Case Report

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Fixation of Multiple-Segmented Costosternal Cartilage Fracture in Flail Chest Injury: A Case Report

Pornpanit Dissaneewate, M.D., Methasit Suksintharanon, M.D., Chulin Chewakidakarn, M.D., Wich Orapiriyakul, M.D., Apipop Kritsaneephaiboon, M.D.

Department of Orthopaedic and Rehabilitation, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.

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Abstract:

Early internal fixation of rib fractures in the setting of flail chest has proven benefits over traditional conservative treatment. This can decrease pneumonia, time on mechanical ventilation, length of stay in intensive care units, need for tracheostomy and increase in the pulmonary function test. However, there are few reports regarding on how to restore the costochondral junction, or costal cartilage in cases of anterior or anterolateral flail chest involving cartilage matrix of the ribs or costochondral joint. This case report describes a surgical technique to restore the costochondral junction with plate osteosynthesis and the results.

Keywords: chest wall stabilization, costosternal fixation, flail chest, rib fixation, thoracic trauma

Introduction

Ribs fractures are common injuries following blunt chest trauma. While most cases can be treated non-operatively, severe chest wall injury is associated with high morbidity and mortality. Patients with flail chest often struggle with hypoxemic respiratory failure, due to: insufficient ventilatory mechanics, pulmonary contusion, and subsequent pneumonia.[1] The mortality rate can be as high as 9.0-16.0%.[2,3] A combination of adequate pain control, respiratory assistance, and physiotherapy is considered the gold standard in management of rib fractures.[4] However, is mounting evidence supporting surgical rib fixation, following flail chest injury, over traditional non-operative management; because of a decrease in pneumonia, time on mechanical ventilation, length of stay in the intensive care unit (ICU), need for tracheostomy

Contact: Pornpanit Dissaneewate, M.D.
Department of Orthopaedic and Rehabilitation, Faculty of Medicine,
Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.
E-mail: dpornpanit@yahoo.com

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and an increase in the pulmonary function test.[5-7] One of the fixation methods, a plating system, is designed for the placement of bicortical screws on the outer cortex of the rib.[1] This plate fixation system requires the flail segment to be confined within the bony part of the rib to be effective. In case of anterior or anterolateral flail chest, that also involve cartilage matrix of the ribs or costochondral joint, there are few reports regarding on how to restore the costochondral junction. This case report describes a surgical technique to restore anterior flail chest that involved costochondral disruption, with plate osteo-synthesis and the results.

Case presentation

A 43-year-old, male, Thai was referred from a rural hospital; due to right flail chest injury with pneumo-hemothorax occurring from a motor vehicle accident. Upon arrival, he had already been intubated and an intercostal tube was inserted into his right chest wall. His vital signs were stable, and arterial blood gas showed acceptable oxygenation. Physical examination revealed paradoxical chest movement, diffused subcutaneous emphysema around the right chest wall as well as decreased breath sounds of the right lung. Chest computerized tomography (CT) scanning revealed right anterior 3rd to 6th ribs fractures, with costosternal disruption of the 4th-8th right ribs, causing floating segments of the 4th-6th ribs (Figure 1). No diaphragmatic injury was detected. He was diagnosed with right sided flail chest, and was classified as having a costal margin rupture, according to Sheffield classification of injuries involving the costal margin. Initially, he was admitted to the intensive care unit. However, it was difficult to wean him off from invasive mechanical ventilation, and he tended to be ventilator dependent; despite lung parenchymal improvement coupled with good cooperation with the respiratory rehabilitation program. We suspected that the cause of difficult weaning was from fail chest. The patient then underwent costosternal fixation 3 days after

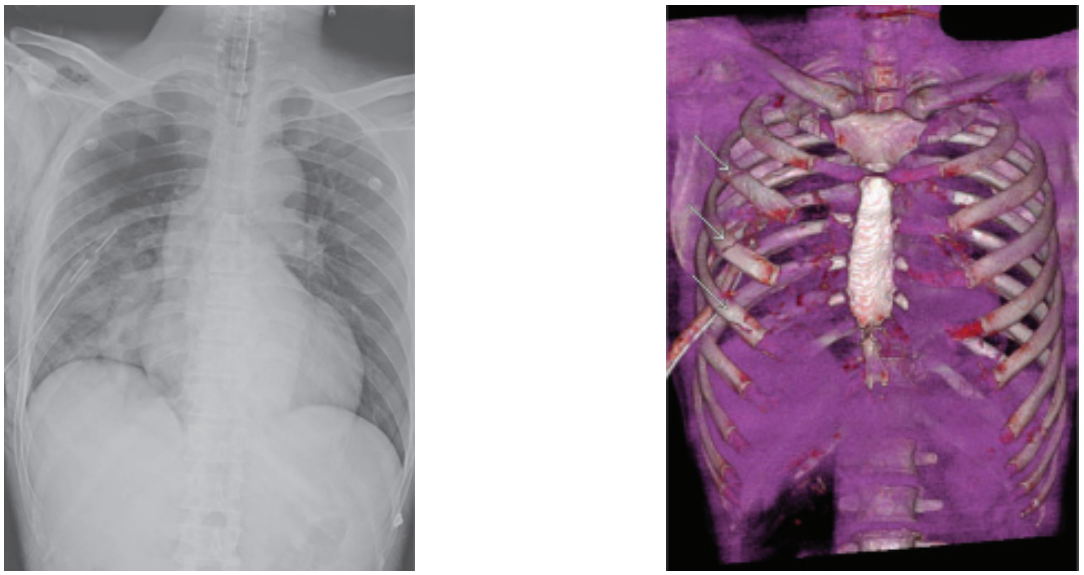

Figure 1 Initial plain radiography, and three-dimensional chest computerized tomography scan after chest tube insertion

injury. During the surgery, the patient was mechanically ventilated utilizing the one-lung ventilation technique. Muscle sparing, right anterolateral thoracotomy was performed by a trauma surgeon. Direct reduction of the flail segment was performed with reduction clamps. Depuy Synthes MatrixRib precontoured plates were used to stabilize the free segments of the 4^{th}-6^{th} ribs, so as to enable stabilization of the lateral rib parts and sternum. The plates were spanned from the stable lateral ribs to the sternal body. This required fine adjustment of the pre-contoured plates, as they were designed for specific rib curvature. Fixations of the bony parts were achieved with screws, whereas, the cartilaginous parts were stabilized with number 5 Ethibond sutures to the plates and sternum (Figure 2 A, B). It is important to measure the rib and sternal thickness with a caliper first, then use a depth-limiting drill bit, or self-drilling screw, as this technique can prevent iatrogenic pleural or mediastinal injury. At least three bicortical screws on each bony segment (sternum and lateral rib) were achieved.

Post-operatively, the patient was able to wean off invasive mechanical ventilation and was extubated three days after the surgery. We were able to discharge this patient without further complications. Upon his follow up visit, at one month after surgery, the patient had no complications and his follow up X-ray showed no implant failure, or loss of initial fixation (Figure 2C). Unfortunately, we did not have data of his pulmonary function, because he did not return for another follow up after this. However, we reached him by phone every two or three months. The patient reported no discomfort related to the implants, no restrictions in respiratory movements, and was able to resume pre-injury activities as a construction worker after 3 months post-surgery. We failed to contact the patient, or his relatives after 14 months.

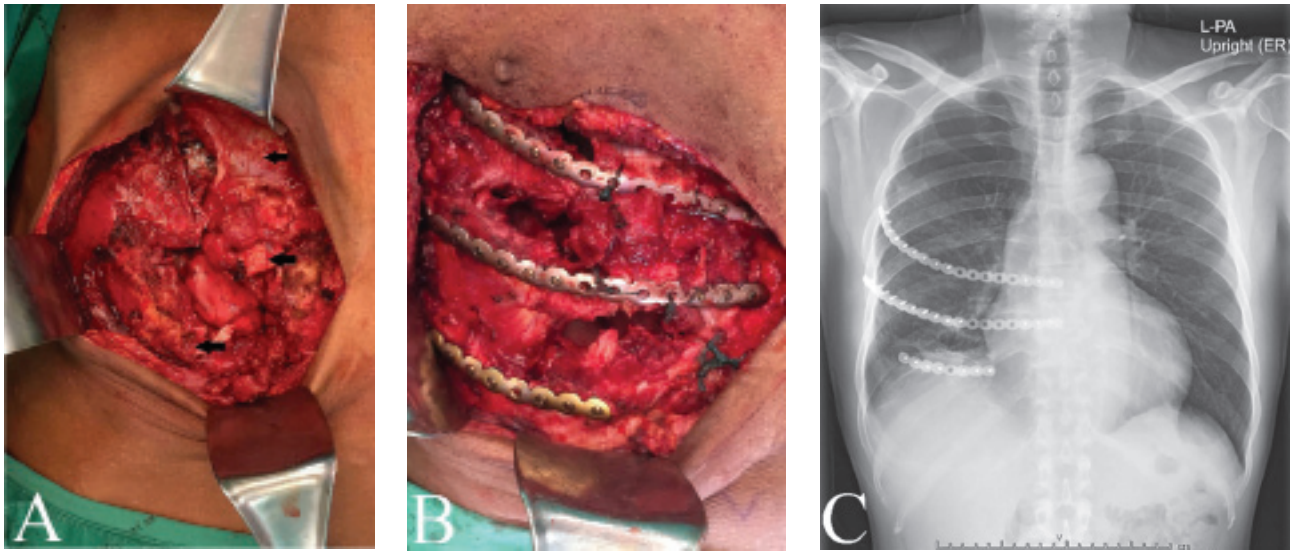

Figure 2 Floating fragments of 4^{th}-6^{th} ribs (arrows), via anterolateral thoracotomy (A). Final fixation construct of 4^{th}-6^{th} ribs (B). Follow up chest radiography 1 month after surgery (C).

Discussion

Multiple rib fractures and flail chest are common among patients sustaining severe chest trauma. However, costal cartilage fractures are easily overlooked, due to not being visible on plain chest radiographs; unless there is severe calcification of the cartilage, or there is overlapping osseous in the junctional regions. Chest CT scanning offers the advantage of demonstrating other injuries, such as costal cartilage fractures, diaphragmatic injury and lung parenchyma. Due to the function of the rib cage providing the mechanical support for the respiratory system, flail chest can compromise the respiratory mechanic. This in turn leads to prolonged mechanical ventilation, ICU stays and an increased pneumonia rate. Although, conventional treatment includes pain control, physical therapy and ventilation support has been the mainstay treatment for many decades. As technology of internal fixation has improved, and the biomechanical properties of the ribs are now better understood, surgical fixation has become more popular. In addition more literatures, regarding rib fixation, have been published over the past decade.[8] The indication for rib stabilization includes multiple ribs fractured with a flail, requiring positive pressure ventilation; except for those requiring long-term mechanical ventilation for other reasons.[8] A few randomized control trials, as well as other cohort studies, have demonstrated a reduced need for mechanical ventilation, less pneumonia, less pain and reduced ICU duration when early surgical intervention is performed.[5-7,9-11] Recent metanalyses confirmed these findings and suggests a mortality benefit as well.[12-14] Additionally, several investigators have found early surgical rib stabilization to be more cost effective than non-operative treatments.[5,15]

There are several options for rib fixation available, such as: plating osteosynthesis, absorbable plating, Judet struts, Kirschner wires and intramedullary rods. There are however, no studies suggesting one device being superior to another, although the most dominant method currently used is plating osteosynthesis.[1] In order to optimize fixation stability, Depuy Synthes recommends at least three screws, per plate, per fracture side. In cases of anterior or anterolateral flail chest wherein the costochondral junction is also compromised, plate osteosynthesis for rib fractures alone is not stable enough, because there is no place for medial insertion of three screws at the fracture site. There are a few reports on the methods of stabilization in this area of injury, including the use of suturing or screw fixation to the costal cartilage fragment through a transsternal bar; however, the evidence on the biomechanics of either is limited. Since, the sternum is also eligible for fixation with plates and three screws, we performed fixation by spanning pre-contoured plates from the stable lateral rib to the sternal body. Free chondral fragments were sutured to the plate to prevent pain, or further lung injury during chest wall movement. Our case had an excellent outcome, without any early or late complications from surgery. Costosternal fixation could potentially be another tool for extubating patients with anterior or anterolateral flail chest; wherein, the bony parts of the ribs are too short to allow for the insertion of three screws at each segment.

Conclusion

Flail chest injury is a life-threatening complication of blunt chest trauma, and mounting evidences support early surgical fixation over traditional, conservative treatment. In cases of anterior flail chest, which involve chondral parts of cartilage that are not fixable with plate osteosynthesis, we therefore opt to perform costosternal fixation. This is achieved by spanning the plate across the chondral part of the rib to the sternal body, and suturing free chondral fragments to the plate. Our case could successfully be extubated 3 days post-operatively, and had a good to excellent outcome without any complications.

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Conflict of interest

The authors declare no conflicts of interest.

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