# Outcomes of Bentall procedure for prosthetic aortic valve endocarditis with a periannular abscess: a retrospective study

R.M. Samur[a], H. de Beaufort[b], U. Sonker[b],

[a] *Faculty of Medicine of Utrecht University*

[b] *Department of Cardiothoracic Surgery, St. Antonius Hospital, Nieuwegein, The Netherlands*

Student number: 6109292
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**List of abbreviations**

PVE = prosthetic valve endocarditis
AVR = aortic valve replacement
LVOT = left ventricular outflow tract
CRP = C-reactive protein
TTE = Transthoracic Echocardiography
TEE = Transesophageal Echocardiography
CT = Cardiac Computed Tomography
PET = Positron Emission Tomography
CABG = coronary artery bypass grafting
NYHA = New York Heart Association
SD = standard deviation
IQR = Interquartile range
ICU = intensive care unit

# Abstract

**Background and aims**: Prosthetic aortic valve endocarditis (PVE) with aortic root abscess is a lethal condition requiring surgical treatment. The Bentall procedure, involving replacement of aortic valve, aortic root, and ascending aorta is a valuable approach for managing PVE. The objective of this study was to evaluate the clinical outcomes of patients who underwent a re-operation of the aortic root for prosthetic aortic valve endocarditis.

**Methods**: A retrospective analysis was conducted of all consecutive patients who underwent aortic root replacement surgery for PVE with or without a periannular abscess at Sint Antonius Hospital between February 2011 and August 2022. The primary outcome included in-hospital mortality. Secondary outcomes are follow-up survival rates, postoperative complications.

**Results**: Thirty-eight patients were included. The in-hospital mortality was 18.4% (n=7) and 5-year survival was 73.7%. The causes of death were various, consisting of heart failure, myocardial infarction, liver failure, hemodynamic shock, and poor neurological outcome leading to treatment discontinuation. Other postoperative complications such as re-intubation for respiratory complications, renal failure requiring dialysis, and permanent neurologic dysfunction were observed in five (13.2%), seven (18.2%) and five (13.2%) patients, respectively. Late complications included re-endocarditis in three patients (7.9%), wound complications in three patients (7.9%), and mitral valve insufficiency in 3 patients (7.9%).

**Conclusions**: The Bentall reoperation is an effective approach for addressing prosthetic aortic valve endocarditis with root abscess, although it is associated with high postoperative mortality and morbidity rates. However, the 5-year survival outcome remains satisfactory in this context.

**Keywords**: prosthetic aortic valve endocarditis; Bentall procedure/technique; re-operation; aortic root abscess; aortic valve; postoperative outcomes; mortality; complications; retrospective study

# Introduction

Endocarditis, also known as infective endocarditis, is an inner wall inflammation of the heart and heart valves. [1-3] The estimated incidence of endocarditis ranges from 3 to 10 cases per 100,000 people per year.[1] Twenty percent of cases of endocarditis are cases of prosthetic valve endocarditis (PVE). [4-6]

PVE after aortic valve replacement (AVR) is a commonly performed surgery with nearly 1,500 isolated AVR procedures and 800 combined with CABG in 2022 in the Netherlands *(Hart en Vaatcijfers, 2022)* [7]. Furthermore, it is a serious and life-threatening condition. [8-10] The incidence of PVE after AVR varies in different studies and populations, but it range between 1% and 2% per year in the majority of observational studies. [9,11] Patients with PVE are initially treated with antibiotics for 6 weeks, but occasionally surgical intervention is required to remove the infected tissue and repair or replace the prosthetic valve. [12] According to the European Society of Cardiology guidelines of 2023, surgical intervention is required for example in those patients who exhibit resistant bacteria, have continue positive blood cultures despite treatment, experience vegetation enlargement, or develop an aortic root abscess or fistula. [12]

Prosthetic aortic valve endocarditis or aortic root abscess can be addressed through the Bentall procedure. This procedure is a complex surgical intervention that involves removing the infected tissue, replacing the aortic valve, reconstructing the aortic root, and replacing the ascending aorta with a composite graft. [13,14] The use of mechanical or bioprosthetic valve graft for aortic root replacement was first introduced in 1968 by Bentall and De Bono. [14,15] After improving the technical details, the Bentall procedure has become the standard operation for addressing aortic root conditions. [13,15] A new technique is a combination with left ventricular outflow tract (LVOT) reconstruction which might be considered in cases where the patient has developed complex destructive aortic root and LVOT endocarditis. [16] Re-operation with the Bentall procedure for PVE is associated with high mortality and morbidity rates in available literature. [15,17,18] In prior investigations, the rates of in-hospital mortality have exhibited variations, ranging from approximately 13% to 25%. [17-21] However, due to the relatively infrequent occurrence of reoperation surgery for PVE, most studies are relatively small and heterogeneous. . [6,9,11,15,17-22]

The objective of this study was to evaluate the clinical outcomes of patients who underwent a re-operation of the aortic root for prosthetic aortic valve endocarditis.

# Patients and methods

**Design**
This study is a single center retrospective cohort study in outcome of patients undergoing a Bentall re-operation for prosthetic aortic valve endocarditis with or without aortic root abscess with the primary objective to analyze the in-hospital mortality.

**Study population**
The study was performed in accordance with our guidelines for human studies and approved by Medical Ethical Committee of the Sint Antonius Hospital and Medical Research Ethics Commitees United. Due to its' retrospective nature, the local medical ethical committee waived the need for informed consent. All patients who underwent an aortic root re-operation for prosthetic aortic valve endocarditis or aortic root abscess after previous cardiac surgery between February 2011 and August 2022 at Sint Antonius Hospital, Nieuwegein, the Netherlands, were studied. Patients also undergoing concomitant (cardiac) surgery were included, but patients undergoing only re-AVR without aortic root replacement or LVOT reconstruction were excluded.

**Definitions**
Prosthetic aortic valve endocarditis or aortic root abscess were considered to be present if there was clinical evidence, as fever, cardiac murmur, septic embolism, positive blood cultures, increased C-reactive protein (CRP), and signs of infection or abscess on imaging. The imaging techniques used to diagnose endocarditis were Transthoracic Echocardiography (TTE), Transesophageal Echocardiography (TEE), Cardiac Computed Tomography (CT), Positron Emission Tomography (PET).
Patient characteristics collected in the data were defined according to European System for Cardiac Operative Risk Evaluation (Euro SCORE) II parameters. [23] Hypertension was scored by using one or more antihypertensive medication and coronary artery disease was scored by presence of percutaneous coronary intervention, coronary artery bypass grafting (CABG) or stenosis >70% with conservative management in past medicalhistory. Furthermore, New York Heart Association (NYHA) Classification was used to define heart failure symptoms. [24] The primary outcome, in-hospital mortality, was defined as death during first hospitalization stay before discharge regardless of hospitalization duration. Secondary outcomes were overall mortality, follow up outcomes and other early major postoperative complications during first hospitalization, including acute myocardial infarction, complete atrioventricular block, stroke, respiratory complications, renal failure, low output state, and re-thoracotomy for operative related complications. Overall mortality was defined as death after hospital discharge.

**Surgical technique**
All patients were reoperated by median sternotomy. Cardiopulmonary bypass was performed by cannulating ascending aorta, aortic arch, or femoral artery and bicaval cannulation. All procedures were performed on-clamp, with the crossclamp placed in the proximal aortic arch. In most cases, procedures were done under moderate hypothermia (32°C). The infected region was approached by aortotomy incision. After excision of the infected valve and debridement of all necrotic tissue, the size of aortic annulus was measured. Aortic valve and root replacement was constructed by biological or mechanical prosthesis. The selection of the type prosthesis was based on patient characteristics. In patients with annular erosion due to extensive annular abscess and aortic root destruction, LVOT reconstruction was performed with bovine pericardial patch. This patch was used to restore the aortomitral continuity, allowing the positioning of a new valve prosthesis and keeping the function of the mitral valve intact. Associated other surgical procedures such as CABG or MVP were commonly performed prior to the Bentall.

**Data collection and statistical analysis**
Data was extracted from Electronic Medical Records (EPIC and Metavision) and collected in REDCap® by one investigator, but any issues were discussed with other investigators. Categorical data were presented as number (%). Continuous data were presented as mean ± standard deviation (SD) or median [Interquartile range; IQR]. Survival analysis was performed using SPSS software version 26. The Kaplan-Meier method was used to outline overall mortality.

Pre-operative data included patient characteristics (demographic, comorbidities, clinical presentation), microbiologic data, and imaging details. Operative data included type of explanted and implanted prosthesis, concomitant surgery, operative time, cardiopulmonary bypass time, cross-clamp time, severity of endocarditis, arterial cannulation, minimum hypothermia, and intra-operative cultures. Postoperative data included mortality, hospital stay duration, major complications, organ failure, neurological dysfunction and late outcomes.

# Results

**Baseline patient characteristics**

We identified 38 patients, comprising 30 males (78.9%) and 8 females (21.1%), with a mean age of 61.5 (± 12.6) years (Table 1).

Approximately one-quarter of patients presented with one or more clinical signs of decompensation. Among these, 11 patients (28.9%) displayed peripheral edema, and 4 patients (10.5%) required oxygen support. Not all of these were the same patients, but 11 of the decompensated patients (28.9%) were treated pre-operatively with intravenous diuretics. Notably, none of the included patients had a left ventricular ejection fraction below 30%. Only 8 patients (21.1%) had a moderate reduced ejection fraction within the range of 30-50%, while the majority (n=30; 78.9%) had a preserved ejection fraction exceeding 50%. Moreover, 14 patients (36.8%) were classified as NYHA class one, 13 (34.2%) as NYHA class two, 5 (13.2%) as NYHA class three, and 6 (15.8%) as NYHA class four.

Furthermore, several patients had one or more septic emboli, which complicated by endocarditis during their pre-operative clinical admission. The subsequent data on these septic emboli have been collected: 3 patients (7.9%) experienced renal infarction, 4 patients (10.5%) exhibited splenic infarction and 8 patients (21.1%) suffered from embolic stroke.

Regarding temperature (°C) and CRP data, the highest values during the current hospitalization were recorded. The median temperature was 38.4°C [37.8-39.0] and the median CRP level was 207 [106-273].

In terms of the timing of surgery, all patients presented with an urgent surgical indication (n=37; 97,4%) except one patient who was classified as emergent (2.6%) and required immediate intervention due to the presence of a vegetation exceeding 2 centimeters in size. Urgent operation was defined as surgery within the same hospital admission. Furthermore, the preoperative surgical risk was assessed using EuroSCORE II, yielding a median score of 16.6 [11.6-39.4].

The clinical preoperative electrocardiograms demonstrated sinus rhythm in 16 patients (42.1%), supraventricular tachycardia in 9 patients (23.7%), right or left bundle branch block in 2 patients (5.3%), first-degree atrioventricular block in 3 patients (7.9%), second-degree atrioventricular block in 1 patient (2.6%), and total atrioventricular block in 7 patients (18.4%). Among the patients with atrioventricular block, 5 (13.2%) had an internal pacemaker in place prior to aortic root replacement, while the remaining two cases were new occurrences possibly related to the endocarditis. One patient received a permanent pacemaker postoperatively, whereas the other patient did not survive the postoperative period.

Ultimately, all patients had previously undergone aortic valve surgery, with several having also undergone additional cardiac or thoracic surgical procedures. Of the total cohort, 19 patients (50%) had a surgical history of AVR, and an equal number, 19 (50%), had a surgical history of a Bentall procedure. Additionally, 11 patients (28.9%) had undergone supracoronary ascending or arch replacement, 2 patients (5.3%) had undergone valvulotomy, and the remaining 3 patients (7.9%) had undergone various other thoracic surgeries, including a Ross procedure, segmental lung resection, and ventricular septal defect patch closure.

**Table 1: Baseline patient characteristics (n=38)**

| Variable | Result |
|---|---|
| | N (%), mean ± SD (range) or median [IQR] |
| Age (y) | 61.5 ± 12.6 |
| Male | 30 (78.9) |
| Comorbidities | |
| Hypertension | 19 (50.0) |
| Smoking | 8 (21.1) |
| IDDM | 3 (7.9) |
| Obesity (BMI ≥ 30) | 6 (15.8) |
| Chronic pulmonary disease | 6 (15.8) |
| PAD | 4 (10.5) |
| CAD | 14 (36.8) |
| Renal insufficiency (GFR <50 ml/min) | 9 (23.7) |
| Stroke or TIA | 10 (26.3) |
| Clinical presentation | |
| Signs of decompensation | |
| Nasal cannula oxygen support | 4 (10.5) |
| Intravenous diuretics | 11 (28.9) |
| Peripheral edema | 11 (28.9) |
| Pre-operative LVEF (%) | |
| 30-50% | 8 (21.1) |
| >50% | 30 (78.9) |
| NYHA | |
| I | 14 (36.8) |
| II | 13 (34.2) |
| III | 5 (13.2) |
| IV | 6 (15.8) |
| Septic embolism | |
| Renal infarction | 3 (7.9) |
| Splenic infarction | 4 (10.5) |
| Stroke or TIA | 8 (21.1) |
| Temperature (°C) | 38.4 [37.8-39.0] |
| CRP (mg/l) | 207 [106-273] |
| Timing of surgery | |
| Urgent | 37 (97.4) |
| Emergency | 1 (2.6) |
| Euro SCORE II (%) | 16.6 [11.6-39.4] |
| Pre-operative electrocardiogram | |
| Sinus rhythm | 16 (42.1) |
| (Paroxysmal) atrial fibrillation or flutter | 9 (23.7) |
| Right/left bundle branch block | 2 (5.3) |

| | |
|---|---|
| 1st degree AV-block | 3 (7.9) |
| 2nd degree AV-block | 1 (2.6) |
| Total AV-block | 7 (18.4) |
| Internal pacemaker | 5 (13.2) |
| Previous thoracic surgery | |
| CABG | 12 (31.6) |
| AVR | 19 (50.0) |
| Valvulotomy | 2 (5.3) |
| Bentall | 19 (50.0) |
| Supracoronary ascending or arch replacement | 11 (28.9) |
| Other* | 3 (7.9) |

*Data shown are numbers of cases (%), mean ± standard deviation, and median [interquartile range]. IDDM, insulin dependent diabetes mellitus; PAD, peripheral artery disease; CAD, coronary artery disease; GFR, glomerular filtration rate; TIA, transient ischemic attack; LVEF, left ventricle ejection fraction; NYHA, New York Heart Association; CRP, C-reactive protein; AV, atrioventricular; CABG, coronary artery bypass grafting; AVR, aortic valve replacement.*
**Other: Ross switch, ventricular septal defect closure and segmental lung resection*

**Bacterial origins of endocarditis**

Table 2 presents the causative microbes of prosthetic aortic valve endocarditis. *Staphylococcus aureus* was the most prevalent organism, detected in 14 cases (36.8%). Streptococci were the subsequent most common species, appearing in 8 cases (21.1%). Enterococci were identified in 6 cases (15.8%), and *Propionibacterium acnes* in 3 cases (7.9%). In one instance (2.6%), the culture yielded no growth.

Additionally, the median duration of antibiotic use before the surgery was 16 [8-26] days. In relation to this, two patients had not received pre-operative antibiotic management. In the first case, endocarditis was not suspected; however, the operation was indicated due to anastomotic leakage after a Bentall operation. In the second case, the patient had been managed with long-term antibiotics a year prior. Following aortic root abscess and clinical deterioration one year later, the patient underwent a Bentall reoperation.

**Table 2: Microbiologic data (n=38)**

| Variable | Result |
|---|---|
| | N (%) or median [IQR] |
| Microorganism | |
| Enterococcus faecium/faecalis | 6 (15.8) |
| Propionibacterium acnes | 3 (7.9) |
| Staphylococcus aureus | 14 (36.8) |
| Streptococcus species | 8 (21.1) |
| Other | 6 (15.8) |
| Culture negative | 1 (2.6) |
| Antibiotic use before the surgery | 36 (94.7) |
| Duration of antibiotic use before the surgery (days) | 16 [8-26] |

*Data shown are numbers of cases (%), and median [interquartile range].*

**Imaging**

The outcomes arising from imaging examinations utilized for the diagnostic assessment of endocarditis are illustrated in Table 3. Initially, TTE was conducted in 34 patients. Within the complete sample, 47.1% (n=16) exhibited neither vegetations nor abscess. Vegetations were detected in 32.4% (n=11) of the cases, while 35.3% (n=12) demonstrated aortic abscess or thickening around the prosthesis. TEE was conducted in 35 patients. Absence of both vegetations and abscesses was observed in 5.7% (n=2) of cases, whereas vegetation was detected in 57.1% (n=20) of cases. Additionally, aortic abscesses or thickening around the prosthesis were identified in 88.6% (n=31) of cases.

Cardiac CT scans and PET-CT scans were undertaken less frequently (in 23 and 22 patients, respectively). In 26.1% of patients (n=6), CT scans exhibited no indications of infection or abscess formation, whereas all PET scans indicated evidence of endocarditis. On the CT scans, aortic abscess were visualized in 47.8% (n=11) of patients, and signs of infection along the aortic wall were observed in 34.8% (n=8) of patients. Conversely, PET scans demonstrated an increased uptake adjacent to the prosthesis in 100% (n=22) of patients who underwent PET imaging. Furthermore, abscesses in aortic root were reported in 2 patients (9.1%) as supplementary findings.

**Table 3: Imaging**

| Variable | Result |
|---|---|
| | N (%) |
| TTE | 34 (100) |
| No vegetations, no abscess | 16 (47.1) |
| Vegetations | 11 (32.4) |
| 1-2cm | 1 (2.9) |
| Not described | 10 (29.4) |
| Aortic (root) abscess/ thickening around prosthesis | 12 (35.3) |
| Aortic aneurysm | 3 (8.8) |
| Aortic valve stenosis | 5 (14.7) |
| Moderate (PG mean 20-40mmHg; PG max 40-70mmHg) | 3 (8.8) |
| Severe (PG mean >40mmHg; PG max >70mmHg) | 2 (5.9) |
| Aortic valve insufficiency | 2 (5.9) |
| Moderate (grade 3) | 1 (2.9) |
| Severe (grade 4) | 1 (2.9) |
| Mitral valve insufficiency | 2 (5.9) |
| Moderate (grade 3) | 1 (2.9) |
| Severe (grade 4) | 1 (2.9) |
| TEE | 35 (100) |
| No vegetations, no abscess | 2 (5.7) |
| Vegetations | 20 (57.1) |
| <1cm | 2 (5.7) |
| 1-2cm | 5 (14.3) |
| >2cm | 1 (2.9) |
| Not described | 12 (34.3) |
| Aortic (root) abscess/ thickening around prosthesis | 31 (88.6) |
| Aortic aneurysm | 5 (14.3) |
| Aortic valve insufficiency | 2 (5.7) |
| Severe (grade 4) | 2 (5.7) |
| Mitral valve insufficiency | 4 (11.4) |
| Moderate (grade 3) | 4 (11.4) |
| Flow between left atrium and aorta suggestive for perforation | 1 (2.9) |
| CT-Heart/Aorta | 23 (100) |
| No signs of infection or abscess | 6 (26.1) |
| Mediastinal fluid collection | 7 (30.4) |
| Aortic (root) abscess | 11 (47.8) |
| Thickened aortic wall/ wall contrast uptake | 8 (34.8) |
| Aortic aneurysm | 8 (34.8) |
| Enlarged mediastinal lymph nodes | 3 (13.0) |
| PET | 22 (100) |
| No signs of infection or abscess | 0 (0.0) |

| | |
|---|---|
| Increased uptake of prosthesis suggestive for infection | 22 (100) |
| Aortic (root) abscess | 2 (9.1) |
| Reactive mediastinal lymph nodes | 10 (45.5) |
| Increased uptake in joints/bones (e.g. spondylodiscitis) | 5 (22.7) |
| Increased uptake in soft tissue (e.g. vasculitis) | 8 (36.4) |

*Data shown are numbers of cases (%). TTE, transthoracic echocardiogram; cm, centimeters; PG, pressure gradient; TEE, transesophageal echocardiogram; CT, computed tomography; PET, Positron Emission Tomography.*

**Operative details**

Table 4 summarize the operative surgical details. At the time of the reoperation, 24 patients (63.2%) received a biological prosthesis, while 13 patients (34.2%) received a mechanical prosthesis. Concomitant surgeries included LVOT reconstruction using a pericardial patch in 33 patients (86.8%), mitral valve repair in 10 patients (26.3%), mitral valve replacement in one patient (2.6%), CABG in 3 patients (7.9%), and pacemaker lead extraction in 4 patients (10.5%). Partial aortic arch replacement was executed in one patient (2.6%) due to an aneurysm. Ultimately, a laparotomy during the surgery was undertaken in another patient (2.6%) owing to perioperative retroperitoneal bleeding as a consequence of iatrogenic injury by advancing a guidewire.

The median operative, cardiopulmonary bypass, and aortic cross-clamp times were 492 [427-627] minutes, 312 [275-395] minutes, and 217 [188-250] minutes, respectively. Deep hypothermic circulatory arrest was utilized in 2 patients (5.3%), the one lasting 30 minutes with a minimum temperature of 20.0°C due to ascending aorta replacement, and the other enduring for 71 minutes with a minimum temperature of 24.2°C due to aortic arch replacement.

After all, half of the intraoperatively obtained cultures (n=15; 39.5%) yielded positive results, although the other half yielded negative results.

**Table 4: Operative data (n=38)**

| Variable | Result |
|---|---|
| | N (%), mean ± SD (range) or median [IQR] |
| Type of explanted prosthesis | |
| Biological aortic valve | 7 (18.4) |
| Mechanical aortic valve | 12 (31.6) |
| Biological Bentall | 7 (18.4) |
| Mechanical Bentall | 12 (31.6) |
| Implanted prosthesis | |
| Name and type | |
| Biological prosthesis* | 24 (63.2) |
| Mechanical prosthesis** | 13 (34.2) |
| Unknown | 1 (2.6) |
| Diameter of aortic valve prosthesis (mm) | 24.5 ± 1.4 |
| Diameter of aortic root prosthesis (mm) | 26.7 ± 2.7 |
| Concomitant surgery | |
| No concomitant surgery | 23 (60.5) |
| Pericardial patch | 33 (86.8) |
| MVP | 10 (26.3) |
| MVR | 1 (2.6) |
| CABG | 3 (7.9) |
| Partial aortic arch replacement | 1 (2.6) |

| | |
|---|---|
| Ascending aorta replacement | 1 (2.6) |
| Lead extraction | 4 (10.5) |
| Laparatomy by perioperative complication | 1 (2.6) |
| Operative time (min) | 492 [427-627] |
| Missing data | 16 (42.1) |
| Cardiopulmonary bypass time (min) | 312 [275-395] |
| Missing data | 2 (5.3) |
| Cross-clamp time (min) | 217 [188-250] |
| Missing data | 2 (5.3) |
| Arterial cannulation | |
| Ascending aorta | 14 (36.8) |
| Arch of aorta | 11 (28.9) |
| Femoral artery | 10 (26.3) |
| Missing data | 3 (7.9) |
| Minimum hypothermia (°C) | 29.5 [28.0-31.3] |
| Missing data | 1 (2.6) |
| Deep hypothermic circulatory arrest (n) | 2 (5.3) |
| Intraoperative cultures | |
| Positive | 15 (39.5) |
| Negative | 15 (39.5) |
| Not performed/no information | 8 (21.1) |

*Data shown are numbers of cases (%), mean ± standard deviation, and median [interquartile range]. MVP, mitral valve plasty; MVR, mitral valve replacement; CABG, coronary artery bypass grafting; mm, millimeters.*
**Biological prosthesis: Mitroflow Crown PRT, Mitroflow Valsalva Conduit, Perimount Magna Ease, Medtronic Freestyle, INSPIRIS Resilia*
**Mechanical prosthesis: Carbomedics Carbo-Seal*

**Postoperative clinical outcomes**
Early postoperative outcomes are outlined in Table 5. No patient died during the operation, but certain patients had a complicated postoperative course In hospital mortality occurred in 7 patients (18.4%). The reasons for death were pneumosepsis, myocardial infarction, septic shock, right ventricle failure, liver failure, hemodynamic instability with recurrent tamponades, and severe neurological injury due to perioperative stroke. The median intensive care unit (ICU) stay was 4 [2-12] days, and hospital stay was 18 [12-32] days. Nevertheless, 44.7% of these patients (n=17) were transferred to another hospital or nursing home for further healing and rehabilitation.

Among the 2 patients (5.3%) who experienced postoperative acute myocardial infarctions, one of them died to the condition. This patient manifested anterior wall infarction given that adhesive material entered the coronary artery during the surgery, which was subsequently aspirated with the expectation that it would not pose a problem. However, postoperatively, elevated cardiac enzyme levels and akinesia of the anterior wall were observed, necessitating coronary angiography. Subsequent assessment revealed sufficient blood flow. Consequently, the patient was managed with high-dose inotropes and ECMO support for cardiac assistance. Despite these interventions, minimal progress was achieved, leading to the unfortunate demise of the patient. The other patient also had increased cardiac enzyme levels postoperatively, necessitating coronary angiography. Subsequently, no coronary artery disease was evident, except for an occlusion of the posterolateral branch, attributed to (septic) embolism originating from the vegetation associated with endocarditis, resulting in papillary muscle infarction and subsequently mitral valve insufficiency. As a solution, a re-operation for mitral valve replacement was performed.

In total, nine patients underwent rethoracotomy during same admission for early complications, which included bleeding/tamponade in 6 patients (15.8%), shock/arrest in 2 patients (5.3%), mediastinitis in 2 patients (5.3%), and valvular complication in 1 patient (2.6%). The valvular complication was a mitral valve insufficiency, for which the patient underwent a re-operation for mitral valve replacement. Furthermore, a number of patients encountered a postoperative low output state. Six patient (15.8%) received extracorporeal membrane oxygenation support and 13 (34.2%) were dependent on inotropy/vasopression for more than 48 hours.

In addition, renal failure needing dialysis occurred in 7 patients (18.4%), and re-intubation due to respiratory complications occurred in 5 patients (13.2%), due to pneumonia, decompensation, septic episode with prolonged mechanical ventilation, pulmonary emphysema with recurrent pneumonia, and ICU acquired weakness with sputum. Other complications included complete atrioventricular block with permanent pacemaker implantation in 7 patients (18.4%), transient neurologic dysfunction in 1 patient (2.6%), and permanent neurologic dysfunction in 5 patients (13.2%), resulting in death in one patient.

**Table 5: Postoperative outcomes (n=38)**

| Variable | Result |
|---|---|
| | N (%) or median [IQR] |
| In-hospital mortality | 7 (18.4) |
| ICU stay (days) | 4 [ 2-12] |
| Hospital stay (days) | 18 [12-32] |
| Acute myocardial infarction | 2 (5.3) |
| Atrial fibrillation new onset | 6 (15.8) |
| New permanent pacemaker implantation | 7 (18.4) |
| Rethoracotomy for early complications | |
| Bleeding/tamponade | 6 (15.8) |
| Shock/arrest | 2 (5.3) |
| Mediatinitis | 2 (5.3) |
| Valvular complication | 1 (2.6) |
| Low output state | |
| ECMO | 6 (15.8) |
| >48 hours inotropy or vasopression dependent | 13 (34.2) |
| Renal failure | 7 (18.4) |
| Respiratory complications needing reintubation | 5 (13.2) |
| Transient neurologic dysfunction | 1 (2.6) |
| Permanent neurologic dysfunction | 5 (13.2) |
| Postoperative echocardiogram: MI | 2 (5.3) |

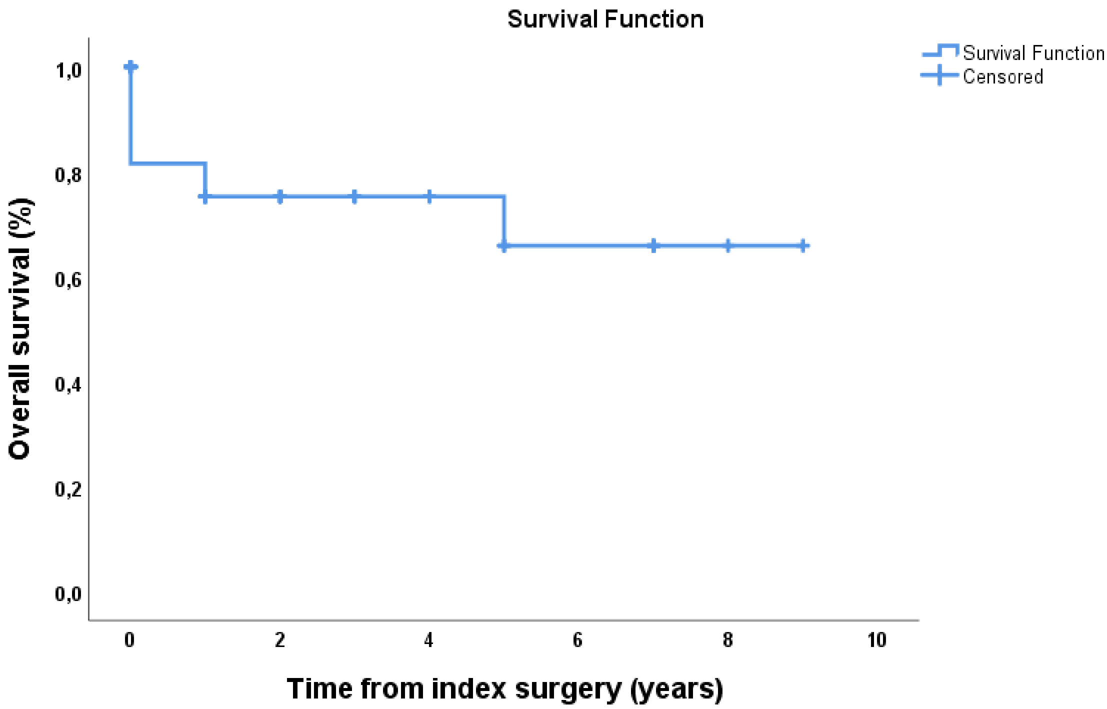
*Data shown are numbers of cases (%), and median [interquartile range]. ICU= Intensive Care Unit, ECMO= extracorporeal membrane oxygenation, MI= mitral valve insufficiency*

**Long-term follow up outcomes**

During follow up, three more patients did not survive; one of these deaths was caused by re-endocarditis. In contrast , the other two deaths were caused by non-cardiac conditions (liver failure and lung carcinoma). Two mortalities occurred one year later and one mortality occurred approximately five years later, resulting in no mortalities after the initial 5-year period. The overall Kaplan Meier estimated survival rate at 5 years was 73.7% (Fig. 1). However, there are patients who have undergone surgery much more recently, and therefore, they have not been followed for an extended duration.

Other late outcome complications included re-endocarditis in 3 patients (7.9%), wound complication requiring re-intervention in 3 patients (7.9%), and pseudo aneurysm requiring re-intervention in 3 patients (7.9%). Furthermore, 4 patients (10.5%) developed heart failure with NYHA ≥ 2, and 1 patients (2.6%) experienced mitral valve insufficiency who underwent mitral valve repair.

**Figure 1: Kaplan-Meier curve for overall survival**




| Time | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| No. of patient at risk | 38 | 16 | 9 | 5 | 1 | 0 |

# Discussion

This study aimed to evaluate the clinical outcomes and long-term results of reoperations for prosthetic aortic valve endocarditis or aortic root abscess. Surgical intervention is typically indicated in these circumstances, although it is associated with high in-hospital mortality rate (18.4%) and postoperative complications. The 5-year survival rate of 73.7% suggests relatively favorable long-term outcomes, considering the complexity of the cases. These findings are reasonably consistent with other publications. Sponga et al. examined 73 patients with Bentall procedure related endocarditis, reporting a 30-day mortality rate of 15% and a 5-year survival rate of 75%. [17] Cefarelli et al. studied 29 patients who undergone a biological Bentall reoperation for aortic valve endocarditis with root abscess. [18] They described a 30-day mortality rate of 13.8% and a 5-year survival rate of 75.6%. [19] Other studies in the literature also report comparable outcomes. However, these outcomes stem from various reoperation techniques, rendering direct comparisons somewhat challenging.

Moreover, the most studies in the literature have explored PVE without patients presenting an aortic root abscess.

In contrast to prior investigation, the prevalent approach in our study cohort involved employing bovine pericardial patches for LVOT reconstruction due to destruction of the aortic annulus caused by paravalvular abscess. The literature describes that LVOT reconstruction is essential for an effective treatment of complex aortic valve endocarditis with paravalvular abscess. [25-28] Regarding the duration of surgical details, operative times were relatively long compared to the previous studies, with long cardiopulmonary bypass time, and cross-clamp time. This may also be attributed to the LVOT reconstruction technique that we predominantly employed in most cases, but the prolonged time complicate the surgical procedure. Several investigations established that prolonged cardiopulmonary bypass time and cross-clamp are associated with an increased risk of postoperative mortality and morbidity. [29-31] From the study by Nissinen et al., it was observed that cardiac procedures with a perfusion time of <240 minutes and a clamp time of <150 minutes are associated with a lower risk of postoperative complications, independently the complexity of the surgical risk. Prolonged durations could potentially contribute our postoperative mortality outcomes.

Interestingly, none of the patients had a left ventricular ejection fraction below 30%, and a limited number belong to NYHA classes III and IV, which is most likely due to patient selection; with patients having a poor left ventricular function turned down for surgery due to the operative risk. In addition, EuroSCORE II was utilized to estimate the risk of postoperative mortality; however it has not validated for this type of surgery. Nonetheless, the preoperative mortality predictions generally aligned with the actual mortality. In conclusion, the EuroSCORE II can provide some estimation of which patients may experience mortality, but approximately half of the patients with exceptionally high scores survived the procedure. Therefore, it cannot be asserted that surgery is futile for patients with a high EuroSCORE II. Furthermore, the outcomes also exhibited that all patients with a very high EuroSCORE II who received ECMO ultimately died. As a result, the efficacy of ECMO treatment may be questionable.

The predominance of *Staphylococcus aureus* as the causative microbe is noteworthy. Leontyev et al. describe that Staphylococcus infection to be an independent prognostic factor for mortality in patients with abscess formation, and report that Staphylococcus infection is associated with a higher incidence of root abscesses compared to non-Staphylococcal infections. [9]

Multiple imaging techniques are followed to diagnose endocarditis. Imaging modalities disclosed signs of infection or abscess in each patient. TTE and TEE were the most commonly utilized diagnostic imaging modality. Our research revealed that the optimal visualization of the aortic root abscess is achieved through TEE. Furthermore, both CT scans and PET scans were employed to assess the extent of infection. Nevertheless, PET scanning emerged as the most sensitive method for the detection of prosthetic aortic valve endocarditis. The systematic review by Machelart et al. describes high sensitivity and specificity of PET scans for diagnosing PVE, ranging between 70% and 93% and between 91% and 93%, respectively. [32] This is also comparable with the outcomes of our study. All by all, for diagnosing aortic valve prosthesis endocarditis or aortic root abscess, a combination of imaging modalities including TTE, TEE, CT, and PET is required, with CT being useful for detecting paravalvular disease that may no diagnosed through echocardiography.

**Limitations**
The study has several limitations. Firstly, it is a retrospective, non-randomized cohort design, leading to both selection bias and information bias. Secondly, its single-center nature entails restricted study population with possibility to referral bias. Additionally, this highly selected group of patients and the small single-center study population render the findings challenging to generalize.

**Conclusion**
In conclusion, this study shows that the mortality rate for patients undergoing reoperation Bentall for prosthetic aortic valve endocarditis is 18.4%.  Despite the early high mortality rate, the long-term survival rates are satisfactory, with a low incidence of recurrent endocarditis.

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