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Surveillance of Microbiological Environment of Operation Theatres

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ABSTRACT

Introduction: Microbial contamination in operating theatres is a critical concern. Control of infections in the operation theater (OT) is of utmost importance. Microbiological surveillance is an effective tool for identifying and controlling infections. Effective infection control practices are essential for minimizing microbial exposure and ensuring patient safety during surgical procedures.

Aims & Objectives: The purpose of this study is to investigate the prevalence rate of microorganisms in OTs, to identify the type of microorganisms, and to detect contamination of various surfaces and air of OT and to finally provide evidence based recommendations for enhancing infection prevention strategies.

Methods: OTs were properly cleaned with soap and water. All surfaces were disinfected, followed by fumigation with quaternary ammonium compounds. OTs were kept closed overnight. In the morning, they were opened, and samples were collected, taking all aseptic precautions. The settle plate method was used for air sampling, and the swab method was used for surface sampling. Samples were collected from four surfaces of OTs, i.e., floor, wall, table, and light, and samples of the OT air were also collected and immediately transported to the microbiology laboratory of the institution in sterile conditions.

Result: A total of 2304 swab samples were taken from 12 OTs, out of which 696 (30.2%) were found positive for bacterial growth. Most of them were non-pathological microorganisms such as aerobic spore-forming Bacilli and Micrococcus. Among various OTs, surgery OT showed the highest bacterial growth (84 positive cultures out of 196). In the surface sampling of various OTs, aerobic spore-forming Bacilli (336/696) was the most common isolate, followed by Micrococcus (116/696), and coagulase-negative Staphylococci (96/696). General
surgery, gynae, and obstretics OTs had maximum air bioload (97, 93, and 91 colony-forming unit (CFU)/M3, respectively).

Conclusion: In surface sampling of OTs, it was found that surgery OT and gynaecology OT were most contaminated where the patient load was high. Among all the surfaces, OT walls and tables were most contaminated with pathogenic microorganisms. The average air bioload of all OTs was ranged between 79 and 97 CFU/M3. This study underscores the importance of microbiological surveillance and effective infection control practices in operating theatres. Implementing regular audits and enhancing training programs for healthcare workers can significantly reduce microbial contamination and improve patient outcomes.

Keywords: environmental monitoring, operation theaters, fumigation, disinfection

Introduction

The environment of operation theater (OT) plays a major role in the postoperative recovery of the patients. Infection acquired in OTs leads to increased morbidity and mortality, prolonged length of hospital stay, increased expenditure of patient and hospital. Using good theater practice, standard cleaning, and proper sterilization, infections in the OTs can be minimized.

Microbiological surveillance in the operating theatres is one of the most important strategies for determining potential sources of contamination and putting infection control strategies into effect. Regular monitoring establishes the environment conducive to surgical site infections and helps in formulating necessary interventions.

The primary objective of our study was to detect if there is any bacterial colonization of indoor air and surfaces of OTs even after cleaning and fumigation. Secondary objectives were to estimate the bacterial colony-forming unit (CFU) rate of indoor air and to identify the type of bacterial contamination of OTs.

Materials & Methods

This prospective observational study was conducted in Department of Microbiology, Index Medical College, and Associated hospitals Indore, Madhya Pradesh.

Inclusion criteria

Samples were collected from all OTs under proper sterile conditions.

Exclusion criteria

If OT was opened before 12 hours, the samples from that OT was not collected. Further, if there was any contamination of samples during collection or transportation, the samples were discarded.

Data collection

Samples were collected for 1 year from 12 OTs and processed in the microbiology department. The human subject or any related biological tissue was not included in the study.

The division of twelve OTs was as follows: OT1: Orthopaedics; OT2 & OT3: Surgery; OT4: pulmonary, OT5,OT6, OT7 & OT8: Gynaecology, OT9 & OT10: obstetrics; OT11: ENT; OT12: Ophthalmology.

Samples were collected from four surfaces (floor, wall, table, and light) and air of OTs. All OTs were properly cleaned with soap and water and thereafter mopped and fumigated with quaternary ammonium compounds. OTs were kept closed overnight. In the morning, OTs were opened, and samples were collected wearing sterile gloves, masks, and sterile gowns. Two sampling procedures were used in this study: the settle plate method was used for air sampling and the swab method was used for surface sampling.

All samples were appropriately labelled and immediately transported to the microbiology laboratory in sterile conditions.

Laboratory diagnosis

Culture

Swabs taken from different sites were inoculated on blood agar, MacConkey agar or cystine-lactose electrolyte-deficient (CLED) agar and incubated at 37°C for 18-24 hours under aerobic conditions. After incubation of blood agar (for air sample) at 37°C for 18-24 hours under aerobic conditions, the colonies were counted and converted into colony-forming units per cubic meter of air (CFU/M3) by using the Omeliansky formula.

$N=5a \times 104\ (bt)-1$

N=colony-forming unit per cubic meter of air (CFU/M3)

a=number of colonies per petri dish

b=surface area of petri dish in cm2

t=time exposure (minutes)

Microscopy
A smear was made from a bacterial colony and examined under oil immersion after Gram's staining. Isolates were identified on the basis of colony morphology, motility, catalase test, coagulase test, oxidase test, and different biochemical tests.

Statistical analysis
Data was analyzed with software IBM Statistical Package for Social Sciences (SPSS) version 23.0 (IBM, Chicago, IL). It was hypothesized that there is no contamination of air or surfaces of OTs. Quantitative data was analyzed by student-t-test and qualitative data by the Chi-square test. P-value less than 0.05 was
considered statistically significant.

Results
A total of 2304 swab samples were taken from 12 OTs, out of which 696 (30.2%) were found positive for bacterial growth. Most of them were non-pathological microorganisms such as aerobic spore-forming Bacilli and Micrococcus.
Among various OTs, surgery OT showed the highest bacterial growth (84 positive cultures out of 196).
In the surface sampling of various OTs, aerobic spore-forming Bacilli (336/696) was the most common isolate, followed by Micrococcus (116/696), and coagulase-negative Staphylococci (96/696). Other organisms isolated were Diphtheroids, Staphylococcus aureus, E.coli, Klebsiella, Pseudomonas, Acinetobacter and Enterococcus.
General surgery, gynae, and obstretics OTs had maximum air bioload (97, 93, and 91 colony-forming unit (CFU)/M3, respectively).

TABLE 1: Surface sampling of OTs according to sterility and culture positivity

Total swabs	**Sterile**	**culture positive**	**P value**
186	132	54	0.001678
192	136	56	
196	112	84	
194	142	52	
188	134	54	
192	140	52	
192	144	48	
196	124	72	
196	128	68	
190	138	52	
190	132	58	
192	146	46	
Total 2304	1608	696	

P-value 0.001678 < 0.05

There is a statistical significance difference in contamination among OT rooms.

TABLE 2: Surface sampling of OTs according to sterility and culture positivity (non-pathogen vs pathogen).

Number of non pathogen	Number of pathogen	P value
30	24	0.08441
36	20	
49	35	
32	20	
36	18	
38	14	
26	22	
46	26	
36	32	
40	12	
44	14	
28	18	
Total 441	255	

P-value 0.08441 > 0.05

The type of contamination (pathogenic vs non-pathogenic) is not significantly different across OTs.

TABLE 3: Contamination status of surfaces of OTs.

Surfaces	Sterile	Culture positive	P value
Floor 576	405	168	0.023913
Wall 576	408	170	
Table 576	415	220	
Light 576	380	138	
Total 2304	1608	696	

P-value 0.023913 < 0.05

Different surfaces show significantly different contamination levels.

TABLE 4: Number of organisms colonizing on various surfaces of OTs.

Organisms	Floor	Wall	Table	Light	Total
Aerobic spore forming bacilli	88	82	89	77	336
Micrococcus	25	32	39	20	116
CONS	19	23	34	20	96
Diptheroids	2	2	2	2	8
Staphylococcus aureus	20	15	30	10	75
E.coli	7	8	5	5	25
Klebsiella	2	4	8	2	16
Pseudomonas	2	2	5	1	10
Acinetobacter	1	1	5	1	8
Enterococcus	2	1	3	0	6
Total	168	170	220	138	696

TABLE 5: Air bioload (CFU/M3) of OTs.

OT No.	Air bioload [CFU/M3]	P value
1	81	X=2.548 P=0.9250
2	79	
3	97	
4	88	
5	93	
6	86	
7	84	
8	91	
9	90	
10	83	
11	80	

12	78	

P-value 0.9250 > 0.05

The average air bioload of all OTs was ranged between 78 and 97 CFU/M 3. The highest air bioload was found in OT3 followed by OT5, OT8, OT9, OT4, OT6, OT7, OT10, OT1, OT11,OT2 and OT12. However, the difference was not significant statistically.

Discussion

Microbial contamination of the OT environment can be due to a variety of causes, and it leads to postoperative infections that can prolong hospital stays, cause long-term disability, and increase resistance to antibiotics. It also imposes an additional financial burden on the patients. [1]

In our study, a total of 2304 swab samples were taken from 12 OTs, out of which 696 (30.2%) were found positive for bacterial growth. The bacterial count was highest in surgery OT (84/196) followed by gynaecology (72/196). Ophthalmology and ENT OTs were the least contaminated where the bacterial count was 46 and 52, respectively. The most common isolates were aerobic spore-forming Bacilli (336/696) followed by Micrococcus (116/696), coagulase-negative Staphylococci (96/696), and Staphylococcus aureus (75/696). Among the various surfaces of OTs, OT tables were highly contaminated, followed by walls. The average air bioload of all OTs ranged between 79 and 97 CFU/M3. The highest air bioload was found in OT3 (97 CFU/M3) followed by OT5 (93 CFU/M3). [2,3]

Najotra et al. collected a total of 4378 samples and out of which only 195 (4.4%) samples were contaminated with pathogenic and non-pathogenic bacteria. The predominant isolates were Bacillus (184) followed by coagulase-negative Staphylococci (17). Though their study surfaces were less infected ,air sampling of
various OTs showed air bioload in ranges of 27-133 CFU/M3 with least contamination of ophthalmic OT and the highest rate of contamination in general surgery OT [4].

In the study by Kausar et al., a total of 134 swabs out of 184 swabs were found to be positive for bacterial growth and total of 41 air samples out of 43 were found to be positive for bacterial contamination. Average air bioload was 4.4 CFU/M3 to 268.7 CFU/M3 with the least CFU/M3 being found in ophthalmology OT (4.4-
10 CFU/M3) and highest in gynecology and obstetrics OT (4.4-268.7 CFU/M3). The most predominant microorganism was Bacillus followed by coagulase-negative S. aureus. These findings co-related with our study [5].

In the study by Kiranmai and Madhavi, a total of 48 bacterial species were isolated from 111 swab samples from all OTs and ICUs. The highest contaminated surface was OT table as found in our study. Their study showed that OTs had bacterial CFU rate of air varying from 6 to 72 CFU/M3 which is much less than in our
study. The most common isolates were Bacillus species 36 (75%) followed by Micrococcus [6].

Deepa et al. did a surveillance of microbiological flora of critical care unit and opined that bioload helps in monitoring the capability of the air filters used in the OTs and also helps in assessing quality and making timely changes in measures that need to be adopted to maintain the air quality in these areas. Therefore, she
stressed upon that strengthening surveillance and laboratory capacity will surely enhance infection prevention and control [7].

It was a routine practice in our theaters to fumigate the OTs after cleaning only once a week except under special circumstances. No ultraviolet device was available. Frequent touching of OT tables by

the staff without wearing gloves and direct contact with the patients might be the possible cause of highly
contaminated OT tables. Therefore, hand hygiene is of utmost importance in preventing cross-infections among staff and patients. The tendency of people leaning against the wall might be one of the reasons of contaminating it.

In our study, septic OT was most infected and it might be because cleaning of these OTs needs special attention as highly infected cases are performed in these OTs, leading to high bacterial load. General surgery OT had the highest patient load and, therefore, should be cleaned and sterilized more frequently and more
meticulously. To control airborne contamination of OTs, it is essential to limit unnecessary traffic inside OTs. Further proper ventilation inside the OT with the provision of laminar flow and change of indoor air at least 20-25 times per hour or more depending upon surgical load is also recommended. Bacterial air count is
costly but a good indicator for predicting postoperative infections, and it is, therefore, recommended.

Mandatory teaching and training of all OT staff should be included in standard operative procedure of OTs. Some studies suggest that the use of alcohol-based gel drastically reduces infection [9]. In addition, all waste from the OT should be collected in closed airtight containers. Time to time surveillance of the environment of OTs should not be ignored at any cost to assess microbial load and to identify predominant pathogens[10,11].

National Infection Control Guidelines, Draft version 2017 suggested few guidelines for prevention and control of infections inside the OTs. Few highlights of the guidelines suggest that at the beginning of each day a clean damp lint should be used to remove all the dust from all flat surfaces of OT. However, after completion of OT, terminal cleaning of all operating room surfaces, hand washing areas, trolleys, and storage areas should be done irrespective of their usages. For wiping of surfaces, freshly prepared solution of 0.5% chlorine should be used. All waste from the OT should be collected in closed airtight containers. Similarly all soiled equipment should be decontaminated by soaking in 0.5% chlorine solution for 10 minutes. Wet clothes easily get contaminated with microorganisms and hence should be dried completely before use [12].

Conclusion

In surface sampling of OTs, it was found that surgery OT and gynaecology OT were most contaminated where the patient load was high. Among all the surfaces, OT walls and tables were most contaminated with pathogenic microorganisms. The average air bioload of all OTs was ranged between 79 and 97 CFU/M3. This study underscores the importance of microbiological surveillance and effective infection control practices in operating theatres. Implementing regular audits and enhancing training programs for healthcare workers can significantly reduce microbial contamination and improve patient outcomes.

Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services
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