ORIGINAL CONTRIBUTION

Minimal vs Median Sternotomy for Aortic Valve Replacement

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ABSTRACT

The aim of this study was to compare postoperative outcomes in patients undergoing aortic valve replacement through a ministernotomy or conventional sternotomy. Sixty patients were randomized into 2 groups of 30 each: group 1 had a full sternotomy and group 2 had a ministernotomy. Pain was evaluated on a daily basis, pulmonary function tests were performed perioperatively. The skin incision was shorter in group 2 (7.17 vs 24.50 cm in group 1). There was significantly less mediastinal drainage in group 2 (233 vs 590 mL in 24 hours in group 1). Group 1 patients had more blood transfusions and longer ventilation time. In group 1, 96.7% experienced severe pain, whereas 93.3% in group 2 reported minimal pain. Hospital stay was 17.7 days in group 1 and 8.0 days in group 2. The ministernotomy had a cosmetic advantage, less blood loss and transfusion requirement, greater sternal stability, better respiratory function, and earlier extubation and hospital discharge.

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INTRODUCTION

The recent interest in minimal access surgery throughout all surgical disciplines is based on the theory that a smaller surgical incision leads to less postoperative pain, shorter hospitalization, faster functional recovery, and cosmetic benefits.[1–8] However, safety and efficacy are more important factors, especially in heart operations.[9,10] Cosgrove and colleagues[11,12] introduced a parasternal approach that includes excision of the 2nd and 3rd costal cartilages, right internal mammary division, and femorofemoral cardiopulmonary bypass (CPB). Other approaches include a partial upper sternotomy with central cannulation, transverse sternotomy, limited sternotomy with a J-incision, right-sided partial sternotomy, reversed L sternotomy, and a limited right thoracotomy for aortic valve replacement (AVR).[12–18] The aim of this study was to compare postoperative outcomes in patients undergoing AVR through a ministernotomy or conventional sternotomy.

PATIENTS AND METHODS

Sixty consecutive patients undergoing first-time elective AVR were randomly assigned to 1 of 2 groups, using the closed envelop method: 30 underwent AVR through a full median sternotomy (group 1) and the other 30 had a ministernotomy (group 2). Informed consent was obtained from the protocol research committee and from all patients. No patient refused to enter the study, which was completed within 5 years. Exclusion criteria were emergency operations, depressed left ventricular function (< 25%), a heavily calcified ascending aorta, redo valve surgery, and AVR associated with other valve lesions. The demographic details of both groups are given in Table 1. Half of the patients in each group had aortic stenosis, the others had aortic regurgitation; none had other valvular lesions.

All patients underwent AVR with a bicuspid St. Jude Medical aortic valve prosthesis by the same surgical

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Table 1. **Profile of Patients Undergoing Aortic Valve Replacement via a Mini or Full Sternotomy**

Variable	Group 1 (Full)	Group 2 (Mini)	*p* Value
No. of patients	30	30	
Age (years)	23.83 ± 3.49	22.93 ± 2.35	0.246
Sex (M/F)	15/15	16/14	0.031
Body surface area (m^2)	1.6 ± 0.5	1.5 ± 0.4	1.000
Aortic stenosis	50%	50%	1.000
Aortic regurgitation	50%	50%	1.000
Ejection fraction	55% ± 2.55%	56% ± 2.32%	1.000

Table 2. **Operative Data According to Type of Sternotomy**

Variable	Group 1 (Full)	Group 2 (Mini)	*p* Value
Length of incision (cm)	24.50 ± 2.57	7.17 ± 1.26	0.001
Sternotomy time (min)	14.83 ± 2.57	7.17 ± 1.26	0.001
Closure time (min)	50.17 ± 8.15	30.67 ± 1.73	0.001
Operation time (hour)	3.583 ± 0.695	2.550 ± 0.422	0.001
Cross clamp time (min)	45.50 ± 4.02	44.33 ± 3.05	0.044
Bypass time (min)	90.00 ± 8.30	85.67 ± 6.79	0.031

team. The 30 patients in group 2 had a reversed L-shaped ministernotomy from the sternal notch to the 3rd intercostal space. In the other 30 patients, a full sternotomy was carried out, with cannulation for CPB, and antegrade cold blood cardioplegia for myocardial protection. Except for the incision and single 2-stage venous cannula in group 2, the surgical protocol was the same for all patients. This included aortic and right atrial cannulas, cold blood cardioplegia directly through the coronary ostium and aortic root in cases of aortic stenosis, and left ventricular venting through the main pulmonary artery or left atrial appendage if easily accessible. The anesthetic protocol comprised induction with etomidate (0.2–0.6 $\mu g \cdot kg^{-1}$) and fentanyl (1–10 $\mu g \cdot kg^{-1}$), pancuronium (80 $\mu g \cdot kg^{-1}$) for muscle relaxation, and propofol infusion (100–300 $\mu g \cdot kg^{-1} \cdot h^{-1}$) for maintenance of anesthesia to promote early extubation. Pain medication comprised continuous infusion of tenoxicam at a rate of 4 g per 12 hours while in the intensive care unit (ICU), and oral acetaminophen (500 mg) while in the ward.

The following data were prospectively collected: pulmonary function tests (preoperatively, 1 week and 1 month after surgery), length of incision, operating time, cross clamp time, CPB time, ventilation time, chest drainage during the 1st 24 hours, blood transfusions, ICU stay, and total postoperative length of hospital stay. Pulmonary function tests were repeated on the 7th day postoperatively, and at 1 month. At this point, patients were asked to evaluate subjectively the cosmetic effect of the incision on a numerical scale ranging from 1 (horrible) to 5 (wonderful).

Statistical analysis was performed with SPSS version 12 software (SPSS, Inc., Chicago, IL, USA), using the Student *t* test for equality of means, Levene's test for equality of variances, the chi-squared and cross tabulation tests. A p value < 0.05 was considered significant. Results are expressed as mean ± standard deviation.

RESULTS

The preoperative clinical characteristics of the patients are listed in Table 1. The size of the skin incision and times required for sternotomy, hemostasis, and skin closure were longer in group 1; the complete operation took 1 hour longer in group 1 (Table 2). Bileaflet St. Jude Medical valves size 21 were used in 50% of cases in both groups, and size 23 in the others. Six stainless steel wires per patient were used in group 1; only 2 wires per patient were needed in group 2. All patients in the ministernotomy group were successfully weaned from CPB without the need for pharmacological or mechanical circulatory support, while 50% of patients in the sternotomy group need small doses of adrenaline (mean, 150 ± 14.50 $\mu g \cdot kg^{-1} \cdot h^{-1}$) to maintain a good cardiac index, although none need mechanical support. Two patients in group 2 were converted to a full sternotomy to explore for bleeding, whereas 5 (16.5%) patients were re-explored for bleeding in group 1. There were 3 (9.9%) cases of superficial infection in group 2

Table 3. **Postoperative Data According to Type of Sternotomy**

Variable	Group 1 (Full)	Group 2 (Mini)	*p* Value
Intubation (hours)	6.43 ± 1.14	2.00 ± 0.30	0.001
Drainage (mL)	590.00 ± 164.74	233.33 ± 47.95	0.001
Transfusion (units)	3.13 ± 0.78	1.77 ± 0.68	0.001
Inotropic support	50%	0%	0.001
NSAIDS (g per 12 hours)	2.50 ± 0.51	1.17 ± 0.38	0.001
Intensive care unit stay (hours)	27.60 ± 14.53	6.75 ± 3.78	0.001
Hospital stay (days)	17.70 ± 8.70	8.00 ± 0.83	0.001
FEV_1 at 1 week	78.47 ± 0.51	80.47 ± 0.51	0.001
FEV_1 at 1 month	80.50 ± 0.51	80.12 ± 0.24	0.001
Forced vital capacity	86.60 ± 0.95	91.50 ± 0.51	0.001
TLC (% of predicted value)	60.50 ± 0.51	65.50 ± 0.51	0.001

FEV_1 = forced expiratory volume in 1st sec. NSAIDS = nonsteroidal antiinflammatory drugs, TLC= total lung capacity.

and one in group 1. The postoperative data are given in Table 3. The chest pain score was higher in group 1, with 93.5% experiencing severe pain, compared to group 2 where 96.3% experienced only mild pain at 1 and 12 hours after awakening. Intensive care unit and hospital stays were shorter in group 2. Subjective evaluation of cosmesis was strongly in favor of the ministernotomy; all patients reacted enthusiastically to smaller incisions, particularly the females. The fact that most of them were young was likely to affect their appraisal. Significant differences were also found in the postoperative analgesia requirements. Forced vital capacity decreased substantially during the postoperative week in both groups. Preoperative forced expiratory volume in 1 sec also decreased postoperatively. Pulmonary function measurements improved during the first postoperative month, particularly in group 2 where they reached preoperative values (Table 3).

DISCUSSION

Several advantages, such as lower mortality and faster recovery with consequent early discharge and lower costs, as well as less postoperative pain, have been attributed to minimally invasive cardiac surgical procedures, mainly to those avoiding extracorporeal circulation.[1,11] For many patients, the favorable cosmesis due to the shorter skin incision is the most important factor in decision making.[4,7,8] Although the traditional cardiac surgical approaches, including sternotomy, give satisfactory exposure, they have some disadvantages, particularly, excessive trauma and unsatisfactory cosmetic results.[17,18] Some investigators compared results of matched populations undergoing standard AVR, and claimed potential advantages for various techniques.[12–14] Our data support the conclusion that a partial upper sternotomy is a safe and effective way to perform AVR.

Durations of ICU and hospital stay are gaining more importance because they are the crucial determinants of costs in cardiac surgery.[16] We can confirm the results of Cosgrove and colleagues[12] who reported a reduction of direct hospitalization costs of approximately 19% due to earlier extubation and reduced length of stay in the ICU. This finding is not in agreement with that of Aris and colleagues[5] and may be explained partly by the longer duration of surgery, CPB and aortic cross clamp times in their minimally invasive group because of a learning curve. We found no difference in cross clamp and CPB times between groups.

We had 3 cases of superficial wound infection in the ministernotomy group. It is possible that tension placed on the soft tissue while working through smaller wounds may have contributed to this problem, so we recommend excision of 2 mm of the skin edge before skin closure to remove ischemic skin and decrease the incidence of superficial infection. No pleural or pericardial effusion was recorded in the ministernotomy group, although increased incidences of both have been reported with this approach.[4] The use of inotropics was higher in the sternotomy group, which also disagrees with the findings of Szwerc and colleagues.[4] Two patients in the ministernotomy group were explored for bleeding by conversion to a full sternotomy, but we found no source of bleeding, just generalized oozing from the bone marrow. Patients in the ministernotomy group returned to normal activity sooner, and this was comparable to the results of Szwerc and colleagues.[4]

We share the concern of others that the smaller incision limits exposure of the rest of the heart, potentially making it difficult to deal with intraoperative complications. However, conversion to a full sternotomy can be accomplished in an expeditious manner should this be

necessary. Some subsets of patients may benefit from a minimally invasive approach for AVR. Young patients should be one such group because they generally have more concern about cosmesis. A partial sternotomy may make redo surgery less difficult because of limited mediastinal tissue disturbance. This would also benefit younger patients who face a greater chance of needing additional cardiac surgery. In the ministernotomy group, the operation was shorter due to less time needed for closure and hemostasis. There were no problems with de-airing because we used an aortic root vent before and after cross clamp removal. Because only one third of sternum was opened, the postoperative stability of the thorax was better than that achieved after a full sternotomy, and pigeon chest could be avoided.[2,11,12,14] Aris and colleagues[5] failed to demonstrate significant differences in blood loss between groups, whereas our study and some others found that blood loss and transfusions in minimally invasive AVR were markedly reduced compared to conventional AVR.[4,5] We attribute this discrepancy to differences in anticoagulation management in the various studies.

Patients undergoing a ministernotomy had improved postoperative respiratory reserve, mostly due to preserved chest wall integrity and reduced postoperative pain. The increased stability of the thoracic cage and integrity of the pleural cavities allowed patients to mobilize early and cough more efficiently. A severe restrictive disturbance of lung function was present in all patients for 7 days postoperatively; it was greater (but not significantly) in the sternotomy group. It is related to surgical trauma, pleural lesions, CPB, and postoperative pain.

There are several important limitations of this study. The number of cases was small, and several of the surgeons choose to do all or most of their AVR operations through a partial sternotomy, while others prefer a traditional sternotomy, so there may have been some selection bias. Although we incorporated standardized protocols in our ICU, the duration of endotracheal intubation and length of postoperative stay is ultimately the decision of the individual surgeon in conjunction with the intensivist. Nevertheless, it was concluded that aortic valve replacement can be performed through a ministernotomy with results comparable to a full sternotomy. The partial sternotomy offers not only a cosmetic benefit but also reduced bleeding, transfusions, postoperative pain, length of ICU and hospital stay, as well as improved pulmonary function, a rapid return to normal activity, and reduced cost.

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