Surgical Treatment of Primary Bone Chest Wall Tumors

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INTRODUCTION

Primary bone and soft tissue chest wall tumors comprise a rare, heterogeneous group with a range of severity from benign to highly aggressive. Surgical treatment of these tumors therefore varies substantially, from a simple marginal resection to cases that need a multimodality approach such as reconstruction surgery, systemic chemotherapy and radiotherapy. Approximately 50% to 80% of chest wall tumors are malignant, and of those, approximately 55% arise from bone or cartilage [1,2] (Table 1).

For a low-grade malignant bone tumor such as chondrosarcoma, complete removal is the treatment of choice as there is no effective chemotherapy or radiotherapy. Osteosarcoma, Ewing sarcoma and other small cell tumors are more responsive and can be treated with surgery, generally combined with perioperative chemotherapy and/or radiotherapy to achieve improved local control, fewer metastases and better survival.

Surgical treatment of a chest wall tumor often poses a challenge due to the thoracic cage and adjacent neurovascular structures that make resection with tumor-free margins difficult. Moreover, reconstruction after tumor resection can be complex and may require specific techniques and strategies. In this short review, we emphasize surgical treatment of bone tumors found in this region.

SURGICAL TREATMENT OF TUMORS OF THE RIB

Tumors of the ribs are rare, comprising less than 10% of all bone tumors [3-9]. Complete en bloc resection is generally advocated for all primary rib tumors, as this procedure is well tolerated and usually results in little functional impairment even if large segments of the chest wall are resected [10]. Prior to operation, careful clinical and radiological analysis of the tumor is important to determine whether it is benign or malignant. Most tumors can be differentiated by radiologic findings [11,12]. Radical wide resection should be performed without hesitation if there is any likelihood of malignancy to avoid local recurrence or dissemination of tumor cells to the thoracic cavity. The resection must include the involved rib with a wide surgical margin, the corresponding costochondral arches and several partial ribs above and below the tumor [3-5]. In cases where there is infiltration of soft tissue, pleura, lung parenchyma or the diaphragm, the affected portions should also be resected. If the tumor is near the sternum, combined sternal resection should be performed. If adjacent vertebral bodies are invaded, thoracic en bloc vertebral resection should be considered [13].

In cases of a large chest wall defect, reconstruction of the bony thorax is needed to maintain sufficient chest wall fixation and adequate respiratory function. If the defect is located near the tip of the scapula, however, it should be closed to avoid impingement of the scapula tip into the chest during arm movement. The lower half of the scapula should also be resected for the same reason. Materials used to repair bony defects include autogenous tissue such as the periosteum or ribs, or prosthetic materials such as meshes, methyl methacrylate, fiberglass or metals (Table 2).

Marlex mesh was first used to repair a bony defect by placing...
it under tension when sewn into place to the ribs of the chest wall defect [14]. However, this material has limited use because it is rigid in only one direction when placed under tension. Prolene, a double-stitch knit polypropylene mesh, is rigid in all directions and is thus used more widely for reconstruction of the chest [15]. The Gore-Tex soft tissue patch has been recently advocated due to the added advantage of reducing permeable fluid and air across the reconstructed chest wall [16]. To improve rigidity, methyl methacrylate-impregnated meshes are available [17], although used less frequently.

Various myocutaneous flaps have been used in repair, where coverage of soft tissue defects is required (Table 2). Flaps can be mobilized on a single axis of rotation using all of the major chest wall muscles, or transposed to another site on the chest wall. These muscles include latissimus dorsi [18], pectoralis major [19], serratus anterior [20], external oblique [21], rectus abdominis and trapezius. In addition to these flaps, large chest wall defects can be repaired by using the omentum and skin grafts [22], and also by using microvascular free flaps when no local flaps are available, such as the tensor fascia lata musculocutaneous flap [23].

**SURGICAL TREATMENT OF TUMORS OF THE STERNUM**

Primary tumors of the sternum are uncommon, and previous reports have stressed that most are sarcomas such as chondrosarcoma, osteosarcoma and Ewing sarcoma [24-27]. Surgical management of these tumors has long been considered a challenge given the local aggressiveness of the tumors and the anatomical difficulty in making full-thickness resections without compromising the stability and reconstruction of the thoracic wall. For these reasons, tumor size and location determine the extent of resection. Preoperative imaging can evaluate not only the precise location of the tumor but also possible invasion of the lungs, pericardium, brachiocephalic vein and superior vena cava. The use of musculocutaneous flaps and prosthetic materials in simultaneous reconstruction of chest wall defects allows for wide full-thickness resection of the sternum [16,17, 28]. To ensure a tumor-free margin, the extent of resection can vary; tumors at the upper third of the sternum need resection of the manubrium and most of the sternal body, as well as the medial ends of the clavicles and adjacent sternocostal cartilages, whereas tumors at the middle third of the sternum need resection of the sternal body while preserving the manubrium and xiphoid process. For a deep tumor, adherent pleura or pericardium should also be resected.

To restore ventilatory mechanics and protect intrathoracic organs, many prosthetic materials with different flexibilities are available for reconstruction of defects after removal of the sternum (Table 2). Polypropylene mesh is often used to repair defects after a partial resection of the sternum. For total resection of the sternum, a methyl methacrylate-impregnated mesh, autogenous bone tissue or metal is needed to give secure fixation rigidity to the anterior chest wall. If primary skin closure cannot be accomplished, musculocutaneous flaps are used to repair the soft tissue layer.

**SURGICAL TREATMENT OF TUMORS OF THE CLAVICLE**

The clavicle has the following functions: (1) propping up and positioning the scapula away from the body; (2) forming a bony framework for muscle origins and insertions; (3) providing bony protection for subclavian and axillary vessels, as well as the brachial plexus; and (4) transmitting the supporting force of the trapezius muscle to the scapula through the coracoclavicular ligament [29].

Although primary bone tumors involving the clavicle are uncommon, almost every type of bone tumor has been found for it [30-34]. Many reports contain multiple descriptions of partial and complete conservative resections for treating the tumor, infection and trauma and for facilitation of surgical exposures, suggesting that results are good to excellent in terms of shoulder function and cosmesis [29,32,35-41]. For tumors in which total resection was indicated, the incision made on the anterior side of the clavicle extended from the acromion to the sternoclavicular joint. Excluding any involved skin would leave the previous biopsy site, subcutaneous tissue, muscle or other soft tissues adherent to the tumor wall.

Although total resection of the clavicle is a rare surgical procedure, it has been previously performed [37] and well-described [35-41]. For partial resection, surgical technique varies based on which side of the bone should be removed. When resecting the outer side of the clavicle, preservation of the coracoclavicular ligament is important; the lateral end of the remaining clavicle would lose its stability without this ligament and press up against soft tissues in the supraclavicular region, resulting in pain and disability. If the coracoclavicular ligament cannot be preserved or repaired, resecting the outer two-thirds of the clavicle is necessary [29], although resecting the middle third is more acceptable as it does not cause functional disability [29,41]. When resecting the inner side of the clavicle, the costoclavicular ligament should be preserved or the inner third of the clavicle should be resected for the reasons previously mentioned for the outer side of the clavicle [29]. If the tumor is at or near the acromioclavicular joint or sternoclavicular joint,
however, an en bloc resection of the entire joint and a portion of the sternum may be required.

Anatomy deep to the clavicle can make a tumor-free margin difficult when the tumor has a soft tissue component. Subclavian vessels and the brachial plexus run below the clavicle as they pass from the base of the neck to the axilla. Behind the middle and inner thirds of the clavicle, the subclavian vessels in particular are located very close to the bone. Behind the medial end of the clavicle and sternoclavicular joint, internal jugular and subclavian veins join to form the innominate vein. These vital vessels are covered by a continuous myofascial layer such as omohyoid and clavipectoral fascia. If the tumor is very close to vital vessels, removal of this layer with the tumor is important when en bloc resection is performed. When there is the possibility of positive surgical margins, postoperative radiotherapy should be included.

CONCLUSION

Primary bone tumors of the chest wall pose a therapeutic challenge. Careful evaluation of radiographic and histopathologic findings is critical before treatment. Malignant chest wall tumors should be resected with wide margins, and chemotherapy and/or radiotherapy should be combined to facilitate negative margins in appropriate cases. The most satisfactory long-term survival and function will best occur in patients with complete surgical resection and appropriate reconstruction.

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REFERENCES


