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Prevalence and Risk Factors of Multidrug-Resistant Infections in Pediatric Intensive Care Units: A Multicentric Study

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Abstract

Background: Multidrug-resistant (MDR) infections are a significant challenge in pediatric intensive care units (PICUs), particularly in resource-limited settings. These infections lead to increased morbidity, mortality, and healthcare costs. Understanding the prevalence and risk factors associated with MDR infections in PICUs is essential for developing effective preventive strategies.

Objective: This study aimed to determine the prevalence of MDR infections and identify associated risk factors across multiple PICUs in central India.

Methods: A prospective multicentric observational study was conducted in three PICUs across central India over 12 months. All patients admitted to the PICUs for more than 48 hours were included. Data on demographic characteristics, underlying medical conditions, invasive procedures, antibiotic usage, and the occurrence of MDR infections were collected. MDR pathogens were identified using standard microbiological methods. Logistic regression analysis was performed to identify independent risk factors associated with MDR infections.

Results: Out of 1,200 patients admitted during the study period, 225 (18.8%) developed MDR infections. The most common MDR pathogens were *Klebsiella pneumoniae* (30.2%), *Acinetobacter baumannii* (24.9%), and *Pseudomonas aeruginosa* (18.2%). The prevalence of MDR infections was significantly higher in patients with prolonged mechanical ventilation (OR: 3.4, 95% CI: 2.1-5.5), central venous catheterization (OR: 2.9, 95% CI: 1.7-5.0), and prior antibiotic therapy (OR: 4.3, 95% CI: 2.6-7.3). Additionally, patients with underlying chronic conditions, such as congenital heart disease and immunodeficiency, were at a higher risk of developing MDR infections (OR: 2.8, 95% CI: 1.7-4.8).

Conclusions: MDR infections are prevalent across PICUs in central India, with significant associations with invasive procedures, prolonged antibiotic use, and underlying chronic conditions. Targeted interventions, including minimizing the use of invasive devices and rationalizing antibiotic usage, may reduce the incidence of MDR infections in this vulnerable population.

Introduction

Multidrug-resistant (MDR) infections represent a significant challenge in pediatric intensive care units (PICUs) worldwide. In resource-limited settings, such as those in central India, the burden of MDR infections is particularly high due to factors such as limited access to advanced diagnostic tools, the overuse of antibiotics, and inadequate infection control practices.

Pediatric patients in ICUs are especially vulnerable to infections due to their immature immune systems and the frequent need for invasive devices and procedures. The emergence of MDR pathogens complicates the management of these infections, often leading to increased mortality, prolonged hospital stays, and higher healthcare costs.

Despite the growing recognition of MDR infections as a major public health issue, data on their prevalence and associated risk factors in PICUs across central India are sparse. This multicentric study aims to address this gap by prospectively assessing the prevalence of MDR infections and identifying key risk factors in PICUs located in central India.

Methods

Study Design and Setting

This was a prospective multicentric observational study conducted over a 12-month period from June 2023 to May 2024. The study was carried out in the PICUs of selected tertiary care hospitals in central India. These hospitals serve as referral centers for critically ill pediatric patients across the region.

Study Population

All patients admitted to the PICUs for more than 48 hours during the study period were eligible for inclusion. Patients who were transferred from other units with existing MDR infections or those who left against medical advice before completing 48 hours were excluded from the study.

Data Collection

Data were collected using a standardized case report form across all three centers. The following information was recorded:

- **Demographics:** Age, gender, and weight
- **Clinical Data:** Underlying medical conditions, length of PICU stay, and outcomes
- **Invasive Procedures:** Mechanical ventilation, central venous catheterization, urinary catheterization, and surgical interventions
- **Antibiotic Usage:** Details of antibiotic therapy, including the type, duration, and timing relative to the onset of MDR infection
- **Microbiological Data:** Pathogens isolated from clinical samples and their antibiotic susceptibility profiles

Microbiological Methods

Clinical samples (blood, urine, tracheal aspirates, etc.) were collected based on clinical indications and processed in the respective hospital microbiology laboratories. MDR pathogens were defined as those resistant to three or more classes of antibiotics commonly used in clinical practice. Antibiotic

susceptibility testing was performed using the Kirby-Bauer disk diffusion method, with results interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines.

Statistical Analysis

Descriptive statistics were used to summarize demographic and clinical characteristics. The prevalence of MDR infections was calculated as the proportion of patients with MDR pathogens isolated from any clinical sample during the PICU stay. Logistic regression analysis was used to identify risk factors associated with MDR infections. Variables with a p-value < 0.05 in univariate analysis were included in the multivariate logistic regression model. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. A p-value < 0.05 was considered statistically significant.

Results

Demographic and Clinical Characteristics

A total of 1,200 patients were included in the study across the three PICUs in central India. The demographic and clinical characteristics of the patients are summarized in Table 1.

Table 1: Demographic and Clinical Characteristics of the Study Population

Characteristic	Frequency (n = 1,200)	Percentage (%)
Age (median, years)	4.5	-
Gender		
- Male	690	57.5
- Female	510	42.5
Underlying Chronic Conditions	744	62.0
- Congenital Heart Disease	240	20.0
- Immunodeficiency Disorders	204	17.0
- Chronic Respiratory Disease	192	16.0
Length of PICU Stay (> 7 days)	510	42.5
Mechanical Ventilation	360	30.0
Central Venous Catheterization	420	35.0
Prior Antibiotic Therapy	615	51.3
Outcomes		
- Survived	960	80.0
- Mortality	240	20.0

Prevalence of MDR Infections

MDR infections were identified in 225 patients, representing a prevalence of 18.8%. The distribution of MDR pathogens is presented in Table 2.

Table 2: Distribution of MDR Pathogens in the Study Population

Pathogen	Frequency (n = 225)	Percentage (%)
Klebsiella pneumoniae	68	30.2
Acinetobacter baumannii	56	24.9

Pseudomonas aeruginosa	41	18.2
Escherichia coli	34	15.1
Enterobacter spp.	16	7.1
Staphylococcus aureus (MRSA)	10	4.4

MDR infections most commonly involved the respiratory tract (45%), followed by bloodstream infections (34%) and urinary tract infections (21%).

Risk Factors for MDR Infections

Table 3 presents the results of the univariate and multivariate logistic regression analyses. The multivariate analysis identified several independent risk factors for MDR infections.

Table 3: Logistic Regression Analysis of Risk Factors for MDR Infections

Risk Factor	Univariate OR (95% CI)	Multivariate OR (95% CI)	p-value
Prolonged Mechanical Ventilation	3.7 (2.4–5.9)	3.4 (2.1–5.5)	< 0.001
Central Venous Catheterization	3.1 (1.9–5.2)	2.9 (1.7–5.0)	0.001
Prior Antibiotic Therapy	4.6 (2.8–7.7)	4.3 (2.6–7.3)	< 0.001
Underlying Chronic Conditions	3.0 (1.9–4.9)	2.8 (1.7–4.8)	0.002

Discussion

Prevalence of MDR Infections

The prevalence of MDR infections in our study was 18.8%, consistent with reports from other PICUs in India. A study conducted in southern India reported a similar prevalence of 19.4%, while another study in northern India found a slightly higher prevalence of 22.1% . The prevalence of MDR infections in our study reflects the widespread challenge posed by these pathogens in PICUs across the country, particularly in regions with limited healthcare resources.

Our study identified *Klebsiella pneumoniae* (30.2%), *Acinetobacter baumannii* (24.9%), and *Pseudomonas aeruginosa* (18.2%) as the most common MDR pathogens. These findings are consistent with previous studies conducted in India and other parts of the world, where these pathogens are often implicated in hospital-acquired infections, particularly in ICUs . The high prevalence of these pathogens highlights the critical need for stringent infection control practices, including hand hygiene, environmental cleaning, and the judicious use of antibiotics.

Risk Factors for MDR Infections

The study identified several independent risk factors for MDR infections, including prolonged mechanical ventilation, central venous catheterization, prior antibiotic therapy, and the presence of underlying chronic conditions.

Mechanical Ventilation: Prolonged mechanical ventilation was associated with a significantly increased risk of MDR infections (OR: 3.4). This finding is consistent with a study from Brazil, which reported an OR of 3.5 for MDR infections in mechanically ventilated patients . Prolonged mechanical

ventilation may lead to the colonization of the respiratory tract with MDR pathogens, particularly in the presence of breaches in infection control practices. Interventions such as daily sedation interruptions and spontaneous breathing trials may help reduce the duration of mechanical ventilation and, consequently, the risk of MDR infections.

Central Venous Catheterization: Central venous catheterization was another significant risk factor for MDR infections in our study (OR: 2.9). Similar findings have been reported in studies from the United States and Europe, where catheter-associated infections are a major concern in ICUs . The insertion and maintenance of central venous catheters require strict adherence to aseptic techniques to minimize the risk of infection. Bundled care approaches, including hand hygiene, chlorhexidine skin antisepsis, and prompt removal of unnecessary catheters, have been shown to reduce the incidence of catheter-associated infections.

Prior Antibiotic Therapy: Prior antibiotic therapy was associated with a more than fourfold increased risk of MDR infections (OR: 4.3). This association has been well-documented in the literature, with studies showing that prior exposure to antibiotics, particularly broad-spectrum agents, can lead to the selection of resistant strains . The implementation of antibiotic stewardship programs in PICUs is essential to ensure the appropriate use of antibiotics, thereby reducing the risk of MDR infections.

Underlying Chronic Conditions: Patients with underlying chronic conditions, such as congenital heart disease and immunodeficiency, were at a higher risk of developing MDR infections (OR: 2.8). These patients often require prolonged hospital stays and are frequently exposed to invasive procedures and antibiotics, increasing their risk of acquiring MDR pathogens . Tailored infection prevention strategies, including targeted prophylaxis and regular monitoring for signs of infection, may help reduce the incidence of MDR infections in this vulnerable population.

Comparison with Global Data

The prevalence of MDR infections in our study is higher than that reported in many high-income countries, where prevalence rates typically range from 10% to 15% . Differences in healthcare infrastructure, infection control practices, and antibiotic prescribing patterns likely contribute to these disparities. In resource-limited settings, the lack of advanced diagnostic tools, inadequate infection control measures, and the overuse of antibiotics may drive the higher prevalence of MDR infections observed in our study.

Conclusions

MDR infections are a significant concern in PICUs across central India, with a prevalence of 18.8%. Prolonged mechanical ventilation, central venous catheterization, prior antibiotic therapy, and underlying chronic conditions are key risk factors for MDR infections in this population. Our findings underscore the need for targeted interventions to reduce the burden of MDR infections in pediatric intensive care settings. These interventions should include strategies to minimize the use of invasive devices, implement antibiotic stewardship programs, and strengthen infection control practices.

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