# Aortic Valve Replacement via Mini-Sternotomy: Results of a Single Centre Analysis

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## Abstract

BACKGROUND: The traditional method of Aortic Valve Replacement (AVR) is via full sternotomy. However, this incision may not heal properly and cause significant pain. Minimally invasive approaches have been adopted, including mini sternotomy. These have gained popularity due to smaller incision, reducing surgical trauma. The hypothesis is that AVR via mini sternotomy is a safe alternative to full sternotomy. The objective was to analyse and describe results of patients who underwent the procedure, including post-operative outcomes.

METHODS: A retrospective database review was performed on patients who underwent AVR via mini-sternotomy between September 2016 and December 2022 in Cork University Hospital (CUH). Exclusion criteria included patients who had an aortic procedure concurrently, such as ascending aorta replacement, and those under 18 years. Results for variables, such as age, were expressed as a mean.

RESULTS: 93 patients were included; the average age was 68. Average bypass and cross-clamp times were 92 and 73 minutes respectively. Median post-operative length of stay was 8 days and median ICU length of stay was 3 days. There were no in-hospital mortalities.

CONCLUSION: This study was completed through a retrospective chart and database review of patients who underwent AVR via mini sternotomy over a 6-year period. The results presented provide valuable information related to patient demographics and peri- and post-operative outcomes. This is the first such chart study related to this procedure in an Irish hospital context.

## Introduction

Aortic valve disease is the most common valvular heart disease affecting millions of people worldwide and the aortic valve is the most commonly replaced heart valve [1]. Aortic valve replacement is the standard treatment for patients with severe or symptomatic aortic stenosis or aortic regurgitation/insufficiency [2]. It was first performed by Harken and Starr in 1960 at the Peter Bent Brigham Hospital in Boston through a full median sternotomy incision [3]. The traditional method of aortic valve replacement is via full sternotomy where an incision is made from the top of the sternum down as far as the umbilicus potentially. However, this long midline incision may not heal properly, may cause a significant amount of pain and may be associated with a prolonged recovery [2]. In patients with conditions such as osteoporosis or diabetes, the thinned out sternum may take a longer than expected time to heal and may lead to severe pain for patients [2]. AVR via mini-sternotomy has cosmetic advantages and is particularly useful in frail patients who may suffer from a conventional sternotomy and associated morbidities [3]. Worldwide, the number of aortic valve replacements in 2003 was 290,000 and is predicted to be 850,000 by 2050 [4].

Over the last two decades, a minimally invasive approach to aortic valve replacement has been adopted by many surgeons internationally [5]. It has generally been accepted as an alternative to a full sternotomy approach in low-risk patients, but there is limited data for its use in high-risk patients. The technique was first described by Cosgrove and Sabik in 1996, but the surgical uptake since then has been patchy [6]. This has been due possibly to the need for extra training for surgeons and the belief that there



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is no surgical benefit compared to the full sternotomy approach. However, the use of the approach has increased in frequency in Europe in recent years [7].

This paper presents a retrospective review of one such minimally invasive technique, the mini sternotomy approach, in Cork University Hospital (CUH). This procedure has been performed by Mr. Kishore Doddakula and his colleagues since 2011. This retrospective database review aims to explore the characteristics of patients who have undergone a minimally invasive aortic valve replacement and examine the outcomes for identified patients.

## Materials and Methods

This study was conducted in the Department of Cardiothoracic Surgery, CUH. A retrospective review was performed on a prospectively collected database of patients who underwent aortic valve replacement (AVR) via mini sternotomy between September 2016 and December 2022 (inclusive). Data was gathered from the PATS (Patient Advocate Tracking System) database in the Department of Cardiothoracic Surgery and was then entered into a data collection sheet, which consisted of parameters such as bypass time, cross-clamp time, and length of post-operative stay. Ethical approval was obtained from the Clinical Research Ethics Committee of the Cork Teaching Hospitals (CREC).

Patients aged 18 years or older who underwent an AVR via mini sternotomy were included in the study. Patients younger than 18 years old, those who underwent a full sternotomy and those who had another cardiac procedure at the same time (such as aortic root replacement or coronary artery bypass graft) were excluded.

Data analysis was performed using Microsoft Excel. Basic descriptive analysis was used to characterise the data. Results for continuous numerical variables such as age, height and weight were expressed as means. Categorical variables such as sex and comorbidities were expressed as percentages.

## Results

A total of 93 patients were included in the study, after the exclusion criteria were applied. Tables 1 to 3 present a summary of the results of the study and data analysis. Table 1 presents the demographic data as the demographic parameter and the corresponding parameter number (n), Table 2 summarises the peri-operative outcomes with the time presented as the average time and also as a range. Table 3 summarises the post-operative outcomes and complications.

The patient demographic data shows that the procedure was performed on more male than female

Table 1: Demographic Data

| Demographic Parameter | Parameter Number (n) |
|---|---|
| Age (years) | 68 |
| Number of males | 52 (55.9%) |
| Number of females | 41 (44.1%) |
| Height (m) | 1.67 |
| Weight (kg) | 81 |
| BMI (kg/m$^2$) | 29 |
| Diabetes | 10 (10.8%) |
| Hypertension | 61 (65.6%) |
| Hyperlipidaemia | 68 (73.1%) |
| Coronary Artery Disease | 13 (14%) |
| Pre-Existing Arrhythmia | 18 (19.4%) |
| Smoker/Ex-Smoker | 48 (51.6%) |
| COPD | 17 (18.3%) |
| Cardiac Ejection Fraction (%) | 54 |
| Creatinine Clearance (ml/min) | 84 |

Table 2: Peri-Operative Outcomes

| Peri-Operative Outcome Parameter | Average Time (Range) |
|---|---|
| Operative time (mins) | 243 (140-465) |
| Cardio-pulmonary bypass time (mins) | 93 (56-138) |
| Cross-clamp time (mins) | 72 (39-105) |
| Ventilation time (hours) | 16 (1-90) |
| Length of ICU stay (days) | 3 (1-65) |
| Length of hospital stay (days) | 11.1 (5-85) |

Table 3: Post-Operative Outcomes and Complications

| Post-Operative Outcome Parameter | Number of Procedures |
|---|---|
| Conversion to Full Sternotomy | 3 |
| Re-do Sternotomy | 5 |
| Sternal Wound Infection | 2 |
| Myocardial Infarction | 0 |
| Paravalvular Leak | 1 |
| Stroke | 1 |
| Acute Kidney Injury | 0 |
| Arrhythmias | 25 |
| Pulmonary Embolism | 0 |
| Deep Vein Thrombosis | 0 |
| Prolonged Use of Inotropes | 18 |

patients. The most common pre-operative patient conditions were hypertension and hyperlipidaemia, both for over 65% of patients. Pre-existing arrhythmia was evident for approximately 20% of patients and approximately 50% of the patients had a history of smoking.

The mean operative time was approximately 4 hours, with average ICU and hospital stays of 3 and 11 days respectively yielding a mean post-operative length of stay of 8 days. Mean bypass and cross-clamp times were 92 and 73 minutes respectively.

A range of post-operative outcomes are presented. Arrythmias were found in 25 patients (26.9%) in comparison to 19.4% of patients identified with the condition pre-operation. Conversion to a full sternotomy was undertaken for only 3 patients (3.2%) and a re-do sternotomy was performed on 5 patients (5.4%). 18 procedures (19.3%) involved the use of inotropes. There were no in-hospital myocardial infarctions, pulmonary embolisms, deep vein thromboses or in-hospital mortalities.

Figures 1 and 2 present two examples where the full dataset is presented without filtering as a scatter diagram. Both figures show clustered data with two outlier points where long periods of hospitalisation were required. A Pearson correlation analysis indicates a stronger correlation with the removal of these two outliers, although the correlation value remains relatively low at 0.25 for the relationship in Figure 1 and very low at 0.1 for the relationship in Figure 2.

## Discussion

Minimally invasive aortic valve replacement has gained increasing popularity over the last 20 years by avoiding a full sternotomy incision, subsequently reducing surgical trauma [8]. Any kind of minimally invasive cardiac surgery is technically more challenging than a procedure performed through a full median sternotomy, mainly due to a limited incision and

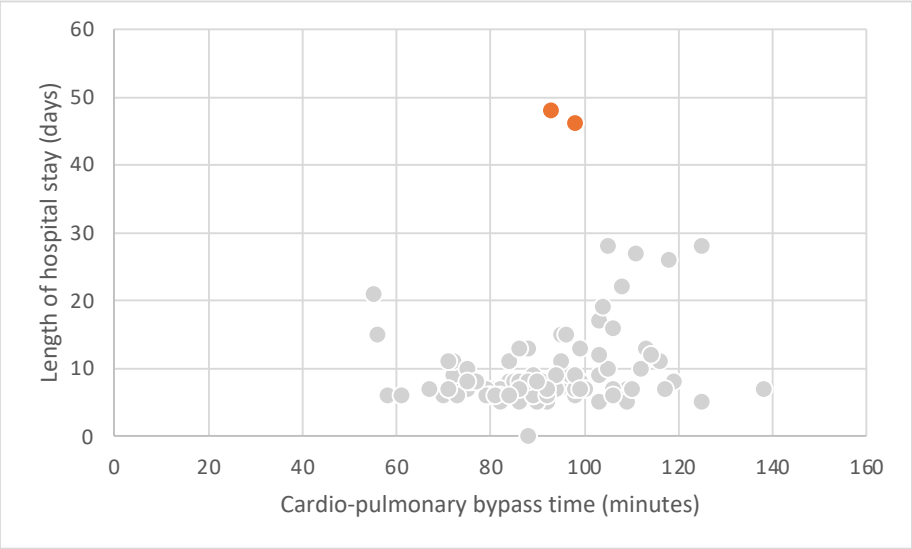


Figure 1 Cardio-Pulmonary Bypass Time versus Length of Hospital Stay

a smaller operative space that leads to restricted manoeuvrability [9]. A steep learning curve associated with minimally invasive aortic valve replacement has been found in several studies, even those involving the most experienced and skilled surgeons [10]. The limited view of the operative field obstructs access to the ascending aorta and may prevent desired sight of the procedure, potentially leading to longer operative times [11]. Despite the complexity of the procedure, it has been shown that there is no increase in early mortality when compared with a conventional aortic valve replacement [6].

This approach has been shown to reduce postoperative morbidity, provide a faster recovery and rehabilitation time, a shorter hospital stay and better cosmetic results compared with conventional surgery [5]. However, the procedure is more technically demanding and difficult for surgeons, which increases the likelihood of errors, especially in those with limited experience. A J-shaped mini sternotomy is the most commonly employed minimally invasive approach [12]. This is performed by making a 2-3 inch incision along the upper part of the sternum. In addition to providing improved cosmetic results compared to a full sternotomy, the smaller incision reduces the likelihood of the development of wound infections, especially in those who are obese or have diabetes [13].

This paper presents valuable results based on a retrospective database review on patients who underwent AVR via mini sternotomy between September 2016 and December 2022 at CUH. Results are presented for the patient demographics, peri-operative outcomes and complications with key results identified.

The key results of the study are as follows:

- For the patient group a large number and a wide variety of co-morbidities were found with the most common being hypertension and hyperlipidaemia at 65% and 73%, respectively.
- For the peri-operative outcome parameters the average value and the range are presented with the range in particular for the ventilation time, length of ICU and length of hospital stay being broad.
- For the post-operative outcome parameters a notable finding was that there was an increase in the incidence of arrhythmias from 18 to 25 for the patient cohort studied. In addition, there were no in-hospital myocardial infarctions, pulmonary embolisms, deep vein thromboses or in-hospital mortalities.

## Conclusions

The objective of the study presented in this paper was to analyse and describe results of patients who underwent aortic valve replacement via mini sternotomy including post-operative outcomes. This was completed through a retrospective chart and database review of patients who underwent this procedure between September 2016 and December 2022 in CUH. Data for 93 patients (after the application of exclusion criteria) was analysed through Excel. The results are presented and described, providing valuable information related to patient demographics and peri- and post-operative

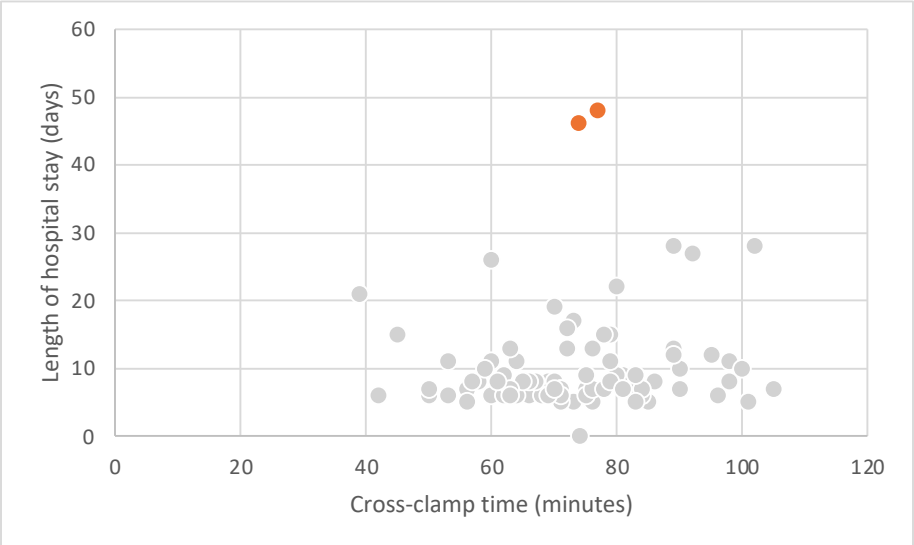


Figure 2 Cross-Clamp Time versus Length of Hospital Stay

outcomes.

It is the first such study related to AVR via mini sternotomy in an Irish hospital context and increases the national knowledge database for this minimally invasive surgical technique.

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## References

1. Musumeci L, Jacques N, Hego A, Nchimi A, Lancellotti P, Oury C. Prosthetic Aortic Valves: Challenges and Solutions. Frontiers in Cardiovascular Medicine 2018; 5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5961329/#B10
2. Goyal A, Chhabra L, Parekh A, Bhyan P, Khalid N. Minimally Invasive Aortic Valve Surgery. StatPearls Publishing 2022. https://www.ncbi.nlm.nih.gov/books/NBK470376/
3. Pozzi M, Mariani S, Scanziani M, Passolunghi D, Bruni A, Finazzi A, Lettino M, Foti G, Bellelli G, Marchetto G. The frail patient undergoing cardiac surgery: lessons learned and future perspectives. Front Cardiovasc Med. 2023 6;10.
4. Yacoub MH, Takkenberg JJ. Will heart valve tissue engineering change the world? Nature Clinical Practice Cardiovascular Medicine 2005; 2(2):60-1. https://www.nature.com/articles/ncpcardio0112
5. Kaczmarczyk M, Szalanski P, Zembala M, Filipiak K, Karolak W, Wojarski J, et al. Minimally invasive aortic valve replacement – pros and cons of keyhole aortic surgery. Polish Journal of Cardio-thoracic Surgery 2015; 12(2):103-10. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4550017/
6. Phan K, Xie A, Di Eusanio M, Yan TD. A Meta-Analysis of Minimally Invasive Versus Conventional Sternotomy for Aortic Valve Replacement. The Annals of Thoracic Surgery 2014; 98(4):1499-511. https://www.annalsthoracicsurgery.org/article/S0003-4975(14)01180-1/fulltext
7. Hamm CW, Mollman H, Holzhey D, Beckmann A, Veit C, Figulla HR, et al. The German Aortic Valve Registry (GARY): in-hospital outcome. European Heart Journal 2014; 35:1588-98. https://pubmed.ncbi.nlm.nih.gov/24022003/
8. Oo S, Khan A, Chan J, Juneja S, Caputo M, Angelini G, et al. Propensity matched analysis of minimally invasive versus conventional isolated aortic valve replacement. Perfusion 2023; 38(2):261-9.https://journals.sagepub.com/doi/full/10.1177/02676591211045802?rfr_dat=cr_pub++0pubmed&url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org
9. Vohra HA, Salmasi MY, Chien L, Baghai M, Deshpande R, Akowuah E, et al. BISMICS consensus statement: implementing a safe minimally invasive mitral programme in the UK healthcare setting. Open Heart 2020; 7(2):e001259. https://openheart.bmj.com/content/7/2/e001259.long
10. Young CP, Sinha S, Vohra HA. Outcomes of minimally invasive aortic valve replacement surgery. European Journal of Cardio-Thoracic Surgery 2018; 53:19-23. https://academic.oup.com/ejcts/article/53/suppl_2/ii19/4988871?login=false
11. Faraz A, Fundano N, Qureshi AI, Tarar MY, Yawar B, Mohammed GDF. Comparison between mini-sternotomy and full sternotomy for aortic valve replacement: A 10-year

retrospective study. Cureus 2022; 14(11). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9757642/#REF1

12. Van Praet KM, Nersesian G, Kukucka M, Kofler M, Wert L, et al. Minimally invasive surgical aortic valve replacement via a partial upper ministernotomy. Multimedia Manual of Cardiothoracic Surgery 2022. https://mmcts.org/tutorial/1770
13. Mikus E, Calvi S, Campo G, Pavasini R, Paris M, Raviola E, et al. Full Sternotomy, Hemisternotomy and Minithoracotomy for Aortic Valve Surgery: Is There a Difference? The Annals of Thoracic Surgery 2018; 106(6):1782-8. https://www.annalsthoracicsurgery.org/article/S0003-4975(18)31184-6/fulltext