

"Microbial Profiling and Hematological Evaluation of Postoperative Infections in Pediatric Cardiac Surgery Patients with Congenital Heart Disease"

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ABSTRACT

Background: Children undergoing cardiac surgery for congenital heart disease are indeed a vulnerable population, prone to developing various infections due to several factors. These young patients often require invasive medical interventions, prolonged hospital stays and exposure to multiple devices such as ventilators, central venous catheters, and urinary catheters, all of which increase their risk of acquiring nosocomial infections.

Objectives: This study aimed to investigate the prevalence and microbiology of nosocomial infections and hematological assessment in children with congenital heart disease (CHD) after cardiac surgery.

Methodology: A cross-sectional study was conducted and taken data from 135 pediatric patients who underwent open-heart surgery between 2023-2024. Demographic and clinical information were recorded, and findings were analyzed using SPSS 21.

Results: Among 135 patients, 68 developed infections (11.96% prevalence), with 81 males (60.1%) and 54 females (39.9%), and a mean age of 8.06 ± 3.86 months. The most common pathogens were Acinetobacter (14.1%), Pseudomonas spp. (9.6%), Enterobacter (9.6%), Corynebacterium diphtheria (7.4%), Staphylococcus epidermidis (7.4%), and Candida albicans (10.4%). Infection rates didn't differ significantly across cardiac abnormalities, sex, age, or weight groups. However, patients with positive cultures had longer hospital stays, intubation, bypass time, and urinary catheterization.

Conclusions: The most common infections in children after heart surgery were caused by Acinetobacter, C. albicans, Pseudomonas, and Enterobacter. Reducing hospitalization, intubation, bypass, and urinary catheterization time may help decrease nosocomial infections and treatment costs

Keywords: *Prevalence, cardiac surgery, children, nosocomial infection, congenital heart diseases*

1. INTRODUCTION

Congenital heart disease stands as the most prevalent form of genetic disorder among children, with studies indicating a birth prevalence ranging between 6 to 13 cases per 1000 live births. Notably, a significant proportion of these children, exceeding half, require surgical intervention within their first year of life[1,2]. This population is particularly vulnerable to infections, not only in terms of frequency but also severity. The susceptibility to infections is further compounded by certain types of congenital heart disease that are associated with genetic disorders, which can lead to varying degrees of immunodeficiency[3-7]. Consequently, children undergoing cardiac surgery are at an increased risk of developing nosocomial infections, a complication that can significantly impact their recovery and outcome.

Post-cardiac surgery infections are a well-documented risk, contributing to heightened morbidity, prolonged intensive care unit (ICU) stays and increased mortality rates. The microbial spectrum responsible for these infections can vary widely depending on the nature and site of the surgical procedure[8,9]. Given the severity of these infections and their implications for patient care, it is imperative to establish a comprehensive understanding of the epidemiological patterns of the causative pathogens[10]. Such knowledge would enable more targeted and effective antibiotic prophylaxis strategies, ultimately improving the outcomes for these vulnerable patients. In light of this, our study aimed to investigate and delineate the microbiological profile of pathogens responsible for infections following cardiac surgery in children with congenital heart disease, thereby contributing to the development of more precise and effective infection control measures[11-13]. Numerous studies have investigated postoperative infections in pediatric patients undergoing cardiac surgery, with surgical site infections being the most prevalent, affecting 1.2% to 48% of cases[14]. The variability in reported prevalence rates can be attributed to differences in several key factors, including body mass index (BMI), duration of cardiopulmonary bypass, length of surgery, age (particularly under one month), blood transfusions, intravenous nutrition, duration of central venous catheter placement, significant bleeding within 24 hours post-surgery, and inappropriate timing of preoperative antibiotics[15-17].

The microbial landscape of surgical site infections in this population is diverse, with common pathogens including *Staphylococcus aureus*, Coagulase-negative staphylococci, *Escherichia coli*, *Enterococcus faecalis* and *Pseudomonas* spp. Notably, the past decade has seen a shift in the epidemiology of these infections, with a decline in Gram-negative bacilli and a corresponding rise in infections attributed to *S. aureus*[18]. This changing pattern highlights the importance of ongoing surveillance and tailored antimicrobial strategies to effectively manage and prevent postoperative infections in children undergoing cardiac surgery. Understanding these trends is crucial for developing evidence-based guidelines and improving patient outcomes.

Despite the significance of congenital heart disease and its associated risks of complications and mortality, research on the prevalence, contributing factors, and treatment outcomes remains limited[19,20]. While studies in both developed and developing countries have shed some light on surgical infections in children with congenital heart disease, these investigations are often hindered by constraints such as small sample sizes and the potential for errors in retrospective data collection[21]. Nonetheless, existing evidence underscores the high prevalence of infections following cardiac surgeries in this vulnerable population.

Identifying the most common pathogens responsible for these infections is crucial for developing targeted prevention strategies. By doing so, healthcare providers can reduce the incidence of nosocomial infections, thereby decreasing hospitalization costs and lengths of stay. Moreover, informed antimicrobial stewardship can minimize the unnecessary use of broad-spectrum antibiotics, which is a key driver of antibiotic resistance. Additionally, rigorous adherence to infection control principles, including thorough disinfection of surfaces and equipment, can significantly mitigate the risk of these infections. By prioritizing these measures, healthcare facilities can improve patient outcomes and reduce the burden of surgical site infections in children with congenital heart disease.

2. OBJECTIVES

The study highlighted that the Children with congenital heart disease are more prone to severe infections, which increases their risk of developing nosocomial infections and subsequent surgical complications. To better understand the causes and risk factors associated with these infections, further research is necessary. Our study aims to investigate the microbial pathogens responsible for post-cardiac surgery infections and explore potential differences in infection patterns based on age, sex, type of disease, and length of hospitalization. By shedding light on these factors, we can inform preventive measures and improve patient outcomes.

3. METHODOLOGY

This cross-sectional study reviewed the medical records of 135 pediatric patients who underwent cardiac surgery for congenital and structural heart diseases, between 2023 and 2024. The study collected demographic data, including age (ranging from less than one month to 36 months), sex, and weight. Additionally, medical information was gathered on hospitalization duration, underlying heart conditions, history of nosocomial infections, infection locations and microbiological results from laboratory samples (including sputum, blood, urine, and surgical wound samples). The study

focused on various types of nosocomial infections, such as ventilator-associated infections, pneumonia, sepsis, urinary tract infections and surgical site infections. The study population consisted of all patients with congenital, structural or valvular heart diseases who underwent palliative or corrective surgery in the pediatric cardiac surgery intensive care unit.

4. STATISTICAL ANALYSIS

The collected data were analyzed using SPSS version 21. A p-value of less than 0.05 was deemed statistically significant. Descriptive statistics, including mean, standard deviation, frequency and percentage were used to summarize the variables. To compare qualitative and quantitative data, the chi-square test and t-test (or its non-parametric equivalent) were employed, allowing for the identification of significant relationships and differences within the data.

5. RESULTS

The study consisted of 135 patients who underwent cardiac surgery, with a male predominance of 60.1% (81 patients) and a female proportion of 39.9% (54 patients). The mean age of the patients was 8.06 months, with a standard deviation of 3.86 months. Notably, the majority of patients (66.7%, n=90) were under the age of one month, highlighting the vulnerability of this age group to congenital heart defects requiring surgical intervention.

The most common congenital heart defects observed in the study population were ventricular septal defect (VSD), affecting 32.9% (45 patients) of the cohort, followed by atrial septal defect (ASD) in 21.9% (32 patients), and atrioventricular septal defect (AVSD) in 10.5% (22 patients) of the patients.

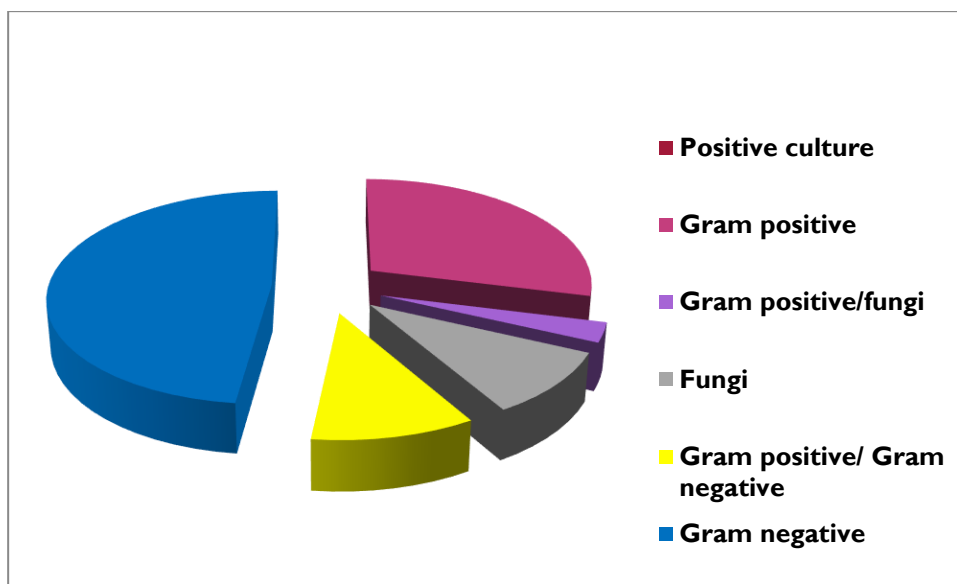


Figure 1 showed the details of study population with positive cultures

In terms of nosocomial infections, the study found that ventilator-related infections were the most prevalent, accounting for 36% of all reported infections. Catheter-related urinary tract infections were the second most common, making up 29% of the infections, followed by surgical wound site infections (16%), sepsis (8%), and skin and soft tissue infections (11%). These findings underscore the importance of implementing effective infection control measures in the hospital setting, particularly for patients undergoing cardiac surgery.

The microbiological analysis of the study cohort revealed a diverse range of pathogens associated with nosocomial infections. Among the Gram-negative bacteria, *Acinetobacter* species were the most prevalent, isolated from 14.1% (14/135) of the patients. *Pseudomonas* spp. and *Enterobacter* species were also commonly encountered, each accounting for 9.6% (13/135) of the isolates. These findings highlight the significant role of Gram-negative bacteria in hospital-acquired infections, particularly in patients undergoing cardiac surgery.

In addition to Gram-negative bacteria, Gram-positive cocci were also represented in the study, with *Corynebacterium diphtheria*, *Staphylococcus epidermidis*, and *S. aureus* each isolated from 7.4% (10/135) of the patients. These pathogens are known to cause a range of infections, from skin and soft tissue infections to more severe conditions such as bacteremia and endocarditis.

Table 1. Study Population Characteristics and Identified Bacterial Types

Characteristic	No. (%)
Age	
< 1 month	90 (66.7)
2 - 5	26 (19.3)
6 - 10	7 (5.2)
11 - 15	3 (2.2)
16 - 20	0 (0)
21 - 25	3 (2.2)
26 - 30	4 (3.0)
≥ 31	2 (1.5)
Sex	
Male	80 (60.1)
Female	55 (39.9)
Hospitalization unit	
ICUA	3 (1.9)
ICUB	62 (48.6)
ICUC	2 (1.0)
ICUD	2 (1.0)
NICU	9 (6.7)
open-heart surgery ICU	44 (31.4)
Children ward	2 (1.0)
open-heart surgery ward	11 (8.6)
Final diagnosis	
VSD	45 (32.9)
ASD	32 (21.9)
AVSD	22 (10.5)
PDA	8 (7.7)
TOF	6 (5.6)
Cardiomyopathy	6 (5.6)
PS	4 (4.0)
PH	4 (4.0)
TGA	1 (1.0)
CAD	1 (1.0)

COA	1 (1.0)
TAPVC	1 (1.0)
Lupus+ cardiac tamponade	1 (1.0)
Heart failure	3 (2.8)
Bacteria type	
<i>Acinetobacter</i>	19 (14.1)
<i>Candida albicans</i>	14 (10.4)
<i>Pseudomonas spp.</i>	13 (9.6)
<i>Enterobacter</i>	13 (9.6)
<i>Corynebacterium diphtheriae</i>	10 (7.4)
<i>Staphylococcus epidermidis</i>	10 (7.4)
Methicillin-resistant <i>Staphylococcus epidermidis</i>	8 (5.9)
<i>Klebsiella</i>	7 (5.2)
<i>Hemolytic Staphylococcus</i>	7 (5.2)
<i>Enterococcus</i>	6 (4.4)
<i>Escherichia coli</i>	4 (3.0)
Multidrug resistant <i>Acinetobacter</i>	3 (2.2)
Gram-negative bacilli	2 (1.5)
<i>Stenotrophomonas maltophilia</i>	2 (1.5)
<i>Vancomycin-resistant Enterococcus</i>	1 (0.7)
Methicillin-resistant <i>Staphylococcus aureus</i>	1 (0.7)
<i>Micrococcus</i>	1 (0.7)
<i>Coagulase-negative staphylococci</i>	1 (0.7)
Gram-positive bacilli	1 (0.7)

Fungal pathogens were also identified in the study, with *Candida albicans* being the most common fungal isolate, detected in 10.4% (14/135) of the patients. This finding underscores the importance of considering fungal infections in the differential diagnosis of patients with suspected nosocomial infections, particularly those with prolonged hospital stays or exposure to broad-spectrum antibiotics. The detailed distribution of all identified bacterial strains is presented in Table 1, providing valuable insights into the microbiological epidemiology of nosocomial infections in this patient population.

Table 2 showed the Distribution of Bacteria Based on Age and Disease type

Bacteria Type	Age; No. (%)							
	< 1 Month	2 - 5	6 - 10	11 - 15	21 - 25	26 - 30	≥ 31	Total
<i>Corynebacterium diphtheriae</i>	7 (7.8)	1 (3.8)	2(28.6)	0	0	0	0	10 (7.4)

<i>Staphylococcus epidermidis</i>	7 (7.8)	1 (3.8)	2(28.6)	0	0	0	0	10 (7.4)
Methicillin-resistant <i>Staphylococcus epidermidis</i>	5 (5.6)	1 (3.8)	1(14.3)	0	0	0	1(50.0)	8 (5.9)
<i>Klebsiella</i>	4 (4.4)	2 (7.7)	0	0	0	1(25.0)	0	7 (5.2)
<i>Acinetobacter</i>	15(16.7)	4(15.4)	0	0	0	0	0	19 (14.1)
<i>Enterococcus</i>	5 (5.6)	0	0	0	0	0	1(50.0)	6 (4.4)
Vancomycin-resistant <i>Enterococcus</i>	1 (1.1)	0	0	0	0	0	0	1 (0.7)
<i>Pseudomonas</i> spp.	6 (6.7)	5(19.2)	1(14.3)	0	0	1(25.0)	0	13 (9.6)
<i>Enterobacter</i>	9 (10.0)	2(7.7)	0	2(66.7)	0	0	0	13 (9.6)
Hemolytic <i>Staphylococcus</i>	4 (4.4)	1 (3.8)	0	1(33.3)	1(33.3)	0	0	7 (5.2)
<i>Candida albicans</i>	10(11.1)	2(7.7)	1(14.3)	0	0	0	1(50)	14 (10.4)
<i>Escherichia coli</i>	4 (4.4)	0	0	0	0	0	0	4 (3.0)
Methicillin-resistant <i>Staphylococcus aureus</i>	1 (1.1)	0	0	0	0	0	0	1 (0.7)
Gram-negative bacilli	1 (1.1)	1(3.8)	0	0	0	0	0	2 (1.5)
Multidrug resistant <i>Acinetobacter</i>	1 (1.1)	0	0	0	1(33.3)	0	0	3 (2.2)
<i>Stenotrophomonas maltophilia</i>	2 (2.2)	0	0	0	0	0	0	2 (1.5)
<i>Micrococcus</i>	1 (1.1)	0	0	0	0	0	0	1 (0.7)
Coagulase-negative staphylococci	0	1 (3.8)	0	0	0	0	0	1 (0.7)
Gram-positive bacilli	0	0	1(14.3)	0	0	0	0	1 (0.7)

The distribution of age and bacterial types was analyzed between male and female patients, revealing that certain pathogens, including *Klebsiella*, vancomycin-resistant enterococci, *E. coli*, methicillin-resistant *S. aureus*, Coagulase-negative staphylococci, and Gram-positive bacilli, were more prevalent in males. However, some bacteria, such as *Enterococcus* and *C. albicans*, showed equal prevalence in both sexes. Although other bacteria were more frequent in females, the differences in bacterial distribution between males and females were not statistically significant ($P = 0.621$).

In terms of age, the majority of positive cultures were found in patients under ten months old, with a particular concentration in one-month-old infants. Notably, *Acinetobacter* was isolated from 15 out of 19 positive cultures in subjects under one month of age, while *C. albicans* was also more common in this age group (10 out of 14 cases). Despite these observations, the differences in bacterial distribution across age groups were not statistically significant ($P = 0.571$). The detailed frequency of isolated bacteria by age group is presented in Table 2.

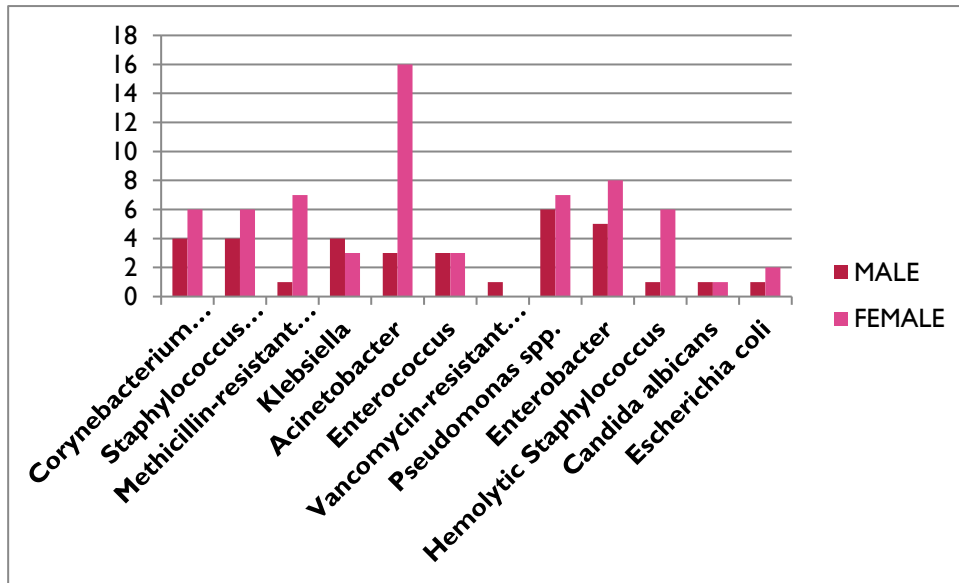


FIG 2 showed the Distribution of Bacteria Based on gender

Regarding the isolated bacteria in different diseases, *Candida* was the most frequently isolated bacteria in ASD subjects. Moreover, *Acinetobacter* was the most abundant bacteria in VSD and AVSD patients. However, there was no significant difference in terms of the bacteria causing infection between different congenital diseases

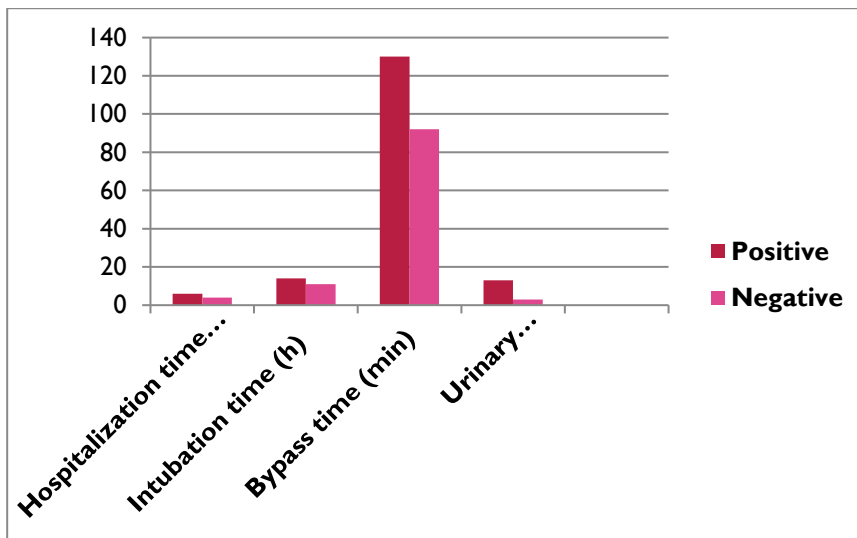


Figure 3 showed the Comparison of Hospitalization, Intubation, Bypass, and Urinary Catheterization Time Between Positive and Negative Cases

The patients were categorized into three weight groups to analyze the distribution of bacterial isolates. Among those weighing less than 5 kg (n=13), the most prevalent bacterium was *Staphylococcus epidermidis*. In the 5-10 kg weight group (n=45), the top three bacteria were *Acinetobacter*, *Staphylococcus aureus* (often co-isolated with *Enterobacter*), and *Enterococcus*. For patients weighing over 10 kg (n=77), the most common pathogens were *Acinetobacter*, *Candida*, *Pseudomonas*, and *Corynebacterium diphtheria*. Notably, statistical analysis revealed no significant difference in the distribution of bacterial types among the three weight groups ($P = 0.786$), suggesting that the type of infecting organism is not strongly influenced by the patient's weight in this study

6. DISCUSSION

This study aimed to investigate the microbial causes of post-cardiac surgery infections in pediatric patients. A total of 135 patients who underwent cardiac surgery were enrolled, and the majority of the subjects were infants. The most common

congenital heart defects observed were ventricular septal defect (VSD), atrial septal defect (ASD), and patent ductus arteriosus (PDA). The microbiological analysis revealed that *Acinetobacter*, *Candida albicans*, *Pseudomonas* spp., *Enterobacter*, *Corynebacterium diphtheria*, and *Staphylococcus epidermidis* were the most prevalent pathogens.

The study found no significant correlation between the type of bacterial species and patient characteristics such as age, sex, weight, or underlying disease. However, a significant difference was observed between patients with positive and negative cultures in terms of duration of hospitalization, intubation, cardiopulmonary bypass time, and urinary catheterization.

The overall prevalence of post-cardiac surgery infections in this pediatric cohort was 11.96%. This rate is consistent with previous studies, which have reported a wide range of nosocomial infection rates, varying from 8.7% to 17.7%[22-24]. A large survey of 11,651 subjects under the age of 10 years reported a nosocomial infection rate of 10.8%, which is comparable to our findings. However, another study reported a significantly higher infection rate of 36% in a smaller cohort of 155 patients[25]. These variations in reported prevalence rates may be attributed to differences in study populations, infection control practices, and diagnostic criteria[26-28].

In this study, the most prevalent pathogens causing infections in infants were *Acinetobacter*, *Candida albicans*, *Enterobacter*, *Pseudomonas* spp., *Corynebacterium diphtheria*, and *Staphylococcus epidermidis*. These findings are consistent with previous research that identified *Staphylococcus epidermidis*, *Staphylococcus aureus*, and *Klebsiella* as common blood-borne pathogens, and methicillin-resistant staphylococci, methicillin-susceptible staphylococci, and other microorganisms as frequent causes of surgical site infections. Other studies have also reported a range of pathogens, including *S. epidermidis*, *Klebsiella*, *Pseudomonas*, *Acinetobacter*, and *Candida*, as common causes of post-cardiac surgery infections in children, although the frequency and ranking of these pathogens varied between studies[29,30].

Our analysis revealed that the distribution of bacterial types was similar across different age, sex, and heart disease groups. While the infection rate was higher in patients under one month old, this difference was not statistically significant. This contrasts with previous studies that identified age as an independent risk factor for surgical site infections after pediatric cardiovascular surgery[31,32]. However, our finding that sex was not a risk factor for infection is consistent with previous research. Notably, we found that prolonged hospitalization, intubation, cardiopulmonary bypass, and urinary catheterization times were significantly associated with positive cultures. These results are in line with previous studies that have reported longer surgery duration, ICU stay, catheter indwelling time, and prior hospital stay as risk factors for nosocomial infections after cardiac surgery. This study is a valuable contribution to the limited body of research on post-cardiac surgery infections in children, particularly in its examination of age distribution and pathogen prevalence across different types of congenital heart disease. The findings of this study have dual implications. Firstly, identifying the causative bacteria of infections in pediatric cardiac surgery patients can inform the selection of empirical antibiotics for treatment and prophylaxis, allowing for more targeted and effective therapy. Additionally, understanding the age-specific distribution of infectious pathogens can guide age-tailored antibiotic prescribing practices. Secondly, this study adds significant evidence to the existing literature on the distribution of pathogens in various age groups and heart diseases, addressing a notable gap in previous research and providing a foundation for future studies.

7. CONCLUSION

In conclusion, this study highlights the significance of nosocomial infections in pediatric patients undergoing cardiac surgery. The findings underscore the importance of strict infection control measures, particularly in the context of invasive medical devices and prolonged hospital stays. The identification of common pathogens such as *Acinetobacter*, *Candida albicans*, and *Pseudomonas* spp. can inform empirical antibiotic therapy and guide targeted interventions to reduce the risk of infection. Further research is needed to develop effective strategies for preventing and managing nosocomial infections in this vulnerable population.

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