Original Article

A New Chest Wall Reconstruction: A Three-layer Technique

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Abstract

Soft tissue sarcomas are rare tumors that represents less than 1% of all neoplasms and only 5.3% of these tumors arises in the chest wall. After resection of these tumors, the defects generated by radical surgery especially when sternum or three or more ribs are resected represent a challenge to the surgeons because of the defect itself and pulmonary physiology alterations. The authors describe a new three-layer technique for chest wall reconstruction, based upon steel stitches, polypropylene mesh and myocutaneous flaps performed in six consecutive patients.

Keywords: Chest wall; Reconstructive surgical procedures; Sarcoma.

Introduction

Primary chest wall tumors are rare entities. The soft-tissue sarcomas represent less than 1% of malignant neoplasms and only 5.3% of those arise from chest wall.[1] The same occurs with osseous and cartilaginous tumors of the chest wall, usually osteo or chondrosarcomas that may reach 8% of them.[2,3]

Other non-primary malignant conditions of the chest wall may require wide excision like metastatic cancers, lung and skin tumors or benign conditions as fibromatosis, osteonecrosis or severe infection.[3,4]

Despite of the advances in chest wall reconstruction (CWR) techniques, the huge thoracic defects generated by radical excisions still represent a challenge to the surgeon.[5] When the procedure requires sternum or more than three ribs resection, the thoracic instability resulting in alteration of pulmonary physiology remains the greatest concern. Minor complications like wound infection, graft necrosis and seroma may lead to poor cosmetic result. Several techniques of CWR and maintenance of thoracic stability had been described: methyl methacrylate "sandwich",[6] myocutaneous,[7,8] fasciocutaneous and osteocutaneous flaps, Lyodura® (dura-mater),[9] bone grafts,[10] metallic plates[11] and steel stitches.[12]

The rationale for this technique was the application of simple technique for bone stabilization and a rigid protection for the chest. The present article describes a new three-layer technique for CWR and the results of its use in six consecutive patients.

Material and Methods

From December of 2004 to July of 2005, six patients with chest wall tumors were treated by the following technique of reconstruction after wide negative margin excision specimens.

Among the six cases three were chondrossarcomas,

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one myofibroblastic tumor, one extra-osseos Ewing sarcoma and one epitelioid sarcoma metastasis. The age range from 22 to 63 years. Three patients were male and three were female. Tumor size specimen varied from 9x6x6 to 16x8x6 cm. and the extent of bone resected were one patient with a sternum resection, two with three ribs resections, one with three ribs and pulmonary segmentectomy and half sternum resection, one with four ribs and pulmonary segmentectomy resection and one with three ribs and half sternum resection. The muscular graft applied in the reconstruction were three with Pectoralis major, two with Latissimus dorsi and one with Serratus anterior. These data are summarized in Table 1. The first step of the reconstruction is the knitting of the steel net. This requires the identification and exposition of the most stable (or resistant) points of the chest defect, usually the extremities of the resected ribs or osseous structures. The perforation of the ribs or sternum is performed and a 1.0 stainless steel stitch is used to knit a square configured net that is crossed transversally and horizontally by the 1.0 stainless steel stitch. The ribs or osseous structures must be slightly tractioned to avoid skeletal fracture or aponeurosis or sustaining structures laceration. Eventually the rectus abdominis muscle's aponeurosis may be used for fixation when total or distal resection of sternum is required.

The second step is the setting up of a polypropylene mesh over the knitted stainless steel net. It is necessary to perform the fixation of the external limits of the mesh at the surrounding tissues as well its fixation at the net.

The last step comprehends the overlaying of a muscular graft, usually the pectoralis major and the latissimus dorsi or rectus abdominis muscle. The drainage of the mediastinum, pleural cavity and subcutaneous is then performed.

Case 1 exemplifies the whole step-by-step technique (Figures 1 to 9).

Results

Among the six patients with chest wall tumors treated with the proposed technique the postoperative mortality was zero. All of them supported early extubation in surgery room. All patients stayed in Intensive Care Unit for 24 hours. Discharge occurred between 2 and 7 days. In the first 30 days, patient 1 presented seroma and he was treated by multiple aspirative punctions. Another patient (case 2) presented graft necrosis and underwent debridement.

One patient (case 4) developed disseminated metastasis and died one year and six months after diagnosis and surgical treatment. During this period she underwent to three different types of chemotherapy. Another patient (case 5) died of disseminated disease four months after surgery, while she was submitted to intensive chemotherapy. The remaining four patients are

Table 1 - Profile of six consecutive patients who underwet ressection of tumor and reconstruction of chest wll using the three-layer technique

Case	Age	Gender	Site	Specimen Size (cm)	Extent of bone resected	Histology	Muscular
1	52	Male	Sternum	16x8x6	Sternum	Chondrosarcoma	*Pectoralis major*
2	63	Female	Left chest wall	9x7x6	3 ribs	Chondrosarcoma	*Serratus anterior*
3	27	Male	Sternum	9x7.5x5.5	3 ribs wtih pulmonary segmentectomy and half of sternum	Myofibroblastic tumor	*Pectoralis major*
4	22	Female	Right chest wall	10x7x7	4 ribs with pulmonary segmentectomy	Extra-osseous Ewing Sarcoma	*Latissimus dorsi*
5	27	Female	Right chest wall	10x5.5x4	3 ribs	Epitelioid sarcoma metastasis	*Latissimus dorse*
6	57	Male	Parasternal	11x7x6.5	3 ribs with half of sternum	Chondrosarcoma	*Pectoralis major*

Figure 1 - Incision of skin with surgical margins of a previous biopsy

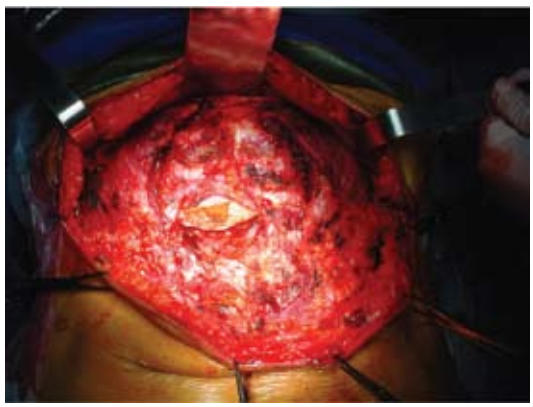

Figure 2 - Raising of the flaps and section of the ribs and sternum

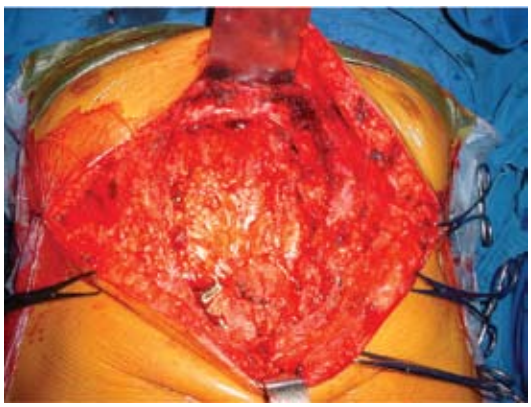

Figure 3 - Thoracic defect left by resection of the ribs and sternum

alive without evidence of disease. None of them were submitted to chemotherapy or radiotherapy.

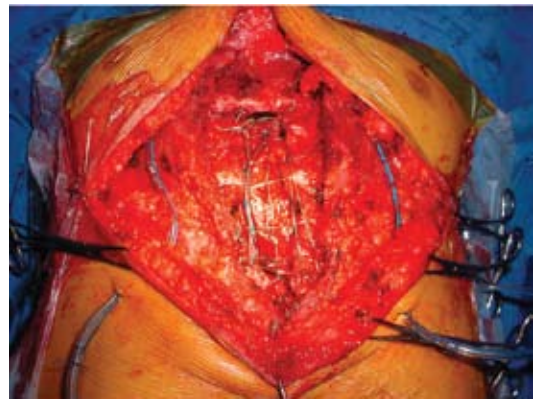

Figure 4 - A square configured net that is crossed transversally and horizontally by the 1.0 stainless steel stitches

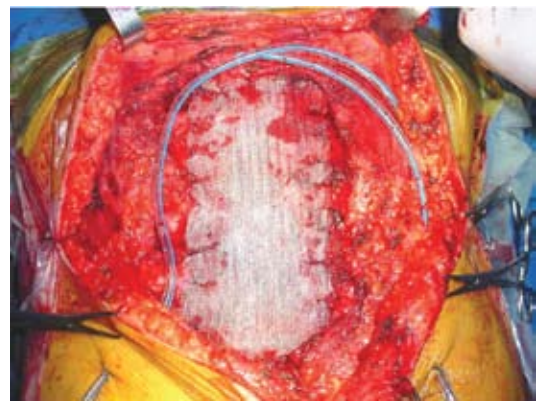

Figure 5 - A polypropylene mesh is attached upon the thoracic defect and the steel net

Discussion

The major principle of sarcoma's treatment is negative margin wide excision increasing overall survival and quality of life. Despite the advances in multi-modal approach of sarcomas, dealing with chest wall tumors that involve mediastinum, ribs, sternum and lungs may require complex excisions to achieve acceptable negative surgical margins.[13]

Planning chest wall reconstruction must consider three points: (1) Need of full-filling the pleural cavity, (2) Chest stability to avoid pulmonary physiology dysfunction, (3) soft tissue reconstruction.The indication of full-filling pleural cavity using muscular grafts or omentum is seldom required in oncological surgery, although necessary in cases like post pneumectomy empyema, broncho-pleural and tracheo-oesophageal

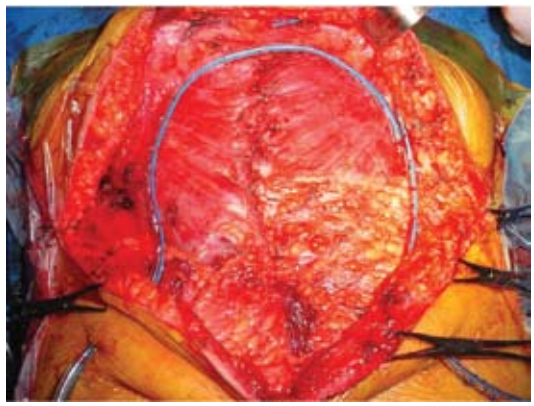

Figure 6 - Muscular graft rotated inward with drains placed

Figure 7 - Final aspect

fistulas.[14]

The main risk factors for thoracic instability are: (1) Resection of three ribs or more, (2) Total or partial resection of sternum, (3) Five centimeters diameter or greater longitudinal defect distant of the scapula, (4) Ten centimeters or greater extension chest wall defect under the scapula, (5) Resection area over 300 cm2. The above mentioned criteria are resected extension related, although less objective factors must also be considered to indicate the need or type of reconstruction. Patients who undergo posterior base thoracic resection are less likely to develop thoracic instability then those with lateral or anterior chest wall resection. Irradiated regions often develop intense fibrosis and support wide resections.

The options of materials available are of huge importance when planning the reconstruction. Consideration of which material to use involves availability of the prosthesis, ease of use, durability, adaptability, non-reactivity and resistance to infection. The list of prosthetic material includes alloplastic such as stainless steel, titanium, Lucite, and fiberglass; synthetic materials include Prolene® mesh, Vicryl® mesh, Gore-Tex®, polypropylene, nylon, silicone, Teflon®, acrylic, and Silastic®.[10] Composite synthetic materials comprise polypropylene mesh and methyl methacrylate. Ulsher was the first to describe the use of polypropylene mesh in 1958. The great disadvantage of this material is the lack of immediate osseous stability requiring its association to methyl methacrylate or alloplastic material.[6,11] The soft tissue reconstruction is often required when dealing with wall chest rebuilding. Chang published a ten-year experience of Memorial Sloan Kettering Cancer Center (MSKCC). This author evaluated 113 patients who underwent 157 CWR, 62 using a polypropylene mesh associated with methyl methacrylate when the defect was greater than 5cm or 300cm². Seven patients

Figure 8 - Specimen of the ressected sternum

Figure 9 - Patient three years and eight months after surgery

(4%) had partial flap loss. The most common remaining postoperative complications were delayed wound healing (3% of patients), infection (2.5%), and hematoma (2.5%).[4] Losken,[14] describing the Emory University of Atlanta experience, analyzed 200 patients treated with thoracectomy in 15 consecutive years, 158 of who were employed prosthetic material and/or pedicled or mixed flaps. Inpatient complication rate was 27% following reconstruction, with a mortality of 6%. Conclude that a better understanding of the respiratory mechanics and local thoracoabdominal anatomy is crucial for managing these complex defects.[14] There are no prospective comparative trials concerning the WCR techniques, maybe due to the great variety of reconstruction techniques or different chest wall resections and the low surgical volume in specialized health centers. Weyant analyzed the rigid reconstruction (polypropylene mesh/ methylmethacrylate composite) in 112 (42.7%), nonrigid (polytetrafluoroethylene or polypropylene mesh) in 97 (37%), and none in 53 patients. In multivariate analysis, the extension of resection and pneumectomy were the most important factors for mortality, and not the type of reconstruction.[15] Some surgical principals must be remembered to achieve better results when planning the flap: (1) The best choice considering regional anatomy, (2) Minimum surrounding tissue dissection and (3) Avoid irradiated regions. Complications related to the flap occur in up to 7% of the cases.[4,9] Covering the prosthetic material with myocutaneous or single muscular flap must be performed to avoid its exposition when skin necrosis or infection occur and to provide better aesthetic result and maintenance of chest stabilization.

Our novel combined technique of CWR is presented to be used after wide chest wall resection. The hand knitted stainless steel net is inert, cheap, resistant and suitable to some extension thoracic defects. With aim to increase intra-thoracic organs protection and respiratory stability, we employed a polypropylene mesh that gains progressive rigidity with time.

The cost based in prices for Public Health Service including only the prosthetic materials, was about US$ 110.30. The cost for the technique with polypropylene mesh associated with methyl methacrylate is about US$ 329.69.

Although a longer follow up is required, the good early aesthetic and respiratory physiological results showed by our six consecutive cases suggests that this might be an attractive chest wall reconstruction technique.

Conclusions

The challenge of wide chest resection and reconstruction requires the surgical team to plan and execute the chosen technique based on the available anatomy options (for pedicled flaps), respiratory stability, cost and feasibility of prosthetic material and safety of the procedure. Despite the short number of patients and the lack of long follow up, the presented three-layer chest wall reconstruction technique (knitted stainless steel net, polypropylene mesh and muscular graft) is a novel, feasible, reproducible and low cost option for wide resection thoracic tumors.

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