ABSTRACT

Background: Despite the low incidence of chest wall defects and infections post operatively after cardiac surgeries, they are significant cause of death and potentially life threatening complication. Therefore, we aimed to review the different surgical techniques for reconstruction of chest wall defects after Cardiac surgery. This will be preceded by reviewing the risk factors, the pathological process involved, diagnostic criteria and the preventive measures to these patients. Methods: This is an observational study that was conducted in Al-Zahraa University Hospital and health Insurance hospital (Cairo, Egypt) over the period from April 2014 to June 2015. We included thirteen cases with different chest wall defects after cardiac surgeries that underwent reconstructive procedures. All patients were subjected to history taking and physical examination. Results: Our study was carried on 30 patients after cardiac surgery as shown in Table 1. The study included 18 males and 12 females and their age ranged from 16 to 70 years old with a mean of 46.72 years. Out of 30 enrolled patients, 18 (60%) were obese, 15 (50%) diabetic, 9 (30%) with chronic obstructive pulmonary disease, 3 (10%) use intra-aortic balloon pumps, and 3 (10%) underwent reoperation for control of postoperative bleeding. The mean number of post-operative days until the last drain was removed was 4 days (ranged from 2 to 7 days). The median length of the ICU stay was 6 days (ranged from 2 to 12 days). The median length of the hospital stay from the original procedure till discharge to home was 21 days, with a range of 14 to 35 days. Conclusion: Early diagnosis and proper treatment is the key point in this serious problem. Early diagnosis depends on high index of suspicion and daily examination of the patient. Once diagnosis established, early treatment is mandatory to prevent more complications and more destruction of tissues.

INTRODUCTION

The median sternotomy incision advocated by Julian in 1956 allowed the surgeon excellent access to mediastinal structures without the pain associated with muscle splitting incisions and rib retraction (1). Despite the relative ease in performing this incision, it is not without complications. Some of these complications are chest wall defects and infections (2). Disruption and infection of chest wall wounds are grave complications occurring in 0.3 – 5% of cases. The problem is associated with a mortality rate between 14 and 47% (3). Risk factors for the development of chest wall defects include factors in the patient, operative causes and supplementary radiation therapy. Patient factors include obesity, osteoporosis, diabetes mellitus, corticosteroid use, chronic obstructive pulmonary disease, and a history of radiation therapy to the chest (4,5).

Technical errors in sternotomy or closure breaks in sterile technique and bilateral internal mammary artery harvest, all increase the probability of wound breakdown (6,7). Sternal wound defects are hard to manage and need the use of flaps for reconstruction. Musculocutaneous flap, the fasciocutaneous flap, omental flap and microvascular composite tissue transplantation have made possible significant advances in the field of plastic and reconstructive surgery (8,9). It was reported that successful treatment of chest wall defect using primary omentoplasty (10). Previous studies presented excellent results in a series of patients treated primarily with muscle flaps (11). Muscles used as flaps for the treatment of chest wall defects include pectoralis major, Rectus abdominis and latissimus dorsi muscles. Pectoral flaps were considered as a treatment for infected chest wall defect of median sternotomy and currently are a standard treatment of this complication (12,13). Hence, there’s no question that the use of the muscle flaps is a significant advance in the treatment of chest wall defects. This study aims to review the different surgical techniques for reconstruction of chest wall defects after Cardiac surgery. This will be preceded by reviewing the risk factors, the pathological process involved, diagnostic criteria and the preventive measures to these patients.

PATIENTS AND METHODS

This is an observational study that was conducted in Al-Zahraa University Hospital and health Insurance hospital (Cairo, Egypt) over the period from April 2014 to June 2015. We included thirteen cases with different chest wall defects after cardiac surgeries that underwent reconstructive procedures. All patients were subjected to history taking and physical
examination. We took the history regarding age, sex, risk factors including obesity, diabetes mellitus, chronic obstructive pulmonary disease, the use of intra-aortic balloon pump, reoperation for postoperative bleeding and the use of internal mammary artery as a graft in CABG. Moreover, complete general and local examination including fever, increased pain, erythema, discharge and chest wall instability were done.

**Laboratory Evaluation**
We evaluated the occurrence of spiking fever with marked leukocytosis, positive blood cultures prompted more intensive investigations of chest wound while other sources of infection were being excluded. Culture and sensitivity results were usually available within 2–3 days of the onset of discharge to modify the antimicrobial therapy when needed.

**Radiological Investigations**
In plain chest X-Ray, midline radiolucent strip on postero-anterior film was sometimes a positive sign that may herald the development of chest wall defect. Also the lateral film may be useful for the evaluation with the presence of air fluid levels, or soft tissue density. CT scanning of the chest had been used successfully to differentiate superficial soft tissue defects and infections from deep defects and retrosternal involvement.

**Indications for Surgical Intervention**

- Culture-positive deep chest wall defects were the most frequent indication for surgical intervention.
- Culture-negative sternal dehiscence and/or culture negative drainage but had clinical course consistent with sternal wound infection.

**Reconstruction of Sternal Wound Defects**
The patient was placed in the supine position with the arms placed by his/her side. A sand bag was put under the shoulders. The patient was dropped in the usual fashion with exposure of the sternum up to the mid-clavicular line and at least one groin. Wound exploration with complete reopening of the sternotomy wound. All wires were removed and wound cultures were taken. The sternal edges were debrided until healthy solid bone with briskly bleeding margins was found. The wound was repeatedly irrigated with copious amounts of betadine solution for clearing of the wound before closure. Two rigid multiperforated retrosternal tubes were placed. Reclosure of the sternum using stainless steel wire was done by using one of two methods; Interlocking figure of (8), or Bilateral longitudinal bars with interrupted transverse sutures. Reconstruction procedures were done by using either pectoralis major muscle flap, rectus abdominis muscle flap or omental flap. Table 1 summarizes the causes of chest wall defects and methods for chest wall reconstruction.

<table>
<thead>
<tr>
<th>The original Procedure</th>
<th>Number of Patients (n=30)</th>
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<tbody>
<tr>
<td>Mitral valve replacement</td>
<td>6 (20%)</td>
</tr>
<tr>
<td>Aortic valve replacement</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Double valve replacement</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>CABG with LIMA</td>
<td>15 (50%)</td>
</tr>
<tr>
<td>CABG with BIMAs</td>
<td>3 (10%)</td>
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</table>

<table>
<thead>
<tr>
<th>The reconstructive procedure</th>
<th>Number of Patients (n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latissimus dorsi muscle flap</td>
<td>6 (20%)</td>
</tr>
<tr>
<td>Pectoralis major muscle flap</td>
<td>15 (50%)</td>
</tr>
<tr>
<td>Rectus abdominis muscle flap</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Omental flap</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Dacron patch reconstruction</td>
<td>3 (10%)</td>
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</tbody>
</table>

**Reconstruction of Lateral Chest Wall Defects**
The patient was placed in the prone position with the side of the defect directed upwards. The latissimus dorsi muscle was harvested through extending the incision on its lateral border. The anterior surface of the latissimus dorsi muscle is undermined to allow complete exposure of the muscle. The muscle was mobilized from the chest wall with its thoracodorsal pedicle intact. The mobilized muscle was sutured to the edges of the defect by interrupted sutures. The skin was closed over multiple drains under the flap.

**Statistical Analysis**

We used Statistical Package for Social Sciences (SPSS, version 15 for windows) software to conduct the statistical analysis. Categorical data were described in terms of frequency and percentages.

**RESULTS**
Our study was carried on 30 patients after cardiac surgery as shown as in Table 1. The study included 18 males and 12 females and their age ranged from 16 to 70 years old with a mean of 46.72 years. Out of 30 enrolled patients, 18 (60%) were obese, 15 (50%) diabetic, 9 (30%) with chronic obstructive pulmonary disease, 3 (10%) use intra-aortic
balloon pumps, and 3 (10%) underwent reoperation for control of postoperative bleeding.

**Preoperative Assessment**

We found that six cases of mitral valve replacement via median sternotomy by carbomedics (2.27, 3.29, and 1.31). Three case of Aortic valve replacement by carbomedics number (21, 19, and 21) reduced via medium sternotomy incision. Three case Double valve replacement via median sternotomy incision. Eighteen cases of CABG operations via median sternotomy. In fifteen cases the LIMA was used and in only three cases the BIMAs were used. Careful observation of the charts determined the earliest signs of defects and infections. The most frequently early abnormalities were a temperature greater than 38.7°C and a white blood cell count more than 12,000 per cubic millimeter and drainage from the wound of the chest tube site. Manifestations of chest wall defects and infections in the thirteen patients under the study include:

(A) **Local wound manifestations:**

- Increased pain: 12 cases
- Erythema discharges: 24 cases
- Chest wall instability: 21 cases

(B) **Systemic Toxicity manifestations:**

- Spiking temperature: 24 cases
- Leukocytosis: 18 cases
- Positive blood culture: 9 cases

In twenty one cases the wound culture and sensitivity were positive (21 sternal defects) while it was negative in nine cases (six associated with sternal dehiscence, three associated with prolonged sternal drainage).

Gram-positive organisms including both staphylococcus aureus and staphylococcus epidermidis were isolated from the wound of twelve patients. Of further significance is the observation that this preponderance of staphylococcal infection occurred despite the fact that specific anti-staphylococcal antibiotics were given prophylactically to all patients. Gram-negative organisms, frequently serratia, and pseudomonas aeruginosa were the responsible pathogen in the remaining three patients, table 2.

<table>
<thead>
<tr>
<th>Organisms</th>
<th>Number (n=21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus aureus</td>
<td>6 (28.59%)</td>
</tr>
<tr>
<td>Staphylococcus epidermidis</td>
<td>3 (14.28)</td>
</tr>
<tr>
<td>Mixed, with staphylococci</td>
<td>3 (14.28)</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>6 (28.59%)</td>
</tr>
<tr>
<td>Serratia</td>
<td>3 (14.28)</td>
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</tbody>
</table>

The mean duration between the surgery and the appearance of signs of defects was 10.6 (range from zero to 27 days). More specifically, in this group of ten patients, the time from the original cardiac procedure to flap closure was less than or equal to 7 days in 6 patients, from 8 to 28 days in the remaining 24 patients.

**Operative Assessment**

The average operative time in this study was 160 minutes (range: 125 to 195 minutes). Also, the average blood loss was 500 ml. In terms of intra-operative deaths, there were no cases reported in this series. Twenty four cases were extubated in the operating room while six cases had prolonged intubation in the ICU for one week and died.

**Post-Operative Assessment**

The mean number of post-operative days until the last drain was removed was 4 days (range from 2 to 7 days). The median length of the ICU stay was 6 days (range from 2 to 12 days). The median length of the hospital stay from the original procedure till discharge to home was 21 days, with a range of 14 to 35 days. Two cases died postoperatively in the ICU (20% of cases).

**DISCUSSION**

This idea of using median sternotomy as an approach to thoracic organs was conceived in the late 1899s. A complete vertical division of the sternum was used in an attempt to explore the posterior mediastinum (14). The incision has been used sporadically for a variety of purposes since that time. Moreover, many researchers used incomplete vertical sternotomy with transection at the second intercostal space for pericardiectomy (15). Surgical procedures on the great vessels at or near their origin, those requiring approach through the right atrium, and those done through a right ventricular incision are all best approached from the front. Two choices of incision are available for such an anterior approach. One is the widely used transverse bilateral thoracotomy and the second is the vertical median sternotomy.

Median sternotomy has become the most commonly used incision in cardiac operations. The rapidity and ease with which it can be performed and the excellent accessed it provides to the heart and great vessels are major factors contributing to its widespread acceptance (16). Nearly a century later, prevention and treatment of its infective complications remain a
formidable challenge for cardiothoracic and plastic surgeons (17). Chest wall defects are either sternal defects or lateral chest wall defects, each of them is either superficial (Confin ed to the soft tissue only) or deep, (extend to the bony frame work and even beyond the thoracic cavity or the mediastinum (6). Disruption and infection of chest wall defects are grave complications occurring in 0.3 – 5% of cases. The problem is associated with mortality rate between 14 and 47% (3). The vast majority of chest wall defects are superficial (2% of sternotomies and approximately 70% of all post sternotomy defects) (1).

Tegnell and colleagues (18) reported that the average hospital cost of patient with postoperative chest wall defect and infection was 30.000$ as compared to 15.000$ for non-infected patients. So the postoperative chest wall defects doubles the hospital stay period and cost. This excess cost is primarily due to the associated high morbidity, prolonged hospital stay, and the need for repeated surgical procedures in these patients. Additional cost for the patient, such as loss of income, travel expenses, may add substantially to this.

The mortality associated with untreated suppurative deep sternal wound defects and infections involving the mediastinum are 100% and therefore no series can include untreated control. All procedures designed to control sternal defects and infections are undertaken with great risk because of possible involvement of vital underlying structures by the infections process (19).

Early diagnosis and treatment of chest wall defects may prevent the spread of infection to the prosthetic materials used in either cardiac or thoracic surgeries, with its devastating sequelae. Operative management varies from single dressing up to extensive myocutaneous plastic procedures (20). Superficial defects and infection are treated by simple incision, drainage, and open dressing changes. Deep defects and infection are harder to manage. The most commonly infective organism in this study was gram-positive organisms (57.16%). Staphylococcus aureus presented in (28.58%), staphylococcus epidermidis in (14.28%) and mixed both in (14.28%) of cases. In two cases (28.58%) pseudomonas aeruginosa was isolated from the wound while serratia was isolated from only one case (14.28%).

Limitations: Due to the small sample size of our study, it could not show a significant correlation between mortality risk and factors, such as diabetes mellitus and obesity. These conditions are known to increase the risk of sternal infections; however, whether they increase the mortality risk from these infections requires further investigation.

Conclusion: Despite the low incidence of chest wall defects and infections post operatively after cardiac surgeries, they are significant cause of death and potentially life threatening complication. Early diagnosis and proper treatment is the key point in this serious problem. Early diagnosis depends on high index of suspicion and daily examination of the patient. Once diagnosis established, early treatment is mandatory to prevent more complications and more destruction of tissues. Recently, reconstruction using variable tissue flaps to obliterate dead space and provide immediate coverage of the thoracic contents, showed very high success rate. The omentum, pectoralis major, rectus abdominis and latissimus dorsi muscles have been the most commonly used tissue flaps. In this study, we reviewed the literature and covered the surgical aspect for the application of tissue flaps for reconstruction of chest wall defects including the criteria of the patients, risk factors, surgical techniques and the post-operative management aiming to improve the outcome and reduce the morbid complications in such patients.

Conflict of interest: None

Acknowledgment: None

REFERENCES


