Operative stabilization of flail chest using a prosthetic mesh and methylmethacrylate

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Abstract
Surgical stabilization of flail chest is a controversial operation, but recent data has shown that selected patients benefit from it. We describe a simple and practical method of operative stabilization of flail chest using a prosthetic mesh and methylmethacrylate anchored to the ribs and sternum. The methylmethacrylate—mesh complex is inexpensive, can be extracted electively as soon as full thoracic stability is achieved, and can be used to stabilize extended chest wall injuries.

Keywords: Flail Chest; Chest wall; Blunt trauma

1. Introduction

Blunt chest wall trauma is a common cause of admission in emergency departments and is associated with high morbidity and mortality. Thoracic trauma can cause an ample variety of injuries, ranging from simple abrasions, pulmonary contusions and rib fractures, to life threatening conditions such as visceral ruptures and flail chest [1].

We describe a simple, practical and inexpensive method for surgical stabilization of severe flail chest using a synthetic mesh covered with methylmethacrylate.

2. Case report

We present the case of a 19-year-old woman victim of an automobile crash that resulted in an important crush injury of the chest, with sternal fracture, bilateral disruption of the costochondral junctions, multiple antero-lateral rib fractures and bilateral hemothorax (Fig. 1A and B). She also suffered a fracture of the fifth cervical vertebra with protrusion of the intervertebral discus. No associated head or abdominal injuries were present.

At inspection, there was severe paradoxical motion of the chest wall and the patient was markedly dyspneic. She was given supplemental oxygen, parenteral analgesics and bilateral thoracostomy was performed. Despite the supportive measures, clear signs of respiratory failure ensued and the patient was intubated. She was transferred to the critical care unit, remained intubated for 5 days and unable to wean from mechanical ventilation. At day 6 she was tracheostomized, but remained unable to wean.

It was imperative that the patient could be weaned and the tracheostomy closed in order to stabilize the cervical fracture by an anterior cervical approach. Therefore, at day 11, the patient was taken to the operating room, placed in the supine position with arms abducted and put under general anesthesia. The thoracic cavities were inspected by videothoracoscopy; clots were removed, the lungs were fully expanded and the pleural cavities washed and drained.

We then proceeded to a wide bilateral inframammary incision in order to expose the sternum and the ribs from the third to the eighth intercostal space. All the fractured ribs were identified. The superior border of each rib was dissected on both sides of the fractures. With a handheld driller machine, we made a hole on each side of the rib fractures, at the superior border of the ribs. Non-absorbable sutures (polypropylene-0) were passed through each opening (Fig. 2A and B). A sheet of Marlex mesh [Bards Implants, Billerica, MA, USA] was placed, covering all the fractured sites. The sutures previously placed on the ribs were tied to the Marlex mesh, avoiding folds and excessive tension (Fig. 2C). With the mesh in place, we covered it with two 20 ml vials of methylmethacrylate (Fig. 2D), forming a plate of approximately 3 mm thickness. The heat produced by the polymerization of the methylmethacrylate involved muscle and bones only, with no direct contact with the thoracic organs. No specific measures were performed to dissipate...
the patient returned to the operating room and the fixation of the cervical fracture. Two months later, the patient returned to postoperative visits every 2 months, allowed the stoma to heal and the patient to be submitted to the fixation of the cervical fracture. Two months later, the patient returned to the operating room and the methylmethacrylate—mesh complex was easily withdrawn. The patient returned to postoperative visits every 2 months, and was followed up to 12 months after surgery. She was able to perform her normal daily activities, with no respiratory impairment and good cosmetic results.

3. Discussion

The surgical treatment of flail chest remains controversial. Despite all medical efforts, some patients will need mechanical ventilation, especially in severely crushed chests, with underlying pulmonary contusion. These patients are prone to require prolonged mechanical ventilation and may develop reductions in tidal volume, sputum retention and ventilator associated pneumonia [1].

Studies comparing internal fixation and endotracheal intubation [2,3] have stated that surgical stabilization of flail chest reduces the need for mechanical ventilation and the incidence of pneumonia; lowers the length of stay in intensive care units, allows quicker return to previous employment, provides better functional results and avoids chest wall deformities.

As advocated by Lardinois et al. [4], indications for the operative stabilization of flail chest will usually fall into four categories: (1) respiratory failure despite aggressive medical therapy, (2) extended antero-lateral flail chest, (3) failure to wean from ventilator and, (4) in patients who require thoracotomy for associated injuries.

Several techniques have been proposed for the operative stabilization of flail chest, the use of the Judet’s struts and other kinds of struts, acetabular reconstruction plates, intramedullary wiring of the fractured ribs, and recently, absorbable plates [5–8]. Intramedullary rib stabilization can be a time consuming procedure and it may be challenging to do it on the curvature of the ribs. Fixation with metal prosthesis provides rigid stabilization but allows practically no mobility to the chest wall.

The technique described herein provides excellent stability to the flail chest, but still allows some mobility to the chest wall, and can be employed in extended thoracic injuries. The methylmethacrylate—mesh plate was anchored with polypropylene sutures instead of absorbable sutures, as we were concerned with chest wall infection, which could lead to dehiscence of the anchoring sutures. A similar approach has produced good results in sternal replacement, as shown by Molnar et al. [9].

The patient’s postoperative period was uneventful and the polypropylene sutures were easily identified at the second operation, facilitating the removal of the methylmethacrylate—mesh complex. If chest wall infection is not a major concern, then absorbable sutures, like Polyglactin, could be used. As those sutures absorb in 6–8 weeks, one would not have to worry about cutting them. Nevertheless, full thoracic stability, which is the primary goal, may not be completely established in 6 weeks.

In this case, we performed a full clamshell incision. The patient had an important sternal dislodgment, and we needed complete access to the anterolateral chest wall, as some sutures would have to be placed through the sternum. In future cases, we may consider one or two separate inframammary incisions, especially in low anterior fractures or unilateral flail chest, which would result in even better cosmetic results without compromising an adequate exposure of the operative field.

We believe that operative stabilization of rib fractures should be an easy and rapid operation. The technique described herein is simple, familiar to the thoracic surgeon, cheaper than previously proposed procedures, and the materials employed can be found in every surgical unit. As the dissection is limited to the superior border of the ribs, the intercostal neurovascular bundle is preserved and the chances of residual pain are diminished. The thoracic curvature is preserved, allowing good cosmetic results. Unlike in other procedures, the methylmethacrylate—mesh cuirass can be easily removed, so the odds of infectious complications due to foreign bodies are
lowered. We believe that this technique could become an important option in the management of complex thoracic trauma.

References