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Upper mini-sternotomy versus right mini-thoracotomy approach in mitral valve surgery

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Abstract

Background:
Full median sternotomy has been a standard surgical approach for heart surgery for more than 50 years. Several advantages increasing the use of less invasive approaches to the mitral valve surgery including, cosmetic, blood product use, respiratory, and pain advantages over conventional surgery. Parasternal incision, right mini-thoracotomy and partial sternotomy are described approaches for less invasive cardiac surgery.

Objective:
Comparing the less invasive approaches via upper partial sternotomy vs right mini-thoracotomy in mitral valve surgery.

Methods:
Sixty patients, underwent mitral valve surgery in NHI, were enrolled in this study and divided into two equal groups, and randomly assigned into two equal groups: group upper mini-sternotomy (UMS group, $n = 30$) or group RMT group ($n = 30$).The preoperative characteristics, operative variables, mortality, and morbidity were analyzed prospectively.

Results:
No difference were found between the two groups as regards the mortality. However, in Group UMS, blood loss was significantly higher, also cross clamp time and total bypass time were significantly longer. RMT group showed less time on mechanical ventilation, ICU stay and total hospital stay. In Group UMS, two patients (7%) developed deep sternal wound infection, and one patient (3%) suffered unstable sternum and one patient (3%) required permanent pacemaker.

Conclusion:
Both approaches upper partial sternotomy and right mini thoracotomy are considered a safe alternative for mitral valve replacement and can provide adequate exposure for mitral valve. In Upper partial sternotomy, conventional cardiopulmonary bypass, no specific instruments or endoscope were needed. In right mini thoracotomy, a longer learning curve and special instruments were required, however, it carried better outcome considering patient satisfaction for pain and cosmetic outcome the hospital stay and short return to activity.

Keywords: Cardiac Surgery, Mitral valve surgery, Upper mini-sternotomy, right mini-thoracotomy, less invasive approaches

Introduction

In the mid-1990s, minimally invasive approaches for mitral valve operations were pioneered with the intent of reducing morbidity, postoperative pain, and blood loss; improving cosmoses; shortening hospital stay; and reducing cost compared with the 50-year-old conventional median sternotomy approach. Furthermore, it was believed that less spreading of the incision, no interference with the diaphragm, and less tissue dissection might improve outcomes, particularly respiratory function [1,2].

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Indeed, a less-invasive approach to cardiac surgery has been widely adopted in clinical practice [3,4]. Compared with conventional full median sternotomy, less-invasive approaches reduce incision size and surgical trauma. It has been reported to reduce morbidity, accelerate

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recovery, and shorten hospital stay [3–5], with equally durable late outcome [6]. Several incisions for minimally invasive cardiac surgery have been described: parasternal incision [7,8], right mini-thoracotomy (RMT) [9–11], and partial sternotomy [12–14].

Patients and Methods

From February 1, 2018, till the end of November 2019, 60 patients were prospectively enrolled in our study and randomly assigned into two equal groups: group upper mini-sternotomy (UMS group, $n = 30$) or group RMT group ($n = 30$).

Operative techniques

Upper mini-sternotomy group

Incision was 8–10-cm long. It began half way between the sternal notch and the angle of Louis and ended above the fourth intercostal space. The UMS was performed from sternal notch and extended to the left fourth intercostal space, forming a reverse j-shape sternotomy. Care was taken not to injure the right internal thoracic artery. Regarding cannulation, central arterial cannulation of the ascending aorta and superior vena cava was done before establishing the bypass, and inferior vena cava was cannulated after initiation of the bypass on an empty heart. Mitral valve exposure was done through the superior transseptal approach. Tricuspid valve exposure was done through the same right atriotomy incision for the transseptal approach, and tricuspid repair was done.

Right mini-thoracotomy group

Right submammary incision of 5–7 cm with antegrade cardioplegia was done, and mitral exposure was done via standard left atrial vertical incision as for the cardiopulmonary bypass), with femoro-femoral cannulation under transesophageal echo guidance.

Anesthetic techniques and myocardial protection

Conventional general anesthesia and myocardial protection using intermittent perfusion of antegrade warm blood cardioplegia into the aortic root were conducted in both groups.

Statistical analysis

All data were collected on standardized forms, entered in a computerized database, and analyzed with a statistical software. Results were statistically represented in terms of range, mean, SD, and percentages. Continuous data of different groups were compared with paired t tests and categorical data (parametric data) by Pearson's χ^2 test was performed. A P value less than 0.05 was considered statistically significant.

Results

There was no statistically significant difference between the two groups regarding the preoperative characteristics, as shown in Table 1.

There was no statistically significant difference between the two groups regarding the patients' preoperative echo data, as shown in Table 2.

Table 1: Preoperative characteristics

	UMS	RMT	*P*
Age	29.07±6.21	30.53±6.60	0.38
Male/female sex [*n* (%)]	14/16 (47)	13/17 (43%	0.8
Body surface area (m²)	1.79±0.08	1.83±0.15	0.22
Noncardiac comorbidities			
Diabetes	1	2	0.561
Hypertension	3	2	0.65
Hepatitis C+ve	2	3	0.65
NHYA classification			
NYHA class I and II [*n* (%)]	6 (20)	4 (13)	0.50
NYHA class III [*n* (%)]	10 (33)	15 (50)	0.20
NYHA class IV [*n* (%)]	14 (47)	11 (37)	0.44
Preoperative treatment			
Antiarrhythmic	12	16	0.31
Diuretics	15	13	0.61
Anticoagulant	16	19	0.44

RMT, right mini-thoracotomy; UMS, upper mini-sternotomy.

Table 2: Preoperative echo data

	UMS [*n* (%)]	RMT [*n* (%)]	*P*
Mitral Stenosis	9 (30)	8 (27)	0.78
Mitral reg.	6 (20)	4 (16)	0.50
Double mitral	15 (50)	18 (60)	0.44
Tricuspid reg.	12 (40)	10 (33)	0.60
EF (%)	59.93±6.32	58.57±5.85	0.38
LVED	5±0.6	4.9±1.1	0.42
LVES	3.3±0.5	3.2±0.9	0.32
LA	4.8±1	5.1±1	0.19

RMT, right mini-thoracotomy; UMS, upper mini-sternotomy.

Table 3: Type of operations in both groups

	UMS [*n* (%)]	RMT [*n* (%)]	*P*
MVR	18 (60)	20 (67)	0.60
MVR and TV repair	12 (40)	10 (33)	0.60

RMT, right mini-thoracotomy; UMS, upper mini-sternotomy.

Table 4: Cardiopulmonary bypass

	UMS	RMT	*P*
Total bypass (min)	88.4±7.4	75.6±4.9	<0.001
Cross-clamp time (min)	64.3±5.9	50±2.6	<0.001
Reperfusion time (min)	30±3.2	20±3.3	<0.001

RMT, right mini-thoracotomy; UMS, upper mini-sternotomy.

Table 5: ICU events

	UMS	RMT	*P*
Blood 1st 24 h	531.6±231.3	326.3±191.8	<0.001
Reopening [n (%)]	1 (3.5)	0	0.561
Mechanical ventilation (h)	11.2±3.2	7±1.2	<0.001
ICU stay (days)	3.8±1	2.1±0.3	<0.05

RMT, right mini-thoracotomy; UMS, upper mini-sternotomy.

There was no statistically significant difference between the two groups regarding the type of operation, as shown in Table 3.

There was a statistically significant difference between the two groups regarding the total bypass, cross-clamp, and consequently, the reperfusion time; all were significantly longer in UMS group, as shown in Table 4.

Regarding ICU events, in UMS group, blood loss was significantly higher, whereas in RMT group, time on mechanical ventilation and ICU stay were significantly less, and there was no significant difference for reopening for bleeding, as shown in Table 5.

Regarding hospital follow-up events in UMS group, superficial wound infection was significantly higher, whereas in RMT group, total hospital stay was significantly less. There was no statistically significant difference between the two groups regarding deep wound infection, sternum instability, the need of temporary or permanent pacemaker, and finally, the ejection fraction at the time of discharge, as shown in Table 6.

Discussion

With respect to mini-thoracotomy versus mini-sternotomy, the most apparent difference between the two approaches is the familiarity of the UMS approach for the surgeon, being comparable to the conventional median sternotomy. We determined adequate familiar working field with appropriate exposure of mitral valve through a smaller limited incision, which appear to be pretty different in comparison with thoracotomies done for exposure for cardiac procedure. McClure *et al*. [15] reported a certain degree of variation from patient to patient regarding the relation between the different structures of the heart and the chest wall, which is not significant for the surgeon when using large incisions. On the contrary, with smaller incisions, the preference is for the mini-sternotomy incision. However, regarding ministernotomy, Hsiao *et al*. [5] reported that this incision affords the surgeon a familiar operative field from which either mitral valve repair or replacement is possible.

Regarding positioning, in our study, all patients were lying in supine, and no special position was required for the UMS group. Moreover, the same position was used for RMT. However, Lehr *et al*. [11] reported that in minimal invasive mitral valve through mini-thoracotomy, the patient is placed on the operating table in supine position, with the right hemi-thorax elevated 30 degrees and the hips flat. We found that elevating the chest makes the heart go further away from the surgeon. Minimally invasive procedure through thoracotomy and partial sternotomy was reported to have patient lying in supine [5,13,14].

Regarding central and peripheral cannulation, in our study, the cardiopulmonary bypass was obtained in the standard approach by central aortic cannulation in UMS group and peripheral femoro-femoral in RMT group. Hsiao *et al*. [5] reported that central aortic and venous cannulations are possible and the ascending aorta can be cross-clamped directly, without the need for endovascular clamping. In contrast with the thoracotomies, the common femoral artery is the most common site for perfusion [11].

Regarding peripheral cannulation, serious drawbacks were recognized for that technique: peripheral atherosclerosis may preclude cannulation, retrograde dissection or emboli may ensue, and other complications such as postoperative wound infection, hematoma, lymphocele, arteriovenous fistula, or stenosis of the femoral vessels may develop [16]. Wolfe *et al*. [17] reported ischemic injury to the leg as a documented potential complication of femoral arterial cannulation. The proposed mechanisms for this injury include misidentification of the common femoral artery, cannulation of a small femoral system, excessive perfusion times, unidentified vascular disease within this arterial system, and vascular injury or narrowing after removal of the cannula. In our study, we did not encounter vascular complications, but we had five patients who experienced superficial wound infection in the femoral incision site, and all of the were females.

Regarding special instruments, in our study, in RMT group, we were in need to use long-shafted instruments, a knot-pushing device, and special aortic clamp and atrial retractor, carrying a disadvantage. The same opinion was by Hsiao *et al*. [5], as they concluded that less-invasive cardiac surgery via partial sternotomy does not need long-shafted instruments or a knot-pushing device. A shorter learning period can be expected, and additional cost for specific instruments or devices might not be necessary.

Regarding learning curve of surgical technique, the main impediment to adoption of any new surgical approach is that it requires the learning of a different technique. There was a learning curve involved in developing the technique, which was, however, technically similar to conventional sternotomy [1]. The surgeon can use this technique with a very short learning period [5].

Cardiopulmonary bypass and aortic cross-clamping times were longer in partial sternotomy surgery and were also reported in other studies. However, Mihaljevic *et al*. [18] reported significantly shorter aortic cross-clamping and cardiopulmonary bypass times in patients undergoing partial

Table 6: General outcome

	UMS [*n* (%)]	RMT [*n* (%)]	*P*
Superficial wound infection	2 (7)	1 (3)	0.023
Deep sternal infection	2 (7)	0	0.041
Sternal instability	0	Not applicable	0.322
Temporary PM	2 (7)	0	0.081
Permanent PM	1 (3)	0	0.322
Hospital stay	6.93±1.98	4.73±2.13	0.00
Early post op. EF (%)	59.7±10.3	60.3±13.4	0.778

RMT, right mini-thoracotomy; UMS, upper mini-sternotomy.

sternotomy. Another opinion was reported by Svensson *et al*. [1] Regarding the intraoperative support among the patients, ischemic time was slightly longer after a minimally invasive approach (65 ± 24 vs. 62 ± 23 min, $P = 0.1$), and cardiopulmonary bypass time was equivalent.

Regarding conversion to full sternotomy, there was only one (3%) patient who underwent conversion from partial to full sternotomy owing to inadequate exposure for mitral valve. Moreover, Hsiao *et al*. [5] reported one (3%) patient who underwent conversion from partial to full sternotomy owing to inadequate exposure for mitral valve replacement. However, Tabata *et al*. [19] reported that 24 of 907 patients required conversion from upper partial sternotomy because of bleeding, ventricular dysfunction, refractory ventricular arrhythmia, poor exposure, and other causes. Of 528 patients, 21 required conversion from lower partial sternotomy; none died postoperatively. The authors concluded that conversion from upper sternotomy was associated with serious morbidity and mortality. Mihaljevic *et al*. [18] reported that when conversion is necessary, partial sternotomy can be easily enlarged to full sternotomy.

Regarding blood loss and need of transfusion, in our study, the blood loss was reported to be significantly higher in UMS. The mean blood loss was 531.6 ml (Table 5). Less invasive cardiac surgery through RMT has been reported to reduce postoperative bleeding, and therefore the less blood transfusion. Many studies support this outcome [1,15,18,20].

Regarding duration of ICU stay and mechanical ventilation, the majority of the authors observed benefits in earlier extubation, better recovery of respiratory function, and the reduction of the time spent in intensive care and total time in hospital [18,21]. Moreover, Svensson *et al*. [1] reported a higher proportion of the patients were extubated in the operating room.

Regarding reduction of infections, there were less incidences of superficial and deep wound infection and also sternal instability (Table 6), lesser incidence of infectious complications, with no deep wound infection in our patients in whom less-invasive cardiac surgery was reported [22,23].

Regarding cosmetic effects, one of the potential advantage in our study is the cosmetic benefit, especially for the young females. Brinkman *et al*. [23] also reported a cosmetic benefit, which is one of the great advantages of these approaches in the case of young patients [21].

Regarding need for pacing, in our study, two (7%) patients in the UMS group needed temporary pace maker for transient instability and only one (3%) patient needed permanent pacing (Table 6). Navia [14] reported 4% of the patients required permanent pacemaker implantation for the postoperative heart block or bradycardia. Moreover, Cosgrove and Gillinov [13] reported 2% of the patients needed a permanent pacemaker. However, Tam *et al*. [24] reported four patients had junctional rhythm in the postoperative period, but this did not persist. As for RMT group, there was no need for pacemakers in all patients, and this is attributed to different atrial incision, as the classic vertical left atriotomy incision being used in RMT is away from the conduction system, especially when compared with the superior transseptal incision in UMS.

Regarding postoperative pain, in our study, we noticed the postoperative need of analgesics to be much lesser in the partial sternotomy group, which reflects the potential benefit of pain reduction. Studies reported the reduction of pain felt by the patient and the demand for analgesics in the immediate postoperative period [15,21]. Svensson *et al*. [1] reported less pain in the first 24 h after the operation ($P < 0.0001$) for minimally invasive surgery patients, but similar pain scores thereafter with the conventional procedure. Compared with patients receiving lateral thoracotomy, less pain was reported in patients undergoing partial sternotomy [25].

Regarding duration of hospital stay and functional recovery, one of the objectives of minimally invasive approaches is to reduce surgical aggression and thus favor functional recovery. In ours, we found the mean duration of hospitalization was 6.9 days (Table 6) in partial sternotomy, but for RMT was 4.7 days. The benefit of these approaches in terms of the effect on the duration of hospitalization is quite uniform, and the majority of authors observed benefits in the reduction of the average hospital stay. On the contrary, the study by Svensson *et al*. [1] does not show differences in the duration of the hospitalization.

Regarding mortality, in ours, there were no mortalities in both groups. Comparative studies have demonstrated that there are no differences in early mortality between minimally invasive approaches and a complete sternotomy [15]. Moreover, late outcome survival rates at 5, 10, and 15 years were 93 ± 1, 86 ± 1, and 79 ± 3, respectively (median survival, 15 years; 95% confidence interval, 14.9–15.4). Freedom from reoperation was 100% for mitral valve replacement at late follow-up [6].

There are some limitations in our study. The patient number was limited, and this was a prospective study in one single hospital. Long-term functional status and survival follow-up are necessary in any future study.

In conclusion, minimally invasive approaches have gained popularity among both the patients and cardiovascular surgeons. Partial sternotomy is a safe alternative to full sternotomy in mitral valve replacement. It provides adequate and familiar exposure, and consequently, a shorter learning period can be expected. Special instruments, endoscopic or robotic assistance, and peripheral cannulation are not required, and it is superior to conventional approach in terms of hospital cost-effectiveness and patient satisfaction. RMT, however, may preclude a learning curve and special instruments, which carries better outcome considering the hospital stay and short return to activity, with avoidance of bone cutting incisions, and for patients who are contraindicated for this approach, partial sternotomy is a feasible alternative.

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Conflicts of interest

There are no conflicts of interest.

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