Investigation of the Performance of the Air Purifier in High-Risk Hospital Rooms by Counting Particles

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Abstract

The air purifiers nowadays, are more preferred than the HEPA filters, because HEPA filters only eliminate the particles from the air, while the air purifier both removes particles without using any filter and gives cleaned-deionized air. Hence, it provides the more qualified air to the patient and health staff. The high-risk hospital rooms must be controlled by counting particles in according to the international standards,. The particles with sizes of 0,1µm, 0,2µm, 0,3µm, 0,5µm, 1µm, 5µm are counted and the measurement results are interpreted in accordance to the international standard; ISO 14644-1:1999(E) Cleanrooms and associated controlled environments Part 1: Classification of air cleanliness.
The objective of this study, is to test the performance of the air purifier in different room conditions. How much air is cleaned in how much time?
In the result, it was observed that the air purifier has cleaned the air efficiently, and it was obtained the optimum time relating to the total air volume for cleaning the room air. This study announces that the air purifiers are efficient solution to obtain clean air without particles in the high-risk hospital rooms. The primary advantage of this study would be that obtained knowledge in this area would lead to wide usage of air purifiers, and hence, to have more qualified air and to decrease the risk of infection in hospitals.

Key words: Air purifier, hepa filter, particle counting

1. Introduction

The quality of air is important in critical areas of hospitals such as operating rooms, intensive care units, bone marrow transplantation units etc, because of the particles. Particles are environmental pollutants that cause the risk of infection in hospitals [1]. But, it is possible to remove the particles from air by using HEPA (High efficiency particulate air) filter, or to clean the air by usingan air purifier [2-3]. Nowadays, the air purifiers are more preferred than the HEPA filters, because HEPA filters only eliminate the particles from the air, while the air purifier both removes particles without using any filter and gives cleaned-deionized air. Hence, it provides the more qualified air to the patient and health staff [2-3]. Although it is more expensive than HEPA filter system, it is preferred because the cost of it is less than the total cost to the hospital of a single nosocomial infection, taking into account additional days in the hospital, antifungal treatment and potential litigation costs.

The objective of this study, is to test the performance of the air purifier in a high-risk hospital room. The performance of the equipment is determined by counting particles that decrease during

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operation of the equipment in the room [4-5]. The measurement results are interpreted to determine ISO class of the room in accordance to the international standard.

2. Materials and Method

The air purifier used in this study (Genano 310 Medical; Genano Oy, Espoo, Finland) is an certified medical device from The University of Greifswald Germany intended as a room air purifier/recirculating air cleaner and used for removing airborne particles from the air for medical purposes. The unit's physical dimensions are 1,46 m high 0,45 m wide 0,39 m deep, and its nominal operating range is 100-200 m^3/hour. It does not contain any filter, HEPA (High Efficiency Particulate Air) or ULPA (Ultra Low Penetration Air). The device works with the technology of multi ionized beams. The negatively charged particles in the air flow are projected onto the positively charged inner wall of the device. The wall is automatically rinsed at regular intervals. The inactivated residue is collected in a container at the foot of the unit.

The effectiveness of the Genano air purifier were tested in a bone marrow transplantation unit by placing it in different locations. The room area is 42 m^2 (7.2 m x 5.8 m) and hasn't got any hepa filter. To obtain 3 different location scenarios, the Genano unit was positioned firstly in the opposite corner of the bed (P1), secondly in the adjacent wall (P2), and thirdly near the bed's headboard (P3).

In this study, the particles in a patient room in bone marrow transplantation unit were firstly counted when the purifier was located in P1 position. The particle counter was placed onto the patient bed and the measurements were taken from the middle of the bed surface [6]. During measurement period, the particles were counted at each 1 minute in total 15 minutes. The results were stored and reported in the equipment automatically. The particle counter (Aerotrak Handheld Particle Counter 9306, TSI, USA) was used to count the particle sizes of 0,3 μm, 0,5 μm, 1,0 μm, 2,5 μm, 5,0 μm and 10,0 μm. The sampling air flow rate was 0,1 CFM (2,83 LPM) [7-9]. The personnel operating the equipment were clothed in body suits and face masks to prevent air contamination by them. The study was repeated in different days by operating the air purifier in other 2 different positions (P2 and P3) in the patient room. The measurement results were compared by considering the decontamination time. The classes of the patient room for 3 different positions of air purifier were determined in accordance to the ISO 14644-1 standardization.

2.1. Theory/calculation

The ISO 14644-1 standard is essential for the classification of clean room [10]. In according to the ISO 14644-1 standardization, the maximum permitted concentration of particles for each considered particle size is determined from the following equation [9-10]:

$C_n = 10^N \times (0{,}1 / D)^{2{,}08}$
C_n is the maximum permitted concentration (particles/m^3 of air)
N is the ISO classification number, which shall not exceed a value of 9.
D is the considered particle size, in micrometers and 0,1 is a constant.

The ISO classes and the corresponding particle concentrations (0,1µm, 0,2µm, 0,3µm, 0,5µm, 1µm and 5µm) can be seen in Table 1. In according to this standard, the mean particle concentration from each point must be equal to the limit particle concentration or lower.

Table 1. ISO Classification for Clean Room [10]

ISO Classification Number (N)	**Maximum concentration limits (particle/m^3 : in air)**					
	0,1 µm	**0,2 µm**	**0,3 µm**	**0,5 µm**	**1 µm**	**5 µm**
ISO Class 1	10	2	--	--	--	--
ISO Class 2	100	24	10	4	--	--
ISO Class 3	1 000	237	102	35	8	--
ISO Class 4	10 000	2 370	1 020	352	83	--
ISO Class 5	100 000	23 700	10 200	3 520	832	29
ISO Class 6	1 000 000	237 000	102 000	35 200	8 320	293
ISO Class 7	--	--	--	352 000	83 200	2930
ISO Class 8	--	--	--	3 520 000	832 000	29 300
ISO Class 9	--	--	--	35 200 000	8 320 000	293 000

The ISO class for operating room and intensive care unit should be ISO Class 5 for 0,3 micron or larger particle size, whereas it for patient room should be ISO Class 6 for 0,5 micron or larger particle size.

3. Results

The particle measurement results obtained from 3 positions and the corresponding ISO classes are shown in Table 2.

Table 2. Results of Particle Counting

Position	Sample ID	Concentration	ISO Spec.	ISO Class
Position P1	1, 04/10 /2014, 18:29:52	8 206 762	35 200 000	Class 9
	2, 04/10 /2014, 18:30:52	6 867 455	35 200 000	Class 9
	3, 04/10 /2014, 18:31:52	4 112 069	3 520 000	Class 9
	4, 04/10 /2014, 18:32:52	3 005 647	3 520 000	Class 8
	5, 04/10 /2014, 18:33:52	2 334 027	3 520 000	Class 8
	6, 04/10 /2014, 18:34:52	1 745 789	3 520 000	Class 8
	7, 04/10 /2014, 18:35:52	975 616	3 520 000	Class 8
	8, 04/10 /2014, 18:36:52	654 082	3 520 000	Class 8
	9, 04/10 /2014, 18:37:52	391 076	3 520 000	Class 8
	10, 04/10 /2014, 18:38:52	245 182	352 000	Class 7
	11, 04/10 /2014, 18:39:52	115 478	352 000	Class 7
	12, 04/10 /2014, 18:40:52	88 326	352 000	Class 7
	13, 04/10 /2014, 18:41:52	53 257	352 000	Class 7
	14, 04/10 /2014, 18:42:52	39 772	352 000	Class 7
	15, 04/10 /2014, 18:43:52	28 113	35 200	Class 6

Position P2	1, 04/12 /2014, 17:14:49	7 555 843	35 200 000	Class 9
	2, 04/12 /2014, 17:15:49	5 132 087	35 200 000	Class 9
	3, 04/12 /2014, 17:16:49	3 458 233	3 520 000	Class 8
	4, 04/12 /2014, 17:17:49	2 135 847	3 520 000	Class 8
	5, 04/12 /2014, 17:18:49	1 444 176	3 520 000	Class 8
	6, 04/12 /2014, 17:19:49	845 679	3 520 000	Class 8
	7, 04/12 /2014, 17:20:49	575 755	3 520 000	Class 8
	8, 04/12 /2014, 17:21:49	385 182	3 520 000	Class 8
	9, 04/12 /2014, 17:22:49	221 076	352 000	Class 7
	10, 04/12 /2014, 17:23:49	105 182	352 000	Class 7
	11, 04/12 /2014, 17:24:49	75 478	352 000	Class 7
	12, 04/12 /2014, 17:25:49	50 275	352 000	Class 7
	13, 04/12 /2014, 17:26:49	37 824	352 000	Class 7
	14, 04/12 /2014, 17:27:49	26 767	35 200	Class 6
	15, 04/12 /2014, 17:28:49	19 945	35 200	Class 6
Position P3	1, 04/14 /2014, 13:01:11	7 866 142	35 200 000	Class 9
	2, 04/14 /2014, 13:02:11	5 354 485	35 200 000	Class 9
	3, 04/14 /2014, 13:03:11	3 512 979	3 520 000	Class 8
	4, 04/14 /2014, 13:04:11	2 148 775	3 520 000	Class 8
	5, 04/14 /2014, 13:05:11	1 514 567	3 520 000	Class 8
	6, 04/14 /2014, 13:06:11	845 789	3 520 000	Class 8
	7, 04/14 /2014, 13:07:11	576 222	3 520 000	Class 8
	8, 04/14 /2014, 13:08:11	374 082	3 520 000	Class 8
	9, 04/14 /2014, 13:09:11	211 116	352 000	Class 7
	10, 04/14 /2014, 13:10:11	103 002	352 000	Class 7
	11, 04/14 /2014, 13:11:11	74 664	352 000	Class 7
	12, 04/14 /2014, 13:12:11	51 257	352 000	Class 7
	13, 04/14 /2014, 13:13:11	36 772	352 000	Class 7
	14, 04/14 /2014, 13:14:11	25 848	35 200	Class 6
	15, 04/14 /2014, 13:15:11	19 854	35 200	Class 6

4. Discussion

From the results obtained, it was evident that following the cleaning operation, the quality of the air is excellent in all position of the air purifier. When the measurement results are interpreted in accordance to the ISO classification, it is seen that the patient room was in ISO Class 9 for all positions initially because the number of particles were counted higher than 3 520 000. After the operating of the air purifier, the class of room decreased to ISO Class 6 that is accepted class for critical hospital rooms. The measured particle number was lower than 35 200.

Although same classification was obtained, a little difference in the particle count was found. The decontamination time is 12 minutes for P2 and P3 positions while it is 13 minutes for P1 position. As it is seen, the decontamination time in P2 and P3 positions is shorter than it in P1 position. The reason of this may be thought that P2 and P3 are near to the measurement point than P1 position. But it is not an important difference because the decontamination were performed in all positions perfectly. It was achieved that the initial ISO class is decreased to the acceptable ISO class in accordance to the international standard.

Conclusions

In the result, it was observed that the air purifier have cleaned the air efficiently, and it was obtained the optimum time relating to the total air volume for cleaning the room air. The measured decontamination time of 12-13 minutes are sufficient to clean room. This study announces that the air purifiers are efficient solution to obtain clean air without particles in the high-risk hospital rooms. This is suggested that the volume of room should be considered during decision of the number of air purifiers that will be worked, and the air purifiers should be replaced near the patient beds.

The primary advantage of this study would be that obtained knowledge in this area would lead to wide usage of air purifiers, and hence, to have more qualified air and to decrease the risk of infection in hospitals. The air purifiers, nowadays, are competitor to the Hepa filters. But, it is thought that in the future they will be preferred completely instead of Hepa filters.

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