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A modified technique for aortic prosthesis implantation after prosthetic valve endocarditis complicated by complex paraannular aortic abscess

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The aim of this study is to describe a modified technique for aortic prosthesis implantation in the sinuses of Valsalva without the use of a patch for aortic annular reconstruction in patients with prosthetic valve endocarditis complicated by aortic abscess. From January 2008 to March 2021, 47 patients underwent aortic valve replacement due to prosthetic aortic valve endocarditis. The new aortic prosthesis was implanted into the sinuses of Valsalva above the abscess left open to drain. The first step consists in passing U-shaped stitches with pledgets through the aortic wall approximately 5–7 mm above the abscess involving the annulus. In the second step, the prosthesis is fixed to the aortic wall. In the third step, a 10 mm wide Teflon strip is positioned along the external course of the aortic wall and U-shaped stitches without pledgets are passed from the outside to the inside to definitively fix the prosthetic annulus to the sinuses of Valsalva. In-hospital mortality was 8.5% (4/47 patients). Mean follow-up was 62 $\pm$ 37.7 months. Four patients died (9.3%). Predicted probability of cardiac vs non-cardiac mortality was not statistically significant (p = 0.88). Overall survival probability (freedom from all-cause death) at 3, 7 and 9 years was 97%, 87.5% and 75%, respectively. No patients presented with grade 2 or 3 peri-prosthetic leak, nor had endocarditis. Prosthetic valve endocarditis complicated by complex paraannular aortic abscess can be successfully addressed with good long-term results by using our alternative technique.

Keywords

Prosthetic valve endocarditis; Prosthetic aortic valve infective endocarditis; Aortic valve replacement; Aortomitral curtain abscess

1. Introduction

Prosthetic valve endocarditis (PVE) is a very serious disease with 30% in-hospital mortality that increases in case of abscess involving the aortic annulus, left ventricular outflow tract, fibrous trigone and mitral annulus. PVE is a life-threating complication of valve replacement accounting for 20–30% of all cases of infective endocarditis (IE) [1, 2]. Its frequency is increasing, ranging from 0.1–2.3 per patient-year [3], especially in cases of late PVE due to the use of broad-spectrum antibiotics in the immediate postoperative period, advanced age of the patients, and major comorbidities.

Despite improvements in medical therapy, PVE is associated with a significant increase in morbidity and mortality [4–6]. Neurological complications are the main cause of higher mortality rates [7, 8]. However, paraannular complications such as abscess, pseudoaneurysms and fistula that develop at an advanced disease stage portend a poor prognosis [7] and represent a surgical challenge associated with high perioperative mortality and instability of the implanted prosthesis.

Surgical therapy has the advantage of eliminating all infected tissue, regardless of the anatomical structures involved, replacing the aortic valve and, sometimes, also the aortic root [9].

The aim of this study is to describe an alternative technique for aortic prosthesis implantation in the sinuses of Valsalva without using a patch for aortic annular reconstruction in patients with PVE complicated by paraannular abscess.

2. Methods

2.1 Patients

From January 2008 to March 2021, 47 consecutive patients underwent aortic valve replacements for isolated aortic PVE unresponsive to antibiotic therapy at Anthea Hospital GVM Care&Research, Bari, Italy. The diagnosis of IE was based on the results of echocardiography and blood cultures [10–12] and made according to the Duke criteria [13]. All patients with positive intraoperative findings of paraannular abscess involving the aortoventricular junction larger than one aortic cusp without dehiscence, fistula to other cardiac chamber or aortic pseudoaneurysm formation were included in the study, and their clinical and laboratory data were collected. If dehiscence, fistula or pseudoaneurysm was present, patients were excluded and treated with radical debridement

of the infected and necrotic tissue around the aortic root, followed by extensive surgical reconstruction with patches and using an aortic homograft, mechanical or biological prosthesis.

Active endocarditis is defined as any patients currently receiving antibiotics at the time of surgery. An abscess was defined as a region of necrosis containing purulent material that had no communication with the cardiovascular lumen. Patient characteristics are reported in Table 1. Mean age was 70.96 ± 5.26 years (range, 46–80), 25 patients (53.2%) were men and 22 (46.8%) women.

Table 1. Preoperative characteristics (n = 47).

Age (years)	70.96 ± 5.26
Male sex	25 (53.2)
Female sex	22 (46.8)
Diabetes	11 (23.4)
NIDDM	5 (10.6)
Diabetes diet	1 (2.2)
IDDM	5 (10.6)
Hypercholesterolemia	24 (51.1)
Systemic hypertension	42 (89.4)
Ex-smoker	8 (17.1)
Current smoker	6 (12.8)
Gastrointestinal disease	0
Renal dysfunction	6 (12.8)
Dialysis	2 (4.3)
COPD	1 (2.2)
Cerebrovascular disease	2 (4.3)
Liver disease	4 (8.5)
Cancer	0
PVD	0
AF	9 (19.2)
EuroSCORE	13 ± 3
Log EuroSCORE	0.33 ± 0.21
EuroSCORE II	26.69 ± 22.41

Values are presented as mean ± SD, or n (%). There were no missing data.

NIDDM, non-insulin-dependent diabetes mellitus; IDDM, insulin-dependent diabetes mellitus; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease; AF, atrial fibrillation; EuroSCORE, European System for Operative Risk Evaluation.

The GVM Care&Research review board approved the study and need for patient consent was waived due to the retrospective nature of the study.

Indication for surgical intervention followed current recommendations [13]. The decision was based on patients' hemodynamic instability, septic shock, or anatomical risk (e.g., detachment of the valve prosthesis with annular abscess and severe perivalvular leakage), and after specialist consultation including a cardiac surgeon, a cardiologist, an anesthesiologist, a neurologist and an infectious disease specialist. Surgical timing is classified into "emergent" and "urgent". Emergent surgery refers to an operation that begins within 24 hours after the diagnosis of IE or heart failure is made while urgent surgery when patients are not electively admitted for surgery but they require surgery during hospitalization.

All patients underwent intraoperative transesophageal echocardiography (TEE), during in-hospital stay and at follow-up.

2.2 Surgical technique

Preoperative TEE was routinely used. All interventions were performed under general anesthesia with re-sternotomy. Femoral vein and arteria cannulation for extracorporeal circulation was performed prior to re-sternotomy. All operations were performed with cardiopulmonary bypass and moderate hypothermia. Cold (4 °C) intermittent antegrade blood cardioplegia was used for myocardial protection. The valve and surrounding infected tissue were carefully inspected (Fig. 1A,B). The prosthetic valve was entirely removed and sent to the laboratory for culture examination (Fig. 1C).

All infected tissue was excised. The abscess was emptied, washed with disinfectant solution, and left open to drain. Subsequently, the new aortic prosthetic valve was implanted into the aortic root, exactly at the level of the sinuses of Valsalva and above the abscess. The first step consists in the passage of U-shaped stitches (Ti-Cron^{TM} 2/0, Covidien, India) with pledgets through the aortic wall approximately 5–7 mm above the abscess involving the annulus (Fig. 2A) in an intact supraannular area. In the second step, the prosthesis is fixed to the aortic wall (Fig. 2B). In the third step, a 10 mm wide circumferential Teflon strip (Bard Peripheral vascular, Inc., Tempe, AZ, USA) is positioned along the external course of the aortic wall and U-shaped stitches are passed from the outside to the inside to definitively fix the prosthetic annulus to the sinuses of Valsalva (Fig. 2C–F).

The choice of bioprosthesis or mechanical prosthesis was on the surgeon's judgment in compliance with current guidelines. Special attention was paid to the patency of the coronary ostia near the new prosthesis.

2.3 Recorded variables

Preoperative, perioperative, and postoperative variables were retrospectively recorded in an institutional database. The assumption of normality of each variable distribution was tested with the Shapiro-Wilk test. Normally distributed variables are reported as mean ± standard deviation or median (interquartile range). Categorical variables are reported as number and percentage.

The overall survival probability was analyzed using the Kaplan-Meier method and corresponding survival curves. All analyses were performed using R 2.13.2 software (R Development Core Team, Vienna, Austria). The variables recorded are listed in Tables 1,2,3.

Perioperative variables were defined as cross-clamp time, bypass time, biological and mechanical prosthesis. Postoperative complications were defined as renal failure requiring dialysis, perioperative stroke, disorientation, coma, atri-

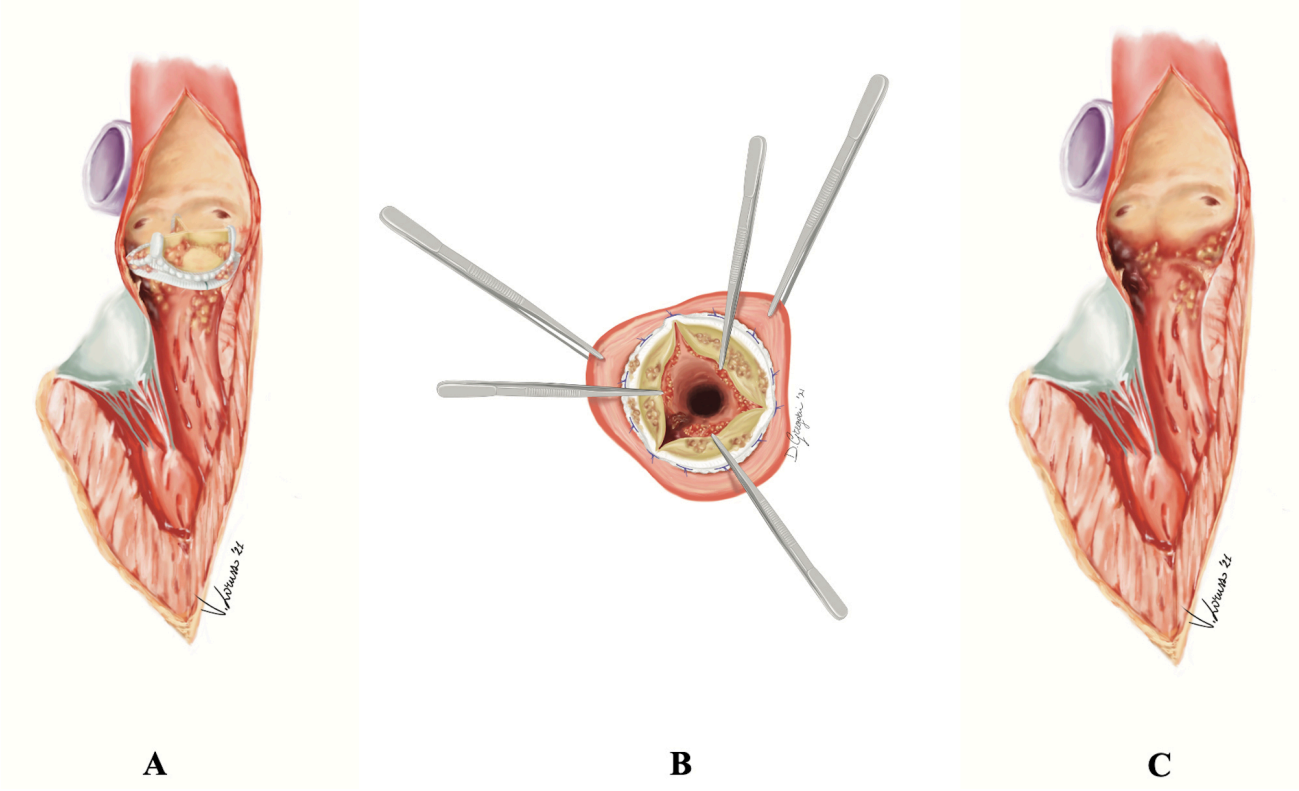

Fig. 1. Valve and surrounding infected tissue. (A) Infected biological prosthetic valve with paraannular aortic abscess. (B) Top view of the abscess. (C) View of the abscess and surrounding infected tissue after removal of the prosthetic valve.

Table 2. Operative characteristics (n = 47).

Cross-clamp time (minutes)	94.96 ± 41.02
CPB time (minutes)	170.03 ± 74.78
Biological prosthesis	25 (53.2)
Mechanical prosthesis	22 (46.8)

Values are presented as mean ± SD, or n (%). There were no missing data.

CPB, cardiopulmonary bypass.

oventricular block requiring pacemaker implantation, re-intubation, septic shock, pulmonary disease.

3. Results

In-hospital mortality was 8.5% (4/47 patients). In no cases the cause of death was a new aortic prosthesis detachment: two patients died of cardiogenic shock, one for septic shock, and one for gastrointestinal complication. All patients were classifiable as early PVE (<1 year between first surgery and re-operation).

Sixteen patients (34%) of the 47 patients had at least one cardiovascular or renal complication (stroke in 3, permanent pacemaker in 2, atrial fibrillation in 4, 1.5-fold increase in creatinine compared to preoperative values in 3, and need for temporary dialysis in 4).

Four patients (8.5%) showed respiratory failure or lung complications (respiratory failure includes prolonged mechanical ventilation time >48 h, need for reintubation and pneumonia; lung complications include persistent airspace or pneumothorax and significant pleural effusion), 10 patients (21.3%) needed inotropic support (defined as the use of adrenaline and/or dopamine and/or dobutamine and/or phosphodiesterase inhibitor/levosimendan), 1 (2.2%) had septic shock and 1 (2.2%) periprosthetic leak (1+).

Two patients (4.3%) needed reintervention for bleeding. Intensive care unit stay was 8 ± 7.6 days (Table 3).

3.1 Follow-up

All patients were followed up at our institution every 6 months after the procedure. Visits included a physical examination, 12-lead electrocardiography, transthoracic echocardiography. Transthoracic echocardiography and TEE were performed once a year. Mean follow-up was 62 ± 37.7 months (median 38, max 152–min 5 months). There was no loss to follow-up.

Four patients died (9.3%, 4/43 patients), 2 due to cardiac causes and 2 due to non-cardiac causes (one cancer, one traumatic accident). Predicted probability of cardiac vs non-cardiac mortality was not statistically significant ($p = 0.88$).

Overall survival probability (freedom from all-cause death) at 3, 7 and 9 years was 97% (95% Confidence Interval [CI] 91.3–100%), 87.5% (95% CI 75–100%) and 75% (95% CI 53–100%), respectively (Fig. 3).

At follow-up, no patient presented with moderate or severe (grade 2 to 3) prosthesis/aortic regurgitation; mild to trivial aortic regurgitation occurred in 9 patients (21%).

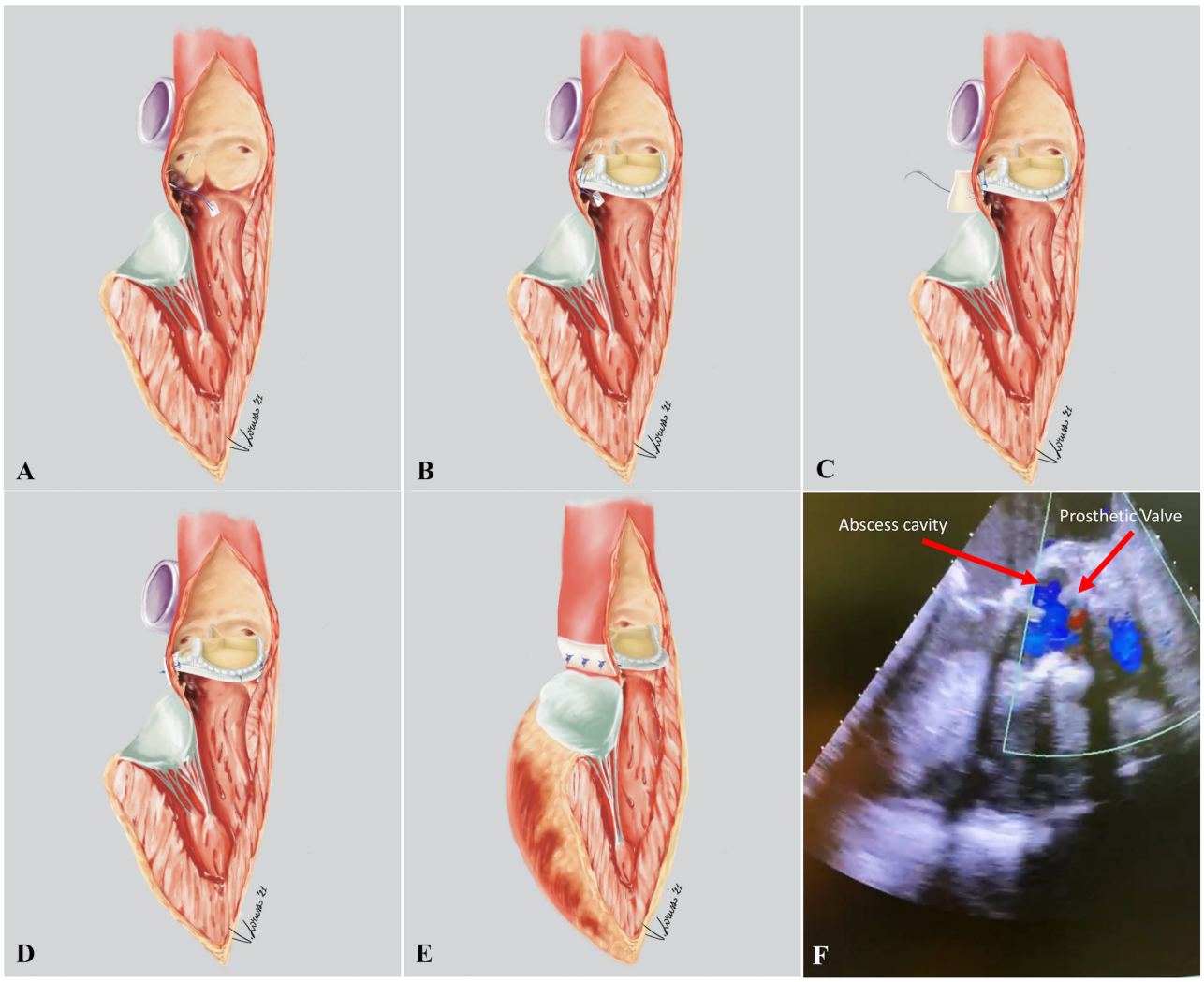

Fig. 2. Illustration of the surgical technique. (A) Passage of U-shaped stitches with pledgets in the thickness of the aortic wall approximately 5–7 mm above the abscess involving the annulus. (B) The prosthesis is fixed to the aortic wall. (C) A 10 mm wide Teflon strip is positioned along the external course of the aortic wall and U-shaped stitches are passed from the outside to the inside of the aortic wall through the prosthetic annulus. (D) Prosthetic annulus fixed to the Valsalva sinuses. (E) Viewing rotated 30° counterclockwise. (F) Transesophageal echocardiogram showing open abscess cavity.

Mean transprosthetic aortic gradient was 14.7 ± 9.3 mmHg; one patient (2.3%) underwent transcatheter aortic valve implantation for structural prosthetic valve deterioration (stenosis) after 7 years of previous surgery. Among survivors, 40 and 3 were in New York Heart Association class II and III, respectively; transient or permanent ischemic accidents were observed in 4 patients (9.3%). No patients had endocarditis. Other relevant outcomes at follow-up are reported in Table 4.

4. Discussion

PVE is a serious complication after aortic valve replacement. The early mortality reported in different studies has varied between 3.9% and 40% in surgically treated patients [14–18] and was higher in patients treated with medical therapy. In our study, the overall 30-day mortality was 8.5% (4/47 patients). In clinical presentation, uncontrolled aortic root abscess can manifest as a burrowing abscess, a cardiac fistula or a rupture into a cardiac chamber, a pseudoaneurysm, or an arrhythmia leading to hemodynamic instability. An early and extensive surgical reconstruction can be essential, because antibiotic therapy alone is usually inadequate to arrest the destructive effect of the abscess. There is no unanimous consensus on which prosthesis is optimal for implantation in patients with PVE. Aortic homografts but also mechanical or biological prostheses are a valid option in patients with extensive root destruction [14–16]. Regardless of the type of prosthesis used, radical debridement of the infected tissue and necrotic tissue around the aortic root, reconstruction of the aortic root by patching or plicating the resected area seems to be the best solution.

When the infection is limited to the prosthetic valve, numerous studies reported the implantation of the new prosthetic valve using standard techniques. If the infection involves the annulus and surrounding tissue, all infected mate-

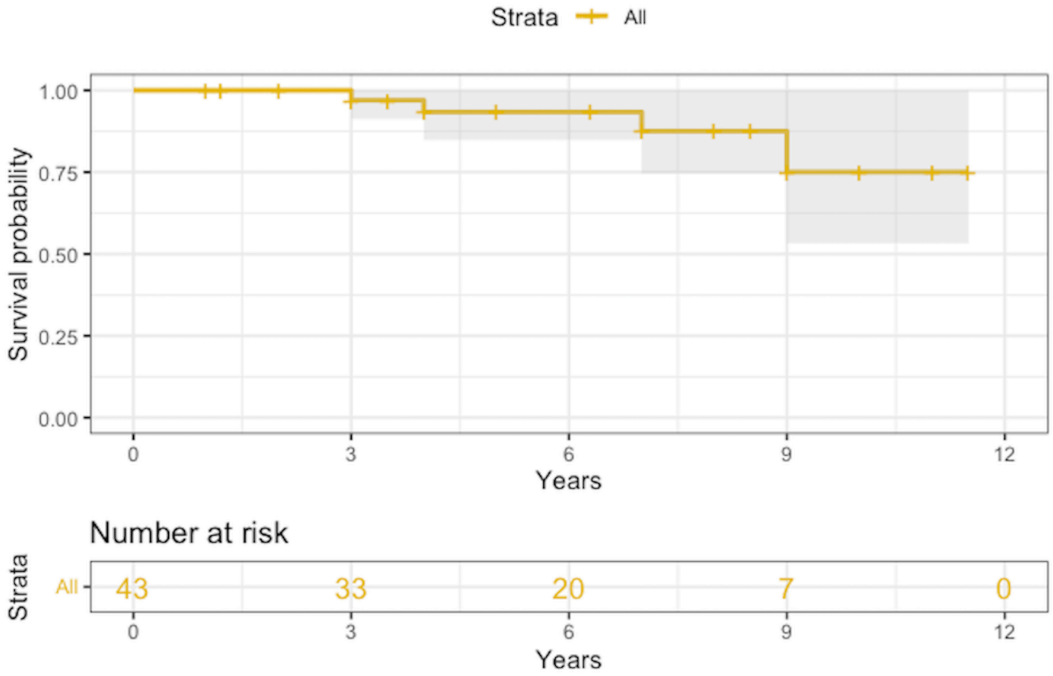

Fig. 3. Kaplan-Meier survival probability (freedom from death, all causes) at 3, 7 and 9 years was 97% (95% CI 91.3–100%), 87.5% (95% CI 75%–100%) and 75% (95% CI 53–100%), respectively.

rial, foreign bodies, and necrotic tissues should be removed to minimize the residual infectious burden and provide optimal access for host defense and antimicrobial therapy. When a localized abscess is not larger than a single aortic cusp, non-pledgeted sutures are placed around the intact annulus and pledgeted sutures are used to obliterate the abscess using a sandwich technique before placement of the stiches across the sewing ring of the prosthetic aortic valve of choice during aortic valve replacement. In the presence of abscess cavities or tissue defects larger than one aortic cusp without aorto-ventricular dehiscence, the defect on the aortic annulus should be reconstructed using autologous pericardium, bovine pericardium, and other materials, and pledgeted sutures placed on this patch during aortic valve replacement. Repair patches must be generous to minimize tension on the suture lines and the valve prosthesis anchored to the ventricular muscle or to the reconstruction patch in a way that prevents leakage and pseudoaneurysm development beneath the prosthesis. In the literature, the risk of death, reinfection and reoperation is higher in the first year after surgery. Grubitzsch *et al.* [19] reported a cumulative incidence of death, reinfection and reoperation of 19% at 30 days and 36.2% at 1 year.

In our study we described an alternative technique for aortic prosthesis implantation in the sinuses of Valsalva without using a patch for aortic annular reconstruction in patients with aortic PVE complicated by an abscess larger than one aortic cusp without aorto-ventricular dehiscence, fistula or aortic pseudoaneurysm. In our department, we have been using this technique as standard treatment for the past 13 years.

The surgical technique consisted of initial cleaning of the aortic annulus and aortomitral curtain. The abscess was left open to drain and the new aortic prosthesis was implanted into the aortic root, exactly at the level of the sinuses of Valsalva and above the abscess involving the aortic annulus. After passing U-shaped stitches with pledgets through the aortic wall, approximately 5–7 mm above the abscess, the prosthesis is fixed to the aortic wall. In the last step, a 10 mm wide Teflon strip is positioned along the external course of the aortic wall and U-shaped stitches are passed from the outside to the inside to definitively fix the prosthetic annulus to the sinuses of Valsalva.

Although the debate remains unresolved on whether to keep open or close the drained abscess with a patch, we believe this alternative technique is useful because the abscess is left open and this allows a continuous drainage of the cavity and an easier achievement by antibiotics. Using standard technique, abscess closure with patches, despite drainage and disinfection, can cause a new abscess as antibiotics alone fail to reach the site of the abscess and eradicate the infection. In addition, it can also lead to detachment of the patch causing devastating damage to the surrounding tissues of the heart and also a detachment of the prosthesis. Furthermore, nowadays new device models have also become available that can reduce the need for an intact annulus (e.g., stentless bioprostheses) [20, 21] or avoid the need for sutures (e.g., sutureless aortic valve prostheses) [22].

Table 3. Postoperative characteristics (n = 47).

Respiratory failure or lung complications[a]	4 (8.5)
Ischemic stroke	3 (6.4)
Disorientation/delirium[b]	1 (2.2)
Coma	1 (2.2)
Inotropic support[c]	10 (21.3)
Cardiogenic shock	3 (6.4)
Sternal wound infection	0
Septic shock	1 (2.2)
Dialysis	4 (8.5)
Creatinine, 1.5-fold increase	3 (6.4)
De novo pacemaker	2 (4.3)
De novo AF	4 (8.5)
Periprosthetic leak (1+/4)	1 (2.2)
Recurrent PVE	0
Intestinal ischemia	1 (2.2)
Reintervention for bleeding	2 (4.3)
ICU stay (days)	8 $\pm$ 7.6
30-day mortality	4 (8.5)

[a] Respiratory failure includes prolonged mechanical ventilation time (>48 h), need for reintubation, and pneumonia; lung complications include persistent airspace or pneumothorax and significant pleural effusion.

[b] Defined as the need for sedative medication to calm the patient in the postoperative phase.

[c] Defined as the use of adrenaline and/or dopamine and/or dobutamine and/or phosphodiesterase inhibitor/levosimendan.

Values are presented as mean $\pm$ SD, or n (%). There were no missing data.

AF, atrial fibrillation; PVE, prosthesis valve endocarditis; ICU, intensive care unit.

Table 4. Outcomes at follow-up (n = 43).

Permanent pacemaker implantation	3 (7)
Stroke/TIA	4 (9.3)
Periprosthetic leak	
Grade 1	9 (21)
Grade 2	0
Grade 3	0
Aortic gradient, mmHg	14.7 $\pm$ 9.3
Pulmonary pressure, mmHg	43.3 $\pm$ 8.3
LVEF, %	41 $\pm$ 9

Data are presented as mean $\pm$ SD, or n (%).

LVEF, left ventricular ejection fraction; TIA, transient ischemic attack.

The absence of patches and other foreign material for annular reconstruction can shorten ischemic times and reduce the risk of reinfection, which is of great advantage for high-risk patients such as those with PVE. Radicality is key but a fast procedure is very important because prolonged cross-clamp time is correlated with postoperative mortality [23]. However, it should be underlined that we did not include a control group in whom the patch annular reconstruction was used, making the comparison between the two techniques unfeasible. However, this goes beyond the scope of our manuscript, which aimed at describing a modified surgical technique for aortic prosthesis implantation.

Finally, our study showed that aortic prosthesis implantation in the sinuses of Valsalva with external aortic reinforcement maintains valve stability without late periprosthetic leak and IE recurrence.

Author contributions

GN designed the research study and wrote the original draft; NDB analyzed the data and wrote the original draft; MM contributed to the interpretation of the results and supervised the project; FF contributed to the interpretation of the results and supervised the project; IC aided in interpreting the results and worked on the manuscript; GSa designed the research study and wrote the revisions; GSp verified the analytical methods and supervised the project. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The GVM Care & Research review board approved the study (internal protocol; decision 08 August 2020) and need for patient consent was waived due to the retrospective nature of the study.

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Conflict of interest

The authors declare no conflict of interest. Giuseppe Nasso is serving as one of the Guest editors of this journal. We declare that Giuseppe Nasso had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to Carmela Rita Balistreri.

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