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ORIGINAL ARTICLE

Suitability of partial sternotomy for aortic valve and major aortic surgery

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ABSTRACT

BACKGROUND: The advantages of minimally invasive access regarding postoperative short- and long-term recovery have been presented in many previous publications. In this retrospective propensity matched study, we aim to report our results on aortic valve and major aortic surgery performed through partial sternotomy, compared with a matched group of patients operated through full sternotomy.
METHODS: Between 2013 and 2016, 163 consecutive patients (group A) operated through partial sternotomy were compared with 315 propensity matched patients operated through full sternotomy (B). The patients' mean age was 68 and 67 years, respectively. The mean ejection fraction was above 50% in both groups and the incidence of comorbidities was also similar. In group A, 79% of the procedures were aortic valve replacements (AVR) (16% sutureless) and 21% were major aortic interventions (modified Bentall 5%, AVR and ascending aorta replacement 1.2%, valve sparing root replacement 4%, aortic valve repair, homograft implantation 3%), and AVR combined with left and right sided radiofrequency ablation (5%). The partial sternotomy was either "J" (25%), or "V" (75%) shaped, to the 3rd intercostal space, with a 3-inch skin incision. In group B, 79% were AVR operations, 21% were major aortic and AVR combined with left and right sided radiofrequency ablation.
RESULTS: The follow-up was between 1 and 3 years. Thirty-day mortality in group A was lower than in group B (0.6% *vs.* 2.9%, P=0.19), as well as the incidence of postoperative neurological complications (1.2% *vs.* 3.2%, P=0.32) and the incidence of postoperative dialysis (1.8% *vs.* 3.8%, P=0.37), the differences were not statistically significant. There were significant differences between cardiopulmonary bypass time (A: 94.24 min *vs.* B: 105.82 min, P=0.013) and cross-clamping time (A: 61.53 min *vs.* B: 76.08 min, P=0.0001)
CONCLUSIONS: The partial sternotomy approach, be it "J"- or "V"-shaped, offers the possibility of safely performing all types of interventions involving the aortic valve, root, and ascending aorta.

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Key words: Minimally invasive surgical procedures - Sternotomy - Aorta - Vascular surgical procedures - Transcatheter aortic valve replacement.

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Minimally invasive aortic valve replacement through superior partial sternotomy has been used since 1996 in selected patients, in only a few centers in the world. Although the beneficial effects of this approach were controversial regarding postoperative recovery, it was shown that the chest stability, early extubation, postoperative bleeding and mobilization along with patient satisfaction, are superior to the interventions performed *via* full sternotomy.[1]

There are only random reports regarding major aortic surgery performed through superior partial sternotomy.[2]

Therefore, the aim of this retrospective propensity matched study is to compare the outcomes of aortic valve replacement and major aortic surgery performed through partial sternotomy approach with those of similar types of operations *via* full sternotomy.

Materials and methods

Between 2013 and 2016, 478 consecutive patients were included in the study, and were divided in two groups: Group A, 163 patients, operated through minimally invasive approach (superior partial sternotomy) and Group B,

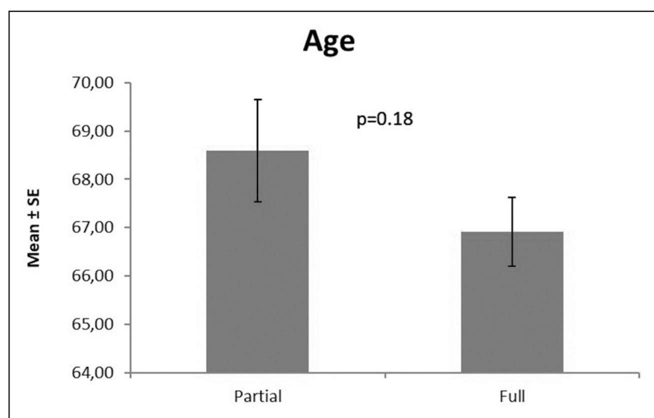

Figure 1.—Mean age of patients in Group A (partial) and Group B (full).

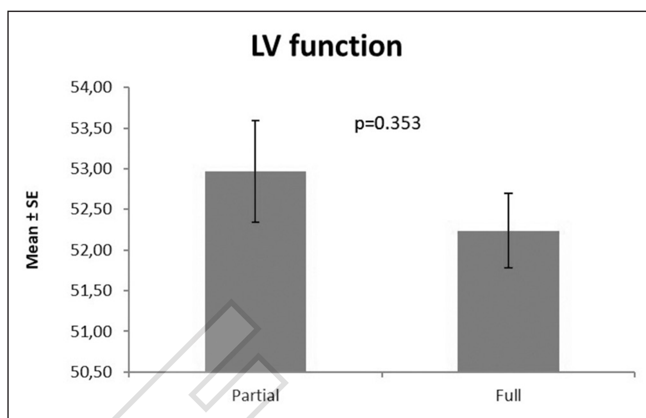

Figure 3.—LV function of patients in Group A (partial) and Group B (full).

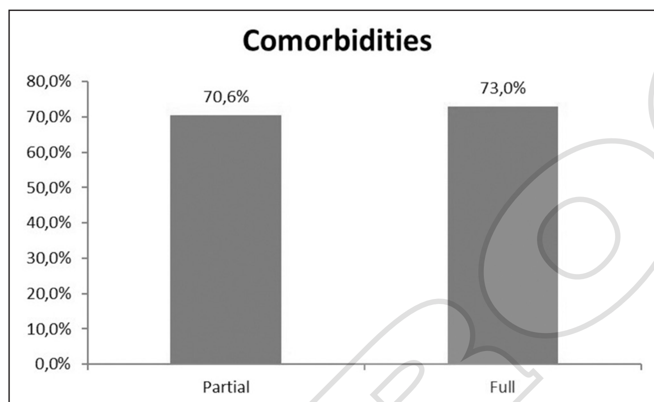

Figure 2.—Incidence of comorbidities in Group A (partial) and Group B (full).

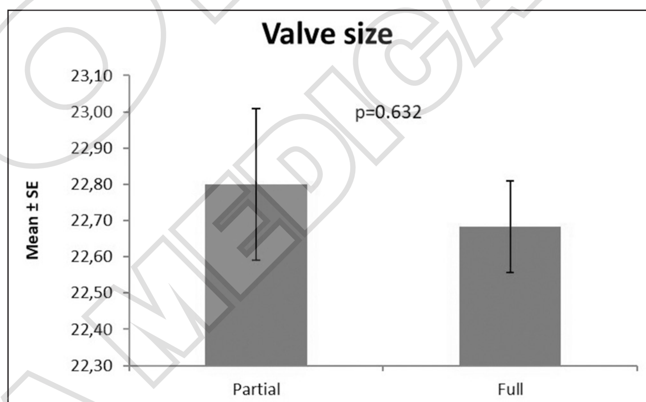

Figure 4.—Size of valves implanted in Group A (partial) and Group B (full).

315 patients, operated through full sternotomy. Age, left ventricular function, incidence of comorbidities and major aortic surgery were the matching criteria between the two groups.

The mean age in Group A was 68.6±11.5 years and 66.91±12.6 years in Group B (P=0.18) (Figure 1). There were 84 (51%) female patients in Group A and 183 (58%) in Group B.

Comorbidities, including diabetes mellitus (DM), hypertension (HT), pulmonary hypertension (PHT), chronic obstructive pulmonary disease (COPD), chronic kidney disease (CKD), were present in 70.6% in Group A and 73% in group B (P=0.65) (Figure 2).

The left ventricular (LV) function also showed no significant differences between the two groups (A: 52.97% *vs.* B: 52.24%, P=0.35) (Figure 3), as well as the size of the implanted valve (A: 22.8±2.24 *vs.* B: 22.68±2.25, P=0.6) (Figure 4).

In Group A, the minimally invasive approach was achieved with "J" shaped superior partial sternotomy to the level of the third intercostal space in 42 patients (25%). They all had aortic valve replacement (AVR). In the rest of the patients from Group A, we performed "V" shaped sternotomy to the third intercostal space, both for AVR and major aortic surgery. There were no differences in the cannulation techniques and myocardial protection between Group A and B. In group A we used the Seldinger technique for aortic cannulation and flat or 3 stage venous cannula. The left ventricular (LV) vent was always inserted through the right superior pulmonary vein. Myocardial protection was achieved with anterograde cold blood root cardioplegia, repeated every 20 minutes with direct coronary cannulation.

In Group A, 130 patients had AVR alone (79%), 21 of which were sutureless valves, and 33 (21%) major aortic surgery and AVR combined with left and right sided radio-

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TABLE I.—*Case mix of Group A and Group B.*

Parameters	Group A	Group B
AVR	130 (79%)	250 (79%)
Bentall	9 (5%)	29 (9%)
Valve sparing root replacement	7 (4%)	1 (0.3%)
Aortic Homograft	5 (3%)	0 (0%)
AVR+AA replacement	2 (1.2%)	26 (8%)
AVR+AA wrapping	0 (0%)	7 (2.2%)
Aortic valve repair	1 (0.6%)	2 (0.6%)
AVR+RAF ablation	8 (5%)	10 (3%)

frequency ablation (RAF) for atrial fibrillation (AF). Of the 33 patients, 9 had modified Bentall procedure, 7 had valve sparing root and ascending aorta (AA) replacement (David 2 procedure), 5 aortic homograft implantations, 1 aortic valve repair, 2 AVR combined with AA replacement and 8 had AVR combined with RAF ablation. In Group B, 79% of patients had AVR (250 cases), no sutureless valves, and 65 patients (21%) had AVR combined with RAF (10 cases) and major aortic surgery: modified Bentall procedure (26 cases), AVR combined with AA replacement (26 cases), valve sparing root replacement (1 case), aortic valve repair (2 cases), and AVR combined with AA wrapping (7 cases) (Table I).

The statistical analysis was performed with the Chi-square test with Yates' correction; the difference was considered significant when the p value was equal or less than 0.05.

Results

The average postoperative in hospital stay was 12 days for the patients in Group A, and 10 for those in Group B (P=0.143) (Figure 5).

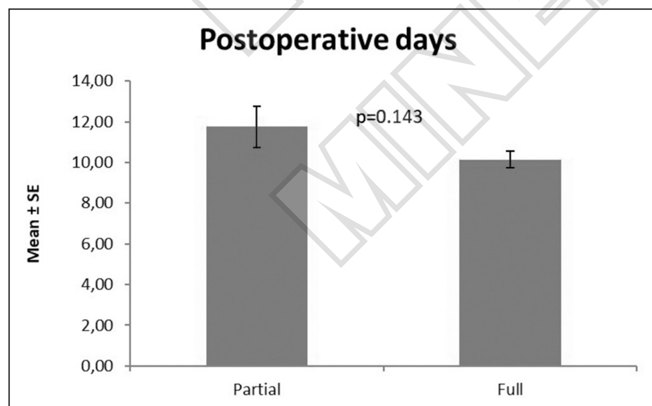

Figure 5.—Postoperative in hospital stay of patients in Group A (partial) and Group B (full).

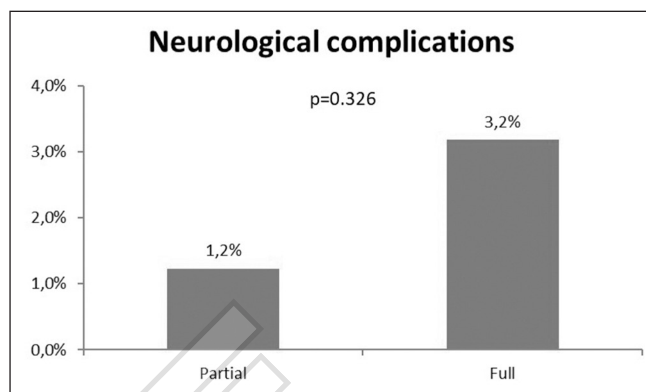

Figure 6.—Incidence of neurological complications in Group A (partial) and Group B (full).

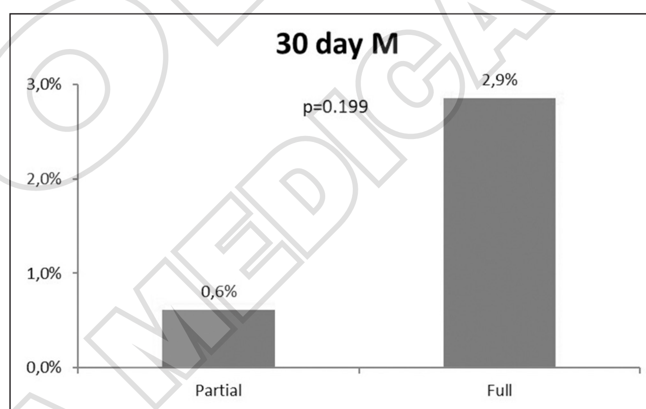

Figure 7.—30-day mortality in Group A (partial) and Group B (full).

Although the percentage of postoperative neurological complications was lower in Group A (1.2%) compared to Group B (3%), the difference was not statistically significant (P=0.326). The difference in 30-day mortality was even more pertinent, 0.6% in Group A *vs.* 2.8% in Group B, but as well as the incidence of postoperative dialysis, which was double in Group B (3.7% *vs.* 1.8% in Group A), none of these differences were significant (P>0.05) (Figures 6, 7, 8).

In the partial sternotomy group, the perfusion time and cross clamp time were significantly shorter than in the full sternotomy group. The cross-clamp time in Group A was 61.53±24.26 min *vs.* 76.08±35.26 min (P=0.0001) (Figure 9), the perfusion time was 94.24±38.16 min and 105.82±53.818 min, respectively (P=0.013) (Figure 10).

In Group A, there were reoperations in two cases (1.2%), one for bleeding, the other one for a paravalvular leak after a sutureless valve implantation at an 84-year-old male patient. Both reinterventions were performed

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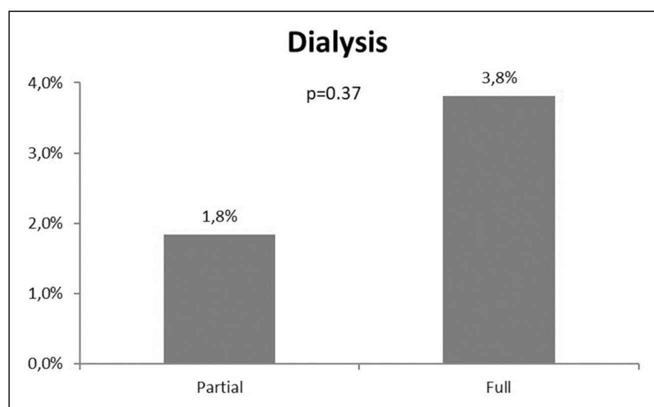

Figure 8.—Incidence of postoperative dialysis in Group A (partial) and Group B (full).

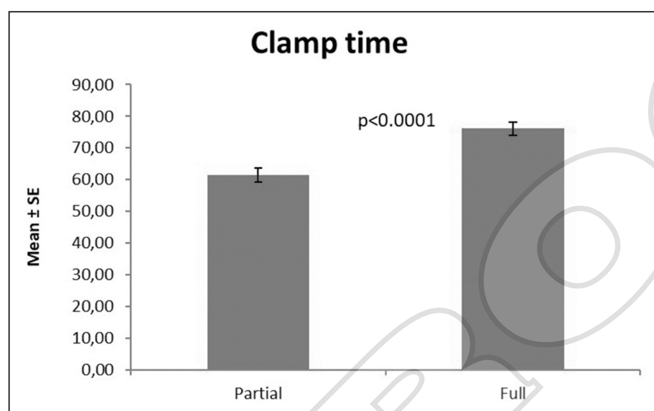

Figure 9.—Aortic cross-clamp times for patients in Group A (partial) and Group B (full).

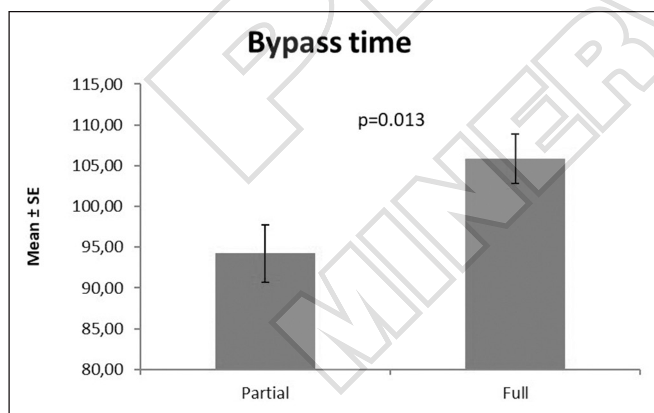

Figure 10.—Perfusion times for patients in Group A (partial) and Group B (full).

through the same partial sternotomy approach, in the case of the paravalvular leak, the sutureless valve was replaced with a conventional tissue valve.

Discussion

Several studies were performed to compare the outcome of AVR through full sternotomy and minimally invasive AVR. Some of these reported shorter postoperative in hospital stay, faster recovery and mobilization as well as better patient feedback in the case of minimally invasive interventions. Among these, the partial sternotomy proved to be the technique of choice in many centers, due to the ease to convert to full sternotomy, if needed.[3-5]

Nevertheless, there are only seldom reports of major aortic surgery performed through partial sternotomy.[2] In this study, 21% of the minimally invasive interventions were major aortic or combined procedures performed by one surgeon. The results show that the complex operations involving the aortic valve, root and ascending aorta can be safely performed through the "V" shaped superior partial sternotomy, which offers a wider, more comfortable approach of the aorta. Both the cross clamp and perfusion times were significantly shorter in Group A, and although not significantly, the postoperative 30-day mortality, incidence of neurological complications and dialysis were approximatively half in this group, compared to the patients in Group B.

There was no significant difference in the postoperative in hospital stay, as opposed to the results published in previous studies, where this was shorter in the mini AVR group of patients.[4, 5] This could be partly caused by the fact that in Group A there were more aortic endocarditis cases, treated with homograft implantation (an alternative of the modified subcoronary technique), which required longer hospitalization for antibiotic therapy.

As a limitation of the study, the postoperative bleeding and ventilation time were not compared, but previous studies reported lower values in the partial sternotomy groups.[3-5]

Also, a patient satisfaction questionnaire is in the process of being implemented. We consider this important because it was not studied in detail previously, and at present, this is one of the major argument for expanding the use of percutaneous valve implantations (TAVI) to younger, intermediate risk patient groups, despite the quite controversial results regarding the longevity of the transcatheter valves[6] and the post interventional high incidence of complications. In Group A, there was no atrioventricular block and 0.6% incidence of paravalvular leak, which was resolved through the same approach.

Since 2013, two residents in cardiac surgery were trained to perform minimally invasive AVR as part of the team who made this study. This suggests that the partial sternotomy approach can be taught in centers which have at least one surgeon who regularly performs this proce-

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dure. This could promote upper partial sternotomy a state of the art approach for certain types of aortic surgery.[7, 8]

Conclusions

The results of this study show that superior partial sternotomy "J" or "V" shaped, offers the possibility of safely performing interventions on the aortic valve ("J" and "V"), root and ascending aorta ("V"), even in the context of reoperations. Although in the studied group there were no conversions to full sternotomy, this can be carried out easily and efficiently, which offers additional safety to these procedures. The ease of conversion to full sternotomy also allows less complicated learning curves, making this procedure easier to teach and adoptable on a larger scale.

The minimally invasive approach, without compromising the well-known high quality of aortic surgery outcomes, could be a better alternative to the transcatheter aortic valve implantation, both by patients and referring doctors.

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Authors' contributions.—All authors have read and approved the manuscript, performed and/or assisted in the surgical interventions.

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