The role of antimicrobial sutures in preventing surgical site infection

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REVIEW

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The role of antimicrobial sutures in preventing surgical site infection

D Leaper[1], P Wilson[2], O Assadian[3], C Edmiston[4], M Kiernan[5], A Miller[6], G Bond-Smith[7], J Yap[8]

[1]University of Newcastle upon Tyne, UK
[2]University College of London Hospitals NHS Foundation Trust, UK
[3]University of Huddersfield, UK
[4]Medical College of Wisconsin, US
[5]University of West London, UK
[6]University Hospitals of Leicester NHS Trust, UK
[7]Oxford University Hospitals NHS Trust, UK
[8]Barts Health NHS Trust, UK

ABSTRACT

INTRODUCTION Healthcare associated infections (HCAIs) are falling following widespread and enforced introduction of guidelines, particularly those that have addressed antibiotic resistant pathogens such as methicillin resistant *Staphylococcus aureus* or emergent pathogens such as *Clostridium difficile*, but no such decline has been seen in the incidence of surgical site infection (SSI), either in the UK, the EU or the US. SSI is one of the HCAIs, which are all avoidable complications of a surgical patient's pathway through both nosocomial and community care.

METHODS This report is based on a meeting held at The Royal College of Surgeons of England on 21 July 2016. Using PubMed, members of the panel reviewed the current use of antiseptics and antimicrobial sutures in their specialties to prevent SSI.

FINDINGS The group agreed that wider use of antiseptics in surgical practice may help in reducing reliance on antibiotics in infection prevention and control, especially in the perioperative period of open elective colorectal, hepatobiliary and cardiac operative procedures. The wider use of antiseptics includes preoperative showering, promotion of hand hygiene, (including the appropriate use of surgical gloves), preoperative skin preparation (including management of hair removal), antimicrobial sutures and the management of dehisced surgical wounds after infection. The meeting placed emphasis on the level I evidence that supports the use of antimicrobial sutures, particularly in surgical procedures after which the SSI rate is high (colorectal and hepatobiliary surgery) or when a SSI can be life threatening even when the rate of SSI is low (cardiac surgery).

KEYWORDS

Surgical site infection – Antimicrobial suture – Triclosan – Care bundle – Systematic review – Meta-analysis

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CORRESPONDENCE TO

David Leaper, E: profdavidleaper@doctors.org.uk

Surgical site infection (SSI) presents a burden to healthcare with significant morbidity and mortality. SSIs may double hospital stay, with an annual increase in cost to the National Health Service (NHS) of £65 million. After open elective colorectal surgery, the SSI rate has been estimated at 17.5% (95% confidence interval [CI]: 13.3–22.9%), after sternotomy for general cardiac surgery at 1.7% (95% CI: 0.9–3.3%) and after coronary artery bypass grafting at 2.4% (95% CI: 1.6–3.8%), with a time to peak presentation of 6–8 days, which may be several days after the patient has returned home.[1–3] Accurate data on SSI rates should include surveillance after discharge,[1,4] using extended follow-up review, telephonic structured questionnaires and visitation by trained staff.[5] Many surgeons are unaware of their individual SSI rates and accurate surveillance may be seen to artificially raise SSI rates.

The common pathogens that cause SSI are *Staphylococcus aureus*, coagulase negative staphylococci (particularly after implant surgery) and Enterobacteriaceae/anaerobes (particularly after colorectal surgery). This pattern is changing, related to antibiotic use, and it is increasingly common to see resistant bacterial strains.[1] Factors that increase the SSI rate include the category of wound (clean to dirty), presence of implant or drain, length of surgery and preoperative stay, carriage of *S aureus*, obesity, underlying chronic illnesses and medication.[6]

Definition of SSI

There are many definitions of SSI. The important clinical features re peri-incisional erythema, serous or purulent exudate and wound superficial dehiscence, which may be accompanied by systemic signs, all of which lack specificity. The most widely used definition is that of the US Centers for Disease Control and Prevention but this is subjective and provides only categorical data[7] whereas the ASEPSIS (Additional treatment, Serous discharge, Erythema, Purulent exudate, Separation of deep tissues, Isolation of bacteria and duration of Stay) score provides interval data useful in audit and research, and allows an assessment of the severity of a SSI.[8]

The SSI surveillance service of Public Health England and Commissioning for Quality and Innovation of NHS England have introduced a voluntary scheme covering 17 surgical procedures. SSIs are registered on inpatient and readmission data only, and are used as performance indicators.[1,2,9] This lack of accuracy has been criticised[10,11] but only diligent infection prevention surveillance and feedback of SSI rates can achieve this accuracy – albeit at a cost.[12]

SSI care bundle concept

The care bundle concept has been shown to be effective for prevention of SSI after colorectal surgery.[13,14] Care bundles comprise groups of evidence-based interventions each ideally having level I effectiveness. However, for care bundles to work, they have to rely on adequate compliance, which can be low with only one in five patients receiving the whole of an agreed bundle.[10,15] Consequently, for the comparison of SSI rates, definitions, surveillance, differences in case mix and effective reporting back to the surgical team are important.

Ownership of a SSI bundle needs to involve the whole surgical team and allied health professionals, preferably with a surgical champion, to achieve the best results. Without the ‘buy in’, compliance is likely to fall and the bundle to fail. SSIs are preventable (as all healthcare associated infections [HCAIs] are) but there is little evidence that SSI rates are falling despite improved definition, surveillance and care bundles. National schemes, with high quality surveillance and rapid feedback, have not led to sustained reduction in SSIs as they have done with infection prevention/control of other HCAIs.

Antibiotic resistance: could antiseptics have a wider role?

The rise of the incidence of HCAIs and antibiotic resistant organisms, through selection and transmission, has been blamed on the overuse and misuse of antibiotics. Nevertheless, according to the latest report by the US Food and Drug Administration, approximately 80% of all antibiotics used in the US are fed to farm animals.[16] All these antibiotics ultimately end up in the environment and food chain, adding to the risk of resistant organisms. Before antibiotics became widely available, there was a wealth of knowledge and use of topical antimicrobials: the antiseptics.

There are many antiseptics available and used in surgical practice (povidone-iodine and chlorhexidine) for preoperative showering, skin and hand preparation, and open wound management. Triclosan is a phenolic antiseptic that has been used successfully to impregnate or coat synthetic absorbable sutures such as polydioxanone, polyglactin and poliglecaprone. This antiseptic has been used for skin preparation and dental care as well as many inappropriate other uses, with a broad spectrum of antibacterial and antifungal properties and a low toxicity.[17,18]

The mechanisms of triclosan antimicrobial activity are multifactorial and its action is bacteriostatic or bactericidal depending on concentration. Some suspicions remain: whether it can select resistant organisms, whether it can influence antibiotic resistance and its transmission, whether its overuse has environmental issues and whether it can reduce SSIs when impregnated in or coated on sutures.

Triclosan inhibits bacterial fatty acid synthesis, reproduction and building of cell membranes by blocking enoyl-acyl carrier protein reductase. There is innate resistance/high tolerability to triclosan with some bacterial strains through bacterial efflux pumps but these have little clinical relevance, especially in regard to SSI. This theoretical risk of resistance has been overstated, as have other health risks relating to potentially harmful side products of triclosan degradation in the environment. Similarly, there are no reported carcinogenic, mutagenic or teratogenic effects.[17–19] The comparatively very small amounts of triclosan used to impregnate or coat absorbable polymer sutures pose no risk to humans or the environment.[20]

SSI after colorectal, hepatobiliary and cardiac surgery

As other nosocomial infections fall in incidence, SSI is becoming the most common HCAI. After colorectal surgery, superficial infections are much more common than deep or organ/space SSIs (although the latter represent surgical failure such as anastomotic leak rather than a failure of bundle/prophylaxis). It is in primary care that the majority of infections are seen, with poor data recording and a likelihood of inappropriate care and healthcare costs (particularly for use of antibiotics). Deep SSIs require prolonged hospital stays, with the need for intensive care/high dependency unit admission, further surgical interventions and extra treatments. All these complications and overall survival are worsened after rectal or emergency colorectal surgery, surgery for inflammatory bowel disease, prolonged operations, presence of a stoma and obesity.[21–23] Compliance with care bundles and even with surveillance programmes for SSI incidence and prevention is not widespread in colorectal surgical practice, nor is it supported by national institutions.[5,15,24]

SSIs are also common after hepatobiliary surgery.[25] In a NHS hospital trust, a simple SSI infection prevention control package of ten items has been found to more than halve SSIs after hepatobiliary surgery, with reduction of hospital stay.[26] Savings from this bundle, which costs little to implement, were equally substantial. However, in order to underwrite its success, the introduction of the bundle needed a surgical champion and team ownership as well as near perfect compliance.

Cardiac surgery has a lower SSI rate but the consequences of deep sternal SSI relate to sternal closure instability, mediastinitis and bone destruction with considerable morbidity and mortality.[27] Specific patient risk factors include peripheral vascular disease, smoking, obesity and diabetes, with operative risk factors being related to techniques of sternal closure, duration of surgery, bilateral use of internal thoracic arteries and need for postoperative ventilator support.[28–30] Management may require extensive intervention, including negative pressure therapy and flap reconstruction. With the implementation of care bundles, the deep sternal wound infection rate has fallen to <2% with a reoperation rate of 0.6%.[31,32]

Are antimicrobial sutures effective?

All surgical wounds are contaminated by the time of closure and related to several risk factors.[33] All sutures (whether they are absorbable or unabsorbable, synthetic or natural) represent a prosthetic implant; a 90cm length of polyglactin presents a total surface area of $130cm^2$. The presence of a suture increases the frequency of a SSI and logarithmically lowers the number of organisms required to produce a postoperative SSI from 10^6 or 10^5 to 10^2 colony forming units.[34,35]

The importance of the role of biofilms has also been recognised; once a biofilm forms on the surface of a suture, its contained organisms become recalcitrant to traditional antimicrobials.[36] Having a wide spectrum biocide (in this case, the antiseptic triclosan) coated or impregnated in a suture can provide high localised antimicrobial concentrations around the suture, preventing it from becoming a nidus for biofilm and infection. The advantage of using an antiseptic as opposed to an antibiotic for this purpose is that triclosan has the valuable benefits alluded to earlier.

The early experimental data on triclosan coated sutures were supportive[17,18] but some of the clinical trials were scientifically flawed because of poor blinding, power calculations or randomisation. Many well designed studies have since been published and deemed adequate in several systematic reviews and meta-analyses using PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines.[37–42] All these meta-analyses report a reduction of approximately 30% in a population of several thousand patients. The studies included general, gastrointestinal, colorectal, cardiac, vascular, breast and prosthetic surgical procedures. The study by Daoud *et al* specifically included different classes of surgery (clean through to contaminated/dirty) and found the same advantage could be attributed to antimicrobial sutures with no publication bias and a robust sensitivity analysis.[39] It concluded that the 33% (95% CI: 16–46%) advantage proffered by antimicrobial sutures was level I evidence.

A more recent scientifically acceptable RCT was more cautious in its findings in colorectal surgery.[43] The study was probably too underpowered to show a significant difference in deep SSIs (although they were reduced), and it was limited by not having the subcutaneous and subcuticular layers closed with an antimicrobial suture. It is unlikely that closure using an antimicrobial suture, only in the deeply placed, musculofascial layer, could prevent a superficial SSI.

Conclusions

A pivotal component of the discussion must be: ‘Why should a surgeon choose to use an antimicrobial suture in his or her clinical practice?’ When triclosan coated, braided polyglactin sutures were first introduced in 1992, there was significant scepticism over its perceived benefit. This was, in part, driven by a lack of published clinical studies documenting efficacy, coupled with a poor understanding of how an innovative suture technology could assist in preventing SSIs. Published in vitro laboratory and animal studies documenting benefit were viewed as insufficient rationale for adopting this technology in routine clinical practices.

Three factors have now played a significant role in tipping the balance for the use of an antimicrobial suture technology in surgical practice. The first is the eventual completion of well designed surgical studies published in peer reviewed surgical journals, which culminated in publication of rigorous meta-analyses,[39–41] documenting 1a clinical benefit. Second, there is recognition that the antimicrobial suture should not be viewed as a ‘silver bullet’ but rather as part of a designed-for-purpose, evidence-based, interventional risk reduction strategy. Finally, recognition of the benefits associated with use of a triclosan coated suture has culminated in universal endorsement of this technology by governmental and professional associations and organisations. The World Health Organization,[44] the American College of Surgeons/Surgical Infection Society[45] and the Healthcare Infection Control Practices Advisory Committee of the Centers for Disease Control (to be published in 2017) have all endorsed the use of triclosan coated/impregnated suture technology as an effective risk reduction strategy for SSIs.

In evaluating the decision whether to adopt an antimicrobial suture in a perioperative care bundle, four levels of evidence should be considered: safety, microbicidal activity, clinical effectiveness and cost effectiveness. While clinical effectiveness has been addressed adequately in this review, patient safety associated with use of any invasive innovative technology should be of paramount concern to all surgeons. In the 14 years since triclosan sutures have been commercially available, there have been no reports to the Food and Drug Administration Manufacturer and User Facility Device Experience website indicating any significant adverse events such as wound dehiscence, delayed healing, emergence of resistant organisms, toxicity or allergic reactions.[46] Furthermore, these sutures exhibit a robust antimicrobial activity, appropriate for common surgical wound pathogens. Finally, several economic analyses have documented a fiscal benefit associated with the use of this technology in both paediatric and adult surgical procedures.[47–49]

Surgical practitioners should now approach their discipline from an evidence-based perspective and include the use of effective surgical care bundles in their clinical practice. The option of using a triclosan coated/impregnated antimicrobial suture in a surgical care bundle should always represent individual preference. However, that decision is now easily made in light of the wealth of evidence supporting the benefit of an antimicrobial closure technology in the presence of co-morbid patient risk factors. For maximum benefit, triclosan coated or impregnated antimicrobial sutures should be used to close all layers of the surgical wound since wound contamination is often linear. Finally, an ancillary benefit of any evidence-based approach for reducing the risk of SSI could lead to a diminished need for perioperative antibiotic therapy, which fits well in our global mandate of effective antibiotic stewardship.

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