

RESEARCH ARTICLE

Value of Porous Titanium Alloy Plates for Chest Wall Reconstruction after Resection of Chest Wall Tumors

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Abstract

Objective: To explore the value of porous titanium alloy plates for chest wall reconstruction after resection of chest wall tumors. **Materials and Methods:** A total of 8 patients with chest wall tumors admitted in our hospital from Jan. 2006 to Jan. 2009 were selected and underwent tumor resection, then chest wall repair and reconstruction with porous titanium alloy plates for massive chest wall defects. **Results:** All patients completed surgery successfully with tumor resection-induced chest wall defects being 6.5×7 cm~12×15.5 cm in size. Two weeks after chest wall reconstruction, only 1 patient had subcutaneous fluidify which healed itself after pressure bandaging following fluid drainage. Postoperative pathological reports showed 2 patients with costicartilage tumors, 1 with squamous cell carcinoma of lung, 1 with lung adeno-carcinoma, 1 with malignant lymphoma of chest wall, 2 with chest wall metastasis of breast cancers and 1 with chest wall neurofibrosarcoma. All patients had more than 2~5 years of follow-up, during which time 1 patient with breast cancer had surgical treatment due to local recurrence after 7 months and none had chest wall reconstruction associated complications. The mean survival time of patients with malignant tumors was (37.3±5.67) months. **Conclusions:** Porous titanium alloy plates are safe and effective in the chest wall reconstruction after resection of chest tumors.

Keywords: Chest wall tumor - chest wall defect - porous titanium alloy plate - chest wall reconstruction

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Introduction

Chest wall tumors include primary tumors from soft tissues and bones of chest walls and secondary ones like metastatic tumors and invasive tumors from adjacent organs, for which the most important therapies are large-scale resection of chest wall followed by chest wall reconstruction because of the large-scale chest wall defects, especially anterior or lateral ones (Nam et al., 2011; Fujii et al., 2014; Yoshiya et al., 2014). In order to prevent chest wall softening or paradoxical breathing, the materials of chest wall reconstruction have always been the continuous exploring issues of physicians in Department of Thoracic Surgery. During Jan. 2006 to Jan. 2009, a total of 8 patients with chest wall defects after the resection of chest wall tumors in our hospital were treated with porous titanium alloy plates and the favorable effects were obtained.

Materials and Methods

General data

A total of 8 patients with chest wall tumors admitted in our hospital from Jan. 2006 to Jan. 2009 were conducted

with chest wall construction after tumor resection due to different degrees of absence of ribs, in which there were 5 males and 3 females, aged from 34 years to 65 years with average age being (54.62±8.91) years.

Methods

Resection method: All patients were given general anesthesia through monotrons or double-lumen tubes. Horizontal position or lateral position was chosen and resection ranges were determined based on tumor patterns and locations. As to patients with benign tumors, local tumor tissues or tissues 1~3 cm around tumors were excised; to patients with malignant tumors, large-scale chest wall should be excised, which meant the tissues 5 cm around tumor margins, including normal ribs and intercostal muscles above and below tumors; and to patients with lung cancers, lobectomy and mediastinal lymph node dissection were performed.

Reconstruction method: Chest wall reconstruction was conducted for patients with large-scale chest wall defects after tumor resection. Firstly, osseous reconstruction was performed, in which porous titanium alloy plates were appropriately clipped and shaped to cover the surfaces of defective chest wall, then stainless steel wires threading

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Table 1. Clinical Data of 8 Patients

Number	Gender	Age	Defect locations	Defect range (cm×cm)	Pathological diagnosis
1	Male	52	7th and 8th ribs on right side	6.5×7	Squamous cell carcinoma of lung
2	Male	34	7th and 8th ribs on right side	7×9.5	Lung adeno-carcinoma
3	Female	51	5th and 6th ribs on right side	8×7.5	Costicartilage tumor
4	Male	60	6th, 7th and 8th ribs on right side	8×12	Malignant lymphoma of chest wall
5	Male	62	4th, 5th, 6th and 7th ribs on right side	12×15.5	Chest wall neurofibrosarcoma
6	Female	62	4th and 5th ribs on right side	6×8	Chest wall metastasis of breast cancer
7	Female	58	4th and 5th ribs on left side	6×8.5	Chest wall metastasis of breast cancer
8	Male	65	5th and 6th ribs on right side	7×8	Costicartilage tumor

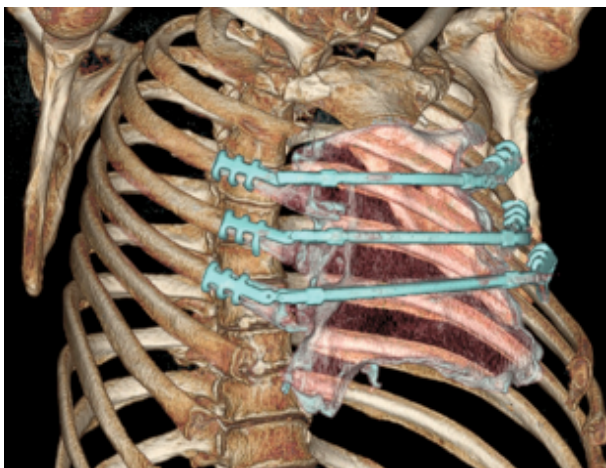


Figure 1. Postoperative Three-dimensional Diagram of Chest Wall Reconstruction with Porous Titanium Alloy Plates

the holes around porous titanium alloy plates were fixed on sternums and/or ribs around defects for several stitches (Figure 1). Secondly, soft tissue repair of chest wall was made, for which anterior chest walls were repaired by free muscle flaps of pectoralis major muscle while posterior and lateral ones by free muscle flaps of latissimus dorsi muscle. Routine closed drainage of pleural cavity was given and no drainage was needed under porous titanium alloy plates and between subcutaneous tissues, which was followed by pressure bandaging on the wounds and the application of antibiotics to prevent postoperative infections.

Observational indexes

Clinical efficacy, pathological diagnosis of tumors and follow-up results of 13 patients were observed.

Results

All patients completed surgeries successfully with tumor resection-induced chest wall defects being 6.5×7 cm~12×15.5 cm in size. After chest wall reconstruction, patients had favorable thorax stability and pulmonary reexpansion without hydrothorax, arothorax and paradoxical breathing. All wounds healed excellently by the first intension at first grade. 2 weeks after chest wall reconstruction, only 1 patient had subcutaneous fluidify, which healed itself after pressure bandaging following the fluid draining. Postoperative pathological reports showed 2 patients with benign costicartilage tumors and 6 with malignant tumors including 1 with

squamous cell carcinoma of lung, 1 with lung adeno-carcinoma, 1 with malignant lymphoma of chest walls, 2 with chest metastasis of breast cancers and 1 with chest wall neurofibrosarcomas (Table 1). All patients had more than 2~5 years of follow-up with average duration being (4.12±0.87) years, during which time no patient was lost. All patients had firm fixation of titanium alloy plates without looseness, detachment and rejection responses, in which 1 patient with breast cancer had surgical treatment due to local recurrence marked by close adhesion of titanium alloy plates with body tissues, fulfillment of titanium alloy plate holes by granulation tissues, evident decrease of chest wall defect sizes, thickened visceral pleura and tightly closed pleural cavity after 7 months. In this study, patients with benign tumors had favorable quality of life (QOL) without recurrence and long-term complication, while the 1-, 2- and 5-year survival times of patients with malignant tumors were 83.33% (5/6), 50.00% (3/6) and 33.33% (2/6) respectively with mean survival time being (37.25±5.67) months.

Discussion

The optimal therapy for chest wall tumors is surgical resection, in which local resection can be performed on benign or malignant tumors (Afsharfard et al., 2013; Alipour et al., 2014; Fouladi et al., 2014; Hu et al., 2013; Sedighi et al., 2013; Talaiezhadeh et al., 2013; Zhu et al., 2013; Hu et al., 2014; Jia et al., 2014; Ozkan-Gurdal et al., 2014). However, the resection range should be properly enlarged to such tumors as desmoids, chondroma and osteoclastoma, or be resolved as in malignant tumors, though with benign pathological examinations (Errani et al., 2010; Nieuwenhuis et al., 2011). Chest wall resection can bring about different degrees of chest wall defects, which need to be repaired and reconstructed (Munhoz et al., 2011; Maeda et al., 2014).

Chest wall reconstruction requires closed pleural cavities, stable chest walls and acceptable appearances, including osseous chest wall reconstructions using biological or artificial materials to recover the robustness and stability and soft tissue reconstructions of chest walls to obtain the impermeability and favorable appearance by means of transplanting muscle flaps of chest wall tissues (Guo et al., 2011; Zhang et al., 2011; Rocco et al., 2012). It is commonly believed that patients with anterolateral chest walls <6×6 cm and posterolateral ones <10×10 cm could be treated by soft tissue repair, which meant to cover the defects with island muscle flaps of latissimus dorsi muscles and flaps of pectoralis major muscles, rectus

abdominis muscles, trapezius muscles and omentum majus so as to eliminate the postoperative paradoxical breathing of chest walls (Kronowitz et al., 2009; Huemer et al., 2012). However, osseous chest wall reconstruction should be given to patients with chest wall defect ranges greater than above ones. Autogenous and artificial materials are available for osseous chest wall reconstructions, the former are consisted of femoral fascia, myocutaneous flaps, ilium pieces and rib frames, etc., which are thoroughly fitted with the physical characteristics of human body and applicable for small defects due to the limited materials, deficient hardness and traumas on normal tissues, whereas the latter, containing polypropylene, artificial titanium alloy ribs and metal wire stents, are perdurable, convenient, effective, stable in fluid, compatible with tissues of human body, valid in anti-infection action and various in shapes, with their therapeutic principles focusing on preventing postoperative chest wall softening and protecting cardiopulmonary functions (Aranda et al., 2008; Mirzabeigi et al., 2011; Noda et al., 2011). Biological materials (like polypropylene) concomitant with myocutaneous flaps could be utilized for massive defects of chest walls but with more complications, in which respiratory system complications were the most common one with its rate up to 20%~24% (Weyant et al., 2006). Miller et al reported that the rate of complications in 25 patients with chest wall defects was 24% after chest wall reconstruction with biological materials (Miller et al., 2013). Steel wire mesh is conventionally applied to osseous chest wall reconstruction, though being indurable and steady, it also can impact respiratory function by limiting thorax movement, while Kirschner wire is insecure in fixation and easy to loosen, slip and puncture ribs. On the contrary, titanium alloy plate has been broadly applied in the repair and reconstruction of chest wall defects in that it can effectively avoid the disadvantages of other materials and protect the completeness of pulmonary function to a larger extent (Nemeth et al., 2009).

Titanium alloy plate is a kind of alloy product with following advantages: (1) Strong but pliable in texture, favorable in shape, and can be made into appropriate radian conformable to chest walls so as to protect the normal volume and respiratory function of chest to a larger extent without inducing rejection responses in human body (Shang et al., 2011); (2) Simple in operation and can be covered on defect surfaces of chest walls by threading several stitches with steel wires; (3) Larger in intensity so as to confront with outside violence and protect intrathoracic organs; (4) No subcutaneous drainage is required as the subcutaneous effusion can flow into chest through holes of titanium alloy plates and been discharged through thoracic ducts (Thomas et al., 2010). Berthet et al found in their study that a female patient with non-small cell lung cancer (NSCLC) was performed with upper right lobectomy and mediastinal lymph node dissection synchronizing with the resections of 3rd, 4th, 5th and 6th ribs and corresponding vertebrae on right rear side followed by reconstruction of the defect chest walls with rib osteosynthesis of vertical peptide and polytetrafluoroethylene mesh, after which no complication like thorax deformation, displacement,

respiratory depression and infection was observed during follow-up (Berthet et al., 2011). In another study of the same year, Berthet et al applied chest wall reconstruction with titanium alloy plates and polytetrafluoroethylene on 19 patients with large-scale chest wall defect due to NSCLC or the resection of chest wall tumors, which showed no obvious complication except 2 infections and 3 respiratory failures (Berthet et al., 2011; 2013). In 2013, Berthet et al conducted chest wall reconstruction with titanium alloy plates on 11 patients with primary or secondary chest wall infections, and none had recurrent infection 6 months after operation except 1 died, therefore the authors believed that osseous chest wall reconstruction with titanium alloy plates concomitant with tissue repair had reliable, safe and rapid clinical efficacy on patients with severe chest wall infections (Berthet et al., 2013). Matsumoto et al reported the application of chest wall reconstruction with titanium alloy plate on 1 case of chest wall chondrosarcoma with chest wall defect 17×14 cm in size after surgical resection and the result showed that no scoliosis was found during 12 months of follow-up after operation and the thorax movement range was satisfactory (Matsumoto et al., 2012).

In this study, all patients had chest wall defects associated with the resection of chest wall tumors with defect sizes being >6×6 cm and treated with osseous chest wall reconstruction with titanium alloy plates, which were successfully completed without death. After resection, titanium alloy artificial ribs had passive movement with normal chest walls, leading to favorable pulmonary reexpansion and no paradoxical breathing. In addition, the follow-up results also demonstrated that patients with benign tumors had excellent QOL without recurrence and long-term complication, while the mean survival time of patients with malignant tumors was (37.25±5.67) months, which were consistent with above reports, suggesting that the application of porous titanium alloy plates on chest wall defects due to the resection of chest wall tumors was safe and effective. However, more cases are needed to be further enlarged so as to conduct deeper researches.

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