



Long-Term Outcomes of Native Infective Endocarditis After Surgery: A Single-Centre Experience

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Abstract: Objective: Infective endocarditis requires prompt recognition and treatment due to its high mortality and morbidity rates. Few studies compare long-term patient outcomes after mitral and aortic valve endocarditis surgery. Hence, we aim to assess this in our cohort. Methods: We included adult patients aged 18 and above who underwent surgery between April 2011 and April 2021 for first-time native aortic or mitral valve endocarditis in our study. Patients were followed up until July 2024. Results: 94 patients were included in our study. Streptococcus was the most common bacterial species causing infective endocarditis and was more prevalent in the aortic group than the mitral group. Conversely, Staphylococci were more common in the mitral group. Patients undergoing mitral valve surgery had longer bypass and cross-clamp times compared to the aortic group. There was no statistical difference between aortic valve (AV) and mitral valve (MV) endocarditis in early post-operative re-exploration rates, post-operative cerebrovascular accidents (CVA), or post-operative dialysis. Patients with AV and MV endocarditis had comparable in-hospital and 1-year post-surgery mortality rates. Although the mortality rate for aortic valve endocarditis was higher at both 5-year and 8-year follow-ups, it was not statistically significant. Conclusions: Despite some differences in peri-operative variables, there was no significant difference in short- and long-term mortality rates after aortic and mitral valve endocarditis surgery.

Keywords: Native Infective Endocarditis, Adult Patients, Post-Operative, Long-Term Outcome, Mortality

1. Introduction

Infective endocarditis (IE) is a rare condition associated with high morbidity and mortality rates, with an estimated 20% mortality by the time of hospital discharge and a long-term mortality rate of 40–50% (Fedeli 2011; Cresti 2017). Despite advancements in the diagnosis and treatment of IE in recent decades, there have been no significant improvements in mortality outcomes (Thuny 2012). Additionally, the incidence of IE has generally increased over the past thirty years (Hammond-Haley 2023). This rise has been attributed to an observable increase in risk factors such as the greater use of implantable cardiac devices, hemodialysis for end-stage chronic kidney disease, improved life expectancy in patients with congenital cardiac disease, and an ageing population (Fernández-Hidalgo 2008; Murdoch 2009; Chaudry 2017).

Recent recommendations for antibiotic prophylaxis during dental treatment may also have influenced the incidence of IE. In 2008, the National Institute for Health and Care Excellence (NICE) made significant changes to its antibiotic prophylaxis guidelines, recommending against the use of antibiotics for any patient undergoing dental procedures (NICE 2018). Similarly, the European Society of Cardiology (ESC) updated its 2009 guidelines, restricting antibiotic prophylaxis to only those at high risk of developing infective endocarditis. However, in 2023 (as also noted in the 2015 IE Guidelines), the ESC refined its criteria, recommending antibiotic prophylaxis for high-risk patients undergoing manipulation of the gingival or periapical region of the teeth or any perforation of the oral mucosa (Delgado 2023).

Left-sided infective endocarditis affects the mitral or aortic valves and requires urgent intervention due to the increased risk of systemic embolic complications and the significant hemodynamic consequences of valve failure (Pettersson 2017). However, the two valves differ physiologically and are exposed to distinct hemodynamic conditions (David 2013). For instance, aortic valve endocarditis is more likely to result in annular destruction and an invasive disease pattern (e.g., annular abscess, fistula formation) compared to mitral valve endocarditis (Pettersson 2017).

Early recognition and treatment of infective endocarditis are recommended to reduce mortality and associated morbidity (Narayanan 2016). Guidelines from both the

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ESC and NICE recommend an initial antibiotic treatment course of 2–6 weeks for native valve IE (NICE 2018; Delgado 2023). Currently, the ESC and the American Association of Thoracic Surgery (AATS) have issued a Class I recommendation for surgical intervention in patients presenting with heart failure, uncontrolled infection, or multiple embolisms despite appropriate antibiotic therapy (Pettersson 2017; Delgado 2023).

Since the changes in NICE guidelines in 2008, there have been very few studies comparing patients who underwent surgical intervention for aortic versus mitral valve endocarditis. The primary aim of our study was to compare differences in postoperative mortality between patients with native mitral or aortic endocarditis, both early and late after surgery. Additionally, our secondary aims were to assess differences in operative variables and postoperative complications, including re-operation, post-operative dialysis, and post-operative cerebrovascular accidents (CVA).

2. Methods

2.1. Study Participants

In our center, every patient has a unique hospital number linked to an electronic patient care record. This system holds demographic information, operative and post-operative details, as well as follow-up letters. Additionally, all investigation reports are uploaded onto a regional reporting database, which allows tracking of follow-up investigation reports and mortality. The list of patients was obtained from our local audit department and cross-referenced with our department's surgical database.

The data collected from the patients includes pre-operative demographic data, postoperative outcomes, comorbidities, and pathogens detected through pre-operative blood culture, microbiological culture, and peri-operative fluid culture from the valve.

2.2. Inclusion criteria

Adult patients (aged 18 years or older) with first-time native left-sided valve endocarditis who underwent surgery between April 2011 and April 2021 were included in our study. The diagnosis of infective endocarditis was based on the modified Duke's criteria (Li 2000).

2.3. Exclusion criteria

The following groups were excluded:

1. Patients with a previous episode of infective endocarditis
2. Patients with prosthetic valve endocarditis
3. Patients who had undergone any previous cardiac surgery
4. Patients who required surgical intervention for more than one valve or had surgery involving the tricuspid or pulmonary valve.

2.4. Antibiotic prophylaxis prior to surgery and post-operative antibiotic protocols

Prior to surgery, patients were typically given 1.5 g of cefuroxime via intravenous (IV) administration, with an additional 400 mg of IV teicoplanin if the surgery lasted longer than four hours. If the patient had a penicillin allergy, this was replaced by 4 mg/kg of IV gentamicin and 400 mg of IV teicoplanin. If an organism was isolated prior to surgery through cultures and sensitivity testing, the choice of antibiotics was tailored accordingly.

Post-operatively, all patients underwent a four- to six-week course of intravenous antibiotics. The type of antibiotics administered was guided by the local cardiology and microbiology teams. Patients were generally started on penicillin-based antibiotics, with gentamicin added if necessary. Patients allergic to penicillin were given either tetracyclines (e.g., doxycycline) or cyclic lipopeptide antibiotics (e.g., daptomycin).

2.5. Follow-up and Outcomes

Patients were followed from the date of their heart valve surgery until death or July 2024, whichever occurred first. The primary outcome was all-cause mortality during surgery, at discharge, at 30 days, at 1-year post-surgery, at a median of 5 years follow-up, at a median of 8 years follow-up, and at the date of censor. A minimum follow-up period of 3 years was confirmed for all patients.

2.6. Statistical Analysis

Categorical baseline and pre-operative characteristics were presented as counts and percentages. Continuous demographic and intra-operative characteristics were presented as means and standard deviations.

Categorical variables were analyzed using the Chi-squared test or Fisher's exact test. All continuous variables were checked for normal distribution using the Student's t-test, which showed that they were not normally distributed ($p < 0.05$). Hence, the Kruskal-Wallis test was performed to compare continuous variables between the two groups.

Survival analysis was estimated using the Kaplan-Meier curve, with the log-rank test used to assess differences in survival between the two groups. The mortality rate for in-hospital, 1-year, median 5-year follow-up, median 8-year follow-up, and at the date of censor was summarized in Table 4.

The level of statistical significance for all analyses was set at $p < 0.05$. The data was stored in a secure database with all patient identifiers removed. Data management and statistical analysis were performed using SPSS (IBM Corp. Released 2023. IBM SPSS Statistics for Windows, Version 29.0.2.0, Armonk, NY: IBM Corp).

3. Results

3.1. Demographic

We identified 176 valve surgeries for infective endocarditis between April 2011 to April 2021 (Figure 1). Of these cases, 24 cases were removed as they were not active ongoing IE, 25 cases were prosthetic valve IE or redo cases, 19 cases were double valve surgery for IE, and 14 cases were isolated tricuspid valve surgery. This resulted in a total of 94 cases of left-sided native valve endocarditis were included in this study.

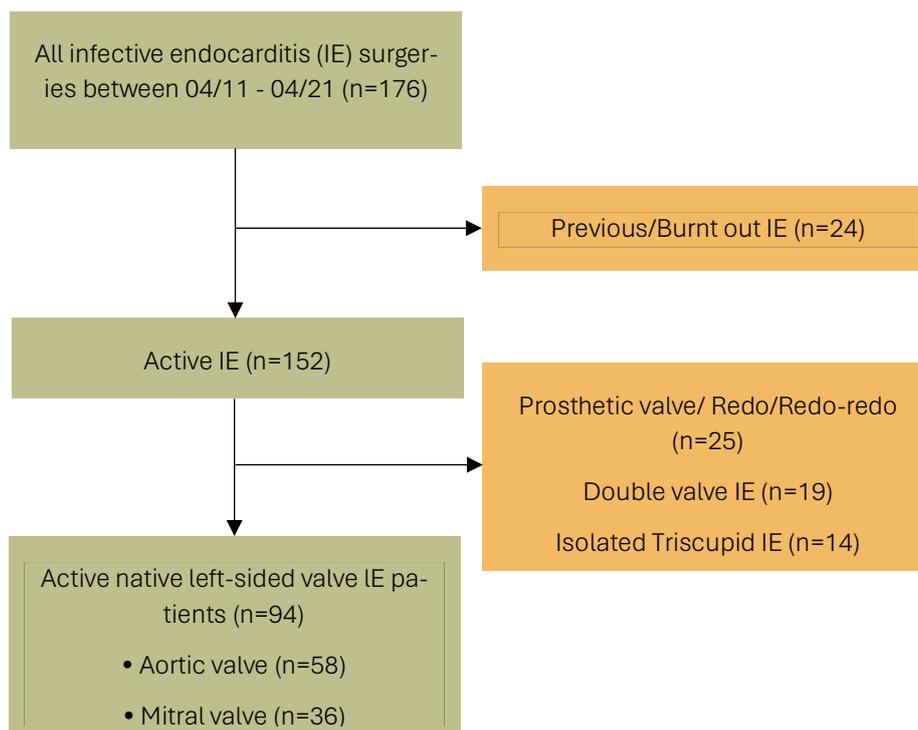


Figure 1: Trial flow diagram of all patients who had infective endocarditis between April 2011 to April 2021 (n=176). Inclusion and exclusion criteria were applied to the cohort and a total of 94 patients were included in this study, with 58 patients in the aortic group and 36 patients in the mitral group.

Of these, 58 (61.7%) were cases of aortic valve IE and 36 (38.3%) were cases of mitral valve IE. The number of cases generally increased between 2011 to 2015, with the peak cases in 2015 (n=14). The number of cases generally declined after 2015 (**Figure 2**).

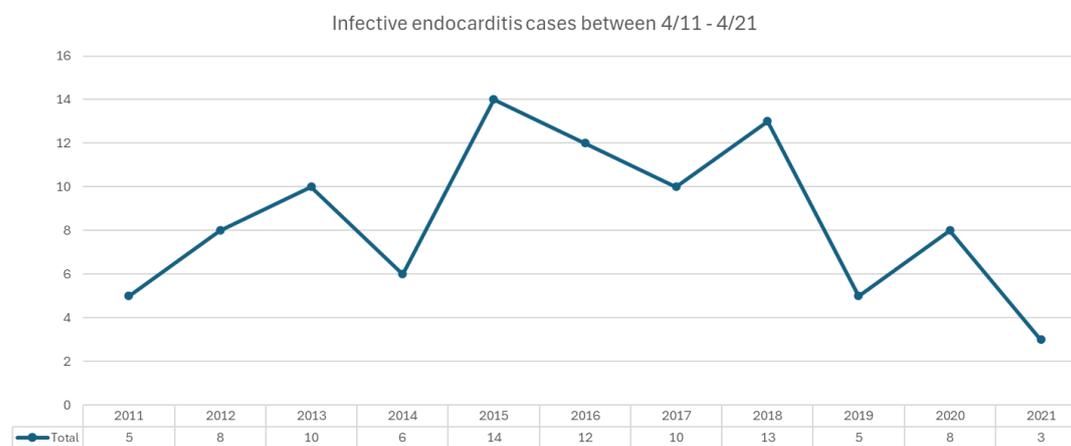


Figure 2: Line graph depicting the 10-year trend of cases from April of 2011 to April of 2021. The peak was in 2015 with 14 cases and has generally decreased since then.

The average age of our cohort was 53.38 ± 14.59 years old, with no significant difference between the aortic (51.98 ± 14.28) and mitral valve (55.64 ± 14.99) cohorts ($p=0.249$). Male patients were predominant in both cohorts, 75.9% in aortic and 72.2% in mitral cases. BMI was higher in the aortic (26.69 ± 5.70) than in the mitral group (24.69 ± 5.11) which was statistically significant ($p=0.034$). Although it was not statistically significant, we have identified that vegetation was diagnosed more commonly in patients with MV endocarditis than the AV endocarditis patients (80.6% vs 69%). Additionally, there was also a significant difference ($p=0.022$) in the distribution of pre-operative left ventricular ejection fraction (LVEF) with a greater number of patients with moderate and severe LVEF in the aortic (35.2%) than the mitral group (11.1%). There was a higher proportion of emergency surgeries (< 2 days of admission) amongst the AV endocarditis patients (36.2%) than the MV endocarditis patients (2.8%), which is statistically significant ($p<0.001$). All the pre-operative variables that we have collected in both groups are summarized in Table 1.

Table 1: Summary of the pre-operative demographic of patients included in the study. All categorical variables were analysed using the chi-squared test. The AVE group had a higher BMI ($p=0.034$) and more patients with moderate and severe LVEF ($p=0.022$). Other variables were not statistically significant ($p>0.05$). AF = atrial fibrillation, BMI = body mass index, COPD = chronic obstructive pulmonary disease, HIV = Human immunodeficiency virus.

	Overall	Aortic	Mitral	p-value
Total	94	58 (61.7%)	36 (38.3%)	-
Age (years)	53.38 ± 14.59	51.98 ± 14.28	55.64 ± 14.99	$p=0.249$
BMI	25.93 ± 5.54	26.69 ± 5.70	24.69 ± 5.11	$p=0.034^*$
Euroscore2	7.73 ± 7.44	8.47 ± 5.15	6.53 ± 7.41	$p=0.167$
Male	70 (74.5%)	44 (75.9%)	26 (72.2%)	$p=0.694$
Female	24 (25.5%)	14 (24.1%)	10 (27.8%)	
Hypertension	22 (23.4%)	16 (27.6%)	10 (27.8%)	$p=0.984$
Diabetes	19 (20.2%)	12 (20.7%)	7 (19.4%)	$p=0.884$
Immunosuppressive therapy	5 (5.3%)	5 (8.6%)	0	$p=0.070$
Intra-venous drug user	12 (12.8%)	8 (13.8%)	4 (11.1%)	$p=0.705$
Smoking	62 (66%)	38 (65.5%)	24 (66.7%)	$p=0.909$
COPD	15 (16%)	9 (15.5%)	6 (16.7%)	$p=0.882$
Pre-operative cerebrovascular accidents (CVA)	20 (21.3%)	9 (15.5%)	11 (30.6%)	$p=0.083$
Previous myocardial infarct (MI)	6 (6.4%)	5 (8.6%)	1 (2.8%)	$p=0.260$
Cancer	6 (6.4%)	4 (6.9%)	2 (5.6%)	$p=0.796$
HIV	2 (2.1%)	2 (3.4%)	0 (0%)	$p=0.260$
Renal dysfunction	13 (13.8%)	8 (13.8%)	1 (13.9%)	$p=0.990$
Cardiac arrhythmia	14 (14.8%)	AF= 5 (8.6%) Other =7 (12.1%)	AF=2 (5.6%)	$p=0.073$
Echo vegetation	69 (73.4%)	40 (69%)	29 (80.6%)	$p=0.216$
Positive bacterial culture	81 (86.2%)	51 (87.9%)	30 (83.3%)	$p=0.530$
Pre-operative left ventricular ejection fraction (LVEF)	1=69 (73.4%) 2=22 (23.4%) 3=3 (3.2%)	1=37 (63.8%) 2=19 (32.8%) 3=2 (3.4%)	1= 32 (88.9%) 2 = 3 (8.3%) 3 = 1 (2.8%)	$p=0.022^*$
1= >50%				
2= 31-49%				
3= ≤30%				
Urgency of surgery	1=22 (23.4%) 2=71 (75.5%) 3=1 (1.1%)	1=21 (36.2%) 2=37 (63.8%) 3=0 (0%)	1=1 (2.8%) 2=34 (94.4%) 3=1 (2.8%)	$p<0.001$
1: Emergency (<2 days of admission)				
2: Urgent (<7 days of admission)				
3: Elective (>7 days of admission)				

3.2. Bacteria species

The bacterial species are summarized in Table 2. The bacteria were identified from either pre-operative blood cultures or intra-operative fluid cultures from the affected valve. All pre-operative blood cultures were assessed from our local surgical centres as well as referring hospitals. The most common bacterial groups were Streptococcus (39.4%), Staphylococcus (29.8%), and Enterococcus (6.4%). Additionally, 13.8% of patients had negative culture results.

Aortic cases had a higher proportion of *Streptococcus* (44.8% vs. 30.6%) and *Enterococcus* (8.6% vs. 2.85%) species compared to the mitral valve group. Conversely, *Staphylococcus* species (38.9% vs. 24.1%), including *Staphylococcus aureus* (30.6% vs. 19%), were more prevalent in the mitral valve endocarditis (MVE) group compared to the aortic valve endocarditis (AVE) group. Among patients with culture-negative IE (13.8%), those in the mitral valve group had a higher incidence of negative results (16.7%) compared to the aortic valve group (12.1%). Additionally, 3.2% of patients had multiple bacterial species in their blood cultures. *Staphylococcus aureus* was associated with the highest in-hospital mortality (30%), followed by *Enterococcus faecalis* (20%). The summary of bacterial growth is shown in Table 2.

Table 2: Summary of bacteria species. They were obtained from blood culture and peri-operative fluid culture from the valves. *Staphylococcus*, *streptococcus* and *enterococcus* account for 75% of the total organisms cultured.

Bacteria species	Overall	Aortic valve IE	Mitral valve IE	In-hospital mortality
No Growth	13 (13.8%)	7 (12.1%)	6 (16.7%)	2 (20%)
Staphylococcus species	28 (29.8%)	14 (24.1%)	14 (38.9%)	-
<i>Staphylococcus aureus</i>	22 (23.4%)	11 (19%)	11 (30.6%)	3 (30%)
<i>Staphylococcus Epidermidis</i>	3 (3.2%)	2 (3.4%)	1 (2.8%)	1 (10%)
<i>Staphylococcus Lugdunensis</i>	2 (2.1%)	1 (1.7%)	1 (2.8%)	-
<i>Staphylococcus Haemolyticus</i>	1 (1.1%)	0	1 (2.8%)	-
Streptococcus species	37 (39.4%)	26 (44.8%)	11 (30.6%)	-
Streptococcus Viridans group (<i>S.Anginosus</i> , <i>S.Mitis</i> , <i>S.Sanguinis</i> , <i>S.Salivarius</i> , <i>S.Mutans</i> , <i>S.Oralis</i>)	20 (21.3%)	15 (25.9%)	5 (13.9%)	-
<i>Streptococcus Agalactiae</i>	6 (6.4%)	3 (5.2%)	3 (8.3%)	1 (10%)
<i>Streptococcus Galloyticus</i>	3 (3.2%)	2 (3.4%)	1 (2.8%)	1 (10%)
<i>Streptococcus Salivaris</i>	3 (3.2%)	3 (5.2%)	0	-
<i>Streptococcus Pneumoniae</i>	3 (3.2%)	3 (5.2%)	0	-
<i>Streptococcus Gordonii</i>	1 (1.1%)	0	1 (2.8%)	-
<i>Streptococcus Coagulase</i>	1 (1.1%)	1 (1.7%)	0	-
<i>Streptococcus Dysgalactiae</i>	1 (1.1%)	0	1 (2.8%)	-
<i>Streptococcus Infantarius</i>	1 (1.1%)	1 (1.7%)	0	-
<i>Streptococcus Pyogenes</i>	1 (1.1%)	1 (1.7%)	0	2 (20%)
Enterococcus faecalis	6 (6.4%)	5 (8.6%)	1 (2.8%)	-
HACEK organisms (<i>Aggregatibacter actinomycetemcomitans</i> , <i>Haemophilus Parainfluenzae</i>)	2 (2.2%)	0	2 (5.6%)	-
Others (<i>E.coli</i> , <i>Aerococcus Urinae</i> , <i>Abiotrophia Defectiva</i> , <i>Klebsiella pneumoniae</i>)	5 (5.3%)	4 (6.9%)	1 (2.8%)	-
Multiple growth in culture	3	2 (3.4%)	1 (2.8%)	-

3.3. Operative details

Most patients underwent valve replacement (84%). However, a significantly greater number of valve repairs were performed in the mitral group compared to the aortic group (36.1% vs. 3.4%, $p < 0.001$). The mean bypass time for the mitral group was 110.47 ± 53.35 minutes, compared to 93.67 ± 44.96 minutes for the aortic group ($p = 0.040$). The cross-clamp time for the mitral group was 87.08 ± 39.87 minutes, compared to 73.81 ± 37.79 minutes for the aortic group ($p = 0.042$). Operative details are summarized in Table 3.

Post-operatively, the median length of hospital stay after surgery was 14.5 days, with no significant differences between the two groups ($p = 0.286$). Post-operative complications included post-operative dialysis (9.6%), new post-operative cerebrovascular accidents (CVA) (9.6%), and re-exploration for bleeding (8.5%), none of which were statistically significant between the two groups. No cases of deep sternal wound infection (DSWI) were reported in our cohort. All post-operative complications are summarized in Table 3.

3.4. Primary outcomes (Mortality at discharge, 1-year, median 5-years, median 8-years, and end of follow-up)

The overall in-hospital mortality rate was 10.6% ($n=10$), comprising 7 deaths (12.1%) in the aortic group and 3 deaths (8.3%) in the mitral group. The overall mortality rate 1-year post-surgery was 13.8% ($n=13$), which consisted of 9 (15.5%) deaths in the aortic group and 4 (11.1%) deaths in the mitral group. At median 5 years post-surgery, the overall mortality rate was 35.1% ($n=33$), with 24 deaths (41.3%) in the aortic group and 9 deaths (25%) in the mitral group. Subsequently, at a median 8 years post-surgery, the overall mortality rate was 39.4% ($n=37$), consisting of 25 deaths (43.1%) in the aortic group and 12 deaths (33.3%) in the mitral group. By the end of the follow-up period, the overall mortality rate reached 40.4% ($n=38$), with slightly higher mortality in the aortic group (43.1% vs 36.1%). The mean survival duration for the overall cohort was 8.47 ± 0.58 years, with no significant difference between the aortic and mitral cohorts (8.95 ± 0.902 and 8.12 ± 0.76 , $p=0.453$), as seen in Figure

3. No significant statistical differences in mortality were noted between the aortic and mitral groups across all periods. Detailed mortality rates for patients with aortic and mitral valve interventions across the specified periods are summarised in Table 4.

Table 3: Intra-operative variables. There were more repair surgeries performed than replacement surgery in the MVE group than in AVE (36.1% vs 3.4% and 96.6% vs 63.9%, $p < 0.001$). Mitral valve surgery had a statistically significant longer bypass (110.47 \pm 53.35 vs 93.67 \pm 44.96 minutes, $p = 0.040$) and cross-clamp time (87.08 \pm 39.87 vs 73.81 \pm 37.79 minutes, $p = 0.042$) compared to aortic surgeries.

	Overall	Aortic	Mitral	p-values
Valve replacement	Repair = 15 (16%) Replacement = 79 (84%)	Repair = 2 (3.4%) Replacement = 56 (96.6%)	Repair = 13 (36.1%) Replacement = 23 (63.9%)	$p < 0.001^*$
Implant type	Mechanical = 38 (40.4%) Biological = 41 (43.6%)	Mechanical = 24 (41.4%) Biological = 32 (55.2%)	Mechanical = 14 (38.9%) Biological = 9 (25%)	$p = 0.145$
Bypass time (mins)	100.11 \pm 48.76	93.67 \pm 44.96	110.47 \pm 53.35	$p = 0.040^*$
Cross-clamp time (mins)	78.89 \pm 38.93	73.81 \pm 37.79	87.08 \pm 39.87	$p = 0.042^*$

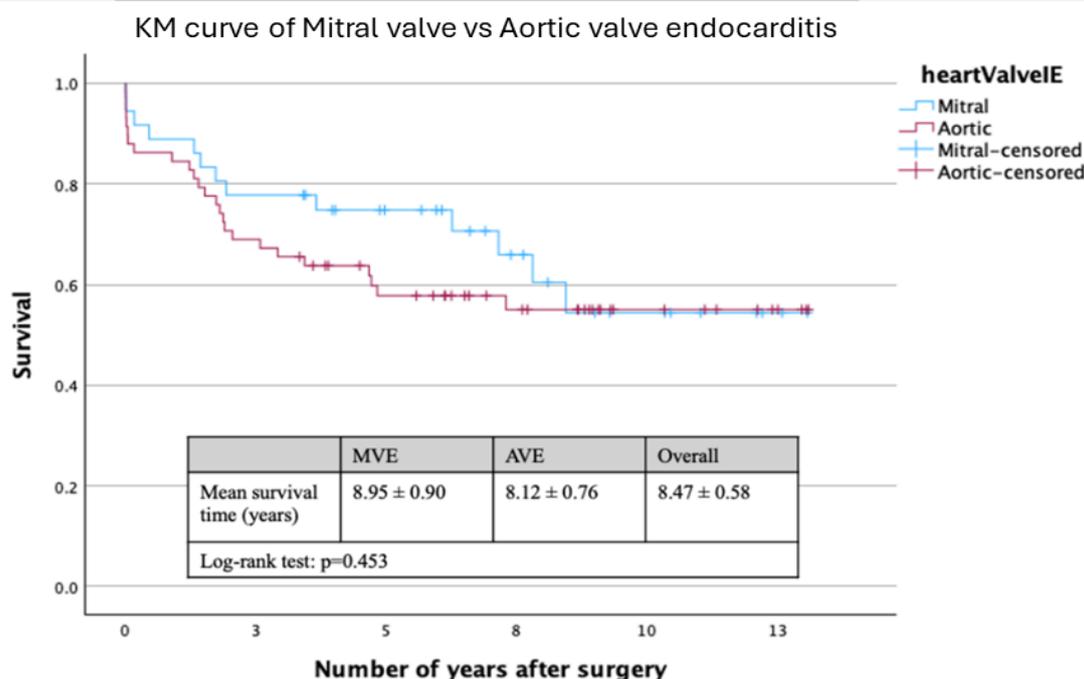


Figure 3: Kaplan-Meier curve for all-cause mortality in-patient and on follow-up. Survival estimates of patients with native valve endocarditis were grouped into aortic valve endocarditis and mitral valve endocarditis. A log-rank test was performed to compare the survival outcomes between the two groups. There was no statistically significant difference in the survival time between the two groups (8.95 \pm 0.902 vs 8.12 \pm 0.76, $p = 0.453$).

Table 4: Summary of the mortality rate at the end of the hospital stay (in-hospital), 1-year post-surgery, median 5 years post-surgery, median 8 years post-surgery, and at the end of the study (07/24). There was no statistically significant difference observed between both groups.

Time points	Overall	Aortic	Mitral	p-value
In-hospital mortality	10 (10.6%)	7 (12.1%)	3 (8.3%)	$p = 0.568$
1-year post-surgery	13 (13.8%)	9 (15.5%)	4 (11.1%)	$p = 0.391$
Median 5 years post-surgery	33 (35.1%)	24 (41.3%)	9 (25.0%)	$p = 0.145$
Median 8 years post-surgery	37 (39.4%)	25 (43.1%)	12 (33.3%)	$p = 0.342$
End of follow-up (07/24)	38 (40.4%)	25 (43.1%)	13 (36.1%)	$p = 0.502$

Further analysis was performed to assess the effect of pre-operative left ventricular ejection fraction (LVEF) against mortality rate. At discharge, patients with LVEF $> 50\%$ had a mortality rate of 8.7%, as compared to 13.6% in those with LVEF between 31-49% and 33.3% in those with LVEF $< 30\%$. At 2 years, the mortality rate of those with pre-operative LVEF $> 50\%$ was 21.7%, as compared to 22.8% in LVEF between 31-49%, and LVEF $< 30\%$ was 100%, within 2 years, this was statistically significant at $p = 0.024$. The mortality at median 8-year follow-up showed a mortality rate of 34.9% in patients with LVEF $> 50\%$ and 40.9% in those with LVEF between 31-49% (Table 6).

Table 5: Mortality rate by grouped by left ventricular ejection fraction (LVEF). Although the number of patients was small, those with LVEF <30% had the highest mortality rate at 100% at a median 2-year follow-up after surgery. Fisher's exact test was used in the analysis due to the small number of patients.

	LVEF >50%	LVEF 31-49%	LVEF <30%	p-value
Mortality at discharge	8.7%	13.6%	33.3%	p=0.349
Mortality at median 2 years after surgery	21.7%	22.8%	100%	p=0.024*
Mortality at median 8 years after surgery	34.9%	40.9%	100%	p=0.083

3.5. Secondary outcomes (postoperative length of stay and postoperative complications)

Table 6: Summary of the post-operative length of hospital stay and postoperative complications including rate of re-operation, dialysis, and cerebrovascular accidents. The patients were grouped into native aortic valve endocarditis and mitral valve endocarditis. Fisher's exact test and chi-square test were used for the analysis. No statistically significant difference was observed between both groups.

	Overall	Aortic	Mitral	p-values
Post-op length of stay (days)	14.5 (7.0,35.0)	15.0 (7.8,36.3)	13.0 (6.3,25.8)	p=0.286
Median (Interquartile range)				
Re-operation during hospital stay	11 (11.7%)	7 (12.1%)	4 (11.1%)	p=0.888
Re-operation for bleeding	8 (8.5%)	5 (8.6%)	3 (8.3%)	p=0.687
New post-op dialysis	9 (9.6%)	7 (12.1%)	2 (5.6%)	p=0.297
New post-op cerebrovascular accidents (CVA)	9 (9.6%)	1 (1.7%)	2 (5.6%)	p=0.304

Post-operatively, the median length of stay after surgery was 14.5 days, with no significant differences between the two groups (p=0.286). Post-operative complications included post-operative dialysis (9.6%), new post-operative cerebrovascular accidents (9.6%) and re-exploration for bleeding (8.5%); none of them were statistically significant between our two groups. There was no deep sternal wound infection (DSWI) reported in our cohort. All post-operative complications were also summarized in Table 5.

4. Discussion

In our current study, the findings indicate that baseline characteristics were largely similar between the groups, with mitral valve cases showing a higher predilection for Staphylococcal infection, more valvular vegetations, and longer cross-clamp and operative times compared to aortic valve surgeries. Despite these variations, no significant difference was observed in early post-operative outcomes or long-term mortality rates between the two groups.

The incidence of surgically treated infective endocarditis in our cohort increased from 5 cases in 2011 to 13 cases per year by the end of 2018, followed by a sharp decline to 5 cases in 2019. This trend is consistent with national and international data reported by Hammond-Haley et al. (2023), who documented a gradual increase in infective endocarditis incidence from 1990 to 2019. They attributed this increase to improvements in diagnostic techniques, changes in clinical guidelines, and modifications in antibiotic prophylaxis recommendations.

Our study also demonstrated a male predominance, with 74.5% of cases occurring in males and 25.5% in females. This aligns with previous data from the Swedish national registry study by Van Vlasselaer et al. (2019), where 67% of native IE cases were male. Similar trends were observed in large international registry data by Fedeli et al. (2011) and Hammond-Haley et al. (2023), who suggested that male gender could be a risk factor for developing infective endocarditis.

The microbiological analysis of our data revealed that Staphylococcus, Streptococcus, and Enterococcus species continue to be responsible for the majority of both aortic valve infective endocarditis (AVE) and mitral valve infective endocarditis (MVE). Streptococcus species (39.4%) was the predominant pathogen in our cohort, whereas Staphylococci were more prevalent in MVE cases. Streptococcus viridans, a frequent commensal in the oral cavity, were likely influenced by changes in prophylactic antibiotic policies implemented by NICE (UK) in 2008, leading to an increase in streptococcal endocarditis cases. This was supported by Epprecht et al. (2024) and Thornhill et al. (2024), who compared the proportion of Streptococcus-related IE before and after 2008 in the UK and reported a 22% increased risk of Streptococcus IE in patients at moderate risk. Both studies suggested that restricting antibiotic prophylaxis may have increased vulnerability to oral Streptococcal species in these patients

(Epprecht 2024; Thornhill 2024). However, as our center lacks data from before 2008, we were unable to fully assess the long-term effects of these policy changes.

Despite *Streptococcus* being the predominant species, *Staphylococcus aureus* remained the organism associated with the highest in-patient mortality (30%). This finding was consistent with Miro et al. (2005), who analyzed 2,212 cases of IE and found a higher early mortality risk in patients with *Staphylococcus aureus* (20% vs. 12%, $p < 0.001$). Similarly, Van Vlasselaer et al. (2019) reported a significantly higher in-hospital mortality risk (OR 3.2, $p < 0.002$) in *Staphylococcus aureus* cases.

At our center, mitral valve repair was performed more frequently than mitral valve replacement (63.9% vs. 36.1%), following AATS guidelines, which emphasize the clinical and survival benefits of mitral valve repair (Harky 2018). Additionally, we observed longer bypass and cross-clamp times for mitral surgery compared to aortic surgery, which can be attributed to the complexity of the mitral valve anatomy, requiring more intricate access (Hussain 2014). Despite these differences, no significant variations were found in early post-operative complications or short- and long-term mortality rates. This contrasts with a study by Farag et al. (2017), which reported a higher 30-day mortality rate in endocarditis surgeries with prolonged bypass and cross-clamp times. Salsano et al. (2018) further examined the risk of early mortality, demonstrating an increased mortality rate when cross-clamp time exceeded 72 minutes (14%) and was even higher when combined with bypass time over 166 minutes (26%). Both studies emphasized the risks of coagulation dysfunction, massive transfusion, and major end-organ damage as potential causes of higher mortality with longer operative times. However, neither study performed subgroup analyses comparing these effects between mitral and aortic cases.

Furthermore, in our study, the mitral group had shorter bypass (110.47 ± 53.35 vs. 139.2 ± 70.4 minutes) and cross-clamp times (87.08 ± 39.87 vs. 89.7 ± 42.1 minutes) compared to the high-mortality group reported by Farag et al. (2017). This may explain why we did not observe a significant difference in mortality outcomes, as our operative times remained within the safer range reported in previous studies (Table 3).

High mortality rates remain the Achilles' heel of endocarditis surgery. A recent study by Weber et al. (2024) found that early mortality rates were comparable between MVE and AVE cases (16.75% vs. 14.6%, $p = 0.095$), but one-year mortality was significantly higher in MVE (35.3%) compared to AVE (29.0%, $p < 0.001$). This increased mortality in mitral valve endocarditis may be due to challenges in radical debridement caused by its localization in the atrioventricular groove.

In contrast, our dataset showed no significant difference in in-hospital mortality between MVE and AVE cases (8.3% vs. 12.1%, $p = 0.56$). Furthermore, there was no significant difference in 5-year (25% vs. 41.3%, $p = 0.14$) or 8-year (33% vs. 43%, $p = 0.34$) mortality rates. The higher non-significant mortality rate in AVE cases could be explained by the higher proportion of emergency aortic valve surgeries compared to mitral cases (36.2% vs. 2.8%, $p < 0.001$). Additionally, aortic valve endocarditis tends to have a more invasive and destructive disease pattern, leading to complications such as aortic root abscesses or annular destruction, necessitating longer and more complex surgical procedures and ultimately resulting in a poorer prognosis (Pettersson 2017).

Several studies, including those by Epprecht et al. (2024), Heiro et al. (2008), and Tahon et al. (2021), have suggested that age, diabetes mellitus, hemodialysis, heart failure, stroke, and non-*Streptococcal* IE at index admission are predictors of long-term mortality. However, we did not find any significant association between these factors and long-term mortality in our patient population. Nevertheless, our study did show that patients with severely impaired LV systolic function (LVEF $< 30\%$) had 100% mortality at 2 years, which was statistically significant ($p = 0.024$). This finding underscores the importance of identifying high-risk patients and ensuring pre-operative optimization of LVEF to improve surgical outcomes. However, our analysis is limited by a small sample size and future studies with larger patient populations are needed to further evaluate the impact of poor LVEF on postoperative mortality.

5. Limitations

Our study was based on retrospective datasets from a single centre, with no matching for comparison. It was also limited by the exclusion of prosthetic valve endocarditis and redo procedures, which may restrict the generalizability of our results. Future studies should consider addressing these limitations. Additionally, we were unable to obtain patient records prior to 2011, as the infective endocarditis database was established that year. This prevented us from comparing the outcomes of patients treated for infective endocarditis prior to 2008.

6. Conclusion

In conclusion, there were no significant differences in early or late post-operative mortality between aortic and mitral valve endocarditis patients, despite pre- and peri-operative differences. Our data suggest that patients with LVEF $< 30\%$ are at a higher risk of mortality and that avoiding prolonged bypass and cross-clamp times may positively impact survival. Further studies with larger patient populations, including prosthetic valve endocarditis and redo valve surgeries, are warranted to better understand the differences between aortic and mitral valve endocarditis.

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