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Early outcome of minimally invasive aortic valve replacement through mini sternotomy and mini thoracotomy versus conventional approach

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Abstract: Minimally invasive techniques are gaining more interest, in an attempt to cope with the advances made with the trans catheter interventions, especially those involving the aortic valve. Mini sternotomy and thoracotomy for aortic valve replacement are becoming effective and more cosmetic substitutes to the standard full sternotomy. Aim of work: The aim of this study is to compare early morbidity and mortality after aortic valve surgeries using minimally invasive approaches through mini sternotomy and right anterior thoracotomy, and conventional full median sternotomy approach. Patients and Methods: A prospective study conducted between August 2014 and August 2016 including 60 patients who were candidates for isolated aortic valve replacement through 3 surgical approaches, the conventional full median sternotomy versus mini sternotomy and right anterior mini thoracotomy, 20 patients for each approach, organized in 3 groups, A: conventional, B: ministernotomy, C: minithoracotomy. Inclusion criteria: Patients with rheumatic or degenerative chronic isolated aortic valve disease, Age: 20-70 years old, scheduled for elective isolated aortic valve replacement, with LV function more than 40 %, with no other comorbidities , and Body mass index less than 30. Results: The mean age was 43.7 years. The study included 31 males & 29 females. The mean cross clamp time for group A, B and C was 50.4, 66.9 and 95.7 minutes respectively. The mean bypass time for group A, B and C was 80.8, 95, and 125.3 minutes respectively. The mean post-operative mechanical ventilation time for group A, B and C was 8.7, 7.7 and 8.3 hours respectively. The percentage of patients requiring inotropic support post- operatively for group A, B & C was 55%, 45% and 50% respectively. The mean ICU stay for group A, B and C was 2.95, 2.8, 2.85 days respectively. The mean in-hospital stay for group A, B and C was 9.95, 8.65, 9.55 days respectively. The percentage of patients suffering from wound infection post- operatively for group A was 10% and 5% for group B & C. There was only one early mortality in a patient treated by conventional method (group A). Conclusion: Data analysis confirmed that ministernotomy and right anterior minithoracotomy did not endanger the quality of the procedure, and that these techniques are safe, effective and reproducible therapeutic options that can be compared with conventional treatment.
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Key words: Aortic valve replacement, Minimally invasive, Ministernotomy, Minithoracotomy.

1. Introduction

Since the first aortic valve replacement in 1960s, hundreds of thousands of lives have been saved and improved by this procedure using the conventional full median sternotomy approach. Minimal access aortic valve surgery theoretically has many potential advantages compared to valve surgery performed through conventional median sternotomy. These advantages include less surgical trauma, less bleeding, decreased pain, reduced risk of wound infection, shorter hospital stay, and faster rehabilitation. The small incisions are also cosmetically better. However, there are also many disadvantages with limited access. The past decade has seen a growing emphasis on less invasive surgical procedures. Incisions have become increasingly smaller as endoscopic techniques have been developed.

In cardiac surgery, minimally invasive has been defined as "A small chest wall incision that does not include a full sternotomy"**.** In 1996 **Cosgrove and Sabik** performed the 1st aortic valve replacement via minimal access, using right parasternal approach(1). **Konertz et al** in 1996 proposed a technique by means of a sternotomy in J in order to reduce intrusion(2)**.Rodriguez et al** described an inverted 'L' mini-sternotomy through an upper sternal incision (3)**.**

Aim of the Work

Aim of this study is to compare early morbidity and mortality during the in-hospital stay after aortic valve surgeries using minimally invasive approaches through mini sternotomy and right anterior thoracotomy, and conventional full median sternotomy approach, in order to identify advantages and disadvantages of these techniques.

Mini-sternotomy wound intraoperatively

2. Patients and Methods

This prospective study will include 60 patients who are candidates of isolated aortic valve replacement through 3 surgical approaches, the conventional full median sternotomy versus 2 minimally invasive approaches, mini sternotomy and right anterior mini thoracotomy, 20 patients for each approach, in several Egyptian cardiothoracic surgery centers after obtaining the approval of the local ethical committee.

Inclusion criteria:

1) Patients with rheumatic or degenerative chronic isolated aortic valve disease.
2) Age: 20-70 years old.
3) Operation type: isolated aortic valve replacement.
4) Operation classification: elective.
5) LV function: more than 40 %.
6) Preoperative general condition: good with no other major comorbidities.
7) Body mass index: less than 30.

Exclusion criteria:

1) Age more than 70 years.
2) Patients who underwent previous cardiac surgeries.
3) Urgent patients with poor general condition or hemodynamic in stability.
4) LV function: less than 40%.
5) Patients with acute aortic regurgitation.
6) Patients with small aortic annulus.
7) Patients undergoing combined AVR plus other cardiac surgery.
8) Significant calcification or porcelain ascending aorta.
9) Patients with body mass index more than 30.

Preoperative Parameters:

1) History:

Demographic data as name, age, gender. Medical history of hypertension, diabetes, renal disorders, smoking, dyslipidemia, previous stroke or myocardial infarction

2) Clinical Examination:

Blood pressure and pulses of upper and lower limbs for hypertension, big pulse volume, absent femoral pulses Cardiac, chest and neurological examination.

3) Investigations:

Laboratory Investigations:

- Complete blood picture (CBC).
- Liver and renal function tests (ALT, AST, total and direct bilirubin, prothrombin time and concentration, INR, albumin, urea, creatinine).
- Electrolytes (Na, K).
- Lipid profile (cholesterol, triglycerides, HDL and LDL)
- HbA_1C.

Electrocardiogram (ECG):

12 lead ECG was done to evaluate any present ischemia, previous myocardial infarction or any arrhythmias.

Radiological Examination:

Plain chest x-ray (PA view) was done in the erect position after full inspiration to assess the cardiothoracic ratio and the chest condition.

Ct chest: to assess distance from aorta to sternum, percent of aortic diameter rightward to sternal border and the angle between midline and inclination of aorta.

Echocardiography (Echo):

-Left ventricular dimensions and function: LVEDD, LVESD, EF.

-Aortic valve morphology and degree of aortic valve lesion, whether stenosis or incompetence

-Diameter of aortic annulus, patients with small aortic annulus that needs surgical intervention were excluded from the study.

- Aortic root dimensions: ascending aortic diameter, for possibility of poststenotic dilatation, patients with any aortic dilatation that needs specific surgical intervention during surgery were excluded from the study.

- Regional wall motion abnormalities, for exclusion of concomitant coronary artery disease, patients with any other cardiac surgical indications were excluded from the study.

The commercially available Echo-Doppler system is 2.5 mega/Hz transducer in 2D, M-mode, PW, and CF mapping studies using parasternal long axis and short axis and apical 4 chamber views.

Coronary Angiography:

For males more than 40 years old and females more than 45 or menopausal.

4) Preoperative Counseling:

In the preoperative visit prior to surgery, a brief explanation of the steps of the surgery and postoperative ICU stay with possible early and late postoperative complications were explained to the patients.

5) Preoperative preparation:

After deciding time of surgery, including:

Preparation of the required blood and blood products units.

Stoppage of any anticoagulants if present and replacing it with heparin or low molecular weight heparin

6) surgery:

Anesthesia:

General IV anesthesia was used with use of muscle relaxants and maintenance anesthetics. A trans esophageal echocardiography probe was placed in most of cases also to assess the cause of the aortic valve disease and to assist in removing air from the heart before removal of the aortic clamp.

Surgical techniques:

With one of the 3 following surgical approaches:

1. The conventional full median sternotomy approach.
2. The two minimally invasive approaches:
   - Ministernotomy approach.
   - Right anterior mini thoracotomy approach.

The skin incision in both minimally invasive groups varied between 4 to 7 cm, without a single recorded injury of the internal mammary artery.

Cannulation varied between femoro-femoral, aorto-femoral, femoro- common atrial and aorto-common atrial connections, with use of a vent line either in RSPV, main pulmonary artery or directly through the aortic valve.

Excisions of the old diseased valve, implantation of the new valve, either prosthetic or biological valve, and closure of aortotomy have been achieved without major obstacles. De-airing was successful, guided by TEE in some cases, and all confirmed by postoperative results. Introduction of either internal pediatric DC shock paddles or external cutaneous paddles was very efficient for managing intraoperative arrhythmias.

7) Monitoring of early postoperative course guided by the following criteria:

1- Intubation time.
2- Need for inotropic support: doses and period of support.
3- Early re-exploration for excessive bleeding.
4- Need for IABP support.
5- Postoperative arrhythmias and AF.
6- ICU stay.
7- Early postoperative cardiac, renal, and cerebral complications.
8- Postoperative echocardiography
9- In hospital stay.
10- In hospital mortality.

Statistical analysis:

Statistical analysis was performed using SPSS statistical software (SPSS version 10.0.5, SPSS Inc, Chicago, IL). The Fisher's exact test and the Mann-Whitney test were used for univariate analysis. P value was calculated for each 2 of the 3 groups separately, comparing conventional versus ministernotomy groups, conventional versus minithoracotomy groups and between the 2 minimally invasive groups together. P value is considered significant if < 0.05.

3. Results:

This prospective study was conducted between August 2014 and August 2016 and included 60 patients underwent isolated aortic valve replacement at several centers in Egypt, patients were divided into 3 groups, 20 patients for each group.

Results were dependent on comparing between conventional group results and every one of both minimally invasive groups separately, and comparing the differences between both two minimally invasive groups.

However, minimally invasive approaches, being relatively recent procedures have multiple factors affecting their results, such as including availability of equipment, lack or inability to assess surgical experience together with this study`s small sample size, short time of the study and complexity of comparison between each 2 of the 3 groups separately, all these factors could be influencing the results dramatically.

A) Preoperative parameters results:

1) Age:

The age ranged from 20 to 70 years with a mean age of total patients 43.7 years with 7 patients 60-65, while 8 patients only were over 65 years.

Table 1: mean age of the three groups of the study.

		SD	Maximum	Minimum
1st group: Conventional	44.4	17.425	69	22
2nd group: Ministernotomy	48.1	17.04		20
3rd group: Minithoracotomy	40	13.08	66	22

B) Intraoperative results:

1) Cross clamp time:

Table 2: Cross clamp time of the three groups of the study.

Cross clamp time/ min.	Mean	SD	Maximum	Minimum
1st group: Conventional	50.35	9.7	74	35
2nd group: Ministernotomy	66.85	.97		50
3rd group: Minithoracotomy	95.7	11.85	120	76

Comparing cross clamp time between conventional and ministernotomy groups showed a mean difference of 16.5 min., p value indicated it was statistically insignificant. While difference between those two groups and minithoracotomy group was 45.35 and 28.85 min. respectively, with p value less than 0.05 indicating its statistical significance.

2) Total bypass time:

Table 3: Total bypass time of the three groups of the study.

		SD	Maximum	Minimum
1st group: Conventional	80.8	17.62	112	57
2nd group: Ministernotomy	95	13	1	83
3rd group: Minithoracotomy	125.25	14.98	158	95

Ministernotomy group had a mean of 14.2 min. longer than conventional group regarding total bypass time, with no statistical significance, while minithoracotomy group recorded 44.45 min. longer than conventional and 30.25 min. longer than ministernotomy group, with statistically significant differences

3) Mechanical ventilation:

Table 4: Mechanical ventilation time of the three groups of the study.

Mechanical ventilation/hour	Mean	SD	Maximum	Minimum
1st group: Conventional	8.7	6.70	32	2
2nd group: Ministernotomy	7.7	7.41	28	1
3rd group: Minithoracotomy	8.3	5.75	30	2

Ministernotomy group recorded the least mean mechanical ventilation time, followed by the minithoracotomy group with 30 min. difference followed by about 30 min. more difference regarding the conventional group. P value indicated no statistical significance.

4) Inotropic support:

The results of the three groups in this study regarding number of patients that needed inotropic support in the ICU were very close, recording 11 patients of the conventional group, nine patients of ministernotomy and 10 of the minithoracotomy group, with no statistical difference.

5) Postoperative arrhythmias and AF:

The result evidence of postoperative arrhythmias of conventional group was 10 patients (40%) having only 1 patient more than ministernotomy group recording 35% , with another 1 patient less in minithoracotomy group recording 30%; p value calculated between each 2 groups separately indicated no statistical significance.

6) Duration of ICU stay

Table 5: ICU stay duration of patients of the three groups of the study

ICU stay/day	Mean	SD	Maximum	Minimum
1st group: Conventional	2.95	1.14	6	2
2nd group: Ministernotomy	2.8	0.83	5	2
3rd group: Minithoracotomy	2.85	1.13	6	2

No important statistical difference was recorded regarding the ICU stay with least mean value 2.8 days in the ministernotomy group and highest mean value in conventional group with 2.95 days.

7) Conversion to full median sternotomy:

1 patient of the 3rd group was converted to full median sternotomy after suspicion of uncontrollable injury of right pulmonary artery, luckily it was intact. The bleeding was caused by injured vein in adventitia of right pulmonary artery which was managed by clip application and use of diathermy.

8) Exploration for cardiac tamponade or excessive bleeding:

There was not any event of cardiac tamponade among the three groups. Only one patient of the conventional group was reopened for excessive bleeding with Hemoglobin drop with no signs of tamponade.

9) Cerebral, hepatic and/or renal complications:

There were not any serious permanent

complications regarding other body systems. However, some events of transient delayed regaining of conscious level, renal impairment and hepatic impairment without evidence of permanent complications.

10) Postoperative pain:

For simplification, a single dimensional verbal numerical pain scale was used to identify the intensity of pain every patient is subjected to postoperatively; this scale is illustrated in the next diagram, followed by table of results of the three groups of the study:

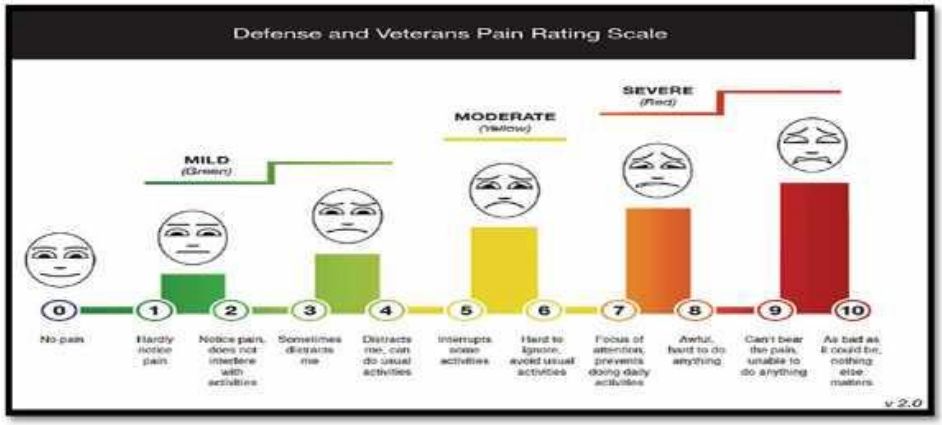

Figure 2: illustration for items of simple numerical verbal pain scale used to detect the degree of pain for each patient, both subjectively and objectively**.**

Table 6: Pain scale for the patients of the three groups of the study.

Pain scale	Mean	SD	Maximum	Minimum
1st group: Conventional	5.95	1.79	9	2
2nd group: Ministernotomy	5.75	2.12		1
3rd group: Minithoracotomy	6.2	1.88	10	3

As illustrated, mean pain scores over 10 degree scale of the conventional, ministernotomy and minithoracotomy groups were 5.95, 5.75 and 6.2 respectively. Being very close, results revealed also no statistical significance. This test is subjective, depending on patients' awareness and threshold for pain which widely varies from patient to another.

11) Wound infection:

Two patients of the conventional group had deep wound infection, while only one patient suffered from infection in the ministernotomy group, and one patient also was recorded in the minithoracotomy group. These data were of no statistical insignificance. All those patients required use of intense course of IV antibiotics, repeated dressings and strict control of blood glucose level. One patient with this wound infection in the conventional group required also vacuum assisted dressing. All patients' wounds recovered without any other complications within less than 24 days postoperatively (Maximum hospital stay duration).

12) Postoperative echocardiography results:

Neither abnormal position, malfunction nor paravalvular leak was recorded in all patients of the three groups of the study. No major permanent deterioration of contractility was recorded for all patients of all groups of the study. only one patient had significant collection with no signs of tamponade.

13) Duration of in-hospital stay:

Table 7: Hospital stay

In-hospital stay/ day	Mean	SD	Maximum	Minimum
1st group: Conventional	9.95	2.30	22	7
2nd group: Ministernotomy	8.65	3.97		
3rd group: Minithoracotomy	9.55	3.21	22	7

Regarding hospital stay, best mean time in days was for ministernotomy group (8.65 days), while the minithoracotomy had a longer time (9.55) but still less than the conventional group
which recorded the longest mean time (9.95), but these results were statistically insignificant.

14) Postoperative Mortality:

Only one mortality was recorded in this study in a patient of the conventional group, patient was diagnosed preoperatively as a case of severe aortic stenosis, presented in the 5 day postoperatively while he was in ward by a sudden attack of malignant ventricular arrhythmia, which did not respond to CPR including repeated DC shocks, this finding has no statistical significance.

4. Discussion:

For some surgeons, as **Woo in 2007** stated, minimal access incisions for valve surgery have supplanted standard sternotomy as their preferred route. Furthermore, with rapid, widespread access to information, especially via the internet, and guidance by well- informed cardiologists, patients have become avid participants in the decision making process on surgical approach. Patients will often present to the surgeon with a clear image of the specific minimally invasive operation desired. Thus, in this rapidly progressing and still evolving field of minimally invasive valve surgery, the importance of remaining up to date cannot be overstated. (4)

1) Cross clamp and total bypass time:

Regarding our study, the least mean time was for the conventional group, with a little difference of 16 min less than ministernotomy, while minithoracotomy had much longer mean time almost doubling the conventional time. It is known that the learning curve plays a determinant role in the results of any new surgical techniques and, of course, in the time spent in theatre. Volume of cases is fundamental in acquiring the dexterity and confidence to carry out these interventions. **Malaisrie in 2014 and Merk in 2014** claimed that the minimally invasive valvular operations required significantly more time than conventional valve operations (5, 6).

2) Postoperative AF:

Although **Bonacchi** stated in his study in **2002**: "postoperative atrial fibrillation remains a problem even when mini-invasive operation is considered". In his study, he did not find a high incidence of postoperative atrial fibrillation in the ministernotomy group, but he recommended that the atria should be manipulated carefully to avoid postoperative arrhythmias (7)

Merk in 2014 reported less incidence of AF with minimally invasive approaches (6).

In our study, AF developed in 25.0% of patients in the ministernotomy group, 30% in the minithoracotomy group and 35% in the conventional group, denoting that there were slight differences between groups with no statistical significance.

3) Mechanical ventilation:

As the integrity of the thorax is maintained, and pain, whichis one of the factors affecting movement of the thorax is reduced, it is logical to expect that the parameters of pulmonary functions will be less affected by minimally invasive approaches.

Bonacchi in 2002 demonstrated shorter mechanical ventilation time, better post extubation blood gases analyses and pain scores, and lower analgesic requirements(7). **Brown in 2009** had the same results that ventilation period was -2.13 hours in ministernotomy group, indicating somewhat shorter ventilation times in the ministernotomy approach (8). Same results were confirmed by **Johnston in 2012 and Malaisrie 2014** with shorter extubation periods and improved respiratory capacity(9, 5). Our study showed shorter time of mechanical ventilation in both minimally invasive groups than conventional group, with the shortest mean time for the ministernotomy groups. However, there was no statistical significance recorded.

4) Hospital stay:

Being one of the objectives of minimally invasive approaches to reduce surgical aggression and favors functional recovery, the benefit of these approaches in terms of the impact on the duration of hospitalization is quite important.

Analysis of results of studies of **Bakir in 2006, Johnston in 2012 and Malaisrie in 2014** showed a significant reduction in hospital stay and cost for minimal access AVR when compared with conventional AVR(10 ,9 , 5). On the other hand, **Aris in 1999 and Ehrlich in 2000** did not find a difference in hospital stay duration between conventional and minimally invasive approaches (11, 12).

Our study revealed that the shortest in-hospital stay was in the ministernotomy group, followed by the minithoracotomy group, and the longest was the conventional group, with no significant differences.

5) Conversion to full sternotomy:

Johnston in 2012 stated that the majority of conversions to full sternotomy occurred before aortic clamping suggests that a careful evaluation of adequacy of exposure of the aorta and right atrium is necessary to achieve optimal results, with no significant difference between studied groups, and this was the same finding of **Bakir 2006 (9 ,10).**

As mentioned before, this study had only one case of conversion to full sternotomy, in a patient for

which minithoracotomy approach was decided, for suspicion of injury of right pulmonary artery.

6)Wound infection:

Grossi et al in 2001 observed less incidence of infection of minimally invasive approaches in comparison to the classic sternotomy approach(13). It has been observed that this difference increases in elderly patients. Other authors as **Lee 2000 and Tabata 2008** observed also that there is a lesser incidence of infectious complications in patients who underwent minimally invasive AVR surgeries (14 ,15).

No wound infections that needed surgical intervention were recorded in this study. Only conservative treatment was enough to treat the superficial infections. However, we couldn't declare any statistical significance of differences between the three groups regarding wound infection.

7) Cosmoses:

Traditionally, cosmetic benefit has been one of the great advantages of these minimally invasive approaches especially in the case of young patients.

Aris in 1999, Bonacchi in 2002, Brinkman in 2010 and Malaisrie in 2014 totally agreed with the cosmetic benefit (10, 7,5)

We did not count patient satisfaction as a parameter to be measured in this study, but we noticed high degrees of satisfaction regarding the cosmetic issue, especially in young females.

8) Postoperative pain:

Pain is an important problem facing both the patient and the surgeon postoperatively. Besides being annoying to the patient, pain prevents also effective coughing and deep breathing, and restricts postoperative mobilization, leading to atelectasis or pneumonia. **Malaisrie 2014 and Johnston 2012** reported also that less pain and less narcotic use were observed with ministernotomy approach (5,9) Same result was obtained regarding minithoracotomy by **Merk and in 2014** (6)

Von Segesser 2014 added that the upper partial sternotomy offers the comfort factor of sternotomy over thoracotomy and prevents complications of other distensions at the costovertebral joint or brachial plexus traction at the thoracic inlet. This causes a reduction in the pain felt by the patient (16).

In our study, the highest mean score was found in minithoracotomy group, and least mean in ministernotomy, with a difference 0.45, recording no statistical significance between conventional and each one of the minimally invasive groups, separately. However, some patients were noticed to be more comfortable with the idea that patients with "the larger incisions" of conventional sternotomies are definitely suffering more pain, increasing doubt about the subjective nature of pain scoring scale.

9) Exploration for bleeding

One of the potential advantages attributed to minimally invasive surgery is the reduction of post-operative bleeding, and therefore the need for hemoderivatives. Many studies support this, including **Bakir in 2006 and Johnston in 2012 (10 , 9)**. **Stamou in 2003** concluded that there were no differences in the rate of bleeding observed between the two groups, the conventional and the ministernotomy (17).

We experienced only one case of re-exploration for excessive bleeding with no signs of tamponade, either clinically or echocardiographically, this was of no statistical significance.

10) Postoperative short term mortality:

Merk in 2014 did not find any difference in mortality rates between conventional and ministernotomy approaches (6). This study showed no statistical significance regarding in- hospital mortality.

Conclusion:

Minimally invasive surgery in the treatment of aortic valve disease has been the subject of considerable developments and improvements in the recent years thanks to the perfection of surgical techniques and the support that the industry has provided for carrying out these techniques.

Outcome analysis of the patients confirmed that the ministernotomy and right anterior minithoracotomy approaches did not endanger the quality of the procedure, and that these techniques are safe and effective therapeutic options that can be compared with conventional treatment even with the contradictory results of different studies in bleeding rates, pain perceived by the patient, infection of surgical wounds, duration of hospitalization, functional recovery and significant cosmetic effects.

The necessary skills to be able to conduct the procedure are not very demanding and are easily reproduced. Limitations due to the surgical field exposed, procedural challenges and potential pitfalls are easily overcome with the right knowledge and strategies.

Unless contraindicated, minimal access approaches, either ministernotomy or minithoracotomy can be used on a routine basis as a safe, reproducible and effective approaches for isolated primary aortic valve replacement.

Study limitations:

1- Short period of postoperative follow up.
2- Small sample sizes of the studied groups.
3- Lack of equipment or experience in some centers, discouraging performing new procedures as minimally invasive surgeries.
4- Lack of proper filing systems in some centers.

References:

[1]. Cosgrove, Delos M., and Joseph F. Sabik. 1996. "Minimally Invasive Approach for Aortic Valve Operations." The Annals of Thoracic Surgery 62 (2): 596-97. doi:l0.l016/0003-4975(96)00418-3.

[2]. Konertz, W, F Waldenberger, M Schmutzler, J Ritter, and J Liu. 1996. "Minimal Access Valve Surgery through Superior Partial Sternotomy: A Preliminary Study." The Journal of Heart Valve Disease 5 (6): 638-40. http://www .ncbi.nlm. nih.gov /pubmed/8953441.

[3]. Rodriguez, J E, M J lopez, Y Carrascal, L C Maroto, A Forteza, J Cortina, E Perez de la Sota, F Ginestal, and J J Rufilanchas. 1996. "[Aortic Valve Replacement via Ministernotomy]." Revista Espanola de Cardiologia49(12): 928-30. http://www.ncbi.nlm.nih.gov/pubmed/9026846.

[4]. Woo, Y. Joseph, JoergSeeburger, and Friedrich W. Mohr. 2007. "Minimally Invasive Valve Surgery." Seminars in Thoracic and Cardiovascular Surgery 19 (4): 289-98. doi:10.10S3/j.semtcvs.2007.10.00S.

[5]. Malaisrie, S. Chris, Glenn R. Barnhart, R. Saeid Farivar, John Mehall, Brian Hummel, Evelio Rodriguez, Mark Anderson, et al. 2014. "Current Era Minimally Invasive Aortic Valve Replacement: Techniques and Practice." Journal of Thoracic and Cardiovascular Surgery. doi:l0.l016/j.jtcvs.2013.08.086.

[6]. Merk, D. R., S. Lehmann, D. M. Holzhev, P. Dohmen, P. Candolfi, M. Misfeld, F. W. Mohr, and M. A. Borger. 2015. "Minimal Invasive Aortic Valve Replacement Surgery Is Associated with Improved Survival: A Propensity-Matched Comparison." European Journal of Cardio-Thoracic Surgery 47 (1): 11-17. dOi:l0.l093/ejcts/ezu068.

[7]. Bonacchi, Massimo, EdvinPrifti, Gabriele Giunti, Giacomo Frati, and Guido Sani. 2002. "Does Ministernotomy Improve Postoperative Outcome in Aortic Valve Operation? A Prospective Randomized Study." Ann Thorac Surg73: 460-66.

[8]. Brown, Morgan L., Stephen H. McKellar, Thoralf M. Sundt, and Hartzell V. Schaff. 2009. "Ministernotomv versus Conventional Sternotomy for Aortic Valve Replacement: A Systematic Review and Meta-Analysis." The Journal of Thoracic and Cardiovascular Surgery 137 {3}: 670-679.e5. doi:10.1016/j.jtcvs.2008.08.010.

[9]. Johnston, Douglas R., Fernando A. Atik, JeevananthamRajeswaran, Eugene H. Blackstone, Edward R. Nowicki, Joseph F. Sabik, TomislavMihaljevic, A. Marc Gillinov, Bruce W. Lytle, and Lars G. Svensson. 2012. "Outcomes of Less Invasive J-Incision Approach to Aortic Valve Surgery." The Journal of Thoracic and Cardiovascular Surgery 144 (4): 852-858.e3. dOi:l0.l016/j.jtcvs.2011.12.008.

[10]. Bakir, Ihsan, Filip P Casselman, Francis Wellens, HuguesJeanmart, Raphael De Geest, Ivan Degrieck, Frank Van Praet, Yvette Vermeulen, and Hugo Vanermen. 2006. "Minimally Invasive Versus Standard Approach Aortic Valve Replacement: A Study in 506 Patients." Ann ThoracSurg 81: 1599-1604. dOi:l0.l016/j.athoracsur.2005.12.011.

[11]. Aris, Alejandro, Maria Luisa Camara, Jose Montiel, Luis Javier Delgado, Josefina Galan, and Hector Litvan. 1999. "Ministernotomy versus Median Sternotomy for Aortic Valve Replacement: A Prospective, Randomized Study." The Annals of Thoracic Surgery 67 (6): 1583-87. doi:l0.l016/S0003-4975(99)00362-8.

[12]. Ehrlich, W, W Skwara, W Klovekorn, M Roth, and E P Bauer. 2000. {{Do Patients Want Minimally Invasive Aortic Valve Replacement?" European Journal of Cardio- Thoracic Surgery: Official Journal of the European Association for Cardia-Thoracic Surgery 17 (6): 714-17. http://www.ncbi.nlm.nih.gov/pubmed/10856865.

[13]. Grossi, E A, A C Galloway, G H Ribakove, P K Zakow, C C Derivaux, F G Baumann, D Schwesinger, and S B Colvin. 2001. "Impact of Minimally Invasive Valvular Heart Surgery: A Case-Control Study." The Annals of Thoracic Surgery 71 (3): 807-10. http://www.ncbi.nlm.nih.gov/pubmed/11269456.

[14]. Lee, J W, S K Lee, S J Choo, H Song, and M G Song. 2000. "Routine Minimally Invasive Aortic Valve Procedures." Cardiovascular Surgery (London, England) 8 (6): 484-90. http://www. ncbi. nlm.nih.gov /pubmed/1099610S.

[15]. Tabata, Minoru, RamananUmakanthan, Lawrence H Cohn, Ralph Morton Bolman, Prem S Shekar, Frederick Y Chen, Gregory S Couper, and Sary F Aranki. 2008. "Early and Late Outcomes of 1000 Minimally Invasive Aortic Valve Operations." European Journal of Cardio-Thoracic Surgery: Official Journal of the European Association for Cardio- Thoracic Surgery 33 (4): 537-41.

doi:10.1016/j.ejcts.2007.12.037.
[16]. von Segesser, L K, S Westaby, J Pomar, D Loisance, P Groscurth, and M Turina. 1999. "Less Invasive Aortic Valve Surgery: Rationale and Technique." European Journal of Cardio- Thoracic Surgery: Official . Journal of the European Association for Cardio- Thoracic Surgery 15 (6): 781-85. http://www.ncbi.nlm.nih.gov/pubmed/l0431859.
[17]. Stamou, Sotiris C, Emmanouil I Kapetanakis, Robert Lowery, Kathleen A Jablonski, Timothy L Frankel, and Paul J Corso. 2003. "Allogeneic Blood Transfusion Requirements after Minimally Invasive versus Conventional Aortic Valve Replacement: A Risk-Adjusted Analysis." The Annals of Thoracic Surgery 76 (4): 1101-6. http://www.ncbLnlm.nih.gov/pubmed/14529994.

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