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Case Report

An innovative technique of chest wall stabilization and reconstruction in traumatic flail chest: The figure-of-eight suture with polypropylene mesh and musculofascial flap

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ABSTRACT

Surgical stabilization of the flail chest is challenging and has no established guidelines. Chest wall integrity and stability are the main factors that ensure the protection of intrathoracic organs and an adequate respiratory function. Here, we report a novel chest wall reconstruction technique in a 45-year-old man with a traumatic left flail chest and open pneumothorax diagnosed both clinically and radiographically. Rib approximation and chest wall reconstruction was done using intercostal figure-of-eight suture and polypropylene mesh with vascularized musculofascial flap. The patient improved gradually and was discharged after three weeks of total hospital stay. He returned to regular working after a month with no evidence of respiratory distress or paradoxical chest movement. Follow-up visit at one year revealed no lung hernia or paradoxical chest movement. This is a novel, feasible and cost-effective modification of chest wall reconstruction that can be adopted for thoracic wall repair in case of open flail chest, which needs emergency surgical interventions even in resource constraint settings.

Introduction

Thoracic trauma is responsible for 25% of deaths and 33% of morbidity in road traffic accidents.[1] Flail chest is the most severe form of chest trauma, occurring in 7% of cases with 16%–20% mortality.[2,3] It occurs when there are fractures and displacements of three or more consecutive ribs in two places, with or without a sternal component, causing a chest wall segment's paradoxical respiratory movement.[4] Associated injuries with flail chest may be pulmonary contusions, hemothorax, pneumothorax, head injury and occasional major vascular injury.[2,5,6]

Chest wall integrity and stability are the main factors for intrathoracic organ protection and respiratory function. Therefore, the immediate management of flail chest consists of respiratory support by mechanical ventilation and pain relief, followed by either medical or surgical management, depending on concomitant injuries. Surgical chest wall stabilization with open fixation of ribs is associated with a faster ventilator wean, shorter intensive care unit stay and less cost in a select group of patients with flail chest.[7]

Here we present a novel, feasible and cost-effective modification of chest wall reconstruction in chest trauma with flail chest and open pneumothorax managed with intercostal “figure-of-eight” suture and chest-wall reconstruction with polypropylene mesh and musculofascial flap.

Case report

A 45-year-old man presented to the emergency department with left flail chest and open pneumothorax following a road traffic accident. The patient was hemodynamically stable, and presented with severe pain and paradoxical breathing. Clinically, a lacerated avulsed wound was noted over the lateral side of the left chest extending from nipple to posterior axillary line, measuring approximately 13 cm × 6 cm in size (Fig. 1A). Abdominal injury was ruled out by an extended focused assessment with sonography for trauma assessment. Contrast-enhanced CT with 3D reconstruction showed multiple rib fractures in 2nd-10th ribs anteriorly and 9th-10th ribs posteriorly with left pneumothorax and type 3 pulmonary

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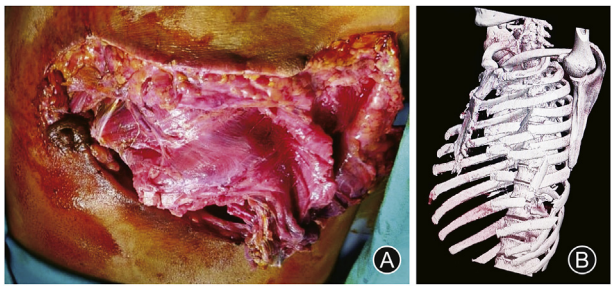

Fig. 1. (A) Lacerated avulsed chest wound; (B) CT chest with 3D construction showing multiple rib fractures.

laceration as per classification for pulmonary injury by Wagner and group (Fig. 1B).

After stabilizing the patient, the thoracic cavity was explored by extending the lateral edge of the chest wound to the posterior axillary line at the level of 6th intercostal space. Superior and inferior musculocutaneous flaps were created by raising the pectoralis major and serratus anterior muscle off the chest wall to expose the injured ribs and lung. The small lacerations present in the left lung were repaired and the lung was further inflated completely without any significant air leaks. Fractured and displaced 3rd-6th ribs on the anterior aspect and 9th rib on the posterior aspect of the left side were identified and sutured with non-absorbable suture (polypropylene No-1) in "figure-of-eight" fashion to the intercostal muscle at the fractured sites very close to the rib borders preserving the neurovascular bundle, to reduce postoperative residual pain (Fig. 2). Chest drain was placed in the thoracic cavity after debridement and lavage of the wound. A polypropylene mesh of size 15 cm × 8 cm was placed and fixed to the periosteum of 4th-8th ribs firmly with polypropylene sutures (2–0) over the defect in the chest wall to maintain the stability of the chest wall and prevent paradoxical movement (Fig. 3).

Soft tissue coverage was done by serratus anterior and pectoralis major muscle flap. The nipple was reconstructed, and skin flaps were raised to achieve a tension-free wound closure. Postoperatively, the patient was on ventilator support for 48 h only, and the flail chest and paradoxical breathing improved (Fig. 4A). On the eleventh postoperative day, the patient developed left lung consolidation, which was improved after bronchoscopic clearance of the airway secretions. Small areas of superficial skin flap necrosis were seen at places where debrided and dressings were done (Fig. 4B). The patient improved gradually and was discharged after three weeks of total hospital stay. He returned to regular working after a month with no evidence of respiratory distress or paradoxical chest movement on the follow-up visit. Even after one year follow-up, he did not have lung hernia or abnormal chest wall movement.

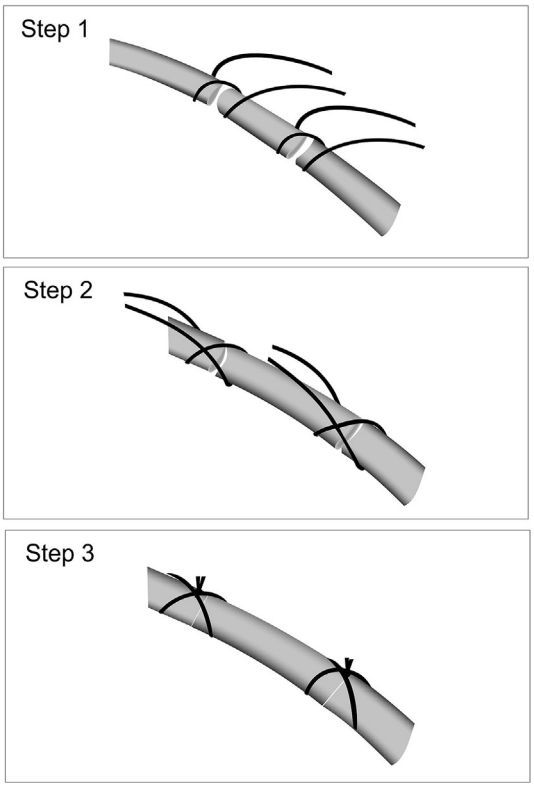

Fig. 2. Schema diagram of "figure-of-eight" suturing technique.

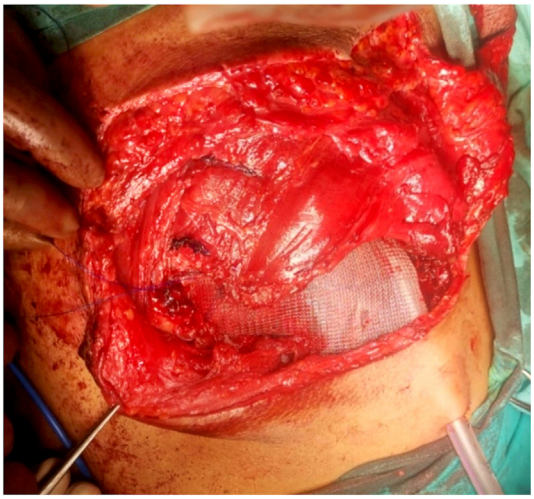

Fig. 3. Reconstruction of the chest wall with polypropylene mesh and musculofascial flap.

Discussion

Clinically, flail chest can be diagnosed by paradoxical respiratory movement and confirmed by 3D reconstruction of contrast-enhanced chest CT images. In the flail chest, surgical fixation is done in cases of severe chest wall instability, unsuccessful weaning from mechanical ventilation, persistent pain, or progressive loss of pulmonary function, along with thoracotomy done for other thoracic injuries.[4] The present patient had chest wall instability with an open chest wound and pneumothorax, lung injury, and severe pain, so an emergency surgical intervention was planned as per standard trauma care guidelines.[4]

The primary aim in open flail chest is to restore the chest wall function and provide soft tissue coverage for preserving pulmonary mechanics. Chest wall defect can be reconstructed with vascularized flaps and non-absorbable polypropylene mesh for ventilation and normal functioning. A recent practice management guideline from the Eastern Association for the Surgery of Trauma conditionally recommends rib fixation in patients with flail chest.[7] Studies have also shown that surgical stabilization of fractured rib segments in the flail chest has statistically reduced the period of mechanical ventilation and its complications, pain, hospital stay, and thus being cost-effective along with improvement in long-term pulmonary function when compared to non-operative management.[4,5]

Various methods and materials have been used for open flail chest, with titanium plates still being the most widely used material

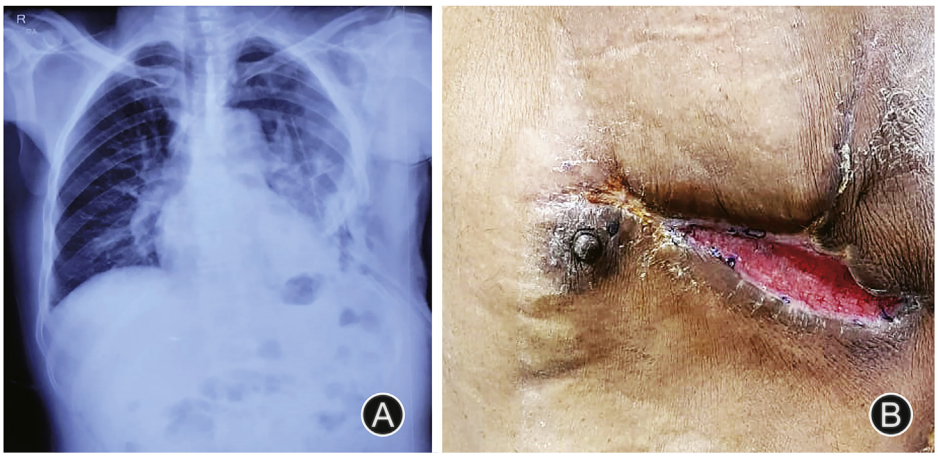

Fig. 4. (A) Postoperative chest X-ray, posterior-anterior view; (B) Healing by primary intention after one month at the site of flap necrosis.

for good chest wall stability; however they are expensive.[7,8] Fixation and stabilization with intramedullary devices provide rigid stabilization, but practically allows no mobility to the chest wall. However, this intercostal suturing in figure-of-eight fashion demonstrated by us is technically more accessible, simple, and less time-consuming as all surgeons are familiar with figure-of-eight suturing. The neurovascular bundle is preserved, and no separation of the periosteum or muscles is required, so postoperative pain is significantly less. Moreover, this procedure is less expensive compared with previously proposed procedures as the materials used can be found in every surgical unit. Ivancic et al.[9] in 2009 was the first one to describe a figure-of-eight encircling along with K-wire to maintain rib stability. Direct fixation of rib individually leads to a restrictive chest wall; however, when implemented appropriately, chest wall stabilization can be achieved with this technique also.

Meshes are usually used in the reconstruction of the abdominal or thoracic wall after resection of malignant tumors. The figure-of-eight method proposed by us can be adopted for thoracic wall repair in a flail chest that needs emergency surgical intervention. The mesh with myocutaneous flaps created additional coverage to the implanted hardware and area reinforcement, thus preventing a possible pulmonary hernia. Here we conclude that the above method is a novel, feasible and cost-effective modification of chest wall reconstruction that can be adopted for thoracic wall repair in cases of flail chest needing emergency surgical interventions, even in resource constraint setting.

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Nil.

Ethical statement

Inform consent from the patient and their relatives has been obtained.

Declaration of competing interest

The authors declared no competing interest.

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Author contributions

Writing-original draft preparation: Klein Dantis and Swagata Brahmachari. Conceptualization: Klein Dantis. Data curation: Swagata Brahmachari. Investigation: Aghosh Raju and Suprabha Shankari. Review and editing: all authors. Manuscript approval: all authors.

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