

Brief Original Article

Reducing bacterial contamination in an Orthopedic Theatre ventilated by natural ventilation, in a Developing Country

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Abstract

Introduction: All surgical procedures have the potential for infection and some of the main sources are contamination from airborne particles, theatre personnel and the theatre environment. There is strong evidence that the use of ultra-clean air flow systems in orthopedic operating theatres reduces the incidence of deep sepsis after surgery. In the developing world however, this is often an unrealistic solution. The aim of this study was to establish baseline levels of contamination in a working orthopedic theatre, at the Queen Elizabeth Central Hospital, Blantyre, Malawi. To feedback results to the theatre team, promote infection prevention discussion and work with the team to implement workable and realistic goals to improve the intra-operative environment.

Methodology: Samples were collected from theatre equipment available at the time of surgery, from theatre water and theatre air using passive air sampling techniques. Samples were immediately transferred to the Central Microbiology Laboratory for culture on basic culture media.

Results: Bacterial contamination of theatre equipment, intra-operative theatre air and water was detected. Results were discussed with the theatre and infection prevention team who were receptive to feedback with regards to infection prevention strategies and keen to develop simple measures which could be put in place to change practice.

Conclusions: In this setting, we suggest that implementing workable and realistic goals such as, establishing baseline rates of bacterial contamination and introduction of strict protocols for asepsis and theatre etiquette, may reduce bacterial contamination rates and subsequent intra-operative infection in the absence of expensive engineering solutions.

Key words: Bacterial contamination; natural ventilation; orthopedic theatre.

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Introduction

Infections acquired in hospital are associated with significant morbidity [1]. Infections of the surgical site can result in extended length of stay, pain, discomfort and sometimes prolonged or permanent disability [1]. In developing countries this can lead to escalating, and in some cases, unaffordable hospital bills. All surgical procedures have the potential for contamination. In the developed world there have been significant advances in theatre design with the introduction of ultra clean laminar air-flow systems, with sterile hoods for orthopedic surgery, which provide ultra clean air into the theater environment. Studies suggest that this has drastically reduced intra-operative bacterial contamination rates [2].

In the developing world however, the use of expensive mechanical techniques is often an unrealistic goal. In these settings it is important to remember that the air flow into theatre is not the only

potential source of contamination. Other important sources of infection are; poorly decontaminated equipment, the theatre built environment, theatre utilities [3] and inappropriate staff behavior [4]. Skin cells are constantly shed from theatre personnel. These are small (5 –15 micron) particles, some of which will carry microcolonies (1–1,000 cells) of those bacteria that live on that person's skin. The more people in a space and the more they move, the greater the concentration of these contaminated skin scales ("squames") and the greater the distribution into the theatre environment.

In this study we sampled available theatre equipment, theatre air (using passive sampling techniques) and water using low cost methods, in a working orthopedic theatre (in the absence of mechanical ventilation). Our aim was to establish the baseline level of environmental contamination, to feedback results to the theatre team, promote infection

prevention discussion and work with the team to implement workable and realistic goals to improve the intra-operative environment.

Methodology

Setting

All samples were collected from Theater 4 (Orthopedics), at the Queen Elizabeth Central Hospital (QECH), Blantyre, Malawi. QECH functions as the teaching hospital for the College of Medicine and as tertiary referral hospital for the whole country. QECH is also the district Hospital for Blantyre, Malawi's largest city and Central Hospital for the southern region (population 7 million). The QECH has approximately 1,200 beds though often the number of patients far exceeds that and many wards have patients cared for on mattresses on the floor. Due to the shortage of trained nurses, basic day to day patient care is often provided by family members (known locally as guardians).

Environmental contamination

Theatre equipment

Theatre environment was analyzed by collecting swabs from various pieces of equipment used in the theatre [5]. Dry swabs were immersed in nutrient agar broth and used to directly swab a variety of environmental sample sites (figures 1,2). Each swab was used to sample one area.

Following collection, all swabs were immediately transferred to the Central Microbiology Laboratory (QECH) and directly plated onto separate blood and CLED agar plate. Plates were spread for discrete colony formation and incubated for 24 hours at 35°C.

Finger dab plates

In addition to sampling theatre equipment, finger dab plates were used to collect hand print samples from the surgeon [6]. The lid of the plate was lifted and the agar surface touched with the tips of all fingers of the surgeon, then the thumb (in the gap on the plate behind where fingers were tested). The lid of the plate was replaced. Plates were incubated for 24 hours at 35°C. Sampling took place at the end of the theatre session after skin closure.

Theatre Air Quality: passive air sampling

Settle plates were used to monitor theatre air quality in an empty theatre (30 minutes prior to theatre use) and during theatre use (whole of the operating session; 2 hours) [5]. To do this, blood agar plates were placed on a flat surface in the following test locations; 30cm in front of wall extract grill, window ledge, theatre

entrance, patient head of the operating area. Two agar plates were left exposed. One plate was exposed for 30 minutes with the theatre empty and a second separate plate was placed and left for the whole of the operating session, with the theatre in use. The lids were replaced and the plates returned to the laboratory immediately for incubation. Plates were incubated for 24 hours at 35°C. Any colony formation was counted and recorded.

Figure 1. Sample collected from the air extract grill¹ located in the far corner of theatre.



Figure 2. Samples were also collected from the theatre table², the traction table foam (not seen), the surgeons soap dish⁴, the operative theatre light handle⁵, the surgeons needle holder, the cauterization handle and the surgeon's scalpel blade.



Water quality

Water samples were collected using an accepted water sampling collection method [5]. Samples were collected in triplicate from the water tank and the tap water (Figure 3). One ml of water from each sample collection tube was transferred to a TSA agar plate, spread for discrete colony formation and incubated for 48 hours at 35°C. Any colony formation was counted and recorded.

Results

Environmental samples results

From the environmental samples collected there was contamination within the theatre environment with a variety of species (Table 1), however *Bacillus* species was isolated from the light handle, the traction foam and the air intake grill. On the operative table itself and the soap dish, a heavy growth of Gram negative organisms, including *Pseudomonas* sp, was detected. The ECG leads were found to be colonized with *Staphylococcus aureus*.

Theatre air samples: settle plates

Baseline bacterial colony counts in an empty theatre appeared to be reasonable (Table 2). Repeat bacterial colony counts in a working theatre are seen to increase.

Figure 3. Water samples were collected from the main water supply to the scrub area¹ and the emergency supply tank located in theatre².



This corresponds to an increased (and varying) number and movement of theatre personnel and equipment during the theatre working session.

Water results

The tank water result suggests contamination with Gram negative organisms (Table 3). The water collected directly from the tap was also contaminated

Table 1. Results of the environmental samples.

Location	Bacterial growth
Operative table	Heavy growth of coliforms including pseudomonas
Light handle	Heavy growth of bacillus species
Traction table foam (stored in sluice between patient use)	Moderate growth of bacillus species, scanty growth of micrococcus, scanty growth of unidentified fungus
Soap dish	Heavy growth of mixed Gram negative bacillus; non mucoid coliforms, mucoid coliforms, pseudomonas (green) – probable aeruginosa
Cautery handle (stored in sydex solution between patients)	No bacterial growth
ECG leads	Heavy growth of <i>Staph aureus</i>
Scalpel blade at (end of surgery)	No bacterial growth
Needle holder (end of surgery)	No bacterial growth
Air intake grill	Moderate growth of bacillus species
Finger dab plates	Scanty growth of <i>Staph aureus</i> and coagulase negative staphylococcus

Table2. Comparison of bacterial colony counts from an empty and in-use theatre.

Location	Sample environment			
	Empty theatre		Theatre in use	
	30 minutes exposure time	Ave Colony Count	2 hours exposure time	Ave Colony Count
Head of patient	8,7,8,	8	87,91,79	86
Air intake grill	16,14,17	16	120,110,105	111
Window ledge	5,5,5,	5	100,110,115	108
Theatre entrance	18,18,20	19	125,120,150,	131

Table 3. Results from water samples collected from the tap supplying the scrub sink and the emergency supply tank.

Location	Colony count (CFU) (samples collected in triplicate)		
Tank water	>500	>500	310
Tap water Direct	>500	>500	450
Tap water post faucet disinfection and 2 minute flush	20	<10	<10

with Gram negative organisms. The bacterial counts fall following disinfection of the faucet and a two minute flush.

Discussion

In this study, the baseline level of bacterial contamination of an orthopaedic theatre was determined using simple, adapted [5], detection methods and basic in-expensive equipment. Results indicate background contamination within the theatre environment, in particular with *Bacillus* species. The theatre is ventilated by “open window”, or natural ventilation methods. This means that rather than using expensive mechanical ventilation systems, air is drawn in to the theater through open windows and through an air intake grill in the far corner of theatre and circulated. No active filtration of the incoming air takes place. This inexpensive form of ventilation is often used in UK settings to ventilate non-critical hospital wards.

Bacillus species are ubiquitous environmental saprophytes that are found in water, vegetation and soil. They form endospores that tolerate extremes of temperature and moisture and are likely to be colonizing the ground and dusty areas outside the theatre, from where the air is being drawn in. *Bacillus* species are associated with various clinical infections including; intravascular or catheter associated infection causing bacteraemia and skin and soft tissue infection. Both of which would be important in the setting of an operating theatre where patients have exposed wounds. Blocking this intake grill was advised and the possibility of closing windows (temporarily), in particularly windy periods, was discussed. This may improve the quality of the air coming into the theatre, without the need for filtration, thereby stopping any airborne contamination from settling out in the open wound.

The baseline bacterial colony count detected from the passive air sampling when the theatre was empty appears to be low. Unlike for active air sampling [5], there are no pass/fail criteria for settle plates used in passive air sampling in operative theatres. There can be local traditions of using settle plates; in particular when there is a worry about environmental contamination. Their interpretation is however subjective. Repeat

testing while the theatre was in use shows an increase in bacterial colony count. This corresponds to an observed increase in movement of theatre personnel and equipment during the theatre working session. It is important for staff to be aware that excessive movement through an operative session is associated with increased shedding of skin squames and dispersal of dust or other particulate matter that may have settled on equipment. A strict theatre etiquette protocol was written. This included for example, ensuring that the amount of theatre traffic is kept to a minimum, restricting the number of personnel allowed in theatre to only those staff who are necessary for the surgical procedure and ensuring that the theatre door is kept closed whenever possible and not opened unnecessarily.

The results from the tank water result suggest contamination with Gram negative organisms. Stagnant water can harbor bacteria and this should be taken into account for surgeons/theatre staff when using this water to scrub or to decontaminate instruments. Samples taken directly from the mains (tap water) showed an unacceptable amount of contamination with Gram negative organisms. This contamination rate was reduced significantly once the faucet was decontaminated. This suggests that the contamination lies at the tap end rather than within the mains water system. A policy for decontamination which included decontamination of the taps along with the general theatre clean was devised. In addition, it was advised to avoid use of tank water wherever possible.

All results were fed back to and discussed with both the theatre team and the hospital infection control team. Staff were engaged and receptive to feedback with regards to infection prevention strategies and were integral in determining simple, in-expensive measures which could be put in place to change practice. Following on from this study, a hospital Infection Control Group was set up headed by the medical director. The group included representatives from theatre, infection prevention, cleaning services and the laboratory and the aim of the Group was to continue to monitor environmental contamination rates (including annual repeat environmental audits), but importantly to discuss and take forward issues such as; protocols for

cleaning, availability of disinfectants in the hospital, staff engagement in infection prevention issues and reporting of autoclave audits results. Following the study, the Group met with theatre staff to optimize environmental decontamination procedures.

Conclusions

In this setting, we suggest that implementing workable and realistic goals such as, establishing baseline rates of bacterial contamination, introduction and adherence to strict protocols for asepsis and theatre etiquette, may help to reduce bacterial contamination rates and subsequent intra-operative infections in the absence of expensive engineering solutions.

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