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ORIGINAL SCIENTIFIC PAPER

Aetiology, clinical characteristics, and risk factors influencing mortality in patients with infective endocarditis: a retrospective study

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ABSTRACT

Introduction: Infective endocarditis is defined as an infection of the endothelial surfaces in the heart (valves and endocardium), prosthetic heart valves, and intracardiac devices (such as pacemaker leads and ventricular assist devices). Due to diagnostic challenges, determining the true incidence of infective endocarditis is difficult. Despite advancements in diagnosis and treatment, incidence and mortality rates have not decreased. In this study, we evaluated the clinical and laboratory parameters of patients with infective endocarditis followed in our hospital between 2005 and 2018 and assessed their relationship with in-hospital and one-year mortality.

Methods: This study retrospectively analysed 145 patients aged ≥18 years who were diagnosed with infective endocarditis and followed in our hospital between 2005 and 2018. Data were analysed using IBM SPSS V23. Statistical analyses included the Shapiro-Wilk test, T-test, Mann-Whitney U test, and Chi-square test.

Results: The average age of the patients was 53 (18–86), and 52.4% ($n=76$) were male. In 34% ($n=37$) of our patients, the predisposing factor for infective endocarditis was rheumatic valve disease. In-hospital mortality was 31.7%, and one-year mortality was 40.6%. A statistically significant difference in in-hospital mortality was found between combination therapy (23%) and medical therapy (40.8%). Mitral valve involvement was the most common, occurring in 48.3% of patients. Staphylococci were the most frequently isolated microorganisms in blood cultures (41.4%). Heart failure was the most common complication and was associated with the highest mortality rate (23.4%). NYHA was an independent predictor of in-hospital mortality.

Conclusion: In our study, surgical intervention, i.e. combination therapy, applied after two weeks of antibiotic treatment, was found to be more effective. Early combination therapy may be life-saving.

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KEYWORDS
Infective endocarditis; risk factors; mortality; aetiology; surgery

Introduction

Infective endocarditis (IE) is a highly fatal disease defined as an infection of the endothelial surfaces in the heart (valves and endocardium), prosthetic heart valves, and intracardiac devices (such as pacemakers, implantable cardioverter-defibrillators, and ventricular assist devices) [1]. The incidence of IE is estimated at 10 per 100,000 according to studies; however, due to variability in diagnostic criteria and the potential for misdiagnosis with various clinical conditions, determining the true incidence of IE is challenging [2].

Although mortality from cardiovascular diseases has declined with advancements in treatment methods, IE continues to carry a high incidence and mortality rate. This persistence is attributed to factors such as the decrease in rheumatic heart disease, an increase in degenerative heart disease, advanced patient age, the prevalence of comorbidities, and an increase in cases of *Staphylococcus aureus* with resistance to various healthcare-associated antibiotic therapies [3–5].

As IE is a relatively rare disease, comprehensive studies on it remain limited. An average of 3000 cardiac procedures are performed annually at our clinical centre. The annual number of hospital admissions is approximately 4000 patients. Our clinical centre, serving as a referral centre for IE cases in our region, receives patients from surrounding areas. This study aims to identify risk factors affecting in-hospital and

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one-year mortality based on the basic demographic and clinical characteristics of patients diagnosed with IE.

Materials and methods

Ethics committee approval for the study was obtained from the Ondokuz Mayıs University Faculty of Medicine Ethics Committee with the decision numbered OMU KAEK 2018/360. The study included 150 patients over the age of 18 who were hospitalised and treated at Ondokuz Mayıs University Faculty of Medicine Hospital between 01/01/2005 and 01/06/2018, diagnosed with IE according to the Modified Duke criteria, and whose treatment was entirely managed at our hospital. Data from 5 patients were unavailable, resulting in a retrospective analysis of records from 145 patients. We evaluated patients' age, gender, predisposing heart disease, accompanying systemic comorbidities, presenting symptoms, physical examination findings, whether the infection was community-acquired or healthcare-associated, laboratory parameters, blood culture results, echocardiography findings, IE-associated complications, types of treatment received, and the relationships between these parameters and in-hospital and one-year mortality.

The Modified Duke criteria were used for diagnosing IE [3]. All patients discharged from the hospital within one month before symptom onset were considered to have nosocomial (hospital-acquired) IE [6].

Statistical analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS) V23 (IBM, Armonk, NY). Normal distribution of data was assessed with the Shapiro-Wilk test. Independent samples *t*-tests were used for comparisons of normally distributed data, while the Mann-Whitney *U* test was used for non-normally distributed data. The chi-square test was applied for categorical data. Results with a normal distribution are presented as mean ± standard deviation, non-normally distributed results as median (min-max), and categorical results as frequency (n) and percentage (%). Logistic regression analysis was performed to identify the factors predicting in-hospital mortality and one-year mortality. A significance level of $p < 0.05$ was adopted.

Results

A total of 145 IE patients were retrospectively evaluated between January 2005 and June 2018. Out of these, 46 patients experienced in-hospital mortality, while 59 patients died within one year. Table 1 shows the basic demographic characteristics of the 145

Table 1. The association of basic demographic characteristics of infective endocarditis patients with in-hospital and one-year mortality.

Basic demographic characteristics	Total ($n=145$)	Survive ($n=99$)	In-Hospital Mortality ($n=46$)	p	Survive ($n=86$)	One-Year Mortality ($n=59$)	p
Age (median, min–max)	53 (18–86)	47 (18–86)	59 (18–81)	**0.001**	45 (18–86)	59 (18–86)	**<0.001**
Gender							
• Total	145	99 (68.3%)	46 (31.7%)		86 (59.4%)	59 (40.6%)	
• Male	76 (52.4%)	53 (69.7%)	23 (30.3%)	0.724	48 (63.2%)	28 (36.8%)	0.398
• Female	69 (47.6%)	46 (66.7%)	23 (33.3%)		38 (55.1%)	31 (44.9%)	
NYHA Classification							
• NYHA Class I	52 (35.9%)	48 (92.3%)	4 (7.7%)	**<0.001**	45 (86.5%)	7 (13.5%)	**<0.001**
• NYHA Class II	73 (50.3%)	48 (65.8%)	25 (34.2%)		38 (52.1%)	35 (47.9%)	
• NYHA Class III	19 (13.1%)	3 (15.8%)	16 (84.2%)		3 (15.8%)	16 (84.2%)	
• NYHA Class IV	1 (0.7%)	0 (0%)	1 (100.0%)		0 (0%)	1 (100.0%)	
Treatment							
• Medical Treatment	71 (49.0%)	42 (59.2%)	29 (40.8%)	**0.021**	38 (53.5%)	33 (46.5%)	0.165
• Combined Treatment	74 (51.0%)	57 (77%)	17 (23.0%)		48 (64.9%)	26 (35.1%)	
Patients Receiving Empirical Treatment	91 (62.8%)	66 (72.5%)	25 (27.5%)	0.319	57 (62.6%)	34 (37.4%)	0.564
Duration of Antibiotic Therapy (days)	28 (2–85)	28 (21–49)	14 (2–85)	**<0.001**	28 (21–49)	23 (2–85)	**<0.001**
Length of Hospital Stay (days)	35 (2–85)	40 (22–75)	14 (2–85)	**<0.001**	40 (22–70)	23 (2–85)	**<0.001**
Antibiotic Use Before Admission	58 (40.0%)	38 (65.5%)	20 (35.5%)	0.560	32 (55.2%)	26 (44.8%)	0.408
Echocardiography							
Transthoracic Echocardiography	144 (99.3%)	98 (68.1%)	46 (31.9%)	0.494	86 (59.7%)	58 (40.3%)	0.226
Transesophageal Echocardiography	89 (61.4%)	64 (71.9%)	25 (28.1%)	0.236	54 (60.7%)	35 (39.3%)	0.673
Infection Source							
Community-Acquired	91 (62.8%)	65 (71.4%)	26 (28.6%)	0.290	58 (63.7%)	33 (36.3%)	0.159
Nosocomial	54 (37.2%)	34 (63%)	20 (37%)		28 (51.9%)	26 (48.1%)	

Bold values indicate statistically differences at $p < 0.005$.

patients and their association with in-hospital and one-year mortality. The average age of the patients was 53 (range: 18–86), with 52.4% ($n=76$) being male. While 49% ($n=71$) of the patients received medical treatment, 51% underwent combined therapy (medical + surgical). Patients in the combined therapy group exhibited lower in-hospital mortality rates ($p=0.021$). The average hospital stay was 35 days (range: 2–85), and the average duration of antibiotic treatment was 28 days (range: 2–85). Higher in-hospital mortality was observed in elderly patients, those receiving medical treatment, and those with poor functional capacity ($p<0.05$). Additionally, age and poor functional capacity were associated with one-year mortality ($p<0.05$). Antibiotic use before admission was reported by 40% ($n=58$) of the patients, and 61.4% ($n=89$) underwent transesophageal echocardiography. Community-acquired IE was observed in 62.8% ($n=91$) of the patients, while nosocomial IE was identified in 37.2% ($n=54$).

Table 2 shows the association between in-hospital and one-year mortality with comorbid systemic diseases and predisposing heart diseases observed in IE patients included in the study. Hypertension, rheumatic valve disease, prosthetic heart valves, and pre-existing heart failure were associated with higher in-hospital mortality rates ($p<0.05$). One-year mortality was significantly higher in IE patients with degenerative valve disease, rheumatic valve disease, and prosthetic heart valve disease ($p<0.05$). Degenerative valve disease was the most commonly observed predisposing heart condition (41.8%).

The most common presenting symptom was fever (95.2%), and the most frequent physical examination finding was a newly developed murmur (44.1%), as shown in Table 3. Increased white blood cell count (WBC), neutrophil percentage, creatinine level, troponin level, CK-MB mass, and C-reactive protein (CRP) levels were associated with a significant increase in in-hospital mortality. Elevated WBC count, neutrophil percentage, creatinine level, troponin level, and CK-MB mass were also linked to higher one-year mortality. Laboratory findings for the patients are presented in Table 4.

According to blood culture results, the most frequently isolated microorganisms were staphylococci (41.4%) and streptococci (12.5%). Additionally, 19.3% ($n=28$) of patients were culture-negative (Table 5). In IE patients with prosthetic valves, 37.1% of blood cultures yielded Staphylococcus aureus, while 28.6% were culture-negative (Table 6).

Of the patients, 23.4% ($n=34$) developed newly diagnosed congestive heart failure (CHF), 17.2% ($n=25$) had central nervous system embolism, 5.5% ($n=8$) had renal infarction, 9.6% ($n=14$) had splenic infarction, 13.1% ($n=19$) experienced peripheral arterial embolism/

Table 2. The association of co-morbid diseases and predisposing heart diseases with in-hospital and one-year mortality in patients with infective endocarditis.

Co-morbid diseases	Total ($n=145$)	Survive	In-hospital mortality	*P*	Survive	One-year mortality	*P*
Diabetes Mellitus (DM)	32 (22.1%)	20 (32.5%)	12 (37.5%)	0.562	16 (50%)	16 (50.0%)	0.312
Hypertension	67 (46.2%)	39 (58.2%)	28 (41.8%)	**0.016**	31 (46.3%)	36 (53.7%)	**0.003**
Coronary Artery Disease (CAD)	28 (19.3%)	15 (53.6%)	13 (46.4%)	0.102	13 (46.4%)	15 (53.6%)	0.183
Heart Failure (prior to endocarditis)	15 (10.3%)	6 (40%)	9 (60.0%)	**0.028**	5 (33.3%)	10 (66.7%)	0.059
Dialysis	27 (18.6%)	14 (51.9%)	13 (48.1%)	0.071	11 (40.7%)	16 (59.3%)	0.050
Malignancy	3 (2.1%)	1 (33.3%)	2 (66.7%)	0.236	0 (0%)	3 (100.0%)	0.065
Immunosuppressive Therapy	9 (6.2%)	7 (67.8%)	2 (22.2%)	0.719	4 (44.4%)	5 (55.6%)	0.486
History of Dental Surgery in the Last Month	2 (1.4%)	2 (100%)	0 (0.0%)	1.000	1 (50%)	1 (50.0%)	1.000
Chronic Obstructive Pulmonary Disease (COPD)	8 (5.5%)	4 (50%)	4 (50.0%)	0.264	4 (50%)	4 (50.0%)	0.716
Predisposing heart diseases							
Degenerative Valve Disease	46 (41.8%)	26 (56.5%)	20 (43.5%)	0.060	21 (45.7%)	25 (54.3%)	**0.036**
Rheumatic Valve Disease	37 (33.6%)	33 (89.2%)	4 (10.8%)	**0.003**	30 (81.1%)	7 (18.9%)	**0.003**
Prosthetic Valve Disease	35 (24.1%)	18 (51.4%)	17 (48.6%)	**0.024**	14 (40%)	21 (60%)	**0.013**
ICD-Pacemaker	8 (5.5%)	4 (50%)	4 (50.0%)	0.264	3 (37.5%)	5 (62.5%)	0.271
Congenital Heart Disease	4 (2.8%)	3 (75%)	1 (25.0%)	1.000	3 (75%)	1 (25.0%)	0.646
Mitral Valve Prolapse (MVP)	3 (2.1%)	3 (100%)	0 (0.0%)	1.000	3 (100%)	0 (0.0%)	1.000
Bicuspid Aortic Valve	5 (3.4%)	4 (80%)	1 (20.0%)	1.000	3 (60%)	2 (40.0%)	1.000
IV Drug Addiction	2 (1.4%)	2 (100%)	0 (0.0%)	1.000	2 (100%)	0 (0.0%)	0.514
IV Drug Therapy	14 (9.7%)	9 (64.3%)	5 (35.7%)	0.556	5 (35.7%)	9 (64.3%)	1.000
Previous Endocarditis	6 (4.1%)	4 (66.7%)	2 (33.3%)	1.000	4 (66.7%)	2 (33.3%)	1.000
No Risk Factor	6 (4.1%)	3 (50%)	3 (50.0%)	0.382	3 (50%)	3 (50.0%)	0.687

Bold values indicate statistically differences at $p < 0.005$.

pulmonary embolism (PE), 12.4% ($n=18$) had chordae rupture/flail mitral valve, 1.4% ($n=2$) had a fistula, 17.9% ($n=26$) suffered cardiogenic shock, and 1.4% ($n=2$) developed atrioventricular (AV) block as complications. No patient presented with coronary embolism. Table 7 presents the in-hospital and one-year mortality rates associated with the complications. CHF, central nervous system embolism, chordae rupture/flail mitral valve, and cardiogenic shock were statistically significant ($p<0.05$). No statistically significant difference was found between other complications and in-hospital or one-year mortality ($p>0.05$).

In the univariable and multivariable regression analysis performed to identify in-hospital mortality, NYHA was found to be an independent predictor (Table 8). In the univariable regression analysis performed to predict one-year mortality, only age was found to be associated with mortality (Table 9).

Table 3. Presenting symptoms and physical examination findings of patients with infective endocarditis.

Symptoms	Total ($n=145$)
Fever	138 (95.2%)
Fatigue	110 (75.9%)
Shortness of Breath	99 (68.3%)
Cough	74 (51.0%)
Loss of Appetite	62 (42.8%)
Chest Pain	47 (32.4%)
Arthralgia	46 (31.7%)
Weight Loss	33 (22.8%)
Headache	28 (19.3%)
Physical examination findings	
Murmur	64 (44.1%)
Hepatomegaly	50 (34.5%)
Splenomegaly	43 (29.7%)
Skin Rash (Osler/Janeway/Petechiae)	19 (13.1%)
Roth Spot	2 (1.4%)

Discussion

Our study has demonstrated that despite advances in treatment methods and medications, mortality rates in infective endocarditis (IE) remain high, underscoring the effectiveness of combined therapy. In our sample, the mean age of patients was 53. Studies conducted in developed countries have reported the mean age of IE patients as >60 years [5,7]. Recent studies in Turkey, however, have found a mean age of 45–51 years

Table 5. Pathogenic microorganisms isolated from blood cultures of patients with infective endocarditis.

Microorganism name	*n* (%)
Staphylococci	41.3%
• *Staphylococcus aureus*	42 (28.9%)
• Coagulase-negative staphylococcus	18 (12.4%)
Streptococci	12.4%
• *Streptococcus viridans*	4 (2.7%)
• *Streptococcus bovis*	2 (1.4%)
• *Streptococcus* spp.	11 (7.6%)
• *Abiotrophia defectiva*	1 (0.7%)
Enterococci	11.7%
• *Enterococcus faecalis*	11 (7.5%)
• *Enterococcus faecium*	2 (1.4%)
• *Enterococcus* spp.	3 (2.1%)
Brucella melitensis	1 (0.7%)
Coagulase-negative gram-negative bacilli	5.5%
• *Pseudomonas aeruginosa*	2 (1.4%)
• *Stenotrophomonas maltophilia*	1 (0.7%)
• *Acinetobacter*	5 (3.4%)
Candida spp.	2 (1.4%)
Other fungal agents	1 (0.7%)
Enterobacteriaceae species	5.6%
• *E. coli*	4 (2.8%)
• *Klepsiella pnömonia*	2 (1.4%)
• *Serratia marcescens*	2 (1.4%)
Others	3 (2.1%)
Culture negative	28 (19.3%)
Total	145 (100%)

Table 4. The association of laboratory parameters with in-hospital and one-year mortality in patients with infective endocarditis.

Laboratory parameters	In-hospital mortality	Survive	*P*	One-year mortality	Survive	*P*
Hemoglobin, g/dL (HGB)	10.3 ± 2.0	10.8 ± 2.1	0.262	10.4 ± 2.0	10.9 ± 2.2	0.175
White Blood Cell (WBC),10^3 /uL	11.8 (10.8 –12.9)	6.8 (5.3–7.5)	**0.026**	10.85 (2.4–38.7)	9.45 (1.9–44.4)	**0.023**
Neutrophil Percentage, %	83.4 (77.1 –89.7)	65.2 (48.8–81.6)	**<0.001**	83.1 (38.9–95)	79.25 (48.8–95.5)	**0.001**
Platelet (PLT), 10^3/uL	193.6 ± 109.5	239.5 ± 113.7	**0.024**	205.8 ± 106.7	238.2 ± 117.7	0.087
Creatinine (CR), mg/dL	1.2 (0.8–1.6)	0.9 (0.8–1.2)	**<0.001**	1.6 (0.7–7.6)	0.9 (0.4–10.4)	**<0.001**
Troponin, ng/mL	0.17 (0.02 –0.33)	0 (0–0.7)	**<0.001**	0.1 (0– 20)	0.05 (0–9.9)	**<0.001**
CK-MB, ng/mL	0.9 (0.4–1.5)	0.26 (0.20–0.33)	**<0.001**	1.9 (0–31.4)	0.98 (0–18.5)	**<0.001**
Total protein, gr/dL	6.5 (5.7–7.3)	7.5 (6.4–7.7)	**0.035**	6.1 (4.5–9)	6.65 (4.4–8.4)	**0.030**
Albumin, gr/dL	2.9 (2.6–4.1)	3.5 (2.6–4.5)	0.103	3 (2–4.6)	3.3 (2.2–4.7)	0.141
Total Cholesterol, mg/dL	157.6 ± 46.3	149.4 ± 44.4	0.363	156.9 ± 47.3	148.6 ± 43.5	0.322
LDL Cholesterol, mg/dL	99.1 ± 37.3	92.4 ± 34.9	0.359	98.2 ± 38.8	92 ± 33.6	0.356
*D-dimer, mg/L	6918 (5830–8006)	2532 (1490–7140)	0.447	1041 (4.5–8006)	2011 (4–7140)	0.600
*Procalcitonin, ng/mL	0.8 (0.35–1.26)	0.1 (0.04–0.38)	0.077	1.3 (0.04–100)	0.42 (0.02–100)	0.255
Erythrocyte Sedimentation Rate (ESR), mm/h	64.3 ± 31.3	62.0 ± 29.9	0.677	63.5 ± 32	62.2 ± 29.3	0.799
C-reactive protein (CRP), mg/L	65 (17–106)	61 (3–83)	**0.008**	93.3 (1–362)	56.2 (3–345)	0.095
Rheumatoid Factor (RF), IU/mL	9.95 (9.9–10)	10 (9.9–10.4)	0.139	10 (8.1–25.3)	10.3 (8–941)	0.135

Normally distributed data were presented as mean ± standard deviation, while non-normally distributed data were presented as median (minimum-maximum). Bold values indicate statistically differences at $p < 0.005$.
*The number of patients tested for these laboratory values is low.

among IE patients, similar to our findings [8,9]. In younger IE patients, rheumatic heart disease is a major risk factor. A study involving 1300 patients in Turkey identified rheumatic heart disease prevalence at 46% among heart disease aetiologies [10], while in developed countries, its prevalence is below 10% [7]. The lower mean age of IE patients in our study compared to developed countries may be attributed to the higher incidence of rheumatic heart disease in Turkey. Therefore, IE risk should be considered in patients with rheumatic heart disease.

Studies have indicated that early surgical intervention combined with antibiotic therapy (combined therapy) significantly reduces in-hospital mortality but does not affect one-year mortality [11–13]. In a 2016 meta-analysis by Liang et al. involving 16 cohort studies and 8141 patients, combined therapy was associated with reduced mortality compared to medical therapy alone. Our results align with these findings, which may be due to the increased risk of embolism, cardiac dysfunction, valve damage, and potential multi-organ failure that may develop while awaiting the completion of antimicrobial therapy and subsequent surgery in IE patients [14].

In our study, increasing age was associated with higher in-hospital and one-year mortality, consistent with findings from Simsek et al. [11]. The higher mortality rates in older patients are likely due to co-morbidities, weakened immune responses, and increased frailty.

Fever, a modified Duke minor criterion, is the most common symptom and finding in IE patients. Simsek et al. reported fever as the most prevalent symptom at 94.4% [11], and our study similarly found fever in 95.2% of patients.

An increase in neutrophil count and neutrophil percentage has been linked to in-hospital mortality in numerous studies [15,16]. Our study observed an increase in in-hospital and one-year mortality with higher neutrophil percentages, similar to other studies. This elevation in neutrophil percentage is associated with widespread systemic infection and increased tissue damage [17–19]. Therefore, an elevated neutrophil percentage is indicative of the severity and extent of infection and correlates with increased in-hospital and one-year mortality in IE.

Patients with elevated creatinine levels in our study also showed higher in-hospital and one-year mortality rates, consistent with other research. Renal failure in IE is typically multifactorial, resulting from immunocomplex and vasculitic glomerulonephritis, antibiotic toxicity, and nephrotoxic contrast agents. Streptococcal infection is also an independent risk factor for renal dysfunction [20]. A range of immune processes, such as immune complex formation, hypocomplementemia, and complement deposition in the renal glomerular basement membrane, were observed in patients with

Table 6. Pathogenic microorganisms isolated from blood cultures of patients with prosthetic valve endocarditis.

Microorganisms isolated in prosthetic valve endocarditis	Early ($n=17$)	Late ($n=18$)	Total ($n=35$)
Staphylococcus aureus n (%)	6 (35.3%)	7 (38.9%)	13 (37.1%)
Coagulase-negative staphylococcus *n* (%)	2 (11.8%)	2 (11.1%)	4 (11.4%)
Pseudomonas aeruginosa n (%)	1 (5.9%)	0 (0.0%)	1 (2.9%)
Acinetobacter *n* (%)	3 (17.6%)	0 (0.0%)	3 (8.6%)
Candida spp. *n* (%)	1 (5.9%)	0 (0.0%)	1 (2.9%)
E. coli n (%)	0 (0.0%)	1 (5.6%)	1 (2.9%)
Others *n* (%)	1 (5.9%)	1 (5.6%)	2 (5.7%)
Culture negative *n* (%)	3 (17.6%)	7 (38.9%)	10 (28.6%)

Table 7. Complications arising in patients with infective endocarditis and their relationship with in-hospital and one-year mortality.

Complication	*n* (%)	Survive	In-hospital mortality	*P*	Survive	One-year mortality	*P*
Newly diagnosed congestive heart failure (CHF)n (%)	34 (23.4%)	13 (38.2%)	21 (61.8%)	**<0.001**	10 (29.4%)	24 (70.6%)	**<0.001**
Cardiogenic shock n (%)	26 (17.9%)	3 (11.5%)	23 (88.5%)	**<0.001**	2 (7.7%)	24 (92.3%)	**<0.001**
Central nervous system embolism n (%)	25 (17.2%)	7 (28%)	18 (72.0%)	**<0.001**	5 (20%)	20 (80.0%)	**<0.001**
Peripheral artery embolism/ Pulmonary embolism n (%)	19 (13.1%)	11 (57.9%)	8 (42.1%)	0.436	11 (57.9%)	8 (42.1%)	1.000
Chordae rüptüre/ flail mitral valve n (%)	18 (12.4%)	17 (94.6%)	1 (5.6%)	**0.023**	15 (83.3%)	3 (16.7%)	**0.050**
Splenic infarct n (%)	14 (9.6%)	9 (64.3%)	5 (35.7%)	0.767	9 (64.3%)	5 (35.7%)	0.910
Renal infarct n (%)	8 (5.5%)	4 (50%)	4 (50.0%)	0.264	4 (50%)	4 (50.0%)	0.716
Fistula n (%)	2 (1.4%)	0 (%)	2 (100.0%)	0.099	0 (0%)	2 (100.0%)	0.164
Atrioventricular (AV) block n (%)	2 (1.4%)	1 (50%)	1 (50.0%)	0.535	1 (50%)	1 (50.0%)	1.000
Coronary embolism n (%)	0	0 (0%)	0 (0.0%)	NA	0(%)	0 (0.0%)	NA

Bold values indicate statistically differences at $p < 0.005$.

Table 8. Regression analysis performed to predict in-hospital mortality.

	Univariable regression		Multivariable regression	
Variables	OR (95% CI)	*P*	OR (95% CI)	*P*
Age	1.040 (1.016–1.065)	0.001	1.012 (0.978–1.047)	0.481
CRP	1.005 (1.001–1.010)	0.017	1.000 (0.994–1.007)	0.968
NYHA	7.899 (3.589–17.385)	<0.001	4.119 (1.582–10.724)	0.004
Treatment (medical)	2.315 (1.128–4.753)	0.022	1.120 (0.388–3.236)	0.834
WBC	1.065 (1.002–1.032)	0.043	0.948 (0.825–1.091)	0.458
Neutrophil percentage	1.066 (1.021–1.114)	0.004	1.041 (0.975–1.112)	0.225
Platelets	0.996 (0.992–1.000)	0.026	0.998 (0.993–1.003)	0.476
Creatinine	1.207 (1.020–1.429)	0.029	1.191 (0.938–1.512)	0.151
CKMB	1.144 (1.032–1.268)	0.010	1.037 (0.922–1.167)	0.542

Abbreviations: OR, Odd ratio; CI, Confidence interval; CRP, C-Reactive Protein; NYHA, New York Heart Association; WBC, White Blood Cell; CKMB, Creatine Kinase-MB.

Table 9. Univariable regression analysis performed to predict one-year mortality.

Variables	OR (95% CI)	*P*
Age	1.047 (1.008–1.088)	0.018
CRP	0.996 (0.987–1.005)	0.393
NYHA	2.268 (0.792–6.500)	0.127
Treatment (medical)	0.561 (0.160–1.964)	0.366
WBC	1.013 (0.914–1.122)	0.806
Neutrophil percentage	0.999 (0.945–1.056)	0.972
Platelets	1.001 (0.996–1.006)	0.758
Creatinine	1.041 (0.794–1.366)	0.769
CKMB	0.961 (0.748–1.235)	0.755

Abbreviations: OR, Odd ratio; CI, Confidence interval; CRP, C-Reactive Protein; NYHA, New York Heart Association; WBC, White Blood Cell; CKMB, Creatine Kinase-MB.

elevated creatinine levels, which correlates with higher in-hospital and one-year mortality.

D-dimer and procalcitonin levels have been associated with in-hospital mortality in various studies [21,22]. As a fibrin degradation product, D-dimer is positively associated with pulmonary thromboembolism (PTE) and systemic emboli in IE patients [21]. Elevated D-dimer levels are also predictive of poor clinical outcomes in sepsis [23]. Similarly, higher procalcitonin levels are closely linked with severe infection and sepsis [22]. In patients with endocarditis, high levels of inflammatory biomarkers, particularly procalcitonin, on admission are associated with an increased risk of S. aureus infection and higher in-hospital mortality rates [24]. In our study, no statistical significance was found between D-dimer and procalcitonin levels and mortality, possibly due to the small sample size of patients with these measurements.

In our study, 48.3% of cases involved mitral valve involvement, 28.3% aortic valve involvement, and 7.6% both valves. A similar study by Tugcu et al. reported 45% mitral valve involvement, 36.8% aortic valve involvement, and 11.8% both valves [25].

Blood culture is a critical laboratory test for diagnosing IE and guiding treatment strategy. Persistent, low-grade bacteraemia is typically observed, with positive blood cultures in approximately two-thirds of cases [26]. In our study, the causative microorganism was identified in 80.6% of cases, while 19% were culture-negative. Factors affecting blood culture results include prior antibiotic use, insufficient blood sampling, and extended incubation times for some microorganisms [27]. Prior antibiotic use, reported in about 40% of patients, may have contributed to the culture-negative cases. A recent study by Simsek et al. found culture positivity rates of 77.8%, similar to our results [11]. Staphylococci, streptococci, and enterococci are the most common IE pathogens [28,29], with staphylococci reported as the leading cause in most studies [30]. In our study, staphylococci (41.4%) were the most frequent causative agent, followed by streptococci (12.5%), which may be linked to the increasing frequency of nosocomial and device-related IE due to invasive procedures.

Major IE complications include heart failure, embolic events, renal failure, cerebral events, and paravalvular abscesses. A study by Sucu et al. in Turkey identified heart failure as the most common complication at 31.9% [9]. Similarly, in our study, heart failure was the most frequent complication, observed in 23.4% of cases. Heart failure, often due to increased valve regurgitation or systemic infection, is associated with higher in-hospital mortality in IE. In our study, patients with endocarditis-related heart failure and reduced ejection fraction (EF%) had higher in-hospital and one-year mortality rates, consistent with other studies.

Severe valve regurgitation and prosthetic valve dysfunction (paravalvular leakage, dehiscence) are poor prognostic factors in IE. Early surgical intervention in severe valve regurgitation cases has been shown to reduce in-hospital mortality rates [31]. In our study, severe valve regurgitation was observed in 42.8% of patients, who were promptly directed towards early surgical intervention per current guidelines. Early surgical treatment contributed to lower in-hospital and one-year mortality rates in this patient group.

In our study, NYHA was identified as an independent predictor of in-hospital mortality. There are studies indicating that NYHA affects mortality in patients with infective endocarditis [32]. Our finding is consistent with other studies.

Our study has some limitations. The demographic characteristics, systemic diseases, predisposing conditions, symptoms at hospital admission, physical examination findings, echocardiographic and laboratory data, complications that developed in the patients, microorganisms cultured from blood cultures, and the relationship of these parameters with in-hospital and one-year mortality were retrospectively investigated in the 145 patients included in our study. Due to missing records during the study, some data from certain patients could not be accessed. As a result of these issues, we encountered difficulties in evaluating some data that were found to be significant in prospective studies. The retrospective nature of our study has been the most prominent issue. Findings such as the Charlson Comorbidity Index, HIV infection, intracardiac device endocarditis (IE), number of intracardiac device extractions, time between IE diagnosis and surgery, presence of Peripherally Inserted Central Catheter (PICC) or Central Venous Catheter (CVC), and details of the antibiotic therapy could not be obtained in our study. The lack of antibiotic therapy information, in particular, hindered the comparison of drug-based medical treatments. For example, daptomycin-based, aminoglycoside-sparing combination therapy appears to be promising in the treatment of streptococcal endocarditis due to its similar efficacy to standard treatment and significantly reduced incidence of acute kidney injury [33]. In our study, the absence of antibiotic data prevented us from identifying which antibiotic therapy was effective. Additionally, the information on lead extraction in our study is incomplete. In one study, single-procedure reimplantation combined with active antibiofilm therapy has been shown to be a feasible and effective therapeutic option for cardiovascular implantable electronic device-dependent, frail patients [34]. The lack of information in our study prevented us from demonstrating the superiority of lead extraction and contralateral implantation over medical treatment.

Conclusion

Our study stands out with its extensive dataset. Despite advances in treatment, IE mortality rates remain high, and changes in bacterial causative agents could affect treatment strategies until culture results are available. Combined therapy is effective, and completing antibiotic therapy should not be delayed.

Disclosure statement

The authors report there are no competing interests to declare.

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