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A Prospective Survey and Analysis of Nosocomial Infections in a Tertiary Care Teaching Hospital in South India

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Abstract-The scope of the present study is to identify the type and incidence rate of nosocomial infections in the intensive care units, the organisms that cause them and their susceptibility pattern to commonly used antimicrobial agents. Patients hospitalized in the intensive care units are 5 to 10 times more likely to acquire nosocomial infections than other hospital patients. Use of mechanical ventilation, urinary catheters and intravenous catheters are major contributing factors to this disparity. The Center for Disease Control reported that 5.7% of all hospitalized patients acquire nosocomial infections. The Joint Commission on Accreditation of Health care Organization (JCAHO) recommends surveillance of nosocomial infections in the United States as an important criterion for hospital accreditation. There are no figures to assess the incidence of nosocomial infections in India. Most of the hospitals in India have not implemented infection control measures and there are no proper surveillance systems. The present study was undertaken in order to understand the etiology of ICU-acquired infections. We prospectively examined the sites of infections, causative agents and their susceptibility pattern to commonly used drugs. The study was carried out over a period of 6 months. Of the 37 specimens processed, 8 grew normal flora. The isolated pathogens were *Escherichia coli* (18.9%), *Klebsiella* (18.9%), *Staphylococcus aureus* (18.9%) and *Pseudomonas aeruginosa* (5.4%). The most commonly reported infections were Thrombophlebitis (40.5%), Urinary tract infection (16.2%) and Pneumonia (8.1%). Susceptibility testing of the organisms to the most commonly used antibiotics showed that all the isolated *E.coli* were resistant to ampicillin, amoxicillin and erythromycin; *Klebsiella* showed resistance to cefotaxime and cefoperazone; *Staphylococcus aureus* to ampicillin, amoxicillin, cloxacillin, erythromycin and amikacin. Various parameters employed to describe the incidence of nosocomial infections in the intensive care units include Crude Infection Rate, Incidence Rate, Device-Associated Infection Rate and Device-Day Utilization. Inadequate infection control is of particular concern because studies have shown that 1/3rd of all nosocomial infections are preventable. A prospective study was conducted in 2 ICUs (Medical Intensive Care Unit and Intensive Pulmonary Care Unit) of a 350-bedded multispecialty hospital in South India for a period of 6 months. Clinical, demographic and microbiological data were collected in customized data entry sheets from patients who developed symptoms of hospital-acquired infections, and were later analysed. The crude infection rate, device-associated infection rate, device day utilization and incidence rate were calculated. The ultimate goal was to improve awareness and understanding of risks of infection and encourage consistent application of infection control in all intensive care units to promote more favorable outcomes for patients.

Key words: Nosocomial, Hospital-acquired infections, E.coli, P.aeruginosa, Klebsiella

INTRODUCTION

Nosocomial infections are defined as "infections acquired during or as a result of hospitalization". Most infections that manifest after 48hrs are considered to be nosocomial**.** The word 'Nosocomial' is derived from the Greek word '*Nosokomeion*', which means 'hospital' [1]. Nosocomial infections contribute significantly to mortality, morbidity as well as excess costs for the hospitalized patients. Hospitals and clinics are places where sick people go with the expectation that they will get better. Unfortunately, there is a risk that clients may become infected due to their visits to these places. Nosocomial or hospital-acquired infections are largely seen as an inevitable 'risk' for any hospital. By its very nature of treating patients of varied infections, the hospital becomes a potential source of infections. Even hospital staffs are at risk of contracting such nosocomial infections. Serious hospital infections due to Gram-negative bacilli, *MRSA* (*Methicillin-Resistant Staphylococcus aureus)* and *VRE (Vancomycin-Resistant enterococci)* have increased greatly in the last 30 years. Nosocomial infections range from fevers, thrombophlebitis, pneumonias, urinary tract infections and septicaemias [2]. The Intensive Care Units represent the most frequently identifiable sources of nosocomial infections within the hospital, with the rates of infection and antimicrobial resistance several-fold higher than in the general hospital setting.

Sites of Nosocomial Infections

The 3 major sites of nosocomial infections in the intensive care units are the respiratory system (31%), urinary tract (24%) and the bloodstream (16%). Common diagnoses for infections at these sites are pneumonia, urinary tract infection (UTI) and septicemia respectively [3].

Urinary Tract

The genitourinary system is the most common site of nosocomial infections in the acute care settings (accounting for 40% of all nosocomial infections). Catheterization and instrumentation of the urinary tract are the precipitating factors in almost 80% of the cases [4]. Groups at high risk for nosocomial urinary tract infections are mostly elderly, diabetic, immunocompromised, critically ill and the malnourished cases. If bacterial infections in the urinary tract are not treated properly, bacteria may enter the bloodstream resulting in a condition called Bacteremia. The point at which systemic inflammatory response occurs to this infection is known as SEPSIS. Unchecked sepsis causes a state known as Septic Shock. With normal bladder function, urine flushes through the urethra, removing bacteria adhering to the urethral walls. The presence of an indwelling catheter hinders the cleansing action of this

protective mechanism. The longer the catheter remains in the bladder, the greater the risk of infection [5]. Nosocomial UTIs can develop by contamination with a patient's faecal flora and cross-contamination by hospital personnel. Bacteria gain entry to the urinary tract via both the lumen and the external surface of the catheter [6].

Respiratory System

Hospital-Acquired Pneumonia (HAP) is the second most common nosocomial infection, but has the highest mortality (30%), morbidity and prolongs the mean duration of hospital stay by an average of 7-9 days per patient [7]. Tracheal intubation is the most significant factor for the development of HAP. If health care personnel and respiratory equipment harbor pathogenic flora, these organisms can be directly inoculated into the tracheobronchial tree [8]. The endotracheal tube can also become coated with a bacterial biofilm, which may embolize into the airway. Instillation of normal saline, a common practice during suctioning may also facilitate the direct entry of bacteria into the respiratory tract [9].

Blood Stream

Intravascular devices bypass skin defenses, thus becoming direct portals for entry of microorganisms into the blood stream [10]. Infections associated with the use of CVCs are most often due to colonization of the insertion site by bacteria (*Staphylococcus epidermidis*) normally present on the skin [11]. Contamination of the lumen from frequent disconnection to administer medications or to obtain blood samples is another contributing factor. The longer the catheter remains in place, the higher is the risk of infection [12]. Proximity of central sites to sources of infection determines the chances of developing infections in those areas (eg: oral, nasal and tracheal secretions for catheters in the neck or subclavian area, faeces and urine for femoral catheters [13].

METHODOLOGY

Surveillance of Nosocomial Infections:

A prospective study was conducted in 2 intensive care units (Medical Intensive Care Unit and Intensive Pulmonary Care Unit) of a 350-bedded multispecialty hospital in South India for a period of 6 months, after attaining the approval of the concerned hospital authorities. Clinical, demographic and microbiological data were collected in customized data entry sheets from patients who developed symptoms of hospital-acquired infections.

HAIs were identified by:

1) Medical record review.

2) Reports of clinical symptoms of nosocomial infections from providers.

3) Review of microbiology report.

The site of infection, time of onset and the underlying diseases were also identified. Use of mechanical ventilation, vascular accesses and other devices in the in-patients were constantly monitored during this period. The patients were evaluated daily to determine whether their stay in the hospital is related to the underlying disease or to the presence of nosocomial infections. Nosocomial infections were evaluated by calculating rates such as Crude infection rate, Device-associated infection rate and Incidence rate as follows…

Crude Infection Rate:

The most common measure for occurrence of nosocomial infections, the crude infection rate, is the ratio of infections per 100 admissions or discharges.

Crude infection rate = No. of NIs / 100 admissions or discharges

Device-Associated Infection Rate:

A Device-associated infection rate can also be called as 'Risk-adjusted infection rate'. The time period for the analysis was decided to be 6 months. Infections such as urinary catheter-associated infections can be calculated using the formula: [No. of UC-associated UTIs / No. of UC days] x 1000

Device – Day Utilization:

The device-day utilization is specifically useful for measuring infection risk among patients in the Intensive Care Units.

Device utilization = No. of device-days / No. of patient-days

Incidence Rate (I):

This is used to measure nosocomial infection frequency in the Intensive Care Unit. 'I' is calculated as follows:

$$\text{Incidence rate} = \frac{\text{No. of new NIs (during a month)}}{\text{No. of patients admitted or discharged (during the same month)}}$$

RESULTS

During the study period, 671 patients were admitted in the ICUs. The number of patients who developed nosocomial infections during this period was 37 (5.5%). The age of patients, who developed nosocomial infections during this period ranged from 16 years to 90 years, with maximum reported infections in the age group 61 – 70 years [Fig-1]. 75.6% of the patients included middle aged (29.7%) and elderly (45.9%). 20 (54.0%) male patients and 17 (46.0%) female patients developed nosocomial infections [Figure-2].

The most common nosocomial infections were Peripheral Septic Thrombophlebitis 15 (40.51%), followed by UTIs 6 (16.2%), Pneumonia 3 (8.1%), Cellulitis 1 (2.7%) and Abscess 1 (2.7%). 11 (29.7%) patients developed Nosocomial fevers. One (2.7%) patient developed Post-surgical sepsis [Figure-3].

The average Crude Infection Rate was 3 cases per 100 admissions. The Incidence Rate of nosocomial infections during this six-month study period was 0.30 (5.1%) [Fig-4]. The rate of Intra Venous Catheter-Associated Peripheral Septic Thrombophlebitis was 21.3 cases per 1000 Intra Venous Catheter-days. The rate of Urinary Catheter-Associated Urinary tract infections was 7.3 cases per 1000 Urinary Catheter-days and ventilator associated pneumonia was 18.9 per 1000 ventilator days. [Table-1]. Device-day utilization for Urinary catheters, Ryle's Tube, Ventilators, and Intravenous catheters were 0.83, 0.70, 0.69, and 0.67 respectively, which shows that 83% of patient-days were Urinary Catheters-days, 70% were Ryle's tube-days, 69% were Ventilator-days and 67% were Intra Venous Catheter-days [Table-2].

A total of 34 bacteria were isolated from the 37 patients.

Table 1: Device-Associated Infection Rates per 1000 Patient-Days

IVC- Associated Thrombophlebitis	*Urinary Catheter - Associated Urinary Tract Infections*	*Ventilator – Associated Pneumonia*
21.3.	7.3	8.7

Table 2: Device - Day Utilization for one month

Days	No : of Device-Days			No. of Patient - Days
	Ventilator	Catheters	IV lines	
1	10	7	11	11
2	10	7	11	11
3	10	11	10	12
4	10	11	10	12
5	10	8	11	12
6	6	8	11	12
7	5	7	9	7
8	9	8	9	7
9	9	8	9	8
10	8	5	11	5
11	8	5	6	19
12	4	4	5	14
13	3	4	5	14
14	3	3	3	11
15	3	6	3	14
16	5	6	2	14
17	5	6	2	13
18	4	8	2	16
19	5	8	1	16
20	6	8	5	20
21	6	11	7	24
22	6	11	7	24
23	6	8	7	22
24	6	8	6	21
25	7	6	4	19
26	8	6	4	18
27	8	6	3	18
28	8	6	3	18
29	8	4	4	16
30	6	4	4	15
31	6	4	2	13

Table 3: Organisms isolated from the sites of infection

Pathogens	Urinary Tract (%)	Blood Stream (%)	Respiratory Tract (%)
E.coli	83.3	5.5	0
Klebsiella	16.6	0	33.3
Pseudomonas aeruginosa	0	22.2	0
Staphylococcus aureus	0	27.2	0

Figure - 1
AGE DISTRIBUTION (%)

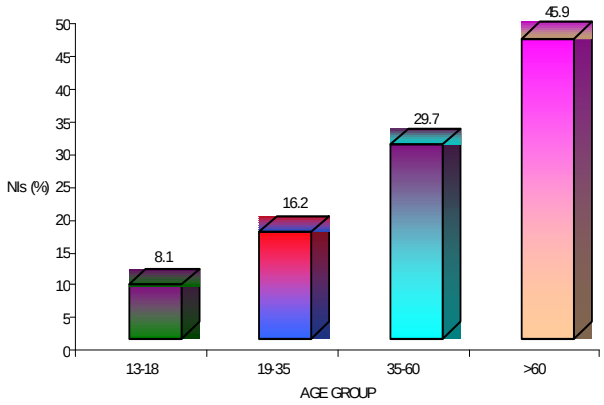

Fig -2
SEX DISTRIBUTION (%)

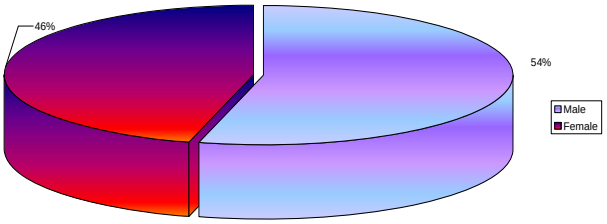

Fig - 3
NOSOCOMIAL INFECTIONS DEVELOPED DURING THE STUDY PERIOD (%)

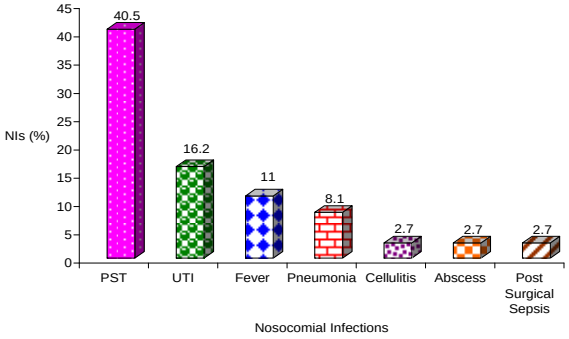

Fig- 4
INCIDENCE RATE OF NOSOCOMIAL INFECTIONS DURING THE STUDY PERIOD (%)

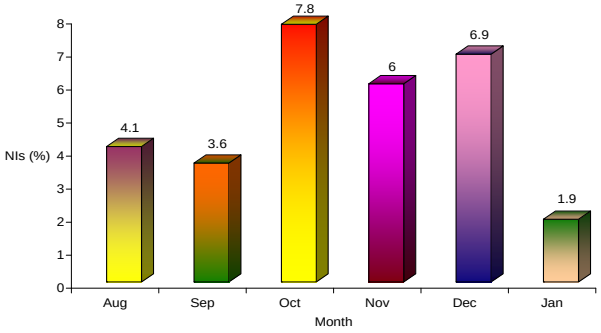

Table-3 shows the distribution of the pathogen isolates from the sites of infection. Of the 34 isolates, 8 consisted of normal flora that was not considered to be contributing to the patient's disease process. Major bacterial pathogens consisted of *Escherichia coli* 7 (18.9%), *Klebsiella* 7 (18.9%), *Staphylococcus aureus* 7 (18.9%) and *Pseudomonas* 2 (5.4%). Of the 34 isolates, 1 (2.7%) was reported to be polymicrobial. The isolates from patients with Peripheral septic Thrombophlebitis were *Staphylococcus aureus* 5 (33.3%) and *Klebsiella* 4 (26.6%). The predominant pathogens causing nosocomial Urinary tract infections were *Escherichia coli* 6 (85.71%) and *Klebsiella* 1 (14.28%). The isolates from patients with Pneumonia were *Pseudomonas aeruginosa* 2 (66.6%) and *Klebsiella* 1 (33.33%). Antimicrobial susceptibility test showed all the isolated *Escherichia coli* to be resistant to ampicillin, amoxycillin and erythromycin; *Klebsiella* showed resistance towards cefotaxime and cefoperazone; *Staphylococcus aureus* towards ampicillin, amoxycillin, cloxacillin, erythromycin and amikacin; *Pseudomonas aeruginosa* towards erythromycin, amikacin, cephalexin, ciprofloxacin, norfloxacin and ofloxacin. The isolated pathogens from the intensive care unit patients and their susceptibility pattern are shown in table.. The time of onset of nosocomial infections in the patients varied from 56 hrs to 7 days. The average time taken for the development of Thrombophlebitis was 3.7 days; 5.3 days for Urinary tract infections; 4.2 days for Pneumonia; 3 days for Cellulitis; 6 days for Abscess and 9 days for Post-surgical sepsis.

DISCUSSION

Patients in the ICUs are at risk of acquiring nosocomial infections, partly because of their serious underlying diseases and also by exposure to invasive procedures [14]. Approximately, 46% of patients who developed nosocomial infections were more than 60 years old. Elderly patients are generally less resistant to infections than their younger counterparts. One possible explanation for this increased susceptibility is the progressive atrophy of the thymus that occurs with age, causing a decreased production of T-lymphocytes and a decrease in Cell-Mediated Immunity. Natural defenses in the elderly are compromised [15].

The underlying diseases of the patients admitted to the intensive care units during the six-month study period were Cerebrovascular Accident (18.91%), followed by Diabetes Mellitus (16.21%), Systemic Hypertension (13.51%), Ischaemic Heart Disease (10.81%) and others. Critically ill patients are more susceptible to overgrowth of resistant endogenous microbes, such as *staphylococci* on the skin and mucosal surfaces, and *enterococci* in the gastrointestinal tract [16]. Patients with cerebrovascular accident require ventilators, intravenous catheters, Ryle's tube and urinary catheters for longer periods of time. Prolonged use of intravenous catheters causes vasculitis or thrombophlebitis. Saliva and other secretions easily clog the Ryle's tube and ventilators, giving rise to ventilator-associated pneumonia or aspiration pneumonia. Nosocomial urinary tract infections are common in these patients due to the urinary catheters affixed onto them. Urinary tract infections can lead to septicaemia and fever [17]. Most of the patients with CVA (57%) admitted to the intensive care units developed urinary tract infections. In diabetes patients, glycosuria is a predisposing factor for urinary tract infections, and this is aggravated by the presence of urinary catheters. Pathogens in the ICUs easily colonize in the patient's body due to non-healing ulcers. Variety of special infections (retinopathy, neuropathy and nephropathy) render the diabetics immunocompromised, making them vulnerable to a wide variety of nosocomial infections, even when there is no device affixed onto them [18].

It is well documented that higher rates of infection and mortality among ICU patients are mostly related to factors such as exposure to invasive procedures [19]. Present study reveals that utilization of urinary catheters, ventilators and intravenous lines were 83%, 69% and 67% respectively. The device-associated infection rates, such as urinary catheter-associated urinary tract infection and ventilator-associated pneumonia were 7.3 cases per 1000 urinary catheter-days and 8.7 cases per 1000 ventilator-days respectively. A report from the Veterans' Affairs Medical Centre, University of Pittsburgh showed that the rate of ventilator-associated pneumonia was 5.8 cases per 1000 ventilator-days in the pediatric ICU, 14.8 cases per 1000 ventilator-days in the surgical ICU, 18.3 cases per 1000 ventilator-days in the neurosurgical ICU[4]. In the present study, Intravenous line-associated thrombophlebitis was the maximum (21.3 cases per 1000 intravenous catheter-days). Measures must be taken to prevent these infections. Incidence rate of nosocomial infections in the ICUs was found out to be 5.1%. Data collected from 112 medical ICUs between 1992 and 1997 indicated that nosocomial infections developed in 7.8% of the hospitalized patients [20].

The most common nosocomial infections that developed in the study site were Peripheral septic thrombophlebitis (40.5%), followed by urinary tract infections (16.2%) and pneumonia (8.1%). Peripheral septic thrombophlebitis is a common problem. Most of the time it is associated with breaks in the skin. Often it produces a septicaemia that can seed secondary sites of infection. The organisms most often responsible for this condition are aerobic organisms. Systemic effects are due to bacteremia or related to bacterial endotoxin production. Streptococcal toxic shock syndrome has been reported in cases of pediatric septic thrombophlebitis. *Staphylococcus aureus*, *E.coli* and *Klebsiella* are the common causes of thrombophlebitis [21]. Genitourinary tract accounts for 16.2% of all nosocomial infections in the study. Groups at high risk for urinary tract infection include those above 60 years of age. Catheter utilization is another factor contributing to it's incidence. The longer the catheter remains in the bladder, the greater is the risk of infection [22].

Pneumonia is the third most common nosocomial infection, accounting for 8.1% in our settings. Aspiration of mouth secretions into the upper airways is the inciting event in most cases [23].

Our study showed that E.coli (18.9%), *Klebsiella* (18.9%) and *Staphylococcus aureus* (18.9%) were the major isolates. A similar study involving 105 patients in Riyadh showed that the major pathogens were *Pseudomonas*

aeruginosa, *Klebsiella*, *E.coli*, *Staphylococcus aureus* and *Streptococcus pneumoniae*. Multiple pathogens were isolated in 11.9% of the episodes [24], compared with 2.7% at this centre. Also, the mean age of patients who developed nosocomial infections was 54 years, compared to 49 years at this center.

It is well known that multidrug- resistant bacteria, in particular, gram-negative bacteria are becoming increasingly prevalent in the hospital environment due to the overuse of antibiotics [25]. Results of the present study also revealed that a few multidrug-resistant gram-negative bacteria (*E.coli*, *Klebsiella* and *Pseudomonas*) were the major cause of infection in the ICU patients, during the six-month study period.

All the isolated *E.coli* were resistant to ampicillin, amoxicillin and erythromycin. *Klebsiella* showed resistance towards cefotaxime and cefoperazone. *Pseudomonas* was resistant to erythromycin, amikacin, cephalexin, ciprofloxacin, norfloxacin and ofloxacin. This increased resistance is because broad-spectrum antibiotics are often prescribed for critically ill patients, when signs and symptoms consistent with infection are present, WBC counts are elevated or invasive procedures are required. Broad-spectrum antibiotics are often given when narrow-spectrum / organism-specific agents would be sufficient to resolve the infection. Indiscriminate use of antibiotics leads to elimination of a greater number of flora, thus enabling modified and more virulent organisms to produce infection. These modified organisms have new characteristics, against which standard agents are no longer effective [26]. Prescription monitoring on a daily basis revealed that ceftriaxone, cefotaxime, gentamicin, amikacin and ofloxacin were widely prescribed during this period. Most of the isolated pathogens were resistant to these drugs. Our study revealed that the isolated pathogens were highly resistant to amikacin (71-100%), ofloxacin (51-100%) and cefotaxime (43-100%). Resistance towards ceftriaxone and gentamicin varied between 43-85%. This clearly shows the requirement of an antibiotic policy as well as restriction and rotation of antibiotics in the ICUs. Patients infected with antibiotic-resistant pathogens generally have protracted hospitalization, increased health care costs and higher mortality rates. Additionally, the absence of infection control with these patients increases the transmission of resistant organisms from one patient to another. However, there are many opportunities to prevent the emergence and spread of the resistant pathogens through improved use of established infection control measures.

CONCLUSION

Nosocomial infections in the intensive care units pose a significant problem today and will continue to do so. Not all nosocomial infections can be prevented, but it is prudent for health care professionals to recognize, implement and use appropriate strategies to prevent these infections and bring about an effective clinical outcome. In this study, the most common nosocomial infections, causative organisms, their susceptibility patterns to various commonly used antibiotics were observed and documented. Crude infection rates, device-day utilization and device-associated infection rates were calculated. It was noted that indiscriminate use of broad spectrum antibiotics did have some effect on the emergence of nosocomial infections due to antimicrobial resistance.

Effective infection control measures must be followed in all intensive care units to prevent patients from acquiring infections in the intensive care units. In order to do this, each hospital must have an enthusiastic, able and vigilant infection control team that is prepared to educate and convince hospital staff about the importance of nosocomial infections and lessen it's impact by application of effective methods. Surveillance is the cornerstone of a successive infection control program. This includes collection of high quality data, their analysis and timely feedback to health care practitioners. To achieve this, hospital surveillance system needs to be prospective, targeted, risk-adjusted and open to valid inter-hospital comparisons. Effective surveillance of hospital-acquired infections is an example of quality improvement. Incidence of nosocomial infections in India is going unobserved and unquantified. The inception of a centralized, updated database of nosocomial infections is a step in the right direction.

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