İzmir Tıp Fakültesi Dergisi
Journal of İzmir Faculty of Medicine

Klinik Araştırma
DOI: 10.57221/izmirtip.1494548

İzmir Tıp Fak Derg. 2024;3(4):152-160.

Evaluation of Infectious Agents in the Pediatric Palliative Care Unit

Pediyatrik Palyatif Bakım Ünitesindeki Enfeksiyon Ajanlarının Değerlendirilmesi

Nilgün Harputluoğlu[1], Yakup Yaman[1], Derşan Onur[1], Miray Yılmaz[2], Mustafa Gülderen[2], Tanju Çelik[1-4], Ünsal Yılmaz[3-4]

[1]University of Health Sciences, Turkey, Izmir Dr. Behcet Uz Child Diseases and Surgery Education and Research Hospital, Clinic of Pediatrics, Izmir, Turkey
[2]University of Health Sciences, Turkey, Izmir Dr. Behçet Uz Child Diseases and Surgery Education and Research Hospital, Clinic of Pediatric Infectious Diseases, Izmir, Turkey
[3]University of Health Sciences, Turkey, Izmir Dr. Behçet Uz Child Diseases and Surgery Education and Research Hospital, Clinic of Pediatric Neurology Diseases, Izmir, Turkey
[4]University of Health Sciences, Turkey, Izmir Faculty of Medicine, Department of Pediatrics, Izmir, Turkey

Abstract

Aim: Broad-spectrum antibiotics, changes in patient profile, prolonged life expectancy, catheters, gastrostomy and tracheostomy applications have led to an increase in infections and a change in the type of microorganisms isolated from cultures. There is no data on infections seen in pediatric palliative care. The aim of this study was to determine the frequency of infections and the pathogens produced in culture, identify the sites of growth, and review what should be done.

Materials and Methods: Sociodemographic data, reason for hospitalization, number of hospitalizations, primary diagnoses, comorbid conditions, medical devices and technology used, time and place of culture, number of cultures, microorganisms grown and factors associated with culture growth were examined. Statistical analysis was performed with the SPSS 18.0 program. $p<0.05$ was considered significant.

Results: 1209 culture examinations were evaluated. The mean age was 5.68±5.33 (SD) years and 56.9% (n=124) were male. When the reason for hospitalization was grouped as infection and non-infection, no difference was found in terms of culture growth (p=0.778). There was a significant difference between medical comorbidities and culture growth (p=0.008) and it was found to be associated with cardiovascular diseases and congenital diseases in post hoc analysis (p=0.001 and p=0.018, respectively).

Conclusion: These results are the first data evaluating culture growth in pediatric palliative care patients and are important in terms of emphasizing the high frequency of infection and providing a basis for future research. Providing trainings on long-term care and prevention of infections and repeating these trainings at regular intervals may contribute to the prevention of infections.

Keywords: Infection; pediatrics; palliative care

Öz

Amaç: Geniş spektrumlu antibiyotikler, hasta profilindeki değişiklikler, yaşam süresindeki uzama, kateterler, gastrostomi ve trakeostomi uygulamaları enfeksiyonlarda artışa ve kültürlerden izole edilen mikroorganizmaların türünde değişikliğe neden olmuştur. Pediyatrik palyatif bakımda görülen enfeksiyonlara dair veri bulunmamaktadır. Bu çalışmada amaç enfeksiyon sıklığını ve kültürde üretilen patojenleri saptamak, üreme yerlerini bulmak ve yapılması gerekenleri gözden geçirmektir.

Gereç ve Yöntemler: Sosyodemografik veriler, yatış nedeni, yatış sayısı, primer tanıları, komorbid durumları, kullandıkları tıbbi cihaz ve teknoloji, kültür alınma yeri ve zamanı, kültür sayısı, üreyen mikroorganizmalar ve kültür üremesiyle ilişkili faktörler incelendi. İstatistiksel analiz SPSS 18.0 programı ile yapıldı. $p<0.05$ anlamlı kabul edildi.

Bulgular: 1209 kültür tetkiki değerlendirildi. Yaş ortalaması 5,68±5,33 (SD) yıl, %56,9'u (n=124) erkekti. Yatış nedeni enfeksiyon ve enfeksiyon dışı olarak gruplandırıldığında kültür üremesi açısından fark saptanmadı (p=0,778). Medikal komorbiditeler ile kültür üremesi arasında anlamlı fark saptandı (p=0,008) ve post hoc analizde kardiovasküler hastalıklar ve konjenital hastalıklar ile ilişkili bulundu (sırasıyla p=0,001 ve p=0,018).

Sonuç: Bu sonuçlar, pediyatrik palyatif bakım hastalarında kültür üremelerinin değerlendirildiği ilk veriler olup, yüksek enfeksiyon sıklığını vurgulaması ve gelecekteki araştırmalar için temel oluşturması açısından önemlidir. Uzun süreli bakım ve enfeksiyonların önlenmesine yönelik eğitimlerin yapılması ve bu eğitimlerin belirli aralarla tekrarlanması enfeksiyonların önlenmesi için katkı sağlayabilir.

Anahtar sözcükler: Enfeksiyon; pediyatri; palyatif bakım

Corresponding Author: Nilgün Harputluoğlu
University of Health Sciences, Turkey
Izmir Dr. Behcet Uz Child Diseases and Surgery Education and Research Hospital Clinic of Pediatrics, Izmir, Turkey
E-mail: nilgunharputluoglu@yahoo.com.tr
Geliş ve Kabul Tarihi: 02.06.2024/06.11.2024

INTRODUCTION

In recent years, the widespread use of broad-spectrum antibiotics, coupled with demographic shifts in patient populations, advancements in medical technology (such as gastrostomy and tracheostomy), and prolonged life expectancies, has precipitated an increase in both the incidence of infections and the proliferation of microorganisms isolated from cultures (1). In PPC (PPC) patient groups, most of whom are bedridden and nursing patients, infections are a significant cause of morbidity and mortality due to low immunity, severe malnutrition, widespread use of medical technology and devices, and frequent intensive care admissions [2]. PPC, being a relatively nascent specialty in our country, lacks comprehensive research addressing infectious diseases within its patient population. Therefore, this study aims to investigate the infection sites, causative pathogens, and risk factors contributing to infections in PPC patients. Specifically, we focus on infections necessitating hospitalization as well as those acquired during hospital stays. In addition, our study sought to assess the influence of medical devices and comorbidities on infection rates.

MATERIALS and METHODS

Informed consent was obtained from the participants. Following the principles of the Declaration of Helsinki, approval was obtained from the local ethics committee (14/09/2023-176).

The organization of PPC Unit: Izmir Dr. Behçet Uz Children's Hospital is a tertiary hospital, and the PPC center was established in November 2018. Our PPC center has 12 beds and is an example of teamwork consisting of two doctors, twelve nurses, six staff members, a psychologist, a dietician, a social worker, a physiotherapist, a religious official, and a secretary. Our clinic, the third PPC center in our country, was founded by considering examples in Europe and America. PPC, which requires multidisciplinary and interdisciplinary work, coordinates with the home health unit.

Study Design: This was as a cross-sectional, retrospective study between 18.11.2018 and 01.09.2023. The frequency of infection, infection sites, and growing microorganisms in children hospitalized at the PPC Clinic of Behçet Uz Children's Hospital were examined. The inclusion criteria encompassed all PPC patients who underwent at least one culture test during their hospital stay. Patients lacking culture testing or with incomplete medical records were excluded from the study.

Data Collection Tools: Data collection included sociodemographic characteristics, reasons for hospitalization, number of hospitalizations, primary diagnoses, comorbidities (e.g. neurological disorders, cardiac issues, metabolic diseases), and usage of medical devices (e.g., mechanical ventilation, tracheostomy, gastrostomy tube, central venous catheter). Additionally, we analyzed the timing and location of culture samples, number of cultures obtained, isolated microorganisms, and cases with multiple pathogen growths.

Statistics: Although it is not a reference study with PPC patients, the culture growth rate was found to be 10% in studies evaluating similar patient populations, so the sample size was calculated to be 116, with a significance level of 95% and an error rate of 5%. The statistical analysis was performed with the SPSS 18.0 program. The results of the descriptive analyses were presented as count (frequency (%)) for categorical variables and mean (standard deviation (SD)) for numerical variables. The statistical significance of the observed differences between the groups was determined by Pearson's chi-square test or Fisher's exact test. The level of statistical significance was determined to be $p<0.05$.

RESULTS

A total of 414 patients were hospitalized in the PPC service during the study period, and 218 who had culture tests were included in the study. A total of 1209 culture samples taken from 392 hospitalizations of 218 patients included in the study were evaluated. The mean age was 5.68 years (SD=5.33, min-max: 1.1-17.75). A total of 56.9% (n=124) of the patients were male, and 43.1% (n=94) were female. The average number of hospitalizations was 1.79 (SD=1.59, min-max: 1-14), and the average number of cultures per case was 5.5±7.05 (SD). The average number of cultures per hospitalization was 3.08 (SD=3.3, min-max: 1-22). Considering the primary diagnoses of the patients, 56% (n=678) had neurological diseases, 13.9% had metabolic diseases, 11.5% had genetic diseases, 6.9% had prematurity and neonatal problems, 3.4% had respiratory diseases, 3.4% had gastrointestinal diseases, 1.8% had cardiovascular disease, 1.3% had renal disease, 0.9% had malignancy and hematological disease, and 0.3% had other diseases. The frequencies of hospitalization-related diagnoses were presented in table 1.

Twenty-five of the 1,209 cultures were excluded from the analysis due to coding and acquisition technique errors.

Of the 1,184 resulting culture tests, 44.09% (n=522) were urine, 34.21% (n=405) were blood, and 13.26% (n=157) were wound culture.

Although no growth was detected in 477 (40.29%) cultures, growth was detected in 450 (38.01%) cultures. A total of 257 (21.71%) cultures were evaluated as contaminated (Table 2).

Three microorganisms were grown in one wound and one DTA culture; two were grown in 56 cultures (35 wounds, nine blood, seven urine, three DTA, one ear, and one abscess. The total numbers and percentages of microorganisms grown in cultures are shown in table 3.

The areas where the cultures were taken, and the total growth numbers are presented in table 4.

When culture growth was examined according to the primary diagnosis category, no significant difference was detected (p=0.960). When the reasons for hospitalization were grouped as infection or non-infection, no significant difference was detected in culture growth (p=0.778). A significant difference was detected between medical comorbidities and culture growth (p=0.008). The group or groups from which this significant difference originated were evaluated by post hoc analysis. In patients diagnosed with cardiovascular disease, contamination was found to be statistically significantly more frequent in the "with growth" and "without growth" groups (p 0.001 and 0.032, respectively). In patients diagnosed with congenital diseases, contamination was statistically significantly more frequent in the presence of growth than in the absence of growth (p=0.018).

Table 1. Hospitalization diagnoses of the cases

Diagnosis	n	%
Lower Respiratory Tract Infection	210	43.93
Urinary Tract Infection	105	21.97
Convulsion	62	12.97
Malnutrition, Dehydration, Electrolyte Imbalance	29	6.07
Acute Gastroenteritis	22	4.60
Wound Infection	16	3.35
Need for Palliative Care or Training	16	3.35
Bleeding (Cannula, Intracranial, Etc.), Anemia	12	2.51
Other (Regular Treatment, PEG Opening, Cannula Change)	6	1.26
Total	478	100.00

PEG: Percutaneous endoscopic gastrostomy

Table 2. Culture results

Culture	No Growth		Growth		Contamination		Total	
	n	%	n	%	n	%	n	%
Urine	274	52.49	130	24.90	118	22.61	522	44.09
Blood	94	23.21	181	44.69	130	32.10	405	34.21
Wound	50	31.85	104	66.24	3	1.91	157	13.26
Stool	34	89.47			4	10.53	38	3.21
BAL	4	36.36	7	63.64			11	0.93
CSF			2	100.00			2	0.17
DTA	12	36.36	19	57.58	2	6.06	33	2.79
Thoracentesis	4	80.00	1	20.00			5	0.42
Abscess			3	100.00			3	0.25
Conjunctiva	3	100.00					3	0.25
Sputum			2	100.00			2	0.17
Ear	1	50.00	1	50.00			2	0.17
Throat	1	100.00					1	0.08
Total	477	40.29	450	38.01	257	21.71	1184	100.00

BAL: Bronchoalveolar lavage, CSF: Cerebrospinal fluid, DTA: Deep tracheal aspiration

Table 3. Growing microorganisms

Microorganisms	Growth		Microorganisms	Growth	
	%	Number		%	Number
Klebsiella pneumoniae spp.	123	24.12	*Pseudomonas aeruginosa*	116	22.75
Candida albicans	34	6.67	*Escherichia coli*	29	5.69
Candida parapsilosis	27	5.29	*Stenotrophomonas maltophilia*	22	4.31
Enterobacter cloacae	20	3.92	*Serratia marcescens*	20	3.92
Enterococcus faecalis	15	2.94	*Acinetobacter baumannii*	11	2.16
Enterococcus faecium	9	1.76	*Enterobacter aerogenes*	7	1.37
Staphylococcus aureus MRSA	7	1.37	*Staphylococcus haemolyticus*	7	1.37
Candida sake	6	1.18	*Candida tropicalis*	6	1.18
Staphylococcus epidermidis	5	0.98	*Staphylococcus epidermidis MR*	5	0.98
Proteus mirabilis	4	0.78	*Staphylococcus haemolyticus MR*	4	0.78
Staphylococcus hominis MR	4	0.78	*Staphylococcus aureus MSSA*	3	0.59
Candida glabrata	2	0.39	*Staphylococcus capitis*	2	0.39
Citrobacter freundii	2	0.39	*Staphylococcus hominis ssp.*	2	0.39
Citrobacter koseri	2	0.39	*Candida spp.*	1	0.20
Achromobacter xylosoxidans	1	0.20	*Micrococcus*	1	0.20
Aeromonas salmonicida	1	0.20	*Pantoea agglomerans*	1	0.20
Streptococcus spp.	1	0.20	*Pseudomonas luteola*	1	0.20
Corynebacterium urealyticum	1	0.20	*Staphylococcus simulans*	1	0.20
Enterococcus durans	1	0.20	*Streptococcus pneumoniae*	1	0.20
Enterococcus gallinarum	1	0.20	*Streptococcus pyogenes*	1	0.20
Enterococcus spp.	1	0.20	*Streptococcus vestibularis*	1	0.20
Klebsiella oxytoca	1	0.20			

MR: Methicillin resistant, MRSA: Methicillin resistant s*taphylococcus aureus*, spp: Species plural, MSSA: Methicillin sensitive s*taphylococcus aureus*.

Table 4. Sites of collection for cultures and total growth numbers

Culture Growth Site Microorganism	Growth Number	Culture Growth Site Microorganism	Growth Number
Blood	190	***Urine***	137
Klebsiella pneumoniae	45	*Klebsiella pneumoniae*	34
Candida parapsilosis	23	*Pseudomonas aeruginosa*	22
Stenotrophomonas maltophilia	19	*Escherichia coli*	18
Pseudomonas aeruginosa	17	*Candida albicans*	15
Enterobacter cloacae	14	*Enterococcus faecalis*	7
Candida albicans	10	*Enterococcus faecium*	7
Serratia marcescens	9	*Candida sake*	5
Enterococcus faecalis	7	*Enterobacter aerogenes*	5
Acinetobacter baumannii complex	6	*Proteus mirabilis*	4
Staphylococcus haemolyticus	5	*Candida parapsilosis*	3
Staphylococcus epidermidis	4	*Candida tropicalis*	3
Staphylococcus epidermidis MR	4	*Acinetobacter baumannii*	2
Staphylococcus haemolyticus MR	4	*Candida glabrata*	2
Staphylococcus hominis MR	3	*Citrobacter freundii*	2
Candida tropicalis	2	*Candida spp.*	1
Enterococcus faecium	2	*Citrobacter koseri*	1
Staphylococcus capitis	2	*Enterobacter cloacae*	1
Staphylococcus hominis ssp	2	*Enterococcus durans*	1
Achromobacter xylosoxidans	1	*Enterococcus spp*	1
Aeromonas salmonicida	1	*Serratia marcescens*	1
Streptococcus spp.	1	*Staphylococcus aureus MSSA*	1
Corynebacterium urealyticum	1	*Staphylococcus haemolyticus*	1
Enterobacter aerogenes	1	***Wound***	141
Micrococcus	1	*Pseudomonas aeruginosa*	53

Pantoea agglomerans	1	*Klebsiella pneumoniae ssp*	41
Staphylococcus aureus MSSA	1	*Escherichia coli*	11
Staphylococcus simulans	1	*Candida albicans*	8
Streptococcus pneumoniae	1	*Enterobacter cloacae*	5
Streptococcus pyogenes	1	*Serratia marcescens*	5
Streptococcus vestibularis	1	*Staphylococcus aureus MRSA*	5
DTA	24	*Acinetobacter baumannii complex*	3
Pseudomonas aeruginosa	17	*Stenotrophomonas maltophilia*	3
Serratia marcescens	3	*Candida tropicalis*	1
Klebsiella pneumoniae ssp	2	*Citrobacter koseri*	1
Enterobacter aerogenes	1	*Enterococcus faecalis*	1
Staphylococcus aureus MRSA	1	*Enterococcus gallinarum*	1
Thoracentesis	1	*Klebsiella oxytoca*	1
Staphylococcus epidermidis MR	1	*Pseudomonas luteola*	1
Ear	2	*Staphylococcus aureus MSSA*	1
Klebsiella pneumoniae ssp pneumoniae	1	***BAL***	7
Pseudomonas aeruginosa	1	*Candida albicans*	1
Sputum	2	*Candida parapsilosis*	1
Pseudomonas aeruginosa	1	*Candida sake*	1
Serratia marcescens	1	*Pseudomonas aeruginosa*	2
Abscess	4	*Serratia marcescens*	1
Pseudomonas aeruginosa	3	*Staphylococcus aureus MRSA*	1
Staphylococcus haemolyticus	1	***CSF***	2
		Staphylococcus epidermidis	1
		Staphylococcus hominis MR	1

BAL: Bronchoalveolar lavage, DTA: Deep tracheal aspiration, CSF: Cerebrospinal fluid, MR: Methicillin resistant, MRSA: Methicillin resistant s*taphylococcus aureus,* spp: Species plural, ssp: Staphylococci surface protein, MSSA: methicillin sensitive s*taphylococcus aureus*.

DISCUSSION

This study showed that the frequency of infection in PPC patients was high, with cultures growing in approximately half of the patients. The most common infections are urinary tract infections, septicemia, and wound infections. *Klebsiella pneumoniae, Pseudomonas aeruginosa, and Candida albicans* are the most common pathogens. Infections were more common in patients with cardiovascular system diseases and congenital diseases.

A rise in the number of microorganisms isolated from cultures has been observed for a number of reasons, including the increased use of broad-spectrum antibiotics, changes in the patient profile, the use of medical devices and applications, the growing number of children with chronic complex conditions, the increased use of catheters and the use of intravenous fluids in nutrition (2). It has been reported that the rate of microorganism production in blood cultures taken in the presence of infection in any region of patients is 7.6%-7.7% (1,3,4). This rate was found to be 10.3% in neonatal intensive care, and 5.2% was found to be clinically significant (1,4). A study conducted in China has revealed that the incidence of sepsis is on the rise. In particular, the study found that 8.7% of cases occur in under one year of age, while 11.7% occur in children between one and nine years of age (5). In our study, the growth rate in all cultures was 38.01%, while the growth rate in blood cultures was 34.21%. The growth of microorganisms in urine samples was the most prevalent, followed by blood and wound cultures. High culture growth rates may be due to respiratory problems, the use of medical technology and devices, repeated hospitalizations, malnutrition, and being bedridden in PPC patient's profile. Urinary tract infections may occur in bedridden care patients due to both diaper use and bladder dysfunction, such as neurogenic bladder. Increasing social and economic support, especially family education, may be beneficial for preventing all infections, including urinary tract infections, by both providing chronic patient care and improving conditions.

The rate of recurrent hospitalization in lower respiratory tract infections within one month is 25.5% (6). This condition is associated with worsening signs and symptoms of infection and comorbid conditions (6,7). Bronchiolitis, pneumonia, and upper respiratory tract infections have been identified as potentially preventable causes of readmission for children with complex problems. Prioritizing children with chronic complex conditions has also been essential for reducing costs (6,7). In our study, a high rate of infection was detected in the patients, and the rate of recurrent hospitalizations was almost twice as high for each patient. Lower respiratory tract infections were found to be the most common reason for hospitalization. Being bedridden, having chronic complex conditions and mainly using devices, being unable to excrete secretions, and having frequent lung problems are predisposing factors for lower respiratory tract infection for PPC patients. Therefore, in this study, lower respiratory tract infection was the most common hospitalization diagnosis, and the presence of comorbid conditions may have caused a higher rate of repeat hospitalizations than in the literature.

Various studies have examined microorganisms that cause intensive-care infections. In recent years, many studies have identified coagulase-negative staphylococcus, *Staphylococcus aureus*, and *Enterococcus spp*. It has been reported that the prevalence of infection by gram-positive bacteria is on the rise (1,2,8,9). Among the gram-negative microorganisms, the most common ones were *Enterobacteriaceae spp., Pseudomonas aeruginosa*, and *Acinetobacter baumannii* (10). *Acinetobacter spp.* and *Pseudomonas spp.* were determined to be the most common microorganisms in hospital-acquired infections (3,11-13). In this study, the most common microorganisms were *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Candida albicans*. Despite the absence of literature on the PPC clinic patients, the frequent detection of gram-negative and fungal group microorganisms may be attributed to the profile of PPC patients, which includes frequent intensive care admissions, catheter applications, recurrent hospitalizations, and extended hospital stays.

The presence of chronic complex conditions, especially comorbid conditions, is a predisposing factor for infections and culture growth. The most common infections in these children are lung infections such as wheezing, bronchitis, and pneumonia. Studies have shown that the maturation process, increase in number, and formation of antibody responses of immune system cells in children with heart disease are weaker than those in other children (14). Stasis and restriction in pulmonary circulation also prolong the hospital stay of children with heart disease when exposed to viral and bacterial infections that affect the respiratory tract. The likelihood of requiring intensive care and mortality rates are 25 times higher in this patient population. In some heart diseases, recurrent lung infections are observed due to increased blood flow to the lungs (14). Frequently recurring respiratory

system, urinary tract, and bloodstream infections are common in some well-known syndromic diseases such as Down syndrome, DiGeorge syndrome, and Turner syndrome (14,15). Both heart disease and infections are common in children with congenital syndromes, such as trisomy 13 and trisomy 18 (15). Susceptibility to infection also increases in these patients due to reasons such as removal of the thymus and low cellular immunity (14). In this study, culture growth rates were greater in patients with comorbid conditions, cardiovascular diseases, and congenital diseases than in other patients. Although the previous studies have similar results, it is important to treat these patients who are hospitalized in PPC with priority and caution.

In study, patients who were transferred from intensive care and patients admitted to the emergency department were not separated, and it is limited in providing information about the source of infection. Single-center results cannot be generalized, and more extensive studies are needed.

CONCLUSION

These results represent the inaugural data in PPC, a nascent field in our country. The data showed that approximately half of the cases had growth in culture, and this was more common in cardiovascular and congenital diseases. The patient profile necessitates long-term treatment and follow-up, family education and care, and regular infection prevention education, which can reduce the frequency of infection.

The study is significant in that it highlights the high frequency of infection in PPC and provides a foundation for future research.

Author's Contribution

The authors declare no conflict of interest.

All authors declared their contribution to the study at all stages and approved the final version of the manuscript.

All authors declared that this manuscript has not been published before and is not currently being considered for publication elsewhere.

This research was orally presented in "1st İzmir Children's Congress" in Izmir/Turkey in May 9-11, 2024.

REFERENCES

1. Ergul AB, Isık H, Altıntop YA, Torun YA. A retrospective evaluation of blood cultures in a pediatric intensive care unit: a three year evaluation. Turk Pediatri Ars. 2017;52:154-61.
2. Weinstein RA. Controlling antimicrobial resistance in hospitals: infection control and use of antibiotics. Emerg Infect Dis. 2001;7:188-92.
3. Gulmez D, Gur D. Microorganisms isolated from blood cultures in Hacettepe University Ihsan Dogramacı children's hospital from 2000 to 2011: Evaluation of 12 Years. J Pediatr Inf. 2012;6:79-83.
4. Saglam D, Ercal BD, Yagmur G, Oz HT, Akin MA, Berk E. Distribution of microorganisms isolated from blood cultures collected from the neonatal intensive care units of Kayseri training and research hospital. Abant Med J. 2015;4:255-60.
5. Celiloglu C, Tolunay O, Celik T, Sucu T, Yurtcu E, Celik E. Assessment of healthcare-associated infections in the pediatric intensive care unit. J Pediatr Inf. 2017;11:129-34.
6. Adamuz J, Viasus D, Camprecios-Rodriguez P, Canavate-Jurado O, Jimenez-Martinez E, Isla P, et al. A prospective cohort study of healthcare visits and rehospitalizations after discharge of patients with community-acquired pneumonia. Respirology. 2011;16:1119-26.
7. Markham JL, Hall M, Goldman JL, Bettenhausen JL, Gay JC, Feinstein J, et al. Readmissions following hospitalization for infection in children with or without medical complexity. Journal of Hospital Medicine. 2021;16:134-41.
8. Cetin S, Celik I, Artan C. Evaluation of microorganisms and antibiotic resistance profile isolated in intensive care unit patients. Turk J Intensive Care. 2021;19:9-17.
9. Bayram A, Balci I. Patterns of antimicrobial resistance in a surgical intensive care unit of a university hospital in Turkey. BMC Infect Dis. 2006;6:155.
10. Erturk A, Copur C, Koksal E, Koksal Z, Ozyurt S. Microorganisms isolated from various clinical samples and their antibiotic susceptibilities in intensive care unit patients. ANKEM Derg. 2012;26:1-9.
11. Atici S, Soysal A, Kadayifci KE, Karaaslan A, Akkoc G, Yakut N, et al. Healthcare-associated infections in a newly opened pediatric intensive care unit in Turkey: results of four-year surveillance. J Infect Dev Ctries. 2016;10:254-9.
12. Aktar F, Tekin R, Gunes A, Ulgen C, Tan I, Ertugrul S, et al. Determining the independent risk factors and mortality rate of nosocomial infections in pediatric patients. Biomed Res Int. 2016; 7240864.

13. Lopez AP, Ladhani SN, Breathnach A, Planche T, Helath PT. Trends in paediatric nosocomial bacteraemia in a London tertiary hospital. Acta Paediatr. 2013;102:1005-9.
14. Wienecke LM, Cohen S, Bauersachs J, Mebazaa A, Chousterman BG. Immunity and inflammation: the neglected key players in congenital heart disease? Heart Fail Rew. 2022;27:1957-71.
15. Furlong-Dillard J, Bailly D, Amula V, Wilkes J, Bratton S. Resource use and morbidities in pediatric cardiac surgery patients with genetic conditions. J Pediatr. 2018;193:139-46e.