A comparison of airborne bacterial fallout between orthopaedic and vascular surgery

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ABSTRACT

INTRODUCTION The objective of the study was to compare bacterial fallout during vascular prosthesis insertion and orthopaedic major joint replacement performed in conventional and laminar flow ventilation, respectively.

MATERIALS AND METHODS A prospective single-centre case control study of 21 consecutive elective vascular procedures involving prosthetic graft insertion and 24 consecutive elective orthopaedic major joint replacements were tested for degree of bacterial fall-out using agar settle plates. Preparation time, waiting time and total procedure duration were collected at the time of surgery, and bacterial colony counts on the agar settle plates from airborne bacterial fallout were counted after an incubation period.

RESULTS Bacterial fallout count in vascular prosthetic graft insertion was 15-fold greater than in orthopaedic prosthetic joint insertion (15, (IQR 15) vs 1, (IQR 3) respectively, $P < 0.0001$, Wilcoxon). Waiting time and patient transfer did not significantly increase bacterial fallout counts during the procedure ($P = 0.9$).

CONCLUSIONS Vascular surgical theatres have significantly higher bacterial fallout compared with orthopaedic theatres. This may be partly explained by orthopaedic surgery being routinely performed in laminar flow ventilation, a practice which has not been widely adopted for vascular surgery, in which prosthetic infection may also result in significant mortality and morbidity.

KEYWORDS

Vascular – Prosthesis – Infection – Airborne – Ventilation

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Introduction

Although prosthetic vascular graft infection is not common (a 5-year retrospective study found an infection rate of 1–6%),¹ graft infection can have catastrophic consequences, with the majority of patients having an increased length of stay and long antibiotic courses. Treatment typically involves graft excision, which when in the abdominal aortic carries a mortality of over 50%² and when in the peripheries carries a significant risk of morbidity, including amputation. Risk factors for graft infections include immunodeficiency (17.7%), multiple interventions in the postoperative period (26%)³ and the site of the graft. The highest risk is seen in grafts involving the groin (up to 6%).¹ In the majority of cases, graft infection occurs at the time of implantation or at the time of a subsequent procedure involving the graft, such as revision or repair.¹ Many strategies are used to minimise surgical site infection, such as antibiotic prophylaxis, wound washout, aseptic techniques, antimicrobial containing grafts and antibiotics beads. Any method to minimise surgical site infection in vascular surgery should therefore be scrutinised, to minimise morbidity and mortality for this typically high-risk cohort of patients.

Several pathogens have been identified in graft infection, including *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Escherichia coli*, isolated in 60% of cases of vascular prosthesis infections. The remainder of these cases have been attributed to organisms including *Pseudomonas*, *Klebsiella*, *Proteus*, *Enterobacter*, *Bacteroides*, nonhaemolytic streptococci and occasionally yeast.⁴

A reduction in bacterial contamination during graft insertion has been shown to reduce infection rates and could potentially be achieved by more frequent air changes,⁵ which occur during laminar flow. The use of laminar flow in orthopaedic procedures has been shown to dramatically reduce bacterial fallout during joint replacement surgery as much as four-fold,⁶ yet in vascular surgery laminar flow is rarely employed.

This study aimed to compare bacterial fallout during vascular operations involving graft insertion, performed in normal theatre ventilation with bacterial fallout during major joint replacement surgery performed in laminar flow ventilation.

Materials and Methods

This study involved no patient information, so ethical approval was not required. The study was approved by Colchester Hospital Research Department. Procedures were divided into two groups, study and control. In the study group, data were collected prospectively in 21 consecutive patients undergoing open elective vascular procedures in which a prosthetic graft was inserted. These included open abdominal aortic aneurysm repair ($n = 1$), aorto bi-femoral graft ($n = 1$), fem-popliteal bypass ($n = 1$), fem-distal bypass ($n = 7$), fem-fem crossover ($n = 3$) and carotid endarterectomy with patch ($n = 11$). The control group consisted of 24 patients undergoing major elective joint replacements, including total hip replacement ($n = 15$), revision of total hip replacement ($n = 1$), total knee replacement ($n = 7$) and elbow joint replacement ($n = 1$). Vascular procedures were performed in conventional plenum ventilation, while joint replacements were performed in exponential laminar down-flow ultraclean air ventilation. Instrument preparation was similar in both groups using in-house sterilisation services.

Bacterial fallout was estimated using 10 agar settle plates, 9 cm in diameter. These plates were placed on the surgical instrument trolley to assess potential contamination of the instruments used during the procedure. In both study and control groups the plates were divided into three subgroups. Group A consisted of two internal control plates, which remained closed at all times. Group B consisted of four plates that were opened only during instrument preparation and surgical procedure and were covered during patient transfer. Group C consisted of four plates that were opened throughout instrument preparation, patient transfer and surgical procedure. All plates were analysed by the in-house microbiology department after incubation at 37°C for 48 hours. Bacterial colony counting was performed by an independent assessor with no prior knowledge of group allocation, using number of colony forming units, as per Pasquarella et al.⁷ Instrument preparation time, transfer time and the duration of the surgical procedure were recorded at the time of surgery.

Data were non-parametric and were therefore compared using the Wilcoxon rank sum test. Linear regression was performed to determine a relationship between time and bacterial fallout and a correlation coefficient calculated. Data were analysed using R-statistics (GNU) and Rkward package under the GNU general public licence.

Results

Data were collected from 21 open vascular cases (study) and 24 orthopaedic major joint replacement cases (control). There was no significant difference in the mean age of the orthopaedic cohort compared with the vascular cohort ($P = 0.4$); the mean age of the orthopaedic group was 3 years older than that of the vascular cohort (75 years vs 72 years). There was a slightly longer preparation time in the vascular cohort of 30 minutes (interquartile range, IQR, 18–36 minutes) compared with 25 minutes (IQR 20–30 minutes) for the orthopaedic cohort but a shorter wait time of 8

minutes (IQR 0–36 minutes) compared with 15 minutes (IQR 4–20) for the orthopaedic cohort. The median operative time was higher in the vascular cohort at 170 minutes (IQR 160–222 minutes) compared with 87.5 minutes (IQR 69–106 minutes) for the orthopaedic cohort and median total time was also higher, at 229 minutes (IQR 190–284 minutes) compared with 125 minutes (IQR 110–141 minutes), $P < 0.001$.

Bacterial fallout in the study group was 15-fold greater in the study group (B and C) compared with the control group (A; 15, IQR 15 vs 1, IQR 3) respectively, $P < 0.0001$, Wilcoxon (Fig 1a). Between the two study groups, B and C, which differed only in that plate B was closed during patient transfer, there was no difference between the subgroups (Fig 1b), indicating that there was no significant bacterial fallout during patient transfer (group B plates 4, IQR 12; group C plates 4, IQR 13, $P = 0.9$). Median bacterial count for control group (plates A) was zero.

There was a weak but significant correlation of bacterial fallout with time when data from all plates and both theatres was combined ($R^2 = 0.136$, $P = 0.001$). However there was no significant correlation between operative time and bacterial fallout out in either the vascular or orthopaedic cases individually.

Discussion

Laminar flow ventilation has been conducted for the past 50 years and it has been shown to reduce surgical site infection in several specialities.^{8–10} It is therefore now commonplace for new theatres to be constructed with laminar flow but the majority of vascular theatres do not have this capability. With the widespread uptake of vascular hybrid theatres, with the addition of C-arms and screens, they would be at higher risk of bacterial fallout and thus the catastrophic consequences of graft infection. To date, there remains a paucity of data regarding bacterial fallout and surgical site infection in vascular surgery, with regards to laminar flow.

This study has identified that bacterial fallout is 15-fold higher in the vascular group performed in conventional theatre, compared with the orthopaedic group performed in laminar flow. Bacterial fallout was also weakly correlated with operative time, which may subsequently affect theatre footfall. Although laminar flow cannot be the sole contributing factor to this increase, it should be noted that this study was in a conventional theatre, not a hybrid suite, and therefore the 15-fold increase may be underreporting the case for other theatre types. Interestingly, no significant increase in bacterial fallout occurred during patient transfer, despite the increased activity during transfer. This may be due to keeping the instrument trolley out of the vicinity of the patient during transfer times.

Lidwell demonstrated a correlation between levels of airborne bacterial contamination and subsequent prosthesis infection.¹¹ Furthermore, he recommended employing directional flow ventilating systems as one of three potential ways of reducing subsequent joint sepsis postoperatively.¹¹ As a result, joint replacement surgery is routinely performed in laminar flow ventilation. However, this practice has not been widely adopted in other specialties, in which prosthetic

infection may result in a significant mortality and morbidity. Airborne infection is not solely responsible for prosthetic infection; endogenous infection from the patient's own bacterial flora is also likely to contribute towards prosthetic infection. However, a multifactorial approach is required to minimise this complication and thus any method of decreasing infection should be investigated.

It is logical that increased operative time increases the probability of bacterial contamination, as shown in this

study, but surgical site infection prevention requires multiple different prevention strategies. Minimising operative time is not always possible, with surgical training and complex revascularisation procedures all increasing wound exposure times. Laminar flow is, however, one additional component that can be employed.

This study is limited by its relatively small patient numbers and single-centre design. In addition, the number of people in theatre was not recorded, which could affect

bacterial fallout. Owing to the small sample size, correlation with postoperative infection was not possible, and a larger multicentre study correlating bacterial fallout with clinical outcome is required to investigate this area further.

Conclusions

The modern hybrid theatre with a plethora of equipment such as C-arm and screens, and the greater number of personnel involved may increase the bacterial fallout on to wounds and instruments, which may overwhelm conventional theatre ventilation. This could result in a rise in vascular prosthetic infection and may be aided by the installation of laminar flow into hybrid theatres.

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