

Evaluation of Stenotrophomonas Maltophilia Bloodstream Infections in a Tertiary Pediatric Cardiovascular Surgery Intensive Care Unit in Turkey

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ABSTRACT

Background: Stenotrophomonas maltophilia poses a significant challenge as a drug-resistant opportunistic bacterium, particularly in ICU settings. However, its impact on pediatric ICU patients, especially those undergoing cardiovascular surgery, are scarce. Therefore, we aimed to analyze the factors behind S. maltophilia bloodstream infections (BSI) in our tertiary pediatric cardiovascular surgery ICU by evaluating the 2-year data.

Methods: In this retrospective study, we analyzed data of 11 (mean age 20.3±17.6 months) and 18 cases (mean age 22.4±18.5 months) diagnosed with S. maltophilia BSI out of 635 and 685 children who underwent cardiovascular surgery from March 2021 to February 2022, and March 2022 to February 2023, respectively. Factors including age, gender, cardiac pathologies, surgical risk scores, duration of extracorporeal membrane oxygenation (ECMO) and mechanical ventilation, length of ICU stay, and use of broad-spectrum antibiotics were compared.

Results: The incidence of S. maltophilia BSI increased by 50.5% in 2022-2023 compared to the previous year. While no significant differences were noted in age, gender, or surgical frequency, notable distinctions emerged in ECMO and mechanical ventilation durations, ICU length of stay, and broad-spectrum antibiotic usage (p values<0.05).

Conclusion: Prolonged ECMO and mechanical ventilation, along with extended ICU stays and broad-spectrum antibiotic administration following high-risk cardiac surgeries, emerged as significant contributors to S. maltophilia BSI in our ICU. This underscores the necessity for a comprehensive approach encompassing infection control protocols, prudent antimicrobial utilization, and strategies to minimize invasive procedures. Such a multifaceted approach is paramount in mitigating the prevalence of S. maltophilia BSI, especially in high-risk ICU environments.

Keywords: S. Maltophilia Bloodstream Infection, Cardiovascular Surgery Icu, Pediatrics, Increase, Factors

Introduction

Stenotrophomonas maltophilia is an aerobic opportunistic gram-negative bacillus mostly found in aqueous media [1,2]. It has been reported as the third most common nosocomial pathogen following Pseudomonas aeruginosa and Acinetobacter spp [3]. S. maltophilia is predominantly linked with pneumonia and bloodstream infections, constituting the primary clinical manifestations. Less frequently observed are urinary tract infections, wound infections, meningitis, biliary tract infections, osteomyelitis, and endocarditis [3,4]. As S. maltophilia is able to survive in a low-nutrient environment, medical equipment and devices become suitable for its biofilm formation [5,6].

S. maltophilia was previously considered an unusual, limitedly invasive opportunistic pathogen, but its overall rate of isolation has increased and infections have become difficult to manage since clinical isolates at present are intrinsically resistant to many broad-spectrum antibiotics [7-9].

In this study, we analyzed the S. maltophilia bloodstream infections in the pediatric cardiovascular surgery ICU of our tertiary healthcare center by evaluating the 2-year data.

Methods

A thorough retrospective analysis of patient records, microbiological data, and infection control logs was conducted for 11 and 18 cases diagnosed with S. maltophilia BSI out of 635 and 685 children who were operated and followed in the pediatric cardiovascular surgery ICU of University of Health

Sciences, Kartal Koşuyolu Research and Training Hospital from March 2021 to February 2022 and March 2022 to February 2023, respectively. The age, gender, cardiac pathologies, RACHS-1 (risk adjustment for congenital heart surgery) scores of the surgeries, length of ICU stay and broad-spectrum antibiotic use, duration on mechanical ventilator and extracorporeal membrane oxygenator device were documented through the Hospital's electronic medical information system [10].

Blood cultures were obtained from the peripheral and central venous catheters of the patients, who needed ECMO and/or mechanical ventilator device and broad-spectrum antibiotics for more than 5 days, if they had fever ≥ 38 degrees Celsius (0C), clinical deterioration, impaired gastric tolerance, and increased acute phase reactant values (leucocyte count $>10000/\text{mm}^3$, C-reactive-protein level $>1 \text{ mg/dl}$) according to Center for Disease Control and Prevention (CDC) criteria [11]. The blood culture samples were immediately carried to the microbiology laboratory in a special transport bag. These samples were cultured in MacConkey and 5% blood agar. Identification of the isolates and the trimethoprim/sulfamethoxazole susceptibility testing were performed by using an automated VITEC-2 Compact system in our hospital. The study received approval from the University of Health Sciences, Kartal Koşuyolu Research, and Training Hospital Ethics Committee.

Statistical Analysis

Statistical analysis was performed by Statistical Package for Social Sciences (SPSS) version 22.0 Descriptive data were

interpreted as mean \pm standard deviation, number, and percent frequency. The chi-square test was used to compare the categorical variables. The Mann-Whitney U test was used to analyze the numerical data that did not show normal distribution. Binary logistic regression test was performed to determine the independent risk factors in *S. maltophilia* bloodstream infections. The criterion for the statistical significance was accepted as $p < 0.05$.

Results

S. maltophilia bloodstream infections exhibited a 50.5% rise in the period of 2022-2023 (n:11/635, 1.73%) compared to 2021-2022 (n:18/685, 2.62%). While there were no significant differences in patient age (22.4 ± 18.5 months and 20.3 ± 17.6 months, respectively) ($p > 0.05$), gender, or the number of operations performed, meaningful distinctions were noted in the risk scores of cardiac surgeries (between 3 and 5 out of 6 in 2022-2023 and between 2 and 4 in 2021-2022). Furthermore, the differences concerning the duration of children on ECMO device (62 ± 28.6 days vs 43 ± 18.4 days), on mechanical ventilator support (75.1 ± 39.2 days vs 51.6 ± 34.2 days), length of cardiovascular surgery ICU stay (78.7 ± 40.1 days vs 57.2 ± 34.3 days) and broad-spectrum antibiotic administration (38.7 ± 18.8 days vs 32.6 ± 16.8 days) were statistically significant (all p values < 0.05). (Table 1)

Table 1: Analysis of the patient characteristics with *S. maltophilia* bloodstream infections in 2021-2022 and 2022-2023

Patient characteristics		2021-2022 (year) (n:11/635)	95%CI	2022-2023 (year) (n:18/685)	95%CI	p-value
Age (months)		20.3 \pm 17.6	12.2-28.4	22.4 \pm 18.5	11.4-33.3	0.2
Gender	F (n)	5		8		
	M (n)	6		10		
Length of pediatric CVS-ICU stay (days)		57.2 \pm 34.3	36.9-77.4	78.7 \pm 40.1	60.1-97.2	0.001
Length of mechanical ventilator (days)		51.6 \pm 34.2	31.4-71.8	75.1 \pm 39.2	56.9-93.2	0.001
ECMO stay (days)		43 \pm 18.4	32.1-53.8	62 \pm 28.6	48.7-75.2	0.002
Duration of broad-spectrum antibiotic (days)		32.6 \pm 16.8	23.6-43.5	38.7 \pm 18.8	28.9-46.2	0.04

ECMO: extracorporeal membrane oxygenator

CVS-ICU: cardiovascular surgery intensive care unit

CI: Confidence interval

p-value < 0.05 was accepted as statistically significant

Discussion

The present study revealed that despite implementing all recommended disinfection rules, the incidence of *S. maltophilia* bloodstream infections showed a substantial increase in 2022-2023 compared to the previous year, coinciding with statistically significant rise in the duration of mechanical ventilator support and ECMO devices, length of ICU stay, and broad-spectrum antibiotic use. These findings align with the limited existing literature on this subject. Such an escalation in bloodstream infections poses significant concerns as *S. maltophilia* is known for its drug resistance and opportunistic nature, particularly

among critically ill patients, leading to outbreaks and compromising patient outcomes [9,12].

The extended ICU stays contribute to the increasing rates of infection by facilitating the transmission of opportunistic pathogens through the invasive medical devices like catheters and central lines into the bloodstream [4,8]. When we reviewed the underlying cardiac pathologies of the children, we detected atrioventricular septal defect (AVSD) (n:5), transposition of great arteries (TGA) (n:2), tetralogy of Fallot (TOF) (n:3), total anomalous pulmonary venous return (TAPVR) (n:1) in 2021-

2022 and TOF (n:4), TAPVR (n:3), TGA (n:2), hypoplastic left heart syndrome (HLHS) (n:1), double outlet right ventricle (DORV) (n:2), tricuspid atresia (TA) (n:2), and combined cardiac pathologies (TGA+DORV, TAPVR+AVSD, VSD+pulmonary atresia, etc.) (n:4) in 2022-2023. We interpreted this to mean that the patients who underwent surgery in 2022-2023 had cardiac pathologies with a higher risk of morbidity and mortality, leading to a longer postoperative ICU stay and exposure to invasive medical devices [12,13].

Another significant factor contributing to the rise in *S. maltophilia* BSI was the prolonged duration of ECMO support and mechanical ventilator devices. Through their biofilm forming capability, *S. maltophilia* strains can easily cause infection by adhering to the surfaces of mechanic ventilators and ECMO devices in hospital settings [14,15]. Mechanical ventilation is commonly employed in post-cardiovascular surgery patients with respiratory compromise. The risk factors associated with mechanical ventilation, such as airway manipulation, exposure to contaminated equipment, and impaired host defenses, may create an environment conducive to *S. maltophilia* colonization and infection. When we compared the mean duration of patients with *S. maltophilia* bloodstream infection on a mechanical ventilator in the current study, we found a statistically significant difference between 2021-2022 and 2022-2023 (51.6±34.2 days vs 75.1±39.2 days).

In children with advanced cardiac failure where medical treatment has failed, mechanical circulatory support in the form of ECMO or ventricular assist device is used [15]. Although they are life sustaining strategies for critically ill children with reversible cardiac failure and/or pulmonary failure, it has been reported in several studies that the incidence of infections occurring while ECMO or assist device use range between 3.5% and 45.1%, most of which were bloodstream infections (32.6%-89.4%) [13,14]. *S. maltophilia* is among the most common three blood culture isolates of these infections [16,17]. In the current study we observed a statistically significant rise in the duration of patients on ECMO support (62±28.6 days vs 43±18.4 days) in 2022-2023 compared to the preceding year. Our hospital serves as a specialized referral healthcare center for pediatric cardiovascular surgeries, handling cases with higher risk levels as indicated by the Risk Adjustment for Congenital Heart Surgery (RACHS-1) scores [10]. During the period of 2022-2023, these scores were generally higher (ranging between 3 and 5 out of 6) compared to those recorded in 2021-2022 (ranging between 2 and 4). This elevation in risk levels correlates with an increased likelihood of prolonged reliance on mechanical ventilation and/or ECMO support, consequently heightening the risk of *S. maltophilia* BSI. Furthermore, Menekşe et al. documented findings from the adult ICU within our institution indicating that *S. maltophilia* bloodstream infections were linked to ECMO water heating units and unexpected sources such as needleless blood gas injectors used for drawing blood gas samples from ECMO devices [18].

Another significant factor supported by considerable evidence is the prolonged administration of broad-spectrum antibiotics like vancomycin, carbapenems, ceftazidime, aminoglycoside, and piperacillin/tazobactam, which increases the susceptibility to *S. maltophilia* bloodstream infection in ICU patients [4,19,20]. Consistent with existing literature, our study revealed that patients

diagnosed with *S. maltophilia* bloodstream infection had a statistically significantly longer duration of broad-spectrum antibiotic use in 2022-2023 compared to the previous year.

Despite meticulous adherence to infection control measures recommended by the infection control committee (including hand hygiene, wound care, sterilization, regular staff training, and standard precautions), a majority of our ICU patients in 2022-2023 experienced various critical bacterial infections, necessitating prolonged use of broad-spectrum antibiotics and elevating the risk of *S. maltophilia* bloodstream infection [21].

Treatment of *S. maltophilia* infections is a challenge due to the resistance of bacteria to a variety of antibiotics [22]. As an increasing number of studies are reporting that *S. maltophilia* has become resistant to trimethoprim-sulfamethoxazole (TMP-SMX), we performed the susceptibility test to TMP-SMX [22]. Fortunately, in our test, *S. maltophilia* was sensitive to TMP-SMX, suggesting that the antibiotic could still be used effectively to treat *S. maltophilia* infections.

Limitation of the Study

The scarcity of literature on *S. maltophilia* infections in pediatric cardiovascular surgery ICUs posed a limitation to our study in investigating the factors contributing to the notable rise within our unit through a single-center approach. Additionally, the retrospective nature and single-center design of our study introduce the possibility of bias, further limiting its scope and generalizability.

Conclusion

Our study highlights a concerning rise in *S. maltophilia* bloodstream infections in the pediatric cardiovascular surgery ICU, primarily attributed to prolonged use of ECMO support and mechanical ventilation, alongside extended ICU stay and broad-spectrum antibiotic treatment. To address this issue effectively, a comprehensive strategy involving infection control practices, prudent antimicrobial usage, and efforts to reduce invasive procedures is crucial. Consequently, we advocate for further research, particularly focusing on the pediatric population, to gain deeper understanding of the factors involved and to mitigate the spread of *S. maltophilia* infections in high-risk ICU environments like pediatric CVS-ICU.

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