Reconstruction of the chest wall and the diaphragm using the inverted Y Marlex methylmethacrylate sandwich flap

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Abstract
Objective: Chest wall resection and reconstruction is a demanding operation involving a dedicated team. It can be performed with minimal mortality with excellent cosmetic and functional results using various substitutes. However, reconstructing the lower costal margin with diaphragmatic resection is a challenging prospect needing special techniques. Methods: We describe a technique of reconstructing the chest wall defect involving the lower costal margin and diaphragm with an Inverted Y Marlex Methylmethacrylate Sandwich Flap. Results: There were no intra operative or postoperative complications and immediate extubation was possible in all six patients without the need for postoperative ventilation. There was a good functional and cosmetic result in all the patients. Conclusions: This is an easy and safe technique resulting in a stable and satisfactory reconstruction after large antero-lateral full-thickness chest wall resections involving the diaphragm. © 2004 Elsevier B.V. All rights reserved.

Keywords: Chest wall reconstruction; Diaphragm; Inverted Y Marlex methylmethacrylate flap

1. Introduction

Chest wall resection is performed for a variety of conditions such as primary tumors of the chest wall or the sternum, lung cancer and metastases invading the chest, infections, radio necrosis and trauma [1].

Chest wall resection involves resection of the ribs, sternum, costal cartilages and the accompanying soft tissues. The reconstruction of the defect depends on the site and extent of the resected chest wall [2,3].

Defects involving just one rib can generally be closed by approximating the overlying muscle and will not require any prosthesis. Some defects even larger than two ribs, but located behind the scapula, do not require any prosthesis as the scapula can quite effectively cover the gap. Defects involving up to two ribs can be closed using either Marlex® mesh or Gore-tex® mesh [4].

A large defect will require some form of rigid support. Various techniques have been used successfully for closure of larger chest wall defects. Since 1972, methylmethacrylate substitutes consisting of two layers of Marlex® mesh and a filling of methylmethacrylate have gained increasing popularity for bridging large antero-lateral chest wall defects [5]. Autologous rib grafts with meshes have also been used [6]. We use a moulded plate made from orthopaedic cement (methylmethacrylate), sandwiched between two layers of either Marlex® mesh.

Cover of the prosthesis is important and this can be achieved using muscle flaps like latissimus dorsi, pectoralis major or rectus abdominis, musculo-cutaneous flaps and the omentum [7–9]. Skin cover is structured either by skin closure, a rotation flap or a split skin graft.

Tumours or lesions involving the lower chest wall may involve the diaphragm requiring resection and reconstruction of the diaphragm. Reconstructing the lower costal margin with diaphragmatic resection needs special techniques as it is a major resection requiring a good structural, functional and cosmetic chest wall reconstruction as well as preserving the physiological function of diaphragm. It requires a combination of reconstruction material and techniques. We have to re-establish the rigid bony contour of the lower costal margin and reconstruct the diaphragm to its structural and functional integrity.
We describe the technique using an Inverted Y Marlex Methylmethacrylate Sandwich Flap to reconstruct these defects.

2. Demographics

Six patients were operated by a single surgeon (FJC) using this technique to restore the lower costal margin and the diaphragm between 1999 and 2003. The age group was 34–62 with a male:female ratio of 5:1. Four of the patients had a right-sided resection and the diagnosis varied with four soft tissue sarcomas, one Chondroblastoma and one non-small cell carcinoma of the lung (Table 1).

All the patients had chest radiographs, computerised tomograms, lung function tests and ECG (Fig. 1). The blood investigations included complete haemogram including a coagulation profile, urea and electrolytes and liver function tests. All patients underwent a bronchoscopy prior to intubation in the anaesthetic room.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>Side</th>
<th>Comorbidities</th>
<th>Number of ribs resected</th>
<th>Diagnosis</th>
<th>Procedure</th>
<th>Soft tissue cover</th>
<th>Complication</th>
</tr>
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<tr>
<td>M</td>
<td>58</td>
<td>R</td>
<td>Obesity</td>
<td>4</td>
<td>Chondroblastoma</td>
<td>Chest wall resection and reconstruction</td>
<td>Omentum</td>
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<tr>
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<td>34</td>
<td>R</td>
<td>None</td>
<td>3</td>
<td>Soft tissue sarcoma</td>
<td>Chest wall resection and reconstruction</td>
<td>Subcutaneous tissue and skin</td>
<td>None</td>
</tr>
<tr>
<td>M</td>
<td>62</td>
<td>L</td>
<td>Diabetes, COAD</td>
<td>4</td>
<td>Soft tissue sarcoma</td>
<td>Chest wall resection and reconstruction</td>
<td>Subcutaneous tissue and skin</td>
<td>Basal collapse</td>
</tr>
<tr>
<td>F</td>
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<td>R</td>
<td>Smoker, hypertensive</td>
<td>4</td>
<td>Squamous cell carcinoma of lung</td>
<td>Right lower lobectomy and chest wall resection and reconstruction</td>
<td>Subcutaneous tissue and skin</td>
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<tr>
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<td>L</td>
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<tr>
<td>M</td>
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<td>Stable angina</td>
<td>3</td>
<td>Soft tissue sarcoma</td>
<td>Chest wall resection and reconstruction</td>
<td>Subcutaneous tissue and skin</td>
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</tr>
</tbody>
</table>

3. Inverted Y Marlex methylmethacrylate sandwich flap

3.1. Technique

Anaesthetic consideration. The patients had a double lumen endotracheal tube. All patients had a triple lumen central venous catheter placed preoperatively. They were monitored with invasive arterial pressure monitoring, electrocardiographic monitoring throughout the procedure. An epidural catheter placed preoperatively provided pain relief.

Resection. The chest wall resection was performed taking all the standard precautions. The patients were placed in a lateral position. The surgical field was creatively prepared ensuring all the areas including donor areas for flaps are prepared. The chest wall was resected using sharp and diathermy dissection and dividing the bones with shears after ligating the vascular pedicles. The ribs and the costal margin were resected with the tumour. The diaphragm was resected with the tumour with an adequate clearance.

Fig. 1. (A) Chest radiograph demonstrating the tumour on the right lower chest wall. (B) CT Scan demonstrating the chest wall tumour involving the diaphragm.
This resulted in a defect in the costal margin with a defect in the diaphragm. The defects were measured to design the flap.

**Sandwich.** The Marlex® sandwich was then custom made according to the size of the defect. The Marlex® mesh was folded on itself and the edges on the three sides are sewn with prolene sutures with a small gap to instill the methylmethacrylate (Fig. 2A). While fashioning the mesh, the edges on one side are left loose as flaps. The methylmethacrylate was then mixed in a pot with gentamycin. It was stirred to a paste-like consistency and instilled into the created marlex pouch. It was carefully smoothed and uniformly spread inside the pouch. The sandwich was then moulded into the contour of the chest wall (Fig. 2B).

**Reconstruction.** The sandwich was then fixed to the defect with interrupted vicryl sutures with the free flaps on the caudal side (Fig. 3). After placing the mesh into a satisfactory position, the edges were secured with continuous runs of Vicryl® sutures to the intercostals. The inner free flap was then folded inwards and trimmed to suit the defect in the diaphragm. It was sutured to the diaphragm using continuous runs of 4 0 Prolene® sutures. The outer free flap was then sutured to the anterior abdominal wall with Vicryl® sutures. This resulted in the stable chest with reconstructed diaphragm (Fig. 4). Two chest drains and sub diaphragmatic drains were placed.

**Soft tissue cover.** We were able to approximate the skin and subcutaneous tissues and closed primarily in four patients. An omental flap was mobilised and placed on the sandwich and the skin was closed on it in one patient and a latissimus dorsi flap was used in one patient. Suction drain was used for the subcutaneous space in the patient with the muscle flap.

### 3.2. Post operative care

The patients were nursed in the thoracic high dependency unit. All the patients had a chest radiograph the following day as per the unit’s policy. The drains were removed when they drained less than 100 ml in 24 h. The patients had epidural anaesthesia which was converted to oral analgesics on day 3. All the patients had an intense post operative chest physiotherapy.

**Results.** Immediate postoperative extubation was performed in all patients and they were nursed in the high dependency unit.

The average length of stay was 8 days. There was no major postoperative morbidity apart from one patient who required chest physiotherapy for basal pulmonary collapse. The 30-day mortality was zero with no late deaths. We have shown satisfying cosmetic results and a good self-assessment at 6 months after the operation with none of the patients having any paradoxical movements or prosthesis dislocation.
4. Discussion

Resection and reconstruction of large chest wall defects of the lower chest wall including the diaphragm usually require a meticulous planning to estimate the preoperative risk, to delineate the extent of resection required, to plan for the cover and anatomic restoration with a low postoperative morbidity. This requires interdisciplinary planning involving medical oncology, radiotherapy, and thoracic surgery.

Reconstruction of the bony chest wall has various options and techniques available each with its own advantages and disadvantages. The reconstruction is not required if the defect is less than 5 cm in any greatest diameter and even defects up to 10 cm in the posterior wall are well covered by the scapula [4].

There is a wide choice of prosthetic material available for reconstruction for the bony chest wall. Goretex and prolene mesh tend to be the regularly used prostheses vicryl mesh used for temporary stabilization [10]. The prolene mesh does not achieve a watertight seal and is difficult to stretch and suture. Goretex mesh is watertight but has to be a thicker 2 mm mesh to hold the sutures at the tension required for stabilization of the chestwall [4]. The complications with the meshes tend to be seromas and if there is an onset of infection, prosthesis have to be removed.

Reconstruction of the diaphragm has been done in various ways. Primary reconstruction of the diaphragm is performed where ever feasible with non-absorbable suture material. However, if the defect is large, various natural and synthetic alternatives are available to reconstruct the diaphragm.

Gortex and prolene mesh are used frequently for the easy availability and technical simplicity [11]. Latissimus dorsi muscle flaps have been used with and without omentum to reconstruct the diaphragm [12,13]. The results are good but the site of the chestwall excision may limit the availability of latissimus dorsi muscle in thoracic patients. Autologous Facia lata has been used but the disadvantage is a separate incision and harvesting techniques [14].

In cases needing chest wall and diaphragm excision, there have been a combination of these choices used to reconstruct the defects. Our technique offers a built-in combination and simple.

This procedure is best performed with a dedicated surgical team, with adequate experience in reconstructing chest walls. Plastic surgical involvement may be required for reconstruction of the overlying soft tissue defect, however, in our experience we did not require the involvement of the plastic surgeons as the muscle flap was performed by the operating surgeon (FJC).

5. Conclusion

Large defects after resection of the antero-lateral chest wall and diaphragm usually require stabilization of the chest wall and reconstruction of the diaphragm in addition to soft tissue coverage.

We believe that the Inverted Y Marlex Methacrylate Sandwich Flap technique fulfills the criteria of an ideal reconstruction providing enough stability for normal spontaneous breathing and cosmetic acceptability.

The results have been gratifying with minimal morbidity and excellent cosmetic and functional outcome. Our experience demonstrates the simplicity and the utility of this technique for a stable and satisfactory reconstruction after large antero-lateral chest wall resections involving the diaphragm.

References


