Case report

Anterior chest wall reconstruction after voluminous tumor resection with 3D printed, anatomically designed, titanium alloy implant and TRAM flap: A case report

ABSTRACT

Surgical treatments of malignant chest wall tumors constitute a difficult challenge. In particular, locally advanced tumors that have already invaded important anatomical structures are associated with high surgical morbidity and can lead to full-thickness chest wall defects. Plastic surgery can reduce the post-resective morbidity and reconstruct the chest wall using a variety of tissue transfer techniques. Proper reconstruction of the soft tissue of the chest wall improves quality of life and reduces functional deterioration after extensive resection. The aim of this article is to demonstrate a combined thoracic and plastic surgery approach for the treatment of a patient with a voluminous chest wall neoplasm.

Key words: TRAM flap, chest tumor, case report, plastic surgery

Introduction

Primary thoracic tumors are rare, and account for 5% of all thoracic neoplasms and 1–2% of all primary tumors. The chest wall is the location for 6–7% of all sarcomas. About 45% of the primary malignant tumors arise from soft tissues and 55% appear in cartilaginous or bony structures. Chondrosarcoma is the most common primary chest wall malignancy. Chest wall is also a well-known site of radiation-induced sarcomas.

Both for soft tissue and bone sarcomas a wide local resection is the best treatment if the tumor is resectable. If the skin and subcutaneous tissues are adherent or infiltrated, a full-thickness chest wall resection is often indicated. Also the previous biopsy needle tracts and scars should be excised. It is essential to include wide radical lateral margins as well as a clear deep margin. This often necessitates a full thickness skeletal resection including the parietal pleura which itself provides a good oncological barrier.

Surgical treatments of malignant chest wall tumors constitute a difficult challenge. In particular, locally advanced tumors that have already invaded important anatomical structures are associated with high surgical morbidity and can lead to full-thickness chest wall defects. Plastic surgery can reduce the post-resective morbidity and reconstruct the chest wall using a variety of tissue transfer techniques. Proper reconstruction of the soft tissue of the chest wall improves quality of life and reduces functional deterioration after extensive resection. The aim of this article is to demonstrate the combined thoracic and plastic surgery approach for the treatment of a patient with a voluminous chest wall neoplasm.

The goals of chest wall reconstruction are generally well defined. Reconstruction should avoid lung herniation, achieve adequate stability to allow physiological movements, create a stable platform to support the shoulders and upper extremities, and achieve an airtight closure. Reconstruction should also maintain adequate respiratory function, obliterate dead space in the chest wall cavity, and protect the vital intrathoracic organs. Coverage with well-vascularized soft tissue is essential not only for achieving the goals of reconstruction, but also for providing an acceptable cosmetic result.

Case presentation

A 64-years-old man was referred to our Hospital due to a large anterior chest wall tumor. He manifests that 8 years ago he had a sebaceous cyst-type lesion in the sternal region, which was resected but the detailed information was not available at presentation in our institution. Subsequently developed a keloid scar wich underwent surgical resection as well. The lesion reappeared and continued to increase in size, with chronic pain, which led him to consult with several specialists and underwent multiple treatments of resection, cryosurgery, and infiltration with corticosteroids, which did not harvest favorable results. On physical examination, the patient presented with a painful large hard stone central mass in the sternal region firmly attached to the sternum and 3rd and 4th costal cartilages that accounted 50% of the anterior chest width (figure 1). In May of 2020 a biopsy was perfomed yielding a differential diagnosis between undifferentiated polymorphic sarcoma and anaplastic carcinoma. Chest X-ray and computed tomography (CT) scan showed no sign of distant metastatic disease.

Fig 1. Large tumor of the chest wall that invades the sternum with inflammatory changes of the surrounding skin.

A combined approach was planned between thoracic and plastic surgery. A wide resection with oncological margins of the tumor, the sternum and costal cartilages of the 3rd and 4th ribs was performed by the thoracic surgeon with special focus on preserving the Internal Mamary Arteries (figure 2A, 2B, 2C). After pathological confirmation of microscopically clear margins by frozen section histological examination, the thoracic surgeon proceeded the reconstruction of the large skeletal defect with a three-dimensional (3D) printed custom-made, anatomically designed, titanium alloy ribs and sternum implant that were fixed with screws to the bony ribs and a polypropylene mesh (figures 3-4). The pectoralis major and pectoralis minor muscles were repositioned with absorbable stitches. A vast soft tissue defect was left as a result of resection, extended between the nipples in width and the sternum in height.

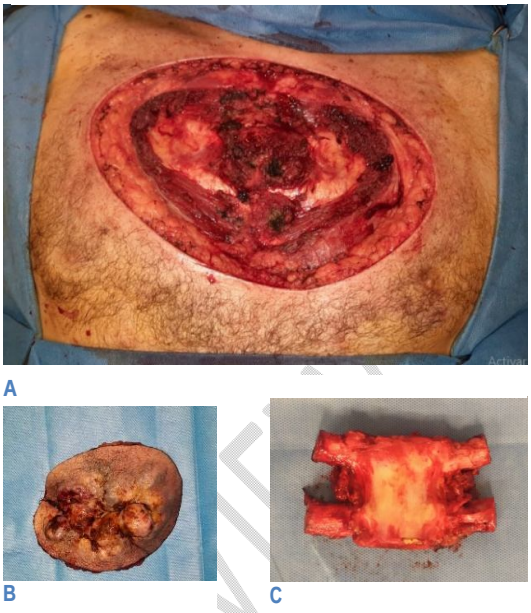

Fig 2. **A**. Post en-bloc resection, full thickness chest wall defect, displaying bilateral pleura. **B, C.** surgical specimen

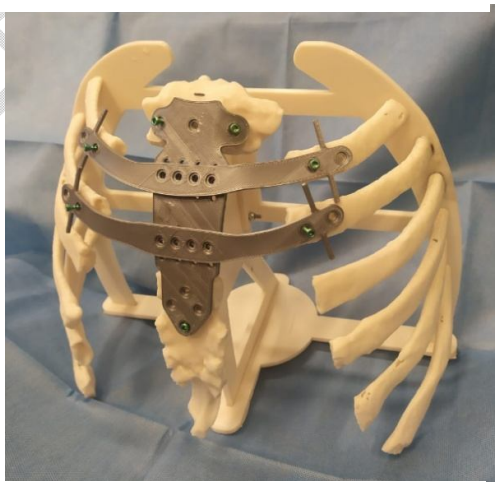

Fig 3. 3-D printed patient-specific model for chest wall reconstruction

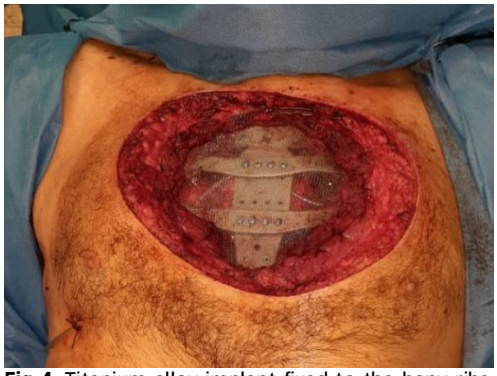

Fig 4. Titanium alloy implant fixed to the bony ribs and a polypropylene mesh

A Transverse Rectus Abdominus Myocutaneous (TRAM) flap was designed to cover the polypropylene mesh with muscle, subcutaneous tissue and overlying skin. The pedicled flap based on the Right Superior Epigastric Artery was tunelized through the subcutaneous tissue to reach the defect loosely (Figure 5). A polypropylene mesh was placed upon the posterior rectus muscle sheath and sutured with non-absorbable materials (Figure 6).

Fig 5. TRAM flap based on the Right Superior Epigastric Artery.

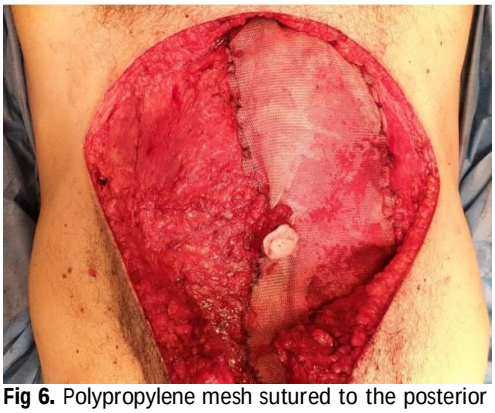

Fig 6. Polypropylene mesh sutured to the posterior rectus abdominis sheath.

Once the abdominal fascia had been securely closed, the upper abdominal skin flap was redraped over suction drains and closed. Subsequently, an umbilicoplasty was performed. As result, an aesthetically acceptable closure of the donor area was achieved, obtaining a hermetic closure of the thoracic defect and the preservation of the patient's respiratory mechanical function (figure 7). The patient was extubated right after the surgery and spent three days hospitalized before discharge.

Fig 7. Immediate postoperative outcomes.

Outcomes

Unfortunately, two weeks posterior to discharge, the patient developed a nosocomial infection that caused a partial dehiscence of the upper edge of the TRAM flap, requiring surgical debridement, placement of a suction drain and broad-spectrum antibiotic therapy (Fig 8). The surgical gap was covered with a

Fig. 8 Partial dehiscence of the upper edge of the TRAM flap

supraclavicular artery island flap (fig. 9 and 10), and the prosthetic material was succesfully shielded without the need for more complex surgical procedures. One year after surgery, the patient referred overall satisfaction with the procedure, good postoperative outcomes and a good quality of life (Figs 11 and 12). This case was recently operated on, hence, there is still need for time to follow-up and document this patient evolution over time.

Fig. 9 Preoperative marking of the supraclavicular artery island flap

Fig. 10 Immediate postoperative

Fig. 11,12: One year follow-up.

Discussion

A complete resection of the tumoral mass with negative surgical margins is essential for long-term disease free and overall survival. Specifically in sarcomas, surgical treatment consisting of a wide-margin-resection is the main factor associated with a good prognosis. The reconstruction of the chest wall with its rigid yet dynamic structure and soft tissue components is a factor of substantial importance for the overall success of the treatment [1]. The planification of cancer treatment and repair of the thoracic wall should involve a careful analysis of the quantity of resected soft tissue, bone, and cartilaginous elements, type of tumor, autologous and synthetic materials available, neighborhood or microvascular flaps, maintenance of functional aspects (such as the pulmonary expansion) and aesthetics, when possible [2]. The plastic surgeon must be a qualified professional to perform multiple complex repairs and must be capable to tailor therapeutic proposals to intraoperative changing conditions, which often enforce the need for adaptation or change of plans (Figs. 13,14).

The importance of preoperative multidisciplinary assessment, including the plastic surgeon is highlighted by several authors as essential to the success of complex treatments involving large resections and reconstructions [3, 4] The perioperative mortality rate after chest wall resection is between 3.5 and 4.5% in the literature [5,6]

CONCLUSION

In the selected group of patients with extensive full-thickness resections of the chest wall for tumor, the use of the superiorly based pedicled TRAM flap proved to be a safe and effective way of transferring tissue with a good blood supply. Such coverage can be safely and successfully accomplished in a single stage with relatively low morbidity. The combined effort of the reconstructive plastic surgeon and thoracic surgeon is mandatory to achieve control of the underlying disease and to reconstruct a mechanically stable tissue cover and a pain-free unrestricted breathing function. [7] The distinct preoperative analysis of the disease and the extent of the expected defect are essential. A stabilization of the chest wall using an alloplastic mesh should be done if paradox breathing is to be expected due to the size of the defect. This multimodal therapy of an extensive chest wall tumor in our Hospital has proved to improve local disease control and minimal morbidity, which contributes to full recovery after oncologic surgery.

References

1. Foroulis CN, Kleontas AD, Tagarakis G, Nana C, Alexiou I, Grosomanidis V, et al. Massive chest wall resection and reconstruction for malignant disease. Onco Targets Ther. 2016;9:2349-58.
2. Franco D, Tavares Filho JM, Cardoso P, Moreto Filho L, Reis MC, Boasquevisque CH, et al. Plastic surgery in chest wall reconstruction: relevant aspects - case series. Rev Col Bras Cir. 2015;42(6):366-70.

DOI: http://dx.doi.org/10.1590/0100-69912015006003
3. Chen JT, Bonneau LA, Weigel TL, Maloney JD, Castro F, Shulzhenko N, et al. A Twelve-Year Consecutive Case Experience in Thoracic Reconstruction. Plast Reconstr Surg Glob Open. 2016;4(3):e638. DOI: http://dx.doi.org/10.1097/GOX.0000000000000603
4. Skoracki RJ, Chang DW. Reconstruction of the chestwall and thorax. J Surg Oncol. 2006;94(6):455-65. PMID: 17061266 DOI: http://dx.doi.org/10.1002/jso.20482
5. Warzelhan J, Stoelben E, Imdahl A, Hasse J. Results in surgery for primary and metastatic chest wall tumors. Eur J Cardiothorac Surg. 2001;19:584–588.
6. Anderson B O, Burt M E. Chest wall neoplasms and their management. Ann Thorac Surg. 1994;58:1774–1781.
7. Riedel K, Kremer T, Hoffmann H, et al. Plastic surgical reconstruction of extensive thoracic wall defects after oncologic resection. Chirurg. 2008;79:164–174.

Fig.13. Evolution of the tumor mass from June 2019 to August 2020, showing its rapid growth and aggressive histology.

Fig.14. Preoperative markings