Reconstruction of Chest Wall Defects Using a Technique Involving Mesh, Titanium Plates, and a Pedunculated Muscle Flap

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We herein present a new surgical reconstruction technique for large chest wall defects after resection of advanced chest wall tumors.

Key words: 1. Chest wall
2. Reconstruction

Introduction

Large chest wall resections are often mandatory in the management of chest wall tumors. Skeletal reconstruction is required to prevent respiratory failure due to paradoxical thoracic movement or infection and to protect the lungs, heart, and greater vessels from injury. Furthermore, reconstruction of the thoracic cage aims to maintain functional and cosmetic integrity. The complication rate of large chest wall reconstructions ranges between 46% and 69%, with a respiratory morbidity rate of 27% [1]. Reconstructions with materials such as methyl methacrylate, bone cement, fascia grafts, and silicone implants have been described [2]. These techniques are not optimal for chest wall reconstruction, and infection of the prosthesis requires complete removal. We describe an alternative large chest wall reconstruction procedure in 4 patients using a combination of a mesh, titanium plates, and a pedunculated muscular flap to ensure flexible movements in combination with a reduced infection rate.

Methods

1) Technique

Patients were intubated with a double-lumen tube. For a right lobectomy, the patient was placed in the left lateral decubitus position, followed by a right posterolateral thoracotomy and mobilization of the latissimus dorsi and intercostal muscles. The involved part of the thoracic wall and involved lobe were resected en bloc with a 2-cm macroscopic margin. The bronchial stump was covered by an intercostal muscle flap. A 'sandwich' technique (mesh, titanium plates, and pedunculated muscle flap) was used to reconstruct the resulting large thoracic wall defect. The defect in the thoracic wall was covered with the mesh as an inner lining, with a 3-cm overlap inside the thoracic cage, and anchored with Mersilene sutures through bore holes of the ribs. To reconstruct the rib cage and to bridge the defects, titanium plates secured with at least 3 screws on either side of the ribs were used (matrixRIB system, Synthes). If possible, the screws were alternately placed to achieve a more flexible construction. The plates were at-
tached to the mesh with Vicryl sutures, which facilitate removal of a broken plate (Fig. 1). A pedunculated latissimus dorsi flap was tunneled under the scapula (nerves were cut), and covered both the mesh and the titanium plates (Fig. 2). Finally, a chest tube and 2 wound drains were placed to secure drainage. The same technique was used for right and left lobectomies.

### Results

1) **Case 1**

A 58-year-old patient presented with a persistent dry cough, dyspnea, and hemoptysis. Computed tomography (CT) showed a solid tumor in the right upper lobe with invasion of the chest wall and pathologic lymph nodes in the right hilum. Bronchoalveolar lavage fluid cytology revealed malignant cells (non-small cell lung cancer [NSCLC]). Mediastinoscopy with lymph node biopsy showed no lymphatic metastases (stage IIb). A sleeve bilobectomy of the right upper and middle lobe was performed, with the right lower lobe attached to the main bronchial tree. The resulting chest wall defect was reconstructed with a polypropylene mesh, titanium plates, and a pedunculated latissimus dorsi flap. Pathologic examination revealed a pT3N1M0R0 carcinoma (stage IIIA). He was extubated immediately afterwards, and was discharged 9 days after surgery. The patient received adjuvant chemotherapy without complications. After 10 months, the patient presented with thoracic pain located at the site of the implanted plates. A chest X-ray revealed spontaneous fracture of a titanium plate. The plate was surgically removed without complications. The patient currently has good pulmonary function without pain or thoracic deformity (Table 1, Fig. 3).

2) **Case 2**

A 64-year-old patient presented with thoracic pain, coughing, and sneezing. CT and positron emission tomography (PET) imaging showed a tumor located at the lingula. CT-guided needle biopsy revealed malignant NSCLC cells (stage IIb). Partial resection of 2 ribs and pericardium and lobectomy of the upper left lobe were performed. Reconstruction of the chest wall defect was achieved with a dual mesh, titanium...
plates, and the serratus anterior muscle. Pathological examination revealed a sarcomatoid carcinoma (pT3N0R0). The patient was rapidly extubated and discharged after 8 days. Adjuvant chemotherapy was initiated. After 4 months, a fracture of the humerus was diagnosed as having resulted from osteolytic metastasis. Internal fixation of the fracture was performed, followed by adjuvant radiotherapy. The patient currently has good clinical pulmonary function without functional loss or visible deformity of the chest.

3) Case 3
A 74-year-old patient was hospitalized for delirium. A tumor of the lung was discovered on a chest X-ray. CT imaging of the chest revealed a Pancoast tumor with invasion of the thoracic wall. PET imaging demonstrated increased uptake at the site of the tumor, and in 1 ipsilateral hilar lymph node. Ultrasound needle biopsy demonstrated a low-grade NSCLC (stage IIIA). Cerebral magnetic resonance imaging (MRI) and mediastinoscopy did not detect additional lymph node metastasis. The patient received neoadjuvant chemoradiation, which resulted in regression of the tumor. Resection of the first 4 ribs and lobectomy of the left upper lobe were performed. A polypropylene mesh, titanium plates, and a pedunculated latissimus dorsi muscle flap were used for chest wall reconstruction. Pathologic examination showed malignant tumor cells and peribronchial lymph node metastasis (pT3N1M0R0). Immediate extubation followed directly, and the patient was discharged 14 days after surgery. The patient died 6 months after surgery due to widespread metastases.

4) Case 4
A 72-year-old presented with chest pain that radiated to the left upper arm. CT imaging showed a tumor in the left upper lobe with invasion of the parietal pleura. PET revealed increased uptake at the site of the tumor and in 1 ipsilateral hilar lymph node. Ultrasound-guided needle biopsy revealed malignant NSCLC cells (stage IIIA). Cerebral MRI and mediastinoscopy did not detect additional lymph node metastasis. The patient received neoadjuvant chemoradiation, which resulted in regression of the tumor. Partial resection of the first 4 ribs with lobectomy of the left upper lobe was performed. Chest wall reconstruction was established with a mesh, titanium plates, and a pedunculated latissimus dorsi muscle flap. Pathologic examination showed fibrosis after chemoradiation (T3N1M0R0). Immediate extubation was performed, and the patient was discharged after 17 days. During 24 months of follow-up no events occurred. The patient has good pulmonary function, and no functional or cosmetic defects of the chest (Table 2).

### Table 2. Pulmonary function tests before and after surgery in case 4

| Variable          | Before surgery | After surgery |
|-------------------|----------------|--------------|
| Total lung capacity | 6,970 mL (100%) | 5,050 mL (75%) |
| Vital capacity    | 4,240 mL (103%) | 2,760 mL (71%) |
| FEV1              | 2,560 mL (85%) | 2,090 mL (73%) |
| FVC/FEV1 ratio    | 61%            | 76%          |

FEV1, forced expiratory volume in 1 second; FVC, forced vital capacity.

Discussion

This study describes 3 patients with stage IIIA NSCLC and 1 patient with a sarcomatoid tumor with large chest wall defects. Reconstruction was performed using a mesh, titanium plates, and a pedunc-
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culated muscle flap. The aim of this reconstruction is to create a flexible fibrous plate resulting from growth of fibroblasts into the mesh, and to prevent recurring infections [3]. Dieterich et al. [3] showed increased proliferation and penetration of myofibroblasts in meshes using scanning electron microscopy. Another study demonstrated that the biocompatibility of the mesh combined with titanium plates facilitated adhesion between the mesh and its surroundings [4]. In fibroblasts, titanium upregulates fibronectin, which is deposited in the extracellular matrix and binds collagen, proteoglycans, and fibrin. Several reports have shown a lower rate of postoperative infections when titanium was used than for other materials [5]. In addition, using a pedunculated muscle as the outer lining stimulates fibrous outgrowth and protects against infections [3]. The fracture of titanium plates (matrixRib system) from a direct impact has been reported once in the literature. In our study, 1 patient developed a spontaneous plate fracture. The plate was removed without complications and did not have to be replaced because a fibrous plate had been formed. Moreover, no patients developed complications related to adjuvant chemotherapy or radiation.

In conclusion, reconstruction of large chest wall defects with a mesh, titanium plates, and a pedunculated muscle flap is feasible.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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