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Is the full sternotomy in cardiac surgery still the preferred approach?

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Abstract

Background

There is increasing interest and patient demand for minimally invasive cardiac surgery.

Aim

We aimed to assess the safety and possibilities of such techniques and debated whether it would become the standard procedure.

Patients and methods

Since February 2013 till June 2019, 696 patients underwent variations of cardiac surgery procedures; of them, 456 patients underwent thoracoscopic minimally invasive mitral and tricuspid valve surgery; 65 patients underwent double valve replacement, and of them, 17 underwent concomitant tricuspid valve repair through upper mini-sternotomy; 88 patients underwent aortic valve replacement through upper mini-sternotomy; five cases underwent Bentall procedure through upper mini-sternotomy; five cases underwent atrial septal defect closure via thoracoscopic right mini-thoracotomy; three cases underwent excision of left atrial myxoma; one case underwent concomitant thoracoscopic mitral valve replacement and coronary artery bypass grafting; and 73 cases underwent coronary artery bypass grafting via right submammary incision, and of them 10 cases underwent hybrid technique.

Results

The procedure was successfully performed in all. Conversion rate to full sternotomy was 0% and to mini-thoracotomy procedure was 10 (1.4%) patients. Hospital mortality was seen in four (0.5%) patients, re-exploration for bleeding was done in four (0.5%) patients, and superficial wound infection was seen in 20 (2.8%) patients. Graft failure occurred in one patient who needed redo-operation, and one patient needed to lengthen the Left Internal Thoracic Artery (LIMA) with a composite vein graft.

Conclusion

Thoracoscopic minimally invasive mitral valve surgery and limited sternotomy incisions can be performed safely but definitely requires a learning curve. Good results and a high patient satisfaction are guaranteed. There is increased patient demand and popularity for such techniques in Egypt. Patient selection at the start of the program is essential. The progress is more rapid and promising, and by the end of this decade, there is strong possibility of becoming the standard procedure in cardiac surgery.

Keywords: Cardiac surgery, minimal invasive cardiac surgery, coronary surgery

Introduction

Minimally invasive heart valve surgery is commonly performed through a right mini-thoracotomy [1–3], a parasternal incision – adjacent to the sternum – or a hemisternotomy. Available evidence shows comparable or better results compared with the conventional surgical approach [4–7], which involves a full median sternotomy. Antegrade ascending aorta cannulation is adopted whenever possible (usually for aortic valve surgery). Another commonly used option is femoral artery cannulation with retrograde arterial perfusion. Although there has been a debate over whether retrograde arterial perfusion carries a higher incidence of stroke and other

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vascular complications [8–14], it is frequently used because it is believed that benefits far outweigh risks.

Venous cannulation is performed through the right atrial appendage or through the internal jugular and femoral veins for bicaval access. After institution of cardiopulmonary bypass (CPB), the aortic cross-clamp is applied to the ascending aorta, endoluminal in mitral and tricuspid valve surgery, using the endoballoon (Edwards Lifesciences, Irvine, California, USA), or externally in aortic valve surgery [11]. Transesophageal echocardiography (TEE) plays an important role in assessment and repair of valve pathology, cannula placement, and de-airing of the heart following the valve procedure.

Regarding coronary artery bypass grafting (CABG), often interventional treatment with PCI appears risky or impossible owing to complex lesions, close relationship to the main stem, or other coronary arteries or total occlusion of the target vessel [12]. In other patients, repeated interventions at the LAD remained without longstanding success. Besides its original intention for revascularization of the LAD, MIDCAB can be a useful part of hybrid procedures in patients with multivessel disease where a major coronary surgery procedure would not be well tolerated [13,14]. Although multivessel disease is a predictor of elevated mortality after CABG, the MIDCAB procedure can be performed as a standalone procedure with acceptable results in midterm morbidity and mortality, even though formally incomplete revascularization may remain [15]. Several studies and our own experience proved that in selected patients with main stem stenosis or multivessel disease, MIDCAB can be safely performed [16]. Complete revascularization can be achieved by a hybrid approach with accompanying PCI [16,17]. Interestingly, we found in our own collective that a significant part of the planned PCI has not been performed, as the MIDCAB resulted in ongoing freedom from angina. This is particular true in multivessel disease where the LAD is the dominating vessel. As a rare indication, we treated two children aged 12 and 13 years who had undergone a switch operation as babies for transposition of the greater arteries. Later they developed significant stenosis of the LAD and were successfully treated by MIDCAB with an uneventful postoperative course and restored coronary circulation. Recently, we demonstrated that MIDCAB can be performed in octogenarians with satisfying midterm results. Especially, these patients benefit from the marginal surgical trauma, less anesthesia, and short ventilation duration and ICU stay [18]. A small subgroup of patients received MIDCAB who experienced severe bleeding complications owing to dual antiplatelet medication after PCI with drug-eluting stents [18].

Aim

Owing to the increasing interest and patient demand for minimally invasive cardiac surgery, we aimed to assess the safety and possibilities of such techniques, as well as debated whether it will become the standard procedure.

Patients and methods

The study was approved by the institutional Ethics Committee of National Heart Institute. Since February 2013 till June 2019, 696 patients underwent variations of cardiac surgery procedures; of them, 456 patients underwent thoracoscopic minimally invasive mitral and tricuspid valve surgery; 65 patients of double valve replacement, and of them, 17 underwent concomitant tricuspid valve repair through Upper mini-sternotomy; 88 patients underwent aortic valve replacement through upper mini-sternotomy; five cases underwent Bentall procedure through upper mini-sternotomy; five cases atrial septal defect closure via thoracoscopic right mini-thoracotomy; three cases excision of left atrial myxoma, one case underwent concomitant thoracoscopic mitral valve replacement and CABG; and 73 cases underwent CABG via right submammary incision, and of them, 10 cases underwent hybrid technique.

Patients are arranged into four groups for feasibility of data analysis, as we are not comparing these procedures.

(1) Group 1: 456 patients underwent thoracoscopic mitral surgery.
(2) Group 2: 88 patients underwent aortic valve surgery through upper mini-sternotomy (manubriotomy).
(3) Group 3: 65 patients underwent double valve surgery (aortic + mitral) through upper mini-sternotomy.
(4) Group 4: 73 patients underwent minimal invasive coronary artery bypass surgery MIDCAB through left mini-thoracotomy incision.
(5) Group 5: a total of 14 cases, where five cases underwent Bentall procedure through upper mini-sternotomy, five cases atrial septal defect closure through thoracoscopic right mini-thoracotomy, three cases excision of left atrial myxoma, and one case concomitant thoracoscopic mitral valve replacement and CABG.

Inclusion criteria

Any patient scheduled for conventional procedure was included.

Exclusion criteria

The following were the exclusion criteria:

(1) Emergency and critically presenting patients are excluded.
(2) Patients with severe LV impairment.
(3) Redo cases.

Exclusion criteria specific for each group were as follows:

(1) Any patient with impaired right ventricular function.
(2) Any patient with pulmonary artery pressure greater than 60.
(3) Any patient with peripheral vascular disease or aortic disease.
(4) Patients with absolute or relative contraindications to the use of TEE.

Absolute contraindications to TEE were as follows:

(1) Patients with history of esophageal spasm.
(2) Esophageal stricture.
(3) Esophageal laceration.
(4) Esophageal perforation.

(5) Esophageal diverticula (e.g. Zenker's diverticulum).

Relative contraindications to TEE were as follows:
(1) Large diaphragmatic hernia may significantly hinder TEE imaging because of lack of transducer mucosal approximation.
(2) Atlantoaxial disease and severe generalized cervical arthritis: TEE should never be performed if there is any question about stability of cervical spine.
(3) Patients who received extensive radiation to the mediastinum: this can cause significant difficulty in probe manipulation within the esophagus and is a relative contraindication if the anatomy of the esophagus is not known.
(4) Upper gastrointestinal bleeding.
(5) Significant dysphagia are also relative contraindications.

Anesthetic technique

The patients underwent the same preparation and same monitoring parameters, except for when minimally invasive CABG, where double-lumen endotracheal tube or bronchial blocker was used to isolate the left lung.

A transesophageal echo was done for the following:
(1) To confirm the appropriateness of the patient for a minimally invasive technique before incision. Ideally, this determination should also be completed before the placement of any specialized CPB cannulas.
(2) Bicaval view to monitor the insertion of the venous cannula.
(3) Confirmation of the wire in descending aorta for arterial cannula insertion.
(4) De-airing.
(5) Weaning off CPB: cardiac function assessment and need for inotropic support.
(6) Evaluation of the surgical procedure either repair of replacement.

Fig. 1.

Results and statistical methods

Statistical method

The data were coded and entered using the statistical package SPSS, version 15 (Chicago, SPSS Inc.).

The data were summarized using descriptive statistics: mean, SD, median, minimum value, and maximum value for quantitative variables. Statistical differences between groups were tested using independent sample *t* test for quantitative normally distributed variables, whereas nonparametric Mann–Whitney test was used for quantitative variables that are not normally distributed. Correlations were done to test for linear relations between variables.

P values less than or equal to 0.05 were considered statistically significant.

Results

Table 1 shows the patients' demographics and operations done of the four groups.

Group 1

Tricuspid valve replacement was done in a 26-year-old female patient with history of intravenous drug abuse. She was presented with severe tricuspid regurge and not toxic and HD stable. There was no masses or vegetations on the tricuspid valve with good ventricular function, and initial plan was to repair the valve but failed.

Mitral valve repair was done for all patients who had mitral regurge, and annuloplasty ring was inserted, with no further techniques, and postoperative echo revealed well-functioning valve with no regurge.

Group 2

One patient had concomitant supracoronary conduit replacement of ascending aorta owing to post-stenotic dilation of the ascending aorta, reaching 4.9 cm, and the patient was 22 years old.

Group 3

One patient had concomitant Cabrol procedure due to very small aortic annulus, and failure to dilate the annulus occurred owing to small distance between the annulus and the prosthetic mitral valve.

Mean bypass and clamp times

In group 1, mean bypass time was 67.8 ± 5.85 min and the cross-clamp time was 53.1 ± 7.14 min; in group 2 was 56.3 ± 3.15 min and the cross-clamp time was 43.5 ± 3.14 min; in group 3 was 95.2 ± 5.85 min, and the cross-clamp time was 83.10 ± 7.14 min; and in group 4 was 60 ± 5.85 min, and the cross-clamp time was 0 min.

This is longer than times recorded for conventional procedures, and this was an expected difference, as the minimally invasive

Table 1: Patients of the main four groups

Groups	*n*	Male	Female	Mean age	Operation	Pathology
1	456	130	326	43	Mitral valve replacement 400 Mitral repair 45 Tricuspid replacement 1 Concomitant tricuspid repair 70	Rheumatic mitral valve stenosis 300 Mitral valve regurge (rheumatic) 150 Mitral valve regurge (degenerative) 6
2	88	52	36	59	Aortic valve replacement Tissue (25) Mechanical (63)	Aortic stenosis 70 Aortic regurge 18
3	65	43	22	47	Tissue (5) Mechanical (60)	Double regurge 52 Double stenosis 13
4	73	65	8	58	LIMA to LAD (53) Hybrid LIMA to LAD and PCI to RCA (8) Hybrid LIMA to LAD and PCI to OM (5) LIMA to LAD and Radial to OM and diagonal (3) LIMA to LAD and SVG to OM and diagonal (4)	IHD (13) In-stent restenosis (35) CTO LAD (24) IHD with coronary ectasia (1)

technique is a relatively new technique and its steps are much more sophisticated and time consuming, in addition to the necessary cautiousness of the surgeons during the steps of the operation.

Postoperative ventilation and ICU time

Postoperative ventilation was 4.78 ± 1.66 h and postoperative ICU stay was 26.1 ± 7.98 h. The postoperative course of the patients was significantly shorter regarding both the ventilation time and the postoperative length of stay in the surgical ICU. We have extubated 50 patients on table intraoperatively from group 1 and group 4.

(1) Ward postoperative hospital stay in days: 8.35 ± 1.55 days.
(2) Return to full activity in weeks: in group 3, 8.1 ± 4.41 weeks, and in groups 1, 2, and 4, 4.45 ± 0.96 weeks.

Again, the postoperative ward length of stay was significantly shorter, indicating a shorter time for recovery, and the same applies to the time to return to full activity.

The procedure was successfully performed in all. Conversion rate to full sternotomy was 0% and to mini-thoracotomy procedure was 10 (1.4%) patients. Hospital mortality was four (0.5%) patients. Re-exploration for bleeding was four (0.5%) patients and superficial wound infection was 20 (2.8%) patients. Graft failure occurred in one patient who needed redo-operation, and one patient needed to lengthen the LIMA with composite vein graft.

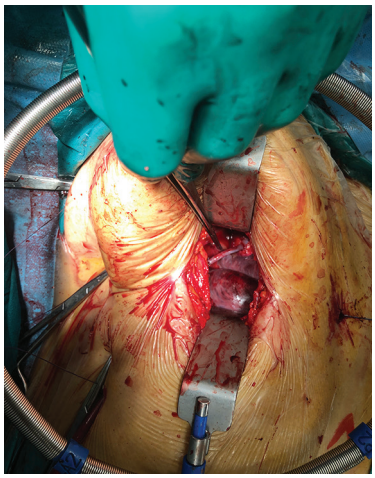

Figure 1: Saphenous vein graft to distal RCA and mitral valve replacement through minimally invasive thoracoscopic right mini-thoracotomy.

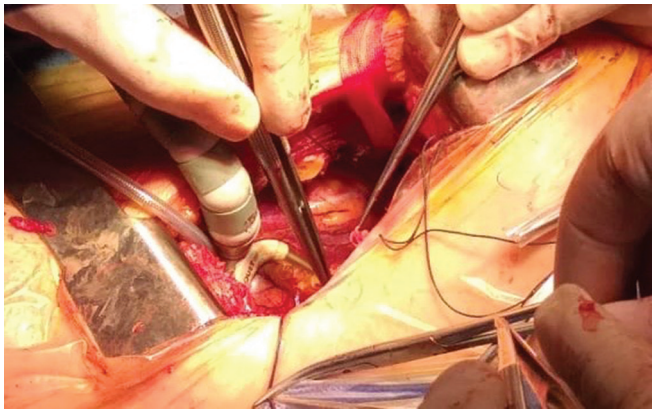

Figure 3: Minimal invasive CABG showing distal anastomosis to OM1. CABG, coronary artery bypass grafting.

Discussion

Advantages of minimally invasive heart surgery are reduced postoperative pain and early mobility [4,8], reduced blood loss, and shorter ventilation time, leading to shorter ITU and hospital stay; this in return has been implicated in reducing hospital costs and leading to savings.

This however is still debated [4,7,8], and when comparing cost models in Egypt versus the western countries, we found the minimally invasive procedure is more costly, and this is mainly related to the difference in cost breakdown, as in Egypt, more than 70% are the operation and ICU costs, and the bed cost is much lower, but in the western models, the financial burden of the patient while staying home on sick leaves is also calculated.

Minimally invasive technique has the benefit of less risk of wound infection, earlier recovery and return to normal activity

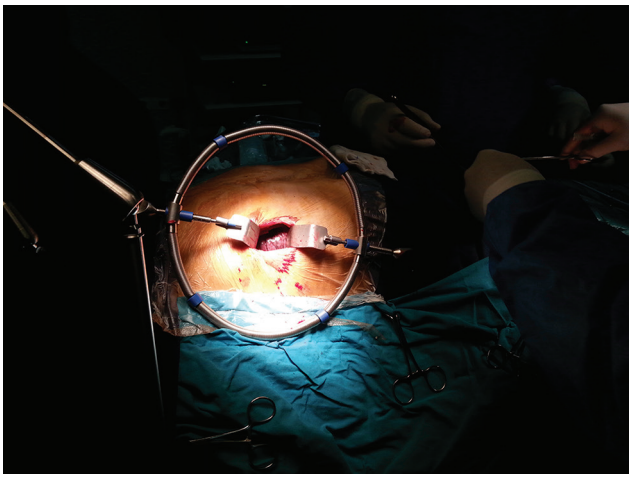

Figure 2: Window incision.

Figure 4: Minimal invasive CABG skin wound 15 days after patient discharge. CABG, coronary artery bypass grafting.

[4], cosmetically acceptable and patient attractiveness [8,15], and reduced trauma and difficult dissection in redo procedures. This is more appreciated in port access mitral valve procedures through right mini-thoracotomy [19,20]. Better visualization using thoracoscope/robot and high-definition screen. Enhanced visualization helps in better insight and training of surgeons.

Pitfalls of minimally invasive heart surgery are as follows.

Patient selection

It may prove more challenging in extreme oversized patients, in patients with Pectus Excavatum (heart may be displaced further into the left thorax), and in patients with previous thoracic surgery. Adhesions following previous thoracic surgery need to be released to create adequate exposure of the surgical field.

Clinical expertise

It requires a different skill set, integrating video images into visual feedback and hand eye coordination. Using longer instruments and loss of tactile sensation in robotic enhanced surgery needs practice. All the aforementioned implicate a longer learning curve to familiarize with the techniques.

Vascular complications

They may occur following cannulation of femoral vessels. Careful preoperative assessment of iliac artery, femoral artery, and aorta undertaken by additional imaging (angiogram/MRI/computed tomographic scan) techniques has significantly reduced this type of complication. It is still debated whether retrograde arterial perfusion increases the perioperative risk of stroke [9,10].

Injury

The lateral pericardial incision for mitral valve surgery should avoid phrenic nerve traction injury (Figs. 2-4).

Conclusion

Thoracoscopic minimally invasive mitral valve surgery and limited sternotomy incisions can be performed safely but definitely requires a learning curve. Good results and a high patient satisfaction are guaranteed. There is increased patient demand and popularity in such techniques in Egypt. Patient selection at the start of the program is essential. The progress is more rapid and promising, and by the end of this decade, there is a strong possibility of becoming the standard procedure in cardiac surgery.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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