# An overview of surgical site infection

KEY WORDS
- Antibiotic prophylaxis
- Antimicrobial sutures
- Antiseptics
- Surgical dressings
- Surgical site infection

Surgical site infection (SSI) is a common healthcare-associated infection (HCAI) and complicates up to 10–15% of operations, with considerable healthcare resources expended in the process. In addition to the use of appropriate hair removal, antibiotic prophylaxis, avoidance of hypothermia and peri-operative blood glucose control to reduce SSIs, there is new research and outcomes that should be considered for inclusion in guidelines. The efficacy of preoperative bathing/showering, antibiotic prophylaxis for clean surgery and peri-operative oxygen supplementation to prevent SSIs remains doubtful. However, the use of 2% chlorhexidine in alcohol skin preparation, postoperative negative pressure wound therapy and antiseptic surgical dressings do show promise. Antimicrobial sutures, in independent meta-analyses, reduced the risk of SSI after most classes of surgery, whereas wound guards did not. The incidence of SSI is not falling and is proportionally rising as the most common HCAI. Some innovations should be included into care bundles, but more research is required for others, together with improved compliance with care bundles.

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Healthcare-associated infections (HCAIs) in England are estimated to affect 6.4% (confidence interval [CI] 4.7–8.7%) of patients in health care, with surgical site infections (SSIs) being the third most common (15.7%) (Health Protection Agency [HPA], 2011a; 2012). These figures are underestimates but the incidences of methicillin-resistant *Staphylococcus aureus* (MRSA) and *Clostridium* (C.) *difficile* infections are falling. Although SSIs are the most preventable HCAI, their incidence is not falling and, as a consequence, they are becoming the most common HCAI.

A High Impact Intervention (HII) care bundle issued by the UK Department of Health (DH, 2010) is based on a guideline for the prevention and treatment of SSIs published by the National Institute for Health and Care Excellence (NICE, 2008; 2013). The HII bundle incorporates the use of antibiotic prophylaxis, appropriate pre-operative hair removal, avoidance of peri-operative hypothermia and peri-operative blood glucose control in patients who have diabetes, with other recommendations, which are not of a level-IA evidence base. Despite the introduction of these directives over 5 years ago, no evaluation of compliance or their effectiveness has been published (Leaper et al, 2014).

The national SSI surveillance system (Public Health England), uses SSI data from 17 categories of surgical procedures (HPA, 2011a), but mandatory surveillance is undertaken after orthopaedic surgery (Health Protection Agency [HPA], 2011b). However, the true prevalence of SSI is underestimated, depending on surgical specialty, accepted and validated definitions and the comprehensiveness of postoperative surveillance (Leaper et al, 2013a; Tanner et al, 2013).

When close post-discharge surveillance is undertaken, 10–20% of surgical operations are found to be complicated by an SSI (Williams et al, 2011; Thibon et al, 2012; Yokoe et al, 2012). SSIs are associated with over a third of postoperative deaths and range from a short-lived wound discharge (e.g. superficial SSI after open hernia surgery), to being life-threatening (e.g. deep sternal wound infection; Astagneau et al, 2001). The actual cost of an SSI can involve extra days of inpatient treatment and added procedures, or litigation, and substantial extra costs to healthcare systems (Bayat et al, 2003; Leaper et al, 2010). Research presenting new data and technology has been published since the NICE guideline

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recommendations and considered in a NICE evidence update (NICE, 2013). Some of these data are suitable for guideline inclusion and high impact interventions, but other data have not added to the evidence already in place.

## PREOPERATIVE BATHING AND SHOWERING

Ensuring personal hygiene of the operative team and surgical patient is not controversial, but the role of preoperative bathing and showering with antiseptics to prevent SSIs is unproven. Only further trials can improve this evidence base, which is based on studies that are mostly over 20 years old.

A Cochrane review of seven randomised controlled trials (RCTs), involving 10,157 patients (Webster and Osborne, 2012), found that preoperative showering or bathing with chlorhexidine was no more effective than placebo, soap or no washing. A further systematic review of 10 studies and 7,351 patients (Jakobsson et al, 2011) found that no conclusions could be made about the optimal number of preoperative showers.

Another inconclusive systematic review of 20 randomised and non-randomised studies involving 9,520 patients (Kamel et al, 2012), evaluated three types of skin antiseptic (povidone-iodine, alcohol, or chlorhexidine) for patient skin preparation, operative team hand scrub procedure, preoperative showering or the use of antiseptic-impregnated incise drapes, across a wide range of surgery. There were methodological flaws in these trials (inconsistencies in the formulation, strength and application of antiseptics) and, although skin bioburden was reduced, this did not seem to correlate with SSI risk. Inclusion for meta-analysis was not possible with many studies because of significant heterogeneity, mixed quality and randomisation, being underpowered, and inclusion of a wide range of procedures.

## PATIENT ANTISEPTIC SKIN PREPARATION

It is conventional to prepare patients' skin at the surgical site before surgery using an antiseptic (such as povidone-iodine or chlorhexidine; aqueous or alcohol-based). A Cochrane review (Hadiati et al, 2014) compared different preoperative skin preparations for preventing SSI after Caesarean section in five randomised, quasi-randomised, and cluster-randomised trials involving 1,462 patients, and found that the use of incisional drapes made no significant difference. No other conclusions could be drawn because of heterogeneity and small numbers of patients in studies; this reflects the conclusions of another review (Kamel et al, 2012). This included an RCT (n=849) (Darouiche et al, 2010) that compared alcoholic 2% chlorhexidine with aqueous povidone-iodine skin preparation. The chlorhexidine group significantly reduced SSIs — from 16.1% to 9.1% — but the comparison with an aqueous-based antiseptic was flawed. The most effective antiseptic for skin preparation before surgical incision is currently uncertain.

## ANTIBIOTIC PROPHYLAXIS AFTER CLEAN SURGERY

The benefit of antibiotic prophylaxis for clean surgery remains controversial. A Cochrane review, which assessed 17 RCTs, including 7,843 patients in adults having open inguinal or femoral hernia repair, found that SSIs were significantly lower when antibiotic prophylaxis was given (3.1% compared with 4.5%). However, infections after herniorrhaphy (no mesh) were not significantly different (Sanchez-Manuel et al, 2012). Another Cochrane review (Bunn et al, 2012) examined seven RCTs, including 1,945 patients undergoing breast cancer surgery, and found a significantly reduced incidence of SSI (by over a quarter) after prophylactic antibiotics. There were flaws in the studies; some were old and various antibiotics were used. However, a more recent double-blind RCT (Cabaluna et al, 2013) found no difference. The risk of antimicrobial resistance and its associated costs have to be considered and the value of prophylactic antibiotics in clean surgery is still not clear.

## NEGATIVE PRESSURE WOUND THERAPY

Negative pressure wound therapy (NPWT) is used for treating chronic wounds to promote wound healing, wound debridement, alleviate exudate and odour, and improve quality of life (Ubbink et al, 2008; Leaper et al, 2012). Success has also been reported in complex wounds (Kirby, 2007), with emerging evidence to show it prevents SSIs after high risk surgery (Matatov et al, 2013; Grauhan et al, 2014).

A retrospective analysis of surgery for intra-abdominal malignancies (Blackham et al, 2013) found that postoperative incisional NPWT was followed by fewer SSIs compared with standard dressings (5.5% compared with 16.0%). A prospective study of obese patients (BMI ≥ 30) having a median sternotomy for cardiac surgery (Grauhan et al, 2014) found that NPWT reduced 16% to 4%.

Portable NPWT devices have been used to decrease the incidence of groin SSIs after vascular surgery (Matatov et al, 2013), from 30% to 6%. In another retrospective review of patients undergoing open colectomy (Bonds et al, 2013), it was found that SSIs were halved by the use of incisional NPWT (from 27.2% to 12.5%). In patients with blunt, high-energy fractures of the lower limb, a randomised multicentre study compared standard dressings to NPWT (Stannard et al, 2012) with a reduction in SSIs. However, a study of surgery for ventral hernias (Pauli et al, 2013) found that NPWT conferred no reduction of SSI after repair of potentially contaminated and infected hernias, nor any reduction of wound complications at a 12-month follow-up.

As these early studies are small, further well-powered and well-designed RCTs and systematic reviews are needed before the use of NPWT can be recommended to reduce the risk of SSI.

## PERI-OPERATIVE OXYGEN SUPPLEMENTATION

Optimal oxygenation during surgery is part of best practice to ensure a haemoglobin saturation of more than 95%. A systematic review and meta-analysis of seven RCTs, including 2,728 patients, examined the role of peri-operative oxygen supplementation in the recovery room to reduce SSIs (Togioka et al, 2012). No significant difference was seen in the rate of SSIs between supplemented oxygen and control groups (15.5% compared with 17.5%). However, two subgroup analyses suggested there may be some benefits, which justifies further research. Flaws in the trials included heterogeneity of antibiotic use, definition of SSI, patient population, and duration of peri-operative oxygen supplementation.

## ANTISEPTIC SURGICAL DRESSINGS

Whether an incisional dressing is necessary after surgery, or whether it should be a transparent polyurethane or absorptive island dressing, is unclear. A Cochrane review of 16 RCTs, involving 2,578 patients (Dumville et al, 2011), found there was no evidence that dressings reduced SSIs. There were many methodological flaws in these trials, including heterogeneity, small size and poor scientific quality; many were old studies. Few studies of antiseptic dressings to prevent SSIs have been undertaken. However, in a small RCT involving 110 patients undergoing colorectal surgery (Krieger et al, 2011), silver nylon dressings were found to reduce SSIs from 33% in controls to 13%. There were flaws in the study and further evidence is needed to advocate the use of antiseptic dressings.

## WOUND GUARDS

The value of wound guards to prevent SSIs after open abdominal surgery has been examined in a systematic review and meta-analysis (Gheorghe et al, 2012). Most studies (10 RCTs and 2 controlled trials, involving 1,933 patients) were old and of poor quality, with variable definitions and risk of bias. The same group of authors have since published an RCT — the ROSSINI trial — which showed there was no benefit conferred by wound edge protection devices in the prevention of SSI (Pinkney et al, 2013).

## ANTIMICROBIAL SUTURES

Laboratory-based evidence has shown that antimicrobial impregnated or coated synthetic absorbable sutures can effectively deliver an antiseptic (triclosan) into tissues. Several flawed and underpowered early clinical studies showed some promise, but three independently undertaken systematic reviews and meta-analyses have shown that there is level 1A evidence for clinical use. The first (Wang et al, 2013) identified 17 RCTs, involving 3720 patients, and found that antimicrobial sutures significantly reduced SSIs by 30% (CI 0.57 to 0.85).

Some studies were flawed by being underpowered, with varying definitions and use of unconventional comparators. The second (Edmiston et al, 2013) identified 13 RCTs, involving 3,568 patients, of better quality and found a reduction of SSIs of 27% (CI 0.59 to 0.91). The third meta-analysis (Daoud et al, 2014) identified 15 RCTs, involving 4,800 patients, using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines and found that antimicrobial sutures reduced SSIs by 33% (CI 0.53 to 0.84) with no evidence of publication bias, a sensitivity analysis robust up to removal of three trials and that the effect was significant in subsets of clean, clean-contaminated and contaminated surgery.

## DISCUSSION

Evidence-based medicine, derived from systematic reviews and meta-analysis, provides the strongest data for the compilation of guidelines. Wherever there are gaps in knowledge, recommendations have to be based on operator experience, patient preferences and data from less-convincing cohort and non-comparative studies. However, many of the RCTs included in meta-analysis are also of less than perfect scientific quality and guidelines should reflect that.

Many aspects of current research, to prevent SSIs, involve a return to the use of antiseptics, which has been commented on before (Leaper, 2011; Leaper et al, 2013) and is timely bearing in mind the worldwide concern of rising antibiotic resistance and the lack of new antibiotic groups entering research trials (Leaper, 2010).

Having several evidence-based interventions in a care bundle has potential because, when enacted together with a high compliance rate, they might act with a summation effect and reduce the risk of an SSI to a low level. SSIs are common HCAIs and require considerable healthcare resources, and compliance with guidelines should minimise this potentially preventable HCAI. However, compliance with care bundles is poor and might account for the failure of SSI rates to fall.

Systematic reviews and meta-analysis show that antimicrobial sutures reduce the incidence of SSIs after most classes of surgery and should be considered for inclusion in care bundles. Two per cent alcoholic skin preparation, postoperative negative pressure incisional wound therapy and antiseptic wound dressings show promise, but more research is needed to confirm their value and inclusion in care bundles. Preoperative bathing/showering, antibiotic prophylaxis for clean, non-prosthetic, surgery and peri-operative oxygen supplementation are still in doubt, but wound guards were not found to reduce SSI. WUK

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