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Survey on Bioaerosols Type and Density and Ach Index Impact on Bioaersols Density in Heart Surgery Rooms and Cardiac Surgery Intensive Care Unit in a Teaching Hospital in Ghazvin

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Abstract: The existence of biological aerosols in the operating room and surgical intensive care units is not only considered as a threat for patients undergoing the surgery, but also it is an occupational hazard for personnel in the referred units. Ventilation systems of operating rooms have high potential to control the postoperation infections. Therefore, the proper design and use of these systems is of particular importance. This cross-sectional study was conducted in heart surgery and cardiac surgery intensive care unit in spring of 2015. In order to evaluate the microbial contamination of air, above than 93 samples were selected using an inactive method and they were incubated, then the number of colonies per plate was counted and was recorded as cfu/plate/h. In order to identify and examine the colonies, the gram stain and differential tests were used. Along with the sampling, data of temperature, humidity and pressure were assessed and the value of ACH (Air Change per hour) was calculated and recorded. According to the results, the numbers of colony forming units of bacteria and fungus in the cardiac surgery intensive care unit were higher than other units. The number of colony forming units in samples taken from the operating room was less than the guide rate of 25 cfu/plate/h and it was more than this amount in 2.4% of the samples in the cardiac surgery intensive care unit. Most of the obtained bacteria were *Staphylococcus epidermidis* and *Staphylococcus saprophyticus* and most abundant fungi belonged to Penicillium species, Curillophyllum and Cladspurium cladspuriudis. ACH rate in the operating rooms was <20ACH which is the guide rate for operating room and it was >6 ACH, the guide rate for the cardiac surgery intensive care unit. Most of bacterial and fungal colonies were recorded in the cardiac surgery intensive care unit. It seems that one of the reasons was the large number of people (patients and staff) in this unit. Additionally, despite the suggested ACH rate had been supplied in this unit, however the density of the bioaerosols in this unit was higher than the guide rate that the entry and exit of air and location of the input and output doors have played important roles to this increased levels of bioaerosols. Therefore, to meet the ACH guide rate cannot ensure the risk reduction of bioaerosols necessarily and this issue and the other factors should be well considered in the design and control of ventilation systems for the different units of the hospitals particularly the surgical ward.

Key words: ACH, bioaerosol, hospital, ventilation, surgery

INTRODUCTION

The most essential human need is the air that contains various particles and microorganisms. While breathing in any environment, leads to a lot of suspended particles inhaled by people (Sadegh *et al*., 2013). Biological aerosols refers to airborne particles (Darvishzadeh *et al*., 2013) which contain microorganisms such as bacteria, viruses, fungi and organic compounds derived from them, such as endotoxin (Noormorady *et al*., 2011) metabolites, toxins and other bacterial components (Mirzaei *et al*., 2014). Contacts with bioaerosols are related to a wide range of health effects which include communicable diseases, acute toxic effects, allergies and cancer (Bhatia and Vishwakarma, 2010; Sadegh *et al*., 2013; Masoudinejad *et al*., 2014). Among the indoor places, health centers need to pay special attention to their indoor air quality (Fekadu and Getachewu, 2015). Since, the release of airborne microorganisms can threaten the health of patients and staff and visitors at these

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places (Hoseinzadeh *et al* ., 2013; Sadegh *et al*., 2013) and cause nosocomial infections (Dehdashti *et al*., 2012; Sudharsanam *et al*., 2012). Patients with impaired immune systems such as cancer patients and those who have received a transplanted organ are vulnerable to contact with biological aerosols (Noormorady *et al*., 2011; Fekadu and Getachewu, 2015). Center for Disease Control and Prevention in America has predicted the number of patients with nosocomial infection to >2 million people a year in America (Ghorbani *et al*., 2004; Sadegh *et al*., 2013; Fekadu and Getachewu, 2015) whereas about 88,000 people of them, directly or indirectly have lost their lives due to nosocomial infection.

The existence of the biological aerosols in the operating room is not only a threat for the people who have the surgery but also it is considered as a occupational risk factor for the operating room staff. The potential risk factors can enter the body through contact with the skin ulcers. On the other hand, the masks used in the surgical operating room are more made from the fabric. In the study of Woke and colleagues, it was found that 83% of the total bioaerosols and 100% of some bioaerosols such as *Bacillus subtilis*, Pseudomona and micrococcus cross from these masks and enter to the respiratory system of the personnel. If aerosols have pathogens then they will threaten the health of this group of people . Two common methods include control of bioaerosols in the operating room with UV lights and ventilation systems. The space sterilization by ultraviolet light has been limited while certain risks may be created. Operating room ventilation systems have high potential for infection control after the action. In addition, they are able to control vapor emissions dispersed in the operating room effectively. The correct application of the system operation room also has a great importance (Ghorbani *et al*., 2004).

The aim of this study was at the first step to determine the quality and quantity of fungi and bacteria in two heart surgery rooms and cardiac surgery intensive care unit and compare it with the available guide value. In the second stage, the rate of ACH (Air Change Per Hour) and other factors affecting the release of bioaerosols such as humidity, temperature and pressure were examined in order to determine their relationship with detected fungi and bacteria.

MATERIALS AND METHODS

This was a cross-sectional study that was conducted in a teaching hospital in ghazvin in the spring of 2015. The heart surgery and cardiac surgery intensive care unit were selected for sampling. There were the air conditioning systems in both units that were equipped with a HEPA filter. In the heart surgery rooms, the filtered air entered through the inputs in the ceiling and removed into the outlet located near the floor. In the cardiac surgery intensive care unit, air inputs and outputs were both in the ceiling. In the present study, the air quality was assessed in two heart surgery rooms and cardiac surgery intensive care unit. In order to assess and quantify the microbial quality of the air of the mentioned units, 93 samples were selected by passive method. Sabouro dextrose chloramphenicol agar and nutrient agar mediums were used in order to identify and count bacteria and fungi, respectively. The plates (9 cm diameter) containing sterile medium were established to the air at some points at a distance of about 1.20 cm from the floor and 1 m from the walls and the obstacles. After a period of an hour the samples were collected and transferred to the incubator. Media containing bacteria were in the incubator for 48 h at 37°C while the media containing fungus were incubated for 5 days at 30°C. Then, the numbers of colonies per plate were counted and they were reported as cfu/plate/h and the counted number were compared with existing guidelines. In order to identify and study the cultures, gram stain and differential tests such as biochemical tests, microscopic examination and cultures were conducted and the results were recorded. Concurrent with the sampling of the air, data of temperature, humidity and pressure were recorded by the device. In order to calculate, the ACH air inlet area in each unit was calculated separately and the average speed of the air inlet was measured by the hotwire thermo anemometer. Then using the referred formula in the existing sources (Shahsavani, 2014). ACH rate in the cadiac surgery rooms and cardiac surgery intensive care unit were calculated. The results were analyzed by using Anova and Pearson Corrlation Analysis of SPSS software.

RESULTS

The quality of hospital indoor air depended on the factors such as ventilation, cleaning methods and the number of people in the location. In this research, 93 samples were taken from the air of two heart surgery rooms and cardiac surgery intensive care unit.The air pollution of these units was determined by the type and number of bioaerosols.

The average number of colony forming units of bacteria and fungi found in heart surgery rooms and cardiac surgery intensive care unit and the average temperature, humidity and ACH is presented in a Table 1.

Table 1: The mean bacterial and fungal colonies and measured factors in studied units in the hospital

Units	Mean bacteriacfu/plate/h	Mean fungicfu/plate/h	MeanTemp (°c)	Mean RH (%)	ACH	Mean pressure (pa)
Heart surgery room 1	6.85 (5.07-8.62)	1.43 (0.7-2.1)	27.65 (26.5-28)	27.65 (25-36.5)	4.03	-0.8
Heart surgery room 2	4.28 (1.35-7.22)	1	26.7 (26-27.1)	22 (22-29)	5.50	-0.8
Cardiac surgery intensive care unit	11.86 (9.01-14.07)	3.23 (0.69-5.77)	26.68 (26.1-28.15)	27.28 (20.50-36.50)	11.10	-0.8

In order to examine the differences in the average number of colony forming units of bacteria and fungi two heart surgery rooms and cardiac surgery intensive care unit, ANOVA analysis was used. According to the analysis, the differences in the average number of colony forming units of bacteria and in the average number of colony forming units of fungus were significant. In order to assess which units have shown a significant difference in terms of the bacterial and fungal bioaerosol density, the multiple comparison of Scheffe was used. Test results revealed that the density of colonies formed by bacteria and fungi in the air of cardiac surgery intensive care unit had significant differences with two heart surgery rooms ($p<0.05$).

Comparison of the numbers of colony forming units in a sample with the selected guideline value as 25 cfu/plate/h (Pasquarella *et al*., 2000; Masoumbeigi *et al*., 2015) showed that all samples were taken from the heart surgery room number 1 and number 2 had the total number of colonies less than the guideline value but in 2.4% of the cardiac surgery intensive care unit the number of colonies formed was more than guidance. Based on the differential tests, a total of 7 species of bacterial and 8 fungal species were isolated. Types of bacteria were identified in various units, included *Staphylococcus epidermidis*, *Staphylococcus saprophyticus*, *Staphylococcus aureus*, *Bacillus subtilis*, *Lactobacillus*, *Clostridium* sp. *Staphylococcus epidermidis* and Acinetobacter that the most frequent case was *Staphylococcus epidermidis* and *Staphylococcus saprophyticus* while the lowest type was Acinetobacter. The types of the detected fungus included *Penicillium corylophilum, Candida albicans*, psedohyphase, *Cladosporium cladosporioides, Alternaria alternata, Curvularia clavata, Fusarium ventricosum, Mucor plumbers* which the most abundant species belonged to the species *Penicillium corylophilum* and *Cladosporium cladosporioides* and the lowest type of species were *Fusarium ventricosum* and *Mucor plumbers.*

Pearson correlation analysis was used to evaluate the relationship between environmental humidity, temperature and concentration of bioaerosols The only significant relationship was observed between the humidity and concentration of bioaerosols ($p<0.05$). According to the Pearson correlation analysis between the minimum required changes of external air per hour index and bioaerosol, there was a significant correlation ($p<0.05$). The pressure was the same in all three sections and <+2.5 Pascal. After calculating the ACH value, these values were compared with the guide value of 20 ACH for heart surgery rooms and 6 ACH for coronary care uint (Ashrae, 2008). Based on the results, ACH in heart surgery rooms was less than guidance value and it was higher than guidance in cardiac surgery intensive care unit.

DISCUSSION

The microbial contamination of the surgical ward is the background for the prevalence of infection in this study. The source of pathogens can be internal or external such as the patient's skin and mucous membranes. Airborne microorganisms can enter the surgical wound through the air. Therefore, it is recommended to reduce the importation, production and survival of pathogens in operating rooms, precautions must be taken (Pasquarella *et al*., 2012).

In the present study, due to the air conditioning system in the studied units, the lower concentration of bioaerosols was observed. In the study of Ghorbani *et al.* (2004) also it was found that in the hospitals having air conditioning systems, low bioaerosols density has been reported. Due to the lack of standards for bioaerosol, findings were compared with the proposed value 25 cfu/plate/h. By comparison, the concentration of bioaerosols in both heart surgery rooms was less than the guidance value. But at 2.4% of the cardiac surgery intensive care unit, the number of colonies was more than the guide. The results of this study was consistent with the study by Abdullahi (2009) who found that the highest number of bacterial and fungal colonies have recorded in the intensive care unit. The number of hospitalized patients as well as staff in this section can cause high density bacterial colonies compared with two heart surgery rooms. In addition, the temporarily opening of windows during the warm weather can greatly cause the increase of fungus numbers in this unit.

The most common bacteria were *Staphylococcus epidermidis* and *Staphylococcus saprophyticus* observed in the studied units of the hospital while most common fungus were *Penicillium curillophyrum* and *Clastridium cladosporioides*. Abdullahi (2009) also achieved in his research in the

Valiyeasr Hospital, similar findings to this research. The results of a study conducted in Taleghani Hospital in Tehran in 2012 indicated that the highest growth rate of colonies was due to the coagulase negative Staphylococci bacteria (Masoudinejad *et al*., 2014). Fleischer *et al*. (2006) reported *Penicillium* sp. and *Cladosporium*. sp as the common fungus in the operating room that had air conditioning system.

Mechanical ventilation system can significantly improve the air quality inside the hospital. The combination of engineering controls such as filtration systems, ultraviolet germicidal irradiation of ultraviolet germicidal irradiation will have a considerable impact on improving indoor air quality (Yau *et al*., 2011). Wan *et al*. (2011) have suggested high class HEPA filters and increasing the amount of ACH to reduce the concentration of particulate matter and bacteria in operating rooms. They have recommended for keeping concentrations of airborne bacteria within the guide range of 50-150 cfu m^3, the ACH value need to be maintained in the range of 20. In this study, although the ACH in the heart surgery rooms was less than the guidance but bioaerosols density was less than the proposed amount and in the cardiac surgery intensive care unit with supply of ACH proposed, the density of bioaerosol was more than the recommended dose. The results are consistent with the findings of research conducted by GrossKopf and colleagues that the increase of ACH from 2-5 will reduce the average 30% of aerosols <5 microns but the pathway of the flow, pressure difference, doors positions and their movements have great impact on movement and transport of bioaerosols and transmission of indoor air pollution (Grosskopf, 2013; Grosskopf and Mousavi, 2014). It seems that in the cardiac surgery intensive care unit, the style of entry and exit of air as well as the position of the entrance and exit doors and also the number of people present in the unit, all have played important roles in improving the bioaerosols in this study.

CONCLUSION

It is recommended that in surgical wards only the number of persons who are required should be present and the proposed minimum pressure difference and ACH should be provided and when a hospital are built, the positions of entering and exiting in the hospital wards and also the direction and way of air distribution have to be particularly considered. It is also suggested that provision of a special ventilation system to provide a desired temperature, pressure, humidity and ACH minimizes the direct contact of units with ambient air.

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