

Reconstruction of Complex Anterior Chest Wall Defects: The Lasagna Technique

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Background: Sternal tumors are rare, comprising only 0.94% of all bone tumors, with the majority being sarcomas. An extensive composite defect is often the result of surgical resection. Reconstruction of this anatomical area is a challenge for plastic surgeons. Reconstruction must fulfil two different tasks: restoration of soft tissues and stabilization of the chest wall. Both are well defined, and many techniques have been historically proposed.

Methods: We present the case of a 66-year-old man affected by sternal metastasis of lung non-small cell carcinoma with sarcomatoid features. After wide tumor resection, a large defect was created.

Results: The patient underwent a complex multilayer reconstruction that combined multiple techniques: Gore DualMesh to reconstruct the pericardial plane and protect the heart muscle, omental flap to facilitate integration of the mesh, titanium bars to recreate chest wall stability, and bilateral pectoralis muscle flaps to cover hardware. This multilayer reconstruction was named the “lasagna technique.”

Conclusions: Due to the rarity of primary malignancies of the sternum, it is difficult to standardize a therapeutic approach. For this reason, it is necessary to customize the surgical treatment by combining several techniques and materials. Our lasagna technique may be considered a valuable option in treating these complex reconstructive cases. (*Plast Reconstr Surg Glob Open* 2023; 11:e5384; doi: [10.1097/GOX.0000000000005384](https://doi.org/10.1097/GOX.0000000000005384); Published online 13 November 2023.)

INTRODUCTION

Sternal tumors are rare, comprising only 0.94% of all bone tumors, with the majority being sarcomas,¹ and sternal metastases represent an even rarer phenomenon.^{2,3} Patients present with variable symptoms, including chest pain, palpable mass, and signs of swelling.²

Although radiation therapy can be indicated based on the type of tumor, radiation-induced sarcomas and other forms of local recurrence should be carefully weighted.⁴ Today, the treatment of choice for sternal tumors is radical or extended resection, as it reduces local recurrences.⁵ Surgical resection of sternal tumors often determines extended and/or segmental bony defects requiring reconstruction.

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Technical reconstruction must fulfil two distinct functions: restoration of all soft-tissue layers and stabilization of the chest wall. Both are well defined and many techniques have been historically devised.⁶

Defects involving the bony structure of the chest wall can cause a floating chest; therefore, reconstruction must provide protection for vital organs within the chest, maintain chest wall stability, and prevent cardiopulmonary dysfunction. Ideal reconstructive materials allow for structural integrity, closely approximate normal anatomy, and sustain long-term retention in the body.⁷ To be ideal, these implants must also be easily cut, radiopaque, and sterilized. Commonly used approaches include bone allografts and autografts, muscle flaps, and omental flaps, often combined with various materials such as porous titanium mesh, steel wire, polyester fabric, silicone rubber sheets, and mesh.⁷ In this article, we present the case of a complex multilayer reconstruction combining multiple techniques: Gore DualMesh Biomaterial to reconstruct pericardial tissue and protect the heart muscle, omental flap to facilitate integration of the mesh, titanium bars to recreate chest wall stability, and double pectoralis flap to cover hardware. This new multilayer reconstruction was structurally similar to a typical dish of the Italian cuisine, and for this reason, we named it the “lasagna technique.”

Disclosure statements are at the end of this article, following the correspondence information.



Fig. 1. Preoperative view of the tumor involving the sternum and the anterior chest wall.

CASE REPORT

A 66-year-old man presented at our hospital with a sternal mass (Fig. 1). The patient was a former smoker, his medical history revealed benign prostatic hyperplasia and hypercholesterolemia, and his body mass index was 20.28. During preoperative work-out, a computed tomography (CT) scan of the chest was performed, and a tumor in the lower lobe of the right lung and an 8.5-cm diameter sternal neoplasm (attributable to lung cancer metastasis) were identified. CT scan also revealed a 10.5-cm diameter lesion with malignant aspects in the left adrenal gland associated with thrombosis of the left renal vein. After a multidisciplinary counseling involving thoracic surgeons, general surgeons, oncologists, anesthesiologists, and plastic surgeons, despite the high grade of malignancy infiltration, a salvage surgical procedure was proposed.

An anterior extended median thoracotomy skin incision was performed. Frozen sections were taken from the skin overlying the mass and were found free from disease. The manubrium and the adjoining part of the sternal body with their attached first costal cartilages were not involved by the cancer and were therefore preserved. The body of the sternum was removed by a submanubrium osteotomy and rib division at the costochondral junction. The xiphoid process and the subsequent bilateral costal cartilages from second to sixth were also resected en bloc with the mass to ensure local surgical radicality (Fig. 2).

A tumor fragment was sent for histology examination. The diagnosis was malignant non-small cell carcinoma with sarcomatoid features. A window on the anterior portion of pericardiac tissue was resected and 400 mL of serous fluid were also drained. Through the anterior chest wall defect, the pulmonary neoplasm was visualized, and an inferior right lobectomy was performed on the lung. Mediastinal lymphadenectomy was also performed.

This procedure was followed by the harvesting of both pectoralis-major muscle flaps for later approximation. The defect on the heart was covered with Gore

Takeaways

Question: How can we reconstruct large anterior chest wall defects?

Findings: A significant number of anterior chest wall reconstructive techniques have been devised. A multilayer reconstruction is mandatory.

Meaning: Our “lasagna technique” may be considered a valuable option in treating these complex reconstructive cases.



Fig. 2. Intraoperative view of the resected specimen involving sternum and second to sixth ribs.

DualMesh Biomaterial. The omental flap was harvested via a supraumbilical midline laparotomy, and this was transposed to cover and protect the mesh. Chest wall stability was obtained by using four transverse titanium bars (MedXpert Stratos). The bars were fixed on both corresponding rib stumps with clips and bridged the second, third, fourth, and sixth ribs. Finally, the pectoralis-major muscle flaps were approximated over the hardware and sutured together in the midline (Fig. 3).

A small portion of the lower bar was not covered by the pectoralis flaps, and a proximal part of the omental flap was doubled to provide coverage. Submuscular and pleural drains were applied, and finally, the wound was closed (Fig. 4). The patient was extubated in the operating room and followed up in an intensive care facility for the first 3 days. The total time of surgery was about 9 hours.

On the first postoperative day, the patient's vital parameters were stable (apyretic, blood pressure 134/76 mm Hg, heart rate 101 bpm, oxygen saturation 96% without support), and breathing difficulties have never been reported. The mild functionality reduction of the upper trunk was compatible with the type of surgery and the recovery time, and so remained during the hospital stay. Drains were removed on the seventh postoperative day. There was no evidence of respiratory limitation. On postoperative day 15, a hematoma in the right pectoral area was reported. On the same day, the patient was taken back to the operating room for surgical drainage and hemostasis control.

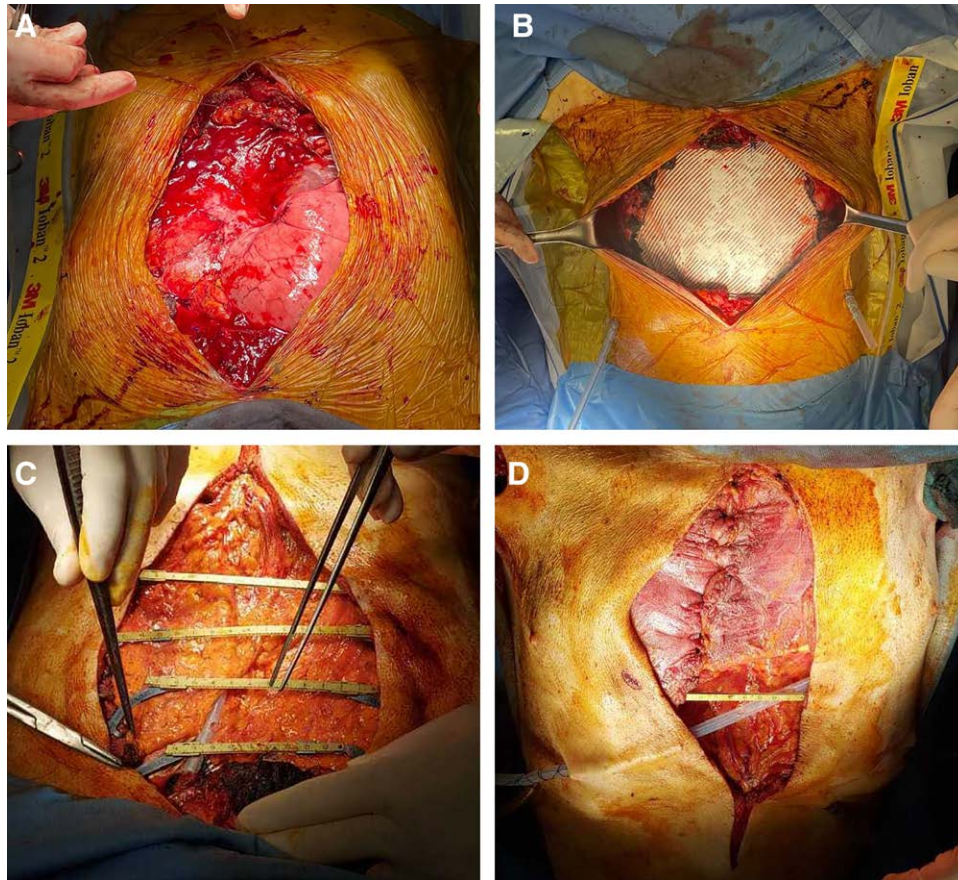


Fig. 3. Intraoperative view showing all reconstructive layers. A, Defect after surgical tumor resection. B, DualMesh covering the heart. C, Omental flap transposed to cover the DualMesh with four titanium bars recreating the chest wall stability. D, Bilateral pectoralis flaps transposed to protect hardware.

During this procedure, it was possible to assess the perfect integration of the mesh and the full vitality of the flaps (Fig. 5). Unfortunately, due to a vascular embolus originating in the renal artery, the patient died on postoperative day 27 after discharge.

DISCUSSION

Surgical resection is an essential treatment for managing malignant chest wall tumors. It is an interesting challenge for plastic surgeons to reconstruct both the skeletal and soft-tissue components in a single step. With the removal of the anterior thoracic wall, a harmful instability of the chest is induced, therefore reconstruction should restore the sternal function.⁸ A wide range of techniques using different materials has been suggested. The ideal reconstruction has to provide stability with no rigidity. Different approaches, including autologous tissue (such as bone, muscle, fascia lata, omentum, free flaps) and synthetic materials (plates, metal mesh, polypropylene mesh, polytetrafluoroethylene, polyethylene, polyglycolic acid mesh, terylene, and silicone rubber), were used alone or in combination according to the reconstructive needs.⁹ Traditionally, the use of methylmethacrylate mesh possibly associated with a single vascularized flap such as omentum

or pectoralis muscle represented a valid option^{8,9} for managing different types of partial sternal defects.

The authors propose a complex multilayer reconstruction combining four different tools, while aware that the lack of follow-up is a major limitation for their work. To recreate pericardial tissue, Gore DualMesh Biomaterial was used. This is an expanded polytetrafluoroethylene matrix and consists of two functionally distinct surfaces. The smoother surface is designed for minimal tissue attachment, whereas the patterned, indented surface is designed for active tissue attachment.¹⁰ It is simple to handle and to suture to the resected edges, it is well-assimilated, and it is resistant to infection.¹¹ All these features were considered optimal to prevent cardiac adhesions. Hamad et al¹² suggest the possibility of applying Gore DualMesh Biomaterial over titanium bars, but in their case, the pericardial layer was intact. A concerning issue of this approach may be the nonintegration of the mesh under the titanium bars. Gore DualMesh Biomaterial needs a well-vascularized tissue to be integrated.¹³ For this reason, the omental flap was used to support tissue integration of the mesh.

The omental flap was first described in 1998,¹⁴ and it is universally considered a safe technique. Kuonqui et al demonstrated that the pectoralis flap in combination with



Fig. 4. Intraoperative view showing the closed chest.



Fig. 5. Full vitality and perfect integration of all elements 15 days postoperatively.

the omental flap is an effective intervention in patients with sternal wounds.¹⁵ According to the literature, adequate skeletal stability without rigid reconstruction may be achieved if a significant part of the sternum is preserved.⁹

Expert consensus suggests that chest wall defects larger than 5cm should be reconstructed with rigid implants.¹⁶ In our case, the patient underwent an extended subtotal sternectomy, so a rigid prosthetic replacement was mandatory to avoid a flail chest and to minimize the risk of respiratory complications such as chest wall floating, paradoxical breathing, and/or respiratory failure. In general, autologous

bone-free flap is restricted by donor bone availability and surgical trauma.^{17,18} Autologous tissues, such as bone grafts, have been proposed for sternal reconstruction with a significant rate of success,^{19,20} but for smaller defects. For these reasons, we opted for titanium bars. The use of titanium, as reported by Ohno et al,²¹ does not preclude future CT or magnetic resonance imaging. Furthermore, titanium-based materials such as bars and plates have shown good long-term results when used to replace or stabilize ribs.²²

Chiappetta et al suggest creating a resistant but elastic system using two Gore-Tex assembled with a “sandwich technique,”²³ but results remain controversial in the literature. In a previous article, our group suggested the mobilization of the pectoralis muscles for hardware protection in the management of severe pectus excavatum.^{24–26} The pectoralis flap is a safe and reliable technique for hardware coverage. Fernandez-Palacios et al compared unilateral and bilateral pectoralis flaps and found that the unilateral technique was significantly associated with a shorter operating time, less need for blood transfusions postoperatively, and earlier extubation. Both methods had similar results regarding mortality, morbidity, and complications.²⁷

The authors are aware of the complexity of the procedure (which requires multiple surgical steps) and of a significant increase of costs related to the different surgical devices being used. Furthermore, the harvest of three different flaps determines a relevant increase in intraoperative time. The harvest of the bilateral pectoralis flap may cause some kind of morbidity, which is, however, usually well tolerated according both to the literature^{15,28} and to our previous published experience.^{24–26,29,30}

A limitation of this report is a short follow-up time, which did not allow us to analyze long-term results in terms of respiratory function. Still, the authors believe that a more anatomical multilayer reconstruction such as the one presented here is capable of improving the local vascularity necessary for Gore DualMesh Biomaterial integration and for promoting wound healing. Furthermore, this approach provides adequate skeletal stability and hardware protection.

CONCLUSIONS

Despite evidence in the literature of the single techniques being used to reconstruct chest wall defects, a multilayer combined approach such as our lasagna technique has not been reported before. The authors suggest this strategy as a promising tool for treating such extensive defects. Limitations for this report include a short follow-up period; perfect integration of the mesh and full vitality of all flaps are still being assessed. Additional studies are necessary to establish the validity of the technique with respect to long-term functional results.

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DISCLOSURE

All the authors have no financial interest to declare in relation to the content of this article.

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