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Case Report

Surgical stabilization of rib fractures under extracorporeal membrane oxygenation: A case report

Jose Alejandro Posso-Nuñez^a, Astrid Carolina Álvarez-Ortega^a, Diego Fernando Bautista-Rincón^b, Carlos Alejandro García-González^c, Indira Fabiana Cujino-Álvarez^d, Álvaro Ignacio Sánchez-Ortiz^{e,*}, Mauricio Velásquez-Galvis^e

^a Fundación Valle del Lili, Clinical Research Center, Kra 98 No. 18-49, Cali 760032, Colombia

^b Fundación Valle del Lili, Department of Critical Medicine, Kra 98 No. 18-49, Cali 760032, Colombia

^c Fundación Valle del Lili, Department of Radiology and Diagnostic Imaging, Kra 98 No. 18-49, Cali 760032, Colombia

^d Fundación Valle del Lili, Department of Anesthesiology, Kra 98 No. 18-49, Cali 760032, Colombia

^e Fundación Valle del Lili, Department of General Surgery, Division of General Thoracic Surgery, Kra 98 No. 18-49, Cali 760032, Colombia

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ABSTRACT

A 47-year-old male patient was referred to a level 1 trauma center with refractory acute respiratory distress syndrome, bilateral lung contusions, and flail chest after initial management for injuries sustained 5 days prior from an 8-m fall from a tower crane. Surgical stabilization of the rib fractures was achieved under extracorporeal membrane oxygenation support, with successful decannulation 4 days after surgery. The patient was discharged after 42 days and following multidisciplinary interventions. Use of extracorporeal membrane oxygenation support in blunt chest trauma patients presents a valuable opportunity as it may enable earlier surgical intervention and reduce in-hospital complications.

Introduction

Flail chest occurs in 1 % of patients with moderate to severe blunt chest trauma, and up to 54 % of these flail chest cases are associated with pulmonary contusions [1]. This combination can lead to acute respiratory distress syndrome (ARDS). Surgical stabilization of rib fractures (SSRF) is recommended for flail chest patients [2], but in those with severe pulmonary contusions, it's controversial. Extracorporeal membrane oxygenation (ECMO) becomes valuable in stabilizing such patients. We present the case of a patient with severe blunt chest trauma with flail chest, bilateral multilobe pulmonary contusions, and refractory ARDS, requiring venovenous ECMO (V-V ECMO) support before SSRF.

* Corresponding author at: Fundación Valle del Lili, Department of General Surgery, Division of General Thoracic Surgery, Kra 98 No. 18 - 49, Cali 760032, Colombia.

E-mail addresses: jose.posso.nu@fvl.org.co (J.A. Posso-Nuñez), astrid.alvarez.or@fvl.org.co (A.C. Álvarez-Ortega), diego.bautista@fvl.org.co (D.F. Bautista-Rincón), carlos.garcia@fvl.org.co (C.A. García-González), indira.cujino@fvl.org.co (I.F. Cujino-Álvarez), alvaro.sanchez@fvl.org.co (Á.I. Sánchez-Ortiz), mauricio.velasquez@fvl.org.co (M. Velásquez-Galvis).

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Case description

A 47-year-old male patient without relevant past medical history was admitted to the emergency department of a level 2 trauma center following an 8-m fall from a tower crane while working. The patient presented with blunt chest trauma, left-sided flail chest, blunt abdominal trauma and multiple osteoarticular injuries. Calculated Injury Severity Score (ISS) was 29 points. Initially, the patient underwent damage control laparotomy, finding grade III spleen trauma that warranted splenectomy. During the postoperative course, he developed mixed respiratory failure with ARDS refractory to conventional therapy. This required the patient's transfer to a level 1 trauma center after 5 days of management. However, the patient was unable to tolerate transfer with a portable ventilator, and ECMO support was indicated. The medical team from the destination hospital performed peripheral cannulation for V-V ECMO at the patient's referral institution before transfer (Fig. 1A).

The chest computed tomography (CT) scan revealed multiple rib fractures of the left side from the second to the tenth ribs (Fig. 2A and C) and bilateral multilobe contusions (Fig. 1B). The patient remained with an unsatisfactory clinical course despite support with heparin-free ECMO. Surgical stabilization of the chest wall was indicated and performed on the 12th post-trauma day after hemodynamic compensation. Intraoperative findings revealed severe overlapping fractures in the lateral aspect of the 3rd, 4th, and 5th left ribs, as well as in the posterior aspect of the 8th, 9th, and 10th left ribs. Stabilization of the fractures was achieved using the Strasbourg Thoracic Osteosynthesis System (STRATOS®) MedXpert GmbH, Heitersheim, Germany (Fig. 2B, D).

After surgery, the patient's clinical condition steadily improved. Tracheostomy was performed on the 13th post-trauma day. Successful decannulation of V-V ECMO occurred on the 16th post-trauma day, for a total of 11 days under therapy. The patient required multiple blood transfusions and underwent two Video-Assisted Thoracic Surgery (VATS) interventions due to massive hemothorax and a loculated pleural effusion with coagulated hemothorax, on the 17th and 21st post-trauma days respectively. The patient developed a high-grade atrioventricular block refractory to a transcutaneous pacemaker, necessitating the implantation of a permanent pacemaker (VITATRON Q70A, AAI-DDD mode) on the 29th post-trauma day. Tracheostomy decannulation took place on the same day. 35 days after trauma, the patient was transferred to the general wards for physical and pulmonary rehabilitation. On the 47th post-trauma day, the patient was discharged to continue recovery with home healthcare services.

Discussion

Flail chest is associated with severe pulmonary restriction, necessitating mechanical ventilation, and is linked to high morbidity and mortality. Analysis of The National Trauma Data Bank indicated that 80 % of patients with flail chest required intensive care unit (ICU) admission and 59 % required mechanical ventilation [1]. Accompanying hemothorax, pneumothorax, and pulmonary contusions further aggravates the condition and facilitates development of ARDS. Delaying the decision for SSRF in these patients may prolong ICU stay and increase risk of mechanical ventilation, pneumonia and mortality [3]. Two of the most controversial aspects that remain in the context of blunt thoracic trauma are timing for ECMO initiation and the selection of an anticoagulation strategy. Nevertheless, ECMO can improve outcomes in patients with severe lung injuries even in conditions such as hemorrhagic shock [4].

The use of ECMO in trauma patients before definitive surgical management has increased with the development of limited-anticoagulation and anticoagulation-free protocols [5]. Moreover, hemodynamic support of trauma patients with ECMO has been described to result in comparable outcomes to those of non-trauma patients [6]. In this case, SSRF was critical to improve the patient's

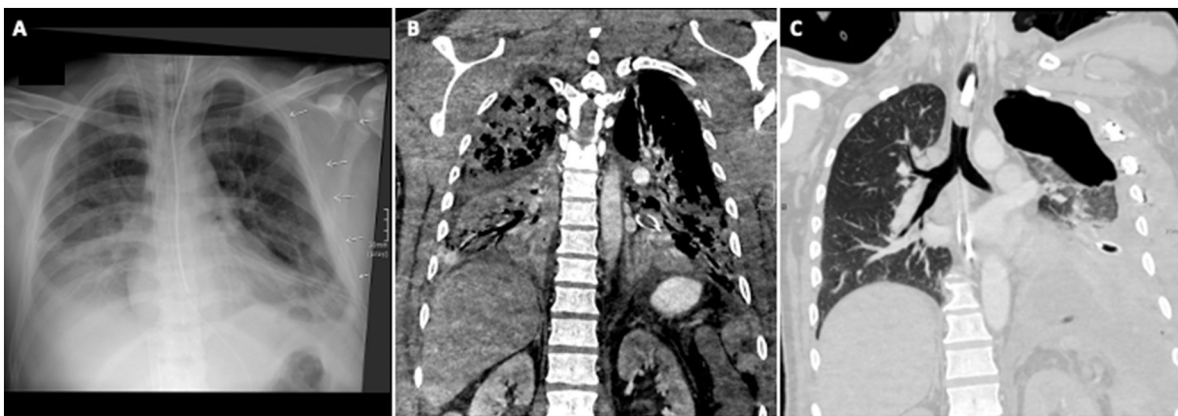


Fig. 1. Sequential imaging of thoracic trauma: radiographic and CT findings.

A. Chest radiograph 7 days post-trauma: demonstrates pulmonary opacities indicative of resolving contusions, bilateral pleural effusion, a left-sided thoracostomy tube, and various medical devices including an ECMO cannula, a left jugular venous catheter, enteral tubes, and an appropriately positioned endotracheal tube. B. Contrast-enhanced thoracic CT scan: reveals consolidation in both right and left lobes, a hyperdense pleural effusion on the right side due to hemothorax, and a thoracostomy tube on the left side addressing pulmonary contusions. C. Contrast-enhanced thoracic CT scan at 21 days post-trauma: displays the resolution of pulmonary consolidations in both right and left lobes, yet a persistent left hemothorax is evident, causing atelectasis in the left lower lobe.

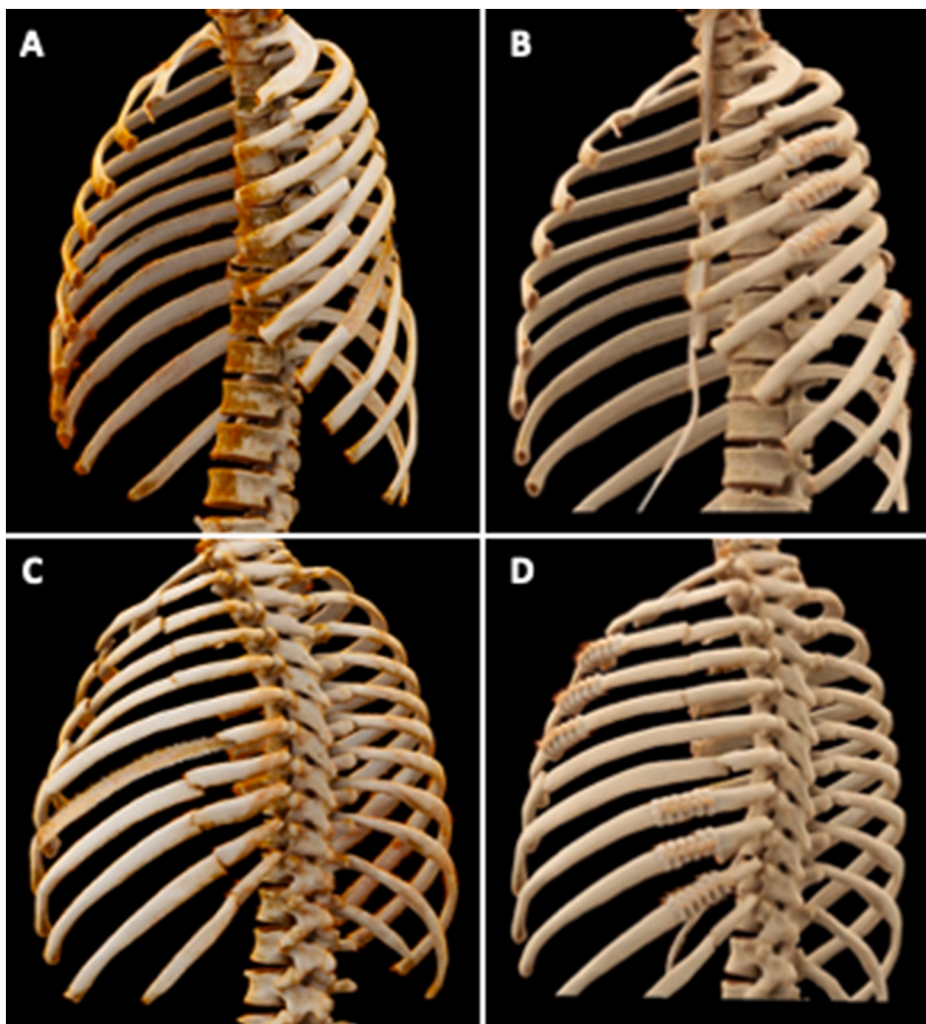


Fig. 2. Comparative 3D CT reconstructions. Three-dimensional CT reconstructions of the thorax pre-operative (A and C) and post-operative (B and D), illustrating the anatomical changes resulting from surgical intervention.

condition, but his hemodynamic instability precluded any surgical intervention. Fixation of rib fractures would not have been possible without ECMO support, avoiding prolonged mechanical ventilation and ICU stay.

Conclusions

Flail chest represents a significant burden and SSRF has been increasingly recommended recently due to its substantial benefits [2]. Pulmonary contusions should not be automatically seen as an absolute contraindication for SSRF. Utilization of ECMO to support blunt chest trauma patients propounds a valuable opportunity for lung recovery before surgical intervention and may reduce the duration of mechanical ventilation, shorten ICU stay, and decrease in-hospital complications.

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Institutional Review Board (IRB) approval

The study has received approval from the Institutional Ethical Review Board (IRB) of Fundación Valle del Lili, on November 17th 2023, with reference number N^o2023.202.

Informed consent statement

The patient involved in this case report has given their informed consent for the inclusion of their medical details and any accompanying images in this publication. The consent was obtained after a thorough explanation of the purpose of this case report and the nature of its public and educational dissemination. This informed consent process conforms to the ethical guidelines of the 1975 Declaration of Helsinki as well as the local laws and regulations where the treatment was administered.

CRedit authorship contribution statement

Jose Alejandro Posso-Núñez: Investigation, Visualization, Writing – original draft, Writing – review & editing. **Astrid Carolina Álvarez-Ortega:** Visualization, Writing – review & editing. **Diego Fernando Bautista-Rincón:** Writing – review & editing. **Carlos Alejandro García-González:** Visualization, Writing – review & editing. **Indira Fabiana Cujino-Álvarez:** Writing – review & editing. **Álvaro Ignacio Sánchez-Ortiz:** Resources, Supervision, Visualization, Writing – review & editing. **Mauricio Velásquez-Galvis:** Conceptualization, Project administration, Resources, Supervision, Writing – review & editing.

Declaration of competing interest

None to declare.

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