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Article

Retrospective Analysis of Clinical Characteristics and Surgical Treatment of Congenital Heart Disease Complicated by Infective Endocarditis From 2009 to 2023

Kadeyanmu Abulimiti[1,2,†], Zekun Ma[3,†], Aizier Abudureheman[4], Yierzhati Aizezi[5], Shayidan Abudunaiyimu[6], Lin Shi[2], Baleheng Bolatihan[2], Weimin Zhang[1,2,*]

[1]State Key Laboratory of Pathogenesis, Prevention and Treatment of High Incidence Diseases in Central Asia, Xinjiang Medical University, 830011 Urumqi, Xinjiang, China
[2]Department of Cardiac Surgery, The First Affiliated Hospital of Xinjiang Medical University, 830011 Urumqi, Xinjiang, China
[3]Department of Spine Surgery, The First Affiliated Hospital of Xinjiang Medical University, 830011 Urumqi, Xinjiang, China
[4]School of Public Health, Xinjiang Medical University, 830011 Urumqi, Xinjiang, China
[5]Department of Critical Care Medicine, The First Affiliated Hospital of Xinjiang Medical University, 830011 Urumqi, Xinjiang, China
[6]The First Clinical Medical College, Xinjiang Medical University, 830011 Urumqi, Xinjiang, China
*Correspondence: xjourheart@163.com (Weimin Zhang)
[†]These authors contributed equally.

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Abstract

Background: A retrospective study was conducted to gain an insight into the clinical characteristics and current surgical treatment status of patients with congenital heart disease (CHD) complicated with infective endocarditis (IE). **Methods**: This research included 110 patients with CHD and IE (74 males and 36 females) who underwent surgical treatment at the Cardiac Surgery Department of the First Affiliated Hospital of Xinjiang Medical University from January 1, 2009 to December 31, 2023. The patients were retrospectively evaluated, and clinical data, blood culture pathogenic types, echocardiography and treatment effects, and all-cause 1-year mortality, etc., were obtained. **Results**: A total of 110 patients with CHD combined with IE were enrolled, and their average age was 36.7 ± 15.1 years. Atrial septal defects (ASDs) (32.7%) and ventricular septal defects (VSDs) (24.6%) were the most common basic congenital heart classifications. Blood culture was positive in 54 cases (49.1%). The Streptococcus group was dominant in 32 cases (59.3%), and *Streptococcus viridans* (22.1%) was the most common pathogen. Vegetation was detected through transthoracic echocardiography of 91 patients, and left IE (60.4%) was more common than right IE (27.5%). All 110 patients underwent surgery, and the most common postoperative complications were heart failure (12.7%) and renal insufficiency (9.1%). Six cases of in-hospital death were recorded (5.5%). The main causes of death included low cardiac output syndrome and acute cerebral infarction. Overall, the in-hospital and one-year survival rates were 94.5% and 85.5%, respectively. **Conclusions**: This study revealed that young and middle-aged male patients with CHD combined with IE were more common, ASDs and VSDs were common, and Streptococcus was the main pathogenic bacteria. Echocardiography is critical to diagnosis, which emphasizes the importance of early diagnosis and surgical intervention.

Keywords

congenital heart disease; infective endocarditis; diagnosis; surgery; therapy

Introduction

Infective endocarditis (IE) refers to a rare, complex, and life-threatening infectious disease characterized by a persistently high global mortality rate that can reach up to 30% overall [1]. The rising incidence of IE has been observed among patients with congenital heart disease (CHD). The structural abnormalities associated with CHD not only predispose the endothelium to damage but also create conditions that are conducive to bacteremia. Patients with CHD are at a higher risk of developing IE compared to the general population [2]. And IE can negatively impact prognosis of CHD, the in-hospital mortality in CHD patients with IE has been reported to range from 5.7% to 9.0%, and the 1-year mortality ranging from 2.4% to 19.4% [3–7]. In this study, the clinical characteristics and surgical treatment outcomes of patients with CHD complicated by IE was evaluated through a retrospective analysis of case data from a tertiary hospital in Xinjiang.

Materials and Methods

Inclusion and Exclusion Criteria

This study was a single-center retrospective research project, and the study population comprised CHD cases combined with IE of those who were admitted to the Heart Center of the First Affiliated Hospital of Xinjiang Medical University, China, from January 1, 2009 to December 31, 2023 and met the inclusion criteria. A total of 110 patients were enrolled in this research, and their information was analyzed in detail.

The inclusion criteria were as follows: (1) diagnosis of IE referring to the modified Duke diagnostic criteria [8]; (2) diagnosis of CHD in accordance with the updated management guidelines for CHD from the American College of Cardiology/American Heart Association [9]; (3) patients undergoing cardiac surgery; (4) patients with complete clinical date. Exclusion criteria comprised the following: (1) no evidence of IE combined with CHD; (2) diagnosis of other wasting diseases (such as malignant tumors, immune deficiency-related diseases, hyperthyroidism, etc.) in the past or during hospitalization; (3) patients with incomplete clinical data; (4) patients lost to follow-up. A flow chart of the inclusion criteria can be seen in Fig. 1.

Data Collection

We reviewed and collected the patients' in-hospital clinical data from the inpatient medical record system of the First Affiliated Hospital of Xinjiang Medical University. The data for 110 patients with CHD combined with IE, including all baseline information, etiological types, echocardiography, comorbidities, surgical procedures, preoperative and postoperative complications, etc., were analyzed in detail. The patients were followed up for 1 year after surgery through telephone and/or outpatient visits. The endpoint of this study was all-cause death during the follow-up period.

Surgical Approach

According to the 2023 European Society Cardiology (ESC) guidelines, surgery aims to achieve complete removal of the infectious focus, prevent the spread or recurrence of infection, repair or replace damaged valves, and correct intracardiac malformations [10]. All patients underwent open-heart surgery under cardiopulmonary bypass (CPB) support for the excision of intracardiac vegetations and correction of congenital cardiac anomalies. Valve repair or replacement and coronary artery bypass grafting (CABG) were also performed during the same procedure when indicated. After surgery, all patients were transferred to the cardiac surgery intensive care unit (ICU) for close postoperative monitoring and management.

Statistical Analysis

SPSS 20.0 software (IBM Corp, Armonk, NY, USA) was used for statistical analysis. Continuous data are expressed as the mean $\pm$ standard deviation and were analyzed using analysis of variance (ANOVA). Categorical data are expressed as the frequency and (%), and the χ^2 test was used for comparisons between groups. Two-tailed p-values less than 0.05 were considered statistically significant.

Results

Demographic Characteristics

Among patients with CHD and IE, more male patients with CHD and IE were [n = 74 (67.3%)] were observed than women with the same condition [n = 36 (32.7%)]. The average age was 36.7 $\pm$ 15.1 years old, with 10 patients (9.1%) being younger than 18 years old, 63 patients (57.2%) aged between 18 and 45 years old, 29 patients (26.4%) having ages between 45 and 60 years old; and 8 patients (7.3%) being older than or equal to 60 years old (Table 1).

Types of CHD in Patients With IE

Among the 110 patients with CHD and IE included in this study, the largest proportion of basic congenital heart types was atrial septal defect (ASD) [n = 36 (32.7%)], followed by ventricular septal defect (VSD) [n = 27 (24.6%)] and ruptured sinus of valsalva aneurysm (RSVA) [n = 13 (11.8%)]. There were 8 cases of patent ductus arteriosus (PDA) (7.3%), 6 cases of VSD + RSVA (5.5%), 2 cases each tetralogy of Fallot (TOF), quadricuspid aortic valve (QAV) and ASD + RSVA (1.8%), 1 case each of Ebstein's anomaly (EA), left ventricular outflow tract obstruction (LVOTO), aortic valve developmental abnormality (AVDA), and ASD + VSD (0.9%) (Table 2). Furthermore, 10 cases (9.1%) of other complex congenital anomalies were detected, and they included various combinations, such as ASD + VSD + RSVA in 2 cases (1.8%); 1 case each (0.9%) of ASD + VSD + dextrocardia, ASD + VSD + double-chamber right ventricle, ASD + VSD + transposition of the great arteries (TGA) + pulmonary stenosis (PS), ASD + VSD + right ventricular outflow tract obstruction (RVOTO) stenosis, ASD + Right ventricular outflow tract stenosis + PS, ASD + PS, VSD + right ventricular outflow tract stenosis, and left main coronary artery to right atrium fistula. 2 patients had a history of VSD surgery (1.8%), and one had a history of ASD surgery (0.9%).

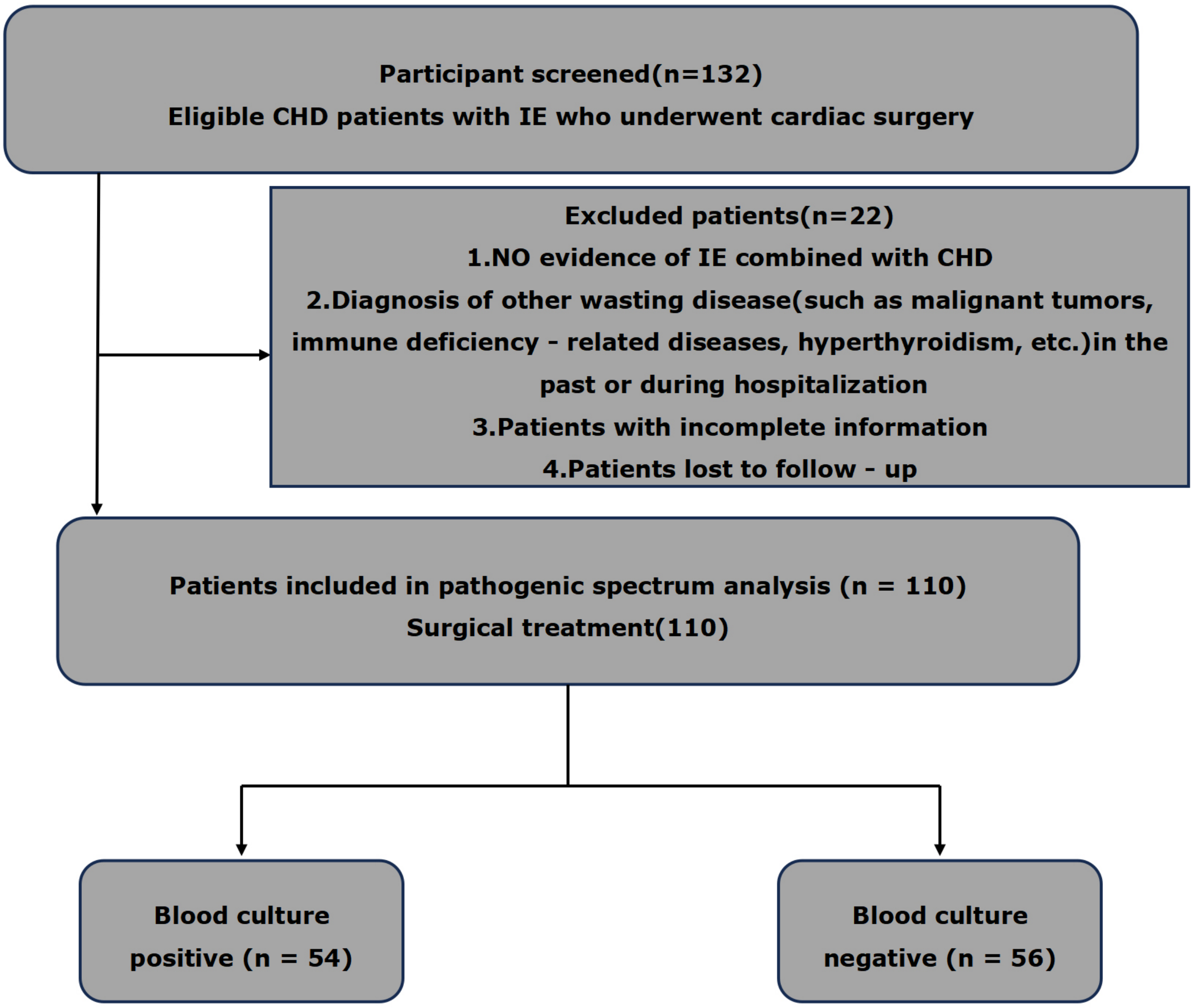

Fig. 1. Inclusion criteria flowchart. CHD, congenital heart disease; IE, infective endocarditis.

Analysis of Surgical Outcomes and Prognosis in Patients with Different Types of Congenital Heart Disease Complicated by Infective Endocarditis

In this study, six in-hospital deaths were recorded. Among them, three cases had VSD, one had ASD, one had PDA, and one had Ebstein's anomaly. Except for one patient with ASD, all others had concomitant valvular dysfunction, primarily involving the mitral and aortic valves. Consequently, five patients underwent CHD surgery combined with valve surgery. During the follow-up period, 10 cases of all-cause mortality occurred within one year. These included 4 cases of ASD, one case of LVOTO, one case of VSD with ruptured aortic sinus aneurysm, one case of ASD with ruptured aortic sinus aneurysm, 2 cases of ruptured aortic sinus aneurysm, and one case of ASD + VSD + TGA + PS. Among these, 3 patients: one with LVOTO, one with ASD + VSD + TGA + PS, and one with ruptured aortic sinus aneurysm, did not have associated valvular dysfunction. In the remaining cases, valvular dysfunction was present, with aortic valve dysfunction being the most common, followed by mitral and tricuspid valve dysfunction. Consequently, 7 patients underwent CHD surgery combined with valve surgery.

Atrial Septal Defect Status

In this study, a total of 47 patients with ASD were included, of which 36 had isolated ASD and 11 had ASD combined with other CHDs. Among these 47 patients, only 6 did not have associated valve problems, while the remaining 41 had valve issues and underwent valve replacement/repair surgery. Additionally, 1 of these patients also underwent CABG in addition to valve surgery. These conditions may increase the risk of IE. Although the 6 patients without valve issues did not have valve problems, 5 of them had multiple CHDs in addition to ASD and underwent complex congenital heart defect surgeries. Therefore, only one patient had isolated ASD with IE who underwent ASD closure.

Table 1. Basic clinical data of patients with CHD complicated by IE.

Project	Cases	Proportion (%)	Project	Cases	Proportion (%)
Gender			Surgical procedures		
Male	74	67.3	Single CHD surgery	24	21.8
Female	36	32.7	Combined aortic valve surgery	22	20.0
Age, years			Combined mitral valve surgery	16	14.5
<18	10	9.1	Combined tricuspid valve surgery	17	15.5
18–45	63	57.2	Combined multi-valve surgery	30	27.3
45–60	29	26.4	Combined valve and coronary artery bypass surgery	1	0.9
≥60	8	7.3	Postoperative complications		
Preoperative symptoms and signs			Mortality	6	5.5
Fever	55	50	Low cardiac output syndrome	7	6.4
Chest discomfort or pain	74	67.3	Multiple organ dysfunction	3	2.7
Dyspnea	65	59.1	Non-onset cerebral embolism	5	4.5
Nocturnal sweating or afternoon low-grade fever	10	9.1	Heart failure	14	12.7
Bilateral lower limb edema	16	14.5	Renal failure	10	9.1
Weight Loss >5% within 3 months prior to surgery	19	17.3	Postoperative arrhythmias		
NYHA classification III–IV	39	35.5	Third-degree atrioventricular block	4	3.6
Preoperative comorbidities			Atrial fibrillation	6	5.5
Hypertension	12	10.9	Postoperative management		
Diabetes	4	3.6	Need for intra-aortic balloon pump	6	5.5
Coronary heart disease	7	6.4	Need for extracorporeal membrane oxygenation	1	0.9
Preoperative complications			Need for hemodialysis	4	3.6
Renal insufficiency	6	5.5			
Liver dysfunction	6	5.5			
Cerebral embolism or hemorrhage	12	10.9			
Preoperative arrhythmias					
Sinus tachycardia	22	20			
Second-degree type I atrioventricular block	2	1.8			
Atrial fibrillation	5	4.5			

Note: NYHA Classification, New York Heart Association Classification.

Table 2. Basic types of CHD in patients with IE.

Types of CHD	Cases	Proportion (%)
ASD	36	32.7
VSD	27	24.6
RSVA	13	11.8
PDA	8	7.3
VSD+RSVA	6	5.5
ASD+RSVA	2	1.8
QAV	2	1.8
TOF	2	1.8
EA	1	0.9
LVOTO	1	0.9
AVDA	1	0.9
ASD+VSD	1	0.9
Other Complex Congenital Anomalies	10	9.1
Total	110	100.0

Note: ASD, atrial septal defect; VSD, ventricular septal defect; RSVA, ruptured sinus of valsalva aneurysm; PDA, patent ductus arteriosus; QAV, quadricuspid aortic valve; TOF, tetralogy of Fallot; EA, Ebstein's anomaly; LVOTO, left ventricular outflow tract obstruction; AVDA, aortic valve developmental abnormality.

Preoperative Clinical Symptoms and Complications

The patients had a preoperative hospital stay of (10.5 ± 5.7) days. Most patients [n = 74 (67.3%)] presented with symptoms of chest tightness and chest pain on admission, and 65 had shortness of breath (59.1%) upon admission. Half of the patients [n = 55 (50.0%)] reported fever on admission. A small number [n = 10 (9.1%)] experienced night sweats or low-grade fever in the afternoon. The other clinical manifestations were edema of both lower limbs in 16 cases (14.5%), weight loss of more than 5% at 3 months before surgery in 19 cases (17.3%). A total of 39 cases (35.5%) were New York Heart Association (NYHA) Classification III–IV. In this study, 12 cases showed symptoms of cerebral embolism or cerebral hemorrhage (10.9%) (11 cases of cerebral embolism, 1 case of cerebral hemorrhage), 12 cases of hypertension (10.9%), and other preoperative comorbidities and complications, including 4 cases of diabetes (3.6%), 7 cases of coronary heart disease (6.4%), 6 cases of renal insufficiency (5.5%), and 6 cases of liver insufficiency (5.5%) (Table 1).

Preoperative Microbiology

Among 110 patients, 54 (49.1%) had positive blood cultures, which was slightly less than those with negative blood cultures [n = 56 (50.9%)]. The pathogenic bacteria identified through blood culture were arranged in descending order: 42 cases (77.8%) of Gram-positive bacteria, including the Streptococcus group in 32 cases (59.3%), Staphylococcus group in 8 cases (14.7%), and Enterococcus and deficiency anaerobes in 1 case each (1.9%). A total of 11 cases (20.3%) showed the presence of the Gram-negative bacteria (GNB) group, including 3 cases (5.6%) of *Brucella*, 2 cases (3.7%) of *Escherichia coli*, 6 cases (11.0%) of other Gram-negative bacilli, and *Candida albicans* in 1 case (1.9%). The most common pathogenic bacteria were *Streptococcus viridans* (22.1%), followed by *Streptococcus sanguis* (11.0%) and *Streptococcus mitis* (9.3%) (Table 3).

Table 3. Preoperative microbiological types.

Pathogens	Cases	Composition ratio (%)
Gram-positive bacteria	42	77.8
Streptococcus	32	59.3
Streptococcus viridans	12	22.1
Streptococcus sanguinis	6	11.0
Streptococcus gordonii	3	5.6
Streptococcus mitis	5	9.3
Streptococcus parahaemolyticus	1	1.9
Streptococcus anginosus	2	3.7
Streptococcus oralis	1	1.9
Streptococcus constellatus	1	1.9
Streptococcus sobrinus	1	1.9
Staphylococcus	8	14.7
Staphylococcus aureus	4	7.3
Staphylococcus epidermidis	2	3.7
Coagulase-negative staphylococci	2	3.7
Enterococcus	1	1.9
Enterococcus faecalis	1	1.9
Anaerobic deficient bacteria	1	1.9
Gram-negative bacteria	11	20.3
Brucella	3	5.6
Escherichia coli	2	3.7
Other gram-negative rods[a]	6	11.0
Fungi	1	1.9
Candida albicans	1	1.9
Total	54	100.0

Note: [a] = Three cases of Klebsiella pneumoniae; two cases of Enterobacter hormaechei; one case of Enterobacter cloaca.

Preoperative Echocardiographic and Electrocardiographic Features

All patients underwent at least one transthoracic echocardiogram (TTE) prior to their surgery. Vegetations were found in 91 patients (82.7%), with left-sided IE being more common than right-sided IE [n = 55 (60.4%) vs. n = 25 (27.5%)]. Bilateral involvement occurred in 6 cases (6.6%), and vegetation appeared in the aortic sinus aneurysm (ASA) of 5 patients (5.5%). Among patients with left-heart system involvement, the aortic valve (AV) was the most commonly affected site [n = 23 (25.2%)], followed by the mitral valve (MV) [n = 17 (18.7%)] and combined AV and MV involvement [n = 14 (15.4%)]. Right-heart system involvement predominantly affected the tricuspid valve (TV) [n = 18 (19.8%)], followed by the pulmonary valve (PV) [n = 4 (4.4%)]. Vegetations were detected simultaneously in 2 or more locations in 22 patients (20.0%); the most severely affected included the AV [n = 41 (37.3%)] and MV [n = 34 (30.9%)], followed by the TV [n = 22 (20.0%)] (Table 4). In addition, 16 patients (14.5%) had ultrasound findings revealing key cord breakage, 15 (13.6%) suffered from valve perforation, and 1 (0.9%) had a paravalvular abscess.

All patients, including 22 cases (20.0%) of sinus tachycardia, 2 cases (1.8%) of second-degree type 1 conduction block, and 5 cases (4.5%) of atrial fibrillation, underwent at least one electrocardiogram before surgery.

Table 4. Preoperative distribution of cardiac vegetations.

Affected Sites	Cases	Composition Ratio (%)
Left Heart System	55	60.4
AV	23	25.2
MV	17	18.7
AV + MV	14	15.4
LA	1	1.1
Right Heart System	25	27.5
TV	18	19.8
PV	4	4.4
PV + DA	2	2.2
RV	1	1.1
Simultaneous Involvement of Both Sides	6	6.6
AV + PV	1	1.1
MV + TV	1	1.1
MV + PV	1	1.1
AV + MV + TV + PV	1	1.1
AV + TV + VSD	1	1.1
AV + TV	1	1.1
Others	5	5.5
ASA	5	5.5
Total	91	100.0

Note: AV, aortic valve; MV, mitral valve; LA, left atrium; TV, tricuspid valve; PV, pulmonary valve; DA, ductus arteriosus; RV, right ventricle; ASA, aortic sinus aneurysm.

Surgery and Outcomes

All patients with CHD and IE underwent cardiac surgery. The most common CHD surgical repairs included 36 cases of ASD (32.7%), followed by 27 cases (24.6%) of VSD and 13 cases (11.9%) of RSVA repair. During the same period, 86 cases (78.2%) underwent valve replacement or repair surgery, the most common of which was AV surgery in 49 cases (44.5%, including 1 aortic valvuloplasty), followed by MV surgery in 46 cases (41.8%; including 4 cases of mitral valvuloplasty) and 24 cases of TV surgery (21.8%, including 12 cases of tricuspid valvuloplasty). The intraoperative CPB time reached (88.7 $\pm$ 46.0) min. Vegetation was detected during surgery in 98 cases (89.1%).

The postoperative complications of patients with CHD combined with IE were as follows: 14 cases of cardiac insufficiency (12.7%), 10 cases of renal insufficiency (9.1%), 7 cases of low cardiac output syndrome (6.4%), 5 cases of new cerebral embolism (4.5%), 3 cases (2.7%) of multiple organ dysfunction, 4 cases (3.6%) of third degree conduction block, 6 cases (5.5%) of atrial fibrillation, and 3 cases (2.7%) involving pacemakers. A total of 6 cases (5.5%) used intra-aortic balloon pump, 4 cases (3.6%) had hemodialysis, and 1 case (0.9%) involved extracorporeal membrane oxygenation. One patient developed valve perforation and insufficiency 19 days after surgery and underwent secondary valve surgery, and a dual-chamber pacemaker was installed postoperatively.

During postoperative hospitalization, 6 patients died, and the in-hospital mortality rate was 5.5%. Among these patients, 5 cases died of low cardiac output syndrome, and 1 case died of acute cerebral infarction. During the follow-up period, 10 patients died, which resulted in an all-cause mortality rate of 9.1%. The causes of postoperative mortality in patients with IE were as follows: low cardiac output syndrome was the most common cause, accounting for 6 cases (5.5%), followed by neurological complications and cardiac complications, each responsible for 3 cases (2.7%). Unknown causes were identified in 2 cases (1.8%), while multiple organ dysfunction and other causes were each observed in 1 case (0.9%) (Table 5).

The average follow-up time was 146 $\pm$ 6 months (range,1-174months). The postoperative survival rates were 85.5% after 1 year. The Kaplan-Meier survival analysis of CHD patients with IE who underwent surgery from January 2009 to December 2023 is shown in Fig. 2.

Table 5. Postoperative cause of death in patients with IE.

Cause of Death	Cases	Composition Ratio (%)
Low cardiac output syndrome	6	5.5
Neurological complications	3	2.7
Cardiac complications	3	2.7
Unknown causes	2	1.8
Multiple organ dysfunction	1	0.9
Other	1	0.9

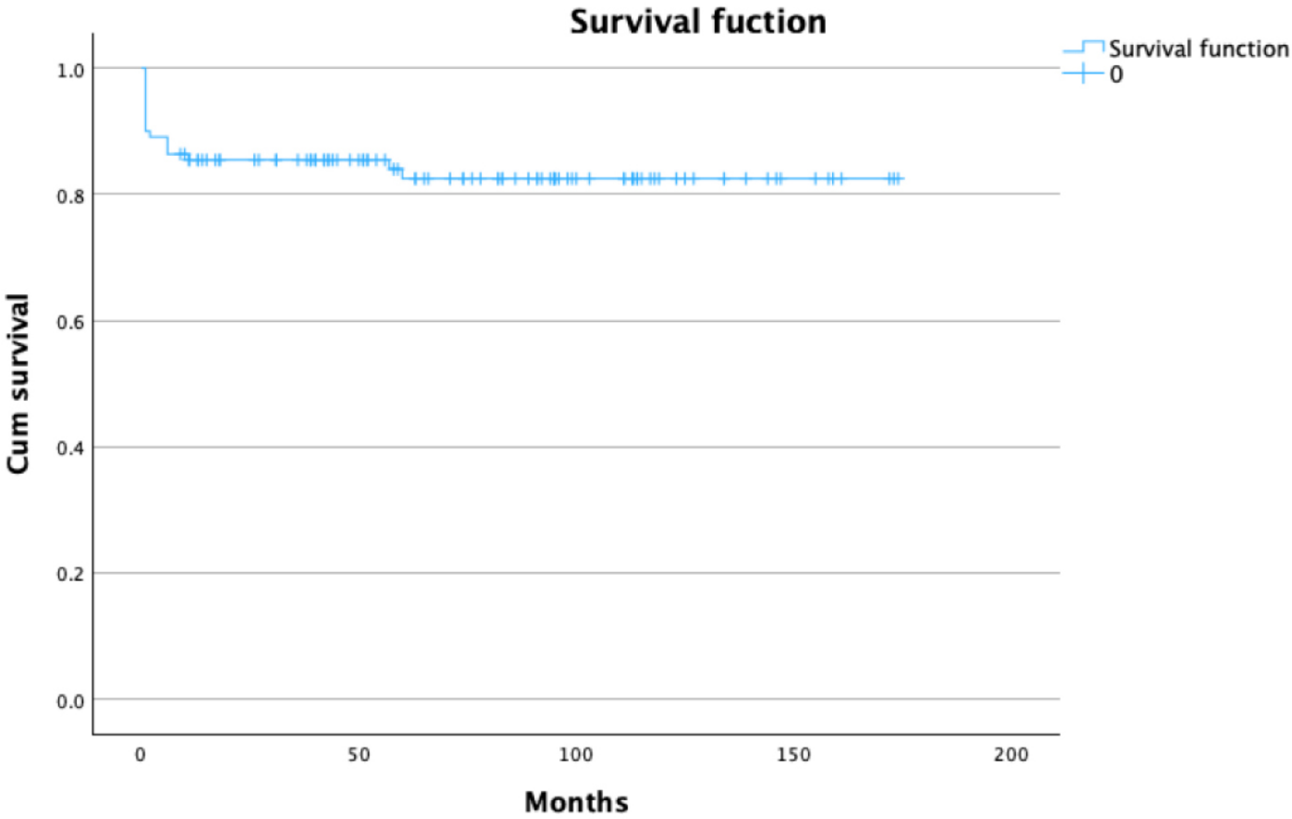

Fig. 2. Kaplan-Meier survival analysis of patients with CHD complicated by IE.

Discussion

With the development of society and medical technology, CHD has emerged as a major cause of IE, especially in young and middle-aged populations[1,7,11,12]. This retrospective analysis identified several clinical features and surgical outcomes of CHD complicated by IE patients in Xinjiang. The mean patient age (36.7 ± 15.1 years) was lower than in non-CHD populations, consistent with previous findings [13]. The male predominance (67.3%) suggests male gender as an independent risk factor, likely linked to occupational exposure, poor oral hygiene, anatomical factors, immune differences, and genetic predisposition [14]. In Xinjiang, male patients had higher rates of GNB infections, potentially related to occupations. Additionally, factors such as reduced oral hygiene [15], sex-related immunological differences [16,17], and Toll-like receptor gene polymorphisms may contribute to their vulnerability [18,19]. Although in-hospital mortality between sexes was similar (5.4% vs. 5.6%), the slightly higher one-year mortality in males (9.5% vs. 8.3%) may reflect the impact of GNB-related complications, including bacteremia and valve failure.

ASD and VSD were the most common CHD types in this cohort, differing from UK data showing TOF and VSD dominance but aligning with Canadian studies [20]. While ASD is generally regarded as low-risk due to its low-pressure and low-turbulence blood flow, our findings challenge this perception, as ASD patients exhibited an unexpectedly high incidence of IE. Although our dataset included 47 cases of ASD, only one patient had isolated ASD with IE who underwent ASD closure. This may be attributed to factors such as concomitant valvular disease, pulmonary hypertension, post-surgical residual defects, or the presence of other high-risk factors, all of which facilitate bacterial adherence and systemic infection. These results underscore the multifactorial nature of IE in ASD patients and highlight the need for long-term surveillance and early intervention. All patients underwent median sternotomy and CPB (88.7 ± 46.0 min). Valve replacement was favored over repair due to extensive valvular damage. Although biological valves have gained popularity, particularly in older patients, survival outcomes remain controversial. Studies by Toyoda et al. and Nguyen et al. reported inferior long-term survival in biological valve recipients, especially those ≤65 years [21,22]. In our study, no significant survival difference was observed by valve type (p = 1.0 for aortic and tricuspid valves; p = 0.14 for mitral), and mechanical valves were primarily used. Valve replacement was more frequently performed due to severe structural compromise, especially in patients with multivalvular involvement, consistent with previous evidence supporting valve replacement when function is lost or repair is infeasible [23]. Bicuspid aortic valve (BAV) is reportedly the most common CHD subtype in IE [6], but our focus on non-valvular CHD (mainly ASD and VSD) reflects the regional demographic and clinical characteristics in Xinjiang. This targeted approach enhances understanding of CHD complicated by IE profiles in non-valvular conditions, although broader studies including valvular CHD are warranted. IE diagnosis remains challenging due to non-specific symptoms. Blood culture, though essential, had a 49.1% positivity rate—within the expected range (45.4%–79.0%)—with Streptococcus spp. (59.3%) being most prevalent, followed by Staphylococcus spp. (14.7%) [1,2,13,24]. GNB and Enterococcus infections were also noted but less frequent ($p < 0.01$), potentially influenced by regional pathogen exposure [25–27]. The Xinjiang region is an endemic area for brucellosis in China, with an incidence rate of 36.08 per 100,000 in 2023. This high incidence rate makes Brucella not uncommon as a pathogen in IE. This is particularly evident in populations engaged in occupations such as animal husbandry and agriculture, which significantly increase the risk of exposure to animal-borne pathogens like Brucella [28,29]. Given the limitations of blood culture, echocardiography plays a crucial role. TTE revealed vegetations in 82.7% of cases, mainly involving the AV, MV, and TV, although TEE is recommended when TTE is inconclusive to enhance detection sensitivity.

Preoperative complications were common: heart failure (35.5%), renal insufficiency (5.5%), cerebrovascular events (10.9%), and arrhythmias such as sinus tachycardia and atrial fibrillation. New-onset AF may predict poor outcomes and pacemaker dependency post-surgery [30–32]. All patients underwent CHD correction and valve surgery. While CPB is indispensable, prolonged extracorporeal time may elevate early postoperative mortality risk [33]. Surgical complexity was closely tied to CHD type and IE severity. Patients with simple CHD (ASD/VSD) generally had favorable outcomes, whereas complex CHD and multivalvular involvement were linked to increased in-hospital and follow-up mortality, especially when extensive debridement or multi-valve procedures were needed. Periannular abscesses further complicated prognosis, increasing recurrence risk and prosthetic dysfunction. Common postoperative complications included heart failure (12.7%), renal insufficiency (9.1%), and new third-degree AV block (3.6%), with some requiring intra-aortic balloon pump, continuous renal replacement therapy, or pacemakers. These findings highlight the need for multidisciplinary care and strict perioperative management, including early antimicrobial therapy and organ support. Although CHD patients have an IE risk up to 55 times higher than the general population, but their prognosis is usually better due to earlier diagnosis and fewer comorbidities [11,34,35]. Our in-hospital (5.5%) and one-year mortality (9.1%) are akin to prior studies [3,5,36,37], potentially reflecting benefits from timely surgery. Notably, ASD, though traditionally low-risk, showed a higher than expected IE incidence ($p < 0.05$), likely due to chronic shunting, atrial remodeling,and valvular abnormalities allowing systemic bacteremia. Therefore, comprehensive follow-up is essential, particularly for ASD patients with additional risk factors, to prevent IE and improve long-term outcomes.

CHD combined with IE is a relatively rare disease combination, especially in specific medical centers where the number of cases meet the inclusion criteria is limited. To ensure the quality of the study and the reliability of the data, we set strict inclusion and exclusion criteria, which to some extent limit the number of cases included in the final study. As a single-center study, our resources and manpower are limited, making it difficult to collect more cases in a short period of time. We fully acknowledge that the small sample size is an important limitation of this study. Future research will focus on expanding the sample size through multicenter collaboration to improve the representativeness and reliability of the results. Despite the limited sample size, this study still provides valuable preliminary data on the clinical characteristics and surgical treatment of CHD combined with IE.

Conclusions

This study retrospectively analyzed the clinical characteristics and surgical treatment effects of CHD combined with IE. In Xinjiang, among patients with CHD combined with IE, which is more common among young and middle-aged people, with male patients accounting for a higher proportion of. ASD and VSD are the most common basic congenital heart classifications. Streptococci remain the most common pathogenic bacteria. Surgery is crucial to the removal of the source of infection, repair of cardiac structure, and improvement of cardiac function, and early surgical intervention substantially reduces in-hospital mortality.

Availability of Data and Materials

Data to support the findings of this study are available on reasonable requests from the corresponding author.

Author Contributions

KA and WZ designed and conducted this research. ZM and AA collected the data. YA and SA were responsible for statistical analysis.LS and BB contributed to patient follow-up and investigation. KA and LS drafted the manuscript. WZ revisedthe manuscript. All authors contributed to editorial changesin the manuscript, read and approved the final version, and agreed to be accountable for all aspects of the work, ensuring that any questions related

to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

The study was carried out in accordance with the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University (No.K202411-32). As a retrospective study, it is not necessary to obtain informed consent of patients.

Acknowledgment

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest.

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