Sterile surgical helmet system in elective total hip and knee arthroplasty

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ABSTRACT

Purpose. To evaluate the sterility of the sterile surgical helmet system (SSHS) during elective total hip and knee arthroplasty in theatres with (n=20) and without (n=20) laminar flow.

Methods. Three surgeons performed 14 total knee arthroplasties (TKAs) and 6 total hip arthroplasties (THAs) in a laminar flow theatre and 15 TKAs and 5 THAs in a non-laminar flow theatre. An SSHS was used in all the procedures. Samples were taken from the hood at 30-minute intervals during surgery. Swabs were then broken into cooked meat broths for cultivation of organisms. The broths were then directly inoculated onto blood agar and fastidious anaerobic agar for culture of aerobic and anaerobic bacteria, respectively. After 24 hours, these plates were reinoculated with broths that had been incubated for 24 hours. Microbial growth was quantified as 0 (none), 1 (mild), 2 (moderate) and 3 (heavy). Bacterial contamination in the 2 groups at 30, 60, and 90 minutes was compared.

Results. Respectively in the laminar and non-laminar flow theatres, 0 and 9 of the SSHSs showed bacterial growth after direct inoculation, and 14 and 18 of the SSHSs grew 18 and 24 types of organisms in the swab cultures after 24 hours of incubation. Respectively at 30, 60, and 90 minutes, the degree of contamination from direct incubation was significant, but the degree of contamination on swabs after 24 hours of inoculation was not significant. The mean time-dependent contamination after direct inoculation was 0 for the laminar flow group and 0.5, 0.75, and 1.0 for the non-laminar flow group, whereas the corresponding values after 24 hours of incubation were 1.8, 1.8, and 2.6, and 2, 2.75, and 2.95. Coagulase negative Staphylococcus aureus was the most common organism in both groups.

Conclusion. 80% of SSHSs used were contaminated intra-operatively. Direct contact with the SSHS should be avoided by the operating team during surgery. Routine changing of gloves in case of contact with the SSHS should be practised.

Key words: arthroplasty, replacement; environment, controlled

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INTRODUCTION

Deep periprosthetic infections occur in one to 2% of patients undergoing total hip arthroplasty (THA) and 2 to 4% of those having total knee arthroplasty (TKA). This results in multiple surgeries, prolonged hospital stay, increased expenses, and compromised functional outcomes. Identifying the possible sources of infection minimises the risk of joint infection. Measures to reduce infection risks entail lowering theatre traffic, using laminar flow, preoperative antibiotics, face masks, body exhaust suits, and/or sterile surgical helmet system (SSHS). The SSHS comprises an unsterile helmet covered with a sterile visor mask hood and is presumed sterile; routine change of gloves is not practiced in case of contact with the SSHS. We evaluated the sterility of the SSHS during elective total hip and knee arthroplasty in theatres with (n=20) and without (n=20) laminar flow.

MATERIALS AND METHODS

Between October 2009 and February 2010, 3 surgeons performed 14 TKAs and 6 THAs in a laminar flow theatre and 15 TKAs and 5 THAs in a non-laminar flow theatre. A sterile surgical helmet system (SSHS) [Stryker Sterishield personal protection system; Stryker Medical, New Jersey, USA] was used in all the procedures. The SSHS comprised an unsterile helmet with a built-in fan for ventilation covered with a sterile visor mask hood. The unsterile helmet was worn before scrubbing, and the sterile hood was applied by an unscrubbed nurse prior to the surgery. Theatre traffic was kept to a minimum and comparable in both groups. A medial parapatellar approach under tourniquet control was used in all TKAs. The Hardinge approach in a lateral position was used in all THAs. This study was approved by the ethics committee of our hospitals.

Figure  Steps during swab processing
Samples were taken from the hood at 30-minute intervals during surgery and at the end by swabbing 6 times from top to bottom and another 6 times from left to right. Each swab was taken by an unscrubbed member after scrubbing and donning sterile gloves to minimise any contamination.

Swabs were then broken into 20 ml cooked meat broths (enrichment media for cultivation and storage of anaerobic and aerobic organisms). The broths enable bacterial growth from very small inocula and maintain the viability of cultures over long periods of time. The broths were sealed, labelled, and transported to the microbiology department for culture after the procedure.

To evaluate the bacterial load on the original swabs, the broths were then directly inoculated onto blood agar and fastidious anaerobic agar for culture of aerobic and anaerobic bacteria, respectively. Each culture agar was divided into 3 segments, and each segment was inoculated with 50 µl of the cooked meat broth, with each inoculum kept separately (Fig.). The blood agar plates were incubated at 37°C in CO2 and the fastidious anaerobic agar plates in an anaerobic cabinet for 24 hours. This enabled optimum growth of any small bacterial inocula (which may not have been isolated from direct inoculation) and isolation of any anaerobic pathogens (which may be slow growing and missed). After 24 hours, these plates were reincubated with 50 µl of broth that had been incubated for 24 hours and were sub-cultured (inoculation after 24-hour incubation). Blood agar plates were left for 48 hours and fastidious anaerobic agar plates were left for 5 days to assess any growth of aerobic and anaerobic bacteria, respectively (Fig.). Microbial growth was quantified as 0 (none), 1 (mild), 2 (moderate) and 3 (heavy).11

Bacterial contamination in the 2 groups at 30, 60 and 90 minutes was compared using Mann-Whitney U test. A p value of <0.05 was considered statistically significant.

RESULTS

Respectively in the laminar and non-laminar flow theatres, 0 and 9 of the SSHSs showed bacterial growth after direct inoculation, and 14 and 18 of the SSHSs grew 18 and 24 types of organisms in the swab cultures after 24 hours of incubation (Table 1). Respectively at 30, 60, and 90 minutes, the degree of contamination from direct incubation was significant (Mann-Whitney $U=130.0$, $p=0.004$; and $U=130.0$, $p=0.004$; and $U=100.0$, $p=0.0001$), but the degree of contamination on swabs after 24 hours of inoculation was not significant (Mann-Whitney $U=180.0$, $p=0.29$; $U=145.5$, $p=0.066$; and $U=126.5$, $p=0.41$) [Table 2].

The mean time-dependent contamination after direct inoculation was 0 for the laminar flow group and 0.5, 0.75, and 1.0 for the non-laminar flow group, whereas the corresponding values after 24 hours of incubation were 1.8, 1.8, and 2.6, and 2.2, 2.75, and 2.95 (Table 2). Coagulase negative Staphylococcus aureus was the most common organism (83% and 71% in the respective groups) [Table 1].

DISCUSSION

Deep periprosthetic infection is devastating for both patients and surgeons.6,7 Understanding the source of bacterial contamination and its mode of transmission is important to minimise patient morbidity, length of hospital stay, and medical expenses.1 Early postoperative infection (within 6 months) is most likely due to microbial contamination in theatre,12 Contamination during surgery can lead to subclinical or late infection, especially around joint prostheses.13,14

Possible sources of contamination have been identified and changes (use of laminar flow theatres, sterile hoods, and body-exhaust systems) have been instigated.2–10 The infection rate of THA decreased to 1% from 7% after the use of clean-air operating theatres.12

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Organisms cultured from swabs</th>
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<tbody>
<tr>
<td><strong>Laminar flow theatre</strong></td>
<td><strong>Non-laminar flow theatre</strong></td>
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<tr>
<td>Coagulase negative Staphylococcus aureus (n=15)</td>
<td>Coagulase negative Staphylococcus aureus (n=17)</td>
</tr>
<tr>
<td>Streptococcus anginosus (n=2)</td>
<td>Diptheroids (n=3)</td>
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<tr>
<td>Streptococcus oralis (n=1)</td>
<td>Bacillus species (n=1)</td>
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<tr>
<td>Proteus species (n=1)</td>
<td>Streptococcus oralis (n=1)</td>
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<td>Escherichia coli (n=1)</td>
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<thead>
<tr>
<th>Table 2</th>
<th>Bacterial growth in laminar and non-laminar flow theatres</th>
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<tr>
<td><strong>Swab</strong></td>
<td><strong>Mean degree of contamination</strong></td>
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<tr>
<td></td>
<td><strong>Laminar flow theatre</strong></td>
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<tr>
<td>After direct inoculation</td>
<td></td>
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<tr>
<td>30 minutes</td>
<td>0</td>
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<tr>
<td>60 minutes</td>
<td>0</td>
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<tr>
<td>90 minutes</td>
<td>0</td>
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<td>After 24-hour incubation</td>
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<tr>
<td>30 minutes</td>
<td>1.8</td>
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<tr>
<td>60 minutes</td>
<td>1.8</td>
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<td>90 minutes</td>
<td>2.6</td>
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Bio-aerosols are implicated in the transmission of nosocomial pathogens. They increase the rates of air contamination and wound infection. Most pathogens responsible for contamination are commensals present on the skin. Bacteria on skin surfaces, lint, and dust become aerosolised and settle on sterile surfaces. The number of microbes present in the operating room is directly proportional to the number of personnel within, around, and moving in and out of the theatre room. Around 30% of operating room staff carry *Staphylococcus aureus*. An outbreak of Streptococci from operating room personnel to patients has been reported. The source of microbial contamination is 2% from the patient’s skin and 98% from the skin of theatre staff; 30% of such contamination instances occurred through air and 70% via hands of surgical personnel. 29% of gloves used during preparation, 20% of collection bags, 17% of theatre gowns, 14% of light handles, 11.4% of sucker tips, and 9% of skin blades get contaminated during surgery. Therefore, theatre personnel should use over-gloves to hold legs while preparing, discard any object coming in contact with the collection bag, wear waterproof gowns, use a sterile cloth to manipulate the light handle (and discarded it afterward), change the tip of the catheter before preparation of the femoral canal, and turn the suction off when it is not in use.

In our study, 80% of SSHSs used were contaminated intra-operatively. Sterile hoods got contaminated as early as 30 minutes and most showed heavy growth of skin commensals. Initial bacterial load was higher in non-laminar flow theatres; after 24 hour of incubation bacterial load was slightly higher in non-laminar flow theatres. The SSHS is unable to protect patients from reverse splash (the falling of bony particles or tissues into the surgical field after hitting a visor mask of SSHS). The continuous passage of air through the SSHS may also lead to contamination. The higher and earlier contamination rates in our study was probably due of the more sensitive culture techniques used and the larger surface area for bacteria to congregate around the SSHS. Direct contact with the SSHS should be avoided by the operating team during surgery. Routine changing of gloves in case of contact with the SSHS should be practised.

Our study was limited by the small number of samples. Potential source of contamination was not identified (commensals from the patient or any theatre personnel). We did not swab everyone in the theatre owing to limited resources. This may have revealed differences in the level of potential contamination from different personnel. Whether high levels of contamination translate into high rates of post-operative infection was not studied. The clinical implication of the contaminated SSHS with respect to wound infections is multifactorial and depends on intrinsic (patient risk factors) and extrinsic (type of antibiotics at induction, surgical technique) factors.

REFERENCES