

Original Research Article

Study of pattern and etiological factors of nosocomial infections in critical care unit in a multispecialty, tertiary care hospital in Central India

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ABSTRACT

Background: Nosocomial infection is a key factor determining the clinical outcome, especially among patients admitted in critical care areas. The objective of the study was to ascertain the pattern and risk factors of nosocomial infections in Critical Care Unit in a tertiary care hospital.

Methods: This prospective, observational clinical study included patients admitted in intensive care unit over a period of one and a half years. Routine surveillance of various nosocomial infections such as catheter-associated urinary tract infections, central-line-associated blood stream infections, and ventilator-associated pneumonias was done through specific infection surveillance proforma.

Results: Out of 679 patients, 166 suffered 198 episodes of device-associated infections. The infections included CAUTI, CLABSI, and VAP. The number of urinary tract infection episodes was found to be 73 (10.75%) among the ICU patients who had indwelling urinary catheter. In addition, for 1 year CAUTI was calculated as 9.08/1000 catheter days. The number of episodes of blood stream infection was 86 (13.50%) among ICU patients having central line catheters. Also, CLABSI was found to be 13.86/1000 central line days. A total of 39 episodes (6.15%) of VAP was found in ICU patients over 18 months and VAP present for 6.04/1000 ventilator days.

Conclusions: The organisms most commonly associated with nosocomial infections were *Pseudomonas Aeruginosa* and *Acinetobacter* species. The risk factors identified as being significantly associated with device associated infections in our ICU were diabetes, COPD and ICU stay for ≥ 8 days ($p < 0.05$).

Keywords: Critical care, Nosocomial infections, Pattern, Etiological factors

INTRODUCTION

Nosocomial infection is a key factor determining clinical outcome among patients, especially those admitted in critical care areas. Surveillance of device-associated infections has become an integral feature of infection control in all hospitals. These infections include catheter-associated urinary tract infections (CAUTI), central-line-associated blood stream infections (CLABSI), and ventilator-associated pneumonias (VAP).

The centre for disease control and prevention (CDC), USA has provided simple definitions for the diagnosis of these infections.¹ In addition, estimation of nosocomial infection rate/1000 device days allows all hospitals to assess and compare their rates and also recognize exclusive problem that need reappraisal. Moreover, surveillance of nosocomial infections defines the extent and nature of problem, which is the initial step toward reducing threat of infection in vulnerable hospitalized patients.² Generation of infection-control surveillance

data from time to time is pertinent for empirically treating infections, especially in the intensive care unit (ICU) setting; where a thorough knowledge of the epidemiology, type, nature, and risk factors for infections as well as the antimicrobial resistance patterns of invading microorganism is needed as a step towards comprehensive patient recovery.³ It has been observed that there is scanty published data on device-associated infections available from Indian ICUs. The objective of the study was to ascertain the pattern and risk factors of nosocomial infections in the ICU of a tertiary care hospital in Central India.

METHODS

This observational study was conducted from 1st May 2020 to 31st October 2021 (18 months) at Alexis Multi-specialty hospital, Nagpur, which is a 200 bedded, tertiary care hospital with a 32 bedded ICU. It is a multidisciplinary ICU, with nurse patient ratio of 1:2 for non-ventilated and 1:1 for ventilated patients. Each bed is equipped with a single hand sanitizer fitted at foot end of the bed. Routine surveillance of various nosocomial infections such as CAUTI, CLABSI, and VAP was done through specific Infection Surveillance Performa. These forms were filled up by infection control nurse along with doctor in-charge of the ICU. Data of all the patients admitted in the ICU of study centre during the study period and were part of infection control surveillance were included in the study. No patients whose data were captured during surveillance were excluded from the study. Thus the total sample size was 679, i.e. the total number of patients admitted in the one and a half year period in our ICU. First sample (urine, blood, and tracheal aspirate) of every patient admitted in ICU was sent for bacteriological culture to keep a baseline record to exclude infection at the time of admission into ICU, to get the true picture of infection rate. The laboratory evidence such as TLC/DLC, culture reports and other investigations like X-ray findings were correlated with the clinical findings such as temperature, pulse rate, blood pressure, auscultatory findings, and any other specific symptoms to assess infection.¹ Antibiotic susceptibility testing was carried out following Clinical Laboratory Standards Institute (CLSI) guidelines using the Kirby Bauer method.⁴ The antibiotics that were tested included amoxycylav (20/10 µg), cefotaxime (30 µg), ceftazidime (30 µg), piperacillin (100 µg), piperacillin+azobactam (100/10 µg), imipenem (10 µg), ciprofloxacin (5 µg), norfloxacin (10 µg), gentamicin (10 µg), netilmicin (30 µg), tobramycin (10 µg), ceftoxitin (30 µg), erythromycin (15 µg), vancomycin (30 µg), and linezolid (30 µg). At the end of each month the data were analyzed, and based on CDC guidelines, infection rates were calculated and findings shared with relevant stakeholders. Symptomatic CAUTI and asymptomatic bacteriuria were diagnosed for the study in-line with the 2022 NHSN Urinary Tract Infection (UTI) Checklist.⁵ In our study, for diagnosis of CAUTI, asymptomatic bacteriuria was included as all the patients had Foley's catheter in situ.

Central-line associated blood stream infection was considered if a central line was in place for 48 h before the onset of signs and symptoms, there being no other recognized cause for positive blood culture and: 1 positive blood culture with recognized pathogen or >2 blood cultures, drawn on separate occasions, positive for common skin contaminant (including *Diphtheroids*, *Bacillus*, *Propionobacterium spp*, coagulase-negative *Staphylococci*, *Viridans group Streptococci*, *Micrococcus spp*). The diagnosis of VAP was considered in patients who had a device to assist or control respiration continuously through a tracheostomy or by endotracheal intubation within the 48-h period before the onset of infection, inclusive of the weaning period. As per guidelines, VAP was diagnosed through combination of clinical, radiographical and microbiological findings as follows: Dullness to percussion on physical examination of chest and/or chest radiographic examination showing new or progressive infiltrate, consolidation, cavitations or pleural effusion and any of the following: new onset of purulent sputum or change in character of sputum, organism isolated from blood culture, positive quantitative culture from specimens like transtracheal aspirate, bronchial brushing, or lung parenchyma biopsy. In our study, quantitative transtracheal aspirates with counts of $\geq 10^6$ colony forming units/ml was used as a marker for the diagnosis of VAP.^{1,6} For all patients, data regarding various risk factors for device associated infections were collected. These risk factors included age (>60 years), male sex, length of ICU stay (≥ 8 days), and various co-morbidities like diabetes type II, chronic obstructive pulmonary disease (COPD), previous hospitalization, and surgical interventions. Comparison of the aforementioned risk factors was done between the patients known to have nosocomial infections and those without nosocomial infections in ICU. The statistical significance of these risk factors was calculated by using the Chi square test. The factors associated with <0.05 were considered to be statistically significant. Also, the odd's ratio was calculated to ascertain the strength of association of each risk factor.

RESULTS

The total number of patients admitted in the one-and-a-half-year period in our ICU was 679, 369 male patients and 310 female patients. Age of 117 patients was more than 60 years and rest (562) were under 60 years. Among 679 patients, 334 were medical patients and 345 were surgical patients. 28 patients had diabetes among the patients included in the study. Out of 679 patients, 166 suffered 198 episodes of device-associated infections. Thus, the overall infection percentage was 24.44% and infection rate was 29.1%. Central-line-associated blood stream infection (13.50%) was the most common nosocomial infection followed by UTI (10.75%) and VAP (6.15%) (Table 1). Among the 166 patients diagnosed with device associated infections 81 died (48.7%), whereas 162 patients out of 513 (31.5%) died among the group not having device-associated infections.

Table 1: Demographic details of the participants.

Variables	N	%
Gender distribution		
Male	369	54.34
Female	310	45.66
Age distribution (years)		
>60	117	17.23
<60	562	82.77

All of the 679 patients had indwelling urinary catheter and total number of Foley's catheterization days was 8039. The number of UTI episodes was found to be 73 (10.75%) among the ICU patients who had indwelling urinary catheter. In addition, CAUTI was calculated as 9.08/1000 catheter days. Poly microbial infection caused by two organisms was seen in eleven cases, total of 84 uropathogens were isolated. Out of the total number of 84 urinary isolates, *Pseudomonas aeruginosa* (30) and *enterococcus species* (13) were more commonly implicated.

Table 2: Rate of health care associated infections and its associated parameters.

Parameters	UTI	CLABSI	VAP
Percentage of the total health care associated infections (%)	10.75	13.5	6.15
No. of infection/1000 device days	9.08/1000 catheter days	13.86/1000 central line days	6.04/1000 ventilator days
Most common organism isolated (%)	<i>Pseudomonas aeruginosa</i> (35.7)	<i>Klebsiella pneumoniae</i> (29.2)	<i>Acinetobacter spp.</i> (41.3)

UTI-Urinary tract infection, CLABSI-Central-line-associated blood stream infections, VAP-Ventilator-associated pneumonias

Table 3: Organism isolated from various nosocomial infections.

Organism	Urine N (%)	Blood N (%)	Tracheal N (%)
<i>Acinetobacter species</i> (51)	08 (9.5)	24 (26.9)	19 (41.3)
<i>Pseudomonas aeruginosa</i> (59)	30 (35.7)	13 (14.6)	16 (34.7)
<i>Klebsiella pneumonia</i> (46)	13 (15.4)	26 (29.2)	7 (15.2)
<i>Enterococcus species</i> (25)	13 (15.4)	09 (10.1)	03 (6.5)
<i>Candida species</i> (14)	10 (11.9)	04 (4.4)	-
<i>Escherichia coli</i> (12)	09 (10.7)	02 (2.2)	01 (2.1)
<i>Staphylococcus aureus</i> (11)	-	11 (12.3)	-
<i>Morganella morganii</i> (1)	01 (1.1)	-	-
Total	84	89	46

A total of 637 patients had intravascular catheter (right subclavian or internal jugular) and total number of central venous line days was 6202. The episodes of blood stream infection were 86 (13.50%) among ICU patients having central line catheters. Also, CLABSI was found to be 13.86/1000 central line days. Polymicrobial infection caused by two organisms was seen in three cases; therefore, a total of 89 pathogens were isolated from blood. *Klebsiella pneumoniae* was the most commonly isolated organism from blood stream infections among ICU patients. None of the common skin contaminants including *Staphylococcus epidermidis* was established as a cause of CLABSI.

A total of 634 patients were intubated/tracheostomized and total number of ventilator days was 6455. A total of 39 (6.15%) episodes of VAP was found and for 18 months VAP was calculated as 6.04/1000 ventilator days. Polymicrobial infection caused by two organisms was seen in seven cases; therefore, a total of 46 pathogens

were isolated. *Acinetobacter species* (41.03%) was the most common isolate from tracheal secretions of ICU patients. The type and number of organisms designated as the culprits for various types of hospital acquired infection is shown in (Table 2). The number of gram-negative bacilli contributing to nosocomial infections was 183 and that of gram-positive cocci was 36. The antibiotic resistance pattern of the isolates implicated in nosocomial infections is shown in (Table 3). High degree of resistance was seen to Amoxicillin clavulanate, third generation Cephalosporins, Gentamicin, and Netilmicin. All the Gram-negative bacilli showed maximum sensitivity to Imipenem. Only 25-40% of *Pseudomonas spp* and *acinetobacter spp.* were sensitive to imipenem, while 55-90% of *E. coli* and *Klebsiella spp.* were still sensitive to Carbapenem. The prevalence of MRSA was 30% also *Staphylococcus aureus* showed 100% sensitivity to both vancomycin and linezolid and *Enterococcus species* showed 100% sensitivity to Linezolid, while 12.5% of the strains were resistant to vancomycin.

Table 4: Antibiotic resistance percentage of various pathogens causing health-care associated infections.

Antibiotic	<i>Acenitobacter species</i> (51) (%)	<i>Pseudo-monas aeru-ginosa</i> (59) (%)	<i>Klebsiella pneumoniae</i> (46) (%)	<i>Escherichia coli</i> (12) (%)	<i>Enterococcus species</i> (25) (%)	<i>Staphyococcus aureus</i> (11) (%)
Amoxicillin+ clavulanic acid	-	-	100	100	100	-
Cefotaxime	90.3	83.3	96.3	84.6	-	-
Ceftazidime	95.8	94.4	94.1	100	-	-
Piperacillin	64.3	92.9	100	83.3	-	-
Piperacillin+ Tazobactam	50	77.8	71.4	62.5	-	-
Imipenem	57	76.8	46.7	11.8	-	-
Ciprofloxacin	69.7	61.1	89.5	91.7	80	72.7
Norfloxacin	-	-	100	100	100	-
Netilmicin	85.7	93.3	71.4	66.7	63.6	66.7
Tobramycin	90	95.6	83.3	-	-	-
Cefoxitin	-	-	-	-	-	30
Erythromycin	-	-	-	-	88.9	60
Vancomycin	-	-	-	-	12.5	0
Linezolid	-	-	-	-	0	0

Table 5: Risk factors for the development of nosocomial infections (n=166).

Risk factor	Patients with nosocomial Infections; N (%)	Patients without nosocomial Infections; N (%)	P value	Odd's ratio
Age ≥ 60 years	32 (19.27)	85 (16.56)	0.422	1.20
Male sex	97 (58.43)	272 (53.02)	0.224	1.24
Diabetes mellitus type II	12 (7.22)	16 (3.11)	0.0215	2.42
Previous surgery	85 (51.20)	260 (50.68)	0.906	1.02
ICU stay ≥ 8 days	153 (92.16)	248 (48.34)	<0.001	12.57
Previous hospitalization	13 (7.83)	26 (5.06)	0.185	1.59
COPD	81 (48.7)	162 (31.57)	<0.001	2.06

Comparison of various risk factors for acquiring nosocomial infections in our ICU is shown in (Table 4). The presence of diabetes and COPD as well as length of ICU stay ≥ 8 days were found to be significantly associated with nosocomial infections. Age, male gender, previous hospitalization, and postoperative state were not significant associations for acquiring nosocomial infections. Similarly, by calculating the odd's ratio, the strength of association of these three risk factors (diabetes and COPD as well as length of ICU stay ≥ 8 days) was found to be considerable.

DISCUSSION

A robust infection surveillance program is very important in any healthcare facility. It is an obvious requirement for prevention of device-associated infections, which has a significant impact on successful patient recovery. There

is enough evidence to show that routine surveillance of these infections can reduce the incidence by as much as 30%.⁷ In developing countries, the rate of nosocomial infections is relatively higher due to lack of good surveillance activity and poor hand hygiene compliance. In India, the rates of device associated infections vary widely. Habibi et al in their study from Delhi reported the incidence rates of nosocomial infections to be 11.3/1000 urinary catheter days, 3.4/1000 central venous pressure line days and 31.4/1000 ventilator days.⁸ In the ICUs of seven hospital members of the international infection control consortium (INICC) of seven Indian cities, the overall infection rates were 1.41/1000 catheter days for CAUTI, 7.92/1000 catheter days for CLABSI and 10.46/1000 ventilator days for VAP.⁹ Considering these values, the rate of VAP was relatively less, whereas CLABSI was significantly higher in our ICU. Rates were comparable with that of 55 ICUs in developing countries

(CAUTI-8.9/1000 catheter days, CLABSI 12.8/1000 catheter days and VAP 24/1000 ventilator days).¹⁰ Thus, the value of surveillance activity and analysis of findings, under the overall umbrella of infection control, cannot be over-emphasized, especially in critical areas.

The incidence of CLABSI depends upon the site, type of catheter, frequency of catheter change, and underlying illness. Putting central line through the subclavian access (in contrast to internal jugular or femoral access) supposedly reduces infection rates.¹¹ In our hospital, one of the plausible reasons for increased incidence of CLABSI could be multidisciplinary ICU, with infrequent appropriate hand hygiene practices by stakeholders. Berenholtz et al reported significant decline in CLABSI after implementation of five points intervention module in the surgical ICU. The applied module consisted of staff-education, creation of catheter insertion cart, checking daily with the concerned healthcare providers if removal of the catheter is possible, formulation of a checklist for checking compliance to the evidence based guidelines for preventing CLABSI and assigned nurse empowerment to disallow the catheterization in case of violation of the same.¹² The relative lower incidence of CAUTI and VAP in the present study could be due to active nursing care. The nurses in our ICUs take care of catheter by cleaning the entry site and few inches of the catheter daily, placing the urobags below the bladder, and emptying them at fixed frequency, etc.¹³ Semi-recumbent position is deployed for prevention of VAP. Other measures include draining of condensate from ventilator circuits after a particular period (after 4-6 h or earlier); continuous subglottic suctioning, adequate pressure in endotracheal tube cuff (palpation method), and regular compliance of ventilator bundle protocol.¹⁴ Gram negative bacteria were observed to be more commonly isolated from cases of nosocomial infections in the present study. *P. Aeruginosa* and *Acinetobacter* Species were reported to be the commonest incriminated organisms in our ICU, much in line with the previously available evidence.^{8, 15-17} The study of Agarwal et al. in another institute, from our geographical region, also found majority of infections with gram-negative bacilli in their respiratory ICU. Moreover, *Acinetobacter* Species followed by *P. Aeruginosa* were found to be the most common cause of pneumonia.¹⁸

The mortality rate was comparatively higher amongst patients with device associated infections. High drug resistance rate and limited drug options for these patients were also noted, with many of the isolates being resistant to all the drugs tested. A very high resistance was observed to third generation cephalosporins (ceftazidime and cefotaxime). The organisms even showed high resistance to beta lactam and beta lactamase inhibitor combination (Piperacillin+tazobactam) and carbapenems (imipenem), thus limiting their importance as single drug empirical therapy in ICU. In our ICU, methicillin resistant *Staphylococcus aureus* (MRSA) was found in 30%, although no resistance to vancomycin and linezolid

was seen in *S. aureus* isolates. Scenario of high resistance was noticed with aminoglycosides and quinolones in both gram-positive and gram-negative organisms. For gram-positive cocci, although a high resistance to other commonly used drugs was seen, yet vancomycin and linezolid were found to be of utmost importance in case of multidrug resistance. The isolation of vancomycin-resistant enterococci (VRE) was very concerning with direct negative implications for the patient in the form of increased morbidity rate and the heightened cost of treatment. The infection control team needs to implement behavior change in the form of usage of appropriate barrier precautions, enforce the aseptic techniques and hand washing practices. Glycopeptides resistance was not noted amongst *Staphylococcus* isolates in the present study. Kamat et al had reported 11.8% Vancomycin resistance in their nosocomial *Staphylococcus* isolates in their study from Goa.¹⁵ Gender and age were not seen to be predictors of infection in ICU; much in line with findings of Meric et al and Agarwal et al.^{18,19} The significant risk factors for nosocomial infections did include length of ICU stay though. Previous researchers have quoted this as an important predictor for development of infection, with the patient stay in ICU being directly proportional to chances of multidrug resistant bacteria colonization.^{8,18-20} Further, diabetes and COPD were found significantly associated with infection as well. This may be because patients with diabetes and COPD come at terminal stage when they are highly immunosuppressed making them highly susceptible to nosocomial infections and multidrug resistant bacteria present in the ICU environment. History of previous hospitalization and patient being a postoperative case reported to be significant risk factors in previously similar studies, a finding which our study failed to substantiate.²⁰

Limitations

The major limitations of the present study could be; that the severity of illness (SOFA or APACHE) scores were not assessed as important risk factors, and that the data with respect to various catheter insertion sites like subclavian vein, internal jugular vein and femoral vein was not checked for any association with incidence of CLABSI.

CONCLUSION

In conclusion it may be said that the interventions to control spread of the resistant bacteria are of utmost importance towards better clinical outcomes; including optimizing antibiotic selection and dosing, adherence to infection control practices and rational use of antimicrobial combinations.

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