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Original Article

Microbial Profile of Air Contamination in Hospital Wards

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ABSTRACT

Background and Aims: **Nosocomial infections cause considerable morbidity and mortality and pose high financial burden on healthcare systems. Although surface contact, surgical incisions, wounds and catheters are responsible for a high percentage of nosocomial infections, bacterial and fungal air contaminations in hospitals have an important role in development of hospital infections. The purpose of this study was to determine the microbial profile of air contamination in some hospital wards. Furthermore, we compared the results with cultures obtained from hospitalized patients.**

Materials and Methods: **We performed a cross-sectional analysis at Imam Hospital, Tehran, Iran. Active (Quick Take 30 pump) and passive air samplings were performed in different wards of the hospital. Air samples were cultured to detect fungi and microorganisms. The results were compared with cultures obtained from hospitalized patients at the same time. Air microbial profiles of various wards were also compared.**

Results: **The microbial profile of air samples showed that *Micrococcus* was the most common bacteria. *Cladosporium* was the most frequent fungi found while Aspergillus niger and *Alternaria* were the least frequent ones.**

Conclusion: **In some wards, the results of blood cultures were similar to microbial profile of air samples. Thus, utilizing air purification systems and air sterilization is recommended. Our findings emphasized the role of regular monitoring of the biological risk for both patient and health care workers. The results would be useful in planning for employing appropriate strategies to reduce air burden in this hospital and other hospitals with similar conditions.**

Keywords: **Air, Bacteria, Hospital**

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Introduction

Nosocomial infections cause considerable morbidity and mortality and pose high financial burden on healthcare systems. Around two million patients suffer from healthcare-associated infections, and nearly 90,000 are estimated to die each year in USA from hospital infections (1). Although surface contact, surgical incisions, wounds and catheters are responsible for a high percentage of nosocomial infections, bacterial and fungal air contaminations in hospitals have an important role in development of hospital infections (1). Approximately 10% of the nosocomial infections in both immune-compromised and healthy people are caused by airborne bacteria (2). Moreover, fungal contamination in healthcare systems has been assessed in several studies. The results of these studies showed that fungi including *Candida albicans* and different species of *Aspergillus, Cladosporium* and *Penicillium* are present in some hospital infections (3-6). Thus, recognition and control of microbial contamination of hospital air wards has great importance especially for those infections that an airborne transmission is postulated (4).

It has been suggested that many pathogens can survive as bio-aerosols, spread considerable distances, and result in infection (7). In addition, it seems that the role of airborne microorganisms in development of hospital-acquired infections has been underestimated because many of these airborne microorganisms cannot be cultured easily (8). Moreover, some of the infections resulting from contact rout have resulted from airborne transportation of microorganisms onto these surfaces (9- 11).

Although the cause-and-effect relationship between airborne pathogen levels and nosocomial infections is not known yet, it could be hypothesized that lowering the level of these pathogens in the air would result in providing an environment that would help decrease the risk of nosocomial infection (9, 12). As there are several pharmacologic and non-pharmacologic ways to reduce air contamination and hospital-acquired infections (10, 13), identifying the microbial profile of air is of special importance. In the present study, we intended to determine the microbial profile of air contamination in some wards. Then, the obtained results were compared with other cultures from hospitalized patients at the same time. The air microbial profiles of various wards were also compared in a referral hospital in Iran.

Materials and Methods

We performed a cross sectional analysis from January to December 2008 at Imam Hospital, Tehran, Iran. Air sampling was performed from operating rooms, intensive care unit (ICU), thoracic surgery, and neonatal and bone marrow transplantation wards. We chose operating rooms and thoracic surgery ward because of more exposure of internal spaces of human body to possible infections, ICU for complicated patients, neonatal and bone marrow transplantation wards for lower immunity of the patients.

Air samples were collected using Quick Take 30 sample pump (SKC, Illinois, USA) based on manufacturer instructions. The flow rate was calibrated at 28.3 l/min and samples were collected in two minutes. Active air sampling was repeated twice in each location. We also took passive air samples by means of settle plates. Trypticase soy agar plates were placed open and exposed to the air for four hours. Three plates were inserted in each location. The microbes transported by inert particles were deposited on the surface of agar. All samples were collected when the windows and doors were closed and transported immediately to microbiologic laboratory for culture. Sabro dextrose agar and eosin methylene blue, 5% sheep blood agar, and

chocolate agar media, Klinger's iron and triple sugar iron was used to culture fungi and other microorganisms respectively. Air contamination was measured according to colony forming units of microbes per cubic meter (m^3). All diagnostic procedures were performed according to the recommendations of Clinical and Laboratory Standards Institute (CLSI). The microbial profile obtained from these samples was compared with different microbial cultures from hospitalized patients.

The study was approved by Research Ethics Committee of Tehran University of Medical Sciences (TUMS).

Results

Microbial profiles of simultaneous cultures obtained from hospitalized patients in different wards are presented in Table 1. *Stenotrophomonas maltophilia* was cultured in thoracic surgery, ICU, and neonatal wards. *Pseudomonas aeruginosa* was the most frequent microorganism cultured from patients hospitalized in thoracic surgery ward. We obtained *Staphylococcus epidermidis* as the most frequent pathogen in bone marrow transplantation and neonatal wards. In the ICU and operating rooms, *Enterococcus* and *Acinetobacter* were the predominant pathogens respectively.

Table 1: Microbial profiles of simultaneous cultures obtained from hospitalized patients in different wards

	Cultured organisms
Thoracic surgery (%)	*Pseudomonas aeruginosa* (29%) ,*Acinetobacter* (19%) *Proteus* (12%) ,*Stenotrophomonas maltophilia* (11%) *Enterobacter* (9%) , Others (20%)
Bone marrow transplantation ward (%)	*Staphylococcus epidermidis* (48%), *Staphylococcus aureus* (9%), *Streptococcus group* D (8%), *E. coli* (7%), Others (28%)
ICU (%)	*Enterococcus* (41%), *Stenotrophomonas maltophilia* (25%), *Acinetobacter* (11%), *Enterobacter* (4%), *Klebsiella* (3%), *Pseudomonas aeruginosa* (2%), *E. coli* (2%) , Others (12%)
Neonatal ward (%)	*Staphylococcus epidermidis*(38%), *Staphylococcus aureus* (16%), *Candida albicans* (14%), *Enterobacter* (8%) *Klebsiella* (7%), *E. coli* (5%), *Stenotrophomonas maltophilia* (4%), Others (8%)
Operating room (%)	*Acinetobacter* (42%), *E. coli* (26%), *Staphylococcus aureus* (12%), *Staphylococcus epidermidis* (11%), Others (9%)

Microbial profiles of air obtained from wards are presented in Table 2. *Cladosporium* was the most frequent and *Aspergillus niger* and *Alternaria* were the least frequent fungi obtained from the air of the wards. *Micrococcus* and *Staphylococcus epidermidis* were the most frequent bacteria in all wards when *Stenotrophomonas maltophilia* was only found in the thoracic surgery ward. Table 2 shows the details. The bone marrow transplantation ward and ICU had respectively the lowest and highest contamination [12 colonies (212 CFU/m^3) and 43 colonies (760 CFU/m^3) respectively]. Bone marrow transplantation ward was the only ward equipped with air purification system.

Table 2- Microbial profiles of air obtained from wards. Numbers of colonies for various microorganisms in the air of different wards are presented

	Operating room (n, %)	Thoracic surgery (n, %)	Intensive care unit (n, %)	Neonatal ward (n, %)	Bone marrow transplantation ward (n, %)
Micrococcus	10 (43.47)	10 (30.30)	5 (11.62)	3 (15)	3 (25)
Staphylococcus epidermidis	5 (21.73)	5 (15.15)	10 (23.25)	3 (15)	4 (33.33)
Stenotrophomonas maltophilia	-	1 (3.03)	-	-	-
Aspergillus niger	-	1 (3.03)	-	1 (5)	-
Aspergillus flavus	1 (4.34)	-	-	1 (5)	1 (8.33)
Aspergillus terreus	-	-	2 (4.65)	1 (5)	-
Penicillium	1 (4.34)	2 (6.06)	16 (37.2)	2 (10)	1 (8.33)
Cladosporium	6 (26.08)	14 (42.42)	9 (20.93)	8 (40)	3 (25)
Alternaria	-	-	1 (2.32)	1 (5)	-

Discussion

Our findings showed that the air profile of thoracic surgery, ICU and neonatal wards were contaminated with *St. maltophilia*. Furthermore, other microorganisms including *Staphylococcus* were also isolated from the air. In the thoracic surgery ward, *St. maltophilia* grew in both blood and air cultures. This shows that microbial air profile of wards are in agreement with those obtained from cultures of the patients.

Stenotrophomonas maltophilia is an important aerobic gram-negative organism, which cause considerable nosocomial infection, associated with significant mortality in certain patient populations, particularly in individuals who are severely debilitated or immune-suppressed (14). Its importance is mainly due to its resistance to many currently available broad-spectrum antimicrobial agents, including those of the carbapenem class (11) and is associated with an expanding spectrum of clinical syndromes such as bacteremia (12), endocarditic, respiratory tract infection (13), central nervous system infection (14), ophthalmologic infection (15), urinary tract infection (16), skin and soft tissue infection (14), bone and joint infection and gastrointestinal infection (14). The spread of *St. maltophilia* by cross-contamination from contaminated equipment or from an environmental source has already been reported (17). Therefore, it could be concluded that a high frequency of *St. maltophilia* in the studied wards, results in a high percent of infected patients. Consistently *St. maltophilia* was cultured from patients of thoracic ward surgery which had the highest frequency of infection. Ramazanzadeh *et al.* conducted a cross sectional study in two hospitals in the northwestern Iranian province of Kurdistan, showed that *St. maltophilia* had 1.52% prevalence in ICU ward (18). However, they did not culture *St. maltophilia* from any of the patients (18).

We also showed that *Cladosporium* was the most frequent fungus found while *Aspergillus niger* and *Alternaria* were the least frequent ones. Bone marrow transplantation ward had the lowest air contamination mainly due to air purification system while the ICU had the highest air contamination. In other studies, the same fungi have been isolated from the hospital

air; however, their frequency varies in different studies. In consistence with our findings; it is showed that the most frequent fungus in hospital air ward was *Penicillium* while *Cladosporium* and *Aspergillus* were the next frequent ones (4, 5). The most frequent fungi were *Penicillium, Aspergillus* and *Bjerkandera adusta* in outdoor and indoor air of two hematological units of a French hospital (3). The most frequent fungus obtained from the air in a Campania region was *Aspergillus* (6). In a study by Fox *et al.* the most frequent fungus found in the air was *Penicillium* (19). Fungal contamination (*Penicillium* and *Aspergillus*) of hospital rooms has been reported as 26-78 cfu/m³ in Lithuania (20).

Several factors contribute to fungal air contamination in healthcare centers. Ineffective aseptic procedures, inappropriate air conditioning system, open windows, and doors are among the culprit mechanisms (21-23). The index of microbial air contamination increases during work activity and using effective tools to reduce the risk of patients and healthcare workers from being contaminated is highly recommended (24). Consistently using nanosilver paints reduces the bio-burden of air in hospital's wards (25).

The principal limitation of the present study was its cross sectional nature which precludes the determination of the direction of causality. Furthermore, we did not use various growth environments for different species of fungi and bacteria. However, we took advantage of a relatively large sample size and close similarity between groups in most of the confounding variables.

Conclusion

Our findings emphasize the role of regular monitoring of the biological risk for both patient and healthcare workers. The results would be useful in planning for employing appropriate strategies to reduce air burden in this hospital and other hospitals with similar situation.

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