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Diagnosis and Surgical Treatment of 105 Cases with a Tumor of the Chest Wall

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OBJECTIVE To summarize the experience in diagnosis and surgical treatment of 105 cases with a tumor of the chest wall, and to investigate reconstruction of a large chest-wall defect after resection of a chest wall tumor.
METHODS Clinical data from 105 patients with a tumor of the chest wall were retrospectively analyzed. There were 78 males and 27 females with ages ranging from 6 to 70 years. Of the 105 cases, 94 had a primary tumor, among which 75 were benign, 19 malignant and the other 11 metastatic. After a resection of a chest-wall tumor in 19 patients, reconstruction of the large chest-wall defect was conducted.
RESULTS All surgical operations were smoothly performed, without an intraoperative death. The results of postoperative follow-up were as follows: 48 patients with a benign tumor were still living and well, 16 patients with a benign tumor died of other diseases, 13 with a malignant tumor survived for a period from 21 months to 8 years, and the others with a malignancy died of local recurrence or distant metastasis. All of the 11 patients with a metastatic tumor died of carcinomatous deseases during a period from 10 to 76 months.
CONCLUSION With regard to a primary costal tumor without a pathological diagnosis, a restricted radical excision should be conducted first. Use of suitable repairing materials is very important for reconstruction of a massive chest-wall defect.

KEYWORDS: tumor of chest wall, massive chest-wall defect, prosthesis.

Tumors of the chest wall are usually localized tumors, but include tumors of various parts of the skeleton and soft connective tissues. These tumors present a definite difficulty in diagnosis and treatment, because of their complicated tissue sources and varied pathologic types. During the period from 1962 to 2005, 105 cases with a tumor of the chest wall were treated in our hospital[1]. In our study, diagnosis and surgical treatment of a chest-wall tumor, as well as a reconstruction of large chest-wall defect, were analyzed and investigated.

MATERIALS AND METHODS

Sex and age

In this study, there were 78 male and 27 female patients, with a sex ratio of 2.9:1. Their ages ranged from 6 to 70 years. The mean age was 36.8 years for benign tumor patients, 48.3 for patients with a malignant tumor, and 59.6 for those with a metastatic carcinoma. There was a characteristic age distribution of the patients with different types of tumors.

Clinical situation

Symptoms resulting from a chest-wall tumor depend on the site, size, nature and velocity of tumor growth, as well as its relationship with peripheral tissues and other organs. However, the most common symptom is regional pain. The site of pain is usually concordant with the tumor site, but in a few patients the pain may spread to other sites. There were 92 patients with a chest pain in this study (87.6%), among which 51 had only a slight pain. Of these 51 cases, 46 (90.2%) had a benign tumor and 5 (9.8%) were malignant cases. Of the 24 cases with a moderate pain, there were 16 (66.7%) benign, and 8 (33.3%) malignant cases. In the 17 severe-pain cases, all had a malignant tumor. It can be seen that the most severe sustained regional pains were brought about by a malignant tumor. Owing to rapid growth of malignant chest-wall tumors, they can expand peripherally, and thus impress and encroach upon intracostal nerves and part of the pleura, causing more significant painful symptoms compared to benign tumors. Few patients had symptoms such as cough and fever, etc.

Course of the disease and signs

The course of the benign tumor cases in our study ranged from 6 months to 13 years, averaging 4.5 years. Malignant tumor courses were within a period from 2 to 25 months, with a mean of 7.5 months, whereas for metastatic tumors the course ranged from 3 to 18 months, with an average of 6 months. The major sign of the disease was a thoracic lump, with palpable lumps detected in 84 cases (80%). In 36 cases (42.9%), the diameter of the lump was larger than 5 cm, with benign lumps in 14 cases (38.9%) and 22 (61.1%) in malignant and metastatic cases.

Quality and classification of tumors

In our study, 75 cases were benign tumors (71.4%), 19 were malignant tumors (18.1%) and 11 metastatic carcinomas (10.5%). Among the primary benign tumors of the chest wall, skeletal tumors accounted for 64.0%, while in the primary malignant chest-wall tumors, soft connective tissue tumors comprised 68.4%, much higher than in bone tumors. Based on the pathologic type of tumor, fibroma, angioma and lipoma were more frequently seen in the benign soft tissue tumor types, while among malignant tumors, fibrosarcoma and rhabdomyosarcoma, as well as primitive neuroectodermal tumors ranked first. Concerning benign osseous tumors, fibrous dysplasia was the most commonly seen, and secondly chondromas. Among malignant neoplasms, costochondral sarcoma was frequently found and adenocarcinoma ranked first in incidence of the metastatic carcinomas. For details, see Tables 1 and 2.

Site of tumorigenesis

The anterior chest wall was the most common site for chest-wall tumors in our study, with an occurrence in 56 cases (53.3%). The lateral chest bone ranked second, with an onset in 29 cases (27.6%), and the posterior chest wall last, with 20 cases (19%). As for the primary skeletal tumors, they were most frequently seen in the ribs, with a morbidity in 52 cases (96.3%). Only 2 cases occurred in the chest bone (3.7%).

Mode of operation

In our study, the number of cases receiving a local excision amounted to 26 case-times, restricted radical excision 54 case-times, enlarged radical excision 16 case-times and palliative resection 18 case-times. Of these patients, 8 received a second-time operation and 1 underwent a third-time operation. Nineteen patients received a reconstruction of a large chest-wall defect, among which the Marlex net repair was performed in 8 cases, Gore-Tex fiber repair in 6 cases, and tension-less Perfix plug repair in 5 cases.

Table 1. Pathologic types of 75 cases with a benign chest-wall tumor.

Skeletal tumor	Cases	Soft connective tissue tumor	Cases
Fibrous dysplasia	21	Angioma	7
Chondroma	13	Desmoid tumor	5
Osteochondroma	5	Myofibroma	4
Eosinophilic granuloma	3	Fibrolipoma	3
Aneurysmal bone cyst	3	Myolipoma	2
Giant cell bone tumor	2	Myxolipoma	2
Osteoblastoma	1	Neurofibroma	2
Schwannoma	2		
Totals	48	Totals	27

Table 2. Pathologic types of 30 cases with a malignant chest-wall tumor.

Skeletal tumor	Cases	Soft connective tissue tumor	Cases	Metastatic carcinoma	Cases
Costochondral sarcoma	3	Fibrosarcoma	3	Adenocarcima	5
Plasma cell myeloma	2	Rhabdomyosarcoma	3	Squamous carcinoma	3
Sternal Hodgkin disease	1	Primitive neuroectodermal tumor	3	Undifferentiated large cell carcinoma	1
		Malignant schwannoma	2	Abdominal synoviosarcoma	1
		Leiomyoma	1	Mediastinal malignant fibrous Histocytoma	1
		Angioleimyosarcoma	1		
Totals	6	Totals	13	Totals	11

RESULTS

No intraoperative deaths occurred in the study. The major complication of the disease was a regional tumor recurrence, totaling 11 cases (10.5%). In 75 cases with a benign tumor of the chest wall, follow-up was conducted in 64 (85.3%), of which 48 were still living and well, with the remaining 16 dying from other causes. In 6 cases with chest-wall primary malignant osteoma, bulky resections of chest wall and Gore-Tex repair were conducted in 3 cases with costochondral sarcoma, with a 5 to 8-year follow-up and a good result. One of the 2 patients with plasma cell myeloma underwent adjuvant chemotherapy, following a resection of the sternal body (body of the sternum), and died after a 7-year survival. In another case, the result of a 6-month postoperative follow-up was good after a resection of several ribs and a reconstruction of a large chest-wall defect with the tensionless Perfix plug. One case with a 5-year survival had received a sternal excision in the affected part for Hodgkin disease, and a Gore-Tex repair of a large chest-wall defect. In 13 patients with a primary malignant chest wall soft tissue tumor, 8 died, with a postoperative survival ranging from 1 year and 9 months, to 5 years and 7 months. Two of these cases were still living with an ongoing postoperative survival rate of 4.25 years, and 2.67 years. Follow-up for other 3 cases was lost. All 11 cases with a metastatic carcinoma died. Their postoperative survival time ranged from 10 months to 6.33 years.

DISCUSSION

Diagnosis and differential diagnosis of a chest-wall tumor

The incidence of primary chest-wall tumors has been reported to be 5 to 10% of all bone and soft connective tissue tumors. In China, benign tumors of the chest wall are more commonly seen[2,3], whereas malignant cases are frequently encountered overseas, with a ratio of up to 50 to 80%[4,5]. In our study, benign cases comprised 79.8% of the total, which is similar to the case-history records and literature from China. It is worth noting that in the cases with primary bone tumors, the incidence of tumors in the costal bone (96.3%) ranked first.

Diagnosis of chest-wall tumors mainly depends on the case history, physical examination, imageological examination, laboratory examination and biopsy of the neoplasm, etc. A malignant tumor should be identified based on the following factors: the patients with advanced age, a short course and rapid progression of the disease, a severe pain, a tumor diameter of over 5 cm and encroachment of a soft connective tissue tumor in osseous tissue, as well as an involvement of a bone tumor with the soft tissue, etc. The main points for the differential diagnosis include whether the growth is tumorous or nontumorous, benign or malignant, primary or metastatic.

X-ray examinations

X-rays include the anterioposterior and lateral film of the chest, tangential position film, tomogram and multiaxial fluoroscopy, etc. In general benign skeletal tumors are round, oval shape, without a break of the cortical bone. The character of a malignant skeletal tumor is mainly a bony injury, with an osteolytic or osteogenic alteration, with a coarse verge, defective cortical bone substance, and rupture or pathologic fracture. The chest-wall soft tissue tumor shows a moderate density on an X-ray film. The inner margin of the tumor is limpid and sharp, and the outer margin diffuse. The tangential position radiographs reveal that the center of the tumor is situated at the lateral chest bone, the tumor body forms an obtuse angle with the chest wall, the base body is closely stuck to the chest wall, and the long axis is concordant with the chest wall and fails to separate from each other. The pleural reflection line can be seen on both ends of the tumor body.

CT scanography

CT scans are helpful in determining the site, size, scope of the tumor, and if there are tumor metastases. They also can be used for detecting soft tissue involvement in the pleura, mediastinum and the lungs, ascertaining if there is a tumor on the chest wall or in the lungs, and affirming the true situation of encroachment and metastasis in the intrathoracic organs and mediastinum.

ECT and PET scans

Bone imaging shows a very high sensitivity for diagnosis of metastatic bone tumors. Pathologic lesions can be detected at an earlier period, from 3 to 18 months, compared to X-ray examinations or CT scans. The results of PET and $^{18}F-FDG$ uptake by muscle and skeletal tumors indicated that there was a significant increase in glucose metabolism of tumorous tissue, and that the glucose utilization rate related to the differentiation level of the tumors[6].

Laboratory examinations

Laboratory examinations show a definite diagnostic value for some tumors, such as myeloma, which results in a positive Ben-Jones protein test (BJ test). However, two cases of our group showed a negative BJ test, indicating less significance for the diagnosis. In addition, the level of serum alkaline phosphatase increased in the malignant tumors with an extensive destruction of bone.

Puncturation and frozen sections

Diagnostic accuracy of a fine-needle aspiration biopsy is low. In 13 cases of our group receiving an aspiration biopsy, correct diagnosis was obtained in only 6 cases. Frozen section examinations are unsuitable for lesions with excess sclerotin. The results of frozen biopsy for 24 cases of the group revealed that final diagnosis could not be made in 4 of the 13 cases, and discrepancy in the final diagnosis occurred in another 2 cases, with a correct diagnosis of 75%.

Surgical treatment of chest-wall tumor

Tumor excision is the major therapeutic method for chest-wall tumors. Different incisions and scopes of excision were chosen based on the nature of the tumor. In 52 cases of our group with a primary costal tumor, benign tumors were found in 48 of the cases (92.3%). Therefore we are in agreement with the viewpoint of Cavanaugh et al.[7] that restricted radical excision should first be conducted for the primary costal tumors without a pathologic diagnosis. The scope of excision included the intercostal muscle of the involved ribs, deep partial pleura and shallow affected muscle, with 3 cm and over beyond the affected scope at both ends. After initial report of the pathologic results, a second operation might be performed if the first one was regarded as incomplete. This procedure can avoid an unnecessary wide-ranging massive excision of the chest wall for many patients with a benign lesion. If the results of a postoperative diagnosis indicate a malignancy with a request for a second surgery, surgeons will have time to make a detailed plan for resection and reconstruction of the chest wall. Recurrence of 11 cases with a local tumor suggested that for a radical or enlarged radical excision on the recrudescent or malignant tumor, 5 cm or over beyond the edge of the tumor is needed for the scope of the excised chest wall.

Rules and methods for reconstruction of a massive chest-wall defect

Concerning a definition of a massive chest-wall defect, Sun et al.[8] suggested that those with one of the following conditions should be regarded as a massive defect: a) more than 3 costal bones and their intercostal tissue are to be dissected owing to a surgery or an injury; b) a chest-wall defect after subtotal excision of the chest bone, and c) it is a full chest-wall defect, though only 2 or less costal bones have been excised. This is indicated because the pleural cavity can not be tightly closed and may bring about paradoxical breathing or a pulmonary hernia.

In our group, massive chest walls were excised in 19 cases, which is in accord with the above requirements for a massive defect. The rules for reconstruction of a massive chest-wall defect are as follows: a) to use related materials for reconstructing the rigid chest wall and restoring firmness and stability of the bony thorax, and b) to adopt soft tissue and skin for covering the rebuilt rigid chest wall, so as to maintain tightness against leakage of the chest wall. Reconstruction is not required when the defect is less than 5 cm, regardless of the thoracal sites. The reconstruction is also not needed for defects less than 10 cm at the posterior upper thorax, as the scapular bone at the surface can provide needed support.

Selection and evaluation of prosthetic materials for the chest wall

The prosthetic materials for the chest wall include biomaterials, i.e., the autogeneic and xenogenic materials, as well as the artificial materials. The tissue affinity of the biomaterials is good, especially that of the autogeneic tissue with no foreign body reaction. However, the supporting force of some tissues is weak, and size of the samples, especially that of the

osseous samples has been a problem. In addition, the operative procedure is complicated, and there are indeed some difficulties in extensive restoration of the chest wall.

Optimal artificial material should be as follows: 1) a better supporting force, which can prevent flail chest and paradoxical respiration; 2) no loosening occurs, and suitable for being embedded in the body for a long time and 3) it can permeated by X-rays. Sun et al.[8] suggested that organic glass ribs provided favorable physiologic functions and compliance, whereas Yi et al.[9] insisted that plastic and rigid material with mesh are preferred. Concerning bony reconstruction of a massive chest-wall defect, Duan et al.[10] recommended repair by prosthetic materials, at present, would be a better choice. In 19 cases of our group with a massive chest-wall defect, Marlex net, Gore-Tex patch and tensionless Perfix plug for hernia were used for reconstruction of the chest wall, with a good result. However, these were imported from abroad, and their prices were high.

Marlex net

In our study, 8 cases underwent a massive chest-wall resection. The maximal defective area was 30 cm×12 cm and the minimum 10 cm×8 cm. Repair and reconstruction were conducted for the defective areas using monostratal or bistratal Marlex net. The raw edges of the Marlex net were everted about 1 to 2 cm, then discontinuous mattress sutures were applied between the costal bones and intercostal muscle using coarse suture silk. Intermittent costal perforation sutures could be used to prevent the silk suture line from slipping. If the defect was too large in some parts, such as the skin of the chest wall and muscular tissues, latissimus dorsi muscle with vascular pedicles, or a pectoralis major myocutaneous flap can be shifted to adequately cover the raw surface.

One patient, with a periapical fibroma in the 4th and 6th costal bones and the 4th on the right side and 6th thoracic vertebrae, underwent total resection of the 4th and 6th right costal bones, and bistratal repair of the Marlex net plus focal clearance at the 4th and 6th thoracic vertebrae. The size of the chest-wall defect included a 30 cm×12 cm area, and the Marlex net after repair caused a stress state. The patient was still alive after a 9-year follow-up[11, 12].

Since the 1980s, the Marlex net has widely been regarded in the world as a perfect prosthetic material for reconstruction of the chest wall[12]. The net is weaved with a high-density polyethylene at a high temperature. Its merits are as follows: 1) convenient incision, moulding and saturation; 2) a powerful tensile-strength of 3,500 to 10,500 Kg/cm2 and without movement in the chest wall, to ensure a firmness and stability of the chest-wall repair; 3) minor tissue reaction and a satisfactory anti-infection capacity. Although an infection may occur, it will not affect healing of the injury, and it is unnecessary to take out the net; 4) there are screen meshes (or pinholes) in the net, which are apt for fibroplasia formation that improves the tissular affinity; 5) easily penetrated by X-rays; 6) reliable and safe for sterilization with an autoclave facility, and 7) no carcinogenicity.

Gore-Tex patch

Six patients of our group received a massive chest-wall resection, with the defect area ranging from 10 cm×8 cm to 18 cm×15 cm. Appropriate tailoring of the Gore-Tex patch was conducted, and continuous or interrupted suturing was performed with peripheral tissues and the costal and chest bones, using a round needle and nonabsorbable suture or Gore-Tex special suture.

A 70-year old patient with costochondral sarcoma had undergone an initial resection, with a range of 14 cm×10 cm, using the Gore-Tex repair. A recurrence took place 1 year later, and a second resection was conducted with a scope of 10 cm×8 cm. The Gore-Tex repair was conducted once more, during which the suturing was repeated on the former Gore-Tex patch at one side. Postoperative recovery was good and there was no relapse during a 5-year follow-up[13].

The Gore-Tex patch is a new-type of prosthetic material for repairing a chest-wall defect[14], and is made up from expanded polytetrafluoroethylene (ePTFE). The advantages of the ePTFE are: a) a fine moulding performance, used for tailoring into various sizes and forms, b) a good permeability to X-rays; c) a flexible texture, with a satisfactory tensile strength; repeated movement and compression will not cause loosening or embrittlement; d) a multihole fine structure does encourage tissular growth, resulting in a favorable biocompatibility; e) no carcinogenicity, with little immune rejection and allergic reactions, and f) good impermeability, which can stop the passage of air and fluid leakage. However, it's worth noting that a 2-mm patch should be used to guarantee a sufficient strength. The smooth surface is put inward to reduce the adhesion between the patch and intrathoracic organs, and the coarse side is put outward for easy fusion-stabilization of the patch with the covered soft tissues.

Hernia repair patch (or tensionless Perfix plug)

There are many kinds of patches, such as the Bard Composix EX which is composed of two materials, i.e. one side is formed from polypropylene and an-

other side by expanded ePTFE. It is mostly used for large hernia repair, with the characteristics of desmoplasia on the side of the internal organs, whereas on the side of the abdominal wall there is an enhancement of collagen tissue growth[15].

In 5 cases of our group, a massive portion of the chest wall was excised, with the defects ranging from 9 cm×8 cm to 15 cm×15 cm. Continuous or interrupted suturing of the above patches was conducted with the peripheral soft tissues and the costal bones. Neither hematoma nor infection occurred after the operations, and in addition, local paradoxical breathing was not seen, thus providing satisfactory results.

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