Chest Wall Reconstruction For Non-Neoplastic Lesions Using Prolene Mesh With and Without Methyl-Methacrylate

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Objectives: To evaluate the effectiveness and early outcome of using prolene mesh with and without methyl-methacrylate for chest wall reconstruction in non-neoplastic lesions.

Patients & Methods: The study included 19; three patients had bifid sternum, nine patients had chest trauma in the form of blast injury due to gunshot with lost part of the lateral chest wall (full thickness) and seven patients had chest trauma with flail segment of the lateral chest wall with multiple fragmented ribs. All patients received general anesthesia with endotracheal intubation. Patients with bifid sternum operated in supine position and managed by prolene mesh with methyl-methacrylate. All trauma patients managed in lateral decubitus with the affected side up, prolene mesh used in all patients and methyl-methacrylate used with the prolene mesh in patients with large defect areas.

Results: The study included 19 patients, 14 males and 5 females. The mean age was 39.42 years ranged from one year to 67 years. Methyl-methacrylate (bone cement) sandwiched between two layers of prolene mesh used was in 42.1% of patients, in 57.9% of patients a double layer of prolene mesh used without using methyl-methacrylate. 63.2% of patients had no postoperative complications, 10.5% of patients complicated by prolonged air-leak (>7 days), 10.5% of patients complicated by seroma and 15.8% of patients complicated by wound infection. There was no intraoperative nor postoperative mortality.

Conclusion: Using a prosthesis of double layered prolene mesh if sutured under tension is an effective method of chest wall reconstruction, if the defect area is large addition of methyl methacrylate increases the hardness of the prosthesis. This method of chest wall reconstruction has few postoperative complications and favorable outcome.

Keywords: Prolene mesh • methyl-methacrylate • bifid sternum • flail chest • reconstruction.

The most common indications for chest wall resection include tumors (primary, recurrent, metastatic, or locally invasive), infection, congenital abnormalities, tumor ablation (primary or recurrent), radiation injury, and trauma.1,2

Congenital anomalies that may need surgical management in the form of chest wall reconstruction include pectus excavatum, pectus carinatum, Poland's Syndrome, Cantrell's Syndrome and bifid or cleft sternum.3,4 Sternal cleft is a rare congenital anomaly resulting from failure of fusion of the sternal bands, it may be complete or incomplete. The commonly encountered form is cranial sternal V-shaped defect. It's observed at birth and asymptomatic. Surgery is indicated to protect the heart and major vessels from trauma, to improve respiratory dynamics and for aesthetic reasons. Several methods of correction have been described as approximation of the bifold sternal bands by relaxation of costal cartilages, using tissue grafts (cartilage, bone) and inert artificial prostheses (acrylic plaques, marlex mesh).4,5

Chest wall trauma may result in loss of part of the chest wall like patients with close proximity shotgun-blast injuries of the chest, these injuries were common in wars and
suicidal attempts using shotgun, in these cases reconstruction was performed using Tantalum meshes.\textsuperscript{(5,7,9,10)}

Chest trauma may result in flail chest, flail chest management includes observation with pain management, ventilator support and surgical management. Surgical management includes plate fixation, intramedullary device insertion, vertical bridging and wiring. However, there are several limitations to these techniques in patients with large flail segment with comminuted fractures of the ribs.\textsuperscript{(10)}

**Patients and Methods**

The present study was conducted at Department of Cardiothoracic Surgery, Benha University Hospital since Jan 2008 till Jan 2011 to allow a minimum follow-up period of 6 months from the last case operated upon. The study included 19 patients for whom chest wall reconstruction done. Three patients had bifid sternum, \textbf{figure(1)}: shows a case of bifid sternum preoperatively. And sixteen patients had chest trauma, nine of the patients with trauma had lost part of the lateral chest wall (full thickness) due to gunshot, and seven had flail segment of the lateral chest wall with multiple fragmented ribs.

In patients with bifid sternum and those with flail chest routine laboratory investigations done in the form of CBC, liver function tests, kidney function tests and complete coagulation profile. Also, radiological work-up done in the form of chest X-ray and chest-CT. In gunshot patients, samples for laboratory investigations taken while the patient in the emergency operating room and radiological work-up done post-operatively. All patients received general anesthesia with endotracheal intubation.

Patients with bifid sternum operated in supine position, vertical skin incision done from the root of the neck to the middle of the sternum to expose the sternal defect, a double layered prolene mesh with a layer of methyl-methacrylate sandwiched in between fashioned to take the shape of the defect leaving a rim of mesh to act as a sewing surface, the fashioned piece fixed to the sternal edges by interrupted prolene #0 stitches. A suction drain placed above the mesh and incision closed in layers. \textbf{Figure(2)}: shows a case of bifid sternum during placement of the prolene mesh with methyl-methacrylate intraoperatively. \textbf{Figure(3)}: shows a case of bifid sternum 24 hours postoperatively.

Patients with gunshot operated as emergency cases. \textbf{Figure(4)}: shows a case with lost part of the lateral chest wall due to gunshot. These patients operated in lateral decubitus with the affected side up, the ipsilateral thoracic cavity explored and managed for any lesion of the lung and pleural cavity, then a chest tube inserted and connected to underwater-seal. Area deficient of ribs and intercostal muscles covered by a double layered prolene mesh which is used in all patients and stretched as possible while fixing it to the surroundings by prolene #1,
if the defect area is large with loss of four ribs or more methylmethacrylate layer added between the two layers of the prolene mesh. If methyl-methacrylate is used a rim of mesh left to act as a sewing surface which is fixed to the surroundings by interrupted prolene #1 stiches and a suction drain placed above the mesh. Extensive undermining of the surrounding muscles with pushing the ipsilateral shoulder down was sufficient to approximate edges of the muscles in all patients, edges of the muscles sutured together by vicryl #1, then completing the wound closure. Figure(5): shows a case with lost part of the lateral chest wall due to gunshot 24 hours postoperatively.

Patients with flail segment managed as those with gunshot except that, they were managed as elective cases, the flail segment with fragmented comminuted fracture of the ribs removed surgically with the intercostal muscles in between. There was no need for extensive undermining of the muscle layers as there was no muscle loss. Figure(6): shows an intraoperative case after reseption of the flail segment and placement of the prolene mesh with methyl-methacrylate.

Results

This study included 19 patients, 14 (73.7%) males and 5 (26.3%) females. The age ranged from one year to 67 years with mean (SD) of 39.42 (±23.25) years, the mean age of females included is 32.4 years and the mean age of males included is 41.93 years. In three cases the lesion was bifid sternum, while in the other sixteen patients the lesions were due to chest wall trauma.

In the sixteen patients of trauma, the left side was the affected side in 62.5% (n=10) of patients, while the right side was the affected side in 37.5% (n=6). In 9 (56.3%) patients there was loss of full thickness of part of the affected chest wall, which means loss of skin, muscles and ribs (SMR) with or without affection of the ipsilateral lung. In 7 (43.7%) patients, flail segment with multiple fragmented ribs (with or without affection of the ipsilateral lung) was the indication for reconstruction. There was affection of multiple ribs, either as part of full thickness loss or by being multiple fragmented ribs. The number of affected ribs ranged from 3 to 7 with mean of 4.5(±1.21) ribs. Ipsilateral lung affection varies from pulmonary tear and contusion which occurred in 4 (25%) patients, to minor traumatic consolidation which occurred in 7 (43.8%) patients, in 4 (25%) patients there were minor contusions and in one patient (6.3%) there was major tear of the left lower lobe that necessitates left lower lobectomy. In one patient of those with pulmonary tear and contusion wedge resection done while the other three patients the lung tear treated by suturing the tear with 4/0 vicryl sutures.

Methyl-methacrylate (bone cement) sandwiched between two layers of prolene mesh used was in 42.1% (n=8) of patients, in 57.9% (n=11) of patients a double layer of prolene mesh used without using methyl-methacrylate.
Descriptive Statistics

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Table 1. Shows periods of chest tube stay and hospital stay.

63.2% (n=12) of patients had no postoperative complications, 10.5% (n=2) of patients complicated by prolonged air-leak (>7 days), 10.5% (n=2) of patients complicated by seroma and 15.8% (n=3) of patients complicated by wound infection. No chest tubes were inserted in the three cases of bifid sternum, while in all trauma patients chest tubes were inserted. Chest tube stay ranged from 3 to 14 days with mean of 7.13±3.34 days. Hospital stay ranged from 5 to 15 days with mean of 8.79±3.31 days. Table 1: shows periods of chest tube stay and hospital stay.

Discussion

The current study included 19 patients treated by chest wall reconstruction, three patients had bifid sternum which is a rare condition and as stated by Roccaforte et al.,(13) (In modern literature there are only five cases of bifid sternum reported which were successfully operated upon) and although this statement wrote in 1959, recent literatures confirms the rarity of this condition as Acastello et al.,(14) reported that cleft sternum represented 0.15% of 5,182 patients were seen for chest wall malformations. In these three cases with bifid sternum the defect was triangular affecting the upper part of the sternum and was not associated with ectopia cordis but the skin in the deficient area was moving-in with inspiration and crying. In all these cases the defect covered by a double layers of prolene mesh with a layer of methyl-methacrylate sandwiched in between, Bajani et al.,(15) described the success for use of prolene mesh in a similar case. In this study addition of methyl-methacrylate supposed to add more protection of the underlying structures and pericardium from trauma.

Sixteen of patients included in this study needed chest wall reconstruction because of chest wall trauma. In 9 patients there were loss of full thickness for part of the lateral chest wall, and the ipsilateral lung was visible clearly through the defect. In those patients the lost part was due to being shot from near, by gunshot loaded by ammo in the form of cartridges filled with a lot of little balls made of metals, all these cases operated in the emergency OR.

In our department we noted high mortality rate of old patients presented by flail chest with large flail segment even with good analgesia and positive pressure ventilation, and according to Granetzy et al.,(16) surgical fixation can help significantly in reducing the duration of ventilatory support and in conserving the pulmonary function. Ahmed and Mohyuddin,(17) in a study included 64 cases of flail chest injury, 26 were managed by internal fixation of ribs by using Kirshner wires as a method of fixation of non-comminuted fractured ribs. Each wire was passed through the cortex into the medulla 3 to 4 cm from the fracture site and driven across into the other fragment. Haasler,(18) described the use of multiple metallic struts as a method of open fixation of flail chest after blunt trauma also Paris et al.,(19) described the use of different types of stainless steel struts for surgical stabilization of traumatic flail chest. And as stated by Carbognani et al.,(20) (The surgical stabilization of the complex post-traumatic flail chest, when indicated, can be sometimes a difficult challenge necessitating original technical solutions). Bibas and Bibas(21) reported the use of prosthetic mesh and methylmethacrylate as for surgical fixation of a case of flail chest.

In patients of trauma there were affection of multiple ribs, either as part of full thickness loss or by being multiple fragmented ribs. The number of affected ribs ranged from 3 to 7 with mean of 4.5±1.21 ribs, these results are a little bit less than that obtained by Paolero and Arnold(22) in a study included 205 patients surgically managed for chest wall defects, they reported a mean of 5.4 ribs were resected in 142 patients. Also, regarding this point our results are close to that obtained by Mansour et al.,(23) in a series of 200 patients. The 200 patients underwent chest wall resection with an average of 4±2 ribs (range 2 to 9). The anterior and lateral ribs were the most commonly (72%) resected.

Immediate closure of the thoracotomy was performed for all patients even for those with SMR loss, by extensive undermining of the surrounding muscles; these results are close to that obtained by Mansour et al.,(24) Immediate closure was performed in 195 (98%) of the patients and 5 patients (3%) underwent delayed closure at an average of 10 days after chest wall resection. Also in patients of trauma, ipsilateral lung affection varied from pulmonary tear and contusion which occurred in 4 (25%) patients, to minor traumatic consolidation which occurred in 7 (43.8%) patients, in 4 (25%) patients there were minor contusions and in one patient (6.3%) there was major tear of the left lower lobe that necessitates left lower lobectomy. In one patient of those with pulmonary tear and contusion wedge resection done, while the other three patients
(18.9%) the lung tear treated by suturing the tear. These results were far away from that reported by Karmy-Jones et al.,\textsuperscript{25} in a study included 143 patients for whom surgical treatment of the ipsilateral lung injury was in the form of suture alone in 9%, wedge resection in 30%; lobectomy in 43%; and pneumonectomy in 50%.

In all patients included in this study prolene mesh was used, methyl-methacrylate sandwiched between two layers of prolene mesh used was in 42.1% (n=8) of patients, in 57.9% (n=11) of patients a double layer of prolene mesh used without using methyl-methacrylate. In the three patients with bifid sternum methyl-methacrylate was used, Stanić et al.,\textsuperscript{26} used the same technique in a case report of sternal chondroma surgically treated by subtotal sternectomy.

In this study Methyl-methacrylate (bone cement) sandwiched between two layers of prolene mesh used in 42.1% (n=8) of patients, in 57.9% (n=11) of patients a double layer of prolene mesh used without using methyl-methacrylate these results were far from that reported by Mansour et al.,\textsuperscript{22} who reported the use of Prolene mesh in 25% (n=49), Marlex mesh 11% (n=21) and methyl-methacrylate sandwich in 6% (n=11) of patients. In this study there was no intraoperative mortality.

Only one patient (5.26%) needed postoperative mechanical ventilator for 2 days, that patient was on mechanical ventilator preoperatively for two days because of hypoxia caused by large flail segment and regarding this point our result was better than that reported by McCormack et al.,\textsuperscript{29} in a study included 155 patients for whom chest wall reconstruction done, 13% (n=20) of patients needed mechanical ventilator.

There was no postoperative complications in 63.2% (n=12) of patients, two (10.5%) patients complicated by prolonged air leak (> 7 days), two (10.5%) patients complicated by seroma and three (15.8%) patients complicated by wound infection. The percent of seroma and wound infection in our study was higher than that reported by Deschamps et al.,\textsuperscript{29} in a study included 197 patients for whom chest wall reconstruction was done. Sixty-four patients (32.5%) underwent reconstruction with polypropylene mesh, Seromas occurred in 14 patients (7.1%). Wound infections occurred in 9 (4.6%) patients.

There was no paradoxical movement noticed after surgery in all patients. The suction drain that placed above the mesh removed in the 3\textsuperscript{rd} postoperative day in all patients with minimal drainage in all patients. No chest tubes were inserted in the three cases of bifid sternum, while in all patients of trauma chest tubes were inserted. Chest tube stay ranged from 3 to 14 days with mean of 7.13±3.34 days. Hospital stay ranged from 5 to 15 days with mean of 8.79±3.31 days. Regarding hospital stay our results are close to that obtained by Weyant et al.,\textsuperscript{27} in a study included 262 patients with chest wall resection and reconstruction with and without rigid prosthesis, the median length of stay for all patients was 7 days (range, 1 to 67).

Follow-up of patients for 6 months after discharge, in the outpatient clinic showed that all patients had returned to their normal daily activity and this result is better than that reported by Lardinois et al.,\textsuperscript{28} in a study included twenty-six patients underwent chest wall reconstruction by use of mesh and methyl-methacrylate and follow-up for 6 months, nineteen patients (73%) suffered no restrictions of daily activities.

**Conclusion**

Prolene mesh and methyl-methacrylate are cheap relative to other prosthesis used for chest wall reconstruction, and they are available in most hospitals. Using a prosthesis of double layered prolene mesh if sutured under tension is an effective method of chest wall reconstruction, if the defect area is large addition of methyl methacrylate increases the hardness of the prosthesis. No paradoxical movement noted in our patients postoperatively. This method of chest wall reconstruction showed few and acceptable postoperative complications. Follow-up of the patients for 6 months showed favorable outcome.

**References**


