CASE REPORT

Successful treatment of flail chest with chondrosternal disruption and traumatic parasternal lung hernia with titanium rib bridges

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SUMMARY

The surgical principles for the treatment of flail chest have yet to be fully established. Furthermore, the relationship between flail chest and lung hernias is unclear. We report here a rare case of chondrosternal traumatic disruption and lung hernia that was treated with a novel technique using titanium rib bridges and clips, which successfully reduced the hernia defect and provided stability to the chest wall. This procedure was beneficial in minimising the patient's ventilation time and time away from work.

BACKGROUND

Chest trauma is a common pathological entity and approximately one-third of patients with blunt chest trauma present specific lesions such as haemothorax, pneumothorax, pulmonary contusion, pneumonia, atelectasis, rib fractures, flail chest, lung hernia and pulmonary evisceration.^{1 2} Flail chest occurs when multiple ribs are fractured in multiple places, and rib fragments may move independently and paradoxically from the remainder of the chest wall.³ Lung hernia is a rare finding that involves protrusion of the lung and parietal and visceral pleurae through a defect in the chest.⁴ There is no consensus on the treatment of flail chest associated with lung hernias with or without chondrosternal disruption. This report describes a case of sternal flail chest with lung hernia that was fixed with titanium bridges, which successfully reduced the hernia defect and provided stability to the chest. This treatment allowed the early removal of mechanical ventilation and the rapid return of the patient to work.

CASE PRESENTATION

A 44-year-old man with class II obesity presented to the emergency room following a motor vehicle accident. He scored 15 points on the Glasgow Coma Scale and was experiencing severe chest pain. An airway examination showed paradoxical breathing movements, chest deformity, crepitus, subcutaneous emphysema, hypoventilated lung fields and hyperlucency on percussion. A multidisciplinary treatment approach was performed; the patient underwent intubation and intravenous hydration therapy and was clinically diagnosed with bilateral haemopneumothorax. His lungs were drained with 36 Fr endopleural tubes. Imaging studies were performed once the patient had been

stabilised. Chest radiography showed fractures of the 5th–10th left ribs, resolution of his bilateral haemopneumothorax and evidence that the endopleural tubes were well placed. CT scanning showed craniofacial floor fracture, right-sided subcutaneous cervical and pectoral emphysema, well-defined large vessels with no evidence of pericardial effusion, moderate bilateral pulmonary contusion, residual right pneumothorax and bilateral haemothorax of 30% (figure 1). A three-dimensional reconstruction showed left-sided posterior fractures of the 5th–12th ribs that were displaced, calcification of chondrosternal bilateral cartilage with disruption of the complete chondrosternal union and right lung herniation throughout the disruption (figure 2). The patient was then admitted to the intensive care unit (ICU). Following improvement in his general condition, he underwent surgery with general anaesthesia to repair his chest trauma on day 13 after his admission to ICU. Surgery involved midline sternal dissection to expose the articular portion of the ribs on both sides; the right side showed total chondrosternal disruption (figure 3). After exposing the periosteum, six titanium rib clips were placed symmetrically on both hemithoraces in the second, third and fourth ribs (figure 4). Three titanium rib bridges were used to connect these clips, and the union was secured with steel wire. Two drains were placed within the clip assembly, a bilateral chest tube was replaced prior to closure and a standard wound closure of overlying muscle and subcutaneous tissue was performed over the fixation.

The patient was re-admitted to the ICU where respiratory improvement was observed. The patient's breathing progressed and he was weaned off mechanical ventilation on postoperative day 2 and discharged from the ICU 4 days later. The patient was discharged from the hospital 7 days later.

OUTCOME AND FOLLOW-UP

The patient was seen as an outpatient 7 weeks after his discharge and there was no evidence of respiratory distress. He returned to work 28 days after hospital discharge. A further 12 weeks later, CT revealed no changes in soft tissue, correction of the deformity on the right side, correct placement of the titanium bridges and clips, lung fields without bruising, successful reduction of the lung hernia and consolidation of the chondrosternal disruption

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Figure 1 CT of the chest with pulmonary contusion and bilateral haemothorax, emphysema and lung herniation.

and left posterior fractures (figure 5). Spirometry was performed at postoperative month 8, which revealed a forced vital capacity of 80% and a forced expiratory volume of 85% in 1 s.

DISCUSSION

According to the Centers for Disease Control and Prevention, there were more than 45 000 deaths related to motor vehicle accidents in the USA in 2009; up to 25% of these deaths were secondary to chest trauma.¹ Lung hernia is defined as the protrusion of the lung and parietal and visceral pleurae through a defect in the chest wall. It is a rare entity, with only approximately 300 cases reported in the literature. Its treatment is varied and may be conservative or surgical; conservative treatment is reserved for small or apical hernias, while cases with hernias with pain, incarceration or strangulation are candidates

for surgery. Lung hernia accompanied by chondrosternal disruption is even more complex and rare.⁵ For the case presented here, our treatment protocol was successful in managing the challenging triad of flail chest, chondrosternal disruption and lung herniation. Adequate surgical protocols for this combination of lesions have not been well established. In blunt trauma, lung herniation occurs frequently in the parasternal region, possibly due to the absence of external intercostal muscles in this area.⁶ Other causes may be the use of a seatbelt, a restrained driver and obesity.^{5 6} These factors were all present in the patient presented here. Athanassiadi *et al*³ found that 78% of patients in their series had concomitant thoracic instability and pulmonary contusion, with 11.2% of patients requiring treatment in ICU, and there was a low death rate of 8.8%. This low-reported death rate may have been due to the protocols

Figure 2 Three-dimensional reconstruction showing herniation of lung parenchyma, chondrosternal disruption and left posterior fractures.

Figure 3 Surgical procedure: site of chondrosternal disruption.

employed at the trauma centre, whereby thoracic surgeons are involved in patient assessment and treatment plans at the initial stage of evaluation. By contrast, thoracic surgeons in many trauma centres are only consulted when complications arise. Between 52% and 80% of lung hernias are associated with trauma, with the majority associated with open injuries. Parasternal hernia surgery using polytetrafluoroethylene mesh and direct suturing has been reported for patients with flail chest and lung hernia; extubation in these patients was performed 15–18 days after the procedure and the mean duration to discharge was 42 days.⁶ We agree with reports that suggest that flail chest surgery may lower the incidence of pneumonia and decrease the duration of mechanical ventilation and ICU stay. Prospective studies that compare surgery versus

conservative treatment have shown the benefits of surgical treatment, although no notable differences in spirometry and quality of life were found after 6 months of follow-up.⁷ On average, patients with flail chest are on a ventilator for an average of 9.2 days, in contrast to our patient who was extubated within 48 h after surgery.

Rib fixation helped the patient to regain mobility and breathe normally. Some potential indications for rib fixation are flail chest with failure to be weaned from mechanical ventilation, painful and mobile ribs, deformity, symptomatic non-union and incidental repair while performing thoracotomy for other reasons.^{1 8} A meta-analysis of 11 studies that compared surgical and conservative treatments for flail chest recommended surgery regardless of the technique or material that is used to reduce the

Figure 4 Surgical procedure: treatment of chondrosternal disruption with titanium bridges.

Figure 5 CT three-dimensional reconstruction: reduction of lung hernia and thoracic asymmetry.

fractures.⁸ Titanium is a well-established biomaterial and implants made from titanium enable similar physiological motion to those made from methylmethacrylate prosthesis or mesh. Titanium forms an oxide layer that is highly corrosion resistant, is osteophilic and does not cause interference in imaging studies, which is an advantage while performing three-dimensional reconstructions.⁹ Wiens *et al*¹⁰ reported successful rib fixation and pulmonary hernia reduction by adapting titanium rods designed for spinal surgery. Patients were discharged 4–5 days after fixation and exhibited a faster recovery than patients who received polytetrafluoroethylene mesh. This may be due to the more rigid rods preventing the recurrence of hernias and restoring stability to the chest. Pompili *et al*¹¹ reported the successful reduction of a post-traumatic lung hernia using parietal titanium bridges, although only images were presented in this report. Titanium rods have been successfully used to treat congenital chest deformities and oncological resections; however, there are few reports about their use in flail chest, particularly flail chest associated with chondrosternal disruption, with or without pulmonary hernia.⁹ Lanier and Colls¹² described a case of pulmonary hernia with chondrosternal disruption secondary to blunt-chest trauma that was repaired with tubular plates placed from the sternum to the ribs. The rib cage was stabilised and the hernia was successfully reduced; however, it should be noted that surgery was performed 3 weeks after the trauma, at which time the lung was still herniated necessitating a resection of the lung segment. With this case in mind, we feel that surgery is necessary regardless of the usual criteria for costal fixation, so that complications could be minimised.

We conclude that chest fixation with titanium prosthesis is a viable option for the treatment of flail chest and lung hernia. The benefits may include the correction of thoracic deformity secondary to disruption, as well as a decrease in the duration of ventilator usage and ICU stay. This treatment may be effective for the treatment of lung hernias, since the majority are related to chest trauma; however, the relationship between lung hernias and sternal flail chest is yet to be elucidated.

Learning points

- ▶ The incidence of chest trauma is rising; therefore, effective diagnostic methods are needed to identify it.
- ▶ Thorax titanium bridge fixation may be a therapeutic alternative in sternal flail chest.
- ▶ There are few reports on lung hernia, with current treatment options focused on hernia reduction. We suggest that it is also necessary to restore stability to the chest wall.
- ▶ Lung hernia associated with chondrosternal disruption most likely require surgery.

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