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Original Article

Cross-Sectional Study to Evaluate Infection in Operation Theater and Difference in Infection Pattern Between Laminar Air Flow and Non-Laminar Air Flow Operation Theaters.

*Selina F[1], Talha KA[2], Chowdhury NA[3], Das S[4], Khatoon M[5], Hasan MF[6]

Abstract:

This was a cross-sectional study to compare the infection rate between laminar air flow and non-laminar air flow operation theater (OT). This was bi-center study and study places were the OT complexes of Sylhet Women's Medical College Hospital (SWMCH) and Al Haramain Hospital Pvt. Ltd. of Sylhet. A Total 24 samples were collected from 12 OTs. Air and wall swab both types of samples were collected from each OT. Out of these 12 OTs 4 had laminar air flow system. Half of the air samples (50%) and 8.3% of wall samples were infected, whereas overall organism isolation rate was 29.17%. Among all the infected samples 25% were from laminar air flow OTs and the rest 75% were from non-laminar air flow OTs. Commonest isolated bacteria was staphylococcus epidermidis (62.5%) followed by bacillusspp (25%) and staphylococcus aureus (12.5%). staphylococcus epidermidis was predominantly found in General Surgery, Obstetrics and septic OTs. Distance from entry or toilet did not show any significant difference in infection rate in operation theaters.

Key words: OT infection, Laminar air flow, non-laminar air flow.

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Introduction:

Operation theaters (OT) are one of the important structures for any hospital. Routine and emergency both types of surgeries are performed in the OTs.

1. Dr. Farhana Selina
   Associate Professor, Anesthesiology, Sylhet Women's Medical College
2. Dr. Khandaker Abu Talha
   Associate Professor, Neurosurgery, Sylhet Women's Medical College
3. Dr. Nahian Ahmed Chowdhury
   Additional Director- Medical Services, Al Haramain Hospital Pvt. Ltd
4. Dr Shantanu Das
   Associate Prof, Dept of Microbiology, Bangabandhu Medical College, Sunamganj
5. Dr. Mohsina Khatoon,
   Professor and head department of microbiology, Sylhet Women's Medical College
6. Prof. Dr. Md. Ferdous Hasan
   Professor of Community Medicine, Sylhet Women's Medical College

Corresponding author: Dr. Farhana Selina
Associate Professor, Anesthesiology,
Sylhet Women's Medical College, Mirboxtola, Sylhet-3100.
Email: farhana.selina@gmail.com

Ideally the OT complex is divided into clean, sterile and dirty zones. Operation Theater is a part of sterile zone. If the sterility of OT is compromised due to any reason then the rate of postoperative infection is increased and eventually the morbidity and mortality rates rise.

There are different sources of infection in OT have been detected. Common sources are defective waste disposal, ventilation system, air flow system, lack of sterility knowledge of OT personnel including doctor, nurses and other staffs.[1] Movement of OT staffs from outside, wearing clean dress and shoes are also play key role in OT sterility. Shaving and cleaning of patients and quality of antiseptic also has role in controlling infection in OT.[2]

The bacterial air load is calculated by the unit of Colony-Forming Unit (CFU) per cubic meter (m^3). Ideally in an empty OT the bacterial air load should be less than 35 CFU/m3 and less than 1 colony of Staphylococcus aureus or Clostridium per fringes. At the time of the surgery or just after the surgery it should not exceed more than 180 CFU/m3.[3]

Operation theater infection is one of the key reasons of hospital acquired infections (HAI). The average OT contamination rate is from 4 to 37.4%. The common isolated microorganisms from OT are staphylococcus species, E. coli, Enterobacter, Bacillus and Klebsiella species.[4]

There are different types of OT ventilator system. Laminar air flow system uses positive pressure air current to drift away the microorganisms from the operation field. It creates an ultraclean zone around the operative field. The early study proved lower infection rates in the laminar flow OTs, however there are few recent studies who have questioned the importance of the laminar air flow system.[5]

This was a cross-sectional study to find out the difference of infection rate between laminar air flow and non-laminar air flow operation theater (OT). The secondary objectives of this study was to find the isolated microorganisms from infected OT and to evaluate the relationship of OT infection with distance from entry door and toilet.

Methodology:

This was a cross-sectional study on evaluating OT infection pattern and its difference between laminar air flow OT and non-laminar air flow OT. This was a bi-center study. The study places were the operation theatres of Sylhet Women's Medical Hospital and Al Haramain Pvt. Ltd. Hospital of Sylhet. The study period was 3 months, from April 2022 to June 2022. The sample size was 24. Ethical board approval was achieved from the institutional review board (IRB) of Sylhet Women's Medical College. Total 12 operation theaters (OT) were included. The users of these OTs were general surgery (GS), Orthopedics, Obstetrics & Gynecology, Eye, ENT, Neurosurgery, pediatric surgery departments. Both clean and septic cases were performed in these OTs. Among these 12 OTs, 4 had laminar air flow whereas other 8 OTs did not have laminar air flow. Two types of samples were collected from each OT, air sample and wall swab sample. For air sample collection settle plate pattern was followed. Upright open-lid petri dishes were placed on 1 meter height from floor and 1 meter far from a corner for 3 hours. Nutrient agar, MacConkey and Blood agar media were used. Wall swabs were collected by sterile wet swab stick from the nearest wall of the OT table of each OT. All the culture sensitivity tests were performed at the laboratory of the Al Haramain Hospital by the same microbiologist. Distance of OT from entry door and toilet were measured and documented. OT's relationship with the dirty corridor was also documented. The culture reports of the samples were collected and documented on data collection form (DCF). After collecting all data the variables were transferred to an Excel master sheet. Descriptive numerical calculation was done to find out the percentages. Chi-square test (with Yates correction) was done for qualitative data and independent t-test was done for numerical data.

Result:

Samples were collected from 12 OTs of 2 hospitals. From each OT, air samples and wall swab samples were collected.

Table-1: Distribution of source of samples and isolated microorganisms

Source of sample	OT no.	Microorganism isolated OT no.	Percentage	p-value	Total percentage
Air Wall	12 12	06 01	50% 8.3%	0.02	29.17%

*Chi-square test (with Yates correction) was done.

Table-1 shows distribution of source of samples and isolated microorganisms. Air samples had significantly higher infection rate (p=0.02).

Table-2: Number of OTs according to their air flow pattern and isolated microorganisms

Type of air flow	No. of OT	Microorganism isolated OT no.	p-value	Percentage	wall	Air
Laminar Non-laminar	04 08	01 06	0.30	25% 75%	01 00	00 06

*Chi-square test (with Yates correction) was done.

Table-2 demonstrates number of OTs according to their air flow pattern and isolated microorganisms. Non-laminar OTs had higher infection rate but the difference was not statistically significant (p=0.30)

Table-3: OTs in relationship to closeness to dirty corridor.

	No of OT	Microorganism isolated OT no.	Percentage	p-value
Close to dirty corridor Not close to dirty corridor	04 08	3 4	75% 50%	0.83

*Chi-square test (with Yates correction) was done.

Table-3 shows distribution of OTs in relationship to closeness to dirty corridor. The difference of infection rate was not significant (p=0.83).

Table-4: Microorganisms of OTs in relationship to closeness to entry.

Distance from entry	No of OTs	Microorganism isolated OT no.	Percentage	p-value
55 feet or less More than 55 feet	07 05	04 03	57% 60%	0.62

*Chi-square test (with Yates correction) was done.

Table-4 describes number of OTs according to distance from entry door. The difference of infection rate was not significant (p=0.62).

Table-5: Microorganisms of OTs in relationship to closeness to toilet.

Distance from toilet	No of OTs	Microorganism isolated OT no.	Percentage	p-value
55 feet or less More than 55 feet	07 05	04 03	57% 60%	0.62

*Chi-square test (with Yates correction) was done.

Table-5 describes the number of OTs according to distance from toilet. The difference of infection rate was not significant (p=0.62).

Table-6: Mean distances of OTs from entry door and toilet.

	Mean distance from entry	p-value	Mean distance from toilet	p-value
OT of isolated microorganisms OT of non- isolated microorganisms	56.18 49.23	0.234	50.85 50.82	0.498

*Independent t-test was performed.

Table-6 shows the mean distances of OTs from the entry door and toilet in both infected and non-infected OTs. The mean differences were not significant (p>0.05).

Table-7: Different types of microorganisms isolated from different OTs.

Isolated organisms	Number of OT	Percentage	Type(s) of surgery
staphylococcus epidermidis staphylococcus aureus bacillusspp	05 01 02	62.5% 12.5% 25%	GS, OBS, septic cases Orthopedics GS, Urology

Table-7 illustrates the name of the microorganisms and the name of the surgeries which were predominantly performed in those OTs. Staphylococcus epidermidis was commonest isolated bacteria followed by bacillus spp and staphylococcus aureus.

Discussion:

The result of this study was compared with similar international studies.

Mathew D et al published their study on 350 swab samples collected from OTs.[6] The study was performed in Nigeria and sample was collected by swab plate method from the different surfaces of operation theaters. Among these 350 samples 58.6% showed bacterial growth. Out of the isolated bacteria 62.3% were Gram-positive and rest 37.7% were Gram-negative. The common isolated bacteria of their study were Proteus species (86.5%), Staphylococcus aureus (57.5%), Coagulase negative Staphylococci (21.8%), Bacillus species (10.3%), E. coli (8.8%) and Enterobacter species (3.8%). Commonest sensitive antibiotic was cephalosporin and erythromycin was the most resistant antibiotic. In our study the infection rate was much lower (29.17%) and the commonest bacteria was Staphylococcus epidermidis.

Shukla et al's study was performed in northern part of India with 1640 samples.[7] Samples were collected from air and surfaces of eight OTs. The OT surfaces were floor, wall, light and tables. Out of all the samples 29.7% were positive for bacterial growth. Aerobic spore-

forming bacilli (ASB) was the commonest bacteria followed by micrococcus and Staphylococcus aureus. Highest percentage of contamination (41%) was found in septic OT. Among the four sample collecting surfaces wall and floor were found most contaminated. Average air bioload in the non-septic OTs was between 79 – 97 CFU/M^3. In our study most common contaminated OTs were septic OT, GS and OBS OTs.

Okon K et al collected their 267 samples from wall and air of 5 OTs, patient reception room, patient recovery room and staff changing room in a hospital of Nigeria.[3] Open plate and swabbing methods were used to collect the samples. They found 70% samples had bacterial growth. Among these positive samples 14% were collected from air and 86% were from surfaces. Commonest isolated bacteria was coagulase-negative Staphylococcus species (72.1%) followed by Proteus species (8%), E.coli (8%), Pseudomonas (6.9%) and Klebsiellapneumonae (2.2%). Common sensitive antibiotics were cotrimoxazole, ampicillin and gentamycin. In this study 50% air samples and 8.3% wall samples were infected.

Najorta DK et al collected samples from 5 operation theatres of a tertiary hospital of a north India for consecutive 5 years.[8] Among their 4387 samples 4.4% were infected. Bacillus (87.6%) were the commonest isolated bacteria followed by coagulase-negative Staphylococcus (8.1%) and Staphylococcus aureus (2.9%). OT air sample revealed that lowest colony forming unit (CFU) rate was in ophthalmology OT (27 cfu/m3) and the highest rate was in general surgery OT (133 cfu/m3). Surface samples had a predominance over air samples in terms of infection rate. In thiss study CFU was not calculated, but air infection outnumbered wall infection.

Baban ST et al performed their study in a hospital of Iraq where 87 samples were collected from OT and Intensive care unit (ICU).[9] Samples were collected from the surfaces of air, water, floor, doors, telephone handles, wash basin, walls and medical equipment of OT and ICU. Overall 48.3% reported as positive microbial growth whereas from the air samples this rate was 23.8%. Among the isolated bacteria 83% were Gram-positive and 17% were Gram-negative. Staphylococcus aureus (78.6%), Streptococcus (33.3%) and Enterococci (28.6%) were the common Gram-positive bacteria from surfaces. Among the Gram-negative bacteria E. coli and each of Pseudomonas aeruginosa and Proteus were common. Aspergillus (19%) and Molds (14.3%) were common in air contaminations.

Gebremariam TS et al published their systematic review article on 45 articles of which 19 were original articles.[10] Samples from surfaces and air of OTs both were considered. Common surface contamination were occurred by S. aureus, Staphylococcus epidermidis, Escherichia coli and Pseudomonas aeruginosa. OT air were predominantly contaminated by multidrug-resistant Mycobacterium tuberculosis, Legionella, methicillin-resistant S. aureus and Aspergillus spores. The study showed nearly 51.3% (range of 32.9 – 84.0%) OT were contaminated. The mean air load of contamination was 35.3 cfu/m3. The prevalence of S. aureus (62.5%) from air sample was high in all OTs except ENT. CnNS were less in Eye and Urology OTs. Lowest prevalence of Bacillus were found in urology, surgery and orthopedics OTs. On the other hand air from ENT and obstetric &gyne OT had nearly 100% infected by Bacillus. In our study Staph aureus was predominant in Orthopedics OT and Bacillus spp were mostly in GS and Urology OT.

Bali R et al compared the OT infection patter before and after fumigation.[11]A total 6723 samples were collected from the air (2241) and swabs (4,482). Sterile wet swabs were collected from floor, light, shelf, operating table, instrument trolley and instrument surface. Commonly isolated organisms were S. aureus, Streptococcus beta hemolyticus, E. coli and Aspergillus. The organism percentage was calculated both in before and after fumigation of OTs. Among the air samples E. coli (from 6% to 0%) and Strep beta hemolyticus (65.1% to 8.4%) had significant drop in percentage after fumigation. On the contrary, S. aureus showed mark raise (27.7% 95.6%) after the fumigation.

Among the swab samples E. coli (from 8.4% to 0%) and strep beta (from 60.2% to 15.3%) showed marked drop, though staph aureus increased from 25.3% to 84.7%.

The limitation of this study was less number of samples. A big sample study will be able to highlight on further details on this topic. In most of the cases the OTs were not assigned for any particular surgery disciplines, so it was difficult to conclude about discipline or procedure specific organisms.

Conclusion: Operation theaters of non-laminar air flow revealed three times more infection in comparison to OTs of laminar air flow. Distance of OT from entry door or toilet did not make any significant differences in case of OT infection. Air samples were found more infected than wall samples. Air infection was higher in non-laminar air flow OT, on the other hand none of the air sample of laminar air flow OT was found infected. Staphylococcus epidermidis was the commonest isolated bacteria.

Conflict of interest: None of the coauthors declared any conflict of interest.

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References:

1. Fridkin SK, Jarvis WR. Epidemiology of nosocomial fungal infection. Clinical microbiology reviews, 1996, 9:499–511.
2. Siddiqui AR, Luby SP. High rates of discitis following surgery for prolapsed intervertebral discs at a hospital in Pakistan. Infection control and hospital epidemiology, 1998, 19(7):526–9.
3. Okon, K.O., Osundi, S., Diba,l. J., Ngbale, T., Bello, M., Akuhwa, R., T. Bacterial contamination of operating theatre and other specialized care unit in a tertiary hospital in North eastern Nigeria. Africa Journal Microbiology Research. 2012. 6(1): 3092-3096.
4. Laham NAA. Prevalence of bacterial contamination in general operating theaters in selected hospitals in the Gaza strip, Palestine. Journal of Infection and Public Health. 2012;5:43–51.
5. Jain S, Reed M. Laminar Air Flow Handling Systems in the Operating Room. Surg Infect (Larchmt). 2019 Feb/Mar;20(2):151-158. doi: 10.1089/sur.2018.258. Epub 2018 Dec 31. PMID: 30596534.
6. Matthew D., Dadah A.J. and Mohammed S.S.D. Bacterial Contamination of Operating Theatres: A Case Study of A Hospital In Northern Nigeria. Science World Journal. 2020; 15(2): 84-90.
7. Shukla A, Srivastava S, Srivastava A, Srivastava T. Surveillance of Microbiological Environment of Operation Theaters. Cureus. 2021 Dec 20;13(12):e20525. doi: 10.7759/cureus.20525. PMID: 35070559; PMCID: PMC8765562.
8. Najotra DK, Malhotra AS, Slathia P, Raina S, Dhar A. Microbiological Surveillance of Operation Theatres: Five Year Retrospective Analysis from a Tertiary Care Hospital in North India. Int J Appl Basic Med Res. 2017 Jul-Sep;7(3):165-168. doi: 10.4103/ijabmr.IJABMR_281_16. PMID: 28904915; PMCID: PMC5590378.
9. Baban ST, Saeed PA, Jalal DM. Microbial contamination of operating theatres and intensive care units at a surgical specialty hospital in Erbil City. Med J Babylon 2019;16:150-5
10. Gebremariam TT, Declaro MF. Operating theaters as a source of nosocomial infection: A systematic review. Saudi J Health Sci 2014;3:5-8.
11. Bali R, Sharma P, Nagrath S, Gupta P. Microbial isolations from maxillofacial operation theatre and its correlation to fumigation in a teaching hospital in India. J Maxillofac Oral Surg. 2014 Jun;13(2):128-32. doi: 10.1007/s12663-012-0458-3. Epub 2012 Nov 20. PMID: 24822003; PMCID: PMC4016389.