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Surgical Management of Valvular Infective Endocarditis: A Single-Center Experience

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ABSTRACT

Background: The surgical therapy of infective endocarditis (IE) presents considerable challenges, and despite great advancements in preoperative diagnostic and surgical techniques, it continues to be linked with substantial morbidity and death. The aim of this work was to assess our experience with the surgical care of IE, to examine the influence of various perioperative clinical factors on early and midterm outcomes and to assess the influence of perioperative clinical variables pertinent to postoperative problems, morbidities, and mortalities, as well as to identify perioperative prognostic factors.

Methods: This prospective study was carried out on 87 patients aged ≥ 18 years old, with valvular IE, whether native or artificial, treated surgically. Blood cultures (2–3 sets, 5-day incubation) were the diagnostic gold standard, while serology aided in detecting fastidious organisms, with anti-phase I IgG ≥1:800 confirming Q fever endocarditis.

Results: Sex, preoperative renal impairment, active endocarditis, the nature of the valve (native or prosthetic), size of vegetations, microbiological species, and cross-clamping duration exhibit no significant link with surgical mortality. In multivariate regression, Preoperatively, constant were independent predictors of mortality (P=0.001) while Heart rhythm and conduction disturbances, NYHA class (III and IV), Peri-annular abscess, timing of surgery (Emergency), preoperative inotropes and ongoing infection were not. In Multivariate regression, postoperatively, duration of hospital stay were independent predictors of mortality (P=0.005) while postoperative duration of mechanical ventilation, postoperative pulmonary complications and constant were not.

Conclusions: Swift diagnosis of individuals with IE at elevated risk of death may provide the chance to alter the disease trajectory and enhance prognosis.

KEYWORDS: Surgical Management, Valvular Infective Endocarditis, Mortality.

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INTRODUCTION

Infective endocarditis (IE) represents the most severe sequela of valvular and device-associated cardiac disease, affecting native (NVE), prosthetic (PVE), and device-related valves. Its incidence has increased over the past three decades, largely due to aging populations with degenerative valve disease, greater use of prosthetic valves and intracardiac devices, and rising staphylococcal infections. Mortality remains high, and optimal management requires a multidisciplinary approach with early surgical involvement [1, 2].

Surgical indications arise in ~25–30% of acute and 20–40% of convalescent cases. Surgery is warranted for heart failure, severe valve dysfunction, PVE, paravalvular abscess/fistula, recurrent embolization, large vegetations, or persistent sepsis despite ≥5–7 days of antimicrobial therapy. Once an indication is established, delay worsens outcomes; early surgery particularly before heart failure onset reduces embolic stroke risk. Emergency surgery is required for left-sided IE with vegetations >10 mm and embolic events, or right-sided IE with vegetations >20 mm plus persistent bacteremia or septic pulmonary emboli. The risk of embolism peaks during the first 2 weeks of antibiotic therapy and declines thereafter [3, 4].

Surgical principles include sternotomy for optimal exposure, radical debridement of infected/necrotic tissue, and valve repair whenever feasible (especially mitral). Valve replacement should follow standard prosthesis selection criteria [5, 6]. In right-sided IE, the goal is sepsis eradication and embolic prevention, with tricuspid repair preferred. Prosthetic valves in the tricuspid position carried a high risk of reinfection, especially in intravenous drug users, with bioprostheses generally favored [7, 8].

Prognosis improves when surgery is performed promptly, before clinical deterioration. Although some reports link acute-phase surgery to increased recurrent PVE, most data support early intervention for better outcomes, particularly in mitral valve disease [9, 10].

The aim of this work was to assess our experience with the surgical care of IE, to examine the influence of various perioperative clinical factors on early and midterm outcomes and to assess the influence of perioperative clinical variables pertinent to postoperative problems, morbidities, and mortalities, as well as to identify perioperative prognostic factors.

PATIENTS AND METHODS

This prospective study was carried out on 87 patients aged ≥ 18 years old, with valvular IE, whether native or artificial, treated surgically. The study was done from January 2021 to December 2022 after approval from the Ethical Committee Assiut University Hospitals, Assiut, Egypt (approval code: 17200552). An informed written consent was obtained from the patients.

Exclusion criteria were cases of IE associated with non-valvular cardiovascular devices, including pacemakers and catheters, IE treated non-surgically and patients exhibiting significant neurological impairment and CT findings indicative with hemorrhagic transformation.

Preoperative assessment

All patients underwent detailed history, laboratory evaluation (complete blood count (CBC), coagulation profile, liver and renal function, C-reactive reaction (CRP), glucose, B-type natriuretic peptide (BNP), serology) and imaging (Chest X- ray, echocardiography, trans-oesophageal echocardiogram (TOE), cardiac computed tomography (CT). Blood cultures, obtained in 2–3 sets (aerobic and anaerobic), remained the gold standard, with 5-day incubation sufficient for most pathogens including Candida. Serology was applied for fastidious organisms (*C. burnetii*, *Bartonella*), with anti-phase I IgG ≥1:800 confirming Q fever endocarditis per modified Duke criteria. Surgical indications were time-dependent: emergency (<24 h) for acute CHF or shock due to severe regurgitation, prosthesis failure, or fistula; urgent (within days) for persistent CHF, abscess, s*taphylococcal*/Gram-negative PVE, vegetations >10 mm with embolism or >15 mm; and elective (during admission) for controlled CHF, prosthetic dehiscence, abscess, persistent infection, or fungal/resistant pathogens.

Operative procedure:

All patients underwent surgery under general anesthesia, predominantly via median sternotomy, with minimally invasive thoracotomy or femoral cannulation in select cases. Cardiopulmonary bypass was achieved through aortic and bicaval cannulation, and cardiac arrest was induced with antegrade crystalloid cardioplegia. Radical debridement of infected, necrotic, and prosthetic material was performed to reduce infectious load, followed by irrigation and replacement of surgical equipment. In prosthetic valve endocarditis (PVE), complete excision of the prosthesis and suture material was mandatory. Valve repair or replacement was determined by valve involvement, extent of destruction, and patient-related factors; mechanical or biological prostheses were used based on age, comorbidities, and anticoagulation suitability, with bioprostheses favored when cerebral hemorrhage risk was present. Aortic PVE was more often invasive, while mitral valve disease tended to be superficial, allowing for repair or prosthesis implantation. When annular reconstruction was required, autologous or bovine pericardium patches were used to reinforce suture lines and prevent leakage. For right-sided IE, surgery focused on eradicating septic sources and preserving the tricuspid valve whenever feasible, with bioprostheses preferred despite limited comparative evidence. Prosthetic tricuspid valves carried a higher risk of recurrent endocarditis, thrombosis, and restricted access for future interventions. Synthetic grafts were used for aortic root or arch replacement when necessary. In re-operations, removal of additional prostheses or vascular grafts was justified if *Staphylococcus aureus* or fungal infection was implicated, provided surgical risk was acceptable.

Preoperative Diagnosis:

The diagnosis of valvular IE was based on the modified Duke criteria. Pathological criteria include microorganisms identified by culture or histology of vegetation, embolized material, or intracardiac abscess, or histological evidence of active endocarditis. Major clinical criteria comprise: (1) positive blood cultures with typical IE organisms from ≥2 samples, persistently positive cultures, or a single positive for *Coxiella burnetii* with anti–phase I IgG ≥1:800; and (2) echocardiographic evidence of IE (vegetation, abscess, new prosthetic valve dehiscence) or new valvular regurgitation. Minor criteria include predisposing cardiac disease or IV drug use, fever, vascular phenomena (emboli, pulmonary infarcts, mycotic aneurysms, cerebral/conjunctival hemorrhage, Janeway lesions), immunologic phenomena (glomerulonephritis, Osler nodes, Roth spots, RF), and microbiological evidence not meeting a major criterion. Clinically, IE often presents with persistent fever, night sweats, and cardiac symptoms (dyspnea, palpitations, edema), especially in patients with prosthetic valves, structural disease, or recent invasive procedures, with associated vascular and immunological manifestations.

Post-surgical management:

A tailored antimicrobial regimen was administered post-surgery if valve cultures were positive, with therapy continued for six weeks regardless of surgical timing. In late surgeries with persistently positive cultures, treatment duration was individualized with microbiology input. Postoperative transthoracic echocardiography (TTE) established a baseline for long-term monitoring. Patients were counseled on anticoagulation, lifestyle, and exercise tolerance, with special considerations for pacemaker/ICD removal and epicardial lead placement in high-risk cases, management of IV drug users (with addiction therapy), and dialysis patients (mechanical vs. bioprosthetic valve choice due to calcification).

Follow-up included clinical and laboratory monitoring for antibiotic toxicity, infection recurrence, prosthetic function, and secondary heart failure. Scheduled visits were at 1, 3, 6, and 12-months post-discharge, with short-term evaluation (6 weeks) focused on infection and prosthetic complications, intermediate-term (3–12 months) on ventricular dysfunction, valve disease progression, arrhythmias, thromboembolic/bleeding events, and recurrent IE, while long-term follow-up addressed wound healing, mediastinitis, and late prosthetic complications.

The primary outcomes were postoperative mortality and recurrent endocarditis. The secondary outcomes were complications occurring early and late following surgical intervention and duration of hospital and ICU stay.

Statistical analysis

Statistical analyses were conducted utilizing the SPSS program version 20 (IBM Corporation; Endicott, New York, USA). The data were assessed for normality with the Kolmogorov-Smirnov test and for homogeneity of variances before proceeding with any statistical analysis. Categorical variables were characterized by frequency and percentage (N, %), whereas continuous variables were represented by mean and standard deviation (Mean, SD). Comparative statistics and significance tests, including the paired Student's t-test, Mann-Whitney U test, Chi-square test, and Fisher's exact test, were employed. The P-value was deemed statistically significant when it was less than 0.05 and highly significant when it was less than 0.001.

RESULTS

Personal and pre-operative data were enumerated in this table. **Table 1**

Table 1: Personal and pre-operative data of the studied patients

		N=87
Age (Years)	**<40**	26(29.9%)
	40 - 60	37(42.5%)
	>60	24(27.6%)
Sex	**Male**	57(65.5%)
	Female	30(34.5%)
Pre-operative		
Renal impairment	**On dialysis (regardless of serum creatinine level)**	10(11.5%)
	Mild/ Moderately impaired renal function (45-90 ml/min)	9(10.3%)
	Severely impaired renal function (<45 ml/min) off dialysis	0(0.0%)
	Normal (cc more than 90 ml/min)	68(78.2%)
Poor mobility		8(9.2%)
Chronic lung disease		18(20.7%)
Previous cardiac surgery		18(20.7%)
Active endocarditis		41(47.1%)
Critical preoperative state		8(9.2%)
Heart rhythm and conduction disturbances	**Heart block**	15(17.2%)
	AF	36(41.4%)
	Tachyarrhythmia	8(9.2%)
Recent MI myocardial infarction within 90 days		2(2.3%)
Pulmonary hypertension	**Moderate: PA systolic pressure (31-55 mm Hg)**	24(27.6%)
	Severe: PA systolic pressure (>55mm Hg)	14(16.1%)
LV function	**Good (LVEF > 50%)**	32(36.8%)
	Moderate (LVEF > 31%-50%)	53(60.9%)
	Poor (LVEF 21%-30%)	2(2.3%)
	Very poor (LVEF less than 21%)	0(0.0%)
NYHA class	**Class I**	18(20.7%)
	Class II	45(51.7%)
	Class III	20(23.0%)
	Class IV	4(4.6%)
Urgency of surgical intervention	**Emergency "within 24 hours of hospital admission"**	10(11.5%)
	Urgent "within few days of hospital admission"	37(42.5%)
	Elective "after 1-2 weeks of antibiotic treatment"	4(46.0%)
Previous cardiac surgery	**Prior CABG**	0(0.0%)
	Prior valve surgery	28(32.2%)
Type of IE	**Native IE**	61(70.1%)
	Prosthetic IE	26(29.9%)
Type of affected valve	**Mitral**	32(36.8%)
	Aortic	31(35.6%)
	Tricuspid	23(26.43%)
	Multiple " Aorta and Mitral "	1(1.14%)
Size	**Less than 10 mm**	3(3.4%)
	10-15 mm	14(16.1%)
	More than 15 mm	70(80.5%)
Periannular abscess		24(27.6%)
Aneurysm		16(18.4%)
Fistula		14(16.1%)
Leaflet perforation		63(72.4%)
Other anomalies	**VSD**	12(13.8%)

Neurological manifestations	**Ischemic stroke**	27(31.0%)
	TIA "transient ischemic attack"	8(9.2%)
Splenic infarction		14(16.1%)
Renal infarction		8(9.2%)
Pulmonary infarction		16(18.4%)
Diabetes	**Insulin dependent**	50(57.5%)
	Non-insulin dependent	31(35.6%)
Preoperative steroids		12(13.8%)
Preoperative intra-aortic balloon pimp "IABP"		14(16.1%)
Preoperative inotropes		24(27.6%)
Congestive heart failure		63(72.4%)
Hypertension		14(16.1%)
Smoking		40(46.0%)
Preoperative blood cultures	**Positive**	70(80.5%)
	Negative	17(19.5%)
History of drug addiction "abuse"		20(23.0%)
Chronic liver disease		8(9.2%)
Preoperative ventilatory support (either invasive or non-invasive)		8(9.2%)
Microbial species isolated from blood	***Streptococcal spp***	48(55.2%)
	Staphylococcal spp	16(18.4%)
	Enterococci	12(13.8%)
Persistent ongoing infection "not responding to medical treatment"		25(28.7%)
Fever		48(55.2%)
Leukocytosis		36(41.4%)
Raised inflammatory markers		54(62.1%)

Data are presented as frequency (%).

Intra-operative, post-operative data and follow-up data were enumerated in this table. **Table 2**

Table 2: Intra-operative, post-operative data and follow-up data of the studied patients

		N=87
Surgical approach	**Sternotomy**	85(97.7%)
	Thoracotomy	2(2.3%)
Type of cannulation	**Central (aorta, LV apex)**	83(95.4%)
	Peripheral (axillary, subclavian, innominate, femoral)	4(4.6%)
Surgical techniques		
Isolated Aortic valve procedure	**Mechanical valve**	20(64.5%)
	Bio-prosthetic valve	11(35.4%)
Isolated Mitral valve procedure	**Mechanical valve**	25(78.12%)
	Bio-prosthetic valve	7(21.8%)
Isolated Tricuspid valve procedure	**Mechanical valve**	2(8.69 %)
	Bio-prosthetic valve	21(91.3%)
Mechanical Aorta and **Mitral**		1(100.0%)
Operation time, from skin incision (min)		128.07±22.71
Cardiopulmonary bypass time (min)		86.09±13.60
Aortic cross-clamp time (min)		62.90±13.72
Post-operative data		
Postoperative duration of mechanical ventilation (hours)		9.0(3.0-216.0)
Postoperative duration of cardiac inotropes (hours)		96.0(6.0-192.0)
Postoperative re-intervention	**Bleeding necessitate exploration**	18(20.7%)
	Reoperation for valvular dysfunction	2(2.3%)
Postoperative low cardiac output		33(37.9%)
Postoperative wound infection		18(20.7%)
Postoperative mediastinitis		6(6.9%)
Postoperative sepsis		22(25.3%)
Postoperative neurologic complication	**Transient neurologic deficit**	4(4.6%)
	Continuous coma >24 h	3(3.4%)
Postoperative pulmonary complication	**Prolonged ventilation**	13(14.9%)
	Pneumonia	27(31.0%)
Postoperative dialysis		11(12.6%)
Postoperative acute kidney injury (AKI)		17(19.5%)
Postoperative heart block (temporary pacemaker)		26(29.9%)
Postoperative gastrointestinal complication		2(2.3%)

Duration of ICU stay (days)	7.28 ± 2.47
Duration of hospital stay (days)	10.56 ± 3.91
Post-operative mortality	14(16.1%)
Follow-up data (n=85)	
Recurrent IE	12(14.11%)
Anticoagulant complications	11(12.94%)
Sternal dehiscence	8(9.4%)
Superficial wound infection	21(24.7%)
Continue on drug addiction postoperative "for IV drug abuse"	12(60.0%)
Follow up (short and intermediate) mortality	12(4.11%)

Data are presented as median (IQR) or mean ±SD or frequency (%). IE: infective endocarditis

Type of affected valve according to according to type of IE were enumerated in this table. **Table 3**

Table 3: Type of affected valve according to according to type of IE

		Type of IE		Postoperative mortality	
		Native IE	**Prosthetic IE**	**Native IE**	**Prosthetic IE**
Type of affected valve	**Mitral**	20(62.5%)	12(33.3%)	3(15.0%)	3(25.0%)
	Aortic	19(61.2%)	12(38.7%)	4(21.05%)	3(25.0%)
	Tricuspid	21(91.3%)	2(8.6%)	1(4.7%)	0(0.0%)

Data are presented as frequency (%). IE: infective endocarditis

There were a significant relation between postoperative mortality and age, critical preoperative state, heart rhythm and conduction disturbances, LV function, NYHA class, urgency of surgical intervention, Peri-annular abscess, aneurysm, diabetes, preoperative inotropes, congestive heart failure, history of drug addiction "abuse", preoperative ventilatory support (either invasive or non-invasive), persistent ongoing infection "not responding to medical treatment", fever, CRP, bio-prosthetic valve, postoperative duration of mechanical ventilation, postoperative sepsis, postoperative neurologic complication, postoperative pulmonary complication, postoperative gastrointestinal complication and duration of hospital stay ($P<0.05$), while other parameter without significant. **Table 4**

Table 4: Relation of predictors regarding postoperative mortality

		Post-operative mortality		P
		Yes	**No**	
Age (years)	**< 40**	0(0.0%)	26(100%)	**0.000***
	40 – 60	2(5.4%)	35(94.59%)	
	> 60	12(50%)	12(50%)	
Sex	**Male**	7(12.2%)	50(87.7%)	0.224
	Female	7(23.33%)	23(76.6%)	
Renal impairment	**On dialysis (regardless of serum creatinine level)**	0(0.0%)	10(100%)	0.318
	Mild/ Moderately impaired renal function (45-90 ml/min)	2(22.2%)	7(77.7%)	
	Normal (cc more than 90 ml/min)	12(17.6%)	56(82.4%)	
Poor mobility		1(12.5%)	7(87.5%)	1.000
Chronic lung disease		3(16.6%)	15(83.3%)	1.000
Active endocarditis		7(17.07%)	34(82.92%)	0.814
Critical preoperative state		4(50%)	4(50%)	**0.021***
Heart rhythm and conduction disturbances	**Heart block**	7(46.6%)	8(53.3%)	**0.000***
	AF	0(0.0%)	36(100%)	
	Tachyarrhythmias	2(25%)	6(75%)	
Recent MI myocardial infarction within 90 days		0(0.0%)	2(100%)	1.000
Pulmonary hypertension	**Moderate: PA systolic pressure (31-55 mm Hg)**	2(8.33%)	22(91.6%)	0.261
	Severe: PA systolic pressure (>55mm Hg)	4(28.5%)	10(71.42%)	
LV function	**Good (LVEF > 50%)**	0(0.0%)	32(100%	**0.000***
	Moderate (LVEF > 31%-50%)	12(22.64%)	41(80.39%)	
	Poor (LVEF 21%-30%)	2(100%)	0(0.0%)	
NYHA class	**Class I**	0(0.0%)	18(100%)	**0.000***
	Class II	6(13.33%)	39(86.66%)	
	Class III	4(20%)	16(80%)	
	Class IV	4(100%)	0(0.0%)	
Urgency of surgical intervention	**Emergency "within 24 hours of hospital admission"**	6(60%)	4(40%)	**0.000***
	Urgent "within few days of hospital admission"	7(18.91%)	30(81.08%)	
	Elective "after 1-2 weeks of antibiotic treatment"	2.5(7.1%)	39(975%)	
Previous cardiac surgery	**Prior valve surgery**	6(21.42%)	22(78.6%)	0.364

Type of IE	**Native IE**	8(13.1%)	53(86.88%)	0.339
	Prosthetic IE	6(23.07%)	20(76.9%)	
Type of affected valve	**Mitral**	6(18.75%)	26(81.25%)	0.607
	Aortic	7(22.58%)	24(77.41%)	0.238
	Tricuspid	1(4.34%)	22(95.66%)	0.128
Size	**Less than 10 mm**	1(33.3%)	2(66.6%)	0.704
	10-15 mm	2(14.28%)	12(85.7%)	
	More than 15 mm	11(15.71%)	59(84.28%)	
Peri-annular abscess		10(41.6%)	14(85.33%)	**0.000***
Aneurysm		6(37.5%)	10(62.5%)	**0.019***
Fistula		4(28.57%)	10(71.42%)	0.228
Leaflet perforation		10(15.87%)	53(84.12%)	1.000
Other anomalies	**VSD**	0(0.0%)	12(100%)	0.316
Neurological manifestations	**Ischemic stroke**	6(22.22%)	21(77.77%)	
	TIA	0(0.0%)	8(100%)	
Splenic infarction		2(14.3%)	12(85.71%)	1.000
Renal infarction		0(0.0%)	8(100%)	0.345
Pulmonary infarction		4(25%)	12(75%)	0.279
Diabetes	**Insulin dependent**	13(26%)	37(74%)	**0.014***
	Non-insulin dependent	1(3.22%)	30(96.77%)	
Preoperative steroids		1(8.33%)	11(91.66%)	0.681
Preoperative IABP		2(14.3%)	12(85.7%)	1.000
Preoperative inotropes		8(33.33%)	16(66.66%)	**0.018***
Congestive heart failure		14(22.22%)	49(77.77%)	**0.009***
Hypertension		2(14.3%)	12(85.71%)	1.000
Smoking		4(10%)	36(90%)	0.154
Preoperative blood cultures	**Positive**	13(18.57%)	57(81.42%)	0.286
	Negative	1(5.88%)	16(94.11%)	
History of drug addiction "abuse"		0(0.0%)	20(100%)	**0.033***
Chronic liver disease		0(0.0%)	8(100%)	0.345
Preoperative ventilatory support (either invasive or non-invasive)		4(50%)	4(50%)	**0.021***
Microbial species isolated from blood	***Streptococcal spp***	7(14.58%)	41(85.41%)	0.671
	Staphylococcal spp	4(25%)	12(75%)	0.279
	Enterococci	4(33.33%)	8(66.66%)	0.097
Persistent ongoing infection "not responding to medical treatment"		9(36%)	16(64%)	**0.003***
Fever		14(29.16%)	34(70.83%)	**0.000***
CRP		10(27.77%)	26(72.22%)	**0.013***
Raised inflammatory markers		10(18.51%)	44(81.48%)	0.431
Surgical approach	**Sternotomy**	14(16.47%)	71(83.52%)	1.000
	Thoracotomy	0(0.0%)	2(100%)	
Type of cannulation	**Central (aorta, LV apex)**	12(14.45%)	71(85.54%)	0.120
	Peripheral (axillary, subclavian, innominate, femoral)	2(50%)	2(50%)	
Surgical techniques				
Isolated Aortic valve procedure	**Mechanical valve**	5(25%)	15(75%)	0.507
	Bio-prosthetic valve	2(18.18%)	9(81.81%)	**0.019***
Isolated Mitral valve procedure	**Mechanical valve**	5(20%)	20(76.9%)	0.532
	Bio-prosthetic valve	1(14.28%)	6(85.71%)	1.000
Isolated Tricuspid valve procedure	**Mechanical valve**	1(50%)	1(50%)	1.000
	Bio-prosthetic valve	0(0.0%)	21(100%)	0.333
Multiple valve procedure		0(0.0%)	1(100%)	0.161
Operation time, from skin incision (minutes)		131.43±17.99	127.42±23.56	0.549
Cardiopulmonary bypass time (min)		82.14±9.09	86.85±14.23	0.238
Aortic cross-clamp time (min)		65.36±8.20	62.42±14.53	0.467
Postoperative duration of mechanical ventilation (hours)		51.0(5.0-216.0)	9.0(3.0-24.0)	**0.004***
Postoperative duration of cardiac inotropes (hours)		84.0(6.0-168.0)	96.0(7.0-192.0)	0.217
Postoperative re-intervention	**Bleeding necessitate exploration**	2(11.11%)	16(88.88%)	0.645
	Reoperation for valvular dysfunction	0(0.0%)	2(100%)	
Postoperative low cardiac output		8(24.2%)	25(75.7%)	0.106
Postoperative wound infection		4(22.2%)	14(77.7%)	0.475
Postoperative mediastinitis		2(33.3%)	4(66.6%)	0.246
Postoperative sepsis		9(40.9%)	13(59.09%)	**0.001***
Postoperative neurologic complication	**Transient neurologic deficit**	2(50%)	2(50%)	**0.000***
	Continuous coma >24 h	3(100%)	0(0.0%)	

Postoperative pulmonary complication	**Prolonged ventilation**	4(100%)	0(0.0%)	**0.000***
	Pneumonia	4(14.8%)	23(85.1%)	
Postoperative dialysis		1(9%)	10(91%)	0.685
Postoperative acute kidney injury		2(11.76%)	15(88.23%)	0.728
Postoperative gastrointestinal complication		2(100%)	0(0.0%)	**0.024***
Duration of ICU stay (days)		7.0 (3.0-10.0)	8.0 (3.0-13.0)	0.162
Duration of hospital stay (days)		7.0 (3.0-10.0)	11.0 (4.0-20.0)	**0.000***
Anticoagulant complications		--	11(16.4%)	--
Sternal dehiscence		--	8(11.9%)	--
Superficial wound infection		--	21(31.3%)	--
Continue on drug addiction postoperative "for IV drug abuse"		--	--	--

Data are presented as median (IQR) or mean ±SD or frequency (%). * Significant P value <0.05. AF: Atrial Fibrillation, LVEF: Left ventricular ejection fraction, VSD: Ventricular Septal Defect, TIA: transient ischemic attack, IABP: intra-aortic balloon pimp, CRP: C-reactive protein, LV: Left ventricle, ICU: Intensive Care Unit.

There was a significant relation between postoperative mortality and LV function, NYHA class, type of IE, mitral and aortic valve, neurological manifestations, *Streptococcal spp*, persistent ongoing infection "not responding to medical treatment", raised inflammatory markers, prosthetic valve of mitral valve, postoperative duration of mechanical ventilation, wound infection and sepsis, pneumonia and superficial wound infection(P<0.05), while other parameter without significant. **Table 5**

Table 5: Relation of predictors regarding postoperative recurrent IE

		Recurrent IE		**P**
		Yes	**No**	
Age (years)	**< 40**	4(18%)	18(82%)	0.992
	40 – 60	6(18%)	27(82%)	
	> 60	2(16.6%)	10(83.4%)	
Sex	**Male**	10(21.7%)	36(78.2%)	0.314
	Female	2(9.5%)	19(90.47%)	
Renal impairment	**On dialysis (regardless of serum creatinine level)**	4(40%)	6(60%)	0.083
	Mild/ Moderately impaired renal function (45-90 ml/min)	0(0.0%)	7(100%	
	Normal (cc more than 90 ml/min)	8(16%)	42(84%)	
Poor mobility		0(0.0%	7(100%)	0.336
Chronic lung disease		2(13.33%)	13(86.6%)	0.721
Previous cardiac surgery		0(0.0%)	14(100%)	0.058
Active endocarditis		4(12.5%)	28(87.5%)	0.269
Critical preoperative state		0(0.0%)	4(100%)	1.000
Heart rhythm and conduction disturbances	**Heart block**	0(0.0%)	8(100%)	0.244
	AF	8(25%)	24(75%)	
	Tachyarrhythmias	0(0.0%)	6(100%)	
Recent MI myocardial infarction within 90 days		0(0.0%)	2(100%)	1.000
Pulmonary hypertension	**Moderate: PA systolic pressure (31-55 mm Hg)**	6(30%)	14(90%)	0.120
	Severe: PA systolic pressure (>55mm Hg)	0(0.0%)	10(100%)	
LV function	**Good (LVEF > 50%)**	10(35.7%)	18(64.28%)	**0.001***
	Moderate (LVEF > 31%-50%)	2(5.12%)	37(94.87%)	
NYHA class	**Class I**	6(37.5%)	10(62.5%)	**0.021***
	Class II	6(17.14%)	29(82.85%)	
	Class III	0(0.0%)	16(100%)	
Urgency of surgical intervention	**Emergency "within 24 hours of hospital admission"**	0(0.0%)	4(100%)	0.571
	Urgent "within few days of hospital admission"	6(21.42%)	22(78.57%)	
	Elective "after 1-2 weeks of antibiotic treatment"	6(17.14%)	29(82.85%)	
Previous cardiac surgery	**Prior valve surgery**	2(9%)	20(91%)	0.310
Type of IE	**Native IE**	12(25.53%)	35(74.46%)	**0.013***
	Prosthetic IE	0(0.0%)	20(100%)	
Type of affected valve	**Mitral**	8(30.76%)	18(69.23%)	**0.048***
	Aortic	0(0.0%)	20(100%)	**0.013***
	Tricuspid	4(16%)	21(84%)	1.000
Size	**10-15 mm**	4(40%)	6(60%)	0.070

	More than 15 mm	8(14.03%)	49(85.96%)	
Periannular abscess		2(14.28%)	12(85.71%)	1.000
Aneurysm		0(0.0%)	10(100%)	0.188
Fistula		0(0.0%)	10(100%)	0.188
Leaflet perforation		12(22.64%)	41(77.35%)	0.059
Other anomalies	**VSD**	4(33.3%)	8(66.6%)	0.205
Neurological manifestations	**Ischemic stroke**	0(0.0%)	21(100%)	**0.005***
	TIA "transient ischemic attack"	4(50%)	4(50%)	
Splenic infarction		4(40%)	6(60%)	0.070
Renal infarction		2(25%)	6(75%)	0.627
Pulmonary infarction		4(33.3%)	8(66.6%)	0.205
Diabetes	**Insulin dependent**	6(16.2%)	31(83.78%)	0.689
	Non-insulin dependent	6(21.42%)	22(78.57%)	
Preoperative steroids		0(0.0%)	9(100%)	0.196
Preoperative intra-aortic balloon pimp "IABP"		0(0.0%)	12(100%)	0.105
Preoperative inotropes:		0(0.0%)	16(100%)	0.056
Congestive heart failure		6(12.24%)	43(87.75%)	0.070
Hypertension		2(16.66%)	10(83.33%)	1.000
Smoking		8(23.52%)	26(76.47%)	0.223
Preoperative blood cultures	**Positive**	10(18%)	45(82%)	1.000
	Negative	2(16.66%)	10(83.34%)	
History of drug addiction "abuse"		4(20%)	16(80%)	0.741
Chronic liver disease		2(25%)	6(75%)	0.627
Preoperative ventilatory support (either invasive or non-invasive)		0(0.0%)	4(100%)	1.000
Microbial species isolated from blood	***Streptococcal spp***	12(29.26%)	29(70.73%)	**0.002***
	Staphylococcal spp	0(0.0%)	12(100%)	0.105
	Enterococci	0(0.0%)	8(100%)	0.333
Persistent ongoing infection "not responding to medical treatment"		6(37.5%)	10(62.5%)	**0.029***
Fever		8(23.52%)	26(76.47%)	0.223
Leukocytosis		6(27.2%)	16(72.7%)	0.187
Raised inflammatory markers		12(30%)	28(70%)	**0.001***
Surgical approach	**Sternotomy**	12(18.46%)	53(81.53%)	1.000
	Thoracotomy	0(0.0%)	2(100%)	
Type of cannulation	**Central (aorta, LV apex)**	12(18.46%)	53(81.53%)	1.000
	Peripheral (axillary, subclavian, innominate, femoral)	0(0.0%)	2(100%)	
Surgical techniques				
Isolated Aortic valve procedure	**Prosthetic valve**	0(0.0%)	14(100%)	0.058
	Bio-prosthetic valve	0(0.0%)	10(100%)	0.188
Isolated Mitral valve procedure	**Prosthetic valve**	8(40%)	12(60%)	**0.004***
	Bio-prosthetic valve	0(0.0%)	4(100%)	1.000
Isolated tricuspid valve procedure	**Prosthetic valve**	0(0.0%)	0(0%)	--
	Bio-prosthetic valve	4(17.39%)	19(82.6%)	1.000
Operation time, from skin incision (min)		117.17±13.72	127.20±23.87	0.166
Cardiopulmonary bypass time (min)		85.00±8.68	88.25±15.53	0.487
Aortic cross-clamp time (min)		61.50 ± 13.80	63.76 ± 15.10	0.635
Postoperative duration of mechanical ventilation (hours)		7.0 (4.0-10.0)	9.0 (4.0-24.0)	**0.015***
Postoperative duration of cardiac inotropes (hours)		108.0 (72.0-144.0)	120.0 (7.0-192.0)	0.695
Postoperative re-intervention	**Bleeding necessitate exploration**	4(25%)	12(75%)	0.587
	Reoperation for valvular dysfunction	0(0.0%)	2(100%)	
Postoperative low cardiac output		2(8%)	23(92%)	0.186
Postoperative wound infection		8(57.14%)	6(42.8%)	**0.000***
Postoperative mediastinitis		2(50%)	2(50%)	0.144
Postoperative sepsis		6(46.1%)	7(53.84%)	**0.008***
Postoperative neurologic complication	**Transient neurologic deficit**	0(0.0%)	2(100%)	1.000
Postoperative pulmonary complication	**Pneumonia**	8(34.78%)	15(65.21%)	**0.017***
Postoperative dialysis		4(40%)	6(60%	0.070
Postoperative acute kidney injury (AKI)		2(16.7%)	13(23.6%	0.721
Postoperative gastrointestinal complication		0(0.0%)	0(0.0%	--
Duration of ICU stay (days)		7.5 (5.0-10.0)	8.0 (3.0-13.0)	0.462
Duration of hospital stay (days)		11.0 (9.0-15.0)	12.0 (4.0-20.0)	0.656

Anticoagulant complications	0(0.0%)	11(100%)	0.192
Sternal dehiscence	2(25%)	6(75%)	0.627
Superficial wound infection	8(38%)	13(62%)	**0.006***
Continue on drug addiction postoperative "for IV drug abuse"	4(33.3%)	8(66.6%)	0.205

Data are presented as median (IQR) or mean ±SD or frequency (%). * Significant P value <0.05. AF: Atrial Fibrillation, LVEF: Left ventricular ejection fraction, VSD: Ventricular Septal Defect, TIA: transient ischemic attack, IABP: intra-aortic balloon pimp, CRP: C-reactive protein, LV: Left ventricle, ICU: Intensive Care Unit.

In multivariate regression, Preoperatively, constant were independent predictors of mortality (P=0.001) while Heart rhythm and conduction disturbances, NYHA class (III and IV), Peri-annular abscess, timing of surgery (Emergency), preoperative inotropes and ongoing infection were not. In Multivariate regression, postoperatively, duration of hospital stay were independent predictors of mortality (P=0.005) while postoperative duration of MV, postoperative pulmonary complications and constant were not. **Table 6, Figure 1**

Table 6: Multiple logistic regression analysis for mortality risk factors of pre-operative and post-operative variables

	P	OR	95% C.I.	
			Lower	Upper
Pre-operative				
Heart rhythm and conduction disturbances	0.090	0.125	0.011	1.381
NYHA class (III & IV)	0.597	1.939	0.166	22.636
Peri-annular abscess	0.175	3.372	0.582	19.547
Timing of surgery (Emergency)	0.680	1.650	0.153	17.793
Preoperative inotropes	0.116	8.972	0.580	138.807
Ongoing infection	0.063	5.574	0.912	34.061
Constant	**0.001***	0.061		
Post-operative				
Postoperative duration of MV	0.199	1.070	0.965	1.185
Postoperative pulmonary complications	0.057	6.204	0.944	40.764
Duration of hospital stay	**0.005***	0.654	0.487	0.878
Constant	0.856	1.315		

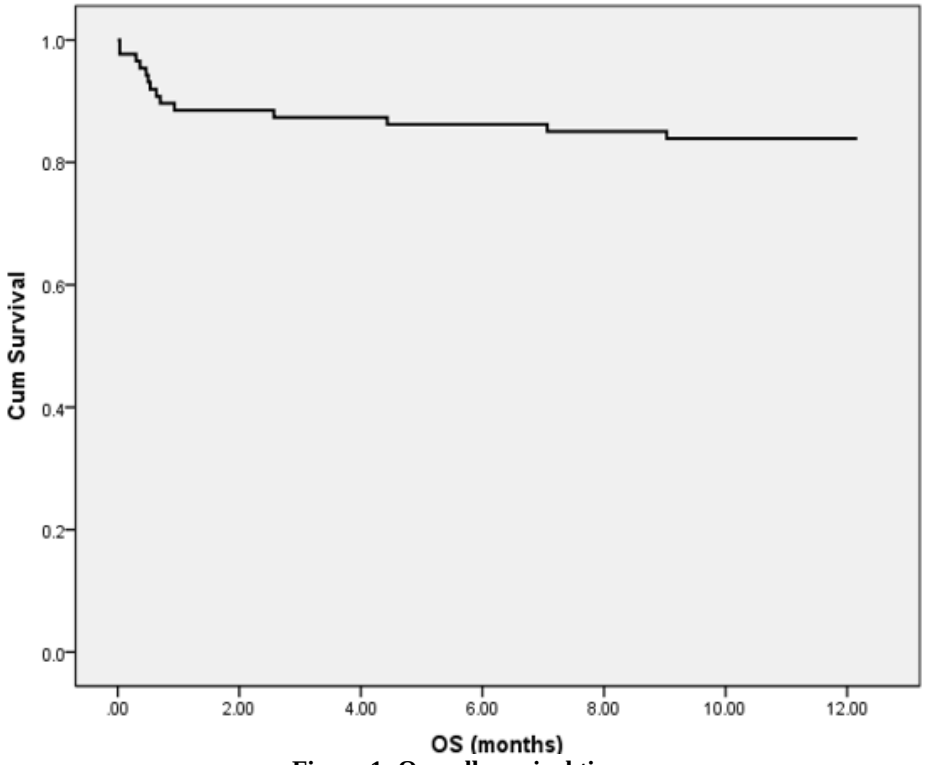

Figure 1: Overall survival time

DISCUSSION

Surgery may be life-saving for patients with complications of IE that are unlikely to be resolved or ameliorated by medicinal treatment alone; nevertheless, the relationship between surgical indications, acute clinical condition, surgical decision-making, and anticipated outcomes is intricate and little comprehended [11].

This study revealed a postoperative mortality rate of 13.33% in NYHA class II, 20% in class III, and 28.6% in class IV. Concerning surgical time, post-operative death rates were 18.9% for urgent interventions, 60% for emergency patients, and 2.5% for elective surgeries. The timing and rationale for surgery are inextricably linked, which elucidates the elevated death rates for urgent and emergency patients. Consistent with other research, Revilla et al. [12] indicate that the primary reason for emergent surgery was heart failure.

No significant difference was seen in this investigation for the type of damaged valve. The greatest death rate of 22.58% was seen in aortic patients, followed by mitral at 18.75% and tricuspid at 4.3%. Gaca et al. [13] determined that age above 60 years and surgery involving several valves were related with significant morbidity and postoperative death.

Comparison of *aureus* with native valve endocarditis or other pathogens. Our observations corroborated the findings of earlier research indicating that the existence of a paravalvular abscess, in conjunction with advanced age and ischemic heart conditions, is significant. Aureus is strongly correlated with increased 30-day postoperative mortality [14].

A research by Kang et al. [6] shown that early surgery for patients with IE with extensive vegetations is more effective than standard treatment in decreasing the incidence of embolic strokes and mortality.

Diabetes is regarded as a preoperative risk factor in this study. A mortality rate of 26% was seen in insulin-dependent patients. Consistent with prior research, Farag et al. [15] observed that non-survivors had elevated rates of preoperative diabetes mellitus; nevertheless, diabetes was not identified as an independent predictor of 30-day death. Yoshioka et al. [16] reported that 470 patients had valve surgery for left-sided active IE, including 374 non-diabetic individuals and 96 with diabetes mellitus. In-hospital mortality was 8% for individuals without diabetes mellitus and 13% for people with diabetes mellitus.

In this study, hypertension and preoperative smoking had a negligible influence. Unlike other trials, postoperative mortality was not observed in patients with chronic liver disease.

Preoperative high CRP was deemed a significant variable in this study. Furthermore, a chronic infection unresponsive to medical intervention is significantly associated with postoperative death. In a prior prospective investigation, Heiro et al. [17] assessed the prognostic significance of monitoring CRP levels during hospitalization in 134 patients with IE and determined it to be beneficial. A retrospective examination of a Finnish population indicated that elevated CRP levels are predictive of short-term and one-year death"86".

Concerning surgical technique, postoperative mortality demonstrates no significant difference between sternotomy and thoracotomy incisions, which can be attributed to the restricted number of patients undergoing thoracotomy. The kind of cannulation, whether central or peripheral, demonstrates no change, similar to the type of cardioplegia. This study finds that, unlike prior research, cardiopulmonary bypass time and aortic cross-clamp time have no significant correlation with postoperative mortality. Gatti G et al. [18] identified correlations between extracorporeal circulation duration and aortic clamping duration. Oliveira JLR et al. [19] reveal that the duration of surgery significantly affects mortality risk: for every additional 5 minutes, the likelihood of death increases by a factor of 1.005, and after 435 minutes, each additional 5 minutes escalates the risk by a factor of 3.90.

The postoperative length of mechanical breathing in this study is significant concerning death. Consistent with other research, Perrotta et al. [20] demonstrated that extended intubation was an independent predictor of hospital mortality.

A mortality rate of 24.2% was documented in instances with inadequate cardiac output. In this study, postoperative decreased cardiac output was deemed a non-significant predictor. Conard LE et al. [21] indicate that postoperative low cardiac output (COP) elevates mortality risk due to diminished peripheral perfusion, placing various organs, particularly the kidneys, at risk of ischemia. Postoperative hemorrhage requiring investigation is deemed a non-significant predictor, with an 11% death rate documented in 2 patients necessitating exploration. The present investigation revealed that the occurrence of new renal impairment was a non-significant predictor of postoperative mortality, including both postoperative dialysis and postoperative acute kidney damage. Smith et al. [22] identified renal problems as a predictor of in-hospital death in prior research. Sheikh et al. [23] identified postoperative renal insufficiency as a predictor of death.

In our analysis, postoperative neurologic complications were identified as a strong univariate predictor, alongside postoperative pulmonary complications. Postoperative atelectasis or pneumonia frequently results in postoperative chest infections, which are linked to fever

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In extreme instances, this infection may advance to respiratory failure, necessitating extended ventilation, inotropic support, and an extended duration of ICU admission. Sheikh et al. [23] and Smith et al. [22] asserted that postoperative pulmonary problems are significant predictors of death.

In relation to postoperative recurrent IE, identified as a secondary objective in this study, age and gender were deemed non-significant preoperative predictors. Preoperative positive blood cultures demonstrate no significant connection with postoperative recurrent IE. In contrast, prior research, like Renzulli A et al. [24] indicated that positive valve tissue cultures possess predictive value for infection recurrence.

This study demonstrates a substantial statistical correlation between the kind of IE, whether native or prosthetic, and the occurrence of postoperative recurrent IE. Unlike other research, recurrent IE has been identified in native patients. This incident can be attributed to the restricted availability of prosthetic valves and the scarcity of follow-up data that has been lost. Moon et al. [25] discovered no disparity in reinfection rates between biological and mechanical valves.

A multivariant logistic regression study for determinants of postoperative mortality has been conducted. Pre-operative predictors including cardiac rhythm and conduction abnormalities, NYHA classes III and IV, peri-annular abscess, emergency procedures, preoperative inotropic support, and persistent preoperative infections unresponsive to medical therapy.

Multi-variant postoperative analysis identifies the following important predictors: duration of mechanical ventilation, postoperative pulmonary problems, and length of hospital stay. Following extrapolation from the Kaplan–Meier curve, the total postoperative all-cause mortality was 14 patients, representing 16.1%.

Limitations of the study included that the study's main limitations include its small sample size, which raises the risk of type II error and variability, and its single-center setting, restricting patient diversity, surgical technique variation, and generalizability. The observational design precludes causal inference, and surgical indications were investigator-assessed rather than centrally adjudicated, though predefined protocols were used. Additionally, causes of death were not determined in some cases, and variability in referral timing from multiple institutions made it difficult to establish the onset of IE.

CONCLUSIONS

Swift diagnosis of individuals with IE at elevated risk of death may provide the chance to alter the disease trajectory and enhance prognosis.

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REFERENCES

1. Baddour LM, Wilson WR, Bayer AS, Fowler VG, Jr., Tleyjeh IM, Rybak MJ, et al. Infective endocarditis in adults: Diagnosis, antimicrobial therapy, and management of complications: A scientific statement for healthcare professionals from the american heart association. Circ. 2015;132:1435-86.
2. Habib G, Lancellotti P, Antunes MJ, Bongiorni MG, Casalta JP, Del Zotti F, et al. 2015 ESC Guidelines for the management of infective endocarditis: The Task Force for the Management of Infective Endocarditis of the European Society of Cardiology (ESC). Endorsed by: European Association for Cardio-Thoracic Surgery (EACTS), the European Association of Nuclear Medicine (EANM). Eur Heart J. 2015;36:3075-128.
3. Nishimura RA, Otto CM, Bonow RO, Carabello BA, Erwin JP, 3rd, Guyton RA, et al. 2014 AHA/ACC Guideline for the management of patients with valvular heart disease: Executive summary: A report of the american college of cardiology/american heart association task force on practice guidelines. Circ. 2014;129:2440-92.
4. Hubers SA, DeSimone DC, Gersh BJ, Anavekar NS. Infective endocarditis: A contemporary review. Mayo Clin Proc. 2020;95:982-97.
5. Byrne JG, Rezai K, Sanchez JA, Bernstein RA, Okum E, Leacche M, et al. Surgical management of endocarditis: the society of thoracic surgeons clinical practice guideline. Ann Thorac Surg. 2011;91:2012-9.
6. Kang DH, Kim YJ, Kim SH, Sun BJ, Kim DH, Yun SC, et al. Early surgery versus conventional treatment for infective endocarditis. N Engl J Med. 2012;366:2466-73.
7. Hussain ST, Shrestha NK, Gordon SM, Houghtaling PL, Blackstone EH, Pettersson GB. Residual patient, anatomic, and surgical obstacles in treating active left-sided infective endocarditis. J Thorac Cardiovasc Surg. 2014;148:981-8.
8. Shrestha NK, Jue J, Hussain ST, Jerry JM, Pettersson GB, Menon V, et al. Injection drug use and outcomes after surgical intervention for infective endocarditis. Ann Thorac Surg. 2015;100:875-82.
9. Kim JB, Ejiofor JI, Yammine M, Camuso JM, Walsh CW, Ando M, et al. Are homografts superior to conventional prosthetic valves in the setting of infective endocarditis involving the aortic valve? J Thorac Cardiovasc Surg. 2016;151:1239-48.
10. Witten JC, Hussain ST, Shrestha NK, Gordon SM, Houghtaling PL, Bakaeen FG, et al. Surgical treatment of right-sided infective endocarditis. J Thorac Cardiovasc Surg. 2019;157:1418-27.
11. Murdoch DR, Corey GR, Hoen B, Miró JM, Fowler VG, Jr., Bayer AS, et al. Clinical presentation, etiology, and outcome of infective endocarditis in the 21st century: the International Collaboration on Endocarditis-Prospective Cohort Study. Arch Intern Med. 2009;169:463-73.
12. Revilla A, López J, Sevilla T, Villacorta E, Sarriá C, Manzano Mdel C, et al. In-hospital prognosis of prosthetic valve endocarditis after urgent surgery. Rev Esp Cardiol. 2009;62:1388-94.
13. Gaca JG, Sheng S, Daneshmand MA, O'Brien S, Rankin JS, Brennan JM, et al. Outcomes for endocarditis surgery in North America: a simplified risk scoring system. J Thorac Cardiovasc Surg. 2011;141:98-106.e1-2.
14. Spelman D, Sexton D. Complications and outcome of infective endocarditis. Ann Thorac Surg. 2014;178:22-35.
15. Farag M, Borst T, Sabashnikov A, Zeriouh M, Schmack B, Arif R, et al. Surgery for infective endocarditis: Outcomes and predictors of mortality in 360 consecutive patients. Med Sci Monit. 2017;23:3617-26.
16. Yoshioka D, Toda K, Yokoyama J-y, Matsuura R, Miyagawa S, Kainuma S, et al. Diabetes mellitus adversely affects mortality and recurrence after valve surgery for infective endocarditis. J Thorac Cardiovasc Surg. 2018;155:1021-9.

17. Heiro M, Helenius H, Sundell J, Koskinen P, Engblom E, Nikoskelainen J, et al. Utility of serum C-reactive protein in assessing the outcome of infective endocarditis. Eur Heart J. 2005;260:1873-81.
18. Gatti G, Benussi B, Gripshi F, Della Mattia A, Proclemer A, Cannatà A, et al. A risk factor analysis for in-hospital mortality after surgery for infective endocarditis and a proposal of a new predictive scoring system. Infection. 2017;45:413-23.
19. Oliveira JLR, Santos MAD, Arnoni RT, Ramos A, Togna DD, Ghorayeb SK, et al. Mortality predictors in the surgical treatment of active infective endocarditis. Braz J Cardiovasc Surg. 2018;33:32-9.
20. Perrotta S, Aljassim O, Jeppsson A, Bech-Hanssen O, Svensson G. Survival and quality of life after aortic root replacement with homografts in acute endocarditis. Ann Thorac Surg. 2010;90:1862-7.
21. Conrad C, Eltzschig HK. Disease mechanisms of perioperative organ injury. Anesthesia & Analgesia. 2020;131:1730-50.
22. Smith JM, So RR, Engel AM. Clinical predictors of mortality from infective endocarditis. Int J Surg. 2007;5:31-4.
23. Sheikh AM, Elhenawy AM, Maganti M, Armstrong S, David TE, Feindel CM. Outcomes of surgical intervention for isolated active mitral valve endocarditis. J Thorac Cardiovasc Surg. 2009;137:110-6.
24. Renzulli A, Carozza A, Marra C, Romano GP, Ismeno G, De Feo M, et al. Are blood and valve cultures predictive for long-term outcome following surgery for infective endocarditis? Eur J Cardiothorac Surg. 2000;17:228-33.
25. Moon MR, Miller DC, Moore KA, Oyer PE, Mitchell RS, Robbins RC, et al. Treatment of endocarditis with valve replacement: the question of tissue versus mechanical prosthesis. Ann Thorac Surg. 2001;71:1164-71.