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Major Article

Intensive care unit-acquired infections in a tertiary care hospital: An epidemiologic survey and influence on patient outcomes

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Background and objective: Nosocomial infections are common in intensive care units (ICUs), but the pattern of infections and the distribution of microorganisms vary. We studied the ICU-acquired infections and their effect on patient outcomes in our ICU.

Methods: Patients admitted to our ICU for >48 hours were studied prospectively over a year. Infections were diagnosed based on Centers for Disease Control and Prevention guidelines. Antibiotics were administered based on culture and sensitivity. Univariate and multivariate logistic regressions were carried out to determine the factors associated with infection.

Results: One hundred ninety-eight patients were studied. The crude infection rate was 50% with ventilator-associated pneumonia (40%) and bloodstream infection (21%) being the most common. *Acinetobacter calcoaceticus-baumannii* complex, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* were the most common microorganisms. More than 90% of patients received antibiotics, the most common being β lactam-β lactamase inhibitors, aminoglycosides, fluoroquinolones, and carbapenems. Thirty-five percent of staphylococci were methicillin-resistant, 50% of *Enterococcus* strains were vancomycin-resistant, and 68% of *Acinetobacter calcoaceticus-baumannii* complex, 47% of *Pseudomonas* strains, and 35% of *Klebsiella* strains were multidrug-resistant. A longer duration of ventilation was associated with infection. The overall ICU mortality rate was 24% and was similar in patients with or without infection.

Conclusions: The incidence of infection and the multidrug resistance in the ICU was high. Infection was associated with duration of ventilation but not mortality.

The incidence of hospital-acquired infections is 2-5 times greater in intensive care units (ICUs) than in the general inpatient population of hospitals.[1] The antimicrobial resistance rates are also much higher in ICUs than in general ward settings.[2]

ICU-acquired infections (IAIs) affect patient morbidity and mortality. The mortality due to infections in an ICU can be effectively reduced by timely and appropriate empiric antimicrobial therapy. The empiric treatment of infections in ICU settings requires knowledge of the epidemiology of infections as well as the antimicrobial resistance patterns of the local microbiologic flora.[3] The rates and types of hospital-acquired infections, the distribution of predominant organisms, and the pattern of antimicrobial resistance vary across geographic regions, among different hospitals, and among different ICUs of the same hospital.

We conducted an epidemiologic study to determine the incidence of ICU-acquired infections and their influence on patient outcome in the main ICU of our hospital.

MATERIALS AND METHODS

A prospective, observational study was conducted from July 2010-June 2011 in the 12-bed main ICU of our hospital (CTRI/2014/08/004879). The main ICU is a mixed ICU that caters to both medical and surgical patients. It is managed by anesthesiologists with anesthesia-specialty resident physicians being present around the clock and has a nurse to patient ratio of 1:2. The standard infection prevention protocols followed in our ICU include hand hygiene

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protocols with bedside availability of hand sanitizers, aseptic precautions (eg, surgical scrubs, gowns, and gloves) for any invasive procedures such as central venous catheterization, and use of antibiotics based on culture and sensitivity.

Ethical clearance for the study was obtained from our institution's Institutional Ethics Committee. All patients admitted to the ICU for more than 48 hours were included in the study after obtaining written informed consent from a relative of the patient. Demographic data and clinical status were recorded at admission to the ICU. The severity of illness was graded using the Acute Physiological and Chronic Health Evaluation (APACHE) II score[4] at admission.

Sequential Organ Failure Assessment (SOFA) score[5] was assessed on admission and every 24 hours until discharge. The worst values of a parameter during the 24-hour period were used for calculation of the SOFA score. For a missing value, the previous day's value was recorded. The highest score (SOFA maximum) recorded during the ICU stay was also noted. Patients were assessed daily for systemic inflammatory response syndrome, sepsis, severe sepsis, and septic shock.[6]

An infection manifesting after 48 hours of admission to the ICU, which was neither incubating nor present at admission, was defined as IAI. The diagnoses of ventilator-associated pneumonia (VAP), catheter-associated urinary tract infection (CAUTI), laboratory-confirmed bloodstream infection, central venous catheter-associated infection (CVCI), and surgical site infection were made based on the Centers for Disease Control and Prevention (CDC) guidelines.[7] In case of suspected infection, antibiotics were started empirically after sending appropriate cultures. Antibiotic agent therapy was changed later according to the sensitivity of the isolated organism. In addition, complete blood count, coagulation profile, hepatic and renal function tests, urine examination, and chest radiography were done in patients with suspected infection. Other body fluids were sampled as clinically indicated. Collection of blood, urine, and other biomaterial for microbiologic investigations were done under aseptic conditions per CDC guidelines. Multidrug resistance was defined as resistance to representative antimicrobial agents of at least 3 different classes.[8]

The data for calculation of patient-days and device-days were collected using standardized CDC National Nosocomial Infection Surveillance protocol.[7,9] Crude infection rate was calculated in the patients whose ICU stay exceeded 48 hours. The incidence density of various infections, device-days, device-associated infection (DAI) rate, and device use ratio were calculated. All calculated parameters other than incidence density were rounded to the nearest integer.

Statistical analysis was performed using the programming language R version 2.15.1 (R Foundation for Statistical Computing, Vienna, Austria). Factors found to be significantly correlated with infection on univariate logistic regression analysis were included in the multivariate logistic regression model. Outcome in patients with IAI and those without it were compared using the χ^2 test. A P value < .05 was considered statistically significant.

RESULTS

Two hundred twenty-five patients were admitted in the main ICU during the study period. Of these, 198 patients stayed for more than 48 hours in the ICU and were included in the study. The demographic and baseline ICU data of the patients are given in Table 1. More than two-thirds of patients were admitted from surgical or trauma wards and the rest from medical wards. Central venous catheters were inserted in a high proportion of patients. All patients had a urinary catheter in situ. Ninety-nine percent of patients required mechanical ventilation.

Table 1
Demographic and baseline intensive care unit (ICU) data

Parameter	Median (interquartile range)	Range	n (%)
Age, y	38 (24-52)	2-92	
Male sex			129 (65)
Comorbidities*			56 (38)
Surgical+trauma admissions			137 (69)
Pre-ICU antibiotics			63 (32)
APACHE II score on admission	12 (8-15)	2-35	
Central venous catheter			167 (84)
Duration of central venous catheter, d	10 (5-18)	0-68	
Hemodialysis/peritoneal dialysis			7/4 (4/2)

APACHE II, Acute Physiology and Chronic Health Evaluation II.
*Comorbidities included hypertension, diabetes mellitus, chronic obstructive pulmonary disease, and chronic kidney disease.

Table 2
Intensive care unit (ICU) infections, antibiotics, and outcome

Parameter	Median (interquartile range)	Range	n (%)
ICU-acquired infections			98 (50)
Severe sepsis/septic shock			67/26 (34/13)
Antibiotics in ICU			190 (96)
Maximum SOFA score	7 (5-10)	0-19	
Duration of ventilation, d	12 (6-19)	0-97	
Duration of ICU stay, d	13 (7-21)	3-101	
Deaths in ICU			48 (24)

SOFA, Sequential Organ Failure Assessment.

SOFA score used to assess organ dysfunction showed central nervous system dysfunction to be the most common (57%), followed by cardiovascular system (29%), respiratory system (23%), renal (10%), coagulation (8%), and liver dysfunction (3%). Seventy-five percent of patients were discharged from the ICU, 24% died, and 1% of patients left against medical advice (Table 2).

Infections and antibiotics

Ninety-eight patients developed IAIs, with a crude infection rate of 50 per 100 patients (Table 3). There were 256 episodes of IAIs with an incidence density of 76.4 per 1,000 patient-days. *Acinetobacter calcoaceticus-baumannii* complex was the most common microorganism causing VAP and bloodstream infection. *Pseudomonas aeruginosa* was the most common organism in CAUTI. *Staphylococcus* was the causative organism in 8% of infections. Details of the organisms isolated are given in Table 4.

Antibiotic susceptibility

Ninety-six percent of patients received antibiotics in the ICU. The most common antimicrobial agents used were β lactam–β lactamase inhibitors (69%), aminoglycosides (39%), quinolones (34%), and carbapenems (32%). A high proportion (60%-77%) of *Acinetobacter calcoaceticus-baumannii* complex infections were resistant to cephalosporins, aminoglycosides, and fluoroquinolones; 38% were resistant to piperacillin-tazobactam, and 46% were resistant to carbapenems. More than one-third of *P aeruginosa* infections were resistant to cephalosporins and one-fifth were resistant to carbapenems. Thirty-five percent of the *Staphylococcus aureus* isolates were methicillin-resistant and 50% of the *Enterococcus* infections were vancomycin-resistant. Sixty-eight percent of the *Acinetobacter* isolates, 35% of