Investigating bacterial growth in surgical theatres: establishing the effect of laminar airflow on bacterial growth on plastic, metal and wood surfaces

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ABSTRACT

INTRODUCTION Infection is a devastating complication of surgery. Intra-operative wound contamination is a common cause of infection. A number of measures have been effective in reducing wound contamination. One such measure is laminar flow. Controversy exists as to whether it is safe to keep open instruments and implants outside the laminar flow. This study compares bacterial contamination of wood, plastic and stainless steel within and outside the laminar flow.

MATERIALS AND METHODS Identically shaped and sized tiles were left for 90 min within and outside the laminar flow and then cultured for bacterial growth.

RESULTS A third of metal and plastic tiles were contaminated, but only 10% of wooden tiles, suggesting that wood is a more hostile environment for bacteria. There was no difference in contamination between tiles placed inside and those placed outside the laminar flow.

CONCLUSIONS This study suggests that placing instruments and implants outside the laminar flow is a safe practice.

KEYWORDS

Infection control – Laminar flow – Surgical theatre – Surface growth

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Although the rate of infection in surgery has decreased, it still occurs,^{1,2} often with devastating clinical and financial repercussions. Dregghorn *et al.*³ found that it is four times more expensive to treat an infected total joint arthroplasty than to perform the primary total joint replacement. Sepsis following arthroplasty is directly related to environmental bacterial contamination of implanted foreign material. In man, 10^6 staphylococci are needed to cause a skin infection but, in the presence of a suture, only 10^2 organisms are needed;⁴ thus, the importance of aseptic technique and a sterile environment are evident.

The use of laminar airflow to produce ultraclean air in orthopaedic theatre has been demonstrated to decrease postoperative infection rates, but does not eliminate it completely.⁵ Sepsis may be the result of bacteria from the air settling directly onto the wound site; however, evidence suggests that contamination of the wound is more likely to occur from bacterial transfer directly from operating personnel and contaminated instruments.⁶

Although, in theory, improvements in technology ought to have resulted in decreased infection rates, there has been

a concurrent laxity in adherence to theatre protocol which has not always led to this in practice.⁷

Another possible reason for such failure could be that, in many theatres, instruments are prepared before surgery in conventionally ventilated preparation rooms and are contaminated at this stage.⁸ In 1993, Taylor and Bannister⁹ performed an experiment looking at bacterial growth on agar plates inside and outside the ultraclean zone. They found that plates outside the ultraclean zone had a mean bacterial count of 3.43 colonies per plate, which was 10 times more than in the ultraclean zone ($P < 0.001$).⁹ This supports research carried out by Chosky *et al.*,⁸ who found that preparation of instruments in an ultraclean air theatre, and subsequent covering before use, reduced bacterial fallout rates 28-fold as opposed to the same preparation and cover of instruments in conventionally ventilated preparation rooms. In this experiment, all measurable bacterial fallout was determined to have occurred during the setting-up and not during surgery.

However, later research carried out by Blom *et al.*¹⁰ found that, when stainless steel clips were placed in these

Table 1 Number of contaminated tiles

Material	Inside laminar flow	Outside laminar flow
Wood	2 of 15	1 of 14
Plastic	5 of 15	5 of 15
Metal	5 of 14	4 of 15

same two environments, there was no difference in bacterial growth rates between the two environments. One explanation offered for this is that surgical stainless steel is a more hostile environment to staphylococci, thus bacterial colonisation occurred neither inside nor outside the laminar airflow zone.

The primary aim of this study was to establish whether the rates of bacterial contamination of metal, wood and plastic surfaces are influenced by their positioning inside or outside laminar airflow. The secondary aim was to determine which materials are the more hostile to bacterial contamination.

The results of this experiment could be used to determine whether it is safe practice to keep surgical instruments outside the laminar airflow area in theatre.

Materials and Methods

Thirty tiles measuring 70 x 70 x 5 mm were cut from oak ($n = 10$), stainless steel ($n = 10$) and high-density polyethylene ($n = 10$). These materials were chosen as they are commonly used to manufacture surgical instruments or implants. Tiles of each type were cut in the same orientation from the same original piece of wood, stainless steel and high-density polyethylene, respectively. The resulting tiles were then washed and sterilised using conventional steam sterilisation techniques.

The tiles were divided into two groups; each group consisted of five oak tiles, five stainless steel tiles and five polyethylene tiles. The tiles were kept sterile in their packaging and taken into theatre. Group 1 was opened and placed inside the laminar flow area and group 2 was opened and placed 1 m outside the laminar flow area for 90 min, which was deemed to be the average duration of total hip or knee arthroplasty. Surgery did not take place in the theatre for the duration of the experiment, but three people were within the laminar flow throughout. Experimenters were fully scrubbed and adhered to techniques of asepsis in order to avoid direct contamination of the plates. At the end of the 90 min, the tiles were collected and the upper surface imprinted on sterile 5% blood-agar plates for 10 s. The plates were incubated at 37°C for 24 h and then inspected for bacterial growth. The entire experiment was then repeated twice to

Table 2 Comparison of wood versus plastic using Chi-squared test

Material	Contaminated tiles (n)	Total tiles (n)	Contamination (%)
Wood	3	29	10.3
Plastic	10	30	33.3

SE = 10.3; 95% CI = 28.0–43.2; $P = 0.028$

Table 3 Comparison of wood versus metal using Chi-squared test

Material	Contaminated tiles (n)	Total tiles (n)	Contamination (%)
Wood	3	29	10.3
Metal	9	29	30.1

SE = 10.3; 95% CI = 0.6–40.8; $P = 0.046$

Table 4 Comparison of plastic versus metal using Chi-squared test

Material	Contaminated tiles (n)	Total tiles (n)	Contamination (%)
Plastic	10	30	33.3
Metal	9	29	30.1

SE = 12.2; 95% CI = –21.6 to 26.2; $P = 0.424$

Table 5 Comparison of tiles inside and outside the laminar flow using Chi-squared test

Laminar airflow	Contaminated tiles (n)	Total tiles (n)	Contamination (%)
In	12	44	27.3
Out	10	44	22.7

SE = 9.22; 95% CI = –13.5 to 22.7; $P = 0.689$

give a total of 45 (15 wood, 15 plastic and 15 metal) plates from within the laminar flow and 45 from outside the laminar flow.

Results

The results are summarised in Tables 1–5. Two plates were lost. All contaminated tiles grew between 1–5 colony forming units.

Discussion

This study demonstrated no significant difference between tile contamination inside and outside the laminar airflow area. These results support the conclusion reached by Blom *et al.* in 1998.¹⁰

Though other studies have shown a difference in contamination of agar settle plates inside and outside the laminar airflow zone, it would seem that the materials of which our tiles were made are a more hostile surface for colonisation than the agar settle plates. These are the same materials that surgical instruments are made of. Often in major surgery with multiple instruments trays there is insufficient space to keep all the open sets of instruments within the laminar flow. Based on these data, it would be reasonable practice to keep sterile instruments in theatre, but not within the laminar flow area. It may be that this study is underpowered to detect a true difference. However, fewer tiles were contaminated outside the flow than in. This study can be used as a pilot to power a larger study.

This study is an experimental model trying to replicate a clinical scenario and, as such, has a number of inherent flaws. These include the lack of a patient, the absence of theatre traffic (people popping in and out of theatre and not adhering to theatre protocols) and the lack of aerosolised blood and fluid as would be generated in a normal orthopaedic theatre.

The agar plates impregnated from the contaminated tiles grew a very low number of colony forming units of bacteria. However, a very small inoculum is needed to cause infection in the presence of implanted materials such as hip and knee implants. Incubation for longer may have yielded higher growths.

Wood appears to be a more hostile environment to bacteria than polyethylene or stainless steel. This may be due to the antiseptic properties of the natural oils in the wood. Wood is porous and thus impossible to decontaminate and sterilise. Despite this, it is still sometimes used to construct instruments used intra-operatively and thus we have addressed it here.

Conclusions

We feel that this study supports as safe, the practice of preparing instruments and implants in theatre outside of the laminar flow area.

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