



Impact of the COVID-19 Pandemic on Surgical Outcomes of Native and Prosthetic Valve Endocarditis: A Retrospective Subanalysis

Jang-Sun Lee¹ , Virna L. Sales² , Annette Moter³ , Walter Eichinger⁴

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Corresponding Author(s):

Jang-Sun Lee

Department of Cardiac Surgery
Kerckhoff Heart Center, Bad Nauheim
Benckestraße 2-8, D-61231
Bad Nauheim, Germany. Email:
j.lee@kerckhoff-klinik.de

Abstract: Background and aim of the study: During the COVID-19 pandemic in Bavaria, surgical ICU resources were reallocated, and elective procedures were postponed, impacting the management of infective endocarditis (IE). This study evaluated early surgical outcomes in patients with native valve endocarditis (NVE) and prosthetic valve endocarditis (PVE) before and during the pandemic. Methods: We retrospectively analyzed 94 patients (66% male) treated pre-pandemic (August 2018–March 21, 2020) and 84 patients (76% male) treated during the pandemic (March 22, 2020–November 2021). NVE cases comprised 78% pre-pandemic and 68% during the pandemic, while PVE cases increased from 22% to 32%. Preoperative characteristics, surgical urgency, postoperative complications, and in-hospital mortality were assessed. Explanted valves underwent histological, microbiological, and molecular analyses, including fluorescence in situ hybridization (FISH) with 16S rRNA PCR/sequencing. Results: During the pandemic, preoperative NYHA class III-IV increased significantly (NVE: 49% to 74%; PVE: 29% to 70%; all $p < 0.05$). Urgent surgeries became more frequent (NVE: 27% to 49%, $p = 0.017$; PVE: 20% to 52%, $p = 0.034$), and the interval from diagnosis to surgery in PVE patients was prolonged (11 vs. 16 days, $p = 0.038$). More complex procedures, including double-valve surgeries, were required (9.5% vs. 37%, $p = 0.022$). Postoperatively, rethoracotomy rates increased in NVE cases (OR: 9.106, $p < 0.001$), while odds ratios for stroke, sepsis, and prolonged ICU stay in PVE patients trended higher but lacked statistical significance. Conclusion: The pandemic led to diagnostic delays, worsened preoperative conditions, and increased surgical urgency in IE patients, underscoring the need for resilient healthcare strategies to maintain timely surgical care during future crises.

Keywords: Endocarditis, Prosthetic Valve Endocarditis, Re-do Surgery, COVID-19, FISH

1. Introduction

The COVID-19 pandemic necessitated the implementation of strict lockdown measures worldwide, including the temporary suspension of non-elective surgeries to prioritize care for patients with COVID-19. Resources were reallocated, with intensive care unit (ICU) beds, ventilators, and ECMO devices redirected to meet the surge in demand. Our institution, a major municipal tertiary hospital in Munich, adhered to directives from the Bavarian government, focusing on the care of critically ill COVID-19 patients. While these measures were crucial, they significantly impacted surgical services, particularly cardiac surgery, which relies heavily on ICU resources and timely intervention for patients with deteriorating conditions (Ad et al., 2021; Hunger et al., 2022; J.-S. Lee et al., 2024).

Native valve endocarditis (NVE) is a life-threatening condition with high rates of in-hospital and surgical mortality. Early diagnosis, appropriate antibiotic therapy, and the optimal timing of surgery remain challenging despite advancements in antibiotic stewardship, actual guidelines, and the collaborative efforts of Heart Teams (Baddour et al., 2015; Delahaye et al., 2007; Delgado et al., 2023). Conversely, prosthetic valve endocarditis (PVE), with an annual incidence of 0.3–1.2% per patient, presents diagnostic difficulties due to non-specific symptoms and imaging artifacts, particularly on transthoracic echocardiography (Ivanovic et al., 2019; Lalani et al., 2013).

This study aimed to analyze the preoperative and postoperative outcomes of patients with NVE and PVE before and during the COVID-19 pandemic, highlighting the impact of pandemic-related healthcare disruptions on these high-risk surgical cohorts.

¹ Department of Cardiac Surgery, Munich Hospital Bogenhausen, Munich, Germany, Technical University Munich, Munich, Germany

¹ Department of Cardiac Surgery, Kerckhoff Clinic, Bad Nauheim, Germany, University Hospital of Giessen, Giessen, Germany

² Department of Cardiac Surgery, Munich Hospital Bogenhausen, Munich, Germany, Technical University Munich, Munich, Germany

² Department of Cardiology, Angiology, and Medical Intensive Care, Cardiovascular Center of Hersfeld-Rothenburg, Germany

³ Institute of Medical Microbiology and Epidemiology of Infectious Disease, University Hospital of Leipzig, Leipzig, Germany

³ Biofilmcenter at the German Heart Institute Berlin, University of Charité, Berlin, Germany

³ MoKi Analytics GmbH, Berlin, Germany

³ Moter Diagnostics, Berlin, Germany

⁴ Department of Cardiac Surgery, Munich Hospital Bogenhausen, Munich, Germany, Technical University Munich, Munich, Germany

2. Patients and methods

This retrospective subanalysis involved 178 adult patients who underwent cardiac surgery and received postoperative antibiotic therapy for infective endocarditis (IE) between August 2018 and November 2021. The patients were categorized into two main cohorts: native valve endocarditis (NVE, $n = 130$) and prosthetic valve endocarditis (PVE, $n = 48$). Each cohort was further subdivided based on the period of surgery: pre-pandemic (August 2018 to March 21, 2020; NVE: 73 patients, PVE: 21 patients) and pandemic (March 22, 2020 to November 2021; NVE: 57 patients, PVE: 27 patients). All surgical interventions were performed following confirmation of a negative COVID-19 test.

Data for this study were extracted from the Cardiac Surgery Outcomes Registry, a dataset approved by the Institutional Review Board. This registry captures comprehensive preoperative, perioperative, and early postoperative outcomes and adheres to the standards of the Institute for Quality Assurance and Transparency in Health Care (<https://iqtig.org>). We also analyzed the time intervals between symptom onset and diagnosis, as well as from diagnosis to surgery, for all cohorts.

Comorbidities were classified according to the Society of Thoracic Surgeons (STS) National Database criteria (www.sts.org). These included the New York Heart Association (NYHA) functional classification and the Canadian Cardiovascular Society (CCS) angina grading system. Cardiac surgeries were performed with cardiopulmonary bypass (CPB), utilizing crystalloid cardioplegia for myocardial protection.

The diagnosis of postoperative IE was established using the modified Duke criteria and intraoperative findings. Intraoperative assessments included histopathological and microbiological evaluations, alongside fluorescence in situ hybridization (FISHseq) analysis. The FISHseq procedure was selectively employed based on preoperative and intraoperative findings and involved the resection of suspicious native or prosthetic valve tissue. Tissue samples were prepared and sent to MoKi Analytics GmbH and Moter Diagnostics in Berlin for FISHseq analysis. This methodology, as described by Eichinger et al., is recognized as a definitive pathological criterion under the 2023 Duke–International Society for Cardiovascular Infectious Diseases (ISCVID) guidelines (Eichinger et al., 2019). Patients who did not meet Duke criteria or showed no intraoperative evidence of IE were excluded from the analysis (Figure 1).

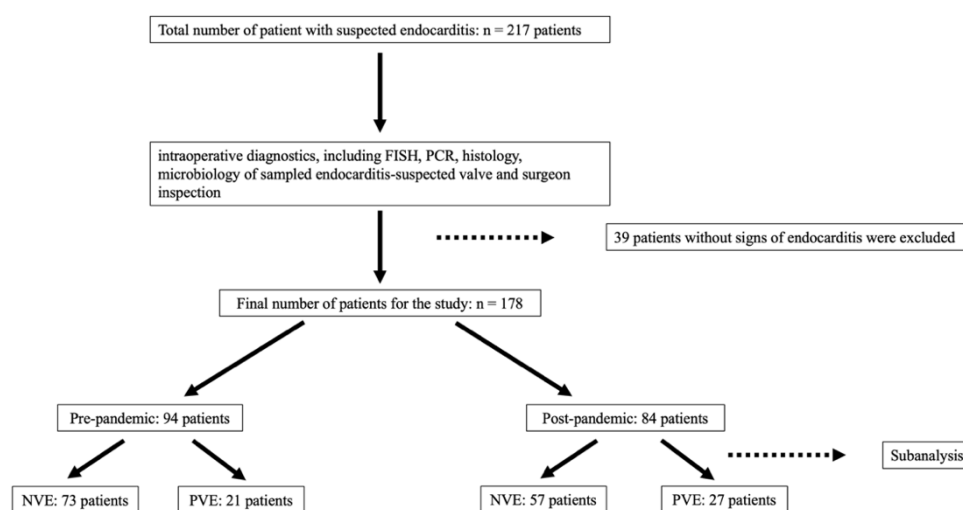


Figure 1: Flowchart of study design. A diagram illustrating the study's methodology, patient inclusion criteria, and division into pre- and post-pandemic cohorts.

Postoperative complications were evaluated, including re-thoracotomy for bleeding, tracheotomy necessitated by prolonged mechanical ventilation, delirium, acute renal failure requiring dialysis, stroke, sepsis, and in-hospital mortality. Patient survival was confirmed through communication with primary care physicians or rehabilitation centers.

3. Statistical Analysis

Demographic characteristics, preoperative cardiac status, surgical details, pathogens, IE diagnostics, and in-hospital outcomes were compared between the subgroups undergoing elective or urgent/emergent surgeries. Categorical variables were expressed as frequencies and percentages, while continuous variables were summarized as means $\pm$ standard deviation (SD). Group comparisons employed t-tests for normally distributed variables and Fisher's exact test for categorical data. Odds ratios (OR) with 95% confidence intervals were calculated. A p -value < 0.05 was considered statistically significant. Analyses were performed using SPSS (Version 29.0.1.0, IBM, Armonk, NY, USA), and visualizations, including boxplots, were created using R (Version 2023.06.1+524).

4. Results

4.1 Patient Characteristics: NVE

A total of 130 patients with native valve endocarditis (NVE) were included in this retrospective study. The gender distribution between the pre-pandemic and post-pandemic cohorts showed no significant difference (male: 51/73 vs. 43/75, $p = 0.556$), and the mean age was comparable (62.9 ± 12.9 vs. 64.3 ± 15.5 years, $p = 0.341$). However, the post-pandemic cohort exhibited a higher prevalence of NYHA functional class IV (13% vs. 18%, $p = 0.018$), alongside an increase in urgent surgeries (27% vs. 49%) and a decrease in elective surgeries (64% vs. 46%; all $p < 0.05$).

The time interval from symptom onset to diagnosis was longer in the post-pandemic cohort compared to the pre-pandemic cohort (9 days vs. 15 days), although this difference was not statistically significant ($p = 0.884$) (Figure 2.1). Other comorbidities, including left ventricular ejection fraction (LVEF), did not differ significantly between cohorts (Table 1). Coronary artery disease and Canadian Cardiovascular Society (CCS) angina classification, which influence LVEF, also showed no significant differences.

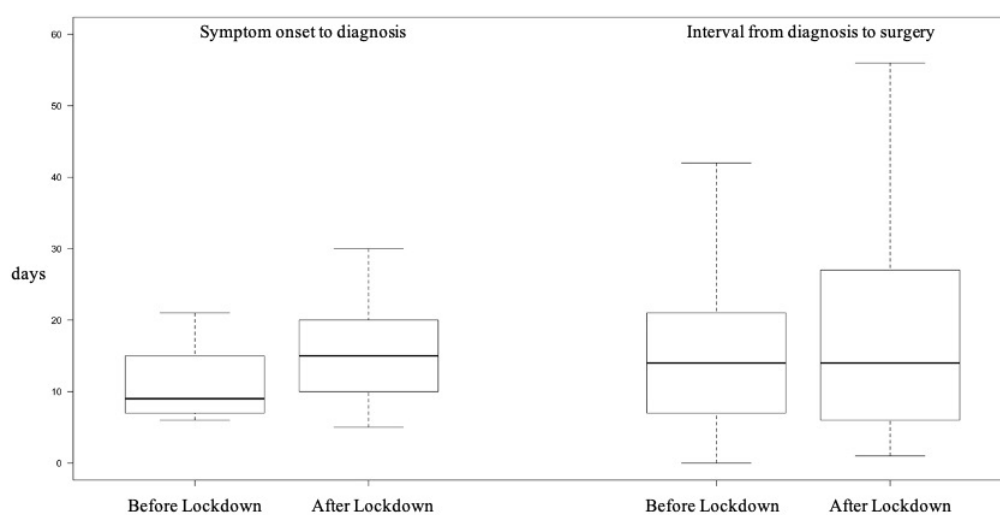


Figure 2: Time intervals from symptom onset to diagnosis and diagnosis to surgery in the NVE Cohort. Boxplots showing the time delays for the NVE cohort, comparing pre- and post-pandemic groups.

Table 1: Demographic and preoperative clinical characteristics of the NVE cohort (N=130).

	8/18 - 3/21/20 Before Lockdown Nr./Mean (%)	3/22/20 - 11/21 After Lockdown Nr./Mean (%)	P-value
Cohort	73	57	
Age	62.9 ± 12.9	64.3 ± 15.5	0.341
Male	51 (70)	43 (75)	0.556
BMI	26.4 ± 6.5	25.9 ± 5	0.964
Creatinine (mg/dl)	1.3 ± 1	1.3 ± 0.8	0.785
Sinus rhythm	62 (85)	46 (81)	0.639
LV EF < 50%	23 (32)	6 (11)	0.005
COPD	9 (12)	8 (14)	0.798
Arterial hypertension	29 (40)	26 (46)	0.592
Diabetes mellitus			0.371
No therapy	2 (3)	5 (9)	0.239
Oral medication	6 (8)	3 (5)	0.731
Insulin therapy	6 (8)	3 (5)	0.731
Hyperlipidemia	17 (23)	16 (28)	0.549
Nicotine abuse	11 (15)	7 (12)	0.799
Alcohol abuse	2 (3)	0	0.504
Family disposition	0	2 (4)	0.190
Coronary Artery Disease	25 (44)	27 (47)	0.151
CCS			0.915
I	67 (93)	52 (90)	1.000
II	4 (5)	2 (4)	0.695
III	1 (1)	1 (2)	1.000
IV	1 (1)	2 (4)	0.581
NYHA			0.012

I	16 (22)	4 (7)	0.026
II	21 (29)	11 (19)	0.227
III	26 (36)	24 (42)	0.473
IV	10 (13)	18 (32)	0.018
Rankin			0.262
No significant disability	11 (15)	12 (21)	0.488
Slight disability	0	2 (4)	0.190
Moderate disability	3 (4)	1 (2)	1.000
Modified Duke			0.122
Definite	53 (73)	49 (86)	0.086
Possible	14 (19)	4 (7)	0.071
rejected	6 (8)	4 (7)	1.000
IE valve position			
Aortic valve	41 (56.2)	22 (38.6)	0.053
.....Mitral valve	29 (39.7)	22 (38.6)	1.000
Tricuspid valve	1 (1.4)	3 (5.3)	0.319
Multiple locations	2 (2.7)	9 (15.8)	0.011
Abscess in TEE	8 (11)	8 (14)	0.603
Type of surgery			0.039
Elective	47 (64)	26 (46)	0.035
Urgent	20 (27)	28 (49)	0.017
Emergent	6 (9)	3 (5)	0.731
Symptom onset to diagnosis (days)	9(6, 21)	15 (5, 30)	0.884
The interval from diagnosis to surgery (days)	14 (0, 42)	14 (1, 56)	0.834
Referral source	54	41	0.844
Internal (In-house)	19 (26)	16 (28.1)	
External (Outside referring clinic)	54 (74)	41 (71.9)	

BMI: Body Mass Index, LV EF: Left Ventricular Ejection Fraction, COPD: Chronic Obstructive Pulmonary Disease, CCS: Canadian Cardiovascular Society, NYHA: New York Heart Association, IE: Infective Endocarditis, TEE: Transesophageal Echocardiography

4.2. Patient Characteristics: PVE

The pre-pandemic prosthetic valve endocarditis (PVE) cohort was older than the post-pandemic cohort (61 ± 12.9 vs. 70 ± 9.9 years, $p = 0.019$). Similar to the NVE group, the post-pandemic PVE cohort showed a higher prevalence of advanced NYHA functional class III (24% vs. 66%, $p = 0.004$), which corresponded with an increase in urgent surgeries (20% vs. 52%, $p = 0.034$).

While the time from symptom onset to diagnosis was longer in the post-pandemic cohort, this was not statistically significant (7 days vs. 12 days, $p = 0.330$) (Figure 2). However, the interval from diagnosis to surgery was significantly prolonged in the post-pandemic cohort (11 days vs. 16 days, $p = 0.038$). Other comorbidities showed no significant differences and are detailed in Table 2.

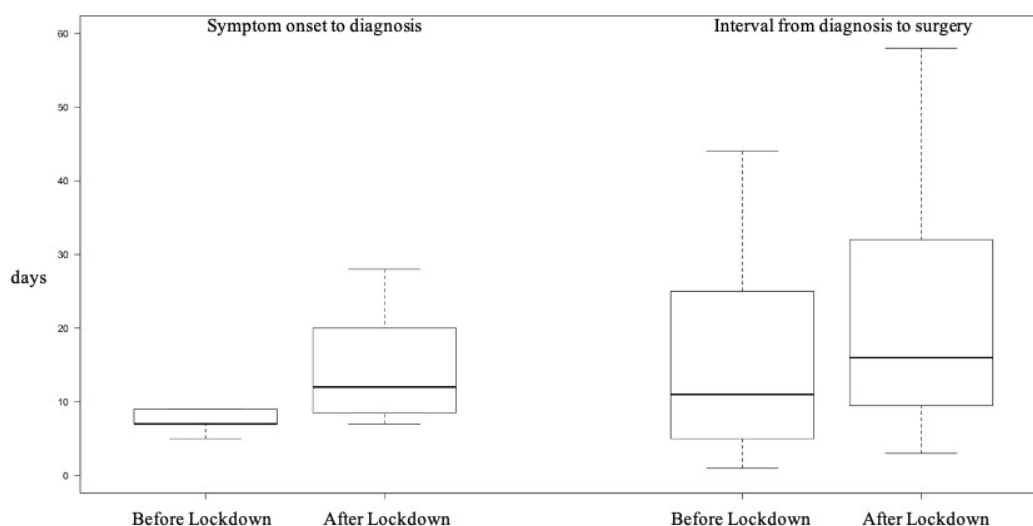


Figure 3: Time intervals from symptom onset to diagnosis and diagnosis to surgery in the PVE Cohort.

Table 2: Demographic and preoperative clinical characteristics of the PVE cohort (N=48).

	8/18 - 3/21/20 Before Lockdown Nr./Mean (%)	3/22/20 - 11/21 After Lockdown Nr./Mean (%)	p-value
Cohort	21	27	
Age	61 ± 12.9	70 ± 9.9	0.019
Male	11 (52)	21 (78)	0.423
BMI	25.1 ± 5.1	27.1 ± 6.3	0.331
Creatinine mg/dl	1.5 ± 1.1	1.4 ± 0.8	0.900
Sinus rhythm	20 (95)	18 (67)	0.029
LV EF < 50%	5 (24)	2 (8)	0.215
COPD	3 (14)	3 (11)	1.000
Arterial Hypertension	7 (33)	13 (48)	0.382
Diabetes mellitus			0.344
No therapy	1 (5)	1 (4)	1.000
Oral medication	0	3 (11)	0.246
Insulin therapy	1 (5)	3 (11)	0.621
Hyperlipidemia	4 (20)	5 (19)	1.000
Nicotine abuse	2 (10)	4 (15)	0.683
Alcohol abuse	0	1 (4)	1.000
Family disposition	2 (10)	2 (8)	1.000
Coronary Artery Disease	3 (14)	14 (52)	0.005
CCS			0.651
I	20 (95.2)	25 (92.6)	1.000
II	1 (4.8)	1 (3.7)	1.000
III	0	0	
IV	0	1 (3.7)	1.000
NYHA			0.019
I	5 (24)	1 (4)	0.073
II	10 (47)	7 (26)	0.140
III	5 (24)	18 (66)	0.004
IV	1 (5)	1 (4)	1.000
Rankin			0.442
No significant disability	3 (14)	2 (7)	0.641
Slight disability	0	1 (4)	1.000
Moderate disability	1 (5)	0	0.438
Modified Duke			0.160
Definite	11 (53)	20 (74)	0.140
Possible	7 (33)	3 (11)	0.081
rejected	3 (14)	4 (15)	1.000
IE valve position			
Aortic valve	17 (81)	16 (59.3)	0.129
Mitral valve	4 (19)	7 (25.9)	0.733
Tricuspid valve	0	0	
Multiple locations	0	4 (14.8)	0.121
Abscess in TEE	6 (40)	9 (60)	0.764
Type of surgery			0.065
Elective	16 (76)	12 (44)	0.040
Urgent	4 (20)	14 (52)	0.034
Emergent	1 (4)	1 (4)	1.000
Symptom onset to diagnosis (days)	7 (5, 9)	12 (7, 28)	0.330
The interval from diagnosis to surgery (days)	11 (1, 44)	16 (3, 58)	0.038
Referral source			0.750
Internal (In-house)	7 (33.3)	7 (25.9)	
External (Outside referring clinic)	14 (66.7)	20 (74.1)	

BMI: Body Mass Index, LV EF: Left Ventricular Ejection Fraction, COPD: Chronic Obstructive Pulmonary Disease, CCS: Canadian Cardiovascular Society, NYHA: New York Heart Association, IE: Infective Endocarditis, TEE: Transesophageal Echocardiography

4.3. Type of Cardiac Surgery

A significant decline in the number of IE surgeries was observed in both cohorts after the pandemic. The post-pandemic PVE cohort showed an increase in double-valve procedures compared to the pre-pandemic cohort (9.5% vs. 37%, $p = 0.022$). Cross-clamp times were not significantly different across groups (NVE pre-pandemic vs. post-pandemic: 87.0 ± 33.5 vs. 94.0 ± 44.6 minutes, $p = 0.486$; PVE pre-pandemic vs. post-pandemic: 105.8 ± 48.5 vs. 121.3 ± 50.7 minutes, $p = 0.208$) (Table 3 and 4).

Table 3: Types of surgical procedures performed in the NVE cohort.

	Before Lockdown Nr. (%)	After Lockdown Nr. (%)	p-value
Cross-clamp Time (min)	87.0 ± 33.5	94 ± 44.6	0.486
Single-valve procedure			
Isolated AV	37 (50.7)	19 (33.3)	0.052
Isolated MV	24 (32.9)	19 (33.3)	1.000
Isolated TV	1 (1.3)	3 (5.3)	0.319
Double-valve procedure	11 (15.1)	14 (26.4)	0.186
Triple-valve procedure	0	2 (3.7)	0.190
Total	73	57	
Concomitant CABG	15 (20.5)	19 (33.3)	0.112
ECMO use	2 (2.7)	1 (1.8)	1.000

AV: Aortic Valve, MV: Mitral Valve, TV: Tricuspid Valve, CABG: Coronary Artery Bypass Grafting, ECMO: Extracorporeal Membrane Oxygenation

Table 4: Types of surgical procedures performed in the PVE cohort.

	Before Lockdown Nr. (%)	After Lockdown Nr. (%)	p-value
Cross-clamp Time (min)	105.8 ± 48.5	121.3 ± 50.7	0.208
Single-valve procedure			
Isolated AV	13 (61.9)	10 (37.0)	0.244
Isolated MV	6 (28.6)	5 (18.5)	0.319
Isolated TV	0	2 (7.5)	
Double-valve procedure	2 (9.5)	10 (37.0)	0.022
Triple-valve procedure	0	2 (7.5)	1.000
Total	21	27	
Concomitant CABG	2 (9.5)	6 (22.2)	0.437
ECMO use	0	2 (7.5)	0.497

AV: Aortic Valve, MV: Mitral Valve, TV: Tricuspid Valve, CABG: Coronary Artery Bypass Grafting, ECMO: Extracorporeal Membrane Oxygenation

4.4. Spectrum of Pathogens in Preoperative Blood Cultures

Across all cohorts, the most commonly identified pathogens were Staphylococci and Streptococci species, followed by Enterococcus faecalis. Detailed pathogen distributions are presented in Tables 4 and 5.

Table 5: Pathogen identified in the NVE cohort. Distribution of pathogens from preoperative blood cultures, focusing on Staphylococci, Streptococci, Enterococcus faecalis, and other less common pathogens, including Abiotrophia defectiva, Actinomyces naeslundii, Aggregatibacter aphrophilus, Bartonella quintana, Gemella morbillorum, Granulicatella adhaerens, Neisseria elongate, Propionibacterium acnes.

	Before Lockdown Nr. (%)	After Lockdown Nr. (%)	p value
Group of Germ			0.220
Staphylococci Group	23 (31.5)	17 (29.8)	
Streptococci Group	20 (27.4)	20 (35.1)	
Enterococcus faecalis	5 (6.8)	9 (15.8)	
ETC	6 (8.2)	2 (3.5)	
No germs	19 (26)	9 (15.8)	
Total	73	57	

Table 6: Pathogens Identified in the PVE Cohort.

	Before Lockdown Nr. (%)	After Lockdown Nr. (%)	p-value
Group of Germ			0.574
Staphylococci Group	5 (23.8)	8 (29.6)	
Streptococci Group	4 (19)	8 (29.6)	
Enterococcus faecalis	1 (4.8)	3 (11.1)	
ETC	2 (9.5)	1 (3.7)	
No germs	9 (42.9)	7 (25.9)	
Total	21	27	

4.3. Surgical Outcomes

No significant differences in in-hospital mortality were observed across cohorts (NVE: $p = 0.388$; PVE: $p = 0.152$). However, the post-pandemic NVE cohort showed a significantly higher rate of re-thoracotomy due to postoperative bleeding (OR: 9.106 [2.502–33.144], $p < 0.001$).

For the post-pandemic PVE cohort, all postoperative outcomes showed an increased odds ratio (OR): in-hospital mortality (4.000), stroke (1.000), re-thoracotomy (1.364), sepsis (1.120), delirium (1.188), hemofiltration (3.400), and tracheotomy (1.600). This resulted in a longer intensive care unit (ICU) stay (median 4.3 days vs. 8.1 days), although this was not statistically significant ($p = 0.182$). Detailed results are available in Tables 6 and 7, and Figures 3 and 4.

Table 7: Postoperative outcomes in the NVE cohort. ICU: Intensive Care Unit

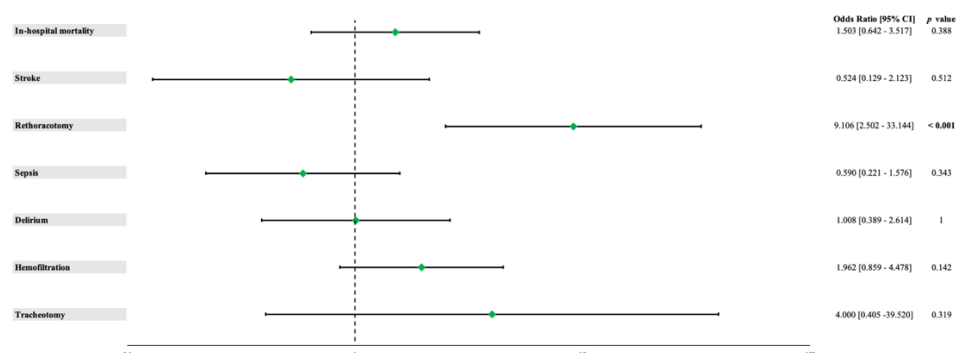
	Before/ Lockdown Nr. (%)	After Lockdown Nr. (%)	p-value
In-hospital mortality	13 (17.8)	14 (24.6)	0.388
Stroke	7 (9.6)	3 (5.3)	0.512
Rethoracotomy	3 (4.1)	16 (28.1)	<0.001
Infection or sepsis	14 (19.2)	7 (12.3)	0.343
Delirium	8 (11.0)	6 (10.5)	1.000
Hemofiltration	13 (17.8)	17 (29.8)	0.142
Tracheostomy	1 (1.4)	3 (5.3)	0.319
Length of ICU stay (days)	5.4 ± 8.8	5.4 ± 13.2	0.991

ICU: Intensive Care Unit

Table 8: Postoperative Outcomes in the PVE cohort.

	Before/ Lockdown Nr. (%)	After Lockdown Nr. (%)	p-value
In-hospital mortality	2 (9.5)	8 (29.6)	0.152
Stroke	1 (4.8)	2 (7.4)	1.000
Rethoracotomy	3 (14.3)	5 (18.5)	1.000
Infection or sepsis	5 (23.8)	7 (25.9)	1.000
Delirium	2 (9.5)	3 (11.1)	1.000
Hemofiltration	4 (19.0)	12 (44.4)	0.075
Tracheostomy	1 (4.8)	2 (7.4)	1.000
Length of ICU stay (days)	4.3 ± 7.4	8.1 ± 10.9	0.182

ICU: Intensive Care Unit

**Figure 4:** Forest plot of postoperative outcomes in the NVE Cohort. Odds ratios and confidence intervals for postoperative complications in the NVE cohort, contrasting pre- and post-pandemic periods.

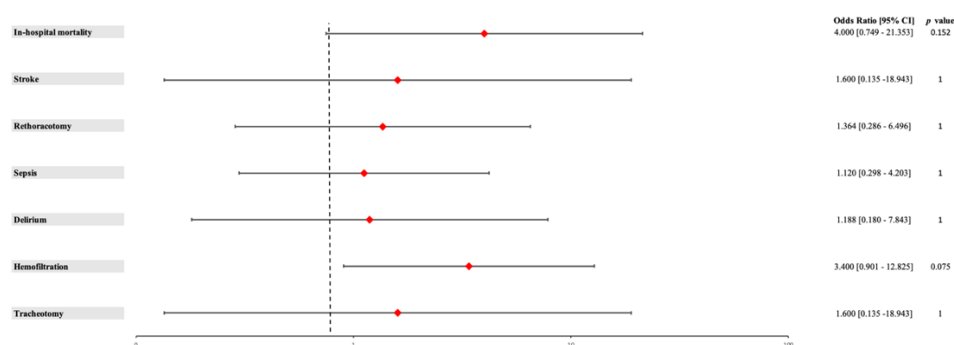


Figure 5: Forest Plot of Postoperative Outcomes in the PVE Cohort. A visual summary of postoperative complication odds in the PVE cohort, highlighting pandemic-related impacts.

5. Discussion

The COVID-19 pandemic significantly disrupted healthcare systems worldwide, including the management of patients with infective endocarditis (IE). Diagnostic efforts during the pandemic were heavily focused on COVID-19, often at the expense of other critical conditions. Triage protocols for intensive care unit (ICU) resources and ventilator availability further impacted surgical departments, delaying necessary interventions. Despite the publication of IE diagnostic guidelines during the pandemic, our findings align with global reports showing worse outcomes for IE patients during this period (Habib et al., 2008; Ivanovic et al., 2019; Ivert et al., 1984; J. S. Lee et al., 2024). However, as this study is limited to a single institution, caution is warranted in extrapolating our findings to other regions or healthcare systems.

Both NVE and PVE cohorts demonstrated more severe preoperative symptoms during the pandemic, necessitating a higher proportion of urgent surgeries (Table 1.1 and 1.2). PVE patients often presented with nonspecific symptoms, contrasting with the characteristic signs of NVE, such as fever, Janeway lesions, and Osler's nodes. Diagnostic challenges in PVE were further complicated by prosthesis-related artifacts in transthoracic echocardiography, requiring transesophageal echocardiography for improved sensitivity (Habib et al., 2008; Ivert et al., 1984). Patients with prosthetic valves were routinely issued implant cards and educated to present these cards during hospital visits to facilitate a more focused diagnostic approach to prosthetic valve endocarditis. Although this practice was intended to improve diagnostic efficiency by alerting physicians to the possibility of prosthetic valve infection, the observed time interval from symptom onset to diagnosis during the pandemic did not reflect a meaningful reduction, suggesting that other systemic factors influenced delays.

The interval from diagnosis to surgery was significantly prolonged in the PVE cohort, likely reflecting pandemic-driven restrictions. Daily institutional meetings to prioritize surgeries based on COVID-19 incidence rates and ICU bed availability further constrained timely interventions. The PVE cohort, comprising older patients with worsening symptoms, exhibited prolonged ICU stays, underscoring the complex perioperative challenges faced during the pandemic (J.-S. Lee et al., 2024).

Pathogen profiles in both cohorts were consistent across periods, with Staphylococci and Streptococci predominating. Advanced diagnostic techniques like FISHseq/PCR, which align with ISVC guidelines, enhanced pathogen detection (Eichinger et al., 2019). Notably, no nosocomial PVE cases were identified, suggesting that stringent hygiene protocols and restricted visitor policies during the pandemic mitigated hospital-acquired infections (Huang et al., 2021; Talic et al., 2021).

Postoperative outcomes revealed non-significant differences in in-hospital mortality. However, the NVE cohort experienced an increase in re-thoracotomies for bleeding, possibly due to higher preoperative risk profiles and systemic constraints during the pandemic. Elevated odds ratios for complications in the PVE cohort highlight the intensified perioperative challenges, with prolonged ICU stays further emphasizing the strain on resources. Although long-term outcomes were not the focus of this study, it is important to consider the potential lasting effects of pandemic-related surgical delays, including recurrent infections, valve dysfunction, and overall patient survival. Future research should explore these aspects through extended follow-up studies.

This study underscores the pandemic's cascading effects, from delayed diagnoses to increased surgical complexity and heightened postoperative morbidity. These findings emphasize the critical need for adaptable healthcare strategies to safeguard the management of non-COVID-19 conditions during public health crises. Consolidating global guidelines and lessons learned can help optimize IE management in future pandemics. Additionally, healthcare systems should develop strategies to mitigate selection bias and maintain continuity of care in emergencies, ensuring that high-risk patient populations receive timely interventions despite systemic disruptions.

6. Limitation

This retrospective subanalysis, conducted in a single-center setting, has inherent limitations. The small cohort size, particularly in the PVE group, restricts the generalizability of our findings to broader populations or healthcare

systems. Additionally, variability in data collection and patient selection introduces potential biases. The retrospective nature of the study also limits the ability to infer causality. Future multicenter studies with larger patient cohorts and longer-term follow-up data are essential to validate these findings and offer a more comprehensive understanding of the pandemic's impact on IE care. Further investigations should assess how pandemic-related delays influenced long-term outcomes, including valve durability, reoperation rates, and overall survival.

7. Conclusion

The COVID-19 pandemic had a profound impact on the management and outcomes of native and prosthetic valve endocarditis. Pandemic-related triage and resource allocation led to delayed diagnoses, worsening cardiac symptoms, and an increased need for urgent surgeries, particularly in the PVE cohort. Despite these challenges, overall mortality remained unchanged, reflecting the resilience and adaptability of surgical teams.

However, the increased postoperative complications in post-pandemic cohorts highlight the necessity for enhanced perioperative management strategies during systemic disruptions. Acknowledging the limitations of our study, including its single-center design and lack of long-term follow-up, future research should focus on evaluating the enduring effects of pandemic-related delays on patient outcomes. Lessons learned from the pandemic should inform the development of adaptive healthcare protocols to ensure continuity of care for IE patients in future public health emergencies. Healthcare policymakers must also consider implementing contingency plans that preserve access to critical surgical interventions while managing resource constraints during future crises.

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