Original Article

Postoperative follow-up of 221 patients with infective endocarditis from Gaoligong mountain area of Yunnan in China: a retrospective, single-center, observational cohort study

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Background: Despite improvements in management, infective endocarditis (IE) is still associated with high mortality and morbidity. The outcome of patients with IE remains unclear in high-altitude areas of China. To characterize the epidemiological features and surgical outcomes, a retrospective analysis was conducted to 221 patients diagnosed with IE from a single center. In addition, to assess the prognosis of patients, a multivariate logistic regression model was performed to analyze the affecting risk factors.

Methods: A retrospective analysis was conducted on the clinical data of 221 patients with IE who underwent surgical treatment at the Department of Cardiac Surgery of Yan'an Hospital Affiliated to Kunming Medical University from January 2013 to December 2019. The analysis evaluated patient demographics, pathogenic bacterial composition, echocardiography results, and surgical treatment outcomes. After a 1-year follow-up period, the mortality rate was statistically analyzed. The patients were divided into two groups based on their survival status: those who survived and those who did not. Relevant factors were compared between the two groups, and a multivariate logistic regression model was used to analyze the risk factors that affect the prognosis of patients with IE.

Results: Out of the 221 patients diagnosed with IE, 164 were male and 57 were female, with an average age of 39.25±14.36 years. The most common underlying heart diseases were bicuspid aortic valve disease (24.9%), congenital heart disease (19.5%), rupture of aortic sinus aneurysm (5.0%) and rheumatic valvular disease (2.3%). The blood culture had a positive rate of 48.42% (107/221), with *Streptococcus viridans* (29.9%) and *Streptococcus haematoides* (13.1%) being the main specifically pathogenic bacteria identified. Transthoracic echocardiography produced positive results in 89.6% (198/221) of cases. The findings included vegetation formation (100%), valve perforation or tear (21.7%), and perivalvular abscess formation (5.6%). Out of the patients, 174 underwent elective surgery, 47 received emergency surgery, and 11 died within 1 year after surgery, resulting in a mortality rate of 5.0%. However, the death group had longer operation time, cardiopulmonary bypass (CPB) time and higher EuroSCORE II compared to the non-death group (P<0.05). Logistic regression analysis identified preoperative hematocrit decrease, prolonged operation time and CPB time, high New York Heart Association (NYHA) cardiac function grade, and liver diseases as risk factors for 1-year mortality in patients with IE (OR =1.003, 0.000, 1.006, 1.026, 1.624 and 4.746).

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Conclusions: IE primarily affects young and middle-aged men with rheumatic heart valvular disease as the main underlying heart disease and *Streptococcus viridans* as the main pathogen. Surgical intervention significantly reduces early mortality in IE patients. To improve postoperative prognosis, clinicians should remain vigilant, especially in high-risk groups with preoperative hematocrit, prolonged operation time, and CPB time, high NYHA cardiac function grade, EuroSCORE II, and vegetation formation.

Keywords: Infective endocarditis (IE); epidemiological characteristics; surgical treatment; prognosis; risk factor

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Introduction

Infective endocarditis (IE) is an infection of the heart valve, endocardial surface, and implanted devices in the heart caused by fungi, bacteria, or other microorganisms (1,2). IE is a complex and variable disease that often presents with clinical presentation such as fever, anemia, heart murmur, and dyspnea (3). Patients with IE often experience serious complications such as cerebrovascular accidents, arrhythmias, and heart failure. This not only increases the difficulty of treatment but also raises the mortality rate and worsens the prognosis. Epidemiological investigations report an annual incidence of IE ranging from 2.4/100,000 to 11.6/100,000, with a mortality rate of approximately 30% 1 year after diagnosis. The mortality rate is as high as 8% within one month after surgery (4,5).

The ideal timing for surgery in patients with IE is still uncertain. Nevertheless, early surgical intervention has been linked to a lower risk of mortality (6,7). In patients with IE, prompt surgical treatment can decrease the risk of bacterial emboli and thromboembolic events, as well as related complications (6). Furthermore, early initiation of surgical intervention reduces the duration of preoperative antibiotic therapy, resulting in improved outcomes in valve cultures. To our knowledge, no correlation has been established between positive valve cultures and other markers of high infection, including preoperative fever, the frequency of emboli, and the presence of cardiac abscess. Patients will therefore benefit most from the formulation of appropriate management strategies, early identification of high-risk groups with poor prognosis, and targeted prevention and treatment. We retrospectively examined the epidemiological characteristics and surgical outcomes of 221 patients with IE. Using a multivariate logistic regression model, we identified the risk factors that affect the prognosis of patients with IE. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-470/rc).

Highlight box

Key findings

- Among the 221 patients diagnosed with infective endocarditis (IE), the most common underlying heart conditions was bicuspid aortic valve disease (24.9%).
- *Streptococcus viridans* (29.9%) was the most common pathogenic bacteria identified in the patients' blood cultures.
- Vegetation formation (100%) and valve perforation or tear (21.7%) were the common presence according to transthoracic echocardiography.
- One-year mortality was 4.98% out of the 221 patients who received surgical treatment.
- Increased EuroSCORE II, prolonged operation time, high New York Heart Association cardiac function classification, as well as liver diseases were identified as risk factors for 1-year mortality in patients with IE.

What is known and what is new?

- To diagnose IE, it is necessary to collect medical history, conduct bacteriological examination, and perform echocardiography. Additionally, surgery is the primary treatment for IE, with some patients requiring emergency surgery.
- This study comprehensively analysed a special group of patients with IE from this high-altitude underdeveloped region, considering its unique minority population, dietary structure, medical care situation, environment, and climate. It was conducted at a single center to assess preoperative factors, clinical baseline, and emergency surgery experience of a unique and heterogeneous group of participants.

What is the implication, and what should change now?

- These findings highlight the significance of timely diagnosis, suitable surgical intervention, and careful management of high-risk patients with IE to enhance outcomes.

Methods

Study design and patients

This is a retrospective, single-center, observational cohort study that received approval from the Human Investigation Committee of the Yan'an Hospital Affiliated to Kunming Medical University (No. 2021-039-01). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Informed consent was not required as this is a retrospective study. We established a database retrospectively and maintained it prospectively. We retrospectively analyzed the clinical data of 221 patients with IE who underwent surgical treatment in the Department of Cardiovascular Surgery of the Yan'an Hospital Affiliated to Kunming Medical University from January 2013 to December 2019.

The criteria for inclusion were as follows: (I) meeting the updated Duke diagnostic criteria; (II) meeting the surgical indications; and (IV) having complete clinical data.

The exclusion criteria were as follows: (I) endocardial clinical symptoms that disappeared or were relieved for ≤4 days after anti-infective treatment; (II) negative results on pathological examination with no evidence of IE; and (III) no data were collected during the follow-up period due to patient reasons.

Clinical baseline data collection

The Department of Cardiovascular Surgery at Yan'an Hospital Affiliated to Kunming Medical University maintained a database from January 2013 to December 2019, which included 221 patients who underwent surgical treatment for IE. For our postoperative follow-up study, we reverified, reread, and re-analyzed the data of these 221 patients, including all baseline data, echocardiography studies, and surgical procedures, in a standardized manner.

Patient data including gender, age, and basic heart conditions (such as rheumatic valvular disease, bicuspid aortic valve disease, prosthetic valve IE, congenital heart disease, postoperative IE of congenital heart disease, and ruptured aortic sinus aneurysm), as well as New York Heart Association (NYHA) cardiac function classification (grades I–IV) and preoperative complications (such as hypertension and cerebrovascular disease) were collected and recorded. All data were cross-checked for accuracy and consistency. Any missing or inconsistent data were double-checked and confirmed by medical staff.

Treatment

Blood culture pathogenic bacteria

Blood culture pathogens were collected from patients upon admission and cultured in an automatic blood culture instrument (BacT/ALERT3D, bioMérieux, Bruz, France). Drug susceptibility testing was conducted using an automated bacterial identification and drug susceptibility analysis system (VITEK®2, Bruz, France). A positive result was determined if any of the following criteria were met: (I) detection of IE pathogenic microorganisms after multiple blood cultures; (II) most blood cultures were positive more than four times, and all three blood cultures were positive; (III) two blood cultures taken at least 12 hours apart were positive; and (IV) two blood cultures taken at different times detected the same typical IE pathogenic microorganism.

Echocardiography

The study employed the iU23 ultrasonic diagnostic instrument (Philips, Washington, USA) with an esophageal probe X7-2t (probe frequency 2–7 MHz) and a two-dimensional M4S probe (probe frequency 0–5 MHz) for echocardiography. A positive result was considered present if any of the following criteria were met: (I) abscess, internal cardiac fistula, or pseudoaneurysm; (II) vegetation; (III) newly occurring partial rupture of the artificial valve; or (IV) valve perforation or aneurysm.

Surgical methods

Following admission, empirical antibiotics were preferred as a treatment until the antibiotic drug sensitivity test results were obtained. Sensitivity antibiotics were adjusted as accurate treatment when results are available. Depending on the severity of valvular disease and clinical presentation, patients underwent either elective or emergency surgery. The main surgical procedures included valve replacement, valve repair, and vegetation removal. If a septal defect was present in combination with congenital heart disease or bacterial erosion, it was repaired simultaneously during surgery. If IE was complicated by severe coronary artery disease, coronary artery bypass grafting was conducted simultaneously with surgery. Concurrent treatment was also provided for other malformations, including thoracic aortic disease.

Clinical outcomes

The patients' mortality rate was determined through door-

Table 1 Analysis of basic data of 221 patients with infective endocarditis

Characteristic	Cases (n)	Proportion (%)
Gender		
Male	164	74.2
Female	57	25.8
Age (years)		
<18	14	6.3
≥18	207	93.7
Basic disease		
Rheumatic valvular heart disease	5	2.3
Bicuspid aortic valve disease	55	24.9
Congenital heart disease	43	19.5
Rupture of aortic sinus aneurysm	11	5.0
NYHA cardiac function grading		
Grade I	2	0.9
Grade II	27	12.2
Grade III	160	72.4
Grade IV	32	14.5
Preoperative complication		
Hypertension	21	9.5
Cerebrovascular disease	61	27.6
Hepatopathy	27	12.2
Diabetes	10	4.5
Chronic pulmonary disease	18	8.1
Pneumonia	49	22.2
Arrhythmia	93	42.1

NYHA, New York Heat Association.

to-door follow-up, outpatient follow-up, WeChat, or telephone 1 year after the operation.

The primary outcome measure was the survival of patients with IE within 1 year after the operation. The main adverse cardiac event was death. Valvular status and cardiac function were analyzed during regular follow-up visits (8). Adverse events were recorded in an electronic file with the exact dates of occurrence.

Statistical analysis

The data were processed using SPSS 22.0 software by IBM Corp (New York, USA). All statistical analyses were descriptive. Continuous variables are expressed as mean ± standard deviation (SD) or median and interquartile range (IQR) as appropriate. Measurement data are expressed as mean ± standard deviation ($\bar{x}$±s) and were compared using the *t*-test. Count data are expressed as numbers with percentages and were analyzed using the χ^2 test or the rank-sum test for ranked data. Risk factors were analyzed using logistic regression. The results include odds ratios (ORs) and corresponding 95% confidence intervals (CIs). Kaplan-Meier curve performed by survival analysis method. A statistically significant difference was indicated by P<0.05.

Results

Patient characteristics

Out of the 221 patients diagnosed with IE, 164 were male and 57 were female. The age range was 9 to 71 years, with an average of 39.25 (SD 14.36) years. The most common underlying heart conditions were bicuspid aortic valve disease, congenital heart disease, rupture of aortic sinus aneurysm, and rheumatic valvular disease, accounting for 24.9%, 19.5%, 4.98% and 2.3%, of cases, respectively (*Table 1*).

Distribution of pathogenic bacteria in 107 patients with IE

Upon admission, blood cultures were obtained from all 221 patients with IE. The positive rate of blood culture was 48.4% (107/221). The most common pathogens identified were *Streptococcus viridans* and *Streptococcus sanguis* (*Table 2*).

Analysis of echocardiographic examination results of 198 patients with IE

Upon admission, all 221 patients with IE underwent transthoracic echocardiography examination. The positive rate of transthoracic echocardiography findings was 89.6% (198/221). Vegetation formation, valve perforation or tear, and perivalvular abscess formation accounted for 100% (198/198), 21.7% (43/198), and 5.6% (11/198) of the positive findings, respectively (*Table 3*).

Analysis of surgical methods for 221 patients with IE

The 221 patients diagnosed with IE showed improved drug sensitivity after admission and received targeted antibiotic treatment for their infection. Out of these patients, 174

Table 2 Distribution of pathogenic bacteria in 107 patients with infective endocarditis

Pathogen in positive blood culture	Cases (n)	Proportion (%)
Streptococcus viridans	32	29.9
Streptococcus sanguis	14	13.1
Staphylococcus	7	6.5
Streptococcus oralis	4	3.7
Other streptococci	20	18.7
Defective anoxic bacteria	5	4.7
Enterococcus	3	2.8
Gram-negative cocci	7	6.5
Fungus	3	2.8
Other pathogen	16	15.0

Table 3 Analysis of echocardiographic examination results of 198 patients with infective endocarditis

Positive transthoracic echocardiography	Cases (n)	Proportion (%)
Type		
Vegetation formation	198	100
Valve perforation or tear	43	21.7
Perivalvular abscess formation	11	5.6
Affected valve		
Isolated aortic valve	79	39.9
Isolated mitral valve	63	31.8
Mitral + aortic valves	23	11.6
Mitral + tricuspid valves	6	3.0
Aortic + tricuspid valves	5	2.5
Simple tricuspid valve or pulmonary valve	22	11.1

underwent elective surgery while 47 underwent emergency surgery. The main surgical methods involved removing vegetation, double-valve surgery, and triple-valve surgery, accounting for 91.0%, 48.42%, and 48.9% of cases, respectively (*Table 4*).

Pathological and surgical findings in 221 patients with IE

Out of the 221 patients who underwent surgery for IE,

Table 4 Analysis of surgical methods in 221 patients with infective endocarditis

Operation mode	Cases (n)	Proportion (%)
Single-valve surgery	84	37.1
Double-valve surgery	107	48.4
Triple-valve surgery	108	48.9
Repair of valve combined with congenital heart disease defect	36	16.3
Repair of ventricular septal defect	31	14.0
Coronary artery bypass grafting combined with valve surgery	2	0.9
Thoracic aortic surgery	94	42.5
Vegetation removal	201	91.0

11 cases (5.0%) died within a year of the operation. This included 6 cases (2.7%) who died during the perioperative period. Three of these cases died due to low cardiac output syndrome and multiple organ failure, while the other three died due to cerebral infarction and cerebral hemorrhage. Additionally, 1 case (0.5%) died on the 20th day after the operation due to cerebral aneurysm rupture and bleeding. Therefore, 30-day mortality calculated to 3.2%. During the observation period, four patients died. Two of them (0.9%) died within 5 months due to the recurrence of IE and ineffective rescue of multiple organ failure. One patient (0.5%) died on the way to the hospital due to hematemesis, and the remaining patient (0.5%) died within 1 year due to the recurrence of IE.

Comparison of related factors between the death group and the non-death group

There were no significant differences between the two groups in terms of age, surgery time, preoperative white blood cell count, preoperative haemoglobin, preoperative serum creatinine, preoperative erythrocyte sedimentation rate, duration of vasoactive drug use, sex, underlying diseases, preoperative hypertension, cerebrovascular disease, liver disease, diabetes, chronic lung disease, pneumonia, type of surgery, blood culture results of pathogens, echocardiographic results of vegetation formation and valve perforation or tear, or affected valve (P>0.05).

Table 5 shows that the preoperative hematocrit was lower in the death group compared to the non-death group. Additionally, the operation time, hematocrit,

Table 5 Comparison of related factors between the death group and non-death group

Factor	Death group (n=11)	Non-death group (n=210)	t/χ^2	P value
Age (years)	43.46±15.03	39.23±14.25	0.738	0.46
Operation time (min)	374±164.49	263±88.00	2.905	0.004
White blood cell count before operation ($\times10^9$/L)	8.49±4.36	8.54±3.60	0.529	0.60
Hematocrit	0.31±0.03	0.35±0.06	1.991	0.047
Serum creatinine (μmol/L) before operation	81.80±28.24	74.28±24.92	1.030	0.30
Creatinine clearance	90.50±40.11	96.95±30.04	0.851	0.40
Preoperative platelet count ($\times10^9$/L)	201.11±78.89	228.43±93.92	1.099	0.27
Cross-clamp time (min)	112±69.31	87±40.76	0.987	0.32
cardiopulmonary bypass time (min)	217±133.64	140±56.23	2.733	0.006
EuroSCORE II	0.08±0.09	0.06±0.49	2.659	0.008
Gender			0.057	0.81
Male (n=164)	9	155		
Female (n=57)	2	55		
Basic diseases				
Rheumatic valvular heart disease (n=5)	1	4	0.273	0.60
Bicuspid aortic valve disease (n=55)	4	51	0.298	0.59
Congenital heart disease (n=43)	2	41	0	>0.99
Rupture of aortic sinus aneurysm (n=11)	0	11	0	>0.99
NYHA cardiac function grading			2.266	0.023
Grade I (n=2)	0	2		
Grade II (n=27)	0	27		
Grade III (n=160)	7	153		
Grade IV (n=32)	4	28		
Preoperative complications				
Hypertension (n=21)	2	19	0.023	0.63
Cerebrovascular diseases (n=61)	5	56	1.026	0.31
Liver diseases (n=27)	4	23	4.147	0.042
Diabetes (n=10)	1	9	0.000	>0.99
Chronic lung disease (n=18)	0	18	0.200	0.65
Pneumonia (n=49)	3	46	0.002	0.96
Arrhythmia (n=93)	8	85	1.374	0.24
Patient admission status			2.211	0.14
Emergency operation (n=47)	5	42		
Elective surgery (n=174)	6	168		

Table 5 (*continued*)

Table 5 (*continued*)

Factor	Death group (n=11)	Non-death group (n=210)	t/χ^2	P value
Results of blood culture pathogens			1.811	0.18
Positive (n=107)	8	99		
Negative (n=113)	3	110		
Types of transthoracic echocardiography				
Vegetation formation (n=212)	10	202	0.037	0.85
Valve perforation or tear (n=42)	2	40	1.129	0.29
Perivalvular abscess formation (n=9)	0	9	0.005	0.95
Affected valve				
Single valve involvement (n=110)	7	103	0.402	0.53
Multiple valves involved (n=97)	4	93	0.042	0.84

Data are presented as n. NYHA, New York Heat Association.

Table 6 Description of assignment of the main independent variables

Variable	Variable classification	Assignment situation
Hematocrit	Continuous variable	–
Cardiopulmonary bypass time	Continuous variable	–
Operation time	Continuous variable	–
EuroSCORE II	Continuous variable	–
NYHA cardiac function grading	Categorical variable	0= grade I, 1= grade II, 2= grade III, and 3= grade IV
Liver diseases	Categorical variable	1= merged, 0= not merged

NYHA, New York Heat Association.

cardiopulmonary bypass (CPB) time, EuroSCORE II, NYHA cardiac function classification, and liver diseases ratio were higher in the death group than in the non-death group (P=0.004, 0.047, 0.006, 0.008, 0.023).

Multivariate analysis on the 1-year mortality rate of patients with IE

Adverse events were documented for all participants, regardless of severity. To determine variables associated with IE-related mortality within 1 year, a multivariable logistic regression analysis was conducted. This analysis included the statistically significant indicators listed in *Table 5* as independent variables (with assigned values from *Table 6*) and the survival status of patients with IE within 1 year as the dependent variable (1= death, 0= non-death). The logistic regression analysis revealed that an increase in EuroSCORE II, prolonged operation time, high NYHA cardiac function classification, and liver diseases were identified as risk factors that affect the mortality of patients with IE within 1 year. The odds ratios for these factors were 1.003, 0.000, 1.006, 1.026, and 1.624, respectively (P<0.05; see *Table 7*). The Kaplan-Meier curve performed to present survival status of patients with post-operation for 1-year follow-up (see *Figure 1*).

Discussion

Cardiac conditions that increase the risk of IE include congenital diseases such as ventricular septal defect and bicuspid aortic valve, as well as acquired valvular diseases such as degenerative valvular disease, aortic stenosis, and rheumatic heart disease. To assess preoperative factors, clinical baseline, and emergency surgery experience of a

Table 7 Multivariate logistic regression analysis on the mortality of patients with IE within 1 year

Index	β	SE	Wald	P value	OR	95% CI
Operation time	0.003	0.006	0.202	0.65	1.003	0.990–1.016
Hematocrit	–10.216	7.787	1.721	0.19	0.000	0.000–155.534
Cardiopulmonary bypass time	0.006	0.009	0.363	0.55	1.006	0.988–1.024
EuroSCORE II	0.025	0.059	0.185	0.67	1.026	0.914–1.151
NYHA cardiac function grading	0.485	0.727	0.445	0.51	1.624	0.390–6.757
Liver diseases	1.557	0.822	3.587	0.058	4.746	0.947–23.781
Constant	–3.549	3.576	0.985	0.32	0.029	–

IE, infective endocarditis; SE, standard error; OR, odds ratio; CI, confidence interval; NYHA, New York Heat Association.

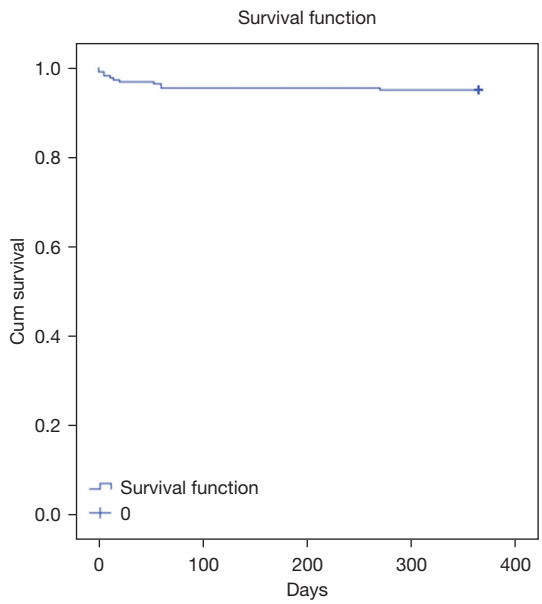

Figure 1 Kaplan-Meier curve for 1-year follow-up of 221 patients.

special and heterogeneous group of patients with IE from this high-altitude underdeveloped region, considering its unique minority population, dietary structure, medical care situation, environment, and climate. This study retrospectively examined the epidemiological characteristics with surgical outcomes and identified the risk factors that affect the prognosis of 221 patients with IE. In developing countries, rheumatic heart disease is the most common predisposing condition for IE. However, in developed countries, the most frequent predisposing cardiac conditions are degenerative valvular diseases, congenital valvular abnormalities, and intracardiac devices (9,10). Compared to patients who had mechanical valves replacement, those who had biologic valves replacement with a higher recurrence risk of IE among patients who underwent valve replacement (11). Correct diagnosis and treatment of IE is a major clinical concern due to its significant mortality and disability rate (12). In recent years, medical technology has advanced, improving the standard of life. Immunosuppressants and antibacterial drugs are now widely used, leading to drastic changes in the clinical manifestations, basic etiology, and pathogenic characteristics of IE (13).

Although there have been improvements in the treatment, prevention, and diagnosis of IE, most epidemiological studies indicate a rise in the incidence and mortality of IE. For example, from 2000 to 2019, the reported incidence of IE was about 15/100,000, and the mortality rate during hospitalization was as high as 20–30% (14,15). A study conducted in China (16) found that the annual incidence of IE ranges from 2/100,000 to 6/100,000. Risk factors for IE in developed countries include primitive heart disease, a history of venous catheter treatment, intracardiac implants, dental procedures, and drug abuse. In China and most developing countries, rheumatic valvular heart disease is a risk factor for IE.

In this study, 221 patients with IE were analyzed. Of these, 87.3% (193/221) had underlying heart conditions, including rheumatic valvular disease, bicuspid aortic valve disease, and congenital heart disease, which accounted for 2.7%, 24.9%, and 19.5% of cases, respectively. The mean age of onset was relatively young at around 39 years. This is in agreement with Abdelgawad *et al.* (17). However, there are differences in risk factors between Yunnan and other regions in China (18). This study found that rheumatic valvular heart disease was the main risk factor, while Ma

et al. (19) and Wu *et al.* (20) found that congenital heart disease and rheumatic heart disease were the main risk factors. This difference may be related to the relatively lower level of Yunnan's economy and medical care compared to North and Central China. This may reflect the existence of IE characteristics and population differences among different regions.

Analysis of blood culture results of IE-positive blood culture is one of the key factors for a diagnosis of IE. Detection of pathogenic bacteria and drug sensitivity tests are conducive to guiding the correct and standardized use of antibiotics. Xu *et al.* (21) retrospectively analyzed the clinical data of 135 patients with confirmed IE and 39 patients with suspected IE from 2008 to 2015. The results showed that the positive rate of blood culture was 60.3%, with *Streptococcus* being the main pathogen identified in the positive blood culture (61.9%). Zhang *et al.* (22) also found *Streptococcus* to be the most common pathogen, accounting for 52.9% of all positive blood culture findings. In our, all 221 patients with IE received blood cultures after admission, and the positive rate of blood culture was 43.89% (97/221). *Streptococcus viridans* and *Streptococcus sanguis* were the most common pathogens, accounting for 34.0% and 14.4% of the positive blood culture findings, respectively, which was consistent with the above-mentioned reports from China. In developed countries, *Staphylococcus aureus* is the prevalent pathogenic microorganism of IE (23). More than 90% of these patients have a history of recurrent fever, which lasts for 1 week to 1 month. After recovery, they do not continue to be treated. Subsequently, the symptoms of fever recur with shortness of breath and chest tightness, which causes the patients to receive antibiotic treatment before admission, so the positive blood culture after admission is not high. Therefore, we prefer to recommend the precise microbiologic diagnosis through positive blood cultures is essential for the appropriate utilization of sensitive antibiotics and contributes to perioperative reduction of the risk of an extensive inflammatory response.

The detection of *Streptococcus viridans* in blood culture is a major concern in both high and low-income countries (24). It is important to note that certain strains of *Streptococcus viridans* can be highly aggressive and difficult to detect even with advanced techniques such as rnpB genotyping and matrix-assisted laser desorption/ionization time-of-flight systems (25). In Kim's study (26), *Streptococcus viridans* was isolated in 38% of patients who received a mechanical valve. In these circumstances, it is important to carefully consider the decision to implant a mechanical valve due to the high rate of recurrence and the increased risk of mortality after reinfection. A study conducted in a community hospital in New York City (27), which captured a real-life picture of patients with IE based on modified Duke criteria, revealed a mortality rate of 27.7% in patients with prosthetic heart valves, compared with only 8.11% in patients with native heart valves. However, this study reported lower mortality rates based on single-center experience and a specified time period.

Standard antibiotic therapy is the recommended treatment for IE. However, due to the prevalence of drug-resistant bacteria and the rapid progression of the disease, surgical treatment is required for over half of these patients. Surgery can clear infected tissues and vegetation, restore heart structure, reduce critical organ embolisms caused by vegetation shedding, and slow the progression of heart failure (28-30).

In our study, a total of 221 patients underwent surgery, 171 elective and 50 emergencies. The main surgical procedures performed were double-valve and single-valve surgeries. The mortality rate within 1 year after the operation was 5.0%, which is significantly lower than the 34.6% reported by Peláez Ballesta *et al.* (31). Most of the six patients who died during the perioperative period in this study did so as a result of severe cerebrovascular accidents and multiple organ failure caused by low cardiac output syndrome. It is possible that IE causes myocardial injury and long-term bacteremia can erode the blood vessel wall. Additionally, prolonged extracorporeal circulation surgery will affect the cardiac on the other complications, such as heparinization of the blood significantly increases the risk of bleeding, postoperative low cardiac output syndrome and cerebrovascular accidents (32). Further logistic regression analysis revealed that an increase in preoperative C-reactive protein level, prolonged cross-clamp time, high NYHA cardiac function grade, preoperative arrhythmia, and perivalvular abscess were identified as risk factors that affect the mortality of patients with IE within 1 year.

Our findings can be explained in this way. CPB is an essential auxiliary method in open heart surgery. However, it can induce an inflammatory reaction and release inflammatory mediators such as C-reactive protein, which can have a negative impact on microcirculation similar to severe sepsis. This is particularly relevant in cases where there is an increase in preoperative C-reactive protein level and prolonged cross-clamp time. To mitigate this, it is important to closely monitor the patient's inflammatory response and take appropriate measures to manage it.

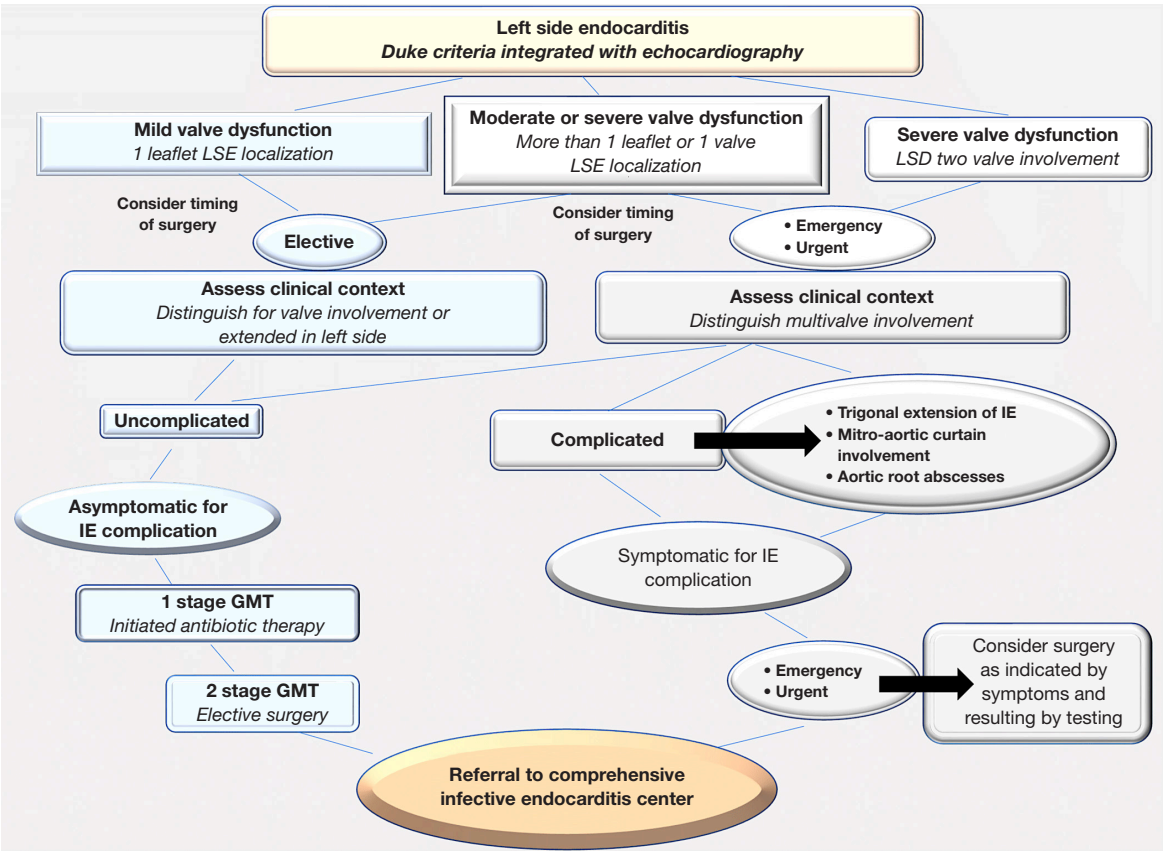

Figure 2 Flowchart for diagnosis and treatment of patients with IE according to Duke criteria integrated with echocardiography. From reference (34) with permission. LSE, left sided endocarditis; LSD, left side dysfunction ; GMT, guide medical therapy; IE, infective endocarditis.

Prolonged CPB can reduce perfusion to vital organs such as the lungs, heart, brain, and kidneys, leading to acute organ injury and increased long-term mortality. A retrospective analysis by Jakuska *et al.* (33) found that cardiopulmonary bypass times over 107.5 minutes and intraoperative CPB times over 84.5 minutes are independent risk factors for early postoperative death in patients with IE, which is consistent with our study. To repair the heart structure and remove necrotic tissue and vegetation during the operation, it is important to simplify the procedure, control the CPB time, and reduce the preoperative C-reactive protein level. This can improve the postoperative survival rate of patients.

Echocardiography may overestimate the ejection fraction due to valve structure and function in some IE patients who experience hemodynamic changes before surgery. However, these patients are generally more susceptible to developing arrhythmias. Preoperative cardiac function can reflect the degree of damage caused by diseases to heart valves and other functions and structures. Patients with reduced cardiac function may have limited tolerance to cardiopulmonary bypass and heart surgery.

Perivalvular abscess can lead to the damage of fiber conduction structure between valves, pseudoaneurysm, intracardiac fistula, and aortic root rupture, thus increasing the difficulty of the operation and elevating the postoperative risk of serious complications such as perivalvular fistula and malignant arrhythmia (*Figure 2*) (34).

The study's main limitation lies in its retrospective design and the examination of a rare and specific disease. However, a key limitation is the low incidence rate of IE, coupled with a lack of awareness and financial resources among the local population based on single-center experience and a specified period. This leads to a lack of enthusiasm for treatment and a shortage of willingness to participate in follow-up. Additionally, the sample sizes of the enrolled participants were small, and the follow-up period for complications,

progression, or survival after surgical treatment was relatively short. Therefore, the results may not be applicable to populations in other low-altitude and developed regions. Further investigation is required to determine the long-term effectiveness of therapy for complications in patients with IE after surgery.

Conclusions

In the population of Gaoligong mountain area of Yunnan, IE was more common in young and middle-aged men, with rheumatic valvular heart disease being the predominant underlying heart condition. The most common pathogen was *Streptococcus viridans*. Surgical intervention significantly reduced early mortality. Patients with specific risk factors should be closely monitored to improve postoperative prognosis. In summary, IE primarily affects young and middle-aged men. The most common underlying heart diseases were bicuspid aortic valve disease, congenital heart disease, rupture of aortic sinus aneurysm and rheumatic valvular disease. *Streptococcus viridans* was the most common pathogen. Surgery effectively reduces early mortality in patients with IE. Clinicians should be vigilant for patients at high risk, including those with elevated preoperative C-reactive protein levels, prolonged cross-clamp time, high NYHA cardiac function grade, preoperative arrhythmia, and perivalvular abscess formation. This will help to improve the postoperative prognosis of patients.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-470/rc

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was approved by the Human Investigation Committee of the Yan'an Hospital Affiliated to Kunming Medical University (No. 2021-039-01). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Informed consent was not required as this is a retrospective study.

References

1. Zhu X, Wang Z, Ferrari MW, et al. Management of anticoagulation in patients with infective endocarditis. Thromb Res 2023;229:15-25.
2. Delgado V, Ajmone Marsan N, de Waha S, et al. 2023 ESC Guidelines for the management of endocarditis. Eur Heart J 2023;44:3948-4042. Correction appears in Eur Heart J 2024;45:56.
3. Wang F, Zhou Z, Teng J, et al. The clinical pattern differentiates ANCA-positive infective endocarditis patients from ANCA-associated vasculitis patients: a 23 years' retrospective cohort study in China and follow-ups. Clin Rheumatol 2022;41:3439-49.

4. Wu Z, Chen Y, Xiao T, et al. The clinical features and prognosis of infective endocarditis in the elderly from 2007 to 2016 in a tertiary hospital in China. BMC Infect Dis 2019;19:937.
5. Shah ASV, McAllister DA, Gallacher P, et al. Incidence, Microbiology, and Outcomes in Patients Hospitalized With Infective Endocarditis. Circulation 2020;141:2067-77.
6. Kang DH, Kim YJ, Kim SH, et al. Early surgery versus conventional treatment for infective endocarditis. N Engl J Med 2012;366:2466-73.
7. Pecoraro AJK, Herbst PG, Janson JT, et al. Early surgery determines prognosis in patients with infective endocarditis: outcome in patients managed by an Endocarditis Team-a prospective cohort study. Cardiovasc Diagn Ther 2022;12:453-63.
8. Said SM, Abdelsattar ZM, Schaff HV, et al. Outcomes of surgery for infective endocarditis: a single-centre experience of 801 patients. Eur J Cardiothorac Surg 2018;53:435-9.
9. Murdoch DR, Corey GR, Hoen B, 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.
10. Ambrosioni J, Hernandez-Meneses M, Téllez A, et al. The Changing Epidemiology of Infective Endocarditis in the Twenty-First Century. Curr Infect Dis Rep 2017;19:21.
11. Anantha-Narayanan M, Reddy YNV, Sundaram V, et al. Endocarditis risk with bioprosthetic and mechanical valves: systematic review and meta-analysis. Heart 2020;106:1413-9.
12. Montané B, Chahine J, Fiore A, et al. Diagnostic performance of contemporary transesophageal echocardiography with modern imaging for infective endocarditis. Cardiovasc Diagn Ther 2023;13:25-37.
13. Liu X, Miao Q, Liu X, et al. Outcomes of surgical treatment for active infective endocarditis under COVID-19 pandemic. J Card Surg 2022;37:1161-7.
14. Hubers SA, DeSimone DC, Gersh BJ, et al. Infective Endocarditis: A Contemporary Review. Mayo Clin Proc 2020;95:982-97.
15. Casabé JH. Infective endocarditis, a disease in constant evolution. Medicina (B Aires) 2019;79:322-4.
16. Yuan XC, Liu M, Hu J, et al. Diagnosis of infective endocarditis using echocardiography. Medicine (Baltimore) 2019;98:e17141.
17. Abdelgawad H, Azab S, Abdel-Hay MA, et al. Clinical features and outcomes of infective endocarditis: a single-centre experience. Cardiovasc J Afr 2023;34:82-8.
18. Xu H, Liu Q, Cao K, et al. Distribution, Characteristics, and Management of Older Patients With Valvular Heart Disease in China: China-DVD Study. JACC Asia 2022;2:354-65.
19. Ma L, Ge Y, Ma H, et al. Infective endocarditis at a tertiary-care hospital in China. J Cardiothorac Surg 2020;15:135.
20. Wu Z, Chen Y, Xiao T, et al. Epidemiology and risk factors of infective endocarditis in a tertiary hospital in China from 2007 to 2016. BMC Infect Dis 2020;20:428.
21. Xu H, Cai S, Dai H. Characteristics of Infective Endocarditis in a Tertiary Hospital in East China. PLoS One 2016;11:e0166764.
22. Zhang X, Jin F, Lu Y, et al. Clinical Characteristics and Risk Factors for in-Hospital Mortality in 240 Cases of Infective Endocarditis in a Tertiary Hospital in China: A Retrospective Study. Infect Drug Resist 2022;15:3179-89.
23. Ambrosioni J, Hernández-Meneses M, Durante-Mangoni E, et al. Epidemiological Changes and Improvement in Outcomes of Infective Endocarditis in Europe in the Twenty-First Century: An International Collaboration on Endocarditis (ICE) Prospective Cohort Study (2000-2012). Infect Dis Ther 2023;12:1083-101.
24. Nappi F, Spadaccio C, Acar C. Use of allogeneic tissue to treat infective valvular disease: Has everything been said? J Thorac Cardiovasc Surg 2017;153:824-8.
25. Isaksson J, Rasmussen M, Nilson B, et al. Comparison of species identification of endocarditis associated viridans streptococci using rnpB genotyping and 2 MALDI-TOF systems. Diagn Microbiol Infect Dis 2015;81:240-5.
26. Kim JB, Ejiofor JI, Yammine 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;151:1239-1248, 1248.e1-2.
27. Alkhawam H, Sogomonian R, Zaiem F, et al. Morbidity and mortality of infective endocarditis in a hospital system in New York City serving a diverse urban population. J Investig Med 2016;64:1118-23.
28. Shmueli H, Thomas F, Flint N, et al. Right-Sided Infective Endocarditis 2020: Challenges and Updates in Diagnosis and Treatment. J Am Heart Assoc 2020;9:e017293.
29. Del Val D, Panagides V, Mestres CA, et al. Infective Endocarditis After Transcatheter Aortic Valve Replacement: JACC State-of-the-Art Review. J Am Coll Cardiol 2023;81:394-412.
30. Kubota H, Minegishi S, Inaba Y, et al. Sutureless aortic

valve replacement in patients with active infective endocarditis: is it contraindicated or recommended? J Thorac Dis 2022;14:4586-9.
31. Peláez Ballesta AI, García Vázquez E, Gómez Gómez J. Infective endocarditis treated in a secondary hospital: epidemiological, clinical, microbiological characteristics and prognosis, with special reference to patients transferred to a third level hospital. Rev Esp Quimioter 2022;35:35-42.
32. Lee J, Lim HA, Hong SB, et al. Is preoperative intracranial hemorrhage a surgical contraindication in infective endocarditis with stroke? J Thorac Dis 2023;15:4765-74.
33. Jakuska P, Ereminiene E, Muliuolyte E, et al. Predictors of early mortality after surgical treatment of infective endocarditis: a single-center experience. Perfusion 2020;35:290-6.
34. Nappi F, Spadaccio C, Moon MR. A management framework for left sided endocarditis: a narrative review. Ann Transl Med 2020;8:1627.

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