Rib Fixation for pediatric blunt chest trauma

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Abstract

Displaced rib fractures as the result of blunt chest trauma impairs chest wall mechanics, causes severe pain, and results in prolonged mechanical ventilation. Rib fixation plates have been developed and manufactured for use in adult patients with improved outcomes over expectant management. The authors report the first case of rib fixation using titanium plates in a child after sustaining significant blunt chest trauma.
Prolonged positive pressure ventilation and chest wall splinting has been the mainstay for significant chest wall injuries since the 1950s [1]. Surgical fixation of flail segments can reduce the amount of time a patient is intubated and thereby decreases the risk of pneumonia [2].

Case Report

A 13-year-old boy presented to the emergency department after crashing an all terrain vehicle (ATV). Physical examination revealed that the one of the vehicle’s handle bars had impaled the patient’s left chest wall, resulting in significant injury. After placement of a chest tube for decreased left breath sounds, a chest radiograph demonstrated displaced fractures of left ribs 4 through 8, right middle one-third clavicle fracture, and extensive emphysema and lung consolidation (Fig. 1). Pelvic radiograph revealed non-displaced bilateral fractures of the superior pubic rami. Computed tomography (CT) scan of the torso showed pneumothorax, left greater than right, with multiple left-sided rib fractures, right clavicle fracture and severe pulmonary contusions (Fig. 2). The patient was intubated for respiratory distress and transferred to the pediatric intensive care unit.

Over the next couple days, attempts were made at ventilatory weaning; however, due to pain control issues and poor respiratory efforts, these attempts were unsuccessful. After discussion with the parents and an orthopedic consultation (MRF), the child’s treating pediatric surgeon (KDB) made plans for an operative open reduction and internal fixation (ORIF) of the child’s displaced rib fractures using titanium plates. After induction of general anesthesia, exposure was obtained using a 12 cm lateral thoracotomy incision. The latissimus dorsi was retracted posteriorly and the insertion of the anterior serratus was reflected posteriorly, as well. Edema and hematoma near the fractured ribs was encountered and drained. Ribs 4 through 8 had
depressed floating segments, creating a concave chest. On examination there were also non-displaced linear fractures of ribs 2, 3, and 9. In consultation with the hardware manufacturer, ribs 4 through 7 were plated sequentially, using Synthes MatrixRIB (West Chester, PA) locking plates, with the plate extending across the fracture line and three screws placed in the rib surrounding the fracture plane (Fig. 3). The majority of the bone was present, but complex comminuted edges were encountered that had to be reconstructed and repositioned prior to plating. The patient tolerated the procedure well and was transferred back to the pediatric intensive care unit intubated. A post-operative chest x-ray demonstrated satisfactory placement of the hardware and alignment of the ribs (Fig. 4).

The patient was extubated on post-operative day 1 with minimal pain, off intravenous narcotics by day 3, and discharged to home on day number 5. Upon follow-up at one month, the patient had no pain or respiratory symptoms and had a good cosmetic outcome. The patient is scheduled for routine follow-up appointments every 6 months to monitor chest wall growth.

Discussion

Surgical repair of traumatic chest wall injuries currently remains underutilized in the United States [3]. While rib plating is within the domain of general, thoracic, and trauma surgeons, non-orthopedic surgeons may be uncomfortable working with plates and screws [3]. In addition, several geometric factors complicate the adequate fixation of flail chest segments. Ribs have an in-plane curvature, an out-of-plane curvature, a twist and conical rather than cylindrical surfaces, all of which vary predictably with thoracic level [6]. These properties make contouring orthopedic plates intra-operatively difficult and time consuming [6]. Intramedullary fixation can be achieved with Kirchner wires, but this comes at the expense of rotational stability.
Intramedullary splints avoid this problem, but are of an inadequate length to span flail chest segments [2]. Labitzke claw plates provide a faster and easier way to achieve fixation, but their flexibility compromises their strength [2].

Recent innovations in hardware have made rib fixation less daunting for the non-orthopedic surgeon. Anatomically pre-contoured plates, such as the ones used in this case, have become widely available. The plates are manufactured with an in-plane curvature and a twist to conform to a rib’s surface with minimal contouring, while out-of-plane curvature can easily be manipulated [7]. A template is created for the desired rib during surgery. The template is then matched to the closest pre-contoured plates, which can be further contoured manually before being affixed to the rib with locking screws.

The best candidates for fixation are those with either fractures that risk significant deformity or with pain severe enough to impede mechanical ventilation [5]. Two randomized prospective studies in adults show that using internal fixation to repair flail-chest injuries significantly reduces short-term morbidity compared to non-surgical treatment [4, 5]. A study by Tanaka et al compared 18 patients treated with internal fixation to 19 patients treated with positive pressure ventilation [4]. All patients had at least six rib fractures and suffered acute respiratory failure. The surgical group spent significantly less time on mechanical ventilation (10.8 days vs. 18.3 days) and in the intensive care unit (16.5 days vs. 26.8 days). Granetzy et al compared two groups of 20 patients with flail chest segments in three ribs or more [5]. One group was treated with internal fixation, the other with external chest wall fixation using adhesive bandages. The surgically managed group showed statistically significant decreases in mean duration of mechanical ventilation (2 days vs. 12), mean ICU stay (9.6 days vs. 14.6), and mean hospital stay (11.7 days vs. 23.1). The improved morbidity associated with surgical
treatment of flail-chest is attributed to the reduced need for mechanical ventilation and decreasing the risk of ventilator-associated pneumonia [4]. ORIF may also prevent symptomatic chest-wall deformity that may occur when using positive-pressure ventilation alone [2]. The utility of internal fixation in repairing pediatric flail-chest injuries remains largely uninvestigated, but surgical repair in pediatric cases may provide similar benefits. Removal of the hardware in the adult studies was not needed. In a growing child, orthopedic hardware may inhibit or alter the growth of a child’s chest wall. For the above case, multidisciplinary discussions were held and it was decided to leave the plates intact unless they were to demonstrate signs of infection or if the child were to begin acquiring an asymmetric chest wall.

In conclusion, this first reported pediatric case demonstrates that adult rib fixation plates may be adopted for use in pediatric blunt trauma patients to decrease pain and improve chest wall mechanics impaired by displaced fractures. Our experience demonstrates that pediatric surgeons can use these implants successfully and comfortably, without routine experience using bone and orthopedic hardware. A child’s future chest wall growth may need to be considered when deciding whether to remove plates after healing. Additional studies regarding the use of adult rib fixation plates in children are needed.

**Legends**

Fig. 1 Chest x-ray at presentation.

Fig. 2 3D reconstruction of CT chest scan.

Fig. 3 Intraoperative placement of fixation plates.

Fig. 4 Postoperative chest x-ray.
References


