Chest wall reconstruction with autologous rib grafts in dogs and report of a clinic case

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Abstract

Objective: Nowadays, in chest wall reconstruction prosthetic materials are generally used. However, the rejections of prosthetic materials and infections frequently occur in chest wall reconstruction, especially after radiotherapy or resection that is performed due to infections.

Methods: We used 10 mongrel dogs and performed resections of 8 cm diameter on their chest walls. In the reconstruction of these defects, in five of the subjects, we used two free rib grafts with periosteum to be resected from the contralateral side and in other five subjects, we used free rib grafts without periosteum. After this experimental study, sternal resection was performed in a 24-year-old man because of sternal osteomyelitis. First to obtain rib grafts with periosteum, partial resection was performed to 5th, 7th, and 9th ribs of the lateral left side. After, total sternal resection, end to end anastomosis was performed to the 2nd, 3rd, 4th and 5th anterior ends of the ribs.

Results: Autogeneous rib grafts were found to be enough to provide chest wall stabilization.

Conclusions: The contralateral autogeneous free rib grafts can successfully be used in reconstruction of wide chest wall defects. This method is found to be effective and sufficient to prevent infection, rejection and to provide stabilization. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Chest wall; Chest wall reconstruction; Chest wall resection; Rib grafts

1. Introduction

After resection of the chest wall, stabilization of the thoracic cage is very important for ventilation. If diameter of the defect is greater than 5 cm, a flail, with a resultant paradoxical respiratory pattern, may result in inefficient ventilation. Adequate fixation of the chest wall can prevent the flailing motion and restore normal ventilation [1]. For larger defects, many different types of materials have been utilized over the years to replace the rigid chest wall. Nowadays, generally prosthetic materials are preferred for providing better stability with shorter and simpler surgical procedure [2]. However, the rejections of prosthetic materials and infections frequently occur in chest wall reconstruction, which especially after radiotherapy or resection that is performed due to infections. The materials should be removed if infections developed [1,3]. Autogeneous bone grafts also have been used for chest wall reconstruction, have proved to be very durable. They allow immediate restoration of a rigid surface without any problem of biological tolerance [2]. We want to report this experimental study and its clinical experience in a case, which autogeneous free ribs are to prevent complications of prosthetic materials and suggest alternative solutions.

2. Materials and methods

2.1. Experimental research

Ten mongrel dogs aged 2 to 5 years were included in the study. All animals received humane care in compliance with the ‘Guide for the Care and Use of Laboratory Animals’ published by the National Institutes of Health (NIH publication 85-23, revised 1985). Ketamine (6 mg/kg) and xylazin HCl (2.5 mg/kg) combination were used for anesthesia. After anesthesia, endotracheal intubation was carried out and, ventilation was maintained mechanically. Premedication and neuromuscular blocking drugs were not used. Firstly, the animals were placed in right lateral position and the skin was prepared with a solution of povidone-iodine. Approximately 10 cm skin and subcutaneous tissue incisions were performed parallel to the 6th rib. After incision of latissimus dorsi muscle, 5th and 7th ribs were
resected 10 cm with periosteum in the first group (five of the dogs). In the second group (other five dogs) resection of the ribs were carried out deperiosteally. After resection, the rib grafts were put on the solution of the isotonic NaCl. The intercostal muscles and the other soft tissue were closed carefully to prevent paradoxical ventilation. Then the animals were turned and placed in left lateral position for chest wall resection. After preparing with solution of povidone-iodine the skin was incised about 10 cm, and 5th, 6th and 7th ribs were resected with intercostal muscles and pleura about 8 cm. So, we obtained defects of about 8 cm diameter on their chest walls. After homeostasis, a chest drain was left in right pleural space. Rib grafts, which were resected from contralateral sides, arranged to maintain the physiologic contour of thoracic cage on the end of the 5th and 7th ribs with monofilament stainless steel wire suture. The latissimus dorsi facia and the other soft tissue were sutured carefully. Chest drain was removed before the dogs were taken to the recover room. During the first 3 days a prophylactic antibiotic and analgesic were injected intramuscular to prevent infection and to control postoperative pain. After 2 months, from the first operation, the animals were operated under general anesthesia similarly. In both groups, the grafts were resected with their anastomosis lines and examined macroscopically and microscopically.

3. Results

During the postoperative 2 months, neither mortality nor morbidity was observed. Excellent short-term and long-term stabilization was achieved in all cases and we did not observe any difference between the two groups. All animals resumed normal activity 10 days after the operation. In the second postoperative month, there were no late infection and stabilization problems in both groups. We resected the grafts with their anastomosis lines. We determined normal wound healing and fibrosis, and adhesion was seen between visceral pleura and graft. In the first group (with periosteal graft), grafts were alive. We observed an improvement to callus tissue on the anastomosis line. On pathologic examination, osteoblastic activity was seen under the periosteum and particularly on the anastomosis lines (Fig. 1). In the other group with deperiosteal grafts, however, there was no sign of rejection and infection, and the grafts have maintained a strong structure yet, but osteolitic areas and fibrosis was determined in some places. Callus tissue improvement was not observed. Microscopically, fibroblastic activity was seen in place of periosteum.

3.1. Clinical experience

A 24-year-old man who had left posterolateral thoracotomy and median sternotomy for his penetrating thoracic trauma. After the operation, sternal osteomyelitis had been developed. He was admitted to our clinic because of pneumonia and sepsis. He had productive cough, fever, and dyspnea. We observed purulent drainage on the incision site of the median sternotomy. Staphylococcus aureus was identified from his sputum, blood, and wound culture. Clinical evidence of pneumonia was supported with chest roentgenogram and computed tomographic scan. After a successful treatment with Vancomysine (4 g/day) for 1 month, resection of sternum was planned for the patient. First to obtain autogeneous costa grafts with periosteum, the patient was placed in a right lateral position. A small

Fig. 1. Photomicrograph showing osteoblastic activity and callus tissue on the anastomosis line in autogeneous rib grafts with periosteum.
incision was performed on the old thoracotomy incision lines and the 5th, 7th, and 9th ribs of the left side were partially resected. In the supine position, because of infection both the manubrium and corpus sterni were completely resected (Fig. 2a). Resection was carried out with difficulty due to the adhesion between myocardium and sternum. The size of the rib grafts were adjusted to the sternal defect and one of the long ones was divided into two parts to use as another graft. Then autogenous rib grafts were arranged between anterior end of the 2nd, 3rd, 4th and 5th ribs (Fig. 2b). Because of opening right pleura during the procedure, mediastinal and chest drain were inserted on the mediastinum and right pleural space. Pectoralis major muscles and subcutaneous tissue were sutured over the grafts. Prophylactic antibiotic regimen with Vancomisine was continued postoperatively for 5 days. We used narcotic analgesics for controlling of pain. Excellent immediate and long-term chest wall stabilization was observed. After an uneventful postoperative course the patient has been discharged for 7 days. He followed up 6 months and we didn’t observe any complication.

4. Comment

Defects of the chest wall may result from congenital anomalies, extirpative procedures, radiation necrosis, infections, or trauma. Reconstruction of these defects is important to maintain adequate ventilation, to protect the heart and great vessels from infections and trauma, and to maintain cosmetic integrity [1,4]. There are two principles in chest wall reconstruction. The first is restoration of the anatomical defect and the second is compensation of the physiological deficit [5]. For successful reconstruction of the chest wall, the materials that are used are very important. Requirements of an ideal replacement are availability, easy of use, adaptability, durability, nonreactivity, and resistance to infection and translucency to X-rays [1].

Myoplasties theoretically seem to be suitable for reconstruction of chest wall because they resist to infection in such contaminated field and radiation-damaged chest wall. On the other hand, the use of muscle flaps may be inadequate to ensure stability of the chest wall, and prolonged intubation and mechanical ventilation can be necessary [6]. Eschappasse and Gaillard [7] report disadvantages of myoplasties; extensive dissections, protracted operation, impossibility of use for very large resections, detachment of respiratory muscles, imperfect stabilization on the chest wall at least during the first days, inadequate protection of the underlying organs, sometimes discomfort and doubtful cosmetic results. In recent years prosthetic materials have been generally used in chest wall reconstruction because they provide adequate stability and easy surgical procedure. Several materials have been used including metal plates and strips, tantalum mesh, Marlex mesh, polytetrafluoroethylene, polypropylene mesh and methyl methacrylate [6]. Rigid materials as strips and plates of metal, stainless steel, and tantalum prevent flail chest and preserve proper ventilatory motion. However the adjustment of these materials sizes to defect size are very hard problems. The rigidity of these materials can create erosion and destruction of adjacent structures during ventilation moving. They have
a significant incidence of rejection by the host [1]. Synthetic meshes are suited better than rigid materials for chest wall reconstruction. However, the infection and rejection also may occur due to implantation in a contaminated field or to inadequate incorporation. Deschamps and colleagues [8] report nine of 197 patients who had been occurred wound infection (4.6%; five patients with polypropylene mesh and four patients with polytetrafluoroethylene). The prosthesis had been removed in all five patients with polypropylene mesh and in none of the patients with polytetrafluoroethylene. Other authors observed late infection of Marlex mesh in 25% of their patients [3]. Puma et al. [2] suggest bone heterograft and vicryl mesh combination. They report that vicryl mesh was totally absorbed and partial resorption was documented for the spongy compound of the bone heterograft, so that later infections were theoretically less. However, rejections and infections may be seen in early postoperative periods before absorption of materials.

In our study autogenous rib grafts have proved to be very durable and they were not rejected by the body. The size and shapes of ribs were adjusted to the defect very easily. There was a greater survival of the grafted osteocytes and new osteoblasts slowly replaced the grafts with periosteum. This replacement did not occur and fibrosis began in deperiosteal grafts. However chest wall stabilization were sufficient in both of them. The disadvantages of reconstruction chest wall with contralateral autogeneous free rib grafts were pain at the donor site and possible instability in the same area.

In conclusion, the contralateral autogeneous free rib grafts can successfully be used in reconstruction of wide chest wall defects, and this method is found to be effective and sufficient in both avoiding infection, rejection and achieving stabilization.

References