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CASE REPORT

Novel use of hand fracture fixation plates in the surgical stabilisation of flail chest

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KEYWORDS

Flail chest fixation;
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Summary Plastic surgeons specialise in working closely with other surgical colleagues to help solve clinical problems. In this case, we performed surgical stabilisation of a large flail chest fragment in conjunction with the cardiothoracic surgical team, using the mini-plating set more commonly used for hand fracture fixation. The use of this fixation system for flail chest has not previously been described, but offers advantages over other reported methods, primarily by dispensing with the need for an extensive thoracotomy incision and by providing robust stabilisation without the presence of prominent hardware.

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Blunt chest trauma is present in one third of all trauma admissions in the US, with more than 60% of cases caused by road traffic accidents.¹ When four or more consecutive ribs are fractured in two places, a flail segment is diagnosed, with a historical mortality rate of 10–36%.² The cause of mortality may be from associated injuries or impaired ventilation, leading to pulmonary sepsis. The flail segment itself compromises ventilation by a combination of paradoxical chest wall motion, pain restricting overall chest wall movement and damage to lung parenchyma by bony fragments.

In recent years, surgical fixation of the flail segment in selected patients has become well accepted and there is evidence that patients managed operatively have better outcome in terms of mortality, period of time on mechanical ventilation, hospital stay and incidence of pneumonia.³ There are no studies comparing pre- and post-operative lung function of individual patients as an objective measure of the effect of surgery, though late post-operative spirometry was measured in some studies and compared to predicted values in order to assess whether lung restriction had been prevented.^{3,4} It is not possible to undertake meaningful spirometry measurements pre-operatively due to intense pain and no studies were found that had recorded these. Despite the acknowledged benefits of surgical management, there is no single recommended form of rib

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fixation and no large series comparing fixation methods. Of the surgical fixation methods previously described, all either require an extensive incision (thoracotomy or clamshell) with muscle dissection and entry into the chest cavity, or have other drawbacks such as lack of rotational stability, vertical bridging of the flail segment (countering the physiological separation of ribs with ventilation) or a fixation method that is more stiff than the ribs themselves, leading to hardware loosening.^{2,5–8}

We describe use of the 8 hole 'H' plates from the Leibinger mini-plate system (Stryker®), using 2.3 mm screws. Two plates were used, providing anterior stabilisation to an 8-rib left-sided flail segment. A limited anterior incision was used, avoiding muscle division or entry into the chest cavity.

Case report

A previously healthy 36-year-old male building site worker attended the Emergency Department with a severe crush injury to his left chest. The patient was using a 14 tonne JCB type digger and left the cab to remove an obstacle. In order to move the digger bucket (weight 0.25 tonne), he leaned back into the cab and operated the bucket lever from outside. A miscalculation resulted in a compression injury to his chest.

Paramedics at the scene diagnosed left tension pneumothorax and performed emergency needle thoracotomy before transfer. On arrival in the Emergency Department he was resuscitated and managed according to ATLS protocols. His injuries were an eight-rib flail segment on the left chest, extensive left haemopneumothorax with marked surgical emphysema, left pulmonary contusions and myocardial contusion with rapid atrial fibrillation (Figures 1 and 2).

He required a chest drain, an amiodarone infusion and respiratory support with CPAP. Analgesia was provided in the form of paravertebral block with continuous infusion, epidural catheter and opioid PCA. The patient was transferred to the cardiac ICU under the care of the cardiothoracic surgeons.

Though the patient did not require mechanical ventilation, the paradoxical movement of his large flail segment



Figure 1 Coronal CT scan of chest showing loss of volume in left hemi-thorax.

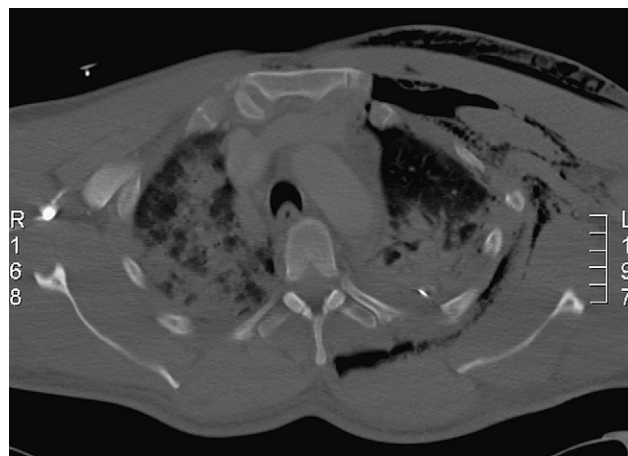


Figure 2 Transverse CT scan of chest showing surgical emphysema and displacement of costo-chondral junction.

was intensely painful, with limited ventilation and movement of the shoulder, therefore surgical fixation was planned.

On day 6 post injury, his left pneumothorax and surgical emphysema had resolved. The patient was brought to the operating theatre on day seven-post injury and underwent anterior surgical fixation of the flail segment. Surgery was performed in the supine position, using a transverse anterior chest incision and splitting of pectoralis muscle fibres to reveal the fracture sites. As the plating system used was small and fixed immediately either side of the fracture site only, exposure and muscle dissection was minimised. The surgical team were prepared to fix as many of the fracture sites as was necessary to achieve reasonable stabilisation. However once two anterior fractures were fixed, the flail

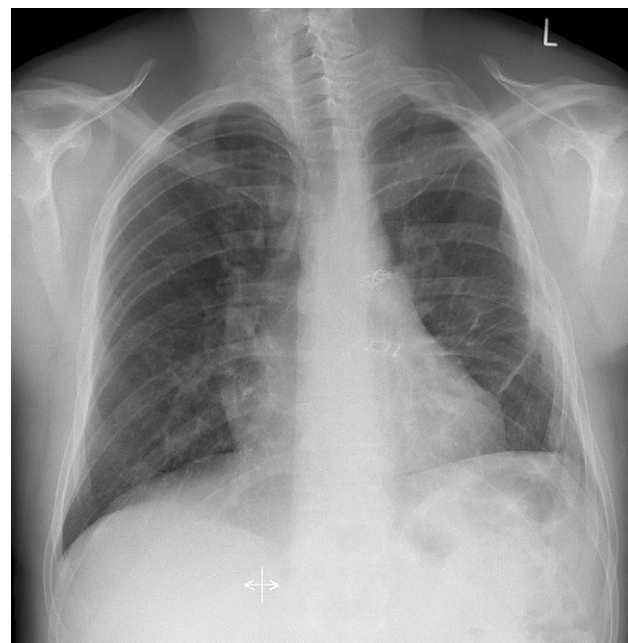


Figure 3 Post-operative PA chest radiograph showing restored intercostal spaces.

Table 1 Comparison of previously described flail chest fixation methods

Fixation method	Potential drawbacks
Kirschner wires	Lack of rotational stability, difficulty of insertion across fracture site
Contoured horizontal plates	Extensive access incision, need for contouring, prominent hardware, screw loosening due to stiff plate against flexible rib
Vertical plates	Extensive access incision, rigid and non-physiological movement of flail segment as one unit
Judet struts	Fixation not strong enough, poor correction of pain and ventilatory compromise
Vicryl suture	Fixation not strong enough, poor correction of pain and ventilatory compromise

segment appeared secure. The wound was closed in layers and a new chest drain inserted.

The patient was extubated immediately post-operatively and the following day reported a significant improvement in pain and shoulder mobility. The physiotherapist also reported a subjective improvement in respiratory effort. The patient was discharged from hospital on day 19 following uneventful wound healing. He remained well and at 4 weeks post-operatively reported minimal residual pain or movement of the flail segment and excellent shoulder mobility (Figure 3).

Discussion

Surgical fixation of a flail segment is an acceptable form of management for selected chest trauma patients, but is not required in all cases. The main indication is a highly mobile flail segment, where fixation of the anterior fracture is prioritised. The cardiothoracic surgeons sought input from the plastic surgery service for an appropriate method of fixing the anterior costal cartilage through a limited approach to minimise muscle dissection. A review of the literature shows that rib fixation has been achieved using a multitude of methods: intramedullary Kirschner wires, contoured plates (from mandibular, acetabular or pelvic plating sets) running along the whole rib segment between both fracture sites, vertical plates spanning all ribs in the

flail segment, Judet struts, size 2 Vicryl thread and methylmethacrylate with mesh.^{5–8}

Current published reports are of single cases or small series and there are no randomised controlled trials comparing fixation methods. The potential drawbacks from each of the previously published methods are shown in Table 1.

Our assessment was that anterior fixation of the costochondral junction using the mini-plate set would meet the needs of this patient and be at least equal to methods previously described. Although strictly objective outcome measures are not available in such cases, flail segment fixation was noted by both patient and physiotherapist to facilitate shoulder and chest physiotherapy and weaning from all forms of analgesia was immediately apparent. We would certainly use this method in the future.

Conflict of interest

None.

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None.

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