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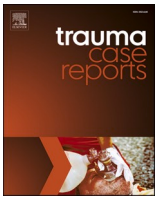

Case Report

Attempted repair of chest wall injury following penetrating injury with surgical stabilization rib and autologous bone graft: A case report

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ABSTRACT

Rib fractures are one of the most common injuries following blunt trauma. When associated with penetrating trauma, the projectile velocity and immense energy transfer cause significant rib fracture displacement and fragmentation. As a result, these patients are potentially exposed to an even higher risk of complications compared to those seen in more simple rib fractures. Unfortunately, there is limited research regarding technical considerations for surgical stabilization of rib fractures (SSRF) in severely displaced rib fractures with bone loss following penetrating injury. We present the case of a 21-year-old male gunshot wound victim with severely displaced and comminuted rib fractures in which we utilized an autologous bone graft bridge during SSRF to enhance fracture unionization, chest wall stability, and cosmesis. Unfortunately, the bone graft failed to incorporate into surrounding tissue.

Introduction

Rib fractures are one of the most common traumatic injuries and occur in nearly 20 % of patients with blunt trauma [1,2]. As with other bony fractures, their presentation is quite variable and depends on the number of rib fractures involved, the number of continuous rib fractures, presence of flail chest, degree of displacement/angulation, and time to presentation. Although non-operative management with multimodal pain control and pulmonary hygiene can be pursued in more simple rib fractures, patients with significant or complex rib fractures are prone to uncontrolled pain, hypoxemic respiratory failure, ventilator dependence, lung herniation, chronic fracture non-union, and chest deformity if left untreated [3,4]. Surgical stabilization of rib fractures (SSRF) is a practical solution in this patient demographic and has demonstrated a significant reduction of morbidity and mortality [5,6]. Two studies have gone further to report the joint use of autologous bone graft for chronic non-union rib fractures in conjunction with rib plating [7,8].

A smaller subset of rib fractures, less than 3 %, occur due to penetrating chest injuries such as projectiles from a firearm [2]. The high energy mechanism of the projectiles causes significant displacement and fragmentation of the ribs and can result in bone loss. Typical strategies of open reduction internal fixation (ORIF) and SSRF are often applied to these fractures but they fail to address the appropriate management of the post-traumatic bony defect. We present a case of a 21-year-old male gunshot wound victim with subsequent severely displaced and fragmented fractures of ribs 4–7 who underwent SSRF with an autologous bone graft bridge.

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Case report

The patient is a 21-year-old male who presented as a category 1 trauma after suffering a single gunshot wound to the chest. The primary and secondary surveys in the trauma bay revealed a hemodynamically stable patient on minimal oxygen support with an entry wound in the right shoulder without an exit wound. Trauma bay chest X-ray revealed a 9 mm metallic bullet at the level of T9-T10 overlying the right aspect of the heart and associated comminuted fractures of the right 4-7th ribs, which was later confirmed on CT imaging (Fig. 1). The patient had significant pain despite a multimodal pain regimen and given the marked destructive gap between rib segments, the patient was taken to the operating room for surgical stabilization of his rib fractures.

The patient was placed under general anesthesia and a curvilinear incision over his rib fractures was made. Subsequent dissection of subcutaneous fat, muscle, and fascia was performed to expose the rib fractures. During dissection, multiple bony fragments were harvested from the extrapleural space and thoracic cavity then preserved in saline. A 50 mm plate (RibLoc U Plus, Acumed, Hillsboro, Oregon, USA) was applied to the 4th rib fracture. Further evaluation of ribs 5–7 demonstrated significant bony loss (25 mm in rib 5, 25 mm in rib 6, and 15 mm in rib 7). In ribs 6 and 7, the previously removed bone fragments were placed within the fracture gap and secured into the plate with screws. The defect in ribs 5 and 6 were especially large and as seen in Fig. 2. For rib 5, multiple bony fragments were wrapped in a proglatin 910 mesh (Vicryl Mesh, Ethicon Inc., Cincinnati, Ohio, USA) and secured in place with silk suture (Fig. 3). The intention was to buttress this posteriorly with a bioabsorbable plate (BioBridge, Acumed, Hillsboro, Oregon, USA) however this was unavailable at the time of surgery. All three of these rib fractures were then stabilized with 75 mm plates. The thoracic cavity was then irrigated, a chest tube was placed, intercostal nerve bundles of 3–7 were cryoablated, and the wound was re-approximated. Post-operative chest X-ray demonstrated good rib fracture alignment (Fig. 4). The patient's post-operative course was uncomplicated with the eventual removal of his chest tube and he was discharged on post-operative day 4. Cross-sectional (CT) imaging obtained 3 months post-operatively demonstrates appropriate healing with proper rib cage stabilization but failure of the bone graft to integrate into the surrounding tissues (Fig. 5).

This study was conducted in compliance with the principles of the Declaration of Helsinki. Written informed consent for publication of the research details and clinical images has been obtained from the patient.

Discussion

Rib fractures following projectile trauma are subject to an immense destructive force and subsequently significant rib comminution and displacement. Non-operative management of these fractures can predispose patients to uncontrolled pain, respiratory distress, pneumonia, and increased mortality [3,4]. Despite advancements in surgical technique and technology, chest wall reconstruction in these patients can be extremely complicated.

The majority of the bone fragments in our patient were harvested from the extrapleural space and then utilized as an autologous bone graft to fill the rib fracture defect. For gaps greater than 1 cm, conventional recommendations are for bone grafting to support fixation hardware and promote bony union. In ribs 6 and 7, large bone fragments were incorporated within the fixation device to provide architectural support for the rib plate with hopes of fracture unionization, chest wall stability, and defect cosmesis. The defect

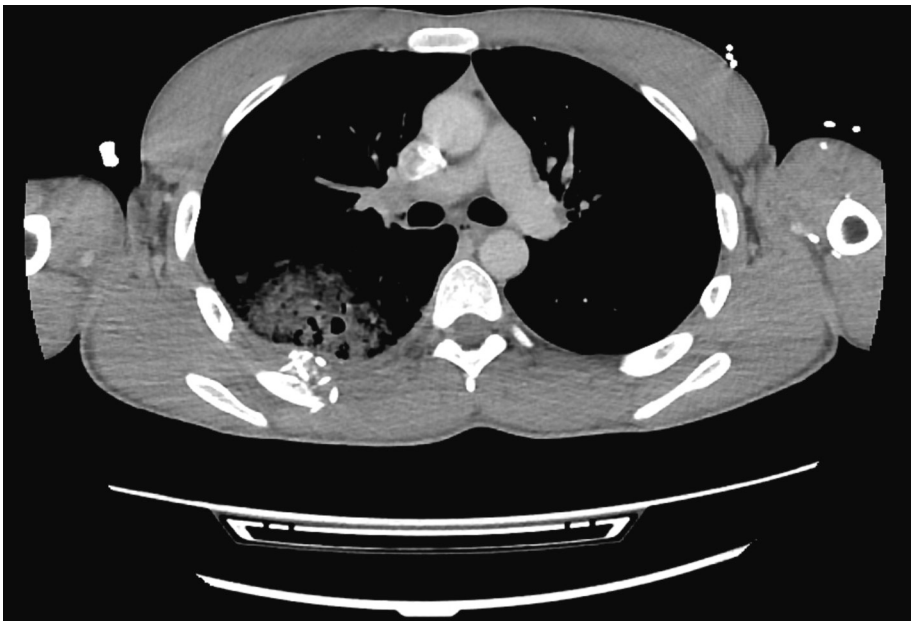

Fig. 1. Axial view of the CT chest demonstrating significant extrapleural bone fragmentation.

Fig. 2. Comminuted fractures of ribs 3 (top), 4 (middle), and 5 (bottom) with plates on ribs 4 & 5. Note the sizeable destructive separation between rib fractures.

Fig. 3. Autologous bone fragments wrapped with a Vicryl mesh.

in rib 5 was large and the fracture segments were too small, preventing secure placement within the plating apparatus. A mesh package of autologous bone fragments was created and sutured to the plate (Fig. 3), but unfortunately, ossification was limited as seen in the 3-month post-operative CT scan (Fig. 5). A bioabsorbable plate was not available at the time of surgery and limited reconstructive options for our patient. This was the initial plan to allow buttressing posteriorly and compression to facilitate structural integrity. A plethora of substitutes have been described for the reduction of significant bony loss in extremity fractures and range from various biosynthetic compounds to allogenic bone grafts [9,10]. These have been employed in the management of chest wall non-union fractures with good success [11,12]. Surgical techniques have also been employed and include limb lengthening procedures, autologous bone harvesting (e.g. iliac crest), vascularized bone flaps (e.g. fibula), and the Masquelet staged technique involving placement

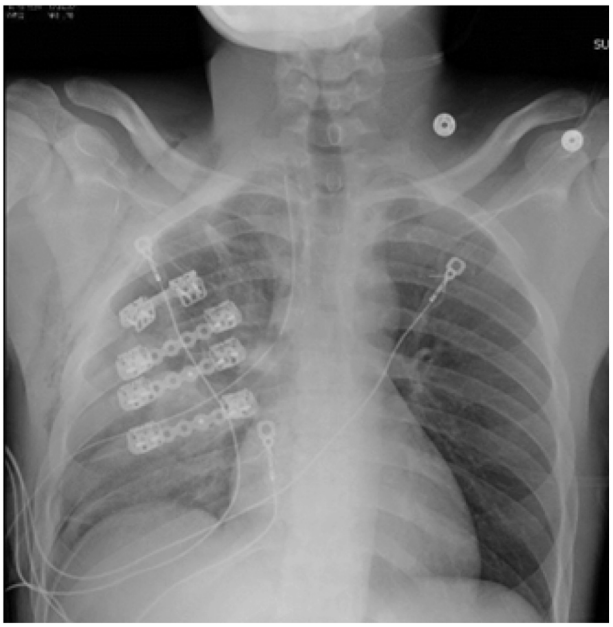

Fig. 4. Post-operative chest x-ray confirming rib alignment and fixation.

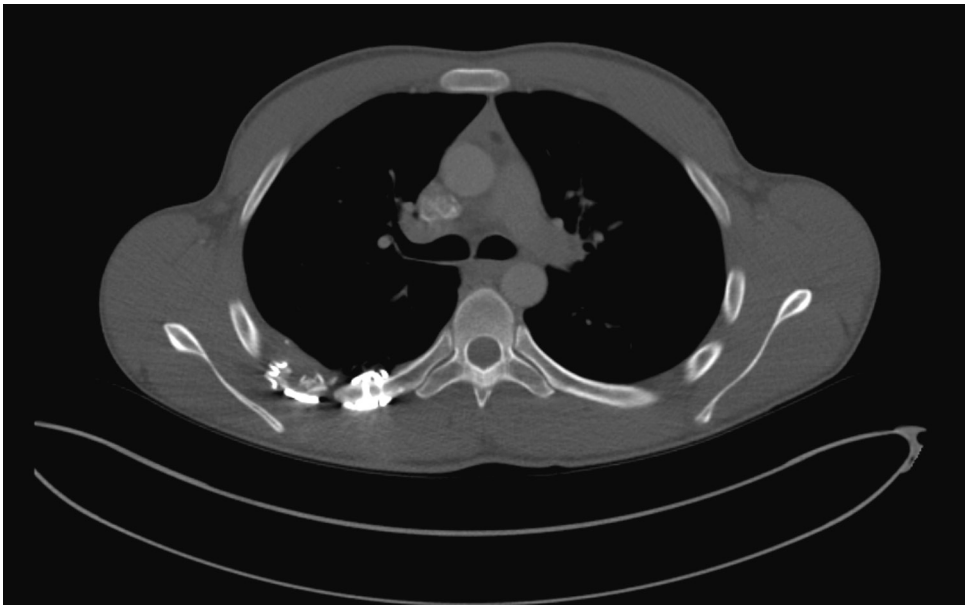

Fig. 5. 3-month post-operative axial view of the autologous bone graft placed in support of rib 5.

of an antibiotic cement spacer with subsequent biomembrane filling [7,9,10,13,14]. Unfortunately, many of these procedures are technically arduous and some techniques have yet to be systematically studied in the context of chest wall rib reconstruction following trauma. Based on the present case, the limited additional time required to harvest the dominant fracture fragments appeared to provide a substrate for gap filling in complex fracture patterns with bone loss, while also providing screw fixation. The smaller fragments encompassed in mesh with suture cerclage failed to ossify, at least after 3 months, suggesting this not be a viable technique for bridging larger fracture gaps. Whether support and posterior compression from a slowing degrading bioabsorbable plate would have impacted bony union remains to be seen. Further investigation can help expand surgical options and improve outcomes in this already vulnerable patient population.

CRediT authorship contribution statement

Vincent E. Serapiglia: Investigation, Project administration, Writing – original draft, Writing – review & editing. **Krishna A. Patel:** Writing – review & editing. **Jaya Sai V. Varre:** Writing – original draft. **Brian T. Dusseau:** Supervision. **William B. DeVoe:** Supervision.

Declaration of competing interest

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