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Original Research Article

Outcome of nosocomial infections in the pediatric intensive care unit

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Abstract

The most common type of HAIs in children is bloodstream infections, pneumonia (ventilator-associated VAP), urinary tract infections (UTI), skin and surgical site infections. Organisms such as gram-negative bacilli, coagulase-negative staphylococci, coagulase-positive staphylococci, *Pseudomonas* spp., and streptococcus are the main causes of HAIs. Children diagnosed to have Community acquired nosocomial infections in the pediatric intensive care unit stay of more than 48 hours between the age group of 1 month to 12 years admitted in PICU of Tertiary care Hospital, who fulfilled the inclusion criteria. The age, sex, nutritional status, incidence of anaemia and site of nosocomial infections of dead and discharged patients was comparable and statistically not significant as per Chi-Square test (p>0.05). The mean duration of PICU stay (10.77 ± 3.80 days vs. 7.63 ± 4.27 days), requirement of mechanical ventilation (86.4% vs. 35.9%) and requirement of reintubation (13.6% vs. 0%) was significantly higher in dead patients compared to discharged patients (p<0.05).

Keywords: HAI, UTI, PICU

Introduction

Children hospitalized in intensive care units (ICUs), are unique population in regard to specific risk factors for HAIs. Small children are more susceptible to many infections because of immaturity of their immune system. Children are at more risk of exposure to environmental contamination (toys, diaper, hugging) and they are treated using multidisciplinary medical and surgical approach.

Healthcare-associated infections (HAIs) are an increasingly recognized problem in hospitals. The World Health Organization (WHO) has reported that the risk of HAIs in the developing countries can be up to 20 times greater than in the developed ones and the proportion of infected patients regularly exceeds 25% [1].

The most common type of HAIs in children is bloodstream infections, pneumonia (ventilator-associated VAP), urinary tract infections (UTI), skin and surgical site infections. Organisms such as gram-negative bacilli, coagulase-negative staphylococci, coagulase-positive staphylococci, *Pseudomonas* spp. and streptococcus are the main causes of HAIs. A common problem in the treatment of NIs in pediatric wards is increasing frequency of antibiotic-resistant organisms. Surveillance activities are the first step in developing infection control programs and may help in decreasing the incidence of infections and reducing costs [2].

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Healthcare-associated infections are of important wide-ranging concern in the medical field. They can be localized or systemic, can involve any system of the body, be associated with medical devices or blood product transfusions. Continued surveillance, along with sound infection control programs, not only leads to decreased healthcare-associated infections but also better prioritization of resources and efforts to improving medical care [3].

Hospital-based programs of surveillance, prevention and control of healthcare-associated infections have been in place since the 1950s. The Study on the Efficacy of Nosocomial Infection Control Project (SENIC) from the 1970s showed nosocomial rates could be reduced by 32% if infection surveillance were coupled with appropriate infection control programs.

Most countries lack surveillance systems for health care-associated infections. Those that do have systems often struggle with the complexity and lack of standardized criteria for diagnosing the infections. While this makes it difficult to gather reliable global information on health care-associated infections. Results from studies clearly indicate that each year, hundreds of millions of patients are affected by health care associated infections around the world [4].

Practice of recommended protocols for patient care will result in improved health care and better clinical outcome. The survey regarding such infections will lead to better understanding towards HAI, thereby enable us to provide adequate infection control measures and reduce the incidence of HAI in the future [5].

The challenges for the future are to minimize HAI in the PICU and ensure better clinical outcome for all.

It has been reported that in hospitals with an effective program for HAI surveillance, infection rates can be reduced by approximately one-third. A multifaceted quality improvement intervention reduces HAI rates, hospital length of stay and mortality in PICU [6].

Hence the present study was done at our tertiary care centre to assess the clinical profile, laboratory investigations and outcome of nosocomial infections in PICU.

Methodology

A hospital based prospective study was conducted with 100 patients to evaluate nosocomial infections in the pediatric intensive care unit in children between 1 month to 12 years.

Study design: A hospital based prospective study.

Study area: The study was done at our tertiary care centre in the department of Paediatrics, Paediatric intensive care unit.

Study population: Children diagnosed to have Community acquired nosocomial infections in the pediatric intensive care unit stay of more than 48 hours between the age group of 1 month to 12 years admitted in PICU of Tertiary care Hospital, who fulfilled the inclusion criteria.

Sample size: 100 patients.

Inclusion criteria

- All the patients in the age group of 1 month to 12 years admitted in PICU with stay of more than 48 hours were daily monitored for fever or any other symptoms or sign suggestive of any infection.
- The patients who developed the same 48 hours after admission, which was not present at the time of admission, were included.
- Centres for Disease Control and Prevention definitions of nosocomial infections, used as criteria for diagnosis of infections.

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Exclusion criteria

- Patients with any clinical feature or laboratory investigation, suggesting concerned infection being prior to the admission to the PICU.
- Blood culture positive at the time of admission.
- Children discharged or died within 48 hours of admission.
- Attendants of those children not interested/not willing to participate in the study.

The study was done at our tertiary care centre in the department of Paediatrics on children diagnosed to have Community acquired nosocomial infections in the pediatric intensive care unit with stay of more than 48 hours between the age group of 1 month to 12 years admitted in PICU of Tertiary care Hospital, after due permission from the Institutional Ethics Committee and Review Board and after taking Written Informed Consent from the patients.
After approval from the Institutional Ethics Committee a valid informed consent was taken. Once the patients were enrolled for the study, a thorough history and physical examination was done as per proforma. An informed consent was taken in written from patients or patient's attendant.
Detailed demographic, laboratory investigations and outcome were recorded in the prestructured questionnaire format.
Patients suspected to have developed nosocomial infections in the PICU, if they developed any one of the following clinical features 48 hours after admission to the PICU.

Results

47 (47%) patients required mechanical ventilation.

Table 1: Distribution of patients according to Requirement of Mechanical Ventilation

Requirement of Mechanical Ventilation	N	%
Yes	47	47%
No	53	53%
Total	100	100%

Of the 3 patients with ventilator associated pneumonia, 1 (33.3%) patient had been reintubated once and 2 (66.7%) patients were reintubated more than once.

Table 2: Distribution of patients according to Requirement of Reintubation (n=3)

Requirement of Reintubation	N	%
Once	1	33.3%
More than Once	2	66.7%
Total	3	100%

27 (27%) patients had culture positive isolates.

Table 3: Distribution of patients according to Blood Culture Findings

Blood Culture Findings	N	%
Positive	27	27%
Negative	73	73%
Total	100	100%

The most common organism was Klebsiella (44.5%) followed by Coagulase negative Staphylococci (CONS) (14.8%), Acinetobacter (11.1%), Staphylococcus aureus (7.4%),

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Enterococci (7.4%), E. Coli (7.4%) and Pseudomonas (7.4%).

Table 4: Distribution of patients according to Bacteria Isolated from Blood Culture (n=27)

Organisms	N	%
Klebsiella	12	44.5%
CONS	4	14.8%
Acinetobacter	3	11.1%
Staphylococcus aureus	2	7.4%
Enterococci	2	7.4%
E. coli	2	7.4%
Pseudomonas	2	7.4%
Total	27	100%

CONS-Coagulase negative Staphylococci

Klebsiella was found to be highly sensitive to Amikacin (83.3%), Imipenem (83.3%), Ciprofloxacin (66.7%), Ceftazidime (41.7%) and Gentamycin (41.7%). CONS was also found to be highly sensitive to Amikacin (75%), Ciprofloxacin (75%), Gentamycin (75%) and Vancomycin (75%). The other sensitive antibiotics for CONS included Cefotaxime (50%), Cephalexin (50%), Cotrimoxazole (50%) and Erythromycin (50%). Acinetobacter was highly sensitive to Ciprofloxacin (100%), Amikacin (66.7%), Amoxyclav (66.7%), Cotrimoxazole (66.7%) and Gentamycin (66.7%). The other microorganisms isolated including Staphylococcus aureus, Enterococci, E. coli and Pseudomonas were also found to be sensitive to Amikacin.

Table 5: Antibiotic sensitivity pattern of bacterial isolates

Bacterial Isolate	Amikacin		Amoxyclav		Ampicillin		Ciprofloxacin		Cefotaxime		Cephalexin	
	N	%	N	%	N	%	N	%	N	%	N	%
Klebsiella (n=12)	10	83.3%	2	16.7%	0	-	8	66.7%	0	-	0	-
CONS (n=4)	3	75%	0	-	0	-	3	75%	2	50%	2	50%
Acinetobacter (n=3)	2	66.7%	2	66.7%	0	-	3	100%	0	-	0	-
Staphylococcus aureus (n=2)	2	100%	0	-	0	-	0	-	0	-	0	-
Enterococci (n=2)	2	100%	0	-	0	-	0	-	0	-	0	-
E. coli (n=2)	2	100%	0	-	0	-	0	-	0	-	0	-
Pseudomonas (n=2)	2	100%	0	-	0	-	0	-	0	-	0	-

Bacterial Isolate	Ceftazidime		Cotrimoxazole		Erythromycin		Gentamycin		Imipenem		Vancomycin	
	N	%	N	%	N	%	N	%	N	%	N	%
Klebsiella (n=12)	5	41.7%	0	-	0	-	5	41.7%	10	83.3%	0	-
CONS (n=4)	0	-	2	50%	2	50%	3	75%	0	-	3	75%
Acinetobacter (n=3)	0	-	2	66.7%	0	-	2	66.7%	0	-	0	-
Staphylococcus aureus (n=2)	0	-	0	-	0	-	0	-	0	-	0	-
Enterococci (n=2)	0	-	0	-	0	-	0	-	0	-	0	-
E. coli (n=2)	0	-	0	-	0	-	0	-	0	-	0	-
Pseudomonas (n=2)	0	-	0	-	0	-	0	-	0	-	0	-

22 (22%) patients died in our study.

Table 6: Distribution of patients according to Outcome

Outcome	N	%
Died	22	22%
Discharged	78	78%

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Total	100	100%

The age, sex, nutritional status, incidence of anaemia and site of nosocomial infections of dead and discharged patients was comparable and statistically not significant as per Chi-Square test (p>0.05). The mean duration of PICU stay (10.77 ± 3.80 days vs. 7.63 ± 4.27 days), requirement of mechanical ventilation (86.4% vs. 35.9%) and requirement of reintubation (13.6% vs. 0%) was significantly higher in dead patients compared to discharged patients (p<0.05).

Discussion

The most common organism in our study was Klebsiella (44.5%) followed by Coagulase negative Staphylococci (CONS) (14.8%), Acinetobacter (11.1%), Staphylococcus aureus (7.4%), Enterococci (7.4%), E. Coli (7.4%) and Pseudomonas (7.4%). This is similar to the studies of Ulus A *et al*. [7], Venmugil P *et al*. [8], Akinkugbe O *et al*. [9], Behzadnia S *et al*. [10] and Costelloe C *et al*. [11].

Ulus A *et al*. [7] study observed Carbapenem resistance at a rate of 50% was determined for both Acinetobacter spp. and Pseudomonas aeruginosa and a strong correlation was determined between VAP and patient days. Most frequently identified agent was Enterobacteriaceae family and infection numbers decreased over time. Other agents identified were Acinetobacter spp. and Pseudomonas aeruginosa. Carbapenem resistance was determined in 50% of these pathogens.

Venmugil P *et al*. [8] prospective, descriptive, observational study showed Klebsiella was found to be the major isolate in tracheal aspirate as well as blood, amounting to 18 out of 35 culture positive isolates (51%). This was followed by Coagulase Negative Staphylococcus (CoNS)-8 isolates (22%) and Acinetobacter-3 isolates (9%), Staphylococcus aureus-2 isolates (6%), Enterococci-2 isolates (6%), Escherichia coli-1 isolate (3%) and Pseudomonas-1 isolate (3%).

Akinkugbe O *et al*. [9] retrospective cohort study showed cultures of blood, respiratory secretions and urine taken at least 48 h after PICU admission yielded a total of 26 positive isolates from 23 different patients. One patient had positive cultures from endotracheal secretions on three different admissions. In another patient two different organisms were isolated from urine culture during the same illness. All three hospital-acquired bloodstream infections were with Gram-positive organisms [Enterococcus faecalis (1), Enterococcus faecium (1) and Staphylococcus epidermidis (1)]. Gram-negative organisms, particularly Enterobacteriaceae and Pseudomonas were dominant among the 15 patients with HAP. The eight urinary tract infections were due to E. faecalis (four isolates) and E. coli (four isolates).

Behzadnia S *et al*. [10] retrospective cross-sectional study found most common bacteria isolated from patients were *P. aeruginosa* and *Acinetobacter* spp.

Costelloe C *et al*. [11] systemic review and meta-analysis on Effect of antibiotic prescribing in primary care on antimicrobial resistance found that individual patients prescribed antibiotics for respiratory or urinary tract infections developed AMR, with the effect greatest in the month immediately after treatment and persisting for up to 12 months.

In the present study, Klebsiella was found to be highly sensitive to Amikacin (83.3%), Imipenam (83.3%), Ciprofloxacin (66.7%), Ceftazidime (41.7%) and Gentamycin (41.7%). CONS was also found to be highly sensitive to Amikacin (75%), Ciprofloxacin (75%), Gentamycin (75%) and Vancomycin (75%). The other sensitive antibiotics for CONS included Cefotaxime (50%), Cephalexin (50%), Cotrimoxazole (50%) and Erythromycin (50%). Acinetobacter was highly sensitive to Ciprofloxacin (100%), Amikacin (66.7%), Amoxyclav (66.7%), Cotrimoxazole (66.7%) and Gentamycin (66.7%). The other microorganisms isolated including Staphylococcus aureus, Enterococci, E. coli and

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Pseudomonas were also found to be sensitive to Amikacin. This is comparable to the studies of Akinkugbe O *et al*. [9] and Venmugil P *et al*. [8].

Akinkugbe O *et al*. [9] retrospective cohort study showed seven isolates with resistance to antimicrobials commonly used as treatment for HCAI. All were Gram-negative organisms: three P. aeruginosa, two Klebsiella oxytoca and two E. coli. There was one K. oxytoca resistant to piperacillin/tazobactam (susceptible to ceftazidime) and one K. oxytoca resistant to ceftazidime (susceptible to piperacillin/tazobactam). Among the three endotracheal isolates with resistant P. aeruginosa, one was resistant to ciprofloxacin and two were resistant to carbapenems. Although an ESBL-producing K. pneumoniae was isolated from one endotracheal sample, both disc testing and determination of MIC demonstrated susceptibility to gentamicin and meropenem. E. coli resistant to gentamicin was isolated from two urine samples. Both isolates were susceptible to amikacin.

Although some bacteria have innate resistance to certain classes of antibiotics, of greater concern is the ability of initially susceptible bacteria to acquire resistance through mutations and selection pressures or by horizontal transfer of genetic material. These mechanisms have enabled organisms to develop MDR, a process that has been demonstrated *in vivo* with the demonstration of evolving resistance patterns of bacterial populations during courses of antibiotic treatment [12].

Resistance to empirical antibiotics has been associated with increased mortality in patients with Staphylococcus aureus, CoNS, enterococci, *Enterobacter* spp., *P. aeruginosa*, *K. pneumoniae* and E. coli.

Venmugil P *et al*. [8] prospective, descriptive, observational study reported Klebsiella was found to be highly sensitive to Amikacin (15 out of 18 isolates, 83%) and Imipenam (16 out of 18 isolates, 89%), followed by Ciprofloxacin (12 out of 18 isolates, 67%), Ceftazidime (8 out of 18 isolates, 44%) and Gentamycin (8 out of 18 isolates, 44%). CoNS was also found to be highly sensitive to Amikacin (7 out of 8 isolates, 88%), followed by Gentamycin (6 out of 8 isolates, 75%) and Vancomycin (6 out of 8 isolates, 75%). The other sensitive antibiotics for CONS included Ciprofloxacin (5 out of 8 isolates, 63%), Cefotaxime (2 out of 8 isolates, 25%), Cephalexin (1 out of 8 isolates, 13%), Cotrimoxazole (1 out of 8 isolates, 13%) and Erythromycin (1 out of 8 isolates, 13%). The other microorganisms isolated including Acinetobacter, Staphylococcus aureus, Enterococci, E. coli and Pseudomonas were also found to be sensitive to Amikacin.

Venmugil P *et al*. [8] prospective, descriptive, observational study reported mortality in 14 (21%) patients.

It was observed in the present study that the age, sex, nutritional status, incidence of anaemia and site of nosocomial infections of dead and discharged patients was comparable and statistically not significant as per Chi-Square test ($p>0.05$). The mean duration of PICU stay (10.77 ± 3.80 days vs. 7.63 ± 4.27 days), requirement of mechanical ventilation (86.4% vs. 35.9%) and requirement of reintubation (13.6% vs. 0%) was significantly higher in dead patients compared to discharged patients ($p<0.05$). Venmugil P *et al*. [8] noted similar observations in their study.

Venmugil P *et al*. [8] prospective, descriptive, observational study reported mortality in 14 (21%) patients while 51 (75%) got improved and later discharged from the ward. Of the remaining patients, 2 (3%) were discharged against medical advice and 1(1%) patient was referred to higher centre for specialty management.

Conclusion

- HAI continue to remain a major threat to hospitalised patients because of the compromised quality of life and added financial burden and a higher incidence of HAI in malnourished children have prolonged period of hospital stay.
- In our study the most common type of nosocomial infection was blood stream infections

and the most common organism found was Klebsiella which was found sensitive more commonly to amikacin. The other microorganisms isolated including Staphylococcus aureus, Enterococci, E. coli and Pseudomonas were also found to be sensitive to Amikacin.

- Hence in our PICU, the antibiotic Amikacin may be considered in the empirical treatment of HAI while culture reports are awaited.

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