Introduction

Mitral valve surgery using full sternotomy (FS) is the conventional approach for the treatment of the mitral valve disease. Despite this procedure has shown excellent postoperative outcomes, in the last two decades minimally invasive mitral valve surgery (MIMVS) has gained consensus among surgeons as it has provided greater patients satisfaction, maintaining the same quality and safety of the standard mitral valve surgery approach(1).

Interest in minimally invasive options arose as a result of the application of less invasive techniques in other branches of surgery, the challenges of accessing the mitral valve in patients with smaller atriums or larger anteroposterior chest wall diameters, the desire to promote cost-efficienc and patient demand for smaller incisions and accelerated, recovery(2).

The Society of Thoracic Surgeons (STS) database. Defines minimally-invasive cardiac surgery as "any procedure not performed with a full sternotomy and CPB support." According to Chitwood et al., minimally invasive valve surgery should not be defined in terms of a specific procedure, but rather a "philosophy" that requires an operation-specific strategy. Each minimally-invasive strategy introduces alternatives for CPB cannulation (central or peripheral), aortic occlusion (endovascular or transthoracic), and cardioplegia delivery (antegrade, atrial retrograde, or transjugular retrograde)(3).

An important adjunct in the evolution of minimally invasive valve surgery is the parallel progress in perfusion technology. First, smaller, nonkinking arterial and venous cannulae have been combined with vacuum-assisted venous drainage to allow maximal space use provided by the smaller incisions. Second, the implantation of transjugular coronary sinus catheters provides cardiac protection via retrograde cardioplegia. Third, the application of carbon dioxide (CO_2) into the operating field limits intracardiac air (to reduce air embolism). Finally, intraoperative transesophageal echocardiography allows for real-time monitoring of cardiac distention, de-airing, and cannula placement[(4)].

The video-assisted minimally invasive mitral valve surgery is already widely accepted and performed in some surgical services with outcomes that are similar to the conventional techniques[(5)].

Current evidence has shown that, when compared to conventional sternotomy (CONV-ST), MIMVS hastens wound healing and return to activity while improving cosmesis and reducing sternal infection, bleeding, ICU and hospital stay lengths, postoperative pain, and mechanical ventilation time.[(6)]

Although these benefits, criticisms have been raised as MIMVS is technically more complex, requires a distinct learning curve and is associated with higher incidence of neurological events, aortic dissection, groin complications and higher rate of mitral valve replacement instead of mitral valve repair.[(7,8)]

Aim of the Work

To compare between the early outcomes for patients undergoing mitral valve surgery through video assisted thoracoscopic technique and those undergoing mitral valve surgery through conventional full sternotomy technique.

Historical Background

The road to the heart is only two or three centimeters in a direct line, but it has taken surgery nearly 2400 years to travel it[9].

The history of thoracic incisions dates to the Hippocratic era when trephination of empyema cavities was first reported. Subsequent reports primarily documented the use of incisional drainage of chest infections since intrapleural surgery was inevitably associated with respiratory failure due to open pneumothorax. Evolution of thoracic incisions evolved gradually until our avoidance of intrapleural surgery was overcome by recognition of the safety of endotracheal intubation, positive pressure ventilation and the ability to operate safely within the pleural cavity. The choice of which incision to use is guided by such considerations as the surface landmarks, a knowledge of intrathoracic anatomy and the relationships between the two[10].

The median vertical sternal approach was first suggested by Milton in 1897. At the time when cardiac operations were performed through a transverse bilateral thoracotomy, Shumaker reported use of the vertical sternotomy incision for pulmonary valvotomy, and Blalock used it for the same lesion in some of his initial cases[10].

Culter & Levine in 1923 reported a case operated on through a median sternotomy incision in which a special curved knife was inserted through the left ventricular apex to cut a stenotic mitral valve[11].

In 1925, Souttar digitally opened a stenotic mitral valve through the left atrial appendage[12].

Over 20 years later, Harken and associates and Bailey independently demonstrated the feasibility and value of digital commissurotomy[13, 14].

Many useful technical modifications were subsequently added to the operation of closed commissurotomy, one of the most important was Tubb's transventricular dilator used with digital control by a finger inserted through the left atrial appendage[15].

Open heart surgery had become feasible by this time, for Gibbon's first successful operation in 1953 was soon followed by independent important achievements by Lillehei & Kirklin in 1955. Initially, the complications of cardiopulmonary bypass made closed digital commissurotomy a safer procedure, but improvements in cardiopulmonary bypass technology enabled open valvotomy during bypass to be adopted by most centers by 1970 to 1972[16].

For mitral insufficiency, a number of ingenious closed techniques were attempted before 1955, but none proved durable. An effective open approach to this problem was first made with cardiopulmonary bypass by Lillehei and colleagues in 1957; they approached the valve through a right thoracotomy approach and an incision in the left atrium posterior to the interatrial groove[16].

A number of surgeons realized very early the need for replacement of at least some diseased mitral valves.

However, from the University of Oregon Medical Center in Portland, Starr and Edwards first reported successful mitral valve replacement in 1961. This valve firmly launched the modern era of prosthetic valve replacement. This remarkable prosthesis evolved from the combined work of Starr, a cardiac surgeon and Edwards, a mechanical engineer[17].

History of Minimally Invasive Mitral Valve Surgery (MIMVS):

Minimally invasive cardiac surgery began in earnest in the mid-1990s. After the introduction of laparoscopic techniques into general surgery in the late 1980s, a trickle-down effect into thoracic surgery occurred[18].

Therapeutic thoracoscopy, or video-assisted thoracic surgery (VATS), became an increasingly used technique[19].

The VATS procedure expanded so that there currently are many procedures (pulmonary wedge resection, sympathectomy, management of pleural disease) in which thoracoscopic techniques have become preferred and routine. Even the most complex thoracic procedures (pulmonary lobectomy, esophagectomy) are performed routinely using minimally invasive approaches in major specialty centers. A further trickle-down effect on cardiac surgery occurred in the mid-1990s. Three separate efforts occurred to decrease the invasiveness of coronary artery bypass grafting (CABG). The first approach, the Heart port technique, used a minimally invasive left internal mammary artery graft placed to LAD on a full cardiopulmonary bypass established through femoral artery and vein cannulation, with ischemic cardioplegic arrest obtained by an ingenious aortic endoclamp placed through femoral artery access. The coronary bypass procedure then was performed though the limited left anterior thoracotomy incision on an arrested heart[20].

Currently, this procedure has largely been supplanted by other approaches, and the Heart port approach, or modifications thereof, are used almost solely for mitral valve surgery. The second approach, the MIDCAB, uses video assistance for the left internal mammary artery harvest. Bypass on LAD then is performed through a limited left anterior thoracotomy incision without cardiopulmonary bypass using a stabilizer. The third approach, off-pump coronary artery bypass (OPCAB), or beating heart surgery, uses a full sternotomy incision, but has eliminated CPB[21].

At that time surgeons became aware of potential benefits when using minimized incisions for corrections of valvular heart diseases. Mid 90's, Cohn and Cosgrove, along with several European colleagues, first modified CPB techniques and reduced incision sizes to enable safe, effective minimally invasive valve surgery[22-24].

Mitral valve operations during that time were performed under direct vision using a lateral minithoracotomy. The first studies led to the conclusion that mitral valve was sufficiently accessible with minimally invasive techniques[25, 26].

In these pioneering series adequate surgical results with low mortality were documented.

Concurrently, Port-access methods using endoaortic balloon occluders were developed by Heartport, Inc. (Redwood City, CA) and had a period of popularity for mitral valve procedures[27-31].

Due to increased complications associated with this technique, there was a search for an even better and eventually less cost-intensive way to clamp the aorta. Chitwood in 1997 introduced a percutaneous transthoracic aortic clamp[32, 33].

This clamp is an easy to apply device and is simple and cost-effective as it can routinely be sterilized. Direct transthoracic aortic clamping using this clamp is now the mainstay of minimally invasive mitral valve surgery (MIMVS) at many centers[5].

In the following years, good results from different series describing MIMVS led to a more widespread application, even though still limited to some centers, of this technique[35].

Most surgeons who performed MIMVS in this era selected either a variation of a sternal incision or a minithoracotomy, and used direct vision with longer instruments. Simultaneous advances in CPB, instrumentation, and robotic telemanipulation then hastened a technological shift with more surgeons adopting MIMVS in their practice[36].

Thus, the next step in the development of MIMVS was the improvement of valve visualization. Two-dimensional endoscopes were introduced leading to successful MIMVS performed by Carpentier and Chitwood and co-workers[32, 33, 37].

In 1998 Mohr and colleagues reported using a three-dimensional videoscope. This was positioned automatically using voice-activated robot assistance (Aesop 3000) leading to solo surgery[38].

Today, both replacing and repairing cardiac valves through small incisions have become a standard practice for many surgeons as patients have become more aware of its increasing availability[36].

Surgical Incisions Related to Mitral Valve Surgery

Introduction:

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Median sternotomy:

History

The median vertical sternal approach was first suggested by Milton in 1897. At the time when cardiac operations were performed through a transverse bilateral thoracotomy, Shumaker reported use of the vertical sternotomy incision for pulmonary valvotomy, and Blalock used it for the same lesion in some of his initial cases(39).

Advantages

The most common approach in Mitral valve surgery is the median sternotomy[40]. It is less painful than the thoracotomy incision, and by maintaining the integrity of the pleural spaces and lungs, it compromises pulmonary function less, particularly in the immediate postoperative period[41].

The median sternotomy incision has been advocated for lower cervical procedures including tracheal resection and reconstruction, and for exposure of mediastinal structures for resection of mediastinal pathology and for exposure of the heart and great vessels[42].

The incision also provides access to both pleural cavities[43]. Thai extended its utilization to include bilateral pulmonary resections such as for pulmonary metastatectomy[44].

Most importantly, the median sternotomy incision has greatly facilitated the performance of cardiovascular procedures requiring cardiopulmonary bypass including heart and heart-lung transplantation[45].

It provides excellent access to all cardiac structures, allowing for central cannulation using ascending aorta and both caval veins[40]. More recently, the median sternotomy approach allowed OPCAB to be performed with ease[45].

Technique

Positioning:

Patient in the supine position, with arms padded and tucked to the side[46].

It was found that by careful positioning and padding of the arms, it is possible to routinely place both arms at the patient's sides, thus improving the comfort of the operating team. By placing a small pad between the patient's scapulae and tilting the head to one side, access to the upper end of incision is improved, especially in obese patients[47].

Skin incision:

Skin incision is made from the jugular notch[48]. Some authors preferred to start the incision at a more caudal level or even at the sternomanubrial junction for the better cosmetic results when significant cervical exposure is not required and ends just below the xiphoid process or may extend few centimetres below it[45].

Subcutaneous tissues and presternal fascia:

Exposure of one of the edges of the pectoralis major muscle on either side alerts the surgeon that the incision is deviating from the midline. In some patients, the pectoral muscles are well developed and enlarged so that the midline incision will inadvertently cut through them[39].

Once the midline of the sternum is outlined, the submanubrial and subxiphoid spaces are developed using blunt dissection with the fingertip. The incision is carried upward a short distance under the skin into the deep cervical fascia and the interclavicular ligament formed by fibres of the superior sternoclavicular ligament from each side is transected. Venous plexuses near the suprasternal notch are identified and clipped or ligated or cauterized, taking care not to injure the innominate vein[45]. A large bridging vein is usually found and is best dealt with by isolation, ligation and division. Also a constantly present venous plexus overlying the sternoxiphoid junction is identified and cauterized(39). Then dissection of upper rectus fascia is done (taking care not to injure the peritoneum). The xiphoid process is resected or divided by electrocautary (some prefer to divide it with scissors for better protection of the peritoneum)(45).

The sternum:

Sternum is divided longitudinally in the midline, classically with the saw(45). Once the sternum is divided, bleeding from the sternal edges is controlled. Pinpoint haemostasis of the anterior presternal fascia is achieved with the electrocautery under vision whereas the edges of the posterior sternal fascia on both sides are cauterized throughout the length of the sternum to assure control of all the bleeding sites(39).

Bleeding from the bone marrow can be controlled with bone-wax which is not preferred by some surgeons(45); some authors stated that rubbing the sternal marrow on both sides with Gel-foam provides good control of bleeding without the added risk of infection or other complications(39).

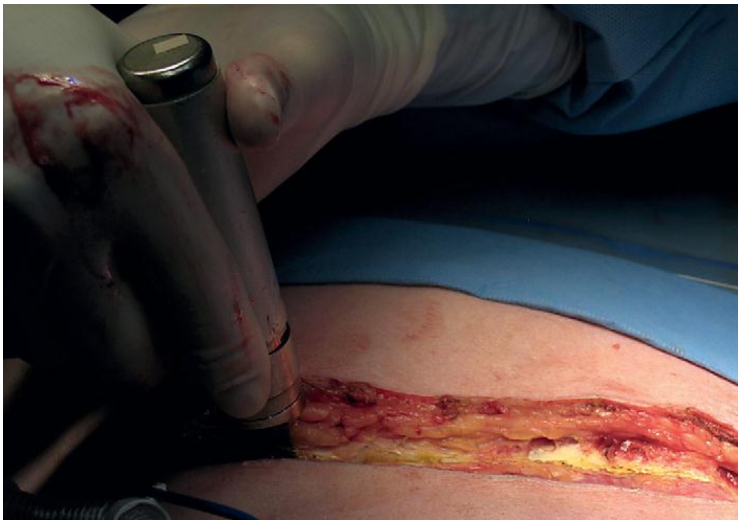

Fig. (1): Median sternotomy incision[52].

Sternal spreader:

"Retractor" is placed in a proper way so as to provide evenly distributed pressure on the sternal edges. It is not to be placed too high, or it will injure the brachial plexus or innominate vein[39].

Retractor is then opened slowly with upper and lower fascial attachments are cut with electrocautary to avoid tearing of tissues along the innominate vein and the diaphragm[46].

The thymic fat pad:

It is divided up to the level of the innominate vein. An avascular midline plane is identified easily, but is crossed by a few thymic veins that are divided between fine silk ties, haemoclips or by electrocautary. Either the left or right, or occasionally both, lobes of the thymus gland are removed only if necessitated to improve exposure. If a portion of the thymus gland is removed, excessive traction may result in injury to the phrenic nerve[48].

The pericardium:

Pericardium is opened anteriorly (inverted T-shaped incision) to expose the heart. Through this incision, operations within any chamber of the heart or on the surface of the heart, and operations involving the proximal aorta, pulmonary trunk, and their primary branches can be performed(48).

Closure:

At the conclusion of the operation, the sternal edges are checked again for any bleeding source. The sternum is re-approximated with stainless steel wires that are passed immediately adjacent to the sternal borders in order to avoid injury to the internal mammary vessels(49).

***When the sternum is soft or osteoporotic*,** it is advisable to wrap the entire sternum with eight stainless steel wires to distribute the load throughout the sternum and to assure a sturdy approximation of the two sternal segments. The usual procedure is to apply two to three wires as wide as possible through the manubrium and then encircle the sternum by applying an additional four to five wires through the intercostal spaces at the level of the sternochondral junction. It should be avoided to place sutures through the sternomanubrial joint or through the costal cartilage or ribs to minimize the chance of inflammation and pain during ambulation(39).

Another useful method of closure of the sternal edges is using three or four interlocking figure-of-eight (butterfly) wire sutures also wrapped around the sternum and passed