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Preventing infection in general surgery – Improvements through education of surgeons by surgeons

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Abstract

Surgical patients are particularly at risk of healthcare associated infection (HCAI) by virtue of the presence of a surgical site leading to surgical site infections (SSI) and because of the need for intravascular access resulting in catheter-related bloodstream infection (CRBSI). A two-year initiative commenced with an initial audit of surgical practice which was used to inform the development of a targeted educational initiative by surgeons as being specific for surgical trainees. Parameters assessed during initial and repeat audits after the educational initiative were related to the intra- and post-operative aspects of the prevention of SSI as well as care of peripheral venous cannulae (PVC) in surgical patients. The proportion of prophylactic antibiotics administered pre-incision across 360 operations increased from 30% to 59.1% ($p<0.001$). Surgical site dressings were observed in 234 patients, with a significant decrease as observed in the percentage tampered during the initial 48 hours post-operatively (6.2% vs. 16.5%, $p=0.030$). A total of 574 PVCs were assessed over the two-year period. Improvements were found in the proportion of unnecessary PVC *in-situ* (37.9% vs 24.4%, $p<0.001$), PVC *in-situ* for more than 72 hours (10.6% vs 3.1%, $p<0.001$) and PVC covered with clean intact dressings (87.3% vs 97.6%, $p<0.001$).

Significant improvements in surgical practice were established for SSI and CRBSI prevention through a focused educational programme developed by and for surgeons. Potentially, other specific measures might be also warranted in order to achieve further improvements in the infection prevention in the surgical practice.

Introduction

The recent Hospital Infection Society Prevalence Survey (HISPS) found an overall prevalence of 4.9% of healthcare-associated infection (HCAI) in Irish hospitals, with this figure increasing to 6% in tertiary referral centres.[1] Surgical patients are particularly at risk of HCAI because of a surgical site leading to surgical site infections (SSI), the need for intravascular access resulting in catheter-related bloodstream infection (CRBSI), and sub-optimal professional practice, specifically, as related to the hand hygiene amongst surgeons and other healthcare professionals.

Approximately 5% of patients undergoing surgery develop a SSI.[2] Surgical site infections are the second most common cause of HCAI. [3] [4] Patients who develop SSI are up to 60% more likely to spend time in an intensive care unit (ICU), five times more likely to be readmitted to the hospital and two times more likely to die than patients without an SSI.[5] Standard procedures for the prevention of SSI include pre-operative patient preparation, appropriate prophylactic antibiotics, careful and skilled surgical technique, intra-operative medical management and post-operative surgical site or wound care.[6]

Catheter-related bloodstream infection accounts for 7% of all HCAIs.[7] With short-term intravascular catheters placement (i.e., <10 days), most device-related CRBSI arise from the insertion site and gain access extra-luminally.[8] The National Nosocomial Infections Surveillance (NNIS) system managed from the CDC in the USA reports a CRBSI rate of 5.7 per 1,000 catheter days.[9] Approaches to reducing the rate of CRBSI include optimizing

insertion techniques, minimizing the duration of use, prompt removal of unnecessary intravenous catheters and the maintenance of clean intact intravascular catheter dressings.

About 20-30% of HCAIs are considered to be preventable through infection prevention and control programme.[10 11] Since it has been shown that hospitals with a higher trainee-to-bed ratio also have an increased SSI incidence[12], there is a need for dedicated infection prevention and control programmes relating to surgical practice and incorporating the education of surgeons.[13] In this way, surgeons will be better educated and motivated and are expected to take ownership of their own input into minimising HCAI.

We aimed to develop a blended learning programme consisting of both online education as well as lectures and posters for surgical trainees to improve infection control practices in the areas of SSI and CRBSI and ascertain clinical effectiveness of our initiative through an initial and post-intervention audit of practice.

Methods

Data collection

The study was carried out in a tertiary hospital focusing on surgical non-consultant hospital doctors (NCHD) and consultant surgeons in the Department of General Surgery. Audit tools were developed and piloted between December 2008 and June 2009. The initial audit of surgical practice was carried out over a five-month period from July to November 2009. Data from the audit were analysed and a web-based educational initiative developed to target the

identified deficiencies in practice. This was then implemented as part of a blended learning program over a six-month period from January to June 2010. Following promotion of the educational initiative, a repeat audit was then carried out between July and September 2010 to determine the effectiveness of our educational initiative.

Through extensive literature review, key clinical practice parameters associated with SSI and CRBSI were identified. These parameters were further divided into intra-operative practice, post-operative care of the surgical site and peripheral venous catheter (PVC) maintenance. Audit data were collected for each of these parameters using Teleform software, thus eliminating transference errors when exporting data to SPSS v17 for the statistical analyses.

Intra-operative parameters assessed included patient intra-operative temperature and oxygenation, both parameters recognized as important in minimizing SSI [14 15] together with the choice and timing of prophylactic antibiotics. Post-operatively the patient's surgical site dressing was assessed to see if it was intact and clean and whether it had been tampered with in the first 48 hours post-procedure. With regard to PVC maintenance, the necessity, duration and PVC dressing quality were assessed.

Data collection was carried out by a single observer (SMcH). Intra-operative data were collected either by directly witnessing the operative procedure or by reviewing the anaesthetic and operative notes immediately post-procedure. Post-operative dressings were assessed at 24 and 48 hours post procedure in the surgical wards. With regard to the collection of PVC-related data, a weekly ward round was undertaken on an alternating

surgical ward. Each patient with a PVC *in-situ* was included. The PVCs were directly assessed by the observer. Patient history, medical notes and the prescription Kardex was reviewed to determine the necessity and duration of the PVC. In cases where it was not clear whether the PVC was necessary or not, a member of the patient's surgical team was directly contacted and consulted about its indication.

Development of educational initiative

After the initial audit where specific deficiencies in practice were identified, the domain name www.SurgInfection.com was purchased and hosted on the world wide web. The development of the website and its content has been previously described elsewhere.[16] Best practice guidelines were summarized and made available for download where possible. Fortnightly podcasts were made available through the iTunes store. A repository of best practice videos as well as interactive clinical cases and tutorials focusing on specific deficiencies in surgical practice were also made available online. Data from the initial audit was fed back to the surgical teams *via* lectures at surgical grand rounds and monthly clinical governance meetings. In addition, posters stressing the importance of infection prevention in surgical patients were placed in high visibility areas on surgical wards and in the general surgery operating theatre. These posters also directed viewers to the SurgInfection website for further information.

Both initial and repeat audit data were exported to SPSS v.17 for the statistical analyses. Descriptive statistics, comparative, correlation and logistic regression analyses were performed at significance level $p<0.05$, unless stated otherwise. Specific tests of statistical

significance included Student t-test and non-parametric Mann-Whitney, chi-squared and repeated-measures Wilcoxin signed ranks test.

Results

SSI prevention

At the initial audit, 161 operations were assessed, of which 72 were directly witnessed. In the post-intervention audit, 199 operations were assessed of which 60 were directly witnessed. Patient temperature was measured in 88 (54.6%) procedures pre-intervention and 89 (44.7%) post-intervention. Of these, temperature was maintained higher than 36°C in 34 (38.6%) pre-intervention and 41 (46.1%) post-intervention patients. This improvement was not statistically significant (p=0.104). With regard to patient oxygenation, pulse oximetry was documented in 157 (97.5%) cases in the initial audit and 197 (98.9%) in the repeat audit. Oxygenation was maintained greater than 96% in 153 (97.5%) pre-intervention and 197 (98.9%) post-intervention patients, however, this increase was not statistically significant (p=0.588) [Table 1].

Overall surgical prophylaxis was assessed in 155 cases in the initial audit. Of these, 147 (94.8%) patients had a data on the use of surgical prophylaxis, with the timing of surgical prophylaxis available in 128 (79.5%) cases. In the repeat audit post-intervention, surgical prophylaxis was used in 188 (94.5%) of cases. Of these, the timing of administration was available in 138 (73.4%). In the pre-intervention audit, prophylactic antibiotics were administered between 60 and 30 minutes prior to incision in only 7 (5.5%) cases. In 32 (25%) procedures, the surgical prophylaxis was administered less than 30 minutes before the

incision. In 50 (31.1%) cases, the antibiotics were given at the time of incision, and in 39 (24.2%) cases the surgical prophylaxis was administered after incision. Post-intervention administration between 60 and 30 minutes pre-incision occurred in 13 (9.4%) of cases. Administration within 30 minutes of incision occurred in 68 (49.3%) of cases, with 27 (19.6%) receiving antibiotics at the time of the incision. Of the remaining procedures, 29 (21%) received antibiotics after the incision with only one patient (0.7%) receiving the prophylactic antibiotics 80 minutes before the incision.

These data represent a statistically significant improvement in the timing of prophylaxis even if only a small increase was seen in the absolute numbers of patients receiving prophylaxis during the optimal period, i.e., 60 to 30 minutes pre-incision (9.4% vs. 5.5%). However, there was a considerable increase in patients receiving antibiotics within 30 minutes of incision (49.3% vs. 25%). As a result, the percentage of cases where prophylaxis was inappropriately administered at the time of incision, or post- incision decreased significantly ($p<0.001$). The mean time for all doses of prophylaxis was 2.75 minutes after incision in 2009 and 6.2 minutes prior to incision in 2010. This represents a statistically significant improvement in the mean time of administration of 3.45 minutes ($p=0.001$ by Wilcoxin signed ranks test) compared with the timing of administration before the intervention.

With regard to post-operative SSI prevention, the surgical site dressings of 128 patients were assessed at 24 hours post-procedure pre-intervention. In the post-intervention audit, the surgical site dressing was reviewed for 106 post-operative patients. Dressings were intact and clean in 126 (98.4%) cases in the initial audit and post intervention, 106 (100%) were observed to be intact and clean. This was an improvement from 2009 although not

statistically significant (p=0.196). At 48 hours post-procedure 115 (89.8%) dressings were reviewed pre-intervention and 81 (76.4%) – post-intervention. Of these, 96 (83.5%) were observed to have been *in-situ* without being tampered with in the initial 48 hours post-procedure pre-intervention, with a statistically significant post-intervention improvement to 93.8% (n=76, p=0.030).

CRBSI prevention

A total of 275 PVC were assessed over the initial five-month audit. In the repeat post-intervention audit a total of 295 PVC were assessed over the 3-month period. Pre-intervention, the majority of PVCs (n=242, 88%) were *in-situ* for 72 hours or less as per hospital guidelines; 29 (11%) were *in-situ* for >72 hours and in 4 PVCs the duration could not be ascertained. Regarding PVC dressings, 240 (87%) were observed to be intact and clean. However, 35 (13%) dressings were either not clean or intact. Of the assessed 275 cannulae, 104 (37.8%) were no longer required at the time of assessment ("unnecessary") while the remaining 171 (62.2%) were still considered necessary.

Post-intervention, 286 (96.9%) were *in situ* <72 hours, representing a statistically significant improvement from the pre-intervention audit (p<0.001). In addition, 288 (97.6%) were observed to be covered by a clean intact dressing, again representing a significant improvement (p<0.001). As in the initial 2009 audit, the necessity of PVC were also assessed. A further statistically significant improvement was noted, with 223 (75.6%) of PVCs deemed necessary (p=0.001) [Figure 1].

Discussion

The motivational factors influencing infection prevention and control behaviour are complex.[17] Multifaceted interventions utilizing a blended learning approach that target a specific healthcare group and aspects of relevant practice such as that detailed in this study are more likely to achieve success. Apart from education regarding HCAI, at a local level it is also important to stress the importance of HCAI as a quality and safety issue, as this is an area not emphasized enough in our medical schools.[18] Through increasing awareness of HCAI in a surgical unit using a focused education initiative we have shown an improvement across a number of infection prevention related parameters relevant to surgical patients.

The timing of surgical prophylaxis and the quality of surgical site dressings post-operatively improved significantly after an educational intervention. Peripheral venous cannulae dressings were also significantly improved along with improvements in necessity and duration of *in-situ* PVC.

Best practice guidelines suggest the administration of surgical prophylaxis within the 60 minutes before the initial incision.[19] [20] Furthermore, it has been suggested that the administration of prophylaxis at 30 to 59 minutes pre-incision is more effective than antibiotics administered within 30 minutes of incision.[21] Although it is well established that the timely and appropriate administration of prophylactic antibiotics reduces SSI rates, ensuring proper administration of antibiotics before surgery continues to be a difficult challenge. Our findings are consistent with what has been previously reported, i.e. much in-hospital antibiotic use is not in keeping with best practice.[22] [23]

Our data confirm improvements in practice, as overall only 30.5% of antibiotics were given pre-incision in our initial audit in 2009. After improvement following our educational initiative, this percentage significantly increased to 58.7%. However, post-intervention, the percentage of administration of prophylaxis between 60 and 30 minutes pre-incision (i.e., during the optimal time interval) remained low despite an increase to 9.4%. The percentage of patients in which the administration happened within 30 minutes of incision increased to 49.3% ($p<0.001$). Although one of the main aims of our educational intervention was to increase the proportion of patients in which the surgical prophylaxis was given between 59 and 30 minutes pre-incision, there was only a minimal improvement in the optimal practice. However, to note, the overall proportion of surgical prophylaxis given in the whole interval of 60 minutes pre-incision increased significantly.

Previous education programmes to increase compliance regarding surgical prophylaxis have included person-to-person educational messages[22], performance feedback to surgical teams[24] or the use of a simple pre-operative checklist.[25] Our study did not introduce a new practice protocol such as a checklist but rather achieved a change through increasing knowledge and awareness. The resultant improvement is comparable to previously reported interventions in the published literature, but if a check list (especially if mandatory) was to accompany our specific approach, it would have ensured the compliance to almost 100%.

Guidelines for best practice relating to post-operative wound care recommend clean intact surgical site dressings which should remain *in situ* without being tampered with for the first

48 hours post-operatively. [6] Following this initial 48 hour period, there is no consensus on best practice and considerable variability in surgical practice is common. [26] Previous initiatives to improve the care of the surgical site post-operatively have utilised a dressing change pro-forma, with monthly medical chart audit and feedback to staff. [26] As part of our initiative, feedback to surgical teams of the 2009 audit data was carried out through the SurgInfection website and also at hospital grand rounds and clinical governance meetings. Through this initiative the proportion of dressings remaining intact for the initial post-operative 48 hours increased, i.e., from 83.5% to 93.8% ($p=0.03$). Also, improvements were seen in the proportion of clean, intact dressings (from 98.4% to 100%) but this increase occurred as starting from a high baseline rate and did not reach statistical significance.

The prevention of PVC-related blood stream infection is paramount to provide safe patient care and to minimise hospital costs as more than 60% of patients admitted to hospital are likely to receive therapy via a PVC.[27] Unfortunately, there is a lack of published studies targeting improvement in CRBSI in PVC, with the majority of such interventions aimed only at central venous catheter insertion and maintenance.[28-31]

Several recent studies have questioned current guidelines on the duration of PVC, reporting no conclusive benefit in routinely changing PVC after 72 hours.[32-34] However, present national guidelines recommend the removal or routine replacement of PVCs after 72 hours.[35] In particular, our current study has found an improvement in adherence to the above guidelines, with significantly fewer PVC *in-situ* for more than 72 hours post-intervention ($p<0.001$).

Irrespective of the impact of decreasing numbers of PVC *in situ* for more than 72 hours, unnecessary PVC should be promptly removed to minimise CRBSI incidence. Our study demonstrated a significant decrease from 37.8% to 24.4% (p=0.001) of unnecessary PVC in the surgical wards. This decrease certainly translates into a reduction of the CRBSI risk and also represents a potential financial benefit for the healthcare system, avoiding the costs associated with PVC insertion and maintenance. Such improvement is also likely to be very welcomed by patients whom would be spared the unnecessary pain of routine replacement in the absence of a continued indication for PVCs. In fact, we have previously demonstrated that patients may potentially have a role to play themselves in the reduction of the numbers of unnecessary PVC.[36]

The benefits of covering intravascular catheters with a clean intact dressing is one which is intuitive and recommended in both national and international guidelines as an essential component of CRBSI prevention. [6 37] We also demonstrated an improvement in adherence to these best practice guidelines, with 97.6% observed to be covered by a clean intact dressing compared with 87.2% before the educational intervention (p<0.001). Interestingly, given that compliance with best practice in relation to PVC dressings was almost 90% in the initial audit, this parameter was not specifically targeted or highlighted in the feeding back of the initial audit data, in posters placed on surgical wards or on the SurgInfection website. Despite this, it is interesting to note that a benefit in terms of an observed statistically significant increase was seen. However, this may be explained as secondary to heightened awareness about PVC care and the associated infection risk. In evolving a culture where the importance

of CRBSI prevention is stressed, improvements in practice can be achieved as part of an overall behavioural change.

There are a number of limitations to this study. These include the study occurring in a single centre and the observations and audit being collected by a single individual. As of now, it was not possible to determine if the improvement in audit results translated into a lower infection rates as an on-going surveillance of relevant HCAIs was not possible within the available resources. Also, there were other, parallel developments, including education initiatives by the infection prevention and control team taking place in the hospital which might have contributed to observed improvements in the audit scores. Finally, there would have been some changes in the list of basic surgical trainees between the first and second audit periods. Although largely similar in experience and background, the basic surgical trainees during the second audit period may have been more conscientious and more likely to comply with the best practice guidelines than those during the first period but neither records nor any details of their knowledge or attitudes to infection prevention measures were possible to collect.

Conclusions

The current study conveys important audit results on the translation of our educational initiative, specifically designed by and for surgeons, into clinical effectiveness as expressed by parameters associated with SSI and CRBSI. Through continued audit a number of key

aspects were noted to be poorly adhered to, and by specifically highlighting these areas to surgical trainees, statistically significant improvements were observed. However, further improvements are essential to achieve compliance levels close to 100% to maximize patient safety and clinical benefits. Finally, the impact of above educational initiative and potential future additional interventions needs to be assessed against and informed by quality outcome measures such as SSI rates, CRBSI rates and patient length of stay, among others.

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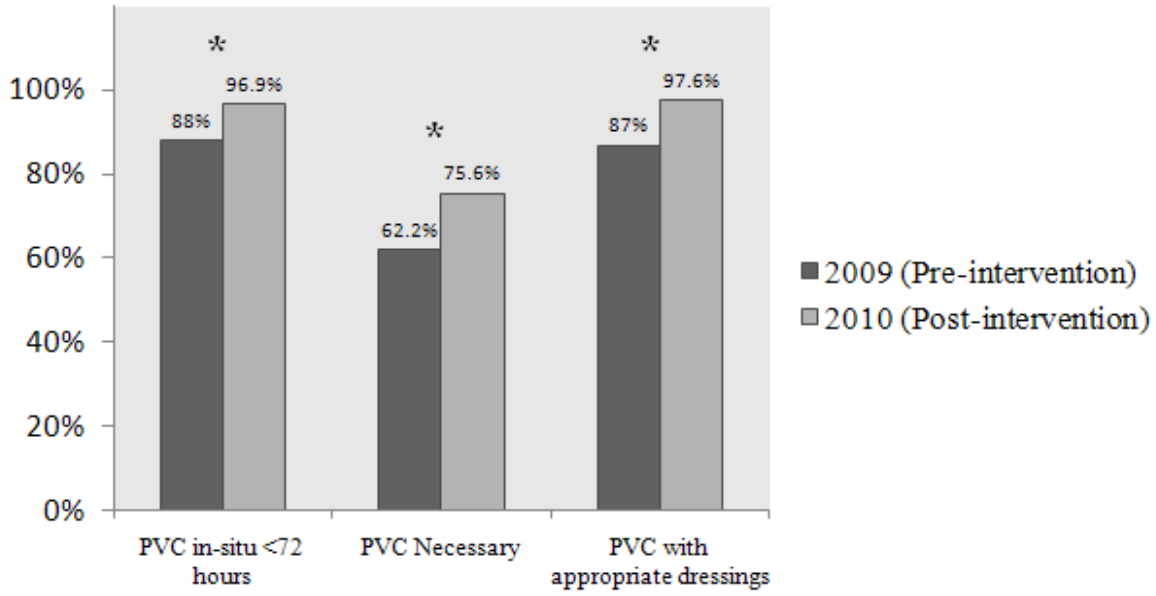
Table 1: Comparison of surgical site infection prevention parameters both pre-intervention in 2009 and post-intervention in 2010

	Pre-intervention	Post-intervention	p value
Antibiotic prophylaxis timing:			
60 to 30 mins pre-incision	7 (5.5%)	13 (9.4%)	
Less than 30 mins pre-incision	32 (25%)	68 (49.3%)	*p<0.001*
At incision	50 (31.1%)	27 (19.6%)	
Post-incision	39 (24.2%)	29 (21%)	
Maintenance of intra-operative:			
Temperature >36°C	34 (38.6%)	41 (46.1%)	p=0.104
Oxygenation >96%	157 (97.5%)	197 (98.9%)	p=0.588
Post-operative dressings:			
Intact and clean	126 (98.4%)	106 (100%)	p=0.196
Intact for the first 48 hours	96 (83.5%)	76 (93.8%)	*p=0.030*

Figure 1: Comparison of catheter-related bloodstream infection prevention parameters with regard to peripheral venous cannulae (PVC) both pre- and post-intervention



*p-value<0.05