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Cardiac surgical theatre traffic: time for traffic calming measures?

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Abstract

Surgical site infections (SSIs) remain a significant cause of postoperative complications. The risk of death from a medical error in a UK hospital remains one in 300. Increased theatre traffic has been identified as a modifiable determinant of SSI and surgical error. This cross-sectional study for the first time describes the pattern of theatre traffic in a UK cardiac centre. An electronic door counter and galaxy theatre management software (v3.4, iSOFT Banbury, UK) were used to calculate frequencies and rates of door opening during operations. Forty-six cases were analysed with 4273 door openings recorded. The median age of patients was 65 (range 43–75) with a median EuroSCORE of 5 (1–14). The mean frequency of door openings per case was 92.9 (45–205), with 19.2 (6.4–38.2) openings per hour. The theatre door was open for 10.7% of each hour of operating. Prolonged, acute and cases involving patients with higher EuroSCORES demonstrated a trend towards increased opening. Door opening disturbs theatre airflow and results in increased air and wound contamination. It is also described as a contributor to surgical mistakes. Current levels of traffic are unacceptably high and represent a modifiable risk factor for SSI and error.

Keywords: Theatre traffic; Door opening; Surgical site infection; Surgical mistakes

1. Introduction

Surgical site infections (SSIs) remain a significant problem in modern surgical practice. The consequences of SSI in cardiothoracic surgery are particularly serious with rates of mediastinitis reported as between 0.25% and 4% with 10–30% mortality [1, 2]. Other common SSI encountered in cardiac surgery, including superficial sternal and vein harvest infections, attract increased morbidity, healthcare costs and a prolonged length of hospital stay [3]. These problems are particularly relevant to increasingly elderly cardiac surgical patients. Established determinants of cardiac SSI include patient co-morbidities, operative techniques, use of antibiotic prophylaxis and operating theatre environment and practices [4].

One of the strategies designed to optimise theatre practices is the use of pre- and postoperative briefing with guidelines identifying the reduction of SSI as a key target [5, 6].

Investigators have previously described the pattern of theatre traffic and proposed a link between increased traffic, SSI and patient outcome [4]. The frequency and rate of door opening has been described as an accurate surrogate for the volume of theatre traffic. The performance of modern operating theatre ventilation systems advocated in clinical guidelines is affected by theatre door opening. Studies have demonstrated increased particulate contamination, colony forming units (CFUs) and SSI with increased theatre traffic and propose a disturbance in airflow dynamics and theatre isolation as mechanism [7, 8].

Researchers have also explored the potential factors which contribute to mistakes during surgical operations [9]. Distractions including door opening and increased theatre traffic have been identified as contributory factors to surgical mistakes. Admission to a UK hospital is associated with a one in 300 risk of dying due to a medical error, some 33,000 times higher than that of dying in an airline crash [6]. Strategies and systems to reduce this sobering statistic deserve our full attention.

In this study, we describe the pattern of theatre traffic in a tertiary cardiac surgical centre and propose a potential area for improving practice and outcomes in cardiac surgery.

2. Materials and methods

We conducted a prospective, cross-sectional study of consecutive patients undergoing cardiac surgery in two cardiac operating theatres at Leeds General Infirmary, a UK tertiary referral centre, between May and July 2009. All staff in theatres except for R.Y. and D.O’R. were unaware of the study in an attempt to minimise the effects on behaviour and theatre practice. Demographic and operative details were recorded and using a digital counter, designed and manufactured by the author, the frequency and rate of main theatre door opening was recorded.
Operative details including the time of the surgery were recorded using the computerised theatre management system (Galaxy® v3.4, iSOFT Banbury, UK). Data on wound infections were recorded prospectively using the PATS™ software application (Axis Clinical Software Inc, Portland). Data were analysed using Microsoft Excel (Microsoft Corporation, Washington).

3. Results

A representative sample of 46 consecutive operations was analysed. Demographic and operative details are shown in Table 1. The total number of door openings recorded during the 46 cases was 4273. The mean frequency of door opening per case was 92.9 (45–205) with the individual data displayed in Fig. 1. When adjusted for the operative time the mean rate of door opening per minute and hour for all cases was 0.32 (0.1–0.64) and 19.2 (6.4–38.2). The average time that it takes the theatre door to close was calculated to be 20 s. In each case the theatre door was open for an average of 31 min and when adjusted for the length of operation the door was open for 10.7% of every hour.

There were five cases of SSI in our series; three superficial long saphenous vein graft site infections and two superficial sternal wound infections. The data in Table 2 demonstrates a trend towards increased frequency and rate of theatre door opening and advanced age in those patients developing SSI.

There is a positive correlation between length of case and frequency of door opening (Pearson’s product-moment coefficient 0.22), as displayed in Fig. 2. The frequency and rate of door opening was stratified according to operation, National Confidential Enquiry into Perioperative Deaths (NCEPOD) classification of intervention and additive EuroSCORE. There is a trend to suggest that more complex and less frequently performed procedures are associated with a greater frequency and rate of door opening, Figs. 3 and 4. Cases analysed were classified according to the NCEPOD guidelines with a frequency and hourly rate of door opening for scheduled elective cases of 90.9 (66–152) and 16.6 (6.4–23.8) compared to 93.6 (45–205) and 20.2 (7.3–38.2), respectively, for urgent cases. The frequency and rate of door opening according to the additive EuroSCORE suggests a trend towards increased theatre door opening and prolonged length of cases with elevated EuroSCORE, displayed in Figs. 5 and 6.

4. Discussion

In this study, we have for the first time described and quantified the pattern of theatre traffic in a UK cardiac centre. Rates of door openings are unnecessarily high and represent an area where simple modifications of practice could enhance patient outcomes. We have shown a possible trend towards increased SSI with increased levels of theatre traffic. SSI in cardiac surgery remain a serious problem despite continuing efforts to reduce incidence, morbidity and mortality. Investigators have proposed increased levels of theatre traffic as a key modifiable determinant of SSI. Theatre traffic also contributes significantly to surgical mistakes and their associated implications.

Data are in line with published US reports, although studies of cardiac surgical practice remain limited. The incidence of SSI in our study is comparable to international standards. High quality data regarding SSI come from studies of orthopaedic surgery, especially with procedures

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic and operative details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age median (min–max)</td>
<td>65 (43–75)</td>
</tr>
<tr>
<td>Males (%)</td>
<td>36 (77)</td>
</tr>
<tr>
<td>Additive EuroSCORE median</td>
<td>5 (1–14)</td>
</tr>
<tr>
<td>Elective (%)</td>
<td>34 (73.9)</td>
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<tr>
<td>Isolated CABG (%)</td>
<td>24 (52.2)</td>
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<tr>
<td>Isolated valvular surgery (%)</td>
<td>9 (19.6)</td>
</tr>
<tr>
<td>Combined CABG–valvular surgery (%)</td>
<td>10 (21.7)</td>
</tr>
<tr>
<td>Aortic root</td>
<td>1</td>
</tr>
<tr>
<td>Other procedure</td>
<td>2</td>
</tr>
<tr>
<td>Operative time mean (min–max)</td>
<td>5 h 18 min (2 h 58 min–12 h 7 min)</td>
</tr>
</tbody>
</table>

CABG, coronary artery bypass grafting.

Fig. 1. Frequency of door opening per case. CABG, coronary artery bypass grafting; AVR, aortic valve replacement; MVR, mitral valve replacement; CEA, carotid endarterectomy.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparison of patients without vs. with SSI</th>
</tr>
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<tbody>
<tr>
<td>Age median (min–max)</td>
<td>No SSI (n=41)</td>
</tr>
<tr>
<td>Males (%)</td>
<td>66 (43–75)</td>
</tr>
<tr>
<td>Additive EuroSCORE</td>
<td>31 (75.6)</td>
</tr>
<tr>
<td>Elective (%)</td>
<td>5</td>
</tr>
<tr>
<td>Combined CABG (%)</td>
<td>12 (29.3)</td>
</tr>
<tr>
<td>Mean door opening frequency</td>
<td>76.4</td>
</tr>
<tr>
<td>Mean door opening rate</td>
<td>14.5</td>
</tr>
</tbody>
</table>

Unpaired t-test. SSI, surgical site infection.

Fig. 2. Door opening frequency as a function of duration of operation. Pearson’s product-moment coefficient $R^2=0.22$. 

rate of door opening was stratified according to operation, National Confidential Enquiry into Perioperative Deaths (NCEPOD) classification of intervention and additive EuroSCORE. There is a trend to suggest that more complex and less frequently performed procedures are associated with a greater frequency and rate of door opening, Figs. 3 and 4. Cases analysed were classified according to the NCEPOD guidelines with a frequency and hourly rate of door opening for scheduled elective cases of 90.9 (66–152) and 16.6 (6.4–23.8) compared to 93.6 (45–205) and 20.2 (7.3–38.2), respectively, for urgent cases. The frequency and rate of door opening according to the additive EuroSCORE suggests a trend towards increased theatre door opening and prolonged length of cases with elevated EuroSCORE, displayed in Figs. 5 and 6.
entailing the implantation of prosthetic material, which set
the standards for minimising SSI. The rate of door opening
for orthopaedic implant procedures in one study was 40/h
[4]. This study of five cases analysed all theatre doors and,
therefore, rates for individual doors will be significantly
lower. The mean rate of door opening for cases in our
series on one sample theatre door was 19.2/h and for cases
involving the implantation of prosthetic material 22.8/h.
This equates to an average period of 6.4 min (10.7%) in
every hour with the door open.

Door opening is a surrogate marker of theatre traffic
levels and influences the effectiveness of theatre ventila-
tion and levels of airborne contaminants. Each time the
airtight seal is broken by opening a door the amount of
airborne particles and CFUs is significantly elevated [10].
The use of theatre ventilation systems with high efficiency
particulate air (HEPA) filters and practices to minimise air
contamination have been proposed as methods to reduce
wound contamination [11]. The use of ‘ultraclean’ theatres,
laminar flow ventilation and clean air suits are common
practice in orthopaedic centres. This approach may provide
useful lessons for cardiac surgery.

Studies into surgical practice and errors have explored
the hypothesis that theatre traffic acts as a distraction to
the operating team [12–14]. One UK study correlated a
validated measure of interference levels with door opening
frequency in a series of 50 general surgical operations.
They conclude it is a marker of poor theatre practice and
a target area for reducing surgical distraction and errors
[9].

Some movement within a theatre complex is requisite for
clinical reasons; analysis of arterial blood gases or throm-
boelastography (TEG) samples at a remote central analyser
and retrieval of blood products for transfusion. All cases in
our study involved cardiopulmonary bypass which requires
movement of the perfusion team and anaesthetists. Other
movements may be logistical including change over of
theatre personnel, staff comfort breaks, movement of
equipment from communal storage areas and communica-
tion between theatre team members and staff from outside
a specific theatre. Staff movement to retrieve missing or
faulty items from a surgeon’s standard list of equipment
for commonly performed procedures is frustratingly com-
mon. Some traffic cannot be anticipated and there is always
the potential for an emergency situation requiring special-
ist staff or equipment from outside theatre. It is clear that
despite consideration of these essential movements door
opening is excessive.

Previous studies have collated qualitative data identifying
reasons for theatre traffic. In one study, 20% of traffic was
related to staff requesting information, 25% staff entering
or leaving theatre for breaks and 20% delivery or retrieval
of equipment. Alarmingly, staff from outside the sterile
‘core area’ were responsible for 37–50% of all theatre
traffic [4].

Education and training combined with a robust audit
process are the strategies most likely to improve current
practice. Our study highlights and quantifies an everyday
clinical problem which could potentially contribute to a
change in attitude and outcomes. It is now the authors’
current practice to complete a pre- and postoperative
briefing. All team members are introduced and identified
on a display board within theatre in an attempt to reduce
casual traffic. The preoperative checklist details any spe-
cific equipment required and the postoperative debrief

Fig. 3. Mean hourly rate of door opening. CABG + CEA, CABG + myxoma and
aortic root $n=1$. CABG, coronary artery bypass grafting; AVR, aortic valve
replacement; MVR, mitral valve replacement; CEA, carotid endarterectomy.

Fig. 4. Mean frequency of door opening according to operation. CABG + CEA,
CABG + myxoma and aortic root $n=1$. CABG, coronary artery bypass grafting;
AVR, aortic valve replacement; MVR, mitral valve replacement; CEA, carotid
endarterectomy.

Fig. 5. Mean frequency of door opening according to additive EuroSCORE.

Fig. 6. Mean hourly rate of door opening according to additive EuroSCORE.
includes a mechanism for reporting faulty or missing equipment. Other areas of interest include optimising the design and utilisation of theatre suites and supply areas in order that equipment is located within close proximity to specific theatres. The use of electronic devices integrated with modern theatre management systems may also play a role.

Limitations of this study include a relatively small sample size and the potential influence of the electronic counter on staff behaviour despite attempts to minimise this confounding effect. The low incidence of SSI limits detailed statistical analysis although the study was never designed powered to interrogate a causal relationship between traffic and SSI. In the cardiac theatres there are two additional access doors. These doors are used much less frequently than the main entrance but we estimate that they may account for an additional 10–20% of unrecorded openings. This equates to a potential period of up to 12% with the theatre doors open. Although the rate of door opening is a validated surrogate marker of theatre traffic and is known to influence particulate and microbiological contamination, it does not provide qualitative data on the causes of theatre traffic.

A further study combining the digital counters and researchers present in theatres would allow determination of the reasons for door opening and excess traffic. Data on traffic in pre-incision, operative and post-closure periods would also allow more detailed description of practice and areas for improvement.

Acknowledgments

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References


eComment: Should we start controlling the operating theatre traffic?

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We read the report by Young and O’Regan [1] on operating theatre (OT) traffic and their recommendation for controlling surgical site infections (SSI) in cardiac surgical patients.

We have a few concerns regarding the result they have presented. Have the authors evaluated the state of premorbid condition in these patients? Was there any relation between prevalence of diabetes, blood transfusion and complexity of surgery in patients where they have observed the higher rate of SSI? We think these conditions should be evaluated in every case of SSI.

Nevertheless, in our practice, we do control the OT traffic by limiting the movement of personnel from one theatre to another. Specially, if a bacterial endocarditis patient is being operated, entrance of personnel from another theatre is almost completely prohibited. Also, to reduce movements we keep most essential materials (like suture materials, valves, vascular prostheses, cannulas) in the same theatre. We do practice preoperative and postoperative preparations as suggested by the authors, which help us reduce the OT traffic significantly.

Reference