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Case report

Flail chest and mediastinitis with total sternal loss post-pediatric cardiac surgery. Reconstruction technique and case report

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ABSTRACT

We present the case of a two-year-old girl, with a history of pulmonary banding surgery who underwent a chest wall stabilization technique with titanium rods and muscle flaps coverage, due to post-surgical mediastinitis associated with total sternal loss after ventricular septal defect closure surgery, debanding, and pulmonary artery plasty. The patient had a favorable postsurgical evolution.

Keywords: Flail Chest; Mediastinitis; Thoracoplasty (source: MeSH-NLM).

Introduction

The deep surgical site infection known as post-sternotomy mediastinal space infection or mediastinitis is a serious complication of cardiac surgery that may be associated with sternal osteomyelitis [1,2]. It has an incidence ranging from 0.2 to 5% [3], with a mortality rate of up to 40% [4]. In pediatric cardiac surgery, an incidence between 1.7 to 8.0 per 100 cases has been reported [1].

Identified risk factors include age younger than 1 month, genetic syndromes, previous hospitalization of more than 48 hours, use of intraoperative hypothermia, the need for multiple procedures during the same surgery, duration of surgery, and the presence of temporary pacemaker wires for more than 3 days [1]. Delayed sternal closure could increase the risk of infections, with a highly variable rate ranging from 1% to 28% [5].

There are multiple surgical procedures and materials used in the adult population for the treatment of mediastinitis and chest wall reconstruction, such as meshes and patches (polytetrafluoroethylene, biological), rigid and semi-rigid prostheses (allografts or bone xenografts), titanium, calcium ceramic, 3D-printed prostheses, biodegradable polymers, nanocomposites, and stem cell-derived bone grafts [1]. However, there is limited information about them in the pediatric population.

Chest wall reconstruction remains a challenge, especially in children, where suitable materials for age and weight may not be readily available. Often, a multidisciplinary approach is required, involving cardiothoracic surgeons, plastic surgeons, and other specialists. The objectives of reconstruction are to restore chest wall rigidity, preserve pulmonary mechanics, protect intrathoracic organs, and minimize chest deformity [6].

We present a case of successful surgical treatment in a girl with post-surgical mediastinitis, associated with total sternal loss and flail chest, following ventricular septal defect (VSD) closure surgery and pulmonary artery debanding performed by the pediatric cardiac surgery team at our institution.

Case report

The patient was a 2-year-old girl, weighing 14.2 kg, diagnosed with a ventricular septal defect and a history of pulmonary artery banding surgery performed at one year of age through a mid-sternal approach.

At our institution, the patient underwent elective cardiac surgery for defect correction. At our institution, and as an elective procedure, the patient underwent cardiac surgery for the correction of defects. Through a mid-sternal approach, with central aortobicaval cannulation under mild hypothermia, ventricular septal defect closure was performed using a bovine pericardial patch, along with debanding and pulmonary artery plasty, involving a prolonged extracorporeal circulation (ECC) time. Sternal closure was performed with reinforcement of the left sternal edge using the Robicsek technique, and the patient was transferred to the pediatric intensive care unit (ICU)

On the third postoperative day, the patient underwent a surgical reintervention due to severe stenosis at the origin of both pulmonary branches. Pulmonary artery and branch plasty were performed using a bovine pericardial patch.

Seven days later, the patient returned to the operating room due to sternal dehiscence, surgical site infection, and high suspicion of mediastinitis. Intraoperative findings included infection and dehiscence of the surgical wound, complete sternal suture dehiscence, total loss of the sternum due to multiple fractures in areas of previous osteosynthesis, and significant involvement of costal cartilages with necrosis and infection. Abundant purulent secretion in the mediastinum was also noted. Various samples were taken for culture and pathology, and surgical cleaning with extensive debridement of necrotic tissues was performed. This involved a wide opening of both pleural spaces, placement of pleural drains, mediastinal drain insertion, catheter placement for mediastinal irrigation, and closure of the skin with total stitches.

Mediastinitis was confirmed in the operating room due to the finding of purulent secretion, while pathology demonstrated acute osteomyelitis. In the ICU, the patient had a stable hemodynamic evolution, received ventilatory support due to chest instability, and mediastinal irrigation with saline solution was maintained for 5 days.

After 3 weeks from the last surgery, with the infection under control, a multidisciplinary medical team decided to perform thoracoplasty with titanium rods for chest stabilization, following chest tomography with chest wall reconstruction **(Figure 1)**.

Surgical technique

The reopening of the skin at the previous incision site was performed, dissection through layers until reaching costal cartilages, curettage of cartilage edges, cavity washing, and release of the muscular flap (bilateral pectoralis major, anterior sheath of the rectus abdominis muscle, and part of the aponeurosis of the external oblique).

The costal cartilages were faced with 1/0 Nylon suture **(Figure 2)**. Four 2.0 titanium miniplates in a C shape (CONMET; LLC 24/1 Onezhskaya str. Moscow) adapted to the costal curves on both hemithoraxes were fixed to ribs 1, 2, 4, and 5 with 1/0 surgical wire suture (TAGUM) and two 5mm titanium miniscrews (CONMET; LLC 24/1 Onezhskaya str. Moscow) on each side.

A 20 Fr mediastinal drain and bilateral subpectoral Hemovac 14 Fr drain were placed. Muscle flaps were approached towards the midline with 2/0 polyglactin suture, covering the entirety of the titanium rods. Skin and subcutaneous tissue were closed with Nylon 2/0 total stitches **(Figure 3)**.

Postoperative evolution

After the thoracic plasty surgery **(Figure 4)**, the patient remained on mechanical ventilation with sedoanalgesia, without inotropic-vasopressor support, continuing parenteral antibiotic therapy. After 6 days of mechanical ventilation, with therapy for withdrawal syndrome and having received prophylactic corticosteroids, a planned extubation was performed. Respiratory support post-extubation continued with nasal CPAP for 6 days, followed by transition to binasal cannula. Respiratory physiotherapy was provided throughout the pre and post-extubation process. The patient completed 6 weeks of parenteral antibiotic therapy and was discharged after a 2-month hospital stay. At the 8-month follow-up, she is asymptomatic, without medication.

Discussion

Mediastinitis is a serious complication of cardiac surgery with a mortality rate of up to 40% [7]; sternal osteomyelitis can be a rare complication with reported mortality ranging from 7 - 80% [8]. Gram-positive bacteria are most frequently isolated.

Various techniques have been described for the treatment of mediastinitis in both adults and children, including extensive surgical debridement, primary or delayed closure of sternotomy, muscle flap interposition, greater omentum flap, and the use of negative pressure, all in conjunction with antibiotic therapy [7-9]. However, when associated with total sternal loss, there are several reports in adult patients describing the use of synthetic, biological, and metallic materials. Additionally, technologies such as computed tomography with three-dimensional (3D) image

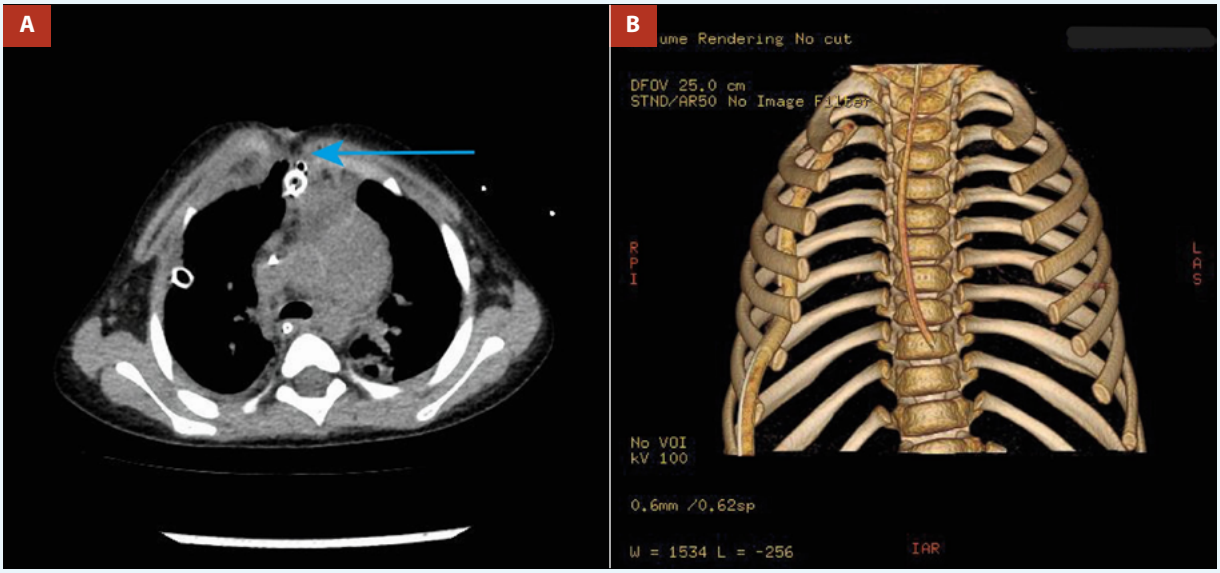

Figure 1. Two-year-old girl with mediastinitis and total sternal loss. **(A)** Chest tomography showing evidence of sternal absence (blue arrow). **(B)** Chest tomography with bone reconstruction showing sternal absence.

reconstruction have been employed to guide the precise production of sternal prostheses through 3D printing technology. In children, there is limited experience with these materials, primarily due to their weight and, more importantly, the potential for growth in their thoracic anatomy.

The indication for chest wall reconstruction is necessary for major defects or when respiratory function is compromised. The primary goal is to restore the integrity of the chest wall, maintain its aesthetics, and improve respiratory dynamics. Titanium rods are presented as an alternative for use in such patients [10]. There is experience in fixing the chest wall with titanium rods in the adult population, yielding good results [11], a practice not extensively described in the pediatric population.

In our setting, we only have rib osteosynthesis materials designed for adults, posing a significant challenge in planning thoracic stabilization, and determining the appropriate timing

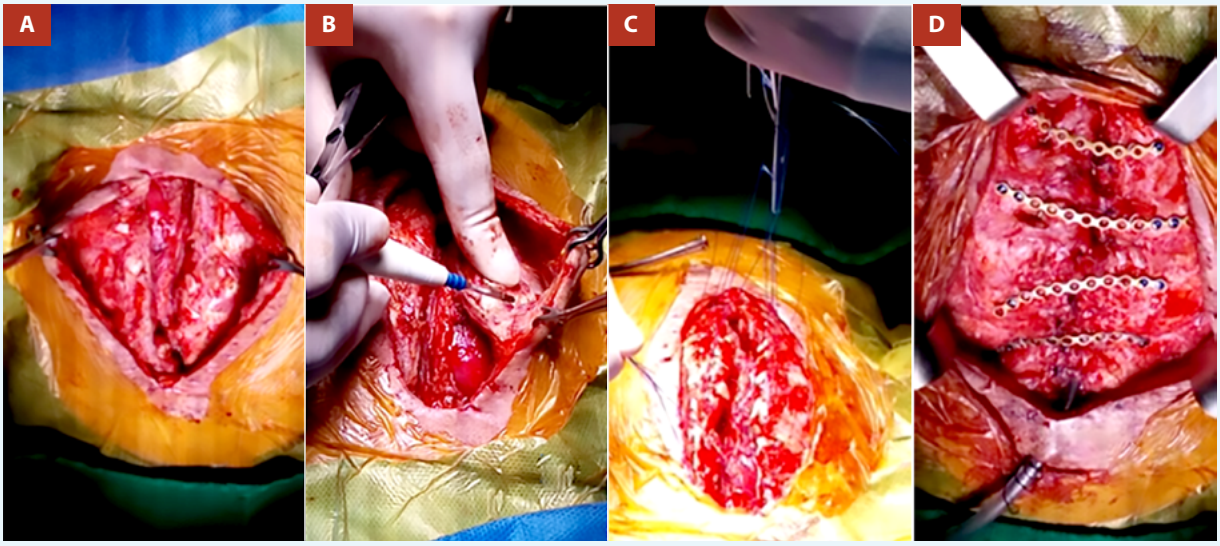

Figure 2. Intraoperative view. **(A)** Opening of skin and subcutaneous tissue, showing sternal absence. **(B)** Release of muscle flap, pectoralis major. **(C)** Approximation of costal cartilages with 1/0 nylon suture. **(D)** Placement of 4 titanium miniplates

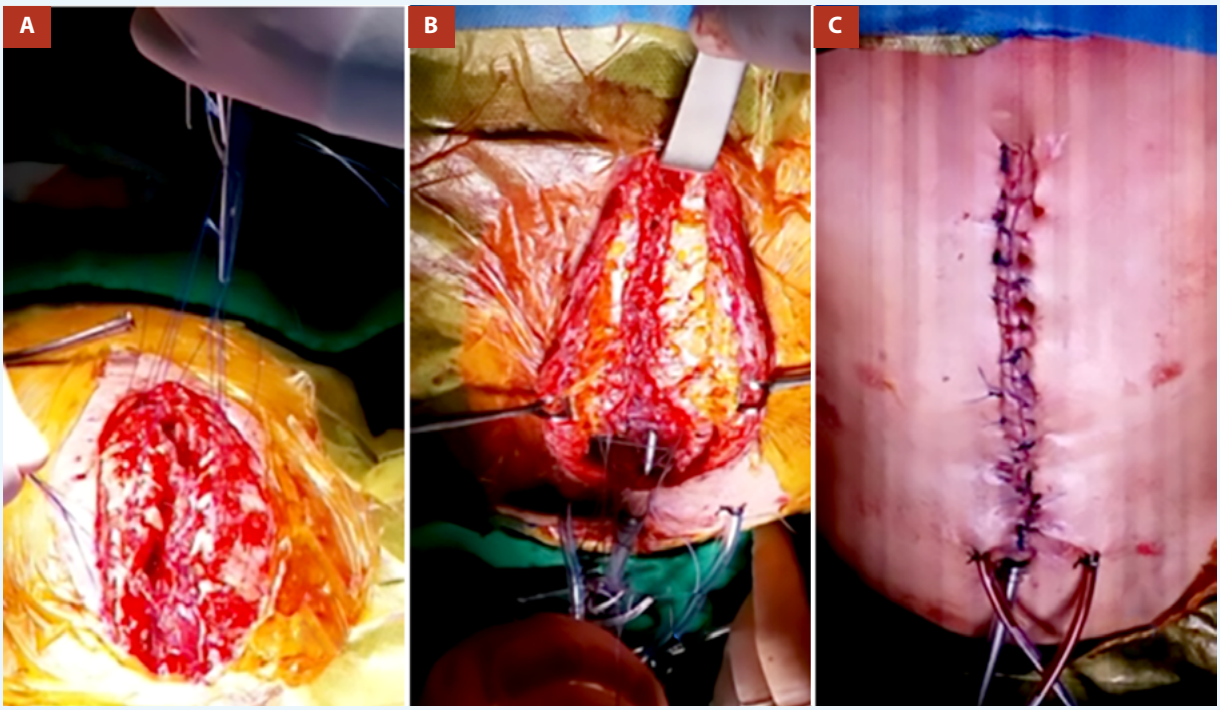

Figure 3. Intraoperative view. **(A)** Approximation of muscle flaps. **(B)** Coverage of the entire prosthetic material. **(C)** Closure of skin and subcutaneous tissue with Nylon suture, mediastinal drainage, and bilateral subpectoral drains.

for it, especially since our patient experienced total sternal loss due to mediastinitis.

Upon evaluating the available materials in our setting, we planned and carried out thoracic stabilization using titanium miniplates, which are routinely used in maxillofacial surgery due to their compatibility with the diameter of our patient's costal cartilages. In addition, titanium rods offer advantages of flexibility and strength, allowing adaptation to the curvature and angulation of the ribs. They can be used without removing the periosteum, maximizing bone perfusion [5]. The use of muscle flaps from both pectoralis major muscles allowed coverage of the entire costal cartilages and titanium plates, enabling the closure of potential dead spaces with well-vascularized tissue.

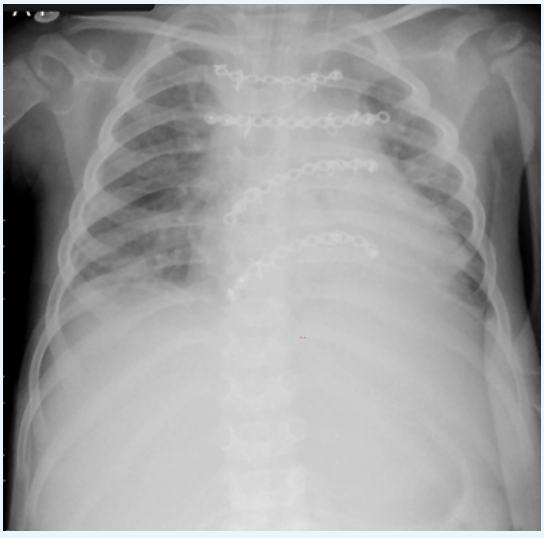

Figure 4. Chest X-ray on the sixth postoperative day after thoracic plasty, showing 4 titanium rods

The optimal timing for chest stabilization is still unclear, as some authors recommend early treatment and reconstruction of the chest wall since prolonging this time has not shown good results [12].

The patient showed appropriate postoperative progress, with planned extubation 6 days after the chest stabilization surgery. However, she experienced prolonged ventilation time before thoracic stabilization, initially for controlling the infectious process and subsequently to acquire the appropriate materials to use.

In conclusion, thoracic stabilization following total sternal loss post-mediastinitis with titanium rods and mobilization of pectoralis major muscle flaps allowed for adequate chest stabilization in our patient. This approach maintained proper respiratory dynamics after extubation and preserved the integrity and aesthetics of the chest wall in the short and medium term. This surgical technique represents an opportunity for research in pediatric patients.

Ethical aspects: The report was approved 2022 by INCOR's Institutional Research Ethics Committee.

Author contributions: LJPO: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing - Review & Editing; HPS: Formal analysis, Supervision, Validation, Writing - Review & Editing; TLPG: Formal analysis, Supervision, Validation, Writing - Review & Editing.

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