

A Study on Device Associated Infections in the Adult Intensive Care Unit at a Tertiary Care Hospital

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Abstract: *The surveillance of Device associated infections in ICUs can reduce incidence of Nosocomial infections (NIs), healthcare cost & a better control of infections. Aims & Objectives: To know the occurrence of device associated infection rate in ICU and to know the bacterial profile of various devices associated infections. Materials and Methods: This study was conducted between October 2011 to May 2012 in a six bedded adult ICU. A total of 1000 specimens of endotracheal aspirate; catheterized specimen urine and intravenous blood were collected from 567 eligible patients (CDC criteria). Identification of pathogens, antibiotic susceptibility testing was carried out as per standard guidelines. Extended Spectrum β -Lactamase (ESBL), Inducible AmpC β -Lactamase, Plasmid-mediated AmpC production, and Metallo- β Lactamase (MBL) were tested for Gram negative bacilli by Combined disc diffusion method, Disk antagonism, Modified three-dimensional test, and Modified Hodge Test (MHT) respectively. Methicillin resistant *Staphylococcus aureus* (MRSA) & inducible clindamycin resistant (D-test) were tested for Gram positive bacteria. The data were analysed for determining DAI rate for Ventilator Associated Pneumonia (VAP), Catheter Associated Urinary Tract Infections (CA-UTI) & Central Line Associated Blood Stream Infections (CLA-BSI) using CDC guidelines. Results: DAI rates for VAP, CLA-BSI and CAUTI were 38.7, 7.6 and 1.47 /1000 device days respectively. *Acinetobacter baumannii* and *Pseudomonas aeruginosa* were predominant isolates. MBL (85%) & ESBL (62%) were most common resistance mechanisms for *Acinetobacter baumannii* and *Pseudomonas aeruginosa* respectively. Conclusion: VAP was most common infection. Multidrug resistant (MDR) *A.baumannii* & *Ps.aeruginosa* were predominant organisms. Most common resistance mechanisms were MBL for *A.baumannii* & ESBLs for *Ps.aeruginosa*.*

Keywords: DAIs, VAP, CLA-BSI, CAUTI, ESBL, Amp-C, MBL, MRSA, MDR

1. Introduction

Healthcare associated infection or Nosocomial infection represent one of the most common complications of health care delivery, affecting approximately 2 million persons admitted to acute care hospitals in the U.S each year. The World Health Organisation has estimated that at any given time, over 1.4 million people Worldwide are suffering from an infection acquired in healthcare setting.[1]

Every healthcare facility should therefore have an infection control program charged with monitoring, preventing & controlling the spread of infections in the health care environment. Because infection control requires the ability to detect infections when they occur, the clinical microbiology laboratory is inextricably linked to any comprehensive infection control program.[1]

Nosocomial Infection (NI) is defined as infection that is acquired in a hospital (i.e., the infection was not present/incubatory at the time of admission).For most bacterial infections, an onset of symptoms more than 48 hrs after admission is evidence of nosocomial acquisition. Between 5 and 10% of patients admitted to acute care hospitals acquire an infection during hospitalization. The urinary tract is the most commonly involved site of all NIs (30-40%), surgical wound(15-20%) & lower respiratory tract infections(15-

20%) next most frequent, followed by Blood stream infection(5-15%). [1] Nosocomial infection rates are one of the most important indicators of the quality of health services.[2]

NIs are frequently encountered in Intensive Care Units(ICUs) because of severity of underlying diseases, the frequency of invasive interventions, and the frequent use of wide spectrum antibiotics.[3]

It has been reported that ICUs account for 25% of NIs, even though they occupy only approximately 10% of the bed capacity of a hospital.[4] The vast majority of NIs are related to devices (e.g., urinary tract catheters, endotracheal tube in ventilated patient and central venous catheter). For this reason, and as way to adjust for risk when comparing rates over time or between similar units in different facilities, the CDC recommends calculating nosocomial infection rates in the ICU by using the number of device utilization days ("device days") as the denominator.[1]

From the 1970s through 2000, the spectrum of nosocomial pathogens shifted from gram negative to gram positive organisms, and candida spp emerged as a major problem. More recently, Multidrug resistance (MDR) gram negative rods have become increasingly prevalent in many hospitals. E.g; 2006-2007 NHSN data reveals *Acinetobacter*

baumannii was 3rd important cause for Ventilator associated pneumonia (VAP) & 30 % isolates were resistant to carbapenems. This represents an astonishing increase from the 1990s, when Acinetobacter didn't even make the list of top eight causes of nosocomial pneumonia.[5]

The study of the efficacy of Nosocomial Infection Control indicated that the presence of an active surveillance & infection control program was associated with a 32% decrease in NI rates while absence of such a program was associated with an 18% increase in nosocomial infection rate.[1]

Surveillance of Device associated infections can reduce the incidence of NIs by as much as 32% & lead to reduced health care costs. Device associated infections such as Ventilator Associated Pneumonia (VAP), Central Line Associated Blood Stream Infections (CLA-BSI) & Catheter Associated Urinary Tract Infections (CA-UTI) have greatest challenge to hospital safety & quality health care in ICU patients.[6] The frequency of such infections, particularly in ICUs & the agents & their resistance rates should be identified in order to better control infections.[2]

2. Materials and Methods

This prospective study was done from 6 bedded ICU of ESIC MC PGIMSR Teaching Hospital, Rajajinagar, Bengaluru and included all patients admitted to ICU with devices (MV, CL & UC) for >48 hour between October 2011 and May 2013.

2.1 Source of Data

Data was collected from the patient's case sheets admitted to 6 bedded recently established intensive care unit of ESIC MC PGIMSR Teaching Hospital, Rajajinagar, Bengaluru.

2.2 Study Period

One year & 8 months from October 2011 to May 2013.

2.3 Sample Size

Minimum of 1000 devices screened for device associated infections according to CDC criteria.

2.4 Standard Definition According to CDC Criteria:

An infection in a patient with a device (urinary tract catheters /ventilator/central line) developed within 48 hrs before onset of infection [7].

Inclusion Criteria:

According to CDC definitions (7)

1) Ventilator Associated Pneumonia (VAP):

Adult patient on mechanical ventilation at the time of or within 48 hours before onset of the event and showing radiological evidence of pneumonia and any 2 of the following:

Temperature $> 38^{\circ}\text{C}$ or $< 35^{\circ}\text{C}$

WBC $> 12000/\text{mm}^3$ / $< 4000/\text{mm}^3$

Purulent sputum

Pathogenic bacteria isolated from endo tracheal aspirate.

2) Catheter Associated Urinary Tract Infection (CA-UTI):

Adult patient with an indwelling urinary catheter at the time of or within 48 hours before onset of the event & microorganisms seen on Gram stain of unspun urine and a positive urine culture of $\geq 10^3$ and $< 10^5$ CFU/ml with no more than 2 species of microorganisms.

3) Central Line Associated-Blood Stream Infection (CLA-BSI):

Adult patient with central line at the time of, or within 48 hours before onset of event, must meet any one of the criteria:

Fever ($> 38^{\circ}\text{C}$) or chills or hypotension (systolic < 90 mm of Hg) & Signs & symptoms & positive lab results not related to infection at another site.

Minimum of 2 blood culture samples taken from different sites at separate occasions showing same organism & same antibiotic susceptibility patterns.

Exclusion Criteria:

Patients with device at the time of admission

Patients not on any device

2.5 Methods of collection of specimens & data analysis:

Clinical specimens (Endotracheal secretions, Catheterized Specimen Urine (CSU) & intravenous blood) will be collected, transported & processed in the diagnostic Microbiology according to standard procedures. (8)

Sampling Technique:

- 1) The Endo-Tracheal Aspirate (ETA) was collected by non-bronchoscopic method. The ETA was collected using a 22-inch Ramson's 12 F suction catheter with a mucus extractor, which was gently introduced through the endotracheal tube for a distance of approximately 25-26 cm. Gentle aspiration was then performed without instilling saline, and the catheter was withdrawn from the endotracheal tube. After the catheter was withdrawn, 2 ml of sterile 0.9% normal saline was injected into it with a sterile syringe to flush the exudates into a sterile container for collection and transported to microbiology laboratory. ETA samples were immediately taken to the laboratory for processing. The results of the Gram's stain were obtained within the first hour and quantitative cultures were performed immediately as proceeded by Rajashekar and co-workers (9).
- 2) The urine sample is collected from catheter collection port, it was disinfected with 70% alcohol and 5-10 ml of the urine was aspirated into the syringe. (10)
- 3) Brain Heart Infusion broth was used for blood culture.

Processing of Sample

- 1) Samples were mechanically liquefied and homogenized by vortexing for 1 min. The 0.01 ml of sample solution were then plated on Blood agar (BA), Chocolate agar

(CA), MacConkey agar (MA) by using 4 mm nichrome wire loop (Hi-media, Mumbai, India). All plates were incubated overnight at 37°C. All plates were checked for growth overnight and then after 24 and 48 h of incubation. For definite diagnosis of VAP, 10^5 CFU/ml was considered as threshold. Growth of any organism below the threshold was assumed to be due to colonization or contamination.(9)

- 2) Urine was inoculated on to MacConkey agar and blood agar by standard loop method for semi-quantitative culture to identify significant bacteriuria. Calibrated nichrome loops that deliver 0.001 mL were used to streak urine onto agar plates. For urine, a count of more than 10^5 colony-forming units per ml or more, and with no more than two micro-organisms isolated was considered as a confirmation of UTI (10)
- 3) The bottle was examined daily for turbidity and subculture was made at regular intervals on to Blood agar & MacConkey's agar.

Any significant growth was characterized by colony morphology and Gram's staining from the plates. Detailed biochemical testing for identifying any significant growth, and antibiotic sensitivity testing was performed on Mueller-Hinton agar (MHA) plates by Kirby-Bauer's disc diffusion method. Escherichia coli strain ATCC 25922, Staphylococcus aureus ATCC 25923 and Pseudomonas aeruginosa ATCC 27853 were used as control strains. (11)(12) (13)

Interpretation of antibiotic as sensitive & resistant as per CLSI guidelines.(14)

For data collection and descriptive analysis, two important parameters were considered. They were:

- 1) Denominator data (population at risk)
- 2) This included all patients exposed to the particular device during surveillance period. A total number of device days was thus calculated.
- 3) Numerator data

This included number of patients who developed bacteriologically confirmed infection on a particular device as per the standard definitions.

2.6 Calculation of Device associated infection rate (DAI) rate

Device-associated infection rate was expressed as the number of DAI per 1000 device days, as calculated by dividing the number of persons developing device-associated nosocomial infection by the total number of device days and multiplied by 1000.

Data, collected in the prescribed formats, were analysed on monthly basis to implement any early interventions and then compiled at the end. (15)

2.7 Statistical analysis

Simple statistics for detection of device associated nosocomial infection rate or Incidence density rate.

3. Results

Among 284 of endotracheal aspirates, 64 were culture positive. Among 149 of intravenous blood, 6 were culture positive. Among 567 of catheterized specimen urine, 5 were culture positive. Thus a total of 75 Device associated nosocomial infections [DANIs] were seen during this period.

Ventilator associated pneumonia [VAP] was commonest, accounting 85.3%, followed by Central line associated blood stream infection [CLA-BSI], 8% and Catheter associated urinary tract infection[CAUTI],6.7%.

Table 1: Distribution of Device associated infections (DAIs)

Devices	Devices screened		Devices-culture positive	
	Number	Percentage	Number	Percentage
VAP	284	28.4	64	85.3
CLA-BSI	149	14.9	6	8
CAUTI	567	56.7	5	6.7
Total	1000	100	75	100

Ventilator associated pneumonia was the most common Device associated infections.

Table 2: Device associated infections (DAIs) rates

Infection site	Device type	Device days	DAI	Distribution of DAIs	DAI rate (rate per 1000device days)*
VAP	MV	1654	64	85.3%	38.7
CLA-BSI	CL	789	6	8%	7.6
CAUTI	UC	3385	5	6.7%	1.47

* Calculation of DAI rate or Incidence density rate:

Device associated nosocomial infection (DANI) rate = DANI X 1000/Device days

Expressed as rate 1000 device days.

VAP rate was 38.7 per 1000 mechanical ventilator days.

CLA-BSI rate was 7.6 per 1000 central line days.

CAUTI rate was 1.47 per 1000 urinary catheter days.

Table 3: Demographic data of Device associated infections (DAIs)

Age group(years)	VAP		CLA-BSI		CAUTI	
	Male	Female	Male	Female	Male	Female
18-29	7	5	1	0	2	0
30-39	4	3	1	0	0	0
40-49	7	2	1	1	0	0
50-59	7	6	2	0	0	1
60-69	10	3	0	0	2	0
70-79	6	2	0	0	0	0
≥80	1	1	0	0	0	0
Total	42	22	5	1	4	1

Most common age group for VAP was 60-69 year for male & 50-59 year for female

Most common age group for CLA-BSI was 50-59 year for male & 40-49 year for female.

Most common CAUTI for male was in younger age group (18-29 year) & elderly age group (60-69 year).

Table 4: Bacterial profile of DAIs (Device associated infections)

Sl.no	Organisms	VAP	CLA-BSI	UCAUTI	Total	Percentage
1	<i>Acinetobacter baumannii</i>	34	3	2	39	44.3
2	<i>Pseudomonas aeruginosa</i>	16	3	2	21	23.9
3	<i>Klebsiella pneumoniae</i>	12	0	0	12	13.6
4	<i>Escherichia coli</i>	8	0	0	8	9.1
5	<i>Enterobacter aerogenes</i>	3	0	0	3	3.4
6	<i>Citrobacter freundii</i>	1	0	1	2	2.3
7	<i>Staphylococcus aureus</i>	3	0	0	3	3.4
Total		77	6	5	88	100
Percentage		87.5	6.8	5.7	100	

Gram negative bacilli were most predominant isolates, accounting for 96.6 %. Non fermenting Gram negative bacteria accounted for 68.2%, followed by Enterobacteriaceae (28.4%) and Staphylococcus aureus (3.4%).

4. Discussion

The present study is a prospective study studied from six bedded adult intensive care unit [ICU] of ESIC MC PGIMSR Teaching Hospital, Rajajinagar, Bengaluru over a period of one year and eight months which included 75 DANIs.

4.1 DAI Rate

In present study, VAP rate was 38.7 per 1000 ventilator days, CLA-BSI rate was 7.6 per central line catheter day and CAUTI rate was 1.47 per 1000 urinary catheter days.

In Rosenthal, et al study (16) VAP rate ranged from 10 to 52.7 per 1000 ventilator days with an overall rate of 24.1 per 1000 ventilator days. CLA-BSI rate ranged from 7.8 to 18.5 per 1000 central line catheter days with an overall rate of 12.5 per 1000 central line catheter days. CAUTI rate ranged from 1.7 to 12.8 per 1000 urinary catheter days with an overall rate of 8.9 per 1000 urinary catheter days.

4.2 Bacterial Profile:

In the present study, Non fermenters Gram negative bacteria accounted for 68.2%, followed by Enterobacteriaceae (28.4%) & Staphylococcus aureus (3.4%). The most common bacteria were *Acinetobacter baumannii* (44.3% of total), *Pseudomonas aeruginosa* (23.9% of total) & *Klebsiella pneumoniae* (13.6% of total). *Acinetobacter baumannii* was most common isolate from Ventilator associated pneumonia (VAP). *Acinetobacter baumannii* & *Pseudomonas aeruginosa* were most common isolate from Central line associated –blood stream infection (CLA-BSI) & Catheter associated urinary tract infection (CAUTI). Overall *Acinetobacter baumannii* was most common isolate.

In Kanj et al study, *Acinetobacter spp* was most common isolate from VAP, while *Escherichia coli* was most common isolate from both CLA-BSI & CAUTI. Overall *Escherichia coli* was most common isolate. (17)

In Sood et al study, Non fermenters Gram negative bacteria accounted for 73.68% infections followed by Enterobacteriaceae (21.05%). The most common bacteria were *Acinetobacter baumannii* (26.31% of total) and *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* (10.52% of total each). (18)

5. Conclusion

A number of factors can lead to the development of health care-associated infections in the hospital setting, including increasing patient acuity levels, chronically ill and acutely ill patients who harbor antibiotic-resistant bacteria, and frequent use of broad-spectrum antibiotics. Health care-associated infections can significantly impact patient outcomes, including morbidity and mortality rates, length of hospital stay, and costs of care. Therefore, focusing on health care-associated infections is an important aspect of providing quality health care.

Targeted surveillance and calculation of device associated infection rates per 1000 device days allows detection of unique institutional problems that need redress.

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