is common to have ribs fractured in two locations (for example anterolateral and posterior), which can create a flail segment. Frequently, fractures are displaced at one of these locations, and the other site may be minimally displaced.

The goal of surgery is to stabilize the chest wall by fixing the most displaced fractures, while minimally displaced fractures can be treated non-operatively. Cross-sectional imaging with computed tomography (CT) scan, including three-dimensional (3-D) reconstruction images, can be helpful to identify the location of fractures, and for surgical planning. Rib fracture fixation can be performed with a thoracotomy-type approach for anterior and lateral fractures, and a posterior approach for posterior fractures.

Given the results of the recent randomized study, if considering surgical fixation, patient selection is important. This procedure should also be performed at a center with available resources and a multi-disciplinary team, such as ICU, respiratory therapy, and thoracic/trauma surgery. It is important to have familiarity with the surgical approach and local anatomy. Working with another surgeon who has expertise in local anatomy can be helpful. The help of a trauma or thoracic surgeon may be required if there are any concerns about other intra-thoracic injuries which may require fixation (such as lacerated lung or diaphragm injury).

**How to Perform Surgical Fixation:** The patient is typically placed in a lateral decubitus position. A regular endotracheal tube can be utilized, and double-lumen ventilation and taking down the affected lung is not mandated. The ipsilateral arm is free-draped and placed on a sterile mayo stand, as manipulation of the arm can help move the scapula out of the way.

For anterior or lateral fractures, a thoracotomy incision is made, centered over the fractures. Muscle-splitting windows are created through the serratus anterior muscle (Figure 2).



**Figure 2.** Intra-operative image of a thoracotomy approach and fixation of multiple left-sided rib fractures via a muscle-splitting window through the serratus anterior muscle

In general, 2 to 3 ribs can be exposed through each muscle-splitting window, and another window can be created to gain access to further ribs as needed (12).

For posterior fractures, a longitudinal incision is made centered over the fractured ribs. Deep dissection is done between the latissimus dorsi caudally, trapezius cranially, and the border of the scapula laterally. Once these structures are retracted (the trapezius cranially, scapula laterally, and latissimus dorsi caudally), the erector spinae muscles are visualized. Once the erector spinae muscles are reflected, the underlying ribs are exposed.

Fracture fixation is relatively straightforward. Plate and screws can be used to fix the fractures utilizing AO principles, either with compression for simple fractures or bridge technique for comminuted fractures. Pre-contoured, rib-specific locking plates can be used, but if these are not available, pelvic reconstruction plates can also be utilized (which may require contouring). Once the fracture is reduced, a plate is placed over the rib and secured with a minimum of 3 bicortical screws on either side of the fracture. Segmental fractures may be fixed with a single plate, or two separate plates depending on the distance between the fractures (12).

Post-operatively, a chest tube should be placed, via a separate incision, and away from the plate and screws (to decrease the risk of infection). Chest tube management should be done per standard protocols. In general, the chest tube may be removed once there is no air leak, and output is  $< 100$  cc per day. Incentive spirometry, pain management, and chest physical therapy should be prescribed postoperatively.

### Conclusion

Flail chest injuries are associated with a high rate of morbidity. Surgical fixation appears to have some benefits in the subset of patients who are on mechanical ventilation at the time of presentation. Surgery can be performed via thoracotomy or posterior approaches, and fractures are fixed with plates and screws. Further research in this area is warranted to assist with patient selection and identify factors associated with poor outcomes.

## Conflict of Interest

The authors declare no conflict of interest in this study.

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## References

- Dehghan N, de Mestral C, McKee MD, Schemitsch EH, Nathens A. Flail chest injuries: A review of outcomes and treatment practices from the National Trauma Data Bank. *J Trauma Acute Care Surg.* 2014;76(2):462-8. doi: [10.1097/TA.000000000000086](https://doi.org/10.1097/TA.000000000000086). [PubMed: 24458051].
- Engel C, Krieg JC, Madey SM, Long WB, Bottlang M. Operative chest wall fixation with osteosynthesis plates. *J Trauma.* 2005;58(1):181-6. doi: [10.1097/01.ta.0000063612.25756.60](https://doi.org/10.1097/01.ta.0000063612.25756.60). [PubMed: 15674171].
- Nirula R, Diaz JJ, Trunkey DD, Mayberry JC. Rib fracture repair: Indications, technical issues, and future directions. *World J Surg.* 2009;33(1):14-22. doi: [10.1007/s00268-008-9770-y](https://doi.org/10.1007/s00268-008-9770-y). [PubMed: 18949513].
- Lafferty PM, Anavian J, Will RE, Cole PA. Operative treatment of chest wall injuries: Indications, technique, and outcomes. *J Bone Joint Surg Am.* 2011;93(1):97-110. doi: [10.2106/JBJS.L00696](https://doi.org/10.2106/JBJS.L00696). [PubMed: 21209274].
- Granetzny A, Abd El-Aal M, Emam E, Shalaby A, Boseila A. Surgical versus conservative treatment of flail chest. Evaluation of the pulmonary status. *Interact Cardiovasc Thorac Surg.* 2005;4(6):583-7. doi: [10.1510/icvts.2005.111807](https://doi.org/10.1510/icvts.2005.111807). [PubMed: 17670487].
- Dehghan N, Mah JM, Schemitsch EH, Nauth A, Vicente M, McKee MD. Operative stabilization of flail chest injuries reduces mortality to that of stable chest wall injuries. *J Orthop Trauma.* 2018;32(1):15-21. doi: [10.1097/BOT.0000000000000992](https://doi.org/10.1097/BOT.0000000000000992). [PubMed: 28902086].
- Ahmed Z, Mohyuddin Z. Management of flail chest injury: Internal fixation versus endotracheal intubation and ventilation. *J Thorac Cardiovasc Surg.* 1995;110(6):1676-80. doi: [10.1016/S0022-5223\(95\)70030-7](https://doi.org/10.1016/S0022-5223(95)70030-7). [PubMed: 8523879].
- Tanaka H, Yukioka T, Yamaguti Y, Shimizu S, Goto H, Matsuda H, et al. Surgical stabilization of internal pneumatic stabilization? A prospective randomized study of management of severe flail chest patients. *J Trauma.* 2002;52(4):727-32. doi: [10.1097/00005373-200204000-00020](https://doi.org/10.1097/00005373-200204000-00020). [PubMed: 11956391].
- Marasco SF, Davies AR, Cooper J, Varma D, Bennett V, Nevill R, et al. Prospective randomized controlled trial of operative rib fixation in traumatic flail chest. *J Am Coll Surg.* 2013;216(5):924-32. doi: [10.1016/j.jamcollsurg.2012.12.024](https://doi.org/10.1016/j.jamcollsurg.2012.12.024). [PubMed: 23415550].
- Slobogean GP, MacPherson CA, Sun T, Pelletier ME, Hameed SM. Surgical fixation vs nonoperative management of flail chest: A meta-analysis. *J Am Coll Surg.* 2013;216(2):302-11. doi: [10.1016/j.jamcollsurg.2012.10.010](https://doi.org/10.1016/j.jamcollsurg.2012.10.010). [PubMed: 23219148].
- Dehghan N, Nauth A, Schemitsch E, Vicente M, Jenkinson R, Kreder H, et al. Operative vs nonoperative treatment of acute unstable chest wall injuries: A randomized clinical trial. *JAMA Surg.* 2022;157(11):983-90. doi: [10.1001/jamasurg.2022.4299](https://doi.org/10.1001/jamasurg.2022.4299). [PubMed: 36129720].
- Dehghan N, Nauth A. Surgical fixation of flail chest injuries calls for multidisciplinary team. *Orthopedics Today* 2022 [Online]. [cited 2022 Jun]; Available from: URL: <https://www.healio.com/news/orthopedics/20220621/surgical-fixation-of-flail-chest-injuries-calls-for-multidisciplinary-team>