Epidemiology and characteristics of nosocomial infections in critically ill patients in a tertiary care Intensive Care Unit of Northern India

ABSTRACT

Background and Aims: The prevalence of nosocomial infection is higher in the Intensive Care Unit (ICU) than other areas of the hospital. The present observational study was undertaken to describe the epidemiology and characteristics of nosocomial infections acquired in a tertiary care ICU and the impact of the various risk factors in their causation.

Materials and Methods: A retrospective study was conducted on the prospectively collected data of 153 consecutive patients admitted in a tertiary care ICU between July 2014 and December 2015. The primary objective was to assess the epidemiology of ICU-acquired bacterial infections in terms of the incidence of new infections, causative organism, and site. The secondary end point was to assess the risk factors for developing ICU-acquired infections.

Results: Out of the 153 patients enrolled in the study, 87 had an ICU-acquired nosocomial infection (58.86%). The most common organism responsible for infection was *Klebsiella pneumoniae* (37%), and the most common infection was pneumonia (33%). The duration of mechanical ventilation and length of ICU stay were significantly prolonged in patients developing nosocomial infections. There was no difference in mortality between the groups. The multivariate analyses identified intubation longer than 7 days, urinary catheterization >7 days, duration of mechanical ventilation more than 7 days, and ICU length of stay longer than 7 days as independent risk factors for nosocomial infections.

Conclusion: The study demonstrated a high incidence of nosocomial infection in the ICU and identified the risk factors for acquisition of nosocomial infections in the ICU.

Key words: Critically ill, ICU, nosocomial infection

Introduction

Nosocomial infections are a major threat to the patients' safety in any health-care facility.[1] However, the prevalence is higher in the Intensive Care Units (ICUs) than other areas of the hospital.[1-3] This increased prevalence of nosocomial infection not only influences the mortality and morbidity pattern of ICU but also poses a significant financial burden to the patient and the society.[3,4]

National nosocomial infections surveillance system has defined nosocomial infection as a localized or systemic condition that results from an adverse reaction to the presence

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of an infectious agent(s) or its toxin(s) that was not present or incubating at the time of admission to the hospital.[5]

The important nosocomial infections in the ICU based on frequency and potential severity include urinary tract infection (UTI), pneumonia, bloodstream infections, skin and soft tissue infections, gastroenteritis, hepatitis, and meningitis.[4-7]

The aim of this observational study was to describe the epidemiology and characteristics of nosocomial infections in our ICU including risk factors, causative microorganisms and the impact of such nosocomial infections on the ICU mortality, and length of stay.

Materials and Methods

After seeking approval from the Institute Ethics Committee for waiver of informed consent, a retrospective observational study of prospectively collected data was conducted in a cohort of 153 consecutively admitted patients in the seven bedded mixed medical-surgical ICU between July 2014 and December 2015.

The data of all patients admitted in the ICU between July 2014 and December 2015 were extracted from the official database maintained for the clinical and administrative purpose. Patients whose length of stay in the ICU was more than 48 h were chosen for enrollment. "ICU-acquired infections" were defined as all new infections acquired in the ICU after 48 h of admission. The preexisting infections were distinguished from the ICU-acquired infections both clinically and microbiologically. Clinical diagnosis was made according to the criteria of the Center for Disease Control and Prevention National Healthcare Safety Network.[8] All microbiological isolates of infected patients were evaluated.

The primary objective was to assess the epidemiology of ICU-acquired bacterial infections in terms of the incidence of new infections, causative organism, and site.

The secondary objective was to assess the risk factors for developing ICU-acquired infections. The group which acquired nosocomial infection (Group A) was compared to the group which did not acquire any nosocomial infection (Group B) according to a number of demographic and clinical factors including age, sex, disease severity at the time of admission (assessed from acute physiology and chronic health evaluation II [APACHE II] score), duration of mechanical ventilation, duration of stay in the ICU, duration of endotracheal intubation, central venous catheterization,

and urinary catheterization. The other secondary objectives were to assess the outcome of patients with ICU-acquired infections in terms of mortality, duration of mechanical ventilation and length of ICU stay.

The incidence of ICU-acquired infections was described as a percentage. The data for continuous variables were presented in terms of mean ± standard deviation and data for categorical variables were indicated by frequency (%). The statistical significance of qualitative variables between the different groups was calculated using Chi-square or Fischer exact test. The statistical significance of quantitative variables was calculated by Student's *t*-test or Wilcoxon test. Mann–Whitney test was done where data did not follow a normal distribution. Independent risk factors for mortality and morbidity were analyzed by multivariate analysis. Results of multivariate analysis were presented as a *P* value and odds ratio (OR) with 95% confidence interval (CI). Data were analyzed using the STATA 9.1 software (STATA Corp, 4905, Lakeway Drive College Station, 77845, Texas, US).

Results

Of the 153 patients enrolled in our study, majority had stroke, liver diseases, and pancreatitis [Figure 1] and 87 had an ICU-acquired nosocomial infection (56.86%). The bacteria responsible for the infection were primarily *Klebsiella pneumoniae* and *Escherichia coli* [Figure 2]. Majority of the infections were due to pneumonia followed by UTIs and blood stream spread [Figure 3]. The patients in the Group A (those who acquired nosocomial infection) and Group B (who did not acquire any nosocomial infection) showed no difference with regard to age, sex, disease severity, and comorbid conditions. The comparison of ICU length of stay (15.24 ± 10.9 vs. 4.46 ± 5.03) and duration of mechanical ventilation (11.9 ± 8.3 vs. 3.07 ± 2.25) showed that these were higher in Group A than in Group B (*P* < 0.001). There was no statistically significant difference
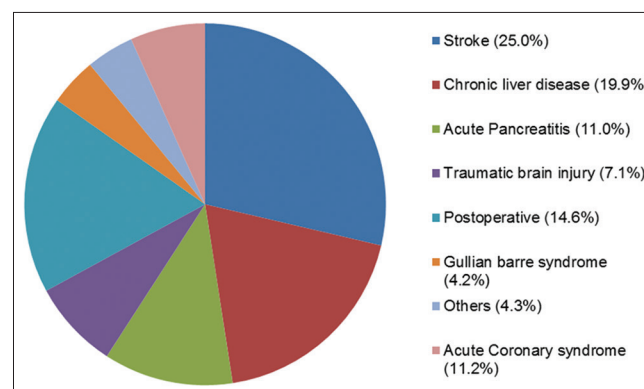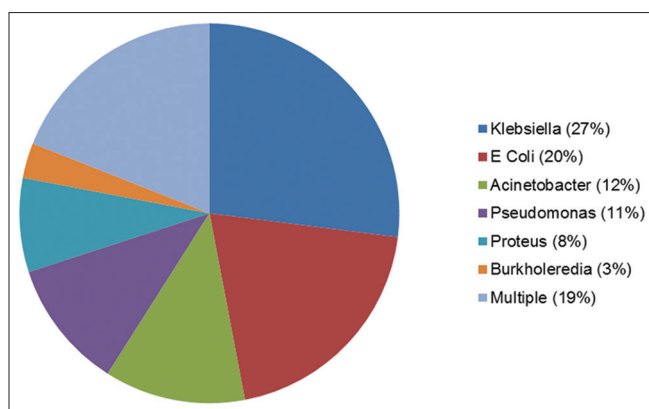

Figure 1: Distribution of enrolled patients

Figure 2: Organisms responsible for causing nosocomial infections in the Intensive Care Unit

Figure 3: Distribution of nosocomial infection

in mortality between the groups (46.15% vs. 53.85%) [Table 1]. The multivariate analysis showed the following to be independent factors associated with nosocomial infections in the ICU: duration of stay ($P < 0.001$, OR 19.7, 95% CI 7.9-49.1), duration of mechanical ventilation ($P < 0.001$, OR: 37.9, 95% CI: 10.9–130.8), duration of tracheal intubation ($P < 0.001$, OR: 14.8, 95% CI: 2.56–86.12), and duration of urinary catheterization ($P < 0.001$, OR: 2.8, 95% CI: 0.71–11.6) [Table 2].

Discussion

Despite contributing to only 15%–20% of the hospital beds, ICUs account for more than 50% of the life-threatening nosocomial infections.[9-11] The incidence of nosocomial infection found in our study is higher than some studies reported from other parts of the world.[12,13] In India, studies reporting nosocomial infections in ICU have ranged from 11% to 60%.[14,15] The wide variance in the prevalence is because of the presence or absence of various risk factors distributed unevenly across the health care settings. Our study found the highest incidence of nosocomial infection to be due to *K. pneumoniae*. *Klebsiella* accounts for approximately 8% of all hospital-acquired infections and as many as 14% of cases of primary bacteremia.[16] The role of extended-spectrum beta-lactamase (ESBL) produced by *Klebsiella* strains in outbreaks of drug-resistant infections has been a major concern since the past decade. It is well known that the ESBLs increase affinity and hydrolytic activity for third generation cephalosporins and monobactams and aggravate cross-resistance among aminoglycosides.[16-18] The outbreaks of K. pneumoniae occur most commonly in the ICU because of the presence of the potential risk factors for colonization and infection. The factors such as disease severity, extreme age, long duration antibiotic usage, and the high prevalence of invasive procedure contribute to their increased colonization and infection.[19,20] Xiong *et al*. from China had reported a 51%
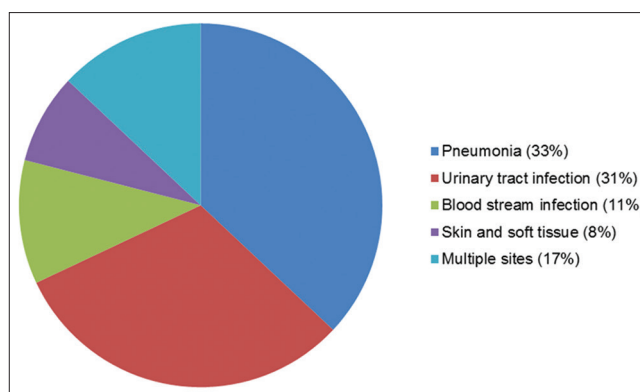
Table 1: Comparison between patients developing (Group A) and not developing (Group B) nosocomial infections

	Group A (*n*=87)	Group B (*n*=66)	*P*
Age - >60 years (%)	36 (40.9)	25 (38.46)	0.80
Sex - male (%)	59 (67.04)	46 (70.76)	0.75
APACHE II - >24 (%)	45 (65.21)	29 (70.73)	0.70
Comorbidities (hypertension, diabetes, heart disease, liver disease, and kidney disease) (%)	72 (82.7)	54 (81.8)	0.20
Mechanical ventilation	11.9±8.3	3.07±2.25	<0.001*
Duration of stay	15.24±10.9	4.46±5.03	<0.001*
Death (%)	46.15	53.85	0.006

P<0.05 significant. APACHE: Acute physiology and chronic health evaluation

K. pneumoniae incidence in the neurosurgical intensive care patients with a greater preponderance of the ESBL producing strains. Although we did not measure the ESBL producing strains in our study, our overall incidence is similar to Xiong *et al*.[21] It was found in another multihospital study that when patients are admitted to acute care hospitals from high acuity long-term care facilities, they are more likely to be colonized with carbapenemase-producing *K. pneumoniae* carbapenemase.[22] Many of our patients were initially admitted to other health-care facilities and later shifted to our center for advanced therapies. This can explain the risk of higher colonization and infection due to *K. pneumoniae* in our patients. Studies have reported *K. pneumoniae* outbreaks with a wide variety of objects such as ultrasonography gel, intravenous solutions containing dextrose, contaminated breast milk, and bath soap.[23-26] Since some of these factors can be relevant in our ICU, their identification and prevention can be useful to reduce the *K. pneumoniae* infections in our patients. Our study also showed a high incidence of *Klebsiella* in the UTIs and the same has also been described in studies reported from other parts of the world.[27] It has been shown in many studies that asymptomatic bacteriuria should be differentiated from symptomatic UTI and only the later should be subjected to antibiotic treatment. This can prevent antibiotic-associated complications and reduce antibiotic

Table 2: Multivariate analysis showing independent predictors of Intensive Care Unit acquired nosocomial infections

Variable	Group A (*n*=87), *n* (%)	Group B (*n*=66), *n* (%)	P	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Age (years)					
<59	52 (59.1)	40 (61.53)	0.80	1	1
≥60	36 (40.9)	25 (38.46)		1.08 (0.57-2.06)	0.93 (0.41-2.13)
Sex					
Male	59 (67.04)	46 (70.76)	0.75	1	1
Female	29 (32.95)	19 (29.23)		0.84 (0.41-1.68)	0.75 (0.36-1.12)
APACHE II					
<23	24 (34.78)	12 (29.26)	0.70	1	1
≥24	45 (65.21)	29 (70.73)		1.29 (0.56-2.97)	
ICU stay (days)					
<7	26 (29.89)	59 (89.39)	<0.01*	1	
≥7	61 (70.11)	7 (10.61)		19.77 (7.97-49.03)	-
Ventilator duration (days)					
<7	31 (35.63)	63 (95.45)	<0.01*	1	
≥7	56 (64.37)	3 (4.55)		37.93 (10.99-130.89)	
CVP duration (days)					
<7	29 (33.33)	23 (34.85)	0.845	1	1
≥7	58 (66.67)	43 (65.15)		1.06 (0.54-2.10)	1.10 (0.47-2.63)
ETT/TT duration (days)					
<7	31 (35.63)	63 (95.45)	<0.01*	1	1
≥7	56 (64.37)	3 (4.55)		37.93 (10.99-130.89)	14.87 (2.56-86.12)
Urinary catheter duration (days)					
<7	26 (29.89)	59 (89.39)	<0.01*	1	1
≥7	61 (70.11)	7 (10.61)		19.77 (7.97-49.03)	2.86 (0.71-11.60)

P value significant <0.05. ETT/TT: Endotracheal tube/tracheostomy tube; OR: Odds ratio; CI: Confidence interval; CVP: Central venous pressure; APACHE: Acute physiology and chronic health evaluation; ICU: Intensive Care Unit

misuse.[27,28] The early identification of Pseudomonas and *E. coli* can make the patients amenable to treatment for UTI before they become more critical in the ICU and a good number of such patients existed in our ICU.

In our study, about 39% patients developed multiple infections due to two or more organisms at more than one site. It has been reported in studies that mortality associated with multiple organism bacteremia is 48% as against 25% in single organism bacteremia.[29] However, such a correlation was beyond the scope of observation in our study.

Our study did not find any difference in mortality between the group which developed nosocomial infection in the ICU and the group which did not. There was also no difference in age, sex, and severity of disease based on APACHE II between the groups. This is because of the complex mix of heterogeneous cases and their inherent differences having a variable effect on all-cause mortality. However, there was a difference in ICU length of stay and duration of mechanical ventilation which has been corroborated in several other studies.[30-32]

Our study has identified duration of intubation, duration of urinary catheterization, duration of mechanical ventilation, and duration of ICU stay as independent predictors of

nosocomial infection in the ICU. In a similar study as ours, age, simplified acute physiology score II score at onset of blood stream infection, colistin resistance, and aminoglycoside were identified as independent predictors of *K. pneumoniae* infection in the ICU.[33] Another study conducted in surgical ICU found admission APACHE II score, presence of peritonitis, pancreatitis, aminoglycoside use, and mechanical ventilation as independent risk factors for nosocomial infection.[34] A retrospective cohort study conducted in a mixed ICU found the need for mechanical ventilation on ICU day 1 and transfer to the ICU from another unit as independent predictors of ICU-attributable nosocomial infections.[35] No study has, however, shown the direct association between a particular organism and a particular infection site on mortality.

However, our study had some limitations. One, the observed variables are simple with regard to the complex nature of their outcomes. Two, since many patients had multi-organ dysfunction at the time of ICU admission, the addition of MODS score or SOFA score to APACHE II could have improved the evaluation. Three, many physiological determinants of outcomes are addressed before ICU admission in the emergency department which impacts the nosocomial infection. These factors were not addressed in our study.

Finally, all inherent drawbacks of a retrospective study can limit our observation and interpretation.

Conclusion

Our study found a high incidence of nosocomial infections in the ICU which did not affect overall ICU mortality. The main cause of ICU infection was pneumonia caused by *K. pneumoniae*. The duration of mechanical ventilation, duration of urinary catheterization, duration of endotracheal intubation, and length of ICU stay were independent predictors of ICU-acquired nosocomial infections. More prospective observational and multicentric studies are necessary to enrich our understanding of the various risk factors and their associations.

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Conflicts of interest
There are no conflicts of interest.

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