

Treatment of open chest rib fractures with the matrix rib internal fixation system

A case report

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Abstract

Rationale: Rib fractures are common among patients with blunt chest wall trauma and often represent life-altering injuries.

Patient concerns: A 31-year-old woman presented with right chest trauma, with pain and bleeding as a result of a traffic accident 1 hour previously.

Diagnoses: Chest computed tomography showed open chest trauma, multiple rib fractures, flail chest, hemopneumothorax, and lung contusion on the right side.

Interventions: We decided to perform debridement via emergency, thoracoscopic exploration to remove blood and contaminants from the chest cavity. Thereafter, the third to seventh fractured ribs were fixed and reconstructed using the matrix rib internal fixation system, followed by suturing of the incision according to the original anatomical level.

Outcomes: The patient was discharged 15 days after surgery, and recovered well with satisfactory results.

Lessons: We believe that initial chest reconstruction with internal fixation in the first stage following thorough debridement may be suitable for treating flail chest, and could save the patient's life in the early stages. However, the decision to perform the first-stage operation for the open contaminated wound should be carefully considered.

Abbreviations: CT = computed tomography; MRI = magnetic resonance imaging; ORIF = open reduction and internal fixation; VAC = vacuum-assisted closure; VATS = video-assisted thoracoscopic surgery.

Keywords: matrix rib internal fixation system, open reduction and internal fixation

1. Introduction

Rib fractures are common among patients with blunt chest wall trauma, and often represent life-altering injuries.^[1] Following multiple segmental rib fractures, the chest wall becomes grossly unstable and thoracic volume decreases; moreover, paradoxical inward motion of the flail segment can be observed during

inspiration.^[2] The decision to perform surgical interventions in these cases remains controversial,^[3] although several reports^[4,5] indicate that patients who undergo open reduction and internal fixation (ORIF) for flail chest injuries or multiple rib fractures require a shorter duration of ventilator support, were less likely to develop infections and septicemia, and were less likely to require tracheostomy, as compared to patients managed non-operatively. In the present report, we describe patients diagnosed with open chest rib fractures.

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These study protocols were approved by the Medical Ethics Committee of the First Hospital of Fuyang District.

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2. Case report

A 31-year-old woman was admitted to our hospital with right chest trauma, as well as pain and bleeding as a result of a traffic accident 1 hour previously. At admission, we observed wounds on the right chest wall from the 4th intercostal of the axillary posterior line to the sternum (Fig. 1); the wound was approximately 40 cm in size. Moreover, the entire breast was torn open; the pectoralis major, latissimus dorsi, and serratus anterior were torn; and the third to seventh ribs on the right side were fractured. Furthermore, the fifth to seventh ribs on the right side were comminuted with certain intercostal muscle defects. Chest CT indicated (Fig. 2) open chest trauma, multiple rib fractures, flail chest, hemopneumothorax, and lung contusion on the right side. After examination and preoperative evaluation, the patient was administered general anesthesia, and underwent single-lumen intubation, emergent debridement, and video-assisted thoracoscopic (VAT) exploration to remove the blood and contaminants from the chest cavity. After thorough



Figure 1. A 40-cm wound in the right chest wall, from the 4th intercostal of the axillary posterior line to the sternum.

debridement, we performed one stage of internal fixation to reconstruct the thorax. As the fractures of the 3, 4, and 5 ribs were moderate, 2 locking screws were fixed at both ends with 6-hole steel plates, and the fixation was smooth. However, the sixth and seventh ribs were fractured at several sites, and were also partially broken and split in a parallel manner along the ribs. We bound the split broken ribs with silk thread, and then fixed the 2 locking screws with 18-hole steel plates at both ends. We then adjusted the ribs bound with silk thread to their original position,

and fixed and secured the ribs with locking screws (Fig. 3A). Thereafter, the incision was then sutured based on the original anatomical level (Fig. 3B). Five drainage tubes were used under the incision and removed after drainage fluid less than 50 ml. Cephalothin was given by intravenous injection for infection prevention. The patient in the present case was discharged 15 days after the surgery, and recovered well with a satisfactory outcome. During half a year follow-up after treatment, the patient recovered well with good movement of the right upper limb and lung function.

3. Discussion

Open chest trauma with multiple rib fractures are rare and difficult to manage. In the present report, we describe a case with an open chest wound, serious wound contamination, and flail chest, as a result of multiple rib fractures. Based on the actual patient status, the open fracture (Gustilo classification^[6]) was classified by the orthopedics department. According to the size of the open wound, the degree of injury to the surrounding soft tissue, and the potential for wound coverage after debridement, the fracture in the present case was categorized as the Gustilo 3A type.

Open fractures were previously contraindicated for internal fixation, primarily because internal fixation may aggravate trauma, diffuse contamination, and increase the likelihood of bone infection. However, internal fixation for open fractures has certain advantages, including good alignment of fracture ends, good stability, and favorable fracture healing. Moreover, internal fixation is useful for the repair of soft tissue injuries, particularly vascular and nerve injuries. In addition, it facilitates wound healing or secondary repair, and reduces the likelihood of infection spread. Furthermore, internal fixation ensures patients can leave the bed as soon as possible, and can begin joint exercises and assess limb function. However, as the open wound is often contaminated in these cases, it is still controversial whether only one stage of internal fixation should be performed after debridement, followed by suturing of the incision, or whether



Figure 2. Chest CT shows open chest trauma, multiple rib fractures, flail chest, hemopneumothorax, and lung contusion on the right side.

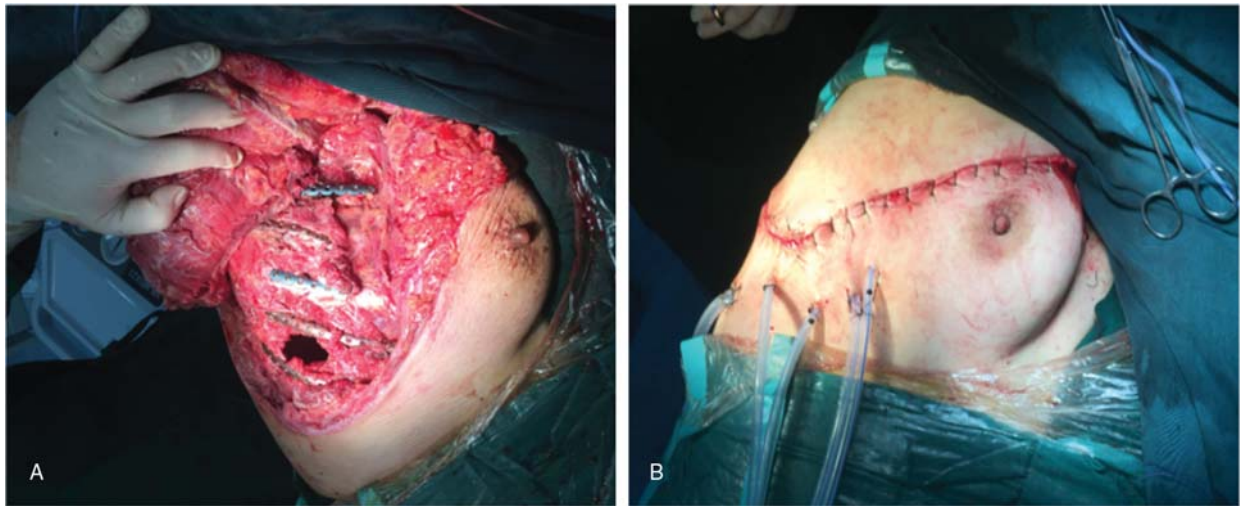


Figure 3. (A) The fractured ribs were fixed and reconstructed using the matrix rib internal fixation system; (B) the incision was sutured at the original anatomical level.

an additional stage of internal fixation should be performed after debridement to reconstruct the thorax. Furthermore, no reports have described the relationship between the treatment time of open fracture and the infection rate.^[7] The treatment principle of 6 to 8 hours after injury is based on experience, rather than scientific basis. Williams et al^[8] previously indicated the importance of doubling of the time of inoculation of bacteria in wounds, as well as the load of wound decontamination, by studying the time dependence of microbial infection. The researchers observed that a certain number of pathogenic bacteria did not cause infection within a certain time frame, due to specific colonization, growth, and death rates; hence, the occurrence of infection could only be controlled after bacteria were removed. In addition, they observed that the necrotic area around the surgical wound would rapidly expand within hours after inoculation with bacteria, and the decrease in the oxygen concentration at the wound site would also increase the possibility of infection. Based on the study of bacterial diffusion and pathology, we strongly suggest the need for the emergent treatment of open fractures, although this does not imply that open fractures should be fixed in a single stage. Nevertheless, in the present case, the patient experienced severe flail chest due to open rib fracture. Flail chest is a serious type of chest rib fracture, with a fatality rate of up to 20.6%, although this value can be higher in patients with other organ injuries.^[9] Moreover, flail chest likely develops due to the loss of support of the ribs between the 2 fractured ends, which softens the chest wall, causes it to float, and leads to abnormal breathing, thus seriously affecting the patient's respiratory and circulatory function.^[10] Therefore, we considered the possibility of long-term endotracheal intubation, as well as lung infection leading to respiratory failure and death, if the internal fixation is not performed in a timely manner.

Thorax reconstruction requires suitable internal fixation materials,^[11,12] such as Kirschner wire, stainless steel wire, silk thread, a memory alloy embracing device, and an absorbable rib nail. In the present case, a matrix rib titanium rib fixation system was used to fix the patient's ribs, and the internal fixation material was composed of pure titanium, which has the following advantages: plasticity, high strength, and difficulty of breakage; no impact on CT or MRI examinations; no need for removal;

good histocompatibility; firm fixation; no damage to the intercostal vascular nerve and internal mammary artery; no damage to the periosteum; no compression on the fracture surface; and no influence on blood supply at the fracture site. In the present case, due to the rib fracture, the common materials could not be used for bridging, and hence, the locking plate of the matrix rib titanium rib fixation system was used.

Due to the likelihood of infection after operation, appropriate drainage of the wound surface after surgery is vital. Postoperative vacuum-assisted closure (VAC) is a relatively novel technique used for the treatment of refractory wounds.^[13] In the present case, 2 negative pressure drainage tubes were placed in front of the chest wall, and 1 negative pressure drainage tube was placed in the muscle and under the skin. If infection of the wound surface developed postoperatively, it could be managed via adequate drainage; extubation is indicated in cases where the drainage volume is <10 ml/d. The use of a reasonable type of antibiotics after surgery is another method for infection prevention. Antibiotics should be administered as early as possible for open fractures, preferably prior to debridement. In addition, the combination of anti-gram negative and positive bacteria drugs is also vital for preventing infection. However, several factors influence the choice of antibiotics, such as injury location and environment, degree of contamination, presence of other combined injuries, conditions of the other injuries, and the bacteria status in the hospital environment. The most frequently quoted and widely used scheme was first described by Gustilo and Anderson,^[14] and later modified to its current form by Gustilo et al.^[15] This classification system involves the intraoperative scoring of open fractures from one to 3 in ascending order of severity, with a Type 1 injury involving a small soft tissue wound, Type 2 involving a large wound with little soft tissue damage, and Type 3 involving extensive soft tissue damage. Type 3 wounds are further subcategorized into 3 subgroups, with Type 3a fractures having extensive soft tissue damage with adequate soft tissue coverage, Type 3b fractures having extensive soft tissue damage requiring transfer of soft tissue to cover the defect, and Type 3c being the most severe due to extensive arterial damage requiring vascular repair. Most Type 1 patients develop injuries as a result of indirect trauma, and bacterial contamination is primarily

attributed to gram-positive bacteria;^[16] hence, anti-gram-positive bacteria drugs are used in these cases. However, combined drug treatment is needed for type 2 or type 3 patients. In particular, in type 3 injuries, drugs with strong effects on gram-negative bacteria should be chosen, so that the rational use of drugs can be achieved and the economic burden of patients can be reduced.

As the patient developed hemopneumothorax and had an open injury, there was a possibility of foreign bodies entering the chest. Hence, video-assisted thoracoscopic surgery (VATS) was used for the surgery. At present, VATS is used for the diagnosis and treatment of various chest injuries,^[17] and has the advantages of not aggravating the original injury, minimal trauma, accurate and definite diagnosis, more rapid operation, faster recovery after operation, shorter hospital stay, and better clinical treatment results in the treatment of chest injuries. Under VATS guidance, we removed blood clots from the chest as well as plastic sheets that had fallen into the chest, and appropriately placed the chest drainage tube.

In this report, we addressed 6 issues including operation time, operation method, material selection, wound drainage, post-operative antibiotic use, and routine use of VATS in such cases. In cases with open rib fracture, severe flail chest, and slight wound contamination, we believe that chest reconstruction should be attempted using internal fixation in a single stage after thorough debridement to correct flail chest and save the patient's life at the initial stage. However, surgeons should carefully consider whether to perform the first-stage operation for the open contaminated wound in such cases.

Author contributions

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