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An *in vitro* evaluation of bacterial penetration through different kinds of surgical drapes

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Abstract:

PURPOSE: Surgical site infection is a major cause of increased post-operative morbidity. The surgical drape functions as a barrier between the surgical field and the potential sources of microorganisms in the environment and operating room personnel. The extent to which the materials act as barrier depends on the closeness of the weave and water-resistant properties of the fabric. This is an *in vitro* study to evaluate the ability of different types of surgical drapes to prevent bacterial strike through.

MATERIALS AND METHODS: Four types of fabrics used as surgical drapes were tested for their ability to prevent strike through when exposed to different bacteria for varying spans of time. We tested the drapes with *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa.*

RESULTS: Drapes made of cotton (CC) or polyester-cotton (PC) textile exhibited least resistance to bacterial penetration. Disposable woven continuous filament polyester fabrics showed better resisting powers. The disposable non-woven polythene fabrics were found to resist bacterial penetration most effectively. The penetration through the woven fabrics was found to be dose- and time-dependent.

CONCLUSION: The practice of using reusable textile clothes as surgical drapes should be discontinued and be replaced by non-woven seamless disposable fabric. Surgical drapes should be tested for their penetrability before introducing in operation theatre.

Keywords:

Bacterial penetration, surgical drapes, surgical site infection

Introduction

Surgical site infections (SSIs) are one of the major causes of post-operative morbidity. The importance of techniques and procedures to minimise SSI cannot be overemphasised. All preventive measures starting from operation theatre (OT) room sanitisation and surgical scrubbing to a clean, aseptic operation procedure and antibiotic prophylaxis are aimed to achieve this goal. However, SSI continues to be a major cause of post-operative morbidity. The burden of SSI in developed countries is estimated to be around 1.9%–5% of the in-patient surgeries[1,2] and contributing to 31%–38% of all nosocomial infections.[2,3] It is much more in resource-constrained developing countries where modern methods are unaffordable or unavailable. In India, various studies had put the incidence between 2.5 and 41.9%.[4,5] In addition to increased morbidity and surgical failure, post-operative wound infections may also lead to an increase in the length of hospital stay of the patient and may be a cause of economic burden to the patient.[6] One of the sources of infection that can occur during the operation procedure is through the surgical drapes.[1,7,8] The following *in vitro* study was undertaken in a tertiary healthcare teaching hospital to evaluate the ability of different types of surgical drapes to prevent bacterial strike through.

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Materials and Methods

Aim

The aim of this is to evaluate four different kinds of surgical drapes for their ability to resist bacterial penetration using different bacterial strains.

A method adopted by Blom *et al*. was used with a little modification.[9,10] The different types of drapes used were tested for their ability to resist penetration by different types of bacteria on exposure to variable spans of time.

Fabrics tested

Surgical drapes made of four types of fabrics were used for this study: (1) Woven cotton, reusable, textile fabric, washed and autoclaved (CC), (2) Woven polyester – cotton, reusable, textile fabric made of 50% polyester and 50% cotton, washed and autoclaved (PC), (3) Woven, disposable, sterile, continuous filament polyester (PS) and (4) Unwoven, disposable, sterile polyethylene (PE) fabric. Under sterile precaution, each of the fabrics was cut into sizes sufficient to cover surface of 50-mm diameter Petri dish.

Test bacteria

Most of the SSIs are caused by staphylococci, *Pseudomonas* and members of the Enterobacteriaceae family. Hence, we have chosen representative members of these organisms. Fresh broth cultures of *Staphylococcus aureus* (ATCC 25923), *Pseudomonas aeruginosa* (ATCC27853) and *Escherichia coli* (ATCC25922) in peptone water were prepared. They were serially diluted to achieve concentrations of 1×10^5, 1×10^6 and 1×10^7 colony-forming unit (CFU)/mL for each bacterium just before inoculation.

Culture media: We used Petri dishes of 50-mm diameter filled with nutrient agar to half thickness and next filled to the brim with 5% sheep blood agar (BA). A set of 3 Petri dishes were assigned and labelled for a single bacterial concentration to be used for a single fabric. One each of the Petri dishes was earmarked for an exposure time of 30, 60 or 90 min. In total, 108 bilayer Petri dishes were used for a single test run.

Test procedure: Each fabric was tested for different concentrations of test organisms by exposing them to different time spans. The method is illustrated in Figure 1. Pieces of each fabric were placed on BA surfaces of 27 plates (arranged in a 3 × 9 panel). Each of the concentrations was inoculated onto a set of 3 Petri dishes. To inoculate, 100 µl of the broth culture from each bacterial aliquot was dispensed evenly on the fabric spread over the BA surface. After 30, 60 and 90 min of exposure time the fabrics from respective plates were removed and the Petri dishes were covered with a lid and incubated at 37°C. On completion of 24 h of incubation, the Petri dishes were inspected for growth of bacteria. The growths were graded into a scale of "-," 1+, 2 + and 3+ ("-" = no growth, "1+" = 1–10 colonies, "2+" = >10colonies, but are separate and "3+" = confluent colonies). The test process was repeated to verify reproducibility of the results.

Results

The results are summarised in Table 1. It was observed that the bacterial strike through in the fabrics made of PE is nil even for long duration of time (90 min). Fabrics made of woven PS were able to resist bacterial penetration satisfactorily for short durations (30 and 60 min) but showed some degree (1+) of penetrability when the exposure time is increased to 90 min. The textile fabrics made of CC or PC offer little or no resistance. CC fabrics are least satisfactory among all resisting only low concentration (10^5 CFU/ml)) of *Staphylococcus aureus* for 30 min. Woven PC is relatively better than CC when the duration of exposure is small, for example, 30 min, but on long-duration exposure, it behaves similar to CC. All the woven fabrics allowed passage of bacteria tested when exposed in high concentration for longer duration.

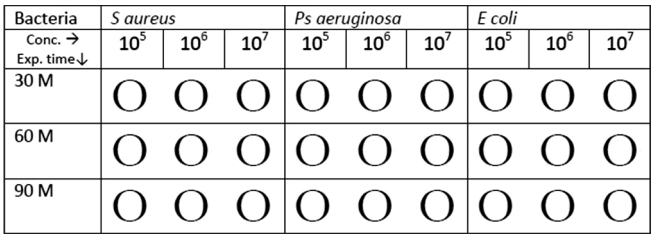

Figure 1: Illustration of procedure for testing a fabric; bacterial concentration in colony-forming unit, exposure, minutes and circles represent Petri dishes

Table 1: Penetration of different bacteria through 4 types of drapes with respect to bacterial concetration and time of exposure

Fabric	Exposure time	Bacteria								
		Staphylococcus aureus			*Pseudomonas aeruginosa*			*Escherichia coli*		
		Conc.								
		10^5	10^6	10^7	10^5	10^6	10^7	10^5	10^6	10^7
CC	30 min	-	+	++	+	++	++	+	++	++
	60 min	++	++	+++	++	++	+++	++	++	+++
	90 min	++	+++	+++	++	+++	+++	+++	+++	+++
PC	30 min	-	-	+	-	+	++	+	++	+++
	60 min	+	+	++	++	++	+++	++	++	+++
	90 min	++	++	+++	++	+++	+++	++	+++	+++
PS	30 min	-	-	-	-	-	-	-	-	-
	60 min	-	-	-	-	-	-	-	-	+
	90 min	-	-	+	-	+	+	-	+	+
PE	30 min	-	-	-	-	-	-	-	-	-
	60 min	-	-	-	-	-	-	-	-	-
	90 min	-	-	-	-	-	-	-	-	-

Conc. - Concentration of bacteria in unit of CFU/ml; CC: Cotton; PC - Polyester + Cotton; PS - Continuous filament Polyester; PE - Polyethylene; CFU - Colony forming units, -: No bacteria grown, +:<10 cfu/surface, ++: >10 cfu/surface with separated colonies, +++:>10 cfu/surface with confluent colonies

Among the tested bacteria *Escherichia coli* and *Pseudomonas aeruginosa* showed no difference in their penetrability behaviour; whereas *Staphylococcus aureus* was relatively less penetrating than them. Again, as the concentration of bacteria increases from 10^5 to 10^7 CFU the bacterial strike through rises proportionately.

Discussion

The above results show that woven and reusable textile fabrics made of CC or polyester – CC offer little resistance to bacterial strike through. This was understandable because of the existence of pores in woven fabrics. The disposable woven, PS fabrics have better resisting powers than the reusable textile fabrics; this may be due to the relatively smaller pore size of the continuous filament fabric. Plastic drapes made of PE are good barriers. This is probably due to the non-porous nature of these materials and the hydrophobic or non-wettability nature of these fibres – more wettable the drape more chance of bacterial strike through. Furthermore, it can be inferred that the amount of bacterial strike through was time- and dose-dependent, particularly when using the woven materials. Longer exposure time or higher bacterial concentration increases the bacterial penetration. We have observed that *Escherichia coli* and *Pseudomonas aeruginosa* showed more penetrability than *Staphylococcus aureus*. This might be related to the motility of these bacteria; motile bacteria being on a more advantageous position.

Surgical attire is intended to function as a barrier between the surgical field and the potential sources of microorganisms in the environment.[3-6] The primary purpose of draping the patient is to isolate the surgical site from other areas of the patient's body, the non-sterile sites of the operating table and the operating team personnel to reduce the risk of SSI.[7] It also performs an additional function of protecting the operator from exposure to blood or body fluids of the patients. Draping not only protects the sterile site but also expands the sterile field allowing the surgical team to place the sterile instruments and supplies on the drapes.[7,8]According to studies by Mackintosh *et al*. and Blom *et al*. the extent to which the materials used for gowns and drapes acts as a barrier depends on the closeness of the weave and water-resistant properties of the fabric.[8-10] Wetting of the drapes by blood, body fluid or saline has been shown to further increase the bacterial strike through. Repeated laundering and autoclaving also decrease the barrier effectiveness of reusable woven fabric.[7,9-12] Although currently many types of impervious and disposable surgical wears and drapes are available in the market, the traditional woven and reusable cloths are still widely used, particularly in peripheral and rural healthcare centres. In resource-poor clinical settings, reusable CC sponges are in use to soak any bleeding or discharge from the operation site. This subjects the patient to potential hazards of cross infection and can lead to SSIs by nosocomial bacteria which are more resistant to antibiotics. Our study is in agreement with the findings of Mackintosh *et al*. and Bloom *et al*.[9,10,12]

Garibaldi *et al*., in a controlled clinical trial had taken 2 groups (1st group using woven reusable drapes and the 2nd group using non-woven disposable drapes) and studied their ability to act as a barrier to intraoperative wound contaminations. They had observed that there was no difference between the two study groups in either the frequency or level of intraoperative wound contamination as judged by cultures of specimens collected at the time of wound closure.[13] However, that study did not take into account the chance of infection arising from environmental bacteria that can strike through the drapes. We had taken *Pseudomonas aeruginosa* as a test organism which is one of the dreaded causes of nosocomial infection and is commonly present in the hospital environment, rather than as a normal microbial flora of patients. The duration of the operation procedure and the bacterial load in the environment are other factors which can affect the degree of penetration.

Conclusion

The practice of using woven fabric as surgical drapes or gowns should be discontinued and should be replaced by sterile, non-woven, lint-free and disposable fabric. They should be impervious and free of tears, punctures or holes.[14] Although the use of non-woven seamless disposable fabric will increase the initial cost to the patient, this cost will be likely offset by reducing the risk of SSI, limiting the hospital stay and the associated human-hour and financial loss. We suggest that in operations of long duration, changing the soiled drapes should be considered. Drapes should also be rigorously tested for their bacterial penetrability before being introduced in the OT.

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Conflicts of interest
There are no conflicts of interest.

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