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Bacterial air contamination of operating theatres and surgical wards of a university teaching hospital

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Summary

A study of the level and significance of air contamination in the four operating theatres and four surgical wards of the University of Nigeria Teaching Hospital, Enugu, Nigeria was carried out. A total of 48 air samples were taken from each of the operating theatres while a total of 36 air samples were taken from each surgical ward, using a "Casella slit Sampler". The means of the bacterial carrying particles per cubic foot of air varied, from theatre to theatre, from 12.29 to 14.29 (in the mornings) and 9.79 to 11.4 (in the evening). Statistically, these differences were insignificant (*t* - value < 1.96). Recognised pathogens were not recovered from both the air and the fomites in the operating theatres. However, free-living fungi were isolated. The air of the surgical wards showed levels of contamination from 20.39 to 35.28 (in the mornings) and 20.33 to 39.55 (in the evenings) bacterial carrying particles per cu.ft. of air. The differences between the counts in the mornings and evenings were also not statistically significant. Some pathogens were isolated from the air in the wards. The findings indicated that the level of air contamination of the surgical wards influenced the rates of post-operative wound sepsis.

Résumé

L' étunde du niveau et de la significance de la contamination d' air dans les quartres théâtres et les quatres salles chirungicales de L' hôspital de Teaching Hospital Enugu a été fait. Untotal de 48 modeles d' air a été pris de chaque théâtre opératif tandis que untotal de 36 simples a été pris da chaque salle chirurgicale, en utilisand un "Casella slit Sampler". Le moyen pour porter des morceaux de bactérie per chaque pied de L' air a été different d' un théâtre a L' autre, de 12.29 à 14.29 (Les matins) et 9.79 à 11.5 (Les soirs). Statistiquement, ces différences etaient insignificatives (*t*- valeau < 1.96). Des pathogènes reconnus n'ont pas ete retrouves de L' air des fomites dans des théâtres des operations. Pourtant, des fungis libre-vivants etaient isolés. L' air des salles chirurgicales a montre des niveaux de contamination de 20.39 à 35.28 (Les matins) et 20.33 à 39.55 (Le soirs) des morceaux portant des bactéries par cu. pied d air. Les différences entre les calculs les matins et les soirs n étaient pas statistiquement significatives. Quelques pathogènes étaient isolés de L'air de ces salles. Les découvertes, ont indiqué que le niveau de la contamination d air des salles chirurgicales a influencé les niveaux des blessures sepis post-opératives.

Introduction

Some workers have observed that there is a relationship between the bacterial air load in the operating theatres and the development of post-operative wound sepsis[1-3]. As part of a study to determine the rate of post-operative wound infections in the University of Nigeria Teaching Hospital, Enugu, Nigeria, the air and fomites in the operating theatres, as well as the air of the surgical wards was sampled and analysed bacteriologically. The aim was to determine the type and frequency of isolation of organisms and the rate of bacterial fall-out in the operating theatres and the surgical wards with a view to determining the significance of air-borne infection to the development of post-operative wounds sepsis at the University of Nigeria Teaching Hospital.

Materials and methods

The technique for air sampling was by the use of "Casella Slit Sampler" (C.F. Casella and Co. Ltd. London). This method was introduced by Bourdillon *et al*[4]. One cubic foot (28.3L) of the air per min. was allowed to impinge on blood agar plates through

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a slit 0.25mm wide.

The air in the four operating theatres designated, 1, 2, 3 and 4 respectively was sampled in the mornings (starting at 7 a.m.) before the start of the days operations and in the evenings (starting at 5.30 p.m.) at the end of the days operations.

Three samples were taken each time in each theatre twice weekly for four weeks, making a total of 24 air samples in the mornings and 24 air samples in the evenings.

Similarly, the air in the four surgical wards (3, 4, Eye, 12) was sampled in the mornings (starting from 10.00 a.m. during wound dressing), and in the evenings (starting from 5.00 p.m. after visits to patients), for 3 week period making a total of 18 air samples in the mornings and the same number in the evenings.

In addition to using blood agar alone, blood agar plus 75 mcg/ml Neomycin Sulphate was also used for the detection of anaerobes.

The fomites in the theatre, that is, the air conditioning units, operating lamps, floors, sterile forceps, textiles and scissors were also sampled. Sterile swabs were moistened in sterile peptone water and rubbed over a wide area of the surface of each of the fomites. Each swab from each material was seeded onto one blood agar plate and one Neomycin blood agar plate. The sterile textiles were sampled by pressing the side against the culture plates. For the sterile forceps and scissors, the operating ends were dipped into bottles of Oxoid Brain Heart Infusion broth and cooked meat broth. These broths were incubated at 37°C for 4 days before being subcultured onto blood/Neomycin blood agar plates.

The blood agar plates were incubated at 35°C for 24 hours aerobically and the colonies were counted and expressed as the number of bacteria carrying particles per cubic foot of air[5]. After counting the colonies, the blood agar plates were re-incubated at 26°C for another 3 days for fungal growth. For the neomycin blood agar plates the incubation was carried out anaerobically in anaerobic jars with gas pack for 48 hours and anaerobes looked for. The organisms found growing on any of the culture plates were identified. The methods of Cowan and Steel[6] were employed in the identification of the organisms.

Results

Evaluation of the airborne bacteria in the operating theatres revealed that the number of viable bacteria present in the operating theatres varied with almost consistent higher counts in the mornings than in the evenings. Also the bacterial counts in the theatres varied from one operating theatre to the other.

In the mornings, the means of the bacteria carrying particles per cubic foot of air were 14.29, 13.83, 12.9, 12.29 for operating theatres 1, 3, 4 and 2 respectively. In the evenings, the means were 11.5, 10.5, 10.04 and 9.79 bacteria carrying particles per cub. foot of air for theatres 1, 4, 3 and 2 respectively, (Table 1).

The differences observed between the counts in the mornings and evenings were analysed statistically and were found not to be significant at 5% level of significance (t-value < 1.96).

Table 1: Bacterial fall-out of the operating theatres (mornings and evenings) expressed as bacterial carrying particles per cubic foot of air.

	Theatre 1		Theatre 3		Theatre 4		Theatre 2	
	morning	evening	morning	evening	morning	evening	morning	evening
Total count*	343	276	332	341	309	252	292	235
No of Samples	24	24	24	24	24	24	24	24
Mean	14.29	11.5	13.83	10.04	12.9	10.5	12.29	9.79

*Represent sum of 3 samples taken on 8 separate days.

The organisms recovered from the air of the operating theatres included fungi, aerobic spore-forming bacilli and *Micrococcus* spp. Known pathogens were not recovered from the air of any of the operating theatres (Table 2). From the fomites in the theatres, no recognized pathogens were isolated, and the surgical instrument did not yield any growth (Table 3).

From the surgical wards the means of bacterial carrying particles per cubic foot of air were found to be 35.28, 28.61, 27.59 and 20.39 for ward 4, 3, 12 and Eye respectively in the mornings, while the mean counts were 39.55, 32.11, 28.61 and 20.33 for wards 4, 3, 12 and Eye respectively in the evenings. The results revealed consistently higher counts in the evenings than in the mornings (Table 4). These differences were also analysed statistically and were found to be insignificant (t-value < 1.96). The organisms recovered from the surgical wards included recognized pathogens as well as non-pathogens as shown in Table 5.

Table 2: Frequency of recovery of various organisms from the 48 air samples (mornings and evenings) in each operating theatre.

Organisms	Theatre 1		Theatre 2		Theatre 3		Theatre 4	
	No.	%	No.	%	No.	%	No.	%
Staphylococcus epidermidis	48	100	48	100	48	100	48	100
Aerobic spore-forming bacilli	48	100	48	100	48	100	48	100
Micrococcus spp.	48	100	48	100	48	100	48	100
Non-sporulating fungus	48	100	48	100	48	100	48	100
Aspergillus spp.	—	—	—	—	40	83.33	—	—
Mucor spp.	—	—	—	—	—	—	38	79.16
Rhizopus spp.	24	50	—	—	—	—	—	—
Syncephalostrum spp.	—	—	24	50	—	—	—	—
Penicillium spp.	—	—	—	—	—	—	16	33.33

Key: — = No growth.

Table 3: Isolates from fomites in the operating theatres

Theatres	Air Conditioners	Operating Lamps	Floors	Sinks	Forceps	Scissors	Textiles
1.	*Rhizopus* spp. *S. epidermidis* A.S.B.	—	*S epidermidis* A.S.B.	A.S.B.	—	—	—
2.	*Rhizopus* spp. *S. epidermidis* A.S.B	—	*S. epidermidis* A.S.B.	A.S.B.	—	—	—
3.	*Rhizopus* spp *S. epidermidis* A.S.B	*S. epidermidis*	*S. epidermidis* A.S.B *Aspergillus* spp.	A.S.B	—	—	—
4.	*Rhizopus* spp. *S. epidermidis* A.S.B	A.S.B	*S. epidermidis* A.S.B *Aspergillus* spp.	A.S.B	—	—	—

Key: — = No growth
A.S.B. = Aerobic spore-forming bacilli

Table 4: Bacterial fall-out of the surgical wards (mornings and evenings) expressed as bacterial carrying particles per cubic foot of air.

	Ward 4		Ward 3		Ward 12		Eye Ward	
	morning	evening	morning	evening	morning	evening	morning	evening
Total Count*	635	712	515	578	495	506	367	366
No. of Samples	18	18	18	18	18	18	18	18
Mean	35.28	39.55	28.61	32.11	27.59	28.61	20.39	20.33

*Represent sum of 3 samples taken on 6 days.

Table 5: Frequency of recovery of various organisms from the 36 air samples (mornings and evenings) in the surgical wards

Organisms	Ward 3		Ward 4		Eye Ward		Ward 12	
	No.	%	No.	%	No.	%	No.	%
Aerobic spore-forming bacilli	36	100	36	100	36	100	36	100
Staphylococcus epidermidis	36	100	36	100	36	100	36	100
Micrococcus spp.	34	94.44	30	83.33	20	55.56	34	94.44
Acinetobacter anitratus	14	38.89	—	—	8	22.22	2	5.56
Alcaligenes odorans	—	—	12	33.33	6	16.67	4	11.11
Pseudomonas spp.	—	—	6	16.67	—	—	8	22.22
Non-haemolytic *Streptococcus*	4	11.11	—	—	—	—	6	16.67
Necromonas spp.	—	—	8	22.22	—	—	—	—
Klebsiella pneumoniae	—	—	2	5.56	—	—	—	—
Aspergillus niger	—	—	18	50	—	—	24	66.67
Non-sporulating fungus	12	33.33	—	—	8	22.22	—	—
Scropulariopsis spp.	—	—	14	38.39	—	—	16	44.44
Aspergillus flavus	—	—	8	22.22	—	—	—	—
Penicillium spp.	24	66.67	18	50	12	33.33	—	—

Key: — = Nil

Table 6: Distribution of the 218 patients and wound infections in the wards.

Wards	No. of Patients	%	No. of Infected Wounds	%
4	92	42.20	36	39.13
Eye	68	31.19	11	16.17
3	38	17.49	8	21.05
12	20	9.17	6	30

Discussion

Bourdillon, *et al*[1] stated that for major operations on tissue with normal resistance to infection, the total count of bacterial carrying particles per cubic foot of air obtained by an efficient air sampler should not exceed 10 per cubic foot.

For neuro-surgical and thoracic operations, where the dangers of infection are potentially great, the count should not exceed 2 per cubic foot of air. Cruickshank[5] agreed with these figures.

The findings from this present study showed that the bacterial air contamination of the operating theatres which varied from 12.29 to 14.29 bacterial carrying particles (bcp.) per cubic foot of air in the mornings; and 10.04 to 11.5 bcp/cubic foot in the evenings, though much higher than the recommended figures for neuro-and thoracic-surgeries, were quite within the range of operation on tissue with normal resistance to infection. However, since the main operating theatres were used for all surgeries including neuro-and thoracic surgeries, the situation could not be

considered ideal and calls for more determined effort to reduce the microbial count.

Though, no known pathogens were recovered from the theatres, the high value of bacterial counts calls for concern. It is known that fatal infections may follow brain and abdominal contamination by bacteria usually regarded as saprophytes[7,8]. A high colony count also indicates danger because pathogens may sooner or later make their appearance. This is particularly important when there is the presence of fungi such as the *Penicillium* and *Rhizopus* spp., suggesting the entry of the outside air into the theatre.

The higher counts noticed in the mornings than in the evenings were related to air disturbances associated with the occupation of the theatre by staff and patients in the mornings. The evening samplings were done when the theatres were not occupied, though after the days usage. The findings go to confirm those of Hart and Schiebel[9] that the operating theatre air contains less bacteria when empty than when occupied.

Contrary to the findings of Raju *et al*[2] and Scott- Emuakpor[3] that *Staphylococcus aureus* was present in the air of the operating theatres, there was no such evidence from our findings, neither did our work indicate that the theatres was a potential source of wound infection. However, in view of the unacceptable air contamination of the operating theatres, it is suggested that entry into and exit from the operating theatres during operations should be restricted. It is also suggested that periodic fumigation of the theatres particularly before neuro and thoracic surgeries should be carried out; while the architectural design and the use of the theatres should be looked into.

In the surgical wards, consistent higher counts in the evenings than in the mornings were obtained. These were attributable to the shedding of bacteria and disturbance of settled bacteria carrying particles by the many visitors to the pateients. The counts were within acceptable limits[5]. However, ward 4 which had the highest bacteria count (Table 4) and contained more pathogens (Table 5) than other ward recorded the highest distribution of post-operative infection rate (39.13%) than the other wards (Table 6). Eye ward, had the lowest bacterial carrying particles per cubic foot of air (Table 4) and the least number of pathogens (Table 5) and also had the lowest distribution of post-operative wound sepsis rate (Table 6). These findings indicate that the airborne contamination of the wards influences the post-operative wound infection rates.

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