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Chest Wall Reconstruction Using a Methyl Methacrylate Neo-rib and Mesh

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Abstract

Prosthetic reconstruction of the chest wall after oncologic resection is performed by means of various techniques using different materials. We describe a new technique of chest wall reconstruction that includes the use of Marlex mesh and the creation of a neo-rib from a Steinmann pin and methyl methacrylate.

Keywords

Chest wall; Surgery/incision/exposure/techniques

Introduction

Surgical management of chest wall defects after oncologic resection requires creativity and flexibility. Several factors are considered when planning the chest wall reconstruction: (1) prevention of lung hernia, for anterior/lateral defects; (2) prevention of scapula impaction, for posterior defects; (3) protection of underlying organs; and (4) cosmesis [1]. Various materials are available, including synthetic mesh, bone substitutes, and metal prosthesis.

Prosthetic mesh offers the advantages of easy handling, long-lasting tolerability, and in-growth of regenerative tissues. However, it does not provide sufficient strength and cannot be formed to the exact shape of the chest wall. To overcome these limitations, the so-called Marlex sandwich technique was introduced in the 1980s, and has since gained popularity [2, 3]. In this technique, methyl methacrylate (MMA) is sandwiched between two layers of Marlex mesh (Marlex, Davol & Bard, Cranston, RI, and Prolene, Ethicon, Somerville, NJ) and conformed to the shape/contour of the defect; the sandwich is then secured to the chest wall. MMA provides more rigidity than isolated mesh and allows customization of shapes to reconstruct different contours and sizes of chest wall defects. The disadvantages of MMA are that the rigidity may actually hinder physiologic movements of the rib cages and MMA may promote seroma formation in the surrounding soft tissues, increasing the risk of infection.

We herein describe our recent technique of chest wall reconstruction using an MMA neorib and Marlex mesh. To provide more core support and malleability when shaping the neo-ribs, while minimizing the amount of MMA required, our neo-ribs are constructed from a Steinmann pin (Biomet, Warsaw, IN).

Case Report and Surgical Technique

A 61-year-old male was diagnosed with recurrent chondrosarcoma of the right 6th rib anteriorly (Fig 1A). He had undergone two previous R1 resections. We performed a redo resection of the tumor, including ribs 5 through 7, leaving a defect of 11×9 cm (Fig 1B). To address this large defect, we constructed an MMA neo-rib using a 5/64-inch Steinmann pin (5/64 inches or 2 mm in diameter). To begin, we drill a hole approximately 4 to 5 mm in depth on each side of the space the neo-rib would bridge. In this case, we anchored the neo-rib to the 6th rib laterally and to the lateral border of the manubrium between the 5th and 6th ribs medially. To allow room for the MMA, the holes should be slightly larger than the diameter of the Steinmann pin. The Steinmann pin is conformed to the desired shape (Fig 2A), and the sharp, trocar end of the pin is cut.

We then use a half-inch Penrose drain cut to a length that will cover most of the exposed pin when 2 to 3 mm of the Steinmann pin is inserted into the holes at each end (Fig 2B). The pin with Penrose drain is placed in the patient (Fig 2C). We then prepare our MMA on the back table. Cobalt MV (medium viscosity) bone cement with gentamicin (Biomet, Warsaw, IN) is mixed and drawn into a syringe. First, a small amount of MMA is injected at the lateral end of the pin to secure the pin in the drilled hole. Next, MMA is injected into the Penrose drain, along its entire length (Fig 2D). During this process, it may be necessary to milk the MMA along, using the operator's finger, as the MMA begins to harden. Finally, a small amount of MMA is injected into the drilled hole at the medial end of the pin to secure the pin. After the MMA is allowed to harden, the Penrose drain is sharply incised and removed (Fig 3A).

Once the neo-rib has been constructed, Marlex mesh is cut to a shape to cover the space between the neo-rib and the native rib above—in this case, the 4th rib. The mesh is sutured to the native rib. On the neo-rib side, the mesh is wrapped tightly around the neo-rib and sutured to itself with Prolene stitches (Fig 3B). This prevents the formation of a space between layers of mesh. The patient in this case had ample subcutaneous tissue, which was then closed over the prosthetic to provide soft-tissue coverage. Final pathologic findings were consistent with chondrosarcoma, with all margins free of disease. The neo-rib is radiolucent and easily identified on postoperative x-rays (Fig 4).

Comment

In this report, we have described our technique of chest wall reconstruction using Marlex mesh and a neo-rib constructed from a Steinmann pin and MMA. A similar technique has been described by Dahan et al., but differs in that the neo-rib is secured with sutures and silicone is used as a mold for MMA[4]. The use of titanium as a neo-rib has also been described [5].

An ideal prosthetic material fulfills the following criteria: (1) rigidity, to protect underlying organs and prevent paradoxical movement; (2) inertness, to allow in-growth of fibrous tissues and decrease infection; (3) malleability, to allow conformation to the desired shape; and (4) radiolucency, to allow reference during follow-up [6].

Our technique combines the positive characteristics of metal prosthesis, MMA, and mesh and offers several advantages over the sandwich technique as well as other techniques. First, the use of a Steinmann pin provides more malleability when forming the neo-rib to the desired shape, allowing for use in various locations of the chest wall. Second, the neo-rib provides necessary rigidity to ensure protection of underlying organs while minimizing the amount of MMA needed. More importantly, the neo-rib allows for more physiologic rib cage movement, compared with the larger reconstruction from the fixed sandwich technique. In addition, minimizing the amount of MMA used also potentially lessens the risk of infection secondary to seroma formation, compared with that from the sandwich technique. Third, the use of mesh prevents lung herniation and allows in-growth of fibrous tissues. In summary, our neo-rib technique provides more malleability when reconstructing various shapes and contours of the chest wall and fulfils the previously described criteria for use of prosthetic materials.

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Fig 1. (A) Computed tomography image of our patient, demonstrating a recurrent chondrosarcoma of the anterior right 6th rib (lesion denoted by the white arrow). (B) A large defect in the anterior chest wall is demonstrated after resection of the tumor, measuring approximately 11 × 9 cm (width × height).

Fig 2.

(A) The Steinmann pin is conformed to the desired shape. (B) The Penrose drain is cut to a length shorter than the Steinmann pin, and the pin is placed through the Penrose drain. (C) The Steinmann pin with Penrose drain is placed in the patient after holes are drilled on each side of the space it will bridge. (D) Methyl methacrylate is injected into the Penrose drain.

Fig 3.
(A) The Penrose drain is removed, and the construction of the neo-rib is complete. (B) Marlex mesh is secured to the superior native rib. The mesh is wrapped around the neo-rib and sutured to itself with Prolene stitches.

Fig 4.
The radiolucent neo-rib is seen in this postoperative x-ray (the neo-rib is denoted by the black arrow).