Prevalence of Hospital Acquired Infection and Antibiotic Trends in ICU in Southern India

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A B S T R A C T

300 patients were screened in ICUs of a tertiary care hospital in southern India to detect the rate of Hospital Acquired Infection (HAI) and antibiotic trends. Clinical samples received in the laboratory were processed as per CLSI (Clinical laboratory standard institute) guidelines. Patients were followed up to 72 hours post discharge. Markers of infection were noted and correlated with the findings in our laboratory. Kirby bauer antibiotic susceptibility test (ABST) was used for isolates with special reference to Extended Spectrum Beta lactamase (ESBL) production and Methicillin Resistant *Staphylococcus aureus* (MRSA). 10.7% were detected to have HAI during their stay in the ICU. Males above 30 years showed higher prevalence of HAI. Respiratory tract infection (RTI) was the commonest nosocomial infection detected in 56.3% of HAI cases, of which 19% were VAP (Ventilator Associated Pneumonia). Urinary tract infection (UTI) was 25% being the second commonest, followed by Blood stream infection (BSI) 12.5%. The most common organism isolated was *Acinetobacter baumannii* 33.4%, followed by *Klebsiella pneumoniae* 19.4%, & *Escherichia coli* (*E. coli*) 16.6%. 24.1% isolates were ESBL producers & 66.6% were MRSA. Gram positive organisms showed 100% resistance to Penicillin G & Erythromycin. However, Vancomycin, Linezolid, Tetracycline, Chloramphenicol, Teicoplanin & Tigecycline were sensitive. 74% of Gram-negative organisms were susceptible to Carbapenems & 2% were resistant to Polymyxin B and Colistin. The only effective way to control HAIs is to continuous monitoring of prevalence of infective organisms with their ABST.

Introduction

Hospital acquired infection (HAI) is a key factor in determining clinical outcomes among patients admitted in intensive care units. Critically ill patients in intensive care unit (ICU) are 5 -10 times more likely to acquire nosocomial infections than those in general wards.[1,2]

Studies on nosocomial infections in ICUs found that respiratory tract infections, blood stream infections, urinary tract infections and soft tissue infections are the common nosocomial infections in ICUs.[3,4,5] Samples of urine, blood, pus, sputum and endotracheal tube (ETT) secretions when evaluated had Gram negative isolates followed by Staphylococcus aureus, Coagulase negative Staphylococcus species and Enterococcus

species.[6,7] Among the Gram negative bacterial isolates there is a high prevalence of *Acinetobacter* among the ICU patients followed by Escherichia coli, Klebsiella pneumoniae, Pseudomonas species and *Citrobacter* species.[8,9]

These organisms isolated are highly resistant to antibiotics. Most of them are methicillin resistant *Staphylococcus aureus*, high level aminoglycoside producing *Enterococci*, vancomycin resistant *Enterococci,* β-Lactamase producing *Escherichia coli* and *Klebsiella* species & carbapenem resistant members of family Enterobacteriaceae [10].

The incidence and prevalence of multidrug resistant organisms are so high in the hospital settings that even effective drugs like fluoroquinolones, third generation cephalosporins, aminoglycosides etc. are fast losing their utility in covering hospital pathogens, thus restricting the choice of antimicrobials for treating serious infections has become the need of hour. Early recognition of bacteria and appropriate antimicrobial therapy are essential for controlling infection, preventing morbidity and mortality and improve the quality of life. Since limited data are available concerning hospital acquired infection and antibiotic susceptibility trends in our ICU therefore this study will help to investigate the cause of various nosocomial infections and isolate the various pathogens to species level and also determine the antibiotic susceptibility pattern of these pathogens. Knowing antibiotic sensitivity pattern of ICU is mandatory for making an antibiotic policy.[12]

Materials and Methods

A descriptive observational study carried out in the department of microbiology of a tertiary care hospital in Pune over a period of one year. A total of 300 patients were screened consecutively during the study period. Various clinical samples such as ETT, BAL, Blood, Pus, Urine, Sputum, and CSF were received in the microbiology laboratory and were processed as per CLSI guidelines. Patients were evaluated on daily basis and up to 72 hours post discharge from ICU. Markers of infection like total leukocyte count, temperature, blood pressure, respiratory rate, fraction of inspired oxygen (FiO$_2$), radiology, discharge from wound, burning micturation or any other clinical signs of infection was noted and correlated with the findings in our laboratory.

Ethical considerations

The study was reviewed and approved by institutional ethical committee.

Specimen collection and transport

The specimens collected were blood, urine, pus, respiratory samples like sputum, endotracheal secretion (ETT), and broncho-alveolar lavage (BAL), body fluids like cerebrospinal fluid (CSF), pleural fluid, peritoneal fluid, and synovial fluids. Pus samples from superficial wound were collected in swab transport system. Pus samples from deep wounds were aspirated and collected in sterile screw capped containers.[13]

Processing

The specimens were collected and processed asper CLSI (clinical laboratory standard institute) standards.

Antibiotic susceptibility testing

Antibiotic susceptibility tests were done on these isolates by Kirby Bauer disc diffusion method according to CLSI guidelines.

Detection of MRSA

Method: Standard disc diffusion method

Procedure: Methicillin resistant staphylococcus (MRSA) was detected by standard disc diffusion method using cefoxitin (30µg). The discs were applied to the MHA plate swabbed with the test strain adjusted to 0.5 McFarland turbidity standards and incubated at 35°C for 24 hours.

Interpretation: The organisms were deemed methicillin resistant when zone of inhibition was ≤ 24 mm for cefoxitin discs.[14]

Quality control: *Staphylococcus aureus* ATCC 25923 was used as quality control strain.

Detection of ESBL

Method: Phenotypic disc confirmatory test (PCT).

Procedure: Extended spectrum β-lactamase (ESBL) was detected by phenotypic disc confirmatory test (PCT) using ceftazidime (30µg) and ceftazidime-clavulanic acid (30µg/10µg) discs.

The discs were applied to the MHA plates swabbed with the test strain adjusted to 0.5 Mc Farland turbidity standards and incubated at 37°C for 24 hours.

Interpretation: A greater than or equal to five (≥5mm) increase in the zone diameter for the ceftazidime/clavulanic acid combination disc versus the zone of the ceftazidime (30µg) when tested alone were considered as ESBL producing organism.[15]

Quality control: *Escherichia coli* ATCC 25922 strains were used as negative control.

Results and Discussion

From the 300 patients admitted 367 various clinical samples were received. Most of the samples were from respiratory tract 152(41.4%), followed by urine 127(34.6%), blood 63(17%), pus 18(5%) and body fluids 7(2%). Out of the total 367 samples received 235 (64%) were from males and 132 (36%) were from females. Only 40% of them showed significant growth while the rest did not show any growth or were insignificant. Out of the total 300 patients admitted 32 (10.7%) were diagnosed to have developed nosocomial infection during their stay in the ICU (Table 1).

Prevalence of HAI in ICU

Most of the patients admitted in the ICU were from 30 to 60 years of age. Similar pattern was also seen in the 32 patients who developed HAI in the ICU. While age group of 30 years and less, showed the least HAI (Table 2).

Male predominance was seen in the study. A total of 20 (62.5%) males and 12 (37.5%) females got HAI during their stay in the ICU (Fig. 1).

Distribution of nosocomial infections in ICU

Among the 32 patients diagnosed with HAI, respiratory tract infection (RTI) was the most common infection 18(56.3%) in the ICU. It was further divided into ventilator associated pneumonia (VAP) 6(19%) and non-ventilator associated pneumonia (NON-VAP) 12(37.3%). Urinary tract infection was the second common nosocomial infection acquired in the ICU seen in 8(25%) patients which was either catheter associated (CAUTI) 5(15.5%) or non-catheter associated UTI 3(9.5%). Blood stream infection due to

central venous catheter (CRBSI) 3(9.5%) or non-catheter associated blood stream infection (BSI) 1(3%) was seen in 4 patients. Skin and soft tissue infection (SSTI) was noted in 2(6.2%) patients (Fig. 2).

Co-morbid conditions

Out of the 32 patients acquiring nosocomial infection in the ICU 26 were having either one or more than one co-morbidity like diabetes (4), hypertension (6), Hypertension & diabetes (4), obesity (2), autoimmune diseases (3), HIV (1), COPD (2), alcoholism (1), or cardiac pathology (3).

Bacteriological profile of organisms causing nosocomial infections in the ICU

Out of the 32 samples received in the laboratory for processing. 36 organisms were isolated in the various samples mentioned. Most of the isolates were gram negative 29(80.5%), followed by gram positive organisms 4(11.2%), and fungal organisms constituted 3(8.3%) isolates (Table 3).

From the total 36 pathogens isolated from various clinical samples 29 were found to be gram negative and *Acinetobacter baumannii* 12(33.4%) was the predominant pathogen isolated. *Klebsiella pneumoniae* 7(19.4%), *E.coli* 6(16.6%), *Pseudomonas aeruginosa* 2(5.5%), *Providencia rettgeri* 1(2.8%) and *Burkholderia cepacia* 1(2.8%) were the other pathogens isolated. 4 isolates were gram positive comprising of *Staphylococcus aureus* 3(8.4%) and *Staphylococcus epidermidis* 1(2.8%). Fungal pathogens isolated were 3 in number which comprised of *Candida albicans* 2(5.5%), and *Non candida albicans* 1(2.8%).

Distribution of pathogens isolated in different nosocomial infections

From the 36 pathogens found to be associated with nosocomial infection in our ICU 4

patients were having co-infection with more than 1 pathogen, 3 in respiratory samples and one in urine. *Acinetobacter baumannii* 11/21(52.4%) was the most common pathogen causing respiratory tract infections, followed by *Klebsiella pneumoniae* 4/21(19%), *Pseudomonas aeruginosa* 2/21(9.5%), *Staph. aureus* 2/21(9.5%), *E.coli* 1/21(4.8%) and *Burkholderia cepacia* 1/21(4.8%).

From blood samples *Acinetobacter baumannii, Staphylococcus epidermidis, Klebsiella pneumoniae,* and *E.coli,* constituted1/4(25%) each.

From urine samples *Escherichia coli* 4/9(44.5%) was the most common organism causing urinary tract infection. Followed by *Candida albicans* 2/8(22.2%), *Providencia rettgeri* and *Non albicans candida* from 1(11.1%) sample each.

From pus, only 2/2 pathogens were found to be the causative agent of SSTI, *Staphylococcus aureus* 1/2(50%) and *Klebsiella pneumoniae* 1/2(50%) (Table 4).

The overall prevalence of ESBL producing pathogens was found to be 24.1% out of the 29 Gram negative organisms isolated. *E.coli* being the most prevalent ESBL producer 2/6(33.3%). Followed by *Klebsiella pneumoniae* 2/7(28.5%) and *Acinetobacter baumannii* 3/12(25%).Out of the 3 *Staphylococcus aureus* isolates methicillin resistance was seen in 2(66.6%). One of them was isolated from ETT while the other was isolated from pus sample causing RTI & SSTI respectively.

The various pathogens causing device induced infection and surgical site infection (Table 5). The rate of various device induced infections was calculated by the total number of infections per 1000 device days.

VAP rate: $\dfrac{\text{No of VAP detected}}{\text{Total ventilator days}} \times 1000$

The VAP rate in our hospital was; $6/631 \times 1000 = 9.5 / 1000$ ventilator days.

CRBSI rate: $\dfrac{\text{No of CRBSI detected}}{\text{Total central line days}} \times 1000$

CRBSI rate in our hospital was; $3/510 \times 1000 = 5.88 / 1000$ central line days.

CAUTI rate: $\dfrac{\text{No of CAUTI detected}}{\text{No of catheter days}} \times 1000$

The rate of CAUTI in our hospital was; $5/1353 \times 1000 = 3.69 / 1000$ catheter days.

SSI rate: $\dfrac{\text{No of SSI detected}}{\text{No of post operative days}} \times 100$

SSI rate in our hospital was; $2/57 \times 100 = 3.5$ %

All the 300 patients taken up in the study were followed up throughout their stay in the hospital and the aim was to evaluated outcome of patients admitted in ICU. In all these 300 patients 32 had acquired nosocomial infection while the rest 268 did not. 7/32(21.8%) patients with HAI died during their stay while 12/268(4.4%) patients who did not have any HAI died while admitted. Male preponderance was seen in the outcome with 6(85.7%) males and 1(14.3%) female expiring with HAI. While 7(58.3%) males and 5(41.7%) females expiring with Non-HAI. With respect to age, majority of the deaths with HAI occurred in patients above 60 years of 2/6(33.3%) followed by age group of 31-60 years 5/21(23.8%).

Staphylococcus aureus showed 100% sensitivity to Gentamicin, Rifampicin, Cotrimoxazole, Clindamycin, Linezolid, Vancomycin, Teicoplanin, Chloramphenicol, Tetracycline, and Tigecycline. *Staphylococcus epidermidis* showed 100% sensitivity to cefoxitin, gentamicin, rifampicin, cotrimoxazole, clindamycin, linezolid, vancomycin, teicoplanin, chloramphenicol, tetracycline and Tigecycline. MRSA showed 100% susceptibility to Rifampicin, Linezolid, Vancomycin, Teicoplanin, Chloramphenicol, Tetracycline and Tigecycline. While it showed 50% susceptibility to Cotrimoxazole and Clindamycin (Graph 1).

We also classified them under two categories the Non-Fermenter GNBs (NF-GNB) and the Enterobacteriaceae GNBs (EB-GNB). The NF-GNB pathogens like *Acinetobacter baumannii* showed 100% susceptibility to Colistin, 91.66% to Ampicillin + sulbactam while it showed 75% susceptibility to ampicillin. *Pseudomonas aeruginosa* was 100% sensitive to Ampicillin, Ampicillin + sulbactam, Ceftazidime, Ciprofloxacin, Amikacin, Gentamicin, Piperacillin + tazobactam, Colistin, Imipenem, and Meropenem while *Burkholderia cepacia* was 100% susceptible to Ampicillin + sulbactam, Cefotaxime, Cefepime, Ceftazidime, Amikacin, Gentamicin, Tigecycline, Piperacillin + tazobactam, Imipenem, Meropenem, Colistin and Polymyxin-B. EB-GNB like *Klebsiella pneumoniae* showed 100% susceptibility to Imipenem, Meropenem and Colistin, while it showed 71.4% sensitivity to Piperacillin + tazobactam. *E. coli* showed 100% susceptibility to Colistin and 83.3% to ampicillin. It showed 66.6% sensitivity towards Imipenem, Meropenem, and Nitrofurantoin. *Providencia rettgeri* showed 100% susceptibility to Amoxicillin, Co-amoxyclav, Ampicillin + sulbactam, Amikacin, Piperacillin + tazobactam, Cefepime, Imipenem, and Meropenem but was resistant to Colistin (Graph 2).

Prevalence of nosocomial infections in ICU

With respect to prevalence of hospital acquired infection, in our study 32 patients developed nosocomial infection during their stay in the ICU with a rate of 10.7%, which is in correlation with the study conducted by Sugata Dasgupta *et al.,*[17] who reported a prevalence of 12%. Adriana *et al.,*[16], Vincent JL *et al*[18] and Ashour *et al.,*[19] reported a higher prevalence of 20%, 20.6% and 24% respectively in their study The higher frequency in these studies could be due to broader criteria of selection of patients and poor infection control practices. Lower level of prevalence of infection in our study could be due to stringent infection control measures and a dedicated staff for ICU.

Distribution of nosocomial infections in ICU

From these 32 patients most of the infections were related to respiratory tract 18(56.3%). It was followed by urinary tract infection 8(25%). Blood stream infection comprised of 4(12.5%) and skin and soft tissue infection was 2(6.2%). Comparable results have been published by Ashour *et al.,*[19], Gunseren *et al.,*[11], Radji *et al*[20], and Sugata Dasgupta *et al.,*[17].It is in contrast with the study conducted by Mythri *et al.,*[21] where the most common nosocomial infection was urinary tract infection followed by respiratory tract infection.

Bacteriological profile of organisms causing Nosocomial Infection in ICU

The predominance of Gram negative bacteria in our study is in concordance with the findings of some recent studies, (Zhanel *et al.,*[22], Patel *et al.,*[5], Al Jawady *et a.,l*[1] and Radji *et al.,*[23]).The data is comparable to other studies as well.[1,22,24] The overall decrease in gram positive cocci in comparison to gram negative bacilli may be due to the direction of empirical therapy towards the gram positive one and over the time the gram negative bacteria show resistance to this therapy.[1]

Distribution of various pathogens in different nosocomial infections in ICU

In the present study *Acinetobacter baumannii* 12(33.4%) was the most common organism causing respiratory tract infections, followed by *Klebsiella pneumoniae* 4(19.4%), *Staph.aureus* 2(9.5%) and *Pseudomonas aeruginosa* 2(9.5%).

Acinetobacter species are important causes of nosocomial infections and also cause community-acquired pneumonia and soft tissue infections in warm and humid climates. The National Nosocomial Infection Surveillance (NNIS) System, implicated *Acinetobacter* species in 7% of nosocomial pneumonias and 2% each of nosocomial blood stream, surgical site, and urinary tract infections in ICUs in the United States in 2003.[25] Importantly, *Acinetobacter* was the only gram-negative bacillus that increased significantly in incidence as a cause of ventilator-associated pneumonia compared to other GNBs. In the SENTRY study from January 2009 to December 2011, *Acinetobacter* species were implicated in 7% of ICU infections in the United States and Europe.[26]Infections with *Acinetobacter* are an independent risk factor for death and carry a crude mortality rate of 30% to 75%, which is partly attributable to comorbidities of the hosts and incorrect choices of antimicrobial therapy. [26,27] Regarding the latter factor, a study of *A.baumannii* isolates from 803 US health-care facilities noted that 60% were resistant to three classes of antibiotics and 34% to four classes.[28] The findings are similar with the study conducted by Sharma SK *et al.*[29] It is in contrast with Patel BV *et*

al.,[5], Zhanel *et al.,*[22] and Al-Jawady *et al.,*[1]

The *Burkholderia cepacia* complex, can cause nosocomial outbreaks of pneumonia and bacteremia in critically ill patients without cystic fibrosis, and are sometimes associated with contaminated medications and toiletries.[30]

Table.1 Showing prevalence of HAI in ICU

HAI	No of Patients	Percentage
Present	32	10.7%
Absent	268	90.3%
Total	300	100%

Table.2 Age wise distribution of HAI in ICU

Age	Patients with HAI	Percentage
≤ 30	5	15.6%
31 - 60	21	65.6%
> 60	6	18.8%
Total	32	100.0%

Table.3 Showing organisms isolated from ICU patients

Organisms Isolated		
Microorganisms	**No. of isolates**	**Percentage**
Gram negative isolates		
Acinetobacter baumannii	12	33.4
Klebsiella pneumoniae	7	19.4
Escherichia coli	6	16.6
Pseudomonas aeruginosa	2	5.5
Providencia rettgeri	1	2.8
Burkholderia cepacia	1	2.8
Subtotal	**29**	**80.5**
Gram positive isolates		
Staphylococcus aureus	3	8.4
Staphylococcus epidermidis	1	2.8
Subtotal	**4**	**11.2**
Fungal isolates		
Candida albicans	2	5.5
Non albicans candida	1	2.8
Subtotal	**3**	**8.3**
Total Isolates	**36**	**100**

Table.4 Pathogens isolated in different nosocomial infection

Organisms	RTI	BSI	UTI	SSTI	Total No
Acinetobacter baumannii	11	1	0	0	12
Klebsiella pneumoniae	4	1	1	1	7
Escherichia coli	1	1	4	0	6
Pseudomonas aeruginosa	2	0	0	0	2
Burkholderia cepacia	1	0	0	0	1
Providencia rettgeri	0	0	1	0	1
Staph.aureus	2	0	0	1	3
Staph.epidermidis	0	1	0	0	1
Candida albicans	0	0	2	0	2
Non albicans candida	0	0	1	0	1
Total organisms	**21**	**4**	**9**	**2**	**36**

Table.5

Pathogen	VAP	CRBSI	CAUTI	SSI
Acinetobacter baumannii	1	-	-	-
Acinetobacter baumannii ESBL	2	1	-	-
Klebsiella pneumoniae	-	-	-	1
Klebsiella pneumoniae ESBL	1	1	-	-
E.coli	-	-	1	-
E.coli ESBL	-	-	2	-
Burkholderia cepacia	1	-	-	-
Providencia rettgeri	-	-	1	-
Staph.epidermidis	-	1	-	-
MRSA	1	-	-	1
Candida albicans	-	-	1	-
Total	**6**	**3**	**5**	**2**

Fig.1 Gender wise distribution of the patients having HAI
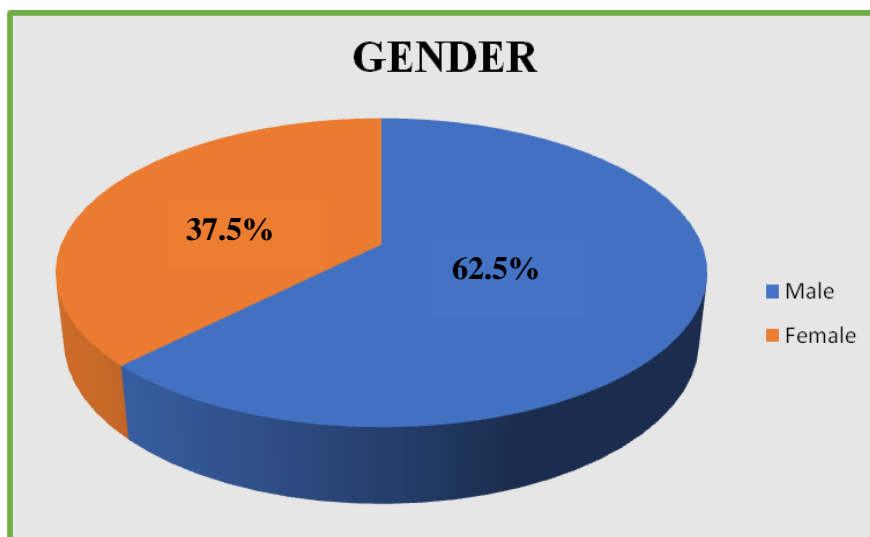

GENDER

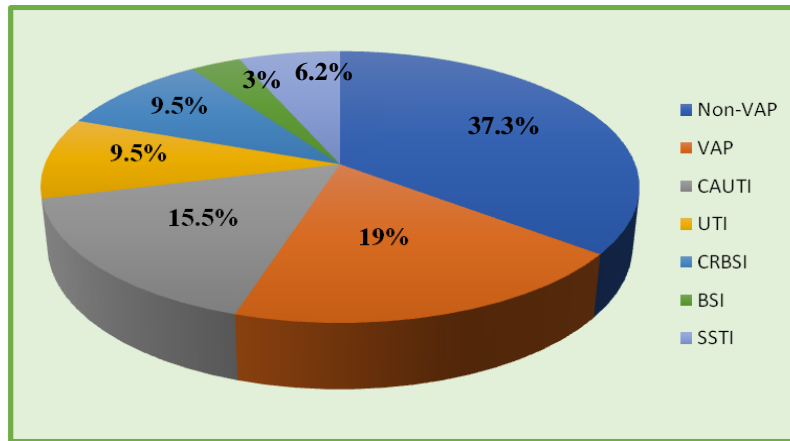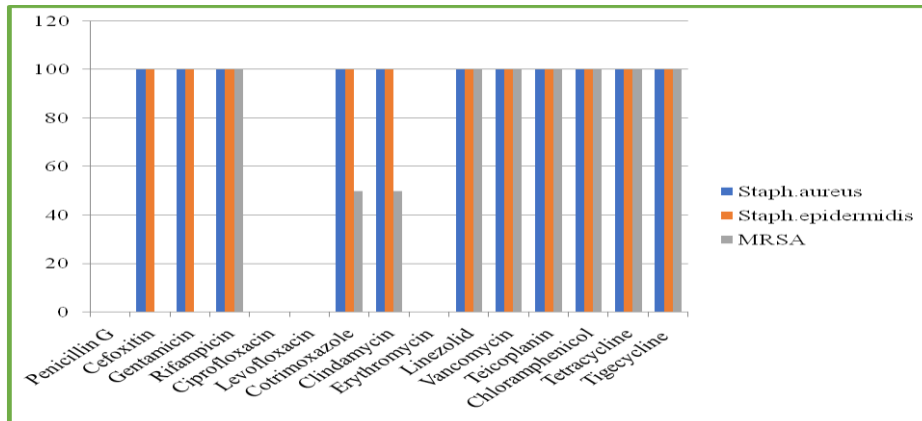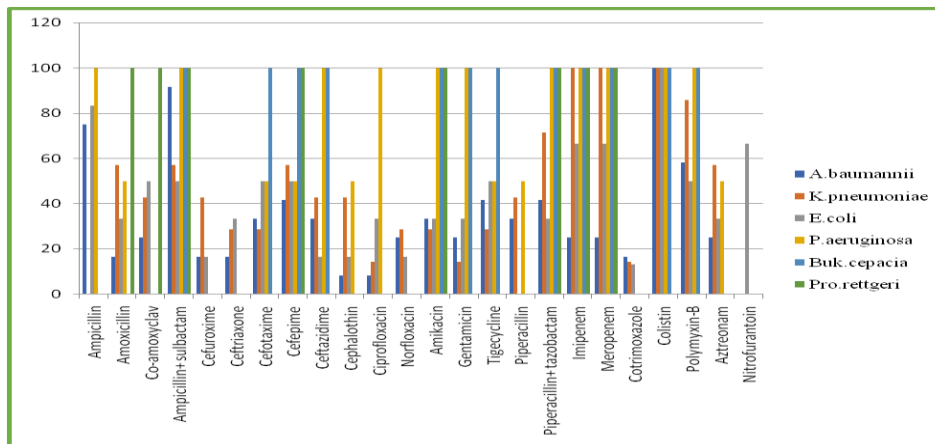37.5% 62.5%

■ Male
■ Female

Fig.2 Distribution of nosocomial infections in ICU

Graph.1 Antibiotic sensitivity pattern of Gram-positive organisms causing HAI in ICU

Graph.2 Antibiotic sensitivity pattern of Gram negative organisms causing HAI in ICU

Prevalence of ESBL production and MRSA in the pathogens isolated

Overall, the total percentage of ESBL producers among gram negative bacteria like *Acinetobacter baumannii, E.coli* and *Klebsiella pneumoniae* was 24.1%. The percentage of ESBL producer among *Acinetobacter baumannii* was 3/12 (25%). In *Klebsiella pneumoniae* it was 2/7(28.5%) and in *E.coli* it was 2/6(33.3%).

Our data correlates with Oberoi L *et al.,*[31] who reported a prevalence of 35.16% in ICU in Punjab. Other investigators from India reported different findings, 68.78% in New Delhi (Srujana Mohanty *et al.,* 2005)[32], 53% in Mumbai (C Rodrigues *et al.,* 2004)[33], and 57.69%-61.11 % in Allahabad (Vipin Kumar *et al.,* 2011)[34], emphasizing that the prevalence of ESBL can vary greatly from one place to another and even over time.[35] This contrast may be due to difference in selective antibiotic pressure because of local hospital antibiotic policy, and also infection control practices in hospitals. Studies show that the epidemiology of MRSA over different parts of India is not uniform. In the present study, we reported 66.6% MRSA among S.aureus isolates. Whereas, others have reported variable percentages, 54.9% in Anantapur (Habeeb Khadri *et al.,* 2010)[36], 68.44% in Varanasi (Hare Krishna Tiwari *et al.,* 2008)[37], another study done by Sangeeta Joshi *et al.,*[38] (INSAR group) in 2008 and 2009 in which 15 different tertiary care centre's all over India participated and reported an overall incidence of 43% in 2008 and 47% in 2009 of MRSA in the ICU.

Although it is extremely difficult to explain these conflicting data with regards to both time and place of study the variation is probably due to differential clonal expansion and drug pressure in community, and also differences in the infection control policies in

ICU. Patients in the ICU are more likely to be colonized or infected with an antimicrobial resistant pathogen than Non-ICU patients, therefore the rates of resistance are significantly higher in patients treated in the ICU than in Non-ICU patients.[39]

Device induced nosocomial infection rates

The VAP rate in our study was 9.5/1000 ventilator days, CRBSI rate was 5.88/1000 central line days, CAUTI rate was 3.69/1000 catheter days, and SSI rate was 3.5%. Which is corresponding to the study done by David J Weber *et al.,* [40], and Jimenez *et al.,* [41]

Our results were in slight dissimilarity with the results obtained by HG. Garcell *et al.,*[42]. Who reported VAP rate of 20.5/1000, CRBSI rate of 2.3/1000, and CAUTI rate of 4.1/1000 days. The reason could be of a lesser patient number in their study as compared to ours. And prevalence of multi drug resistant bacteria in their ICU which can exponentially increase the infection rate in any health care facility.

Antibiotic sensitivity pattern of organisms causing HAI

Among the NF-GNB isolates, a high degree of resistance has been observed to almost all classes of antimicrobials tested such as cephalosporins, carbapenems, aminoglycosides and quinolones. This data is supported by various studies Mohammadi-mehr M *et al.,* Maksum Radji *et al.,* and Kaushal V Sheth *et al.,* [43,23,12] *Acinetobacter* spp was the most resistant organism in our study. 85% of *Acinetobacter* spp were found to be resistant to be meropenem; whereas the cephalosporin resistance varied between 91.7% (cephalothin) and 58.4% (Cefepime). Even resistance to aminoglycosides and quinolones were also much higher (66.7% to amikacin and 91.7% to ciprofloxacin).

Kaushal V Sheth *et al.,* [12] had reported concordance resistance pattern for *Acinetobacter* spp to various class of antimicrobials.[12] Tigecycline and cefepime was found to be more effective against *Acinetobacter baumannii* (41.6%) compared to the other antimicrobials, hence it may be a promising agent for the treatment of *Acinetobacter* infections. *Pseudomonas aeruginosa* was also found to be resistant to several classes of antimicrobials tested, but the intensity of resistance was lower compared to *Acinetobacter baumannii*. Resistance of isolates of *Pseudomonas* to Ampicillin/sulbactam, Meropenem and amikacin was found to be minimal. While as Tigecycline and Pipercillin resistance was around 50%. This is also in agreement to several other Indian studies published in the recent past.[43,23,12]

Among EB-GNB, we noted high degree of resistance to cephalosporins (42.9%-83.4%) & quinolones (66.7%-85.7%) and aminoglycosides (66.7%-85.7%). Resistance was lower on addition of beta lactamase inhibitor, (0% -50% resistance against Amoxicillin/clavulanic acid). Significant resistance to carbapenams (33.4%) was also seen. In general, *E.coli* followed by *Klebsiella pneumoniae* were found to be more resistant as compared to *Providencia rettgeri*. This data is supported by studies of Al Jawady *et al.,*[1], Mahin Jamshidi *et al.,* Mohammadi-mehr *et al.,* Ganguli *et al.,* [44,43,45]

In the Gram positive group, all strains of *S.aureus* were found to be resistant against penicillin and ciprofloxacin (100%). This finding is also supported by Maksum Radji *et al.,* Kaushal V. Sheth *et al.,* Ganguli *et al.,*[23,12,45] In our study, about (50%) of *Staphylococcus species* were found to be Methicillin Resistant (MR). There are several studies which documented the incidence of MR between (30%-50%) among hospitalized

patients.[46,20,12] The increasing incidence of MR is alarming as no beta lactams drug would work in this situation and increase use of vancomycin opens the possibility of emergence of vancomycin resistance in *S.aureus* in near future. However, no vancomycin resistance has been reported in our study in concordance to other Indian studies.

The prevalence of MDR among gram-negative bacilli has significantly increased in recent times.[47,48,23] Emergence of these organisms can lead to increased mortality, morbidity, economic burden and longer hospital stay. We made an attempt to calculate co-resistance among MDR gram-negative organisms. We found that 55.17% (16 out of 29) of the significant GNB isolates were MDR and are resistant to at least 3 or more classes of antimicrobials. Maximum MDR was reported from *Acinetobacter baumannii* (75%), this was supported by study conducted by Aurora E *et al*.,[44], where it was found that 35% of GNB isolates were resistant to 4 antimicrobial groups, and 12% were resistant to 5 antimicrobial groups. [47,44,48,23]

The findings in our study were found to be closer to the lower range of prevalence rates reported in the other studies referred above. This difference in findings is not necessarily related to better quality of care, since many other factors may be responsible including difference in the criteria for patient selection, the case mix, ICU type, length of stay, rate of device utilization and discharge criteria.[24,50] The patients from a single institution can present with different risk of infection in the context of differing case mix, severity of illness and utilization rates of invasive devices.[51]

In the EPIC II study,[56,49] the most frequently reported sites for ICU acquired infections

were the lungs (64%), abdominal (19%), and blood stream (15%). Data from the United States National Nosocomial infections surveillance (NNIS) system showed that the nosocomial pneumonia accounted for 31% of all nosocomial infections followed by urinary tract infections and blood stream infections.[51] The site distribution of nosocomial infections in this study broadly conforms to the findings of earlier and larger studies mentioned above.

The precise pattern of causative organisms, whether bacterial or fungal, varies across countries and between ICUs according to patient case mix, site of infection, antibiotic protocols, infection control practice and local ecology and resistance patterns.[52] Most studies report that more than half of the nosocomial infections occurring in the ICU are due to Gram-negative bacteria.[49,51] In our study too, the most commonly isolated organisms were Non Fermenter Gram-negative bacteria especially *Acinetobacter baumannii* which was the single most pathogen isolated, followed by *Enterobacteriaceae*. The detection of *Candida* species in 9.3% of the isolates in the present study is also consistent to some extent with the studies of Pittet and Wenzel[53,55] and Edgeworth *et al.,*[54] who have reported that fungal pathogens are also becoming increasingly common among patients with nosocomial infections.

Recommendation

A robust and effective hospital infection control policy, Antimicrobial Stewardship Programe (ASP) with frequent revisions of antimicrobial policy guidelines is mandatory and is the only way to control HAIs and AMR (Anti-Microbial Resistance).Interventions to control spread of resistant bacteria causing nosocomial infections include optimizing antibiotic selection and dosing strict

adherence to infection control practices and rational use of antibiotic combinations. Antimicrobial sensitivity pattern in ICU are crucial and important for giving effective treatment and decreasing the spread of resistance.

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