



Gram-Positive Blood Stream Infections in Children After Cardiac Surgery

Çocuklarda Kalp Ameliyatı Sonrası Gram-Pozitif Kan Dolaşım Enfeksiyonu

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Abstract

Objective: There are significant risk factors that predispose patients with congenital heart disease (CHD) to bloodstream infections (BSI) following surgery while staying in the pediatric cardiac intensive care unit (PCICU). It's worth noting that there are relatively few studies that have specifically examined gram-positive BSIs in these patients. Therefore, we aimed to evaluate patients with gram-positive BSI who had undergone cardiac surgery and were hospitalized in PCICU.

Material and Methods: We performed a retrospective study of children undergoing cardiac surgery from March 1, 2022, to 31 March 2023 who were admitted to PCICU postoperatively. The study was conducted at Gaziantep Cengiz Gökçek Pediatrics Hospital.

Results: During the study period, gram-positive BSI was observed in 19 (15%) of 126 patients, who were diagnosed with CHD and underwent surgery. Patients with gram-positive BSI were younger than patients with no growth [median (IQR)= 3 months (63)]. Seven patients (15.9%) were diagnosed with cyanotic CHD. Those with gram-positive BSI had longer hospital stays [median (IQR)= 3 months (63)].

Conclusion: The presence of gram-positive BSI in children with CHD, who were hospitalized in PCICU after cardiac surgery adversely affects the length of stay in the hospital, the length of stay in the ICU, and the duration of intubation.

Keywords: Congenital heart disease, coronary intensive care unit, heart surgery, bloodstream infection, pediatrics

Öz

Giriş: Konjenital kalp hastalığı (KKH) nedeniyle ameliyat olup yoğun bakımda izlenen hastalarda kan dolaşım enfeksiyonuna (KDE) yatkınlık yapan önemli riskler bulunmaktadır. Bu hastalardaki gram-pozitif KDE'lerin gösterildiği az sayıda çalışma vardır. Bu nedenle kardiyak cerrahi geçirmiş ve çocuk kalp damar cerrahisi yoğun bakım ünitesi (YBÜ)'nde yatan gram-pozitif KDE olan hastaları değerlendirmeyi amaçladık.

Gereç ve Yöntemler: Çalışmaya 1 Mart 2022 ile Nisan 2023 tarihleri arasında Gaziantep Cengiz Gökçek Kadın Doğum ve Çocuk Hastalıkları Hastanesi, Çocuk Kalp Damar Cerrahisi Yoğun Bakım Servisinde yatarak tedavi gören, KKH nedeniyle ameliyat edilmiş 1 ay-18 yaş arası çocuk hastalar dahil edilmiştir. Çalışma retrospektif bir çalışmadır.

Bulgular: Ameliyat olmuş KKH tanılı 126 hastanın 19'unda (%15) gram-pozitif KDE geliştiği görüldü. Gram-pozitif KDE olan hastalar hiç üremesi olmayan hastalar ile karşılaştırıldığında bu hastalar daha küçük yaştaydı [medyan (IQR)= 3 ay (63)]. Hastaların yedisi (%15.9) siyanotik KKH tanılı idi. Gram-pozitif KDE olanların hastanede yatış süreleri daha uzundu [medyan (IQR)= 3 ay (63)].

Sonuç: Ameliyat sonrası yoğun bakımda yatan ve KKH olan çocuklarda gram-pozitif KDE olması hastanede yatış süresini, YBÜ'de yatış süresini ve entübe kalış süresini olumsuz etkilemektedir.

Anahtar Kelimeler: Konjenital kalp hastalığı, koroner yoğun bakım, kalp cerrahisi, kan dolaşım enfeksiyonu, pediatri

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Introduction

Children with congenital heart disease are among the patient groups that require special care both because of their existing diseases and because of the surgical procedures they have undergone. These children are susceptible to infection as they often have major surgical procedures, cardiopulmonary bypass, extracorporeal membrane oxygenation, multiple transfusions, long-term central venous/arterial access, and long-term hospitalizations. Therefore, laboratory-confirmed bloodstream infections (BSI) are expected to be common in children after congenital heart surgery, but the published studies on this subject are limited (1-4). Although most of them are considered surgical site infections, the frequency of hospital-associated bloodstream infections is also high. Ascher et al. (5) evaluated 11,638 infants with CHD and reported that 6% of them developed sepsis. In these patients, gram-positive organisms were the most common cause (64%), and coagulase-negative *Staphylococci* and *Staphylococcus aureus* were the most frequently isolated bacteria (5). In a single-center study involving 87 patients diagnosed with CHD undergoing surgical procedures, the most common microorganisms were gram-positive bacteria, including *Enterococcus faecalis* and *Staphylococcus epidermidis* (6).

There are a few centers in our country where these surgeries are performed, and post-operative care is provided. Thanks to early diagnosis and specialized cardiovascular surgery centers, it is believed that the prognosis of these patients is better than in the past. Infections cause negative consequences such as prolongation of hospital stay, surgical failure, prolongation of ventilator stay, and increased hospital costs (2-8). Hospitals and even countries need to determine the number of patients undergoing cardiac surgery, the risks that predispose them to infection, and take the necessary precautions. When BSI is considered, especially in children diagnosed with CHD who have a high risk of developing infection, it is important to conduct studies evaluating the most common bacteria in order to determine empirical treatment and reduce unnecessary antibiotic use. Therefore, we aimed to perform a retrospective study of children undergoing cardiac surgery from March 1, 2022, to 31 March 2023 who were admitted to PCIUC postoperatively at Cengiz Gökçek Gynecology and Pediatrics Hospital.

Materials and Methods

Study design

We performed a retrospective study of children undergoing cardiac surgery from March 1, 2022, to 31 March 2023 who were admitted to PCIUC postoperatively. The study was conducted at Cengiz Gökçek Gynecology and Pediatrics Hospital. Pediatric patients with CHD aged one month to

18 years were included. The patients were retrospectively identified through medical records. Epidemiologic data, including demographic characteristics, underlying medical conditions, invasive procedures, and laboratory findings such as antimicrobial susceptibility, treatment, and prognosis, were collected using a standardized form. Patients with gram-positive growth in blood and/or catheter cultures and patients with no growth were included. In the study, the patients' CHD type, type of surgery, and complexity [RACHS-1 score (*Risk Adjusted classification for Congenital Heart Surgery*)] were evaluated (8).

Definitions

The presence of infection was assessed concomitantly with clinical and laboratory evaluations. Bloodstream infection is defined as the isolation of gram-positive bacteria from one or more blood culture samples taken from a central and/or peripheral vein (or another vascular access) and clinical findings consistent with infection (9). Diagnosis of specific infections, such as catheter-related infections, was made on the basis of the Centers for Disease Control and Prevention criteria (10).

All patients had a central venous and/or arterial catheter after surgery. The growths in patients exhibiting clinical signs of sepsis and/or recurrent coagulase-negative staphylococcal growth in their blood and/or catheters were deemed significant (11). Single growths suggestive of contamination and growths that are not clinically compatible were not considered significant and were not included in the study.

Microbiological evaluations

Gram-positive bacteria isolated from the cultures were identified by both conventional methods (Gram stain, oxidase, and catalase test) and Matrix Assisted Laser Desorption ionization time Flight Mass Spectrometer (MALDI-TOF MS, Bruker, Germany). Phoenix automated microbiology system (Becton-Dickinson Diagnostic Systems, Sparks, MD, USA) equipped with software suitable for the interpretation of the AST result using EUCAST breakpoints was used to perform the microbial susceptibility test.

Statistical analysis

Descriptive statistical analysis was performed using SPSS statistical software (version 20; SPSS, IBM). Data were expressed as mean $\pm$ standard deviation (SD) or median (interquartile range) for continuous variables or as percentages for categorical variables. Categorical variables were expressed as numbers (n) and percentages (%). Mann-Whitney U test was used to compare groups for variables.

The study was approved by Gaziantep University Faculty of Medicine Ethics Committee (Approval Number 2023/133).

Results

A total of 126 patients who underwent surgery in the pediatric cardiovascular surgery department of our hospital and were subsequently admitted to the pediatric cardiovascular surgery intensive care unit were included. Gram-positive growth was identified in the blood and/or catheter cultures of 19 (15%) of these patients. Among the patients with gram-positive bloodstream infections (BSI), ten (52.6%) were female. Demographic and clinical data of the patients are given in Table 1. There was simultaneous growth of gram-positive bacteria in both the catheter and the blood of three patients. Catheters were removed from all patients when a positive result was reported for growth.

The age of the patients with gram-positive BSI was younger than the patients with no growth ($p=0.03$). Fifteen percent of patients with gram-positive bloodstream infections ($n=7$) had cyanotic CHD. Three patients with gram-positive BSI were also diagnosed with Down syndrome. There was gram-positive BSI in eight (8.5%) patients who underwent open heart surgery. While 68.4% of individuals with gram-positive bloodstream infections (BSI) fell into RACHS category 3, only 29% of those without BSI were in this category ($p=0.05$).

Only three out of the 19 patients exhibited simultaneous growth in both blood and catheter cultures. *Staphylococcus hominis* growth was detected in seven patients, *Staphylococcus*

epidermidis in five (26.3%), *methicillin-resistant Staphylococcus aureus* in three (15.7%), and *Staphylococcus haemolyticus* in three (15.7%). Only one patient had vancomycin-resistant *Enterococcus faecalis*. Empirical treatment with vancomycin or teicoplanin was initiated in cases where clinical sepsis developed, taking into consideration the ongoing surgical procedures and the presence of the catheter. However, treatment was changed to linezolid in only one patient who was diagnosed with vancomycin-resistant *Enterococcus faecalis*. PCICU LOS and length of intubation were significantly higher in those with gram-positive BSI than those with no growth ($p=0.04$; 0.001; 0.001; 0.001, respectively).

Discussion

Children who have undergone surgery for congenital heart disease CHD and subsequently remain in the PCICU constitute a distinct group of patients within the intensive care unit setting. Apart from the major surgical procedures, these patients become prone to various infections due to growth retardation, malnutrition, and changes in the immune system response after open heart surgery. Bloodstream infections are particularly important among these infections (2-6,12). In our study, 19 of 126 patients developed gram-positive BSI over a one-year period. The age of the patients with gram-positive BSI was significantly lower than those without BSIs. Apart from the surgery itself, being in the neonatal period may also be one of the factors affecting the development of gram-positive

Table 1. The demographic and clinical characteristics

	Gram-positive growth	No growth	Total	p
Patients n,%	19 (15.07)	107 (84.93)	126 (100)	
Gender (F/M), n (%)	10 (52.6)/9 (47.4)	49 (45)/58 (56)	59 (46.8)/67 (53.2)	
Age, months, median (IQR)	3 (63)	15 (130)	130 (130)	0.03
Congenital Heart Disease				
Cyanotic, n (%)	7 (15.9)	37 (84.1)	44 (100)	
Acyanotic, n (%)	12 (14.6)	70 (85.4)	82 (100)	
Other comorbidities				
Down syndrome	3	10	13	
Achondroplasia	1	0	1	
Multiple anomalies	3	8	11	
RACHS, n (%)				
Category 1-2	6 (31.6)	72 (67.1)	78 (61.9)	
Category 3	13 (68.4)	31 (29)	44 (34.9)	
Category 4	0	2	2 (1.6)	
Category 6	0	2	2 (1.6)	
Open sternum surgery	8 (8.5)	86 (91.5)	94 (100)	
Pre-op LOS, days, mean (min-max)	3.84 (0-19)	1.17 (0-18)	1.57 (0-19)	0.04
Total LOS, days, median (IQR)	33 (206)	9 (203)	9 (208)	0.001
Length of ICU stay, median (IQR)	26.5 (187)	5 (188)	8 (188)	0.001
Length of intubation, median (IQR)	8.5 (68)	2 (69)	2 (69)	0.001

F: Female, M: Male, LOS: Length of hospital stay, ICU: Intensive care unit.

BSI (5,13). Murray et al. (13) reported the neonatal age period as an important risk factor for the development of BSI in patients with CHD.

In the literature, it has been shown that the risk of BSI increases in patients with a RACHS-1 score of Category 3 and above (3,9,13). Similarly, in our study, the majority of patients with gram-positive BSI had a RACHS-1 score of category 3.

No significant difference was found between the type of congenital heart disease (cyanotic/acyanotic) in the gram-positive BSI group. As in the literature, coagulase-negative *Staphylococci* were the most common pathogen (5,12-16). Ward et al. (6) retrospectively evaluated 87 patients with CHD who developed postoperative BSI in their center over a seven-year period and reported that gram-positive microorganism was the most common causative agent. Among these, *Enterococcus faecalis* and *Staphylococcus epidermidis* species were the most common (6). Although the clinical significance of coagulase-negative *Staphylococci* isolated in culture is difficult to determine, members of this species have been associated with an increasing number of hospital-acquired infections (11). Invasive major cardiac surgery, the use of invasive devices such as catheters, and the impairment of the patient's immune system due to the surgical procedure contributed to the increase in the rate of coagulase-negative staphylococcal infections.

The duration of hospitalization before surgery was significantly higher in those with the gram-positive group than in those without, showing that short period of stay before surgery is important for infection control measures.

The length of hospital stay and the length of stay in the intensive care unit are adversely affected in patients with CHD after cardiac surgery. In terms of infection, the long duration of hospital LOS and PCICU LOS adversely affect patients who have undergone cardiac surgery for CHD. In many studies, it has been shown that these patients with BSI stay in the hospital and intensive care unit for a longer time (13-16). Similarly, the total hospital LOS, intensive care unit stay, and even the duration of mechanical ventilation were longer in our patients with gram-positive BSI. This, in turn, can lead to susceptibility to new infections, leading to surgical failure, as well as significant increases in hospital expenditures. Hence, it may be advisable to consider implementing all essential preventive measures against infections and initiating empirical treatments earlier by assessing risk factors prior to surgery.

Yavuz et al. (17) evaluated the risk factors for post-surgical sepsis in 289 patients with CHD and reported only four (1.38%) gram-positive growths. Given the scarcity of studies assessing postoperative BSI in patients with severe CHD in our country, this study holds significant importance.

One of the notable limitations of our study is its single-center nature, encompassing a relatively small patient cohort, which has led to a heterogeneous composition. Secondly, being a retrospective study, we were unable to analyze detailed information. Nonetheless, we believe that the findings of this study carry significance due to the limited number of studies investigating gram-positive bloodstream infections following CHD surgery.

In summary, our study indicates that being in a younger age group, having a higher RACHS category, and experiencing an extended preoperative hospital length of stay may predispose individuals to gram-positive bloodstream infections.

Ethics Committee Approval: The study was approved by Gaziantep University Ethics Committee (Decision no: 2023/133, Date: 26.04.2023).

Informed Consent: Patient consent was obtained.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept- SLG; Design- SLG; Supervision- SLG; Data Collection and/or Processing- All of authors; Analysis and/or Interpretation- SLG; Literature Search - SLG, MB; Writing- SLG; Critical Review- SLG.

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References

1. Jacobs JP, He X, Mayer JE Jr, Austin EH 3rd, Quintessenza JA, Karl TR, et al. Mortality trends in pediatric and congenital heart surgery: An analysis of the Society of Thoracic Surgeons Congenital Heart Surgery Database. *Ann Thorac Surg* 2016;102(4):1345-52. <https://doi.org/10.1016/j.athoracsur.2016.01.071>
2. Barker GM, O'Brien SM, Welke KF, Jacobs ML, Jacobs JP, Benjamin DK Jr, et al. Major infection after pediatric cardiac surgery: A risk estimation model. *Ann Thorac Surg* 2010;89(3):843-50. <https://doi.org/10.1016/j.athoracsur.2009.11.048>
3. Tweddell S, Loomba RS, Cooper DS, Benschoter AL. Health care-associated infections are associated with increased length of stay and cost but not mortality in children undergoing cardiac surgery. *Congenit Heart Dis* 2019;14(5):785-90. <https://doi.org/10.1111/chd.12779>
4. García H, Cervantes-Luna B, González-Cabello H, Miranda-Novales G. Risk factors for nosocomial infections after cardiac surgery in newborns with congenital heart disease. *Pediatr Neonatol* 2018;59(4):404-9. <https://doi.org/10.1016/j.pedneo.2017.11.014>
5. Ascher SB, Smith PB, Clark RH, Cohen-Wolkowicz M, Li JS, Watt K, et al. Sepsis in young infants with congenital heart disease. *Early Hum Dev* 2012;88(Suppl 2):S92-S7. [https://doi.org/10.1016/S0378-3782\(12\)70025-7](https://doi.org/10.1016/S0378-3782(12)70025-7)
6. Ward J, Herrera-Eguizabal J, Andersen K, Ryan K, Guerrero M, Glucoft M, et al. Bloodstream infections in infants and children with congenital heart disease undergoing cardiac surgery. *Am J Crit Care* 2023;32(3):157-65. <https://doi.org/10.4037/ajcc2023155>

7. Tesfaye E, Tadele H. Bacterial sepsis among children with congenital heart disease in Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia. *Ethiop J Health Sci* 2022;32(3):523-32.
8. Jenkins KJ, Gauvreau K, Newburger JW, Spray TL, Moller JH, Iezzoni LI. Consensus-based method for risk adjustment for surgery for congenital heart disease. *J Thorac Cardiovasc Surg* 2002;123(1):110-18. <https://doi.org/10.1067/mtc.2002.119064>
9. Centers for Disease Control and Prevention (CDC). Bloodstream Infection Event (Central Line-Associated Bloodstream Infection and Non-central Line Associated Bloodstream Infection). Available from: https://www.cdc.gov/nhsn/pdfs/pscmanual/17pscnosinfdef_current.pdf
10. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections, 1988 [published correction appears in *Am J Infect Control* 1988 Aug;16(4):177]. *Am J Infect Control* 1988;16(3):128-40. [https://doi.org/10.1016/0196-6553\(88\)90053-3](https://doi.org/10.1016/0196-6553(88)90053-3)
11. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. *Clin Infect Dis* 2009;49(1):1-45. <https://doi.org/10.1086/599376>
12. Prasad PA, Dominguez TE, Zaoutis TE, Shah SS, Teszner E, Gaynor J, et al. Risk factors for catheter-associated bloodstream infections in a Pediatric Cardiac Intensive Care Unit. *Pediatr Infect Dis J* 2010;29(9):812-5. <https://doi.org/10.1097/INF.0b013e3181df6c54>
13. Murray MT, Krishnamurthy G, Corda R, Turcotte RF, Jia H, Bacha E, et al. Surgical site infections and bloodstream infections in infants after cardiac surgery. *J Thorac Cardiovasc Surg* 2014;148(1):259-65. <https://doi.org/10.1016/j.jtcvs.2013.08.048>
14. Hatachi T, Tachibana K, Inata Y, Tominaga Y, Hirano A, Kyogoku M, et al. Risk factors for healthcare-associated infections after pediatric cardiac surgery. *Pediatr Crit Care Med* 2018;19(3):237-44. <https://doi.org/10.1097/PCC.0000000000001445>
15. Costello JM, Graham DA, Morrow DF, Potter-Bynoe G, Sandora TJ, Laussen PC. Risk factors for central line-associated bloodstream infection in a pediatric cardiac intensive care unit. *Pediatr Crit Care Med* 2009;10(4):453-9. <https://doi.org/10.1097/PCC.0b013e318198b19a>
16. Abou Elella R, Najm HK, Balkhy H, Bullard L, Kabbani MS. Impact of bloodstream infection on the outcome of children undergoing cardiac surgery. *Pediatr Cardiol* 2010;31(4):483-9. <https://doi.org/10.1007/s00246-009-9624-x>
17. Yavuz Y, Yurtseven N, Aydemir NA, Korun O, Şimşek Yavuz S. Risk factors for sepsis following congenital heart surgery. *GKD Anest Yoğ Bak Dern Derg* 2019;25(2):85-95. <https://doi.org/10.5222/GKDAD.2019.99815>