



Original article

ACTA FAC MED NAISS 2006; 23 (2): 107-111

Vojkan Stanic¹, Marjan Novakovic²,
Tatjana Vulovic³, Vlado Cvijanovic¹,
Aleksandar Ristanovic¹, Bojan Gulic¹

¹Military Medical Academy,
Clinic for Thoracic Surgery,

²Clinic for Plastic and
Reconstructive Surgery, Belgrade
Clinical Centre Kragujevac,

³Centre for Anesthesia, Kragujevac

RECONSTRUCTION OF LARGE CHEST WALL DEFECTS AFTER RADICAL RESECTION FOR MALIGNANT TUMORS

SUMMARY

The paper presents the results of the reconstruction of large chest wall defects after radical resection for malignant tumors. Twenty seven patients with malignant tumors of the chest wall were surgically treated at the Clinic for thoracic surgery, Military Medical Academy in Belgrade in the period 2000-2005. After radical resection, chest wall was stabilized and the defect was covered. The obtained results were satisfactory. The authors conclude that extended resections of the chest wall should be performed without concerns that chest wall unstableness and problems with breathing mechanics would occur.

Key words: chest wall, resection, reconstruction

INTRODUCTION

Surgical resection of the chest wall includes radical removal of the pathologic process, chest wall reconstruction and resultant defect covering. The method is applied in the management of chest wall neoplasms (primary tumors, metastatic tumors and malignant tumors directly extending from the adjacent organs, eg. breast and lungs), infections (after sternotomy, posterolateral toracotomy, osteomyelitis, costochondritis), postirradiation necrosis, echinococci and trauma. Large defects are the result of the need for radicality or the size and spread of the lesion, regardless of its etiology.

Evaluation of the possibility to reconstruct and close the defect in the chest wall after resection is the mainstay in the reconstructive surgery planning. The basic question to be answered in preoperative planning of the resection and reconstruction extent is the normality of breathing after surgery and appropriate protection of the intrathoracic organs.

Numerous parameters should be taken into account when planning the chest wall reconstruction, such as the site, size, type and extent of the lesion, wall invasion (superficial or to full depth), local

tissue status (postirradiation changes, necrosis, infection, residual tumor, scar), general patient's status, chronic diseases, prior treatment (corticosteroids and/or chemotherapy) and prognosis (1-4).

Certain postulates should be observed when we perform the resection of malignant tumors. Incision to resect the chest wall is parallel to the involved ribs and directed over the tumor volume. Cutaneous scars from prior procedures (open biopsy or draining incisions) and the tumor itself are excised *en bloc*. The tumor-invaded skin and muscle are also excised along with the tumor. It is necessary to expose the whole tumor volume and the surrounding normal tissue, ie. the resection locus. Resection was performed after we established the size and extent of tumor and its relationship with the rest of the wall structures and intrathoracic organs (5,6).

Benign lesions are resected through the immediately adjacent healthy tissue and malignant lesions are widely (radically) resected together with the portion of normal surrounding tissue, with histologic and cytologic control of resection margins. Resection is performed *en bloc* and includes intercostal muscles, ribs, rib cartilages, sternum and pleura, and in certain cases muscles, subcutaneous tissue and

skin as well. In addition to the involved ribs, resection includes at least one or more neighbouring ribs.

In the chest wall portions, where muscle insertions are in close contact with ribs, their resection together with the tumor is performed. In the regions where muscles are away from the ribs and their fascia is a barrier to the tumor, muscle resection is not required. Later, they may serve for reconstruction and covering of the wall defect.

With adherent tumor or when tumor invades the diaphragm, mediastinum or lungs, involved portions have to be resected. Resection line should be situated in the healthy tissue. Pulmonary adhesions in the tumor area are interpreted as the sign of its malignant infiltration; portion of the lungs with adhesions is removed *en bloc* with parietal pleura and primary tumor of the wall. Assessment of tumor expansion requires CT and NMR of the chest (7,8).

Requirement for wide resection is the consequence of the fact that malignant tumors of the bones spread along the bone spongiosa, periosteum, perichondrium and pleura and due to close contact with surrounding structures by direct invasion as well. In that respect, 5-7 cm of the chest wall around the tumor should be resected. The ribs from which tumor originates are resected in a much larger segment (9).

For tumors of the rib cartilage and sternum, the probability of malignancy is so strong that radical resection could be done even without prior histologic verification. Tumors of the costochondral junction (chondrosarcomas) are resected by removing at least 5 cm of the sternum medially from the tumor and 7-10 cm of the rib laterally, as well as one to two ribs above and below the tumor volume.

Most sternal tumors are malignant. Access is most commonly provided through transversal incision. However, when total sternal resection is planned, longitudinal incision is preferred. Resection extent depends on tumor size and resection margins are in the healthy part of sternum 2.5-5.0 cm above and below the tumor. Laterally from the tumor, the corresponding cartilages and ribs are removed to the length of 5-7 cm. When possible, upper and lower sternum parts should be preserved in order to preserve satisfactory chest integrity. In cases where manubrium resection is required, medial ends of both clavicular bones have to be resected as well. In pleural and pericardial infiltration with tumor, both should be excised together with the tumor and sternum (10-13).

Resection of all chest wall layers is necessary when the wall is invaded by breast, skin or lung carcinoma. With lung cancer, the chest wall segment, tumor and lungs are resected *en bloc*. Intercostal incision for thoracotomy must be away from the tumor. Segmental chest wall resection is performed one healthy rib above and below the tumor and at a

distance of 2.5-5.0 cm in front and behind the tumor invasion. Resected chest wall contains adherent lung portion; after that lungs are resected (segmental resection, lobectomy, pneumonectomy or atypical resection). Reconstruction and defect covering are performed as in all other cases of chest wall malignancies.

Metastatic chest wall tumors are relatively common. Surgical treatment is indicated for solitary metastases. Resection involves one free rib above and below the tumor, as well as the rib portion in front and behind the tumor.

MATERIAL AND METHODS

27 patients with malignant tumors of the chest wall were surgically treated at the Clinic for Thoracic Surgery, Military Medical Academy in Belgrade in the period January 2000 - December 2005 and treatment analysis was carried out. There were 23 primary malignant tumors (12 chondrosarcomas, 4 solitary plasmacytomas, 2 Ewing's sarcomas, 3 fibrosarcomas and 2 histiocytomas) and 4 metastatic tumors. In all cases, after radical chest wall resection, defect reconstruction was done with chest wall stabilization and defect covering. Meshes and rib-grafts were used to stabilize the wall and muscles and myocutaneous flaps for defect covering. In addition to standard postoperative monitoring, the parameters of breathing mechanics and pulmonary function were especially monitored (number of respirations per minute, spirometry and gas analyses of arterial blood in resting).

RESULTS

Eighteen resections of anteriolateral chest wall with resection of more than two ribs and 9 complete sternal resections (6 partial and 4 sternal resections together with manubrium, rib cartilages and medial clavicular ends) were performed. In one case a portion of diaphragm was resected together with the wall tumor.

Reconstructions were performed using rib-grafts (2 patients), meshes (12 cases), meshes and muscle (8 cases), muscle (6 cases) and myocutaneous flaps (9 cases). Postoperative results were good. We can cite one case of complication, graft (mesh) rejection, after which we had to remove it - the reconstruction had to be supported by muscular flap only. One patient with radical sternal resection had bilateral pleural empyema which was drained and did not compromise reconstruction.

The analysis of pulmonary function parameters demonstrated restrictive slight ventilation disturbances and mild hypoxemia in 8 patients, though without clinical manifestations. Transient respiratory insufficiency was noted in 1 case; this patient

spent 3 days on artificial respiration and his status was normalized.

DISCUSSION

Direct chest wall defect closure is considered the best choice. In situations when it is not possible, various techniques should be applied to strengthen chest wall integrity and achieve its stability important for normal breathing. Reconstruction aims at stability and firmness of the chest wall, preventing paradoxal movability and lung hernia, enabling adequate respiratory movement and ventilation, and hermetic and esthetic defect closure.

Indications for chest wall reconstruction after tumor resection depend on the size and site of the defect. Defects of less than 5 cm in diameter anywhere in the chest wall do not require reconstruction. Posterior superior defects of less than 10 cm in diameter do not have to be reconstructed since they are covered with shoulder blades and large back muscles - they provide adequate firmness and stability and do not disturb breathing mechanics. The problem may arise in cases when the lower defect border consists of the 4th and 5th rib, since the shoulder blade apex may cave in the defect during arm and shoulder elevation and cause complaints. This complication can be prevented by fixing the shoulder blade apex to the lower rib or by resection of the lower third of the shoulder blade or covering the defect with synthetic mesh.

Various autogenous materials have been used to reconstruct large chest wall defects, such as *fascia lata*, periosteum, rib-grafts, diaphragm and omentum, and out of prosthetic materials we should mention various meshes, the most common of which are prolene and *Marlex* meshes and *Gore-Tex Patch*. Their use (with methylmetacrylate support when necessary) provides adequate stability and firmness of the chest wall. For lesions involving the sternum and manubrium, the so-called sandwiches of methylmetacrylate with various types of meshes are very practical solution. *Marlex* meshes, single or as a sandwich, provide appropriate chest wall stability. These meshes are placed under tension but they can be stretched in one direction only, which is a kind of shortcoming. Prolene meshes can be stretched in all directions, but they frequently induce the reaction of foreign body rejection. In such instances, these meshes have to be removed. *Gore-Tex Patch* meshes, 2 mm thick, have certain advantages since they cannot be passed through by air or water, and they are appropriate for large defects and pneumonectomy. *Marlex* sandwich consists of two sheets of *Marlex* mesh with methylmetacrylate in-between; the second mesh passes the free edge of acrylate for 1 cm and serves to fix to the defect borders. Acrylate

provides firmness and is easily shaped; its main shortcomings are the occasional rejection and infection. In cases of infection or radionecrosis (after adjuvant radiation therapy), acrylate has to be completely removed. Mesh fixation should be performed with non-resorbable suture material. Sutures are placed circumferentially around the defect, through the muscle and fascia, then through the rib, cartilage or sternum. Pleural area drainage is compulsory drains should be put in place before defect reconstruction.

Partial sternal resection is easily reconstructed with *Marlex* mesh. In total sternotomy, *Marlex* sandwich is utilized. Covering of the reconstruction site is easily accomplished with the muscular flap of the major pectoral muscle; proper abdominal muscle is rarely used. In case of skin involvement, myocutaneous flap is used. Pleural drainage is necessary since both pleural cavities are opened during the operation. For defects involving the sternal body, manubrium and sternoclavicular joints, ie. medial clavicular ends, reconstruction is performed also to protect the organs and major blood vessels beneath the removed structures. Respiratory insufficiency is rare after *Marlex* mesh and *Marlex* sandwich reconstruction, but if it develops ventilation, support usually lasts 2-3 days.

In metastatic tumors reconstruction is rarely required since primary covering of the defect is possible. For large metastatic lesions, *Marlex* mesh or muscular and myocutaneous flaps are used for reconstruction.

After wall resection, in most cases there is enough skin, subcutaneous tissue and muscle to cover the defect, ie. to close the incision. It is vital that skin margins are healthy and tension-free, since thus we prevent necrosis, dehiscence and exposure of the reconstruction site, ie. development of infection. In order to cover the defect, some of the plastic surgery procedures are utilized, so that the co-operation of thoracic and plastic surgeons is important.

Large defect coverage in one act is possible if we use cutaneous and myocutaneous flaps. They retain autonomous vascularization which permits reliable and cosmetically acceptable reconstruction of soft tissue defects even at a distance from the muscle bed.

Axial flap is a single, stalk-like flap of skin and subcutaneous tissue with axially placed vascular stalk. It can be freely utilized in spite of its length, far surpassing the base. The most famous axial flap is deltopectoral flap. *Myocutaneous flap* provides good defect coverage and contributes to wall stability. Most commonly utilized are the flaps containing the broad back muscle, large pectoral muscle and proper abdominal muscle. *Pectoral flap* is vascularized by the pectoral branch of the

thoracoacromial artery, entering the muscle lateral to the medioclavicular artery. After the mobilization along the neurovascular trunk, the muscle can be rotated and brought to the desired place. Functional inability and contour defect are minimal. Portions of the muscle may be used as well (the muscle has three segmental branches). *Latissimus dorsi* flap can be used with or without skin, as a muscular or myocutaneous flap. Thoracodorsal artery is the main vessel contributing to the supply of the muscle and the skin above it. By means of dissection it is possible to obtain a large flap (10 cm x 16 cm), with long and continual stalk. Filling up the defect, the flap with its mass provides stability and approximately normal wall configuration. *Rectus abdominis* flap is most commonly used as a transversal flap (*TRAM flaps*). The muscle and the covering skin is supplied by the upper and lower epigastric arteries, running along the posterior aspect of the muscle. The flap may extend to the anterior thoracic wall or the lower part of axilla. *Free flaps* are being introduced through the development of microsurgical vascular technique. They consist of muscular and cutaneous tissues supplied by the autonomous vascular stalk anastomosed with blood vessels in the defect area. Among them, myocutaneous flap *tensor fascia lata* is a familiar one, being used to cover wide chest wall defects induced by radionecrosis. Anastomosis is performed with *a.transversa cervicalis* or *a.toracoacromialis*. *Omentum* can be used if muscular flap is not available or it is not large enough. The basis of omentum consists of the left or

right gastroepiploic artery. Omentum is prepared through laparotomy and it is later brought to the place where it should cover the defect previously reconstructed with rib grafts or mesh. Free autotransplants of the skin are placed over the omentum.

Complications, encountered after block-resections of the chest wall are rare and depend on the extent of tumor invasion, ie. the extent and complexity of surgery. Among the surgical complications after wall resection and defect reconstruction there is bleeding at the resection site, most commonly from the intercostal vessels or *a.mammaria*, pleural effusion, seromas, wound infection, circumscribed empyemas, rejection of alloplastic material. Respiratory insufficiency due to disturbed chest wall stability is rare it is encountered with large defects and usually transient, but sometimes requires artificial respiration. In order to preserve adequate breathing mechanics, potentially compromised by the operation, it is vital to achieve long-lasting analgesic effect. Without pain, the patients very easily adapt to the new situation after extended resection of the chest wall.

CONCLUSION

Due to a wide spectrum of options at the disposal to thoracic and plastic surgeons, it is nowadays possible to perform large-scale, radical resections and reconstructions of the chest wall defects.

REFERENCES

1. Pairolero P.: Chest Wall Tumors. In: Shields T.: General Thoracic Surgery 4th ed. Williams & Wilkins, 1994,579-588.
2. Hood RM.: Surgical Anatomy of the Thoracic Wall and Pleura. In: Surgical Diseases of the Pleura and Chest Wall. WB Saunders, Philadelphia, 1986,1.
3. Martini N, McCormack P, Bains M.: Chest Wall Tumors: Clinical Results of Treatment. In: International Trends In General Thoracic Surgery, Vol 2: Major Challenges. Saunders,1987,284.
4. Allen MS, Mathisen DJ, Grillo HC, Wain JC, Moncure AC and Hilgenberg AD.: Bronchogenic carcinoma with chest wall invasion. Ann Thorac Surg, 1991;51:948.
5. Anderson BO., Burt ME.: Chest Wall Neoplasms and Their Management. Ann Thorac Surg; 1994, 58:1774
6. Athanassiadia K, Kalavrouziotisa G, Rondogiannib D, Loutsidisa A, Hatzimichalisa A, Bellenis I.: Primary chest wall tumors: early and long-term results of surgical treatment. Eur J Cardiothorac Surg, 2001;19:589
7. Albes JM., Seemann M.D, Heinemann M.K., Ziemer G.: Correction of Anterior Thoracic Wall Deformities: Improved Planning by Means of 3D-Spiral-Computed Tomography; Thorac Cardiovasc Surg; 2001, 49: 41
8. Gefter WB. Magnetic resonance imaging in the evaluation of lung cancer. Semin Roentgenol, 1990;25:73
9. Christiansen S, Semik M., Dockhorn-Dworniczak B, Rötger J., Thomas M., Schmidt C, et al: Diagnosis, Treatment and Outcome of Patients with Askin-Tumors. J Thorac Cardiovasc Surg, 2000; 48:311
10. Gros JL, Younes RN, Haddad FJ, Deheinzelin D, Pinto CAL, Costa MLV, Soft-Tissue Sarcomas of the Chest Wall - Prognostic Factors, Chest, 2005;127:902-908
11. Bédard ELR, Tang A, Johnston MR.: Massive primary chest wall chondrosarcoma, Europ J Cardio-Thorac Surg, 2004;25(6):1124-1125
12. Charalambos Zisis, Apostolos Dountsis and Jubrail Dahabreh.: Giant chest wall tumor, Europ J Cardio-Thorac Surg, 2004; 24(5):825
13. Lioulias AG, Kokotsakis JN, Milonakis MC, Skouteli EAT, Boulafendis DG.: Radical resection of a giant chondrosarcoma of the anterior chest wall, Europ J Cardio-Thorac Surg, 2003;75(1):296

REKONSTRUKCIJA VELIKIH DEFEKATA ZIDA GRUDNOG KOŠA NAKON RADIKALNE RESEKCIJE MALIGNIH TUMORA

SAŽETAK

Vojkan Stanic¹, Marjan Novakovic², Tatjana Vulovic³, Vlado Cvijanovic¹,
Aleksandar Ristanovic¹, Bojan Gulic¹

¹Vojno medicinska akademija, Klinika za grudnu hirurgiju, Beograd

²Klinika za plastičnu i rekonstruktivnu hirurgiju, Beograd

³Klinički centar Kragujevac, Centar za anesteziju

U svom radu autori iznose postignute rezultate u rekonstrukciji velikih defekata zida grudnog koša izazvanih radikalnom resekcijom malignih tumora. U Klinici za grudnu hirurgiju Vojnomedicinske akademije u Beogradu, u periodu od 2000. do 2005. godine, operisano je 27 bolesnika sa malignim tumorom zida grudnog koša. Nakon radikalne resekcije, izvršena je stabilizacija zida, a zatim, pokrivanje defekta. Dobijeni rezultati su zadovoljavajući. Autori zaključuju da se slobodno mogu vršiti proširene resekcije zida grudnog koša bez bojazni da će doći do nestabilnosti zida i problema sa mehanikom disanja.

***Ključne reči:* zid grudnog koša, resekcija, rekonstrukcija**