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The air as harbinger of infections in critical care units

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ABSTRACT

Micro flora in air is an important source of infections in critical care units (CCU's). Knowledge of common bacterial isolates in the environment of these CCUs & their antibiotic resistant pattern facilitates better treatment of resistant pathogens. With this background this study was taken for air quality monitoring & environmental survey for microbial resistance. Environmental surface samples were taken from all CCUs& operation theaters. Air quality surveillance was done by settle method. Nasal samples and skin samples from web spaces of health care workers present in each ICU and OT were taken. Isolates were identified and antibiotic susceptibility pattern was studied under standard methods. Bio load in Neonatal ICU- 688 Cfu/m^3 Medical ICU-2401 Cfu/m^3Surgical ICU-4766Cfu/m^3Operation theatre-991Cfu/m^3. A total of 158 isolates obtained from ICUs and OT, 105 (66.45%) were gram-negative bacteria (GNB) and the remaining 53 (33.54%) were gram-positive bacteria (GPB). Commonly isolated bacteria were *Staphylococcus* (32.27%) and *Nf GNB* (25.31%).Isolates were commonly resistant to ampicillin, cotrimaxazole, gentamycinetc 72.2% of Staphylococcus aureus were MRSA. Of 14 isolates from health care workers, commonly isolated bacteria were *Staphylococcus*spp (57.14%), *Nf GNB* (21.43%), *E.coli (*7.14%) *and Acinetobacter* (14.29%). 37.5% isolates of staphylococci in HCW were MRSA.78 isolates of GNB and 38 isolates of GPC were showing resistance to ≥ 3 categories of antimicrobials and were considered as MDR. High prevalence of infective sources in hospital environment is highly alarming. It could be inferred from our study that health care workers, environmental contaminations with MDR pathogens are a definitive risk factor for critical care patients.

Key words: *bio load,* critical care, MDR bacteria

Abbreviations: MDR-multi drug resistant

1. INTRODUCTION

Environmental monitoring means the microbiological testing of air, surfaces and equipment in order to detect changing trends of microbial counts and micro-flora (Sandle, 2006). Patients are primarily admitted into hospital wards for proper management of their ailments, but while on admission some patients acquire other ailments than the one they were admitted for. Thesehospital-acquired infections can be acquired from contact with a carrier directly or indirectly through inanimate objects or air. Hospital-associated infections are an important cause of patient morbidity and death (Zerr et al. 2005).

The indoor air environment can potentially place patients at a greater risk than the outside environment, because enclosed spaces can confine aerosols and allow them to build up to infectious levels (Jaffal, 1997). Infection control and basic hygiene should be at the heart of good hospital management (Griffith et al., 2005). Patients admitted to intensive care units, in particular, often become colonized with resistant organisms and may serve as the focus for hospital-wide bacterial resistance (Archibald, 1997). The high prevalence of resistance in intensive care units (ICUs) has been attributed to the severity of illness of the patients, prolonged hospital stays, and the widespread use of invasive devices and broad spectrum antibiotics (Donowitz et al., 1982; Vincent et al., 1995). Nosocomial infections occur approximately three to six times more frequently in patients admitted to ICUs than in patients residing in general wards (Daschner, 1985). The prevalence of nosocomial infection in critically ill patients is about 20%, depending on the type of admission diagnosis and underlying conditions predisposing to microbial colonization and infection (Vincent et al., 1995).

Also Microbiological contamination of air in the operating room is generally considered to be a risk factor for infections of surgical site in clean surgery (Dharan and Pittet, 2002; Landrin, et al., 2005). Evaluation of the quality of air in operating theatres can be performed routinely by microbiological sampling and particle counting. It is recommended that for conventional operating theatres the bio load should not exceed 35 cfu/m3 in an empty theatre or 180 cfu/m3 during an operation (Arrow smith, 1985).

For this reason, knowledge of the incidence of micro flora in hospitals is important for the infections that may emanate from them. Furthermore, controlling the microbes in these hospital environments may play a role in the prevention of cross infection. Knowledge of an ICU's most common bacterial isolates and their antibiotic susceptibility patterns facilitates effective empirical antibiotic therapy and supports decisions to restrict or reduce the clinical availability of certain antibiotics. Antibiotic interventions should aim to limit the emergence of antibiotic resistance whilst simultaneously improving patient outcomes and decreasing drug costs (Thursky et al., 2006). It has been suggested that surveillance of bacterial resistance patterns is a useful technique to control the emergence of resistant organisms (Stratton et al., 1992). Early detection of resistant organisms allows for specific measures to be implemented preventing the widespread transmission of bacterial resistance. Furthermore, as the choice of antimicrobial therapy for nosocomial infections is often governed by local resistance patterns, surveillance of bacterial susceptibility can aid in making decisions regarding empirical antimicrobial therapy at each institution. The collection of information on antibiotic usage is also essential because selective pressure exerted by the use of certain antibiotics may impact on resistance patterns (Gaynes, 1995). The increased use of third-generation cephalosporins in the ICUs, for example, may lead to the selection of highly resistant Gram-negative bacilli (Chow et al., 1991; Sanders et al., 1988).

In this context, this study was carried out to conduct air quality monitoring in operation theatres and ICUs for the purpose of surveillance of antibiotic use and microbial resistance in ICUs and OTs of tertiary care hospital, Mysore. A Government Hospital was chosen for the study due to its high patronage by patients from surrounding areas, in order to ascertain the nature of the air quality in the hospital environment. It will also provide baseline information on the quality of indoor air, which before now was not available.

2. MATERIALS AND METHODS

The present observational study was carried out in the department of Microbiology, MMC & RI, Mysore and its attached hospitals, for a period of two months during 2013.

Sample collection

Environmental surface samples for colonization of aerobic bacteria in neonatal intensive care unit (ICU), medical ICU, surgical ICU and Operation theatre (OT) were collected. Surface samples for environmental surveillance were taken from table, floor, suction apparatus and trolley in OT. Baby cot, warmer, air conditioners, suction tubes, floor, curtains and other available surfaces in neonatal ICU(NICU). Ventilators, shelves, suction apparatus, cots, air conditioners, floor, curtains in surgical (SICU) and medical ICUs (MICU). Nasal samples and skin samples from web spaces of health care workers present in each ICU and OT were taken.

Table 1

Concentration of airborne bacterial population of all ICUs and OT (cfu/m^3)

Samples (weeks)	1	2	3	4	5	6	7	Average
Neonatal ICU	261.8	209.5	995.5	628.5	366.6	209.5	261.8	688.3
Medical ICU	2095.1	3299.8	2357	3666.4	1571.3	2147.4	1676	2401.8
Surgical ICU	2880.7	4714	5499.6	5394.9	4609.2	5290.1	4975.9	4766.2
Operation theatre	1571.3	942.8	1152.3	838	733.2	628.5	1047.5	991.5

Table 2

Isolates obtained from environmental surveillance

n= 112 samples

Isolates	Number (%)
Staphylococcus	51(32.27%)
Nf GNB	40(25.51%)
Eschericia coli	18(11.39%)
Acinetobacter spp.	11(6.96%)
Klebsiella spp.	17(10.75%)
Aeromonas spp.	5(3.164%)
Proteus spp.	2(1.26%)
Citrobacter spp.	4(2.53%)
Providencia spp.	6(3.79%)
Enterobacter spp.	2(1.26%)
Streptococcus spp.	2(1.26%)
Total	**158**

Nf GNB- non fermenting Gram Negative Bacilli

Air sample

Air quality surveillance was done using settle method (Collee et al. 1996). Microbiological samples were collected from surgical ICU, medical ICU, neonatal ICU and OT in the hospital by exposing prepared nutrient agar plates for a period of 30minutes. Plates were placed such that the chosen place was 1m above and 1m away from the wall. Each week (7 weeks) air samples were collected during morning hours between 10am and 10.30am. After exposure, the plates were transferred to the Microbiology laboratory, for incubation at 37^0 C for 24 hours. The resultant colonies were counted and converted into colony forming unit per cubic meter of air (cfu/m^3) using Omelianskyformula (Abdel Hameed and Abdel Mawla, 2012).

$$N=5a \times 10^4 (bt)^{-1}$$

N=colony forming unit per cubic meter of air (cfu/m^3)
a=number of colonies per petri dish
b=surface area of petridish in cm^2
t=time exposure (min)

Environmental sample

Surface samples were processed according to the standard protocols. Isolates were identified using standard biochemical reactions (Forbes et al. 2007).

Antibiotic Susceptibility Test (AST)

AST was performed using Kirby-Bauer's disk diffusion test as per CLSI guidelines (Wayne, 2010). Ampicillin 10µg, Amoxyclav 30µg, Gentamycin 10µg, Ciprofloxacin 5µg, Cotrimoxazole 25µg, Imipenem 10µg, Tetracycline 30µg, Piperacillin-tazobactum 100/10µg, Amikacin 30µg were used to test antibiotic susceptibility for Gram negative bacteria. Ampicillin 10µg, Amoxyclav 30µg, Cefotaxime 30µg, Ciprofloxacin 5µg, Erythromycin 15µg, Clindamycin 2µg, Cefoxitin 30µg, Chloramphenicol 30µg&Amikacin 30µg were used to test antibiotic susceptibility for Gram positive bacteria.

3. RESULTS

A total of 112 surface samples were taken from Surgical ICU, Medical ICU, Neonatal ICU and Operation Theatre and total of 28 swabs were taken from the health care workers during this period (Table 1) 112 swabs yielded 158 isolates. 30 samples yielded no growth. Among the total of 158 isolates obtained from ICUs and OT, 105 (66.45%) were gram-negative bacteria (GNB) and the remaining 53 (33.54%) were gram-positive bacteria (GPB)**.**Of these 158 isolates, most commonly isolated bacteria were *Staphylococcus* 32.27% and Non fermenting Gram negative bacilli *Nf GNB* 25.31%. Among 51 isolates of *Staphylococcus*, 36 (70.5%) isolates were *Staphylococcus aureus*and 15 (29.5%) isolates were coagulase negative Staphylococci (*CoNS*). Tables 2-4 showing resistance patterns of different isolates.72.2% of *Staphylococcus aureus* showed resistance to cefoxitin, which predicts MRSA.

A total of 28 swabs from health care workers yielded 14 isolates (Table 5). 15 samples yielded no growth. Of these 14 isolates, most commonly isolated bacteria were *Staphylococcus* spp (57.14%), *Nf GNB* (21.43%), *E.coli (*7.14%) *and Acinetobacter* (14.29%).37.5% isolates of staphylococci showed methicillin resistance. The isolates resistant to 3 or more than 3 category, out of the antimicrobials used for testing antimicrobial susceptibility pattern were considered as Multi drug resistant bacteria (Magiorakos, et al., 2012). 78 isolates of GNB and 38 isolates of GPC were showing resistance to ≥ 3 categories of antimicrobials and were considered as MDR.

Table 3

Antimicrobial resistance pattern among the GNBs isolated from Environmental surveillance

Antimicrobials	Ac	G	Cf	Co	I	Te	Pt	Ak	A
Nf GNB *(n=40)*	19 (47.5%)	31 (77.5%)	29 (72.5%)	30 (75%)	11 (27.5%)	17 (42.5%)	12 (30%)	34 (85%)	39 (97.5%)
Eschericia coli *(n=18)*	10 (55.56%)	9 (50%)	9 (50%)	12 (66.6%)	4 (22.22%)	10 (56.56%)	4 (22.2%)	12 (66.66%)	15 (83.3%)
Acinetobacter *(n=11)*	7 (63.63%)	9 (81.81%)	4 (36.36%)	8 (72.72%)	5 (45.45%)	7 (63.6%)	5 (45.5%)	8 (72.72%)	11 (100%)
Klebsiella spp. *(n=17)*	14 (82.35%)	14 (82.35%)	11 (64.7%)	15 (88.23%)	7 (41.7%)	10 (58.82%)	10 (58.8%)	16 (94.2%)	17 (100%)
Aeromonasspp *(n=5)*	2 (40%)	3 (60%)	3 (60%)	3 (60%)	2 (40%)	4 (80%)	1 (20%)	4 (80%)	4 (80%)
Proteus *(n=2)*	1 (50%)	1 (50%)	1 (50%)	2 (100%)	0 (0%)	1 (50%)	0 (0%)	2 (100%)	2 (100%)
Citrobacter *(n=4)*	2 (50%)	4 (100%)	4 (100%)	4 (100%)	1 (25%)	3 (75%)	0 (0%)	4 (100%)	4 (100%)
Providencia *(n=6)*	3 (50%)	6 (100%)	2 (33.3%)	5 (83.3%)	2 (33.33%)	4 (66.7%)	3 (50%)	4 (66.7%)	5 (83.3%)
Enterobacter *(n=2)*	2 (100%)	2 (100%)	2 (100%)	2 (100%)	1 (50%)	1 (50%)	1 (50%)	2 (100%)	2 (100%)

Nf GNB- non fermenting GNB

Ac-Amoxyclavulinic acid, G-Gentamycin, Cf-Ciprofloxacin, Co-Cotrimoxazole, I-Imipenem, Te-Tetracycline, Pt-Piperacillin-tazobactum, Ak-Amikacin, Amp-Ampicillin

Table 4

Antimicrobial resistance pattern among the Gram-positive cocci isolated from Environmental surveillance

Antimicrobials	Ak	Ce	Cf	E	Cd	Cx	C	Amp	Ac
S.aureus *(n=36)*	7 (19.4%)	30 (83.3%)	26 (72.2%)	24 (66.6%)	11 (30.55%)	26 (72.2%)	5 (13.8%)	31 (86.1%)	17 (47.2%)
CoNS *(n=15)*	3 (20%)	12 (80%)	10 (66.6%)	9 (60%)	4 (26.6%)	12 (80%)	2 (13.3%)	13 (86.6%)	7 (46.6%)
Streptococcus sp. (n=2)	0 (0%)	2 (100%)	2 (100%)	0 (0%)	2 (100%)	2 (100%)	0 (0%)	2 (100%)	2 (100%)

Ak -Amikacin, Ce-Cefotaxime, ,Cf-Ciprofloxacin ,E-Erythromycin, Cd-Clindamycin, Cx-Cefoxitin,C-Chloramphenicol, Amp-Ampicillin, Ac-Amoxyclavulinic acid

Table 5

Isolates obtained from Health care workers

(n=28 samples)

isolates	Number
Staphylococcus spp	8
Nf GNB	3
Eschericia coli	1
Acinetobacter spp	2
Total	**14**

Nf GNB- non fermenting GNB

4. DISCUSSION

It has been a long debated issue that airborne sources of possible bacterial contamination of environment in OTs and ICUs can be potential threat for the incidence of nosocomial infection. This increases the morbidity due to surgical site infections and other infections. Additional health care costs becomes taxing to the patient undergoing surgical procedures. It is difficult to make direct comparison with other ICUs without detailed demographic information. The results of our study demonstrated higher incidence of nosocomial pathogens in the hospital environment. Different environmental samples were taken and were processed. *S.aureus, Nf GNB, E.coli, Acinetobacter spp.* were most common isolates in our set up. In Asian counties the most frequent pathogens isolated from ICUs *are Pseudomonas, E.coli, Klebsiella*and *Staphylococci* (Raval, 2012). A study in 2010 has reported similar results of isolates *S.aureus, E.coli* in their hospital (Ekhaise et al., 2010).

The maximum prevalence of *S.aureus* (32.27%) among the environmental samples might be due to its easy way of transmission from skin, anterior nares cuts, boils of health care workers and patients. 72.2% of MRSA in environmental samples and 37.5% in health care workers is a significant finding. The probable carriage of MRSA in health cares workers might be the source for the wide spread of these MRSA strains in the hospital environment. Drug resistance data from environmental surveillance shows strong correlation with the health care workers. In developing countries antibiotics are prescribed for 44%-97% of patients in hospital often inappropriately (Raval, 2012). In a study 59.46% of all *S.aureus* associated infections in ICU were by MRSA (Raval, 2012). Many a times the magnitude of nosocomial infections depends on the level of hygienic conditions of the hospital environment. Ours is a tertiary care hospital with inflow of patient from poor economic background. The lack of education and negligence of patient also contributes to cross infection. Microbiological quality of air may be considered as mirror of the hygienic conditions of the hospital. It has been observed that 700-1800cfu/m^3 were related to significant risk of infection and the risk was slight when they are <180cfu/m^3 (Javed et al., 2008).

In our study bio load was 688.3cfu/m^3 in NICU, MICU=2401.8cfu/m^3, SICU=4766.2 cfu/m^3 and 991.5 cfu/m^3 in OT. We have noticed a significant increased percent of bacterial count in air. A microbiological surveillance study in OTs and ICUs of a tertiary care hospital at Lahore has reported bacterial air count in the range of 6500-15730cfu/m^3 (Javed et al., 2008). We have to take up training of these health care workers regarding infection control protocols. Also in the same way patients should also be counseled regarding infection control practices. Though settle plate method may be regarded as a crude measure of airborne contamination, in places without other facilities it can still provide a simple and cost effective way of enumerating the contamination rate of horizontal surfaces at multiple points. With limited sources in our hospital, settle method and environmental sampling has given a valuable report. This report shows that issue has to be discussed at the administrator level to reduce the level of infections and possible intervention methods to be taken. Also routine sampling is a must so that we can become more aware and alert to control all possible sources of infections. Antimicrobial resistance pattern of hospital pathogens should be known to clinicians, so that antibiotic cycling policies and analysing emergence of new pathogens in critical care medicine becomes helpful guide.

Our study has shown increased prevalence of drug resistant pathogens and variability in resistance patterns in different parts of the hospital. The reason might be, the time of collection of air samples was constant all the days (morning hours). We have not monitored the bio load throughout the day. The probable reason might be more visitors during early hours, change of duty schedules of health care workers, clinical postings for the students etc. Bio load also helps in monitoring the capability of the air filters used in the OT's and also helps in assessing quality and making timely changes in measures that need to be adopted in order to maintain air quality in these areas. We will continue to focus on microbiological surveillance and study whether appropriate monitoring of antibiotic usage and other factors affect emergence of bacterial resistance. Also it is inferred that strengthening surveillance and laboratory capacity will surely enhance infection prevention and control.

5. CONCLUSION

It could be inferred from our study that health care workers, environmental contaminations with MDR pathogens are a definitive risk factor for critical care patients. The high prevalence of infective sources in hospital environment is highly alarming. So that we have to take up infection control protocols seriously and adapt them at all the levels of health care.

SUMMARY

An observational study was conducted on environmental sampling of NICU, MICU, SICU and OT for aerobic bacteria colonisation. 112 samples were collected from different regions. 158 isolates were obtained. 105 GNB isolates and 53 GPB were identified. Common isolates were *S.aureus* (32.27%), *Nf GNB* (25.3%) followed by *E.coli* (11.3%). Antibiotic resistant pattern of these isolates were studied. GNB were mostly resistant to Ampicillin, Cotrimaxazole and Amikacin. GPC were mostly resistant to Ampicillin, Cefotaxime, and Cefoxitin. Among the *Staphylococci* isolates MRSA were 72.2%. A total of 88.1% of MDR bacteria were seen. Pan Drug Resistance was seen in 11%. Health care workers had colonization of 50%. Among them *S.aureus* was the commonest isolate (57%). This isolate was commonly resistant to Ciprofloxacin 87.5% and Ampicillin 62.5%.

FUTURE ISSUES

Definitely there should be a system, which caters to environmental survey of MDR pathogens in hospitals; otherwise it generates visions of the 'potential post-antibiotic era threatening present and future medical advances'.

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