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Geriatric (G60) trauma patients with severe rib fractures: Is muscle sparing minimally invasive thoracotomy rib fixation safe and does it improve post-operative pulmonary function?

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ABSTRACT

Background: Patient outcomes after muscle sparing minimally invasive thoracotomy rib fixation (MSMIT-ORF) in geriatric G60 trauma patients remain poorly studied. This study determined the effect of MSMIT-ORF on pulmonary function (PFT). Non-operatively managed (NOM) patients were also described.
Methods: Medical records of G60 patients with severe rib fractures with PFTs measured before and after MSMIT-ORF were examined. Patient outcomes (MSMIT-ORF vs NOM) were adjusted in a multivariate logistic regression model.
Results: 64 patients underwent MSMIT-ORF, 135 were NOM patients. MSMIT-ORF treated patients showed improvements in PFTs on postoperative day 5, $p = 0.001$. After adjustment analysis, MSMIT-ORF was associated with increased hospital length of stay (OR 44.9; 95% CI, 9.8–205, $p < 0.001$), but a more favorable discharge disposition. There was no difference in the rates of pneumonia ($p = 0.996$) or death ($p = 0.140$).
Conclusions: MSMIT-ORF is safe and improves pulmonary function in G60 trauma patients diagnosed with severe rib fractures. Future randomized control studies are needed for confirmation.

1. Introduction

As the US population ages, trauma centers are seeing an increase in the number of geriatric trauma patients age ≥60 years (G60).[1] Rib fractures remain a significant problem in the geriatric trauma population. The sequelae of clinically significant rib fractures have been well described, and includes severe acute and chronic pain often requiring long term narcotic therapy. This is directly associated with diminished pulmonary function which leads to increased pneumonia rates, need for prolonged mechanical ventilation, and decreased long term functional status. G60 patients are especially vulnerable to these problems and many studies have shown worse overall outcomes in older patients when compared to their younger counterparts. In fact, the risk of pneumonia or death secondary to severe rib fractures is nearly doubled for patients over the age of 60.[2–4]

Despite advances in medicine, the basic medical management of rib fractures has remained unchanged for the past 40 years notwithstanding the wide availability of mechanical ventilation. Traditionally, rib fractures have been managed non-operatively in the majority of cases with flail chest as the exception. Typical treatment adjuncts include thoracic epidural catheters and intercostal nerve blocks.[5,6] Although there is an increasing use of operative rib fixation, the surgical approach is not at present the standard of care for the management of severe rib fractures. In the last decade, the enthusiasm to repair rib fractures has grown. However, outcomes in G60 patients treated with operative rib fixation remain largely unknown. As reported based on a study of the National Trauma data Bank, only a small fraction (<1%) of all patients with flail chest or significantly displaced rib fractures with severe refractory pain or respiratory failure are offered operative

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rib fixation as part of their management strategy.[7]

Operative rib fixation has been described as early as 1961 and has evolved over the years. The operative techniques and equipment available today are more numerous and clearly superior to those available 55 years ago, when this was first attempted.[8] Thus it is imperative that investigators continue to define the role operative rib fixation plays in improving patient outcomes within the context of an evolving technology.

The early surgical techniques employed for operative rib fixation involved large, muscle splitting standard posterolateral thoracotomy incisions (Fig. 1a).[9] At our American College of Surgeons ACS) level I and affiliate ACS level III trauma centers, we have employed more targeted incisions using a muscle sparing minimally invasive thoracotomy for operative rib fixation (MSMIT-ORF) (Fig. 1b). This study aimed to determine and compare pulmonary function (PFT) before and after MSMIT-ORF among G60 trauma patient with severe rib fractures. G60 patients managed non-operatively (NOM) were also described to provide a historical context of non-operative fracture management prior to the introduction of MSMIT-ORF at our trauma centers.

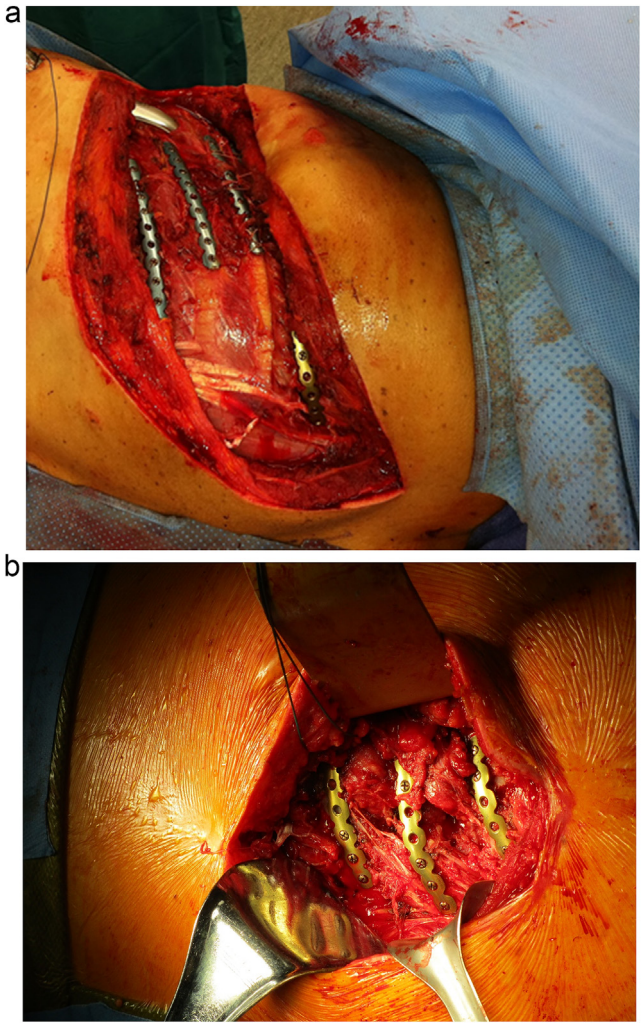

Fig. 1. (a): This is a representative image of a standard curvilinear transverse muscle splitting thoracotomy incision. The muscles of the chest wall were completely divided to gain exposure to the rib fractures. (b): This is a representative image of a Muscle-sparing minimally-invasive thoracotomy (MSMIT-ORF) incision targeted over the area of the fractures to be fixed. Of note, the chest wall musculature has been divided in line with the fibers and flaps have been raised over the surface of the ribs allowing for application of the titanium plates with much less trauma to the chest wall.

2. Material and methods

2.1. MSMIT-ORF management of G60 trauma patients with severe rib fractures from May 2014 to October 2016

We performed a review and analysis of data collected on 64 G60 patients who underwent MSMIT-ORF from May 2014 to October 2016 secondary to severe rib fractures. We operationally defined severe rib fractures as rib fractures in patients characterized by: displaced ribs on 3D computerized axial tomography scan (CT scan), uncontrolled pain, displaced ribs fractured in 2 or more places and reports of ribs crepitus with each breath. Consecutive patients who underwent MSMIT-ORF in this study were admitted to the G60 trauma service. Inclusion criteria: hemodynamically stable patient not intubated at the time of assessment, patient with pain scores $\geq$6 (on a 1–10 scale), inspiratory volume on incentive spirometry (IS) $\leq$ 15 mL/kg, or a weak cough strength score equal to 1 (ranging from 0 = weak to 5 = strong) were eligible for fixation. A patient who was intubated but had a GCS Eye score 4, motor score 6 for a total GCS score of 11T and a candidate for early extubation was also eligible for fixation. Exclusion criteria: hemodynamically unstable patient, pain scores< 6 with aggressive pain management, inspiratory volume on incentive spirometry (IS) $\geq$ 15 mL/kg, or a weak cough strength score of $\geq$2 on 3 consecutive days. The rib fracture clinical pathway protocol included multimodal pain management, physical and occupational therapy, nutrition evaluation, and bedside pulmonary function tests. Patients who performed less than 50% of predicted value for forced expiratory volume (FEV1) were considered for early rib fixation (<24 h).

In summary, the standardized rib fracture protocol followed at our trauma centers included scheduled pain medications, nebulizer treatments, incentive spirometry, intermittent positive pressure ventilation (EZPap®), physical and occupational therapy consultation. Bedside pulmonary function tests were obtained pre-operatively, on post-operative day 2 and again on post-operative day 5 whenever possible. Forty-three (43) of 64 patients had a complete data set of bedside pulmonary function tests at all 3 time points. All the patients in the MSMIT-ORF group also had pre-operative three dimensional reconstructions of their admission chest CT scans that were reviewed prior to undergoing MSMIT-ORF. All operations were performed under general anesthesia and with traditional double lung positive pressure ventilation. The Synthes MatrixRib® rib fixation system was used in all the operations. This system consisted of flexible titanium pre-contoured titanium plates and screws. A Synthes® 90-degree screw driver and drill were used to facilitate the placement of the plates through a small incision. The low-profile design of the instrument allowed facile placement of the plates in places that have been historically inaccessible i.e., under the scapula and near the vertebral transverse processes with as little as 2 cm of clearance. The self-retaining omni retractor was used to elevate the tissues for exposure. Once the ribs were stabilized, the pleural space was routinely irrigated with 2–5 L of sterile saline until the drainage was clear. A 24-french silastic flexible drain was then placed percutaneously into the pleural space and connected to a pleurovac chest drainage system. With the advent of MSMIT-ORF at our trauma centers, no new trauma surgeons have been added to the team that performed the rib fixation procedures. There has been no changes in the referral pattern. We have not encountered situations where insurance coverage was a deciding factor that made a patient more or less likely to undergo MSMIT-ORF.

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