A SURVEY ON THE EFFECT OF NANOSILVER PAINT ON REDUCING THE LEVEL OF FUNGAL CONTAMINATION IN HOSPITALS

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ABSTRACT
Nanosilver-based paints are a new technology which manifest microbial and antifungal characteristic. These characteristic were investigated in this study with regard to fungal contamination in hospitals.
Regarding hospitalization of transplant patients and their sensitivity to hospital infections, two similar rooms were selected in nephrology ward. One of them was painted with Nanosilver paint and the other one with ordinary paint. Sampling was done via the methods of Swap Sterile and Open Plate. The number of samples for both case and control rooms amounted to 350.
After comparing the colony-forming units in Open Plate and Surface Culture methods in case and control rooms, the P-value for each method was found to be 0.00 and 0.01, respectively. This in itself was indicative of a significant difference. In trying to find out whether the passage of time had any effect on the effectiveness of Nanosilver paint, the p-values 0.165 and 0.644 were found for each method, respectively.
In this study, It was found that Nanosilver paint had been indeed effective in reducing the fungal contamination on the surface and air. Moreover, the passage of time had no effect on the effectiveness of the paint and that Nanosilver paint was more effective on the surface than on the air.

Key words: Fungal contamination, Hospital, Nanosilver, Qom

INTRODUCTION
Fungus form about 25% of live mass of the Earth (1). Infact, those are the biological decomposer of many organic materials (2). Spor of fungus can exist in everywhere (3). Those have been seen plenty in hospital environment and are one of factor of hospital infections (4). The opportunistic fungi infections are Aspergillus, Soudoalsheryasis, Candidiasis, Crypyococcus, Rhizopus, Mucormycosis(5). Fungal pathogens are recognized as a risk to increase of infections in patients who have immunity system deficiency (6). Fungus, because of having adaptation potential with different environment conditions, threat easily patients and those who have immunity system deficiency and now are one of the most important factors of people death(7). Offensive Aspergillus is an important opportunistic infection in hematology patients(8). Nanosilver particles, usually are less than 100 nonometer and consist of 20 to 1500 silver atom. Nanosilver, because of its antibacterial and antifungal power, has wild applications but wide use of Nanosilver in health matters is because of its suitable function and safety for environment (9).
Investigations show that Nanosilver antibacterial mechanism destroy micro-organism cell wall (10). There are different studies about hospital air contamination. Perdelli reported average of concentration air-born fungus in hospital air, 19 ± 19 CFU/m³ and announced Cladosporium, Aspergillus, Penicillium and Rhizopus, respectively, as the most
contaminant kind of fungus in hospital wards(11). Panagopoulou found out, environment fungus level, the least in winter and the most in summer and anthem and recognized Aspergillus as the most with 75% frequency (12). Marcelou Kinti in his study about the air of Aten hospital optical ward reported Aspergillus, Penicillium, Mucor and Rhizopus(13). Marjolein’s research proved strongly the role of the air on Aspergillus spreading in environment (14). Chih-Shan announced the average of fungus concentration in clean room air, 4 CFU/m³ (15). Bouza separated Aspergillus Fumigatus, Penicillium, Mucor, Aspergillus Niger, Alternaria and Aspergillus Flavus, respectively, with the most frequency(16). Ross also separated Aspergillus, Rhizopus, Fusarium and Penicillium from hospital air(17). Azizifar announced that average of the contamination in different hospital ward was 200 CFU/m³ (18). Hedayati in a research announced that the infectious ward of children medical center is the most infectious(19). Nourian, also found out Aspergillus, Alternaria, Penicillium, Fusarium, Cladosporium, Rhizopus and Phoma as the most fungus in zajan hospitals(20). Mahdavi Omran got that the Penicillium is the most widespread fungus in babol hospitals air(21). Hashemi has reported that the most widespread fungus are Penicillium, Cladosporium and Aspergillus(22). And also, some studies have performed about the effect of Nanosilver on micro-organisms. Kim show that Nanosilver particles have had many effective activity on Tricofyton Mentagrafits, candidias and Miciliums(23). Jo Young Ki showed that silver, in two shape, ion and nono particles, has antimicrobial characteristic(24). Panacek, in a study found out that less than 0.2 mg/l of Nanosilver has preventing effect on ferments and 0.05 mg/l on candida albicens(25). Kim John Song showed that ferments and E.coli’s growth are stop by a few Nanosilver(26).

The goals of this study were determine of effect of Nanosilver painting on reducing fungal contamination level and compare of rooms air which have painted with Nanosilver and rooms air which have not painted with Nanosilver in Qom Kamkar Hospital.

**METHOD**

This study is a case-control and interventional research that accomplished in qom kamkar-arabnia hospital in 2007. Regarding hospitalization of transplant patients and their sensitivity to hospital infections, two similar rooms were selected in nephrology ward; one as case room and another as control room. was painted with Nanosilver paint and the other one with ordinary paint. Sampling time was selected from 8 to 12 AM and the day after three days. Sampling was done via the methods of Swap Sterile and Open Plate that placed in environment for 15 minutes. In Swap Sterile method sampling surface was 10×10 cm and in Open Plate method, because of being passive of this method, amount of passing air was not measurable and attempted for keeping sampling in similar condition along the time. For measuring the number of sample, regarding to \( \mu = 0.19 \) in similar study and according to reduce fungal contamination to 90% by Nanosilver, \( \mu \) and the number of sample was considered 0.19 and 35, respectively. In Open Plate, for every case and control room, was predicted 35 samples and in Swap Sterile, for every 4 walls of case and control room, was predicted 35 samples, too. Primary culture medium was Sabro Dextrose Agar and special mediums were used for preparing pure cultures. After sampling, plate doors were closed and transferred to laboratory and samples were held in 25-27 °C for 72-120 hours and then plates were investigated according to growth and non-growth and number of colony-formed counted in positive plates and reported as colony-formed units (CFU). Quantitative method help so much to calculative and compare the contamination levels in case and control rooms.

Effective material of Nanosilver particles that used for painting, was BIOCERA A and is made by South Korea. This material was in powder shape and with weight-concentration 2-3% can be combined with ordinary painting. This material has health certificate from FDA and accomplished test on mice shows \( LD_{50} > 10000 \) mg/kg. The size of Nanosilver particles are 3-4 micron. The results of tests were analyzed by use of the Microsoft Excel and SPSS 11.5.
RESULTS
In this study, results have been reported in three forms; Qualitative (presence and absence of fungi in the plates), Quantitative (the number of CFU) and recognizing of growth fungus species in plates. Regarding to Sampling was done via the methods of Swap Sterile and Open Plate, obtained results are presented separately, too.

1. Open Plate method
For proving of the effective of Nanosilver paint in reduce fungal contamination, the average of CFU in every plates in both case and control rooms were compared with the use of Independent Sample Test and $P_{value} = 0.000$. To investigate the effect of passage of time on the characteristic of Nanosilver painting, 35 prepared samples along 114 days sampling from painted rooms with Nanosilver (case), were divided to three equal times; the first period = 11 prepared samples in primary stage, the second period = 12 prepared samples in middle stage and the third = 12 prepared samples in final stage. Every three period were compared, statistically, by use of ANOVA test. In this test $P_{value}$ was 0.165. According to figure 1, maximum of seen colonies were 18 in control room and 6 in case room and change trend of colony number was 1-16 CFU in control room and 0-6 CFU in case room.

![Figure 1: Compare of CFU change trend with time in prepared samples from the air of case and control rooms in Open Plate method](image-url)
Table 1 shows that the most separated fungus are Cladosporium, Penicillium and Aspergillus and yeasty fungus are seen the less number than other.

### Table 1: Separated fungus from case and control rooms in sampling time

<table>
<thead>
<tr>
<th>Yeast</th>
<th>Exophila</th>
<th>Sodo alsheria boyi</th>
<th>Getoniom</th>
<th>Jecidium</th>
<th>Rhodotoria</th>
<th>Micor</th>
<th>Fusarium</th>
<th>Aspergillus terreus</th>
<th>Alocadium</th>
<th>Chryosporium</th>
<th>Phoma</th>
<th>Aspergillus terreus</th>
<th>Aspergillus flavus</th>
<th>Aspergillus Niger</th>
<th>Cladosporium</th>
<th>Penicillium</th>
<th>Alternaria</th>
<th>Rhizopsis</th>
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2. **Surface Culture method**

This section of study reported in two form; Quantitative (the number of CFU) and Qualitative (presence and absence of fungi colonies). In Quantitative method compared, statistically, average of CFU in every plate in both case and control room by use of Independent Sample Test and $P_{\text{value}}$ was 0.001. For assessing the effect of passing of time on Nanosilver painting characteristic, 35 prepared samples along 114 sampling days from painting rooms with Nanosilver (case rooms), divided to three time periods as last method. Every time period compared, statistically, by use of ANOVA test and $P_{\text{value}}$ was 0.644. According to figure 2, the maximum of number of colonies which are separated from control room were 1-50 CFU and from the case room were 0-40 CFU.

![Figure 2: Compare of CFU change trend with time in prepared sampling from case and control rooms in Surface Culture method](image)

In qualitative method, FISHER test was used to investigate the relation of ratio of presence and absence of fungi in case and control rooms and $P_{\text{value}}$ was 0.00. To investigate the effect of passage of time on characteristic of Nanosilver painting,
determined three time periods for case, were compared by use of FISHER test and $P_{\text{values}}$ were 0.183, 0.181 and 0.67, respectively.

DISCUSSION
Regarding to sampling method, results are discussed into part;

1. **Open Plate method**
   According to that the average of CFU in sampling days in case and control rooms, $P_{\text{value}} = 0.000$, can be concluded that there is significant difference between CFU average in case and control rooms and effect of Nanosilver painting on reduce fungal contamination level. Investigating the effect of time on Nanosilver paint antifungal characteristic, with regard to that $P_{\text{value}}$ was 0.165, showed that there is no significant difference between average of colony in every plate (CFU) in three time periods in case room and proved that the passage of time had no effect on Nanosilver paint characteristic at least along 4 months. According figure 1, little diffusion of CFU in case room and much diffusion of CFU in control room shows that Nanosilver paint has steady effect to control of fungal contamination along the time (114 days sampling). Table 1 shows that Nanosilver paint has effect to reduce some fungus such as Penicillium and Cladosporium. However cannot surely said that Nanosilver paint can eliminate some of fungus, choicely. It is necessary to more research in this matter.

2. **Surface Culture method**
   In this method results are reported in quantitative and qualitative shape. In quantitative method, compare the averages of CFU and $P_{\text{value}} = 0.001$ proved that Nanosilver painting has effect to reduce of surface fungal contamination. Results of last method were proved regarding to $P_{\text{value}} = 0.644$ from comparing the averages of CFU in three time periods in case room. Figure 2 shows less diffusion of CFU in case room and some how much diffusion of CFU in control room and this figure also shows steady effect of nono silver paint to control of surface fungal contamination. Table 1 states that the most kind of fungus in air of both case and control rooms almost are similar and Nanosilver effects and reduces most of them.
   In qualitative method, presence and absence of fungus in case and control rooms were compared by use of FISHER test and according to $P_{\text{value}} = 0.00$ there was significant difference and proved results of last method. Investigations on effect of time on characteristic of Nanosilver paint and according to $P_{\text{values}}$ were 0.183, 0.181 and 0.67, respectively, there was not significant difference between groups. And proved the results of last methods.
   Gathered data from Surface Culture and Open Plate method in control room, as case room, divided to equal three time periods to compare of Nanosilver paint effect on air and surface fungus. According to nonparametric test, MANN_WHITNEY, CFUs compared with each other in similar time periods in case and control room, separately. According to $P_{\text{value}} = 0.000$ in three time periods in case and control room in Surface Culture method and $P_{\text{value}1} = 0.024$, $P_{\text{value}2} = 0.056$ and $P_{\text{value}3} = 0.02$ in three time periods in case and control room in Open Plate method, can be concluded that the effect of Nanosilver paint to reduce surface fungal contamination is more than air fungal contamination.
   Results of this study are the same of similar studies and prove that Nanosilver particles has effect to reduce microbial and fungal contamination level. Because of sampling method in this study was passive and there was no air flow along the sampling time, obtained results are similar to other research that perform by use of this method.

RECOMENDATION
Regarding to obtained results of this study can recommend using of Nanosilver painting to prevent of hospital infections. And also, it is advised to more research and
investigations by other scientists and researchers, not only to prove the results of this study but also to present suitable criteria and method to use of Nanosilver paints to control of indoor hospital fungal contamination.

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