Antisepsis, asepsis and skin preparation

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Abstract

Surgical site infections (SSIs) impact significantly on patient mortality, morbidity and quality of life. They also incur financial costs on the healthcare system, although the total cost may vary depending on the severity of the infection. Antisepsis, aseptic technique and skin preparation are important concepts in the preventative strategies to reduce the risks of SSIs. This article reviews these concepts and the role they play in the patient's perioperative journey.

Keywords Antisepsis; Asepsis; Skin preparation; Surgical site infection

Introduction

Surgical wounds offer a portal of entry for pathogenic microorganisms, some of which are multi-resistant. Infection occurs when the host's innate defences are overcome by the dose and virulence of the pathogenic microorganisms contaminating the wound.[1]

Surgical site infections (SSIs) are infections occurring after surgery and may involve the skin or subcutaneous tissue of the incision site (superficial SSI), or the deep soft tissues such as fibrous connective tissue and muscle layers (deep SSI), or part of the anatomy (organ/space SSI). Diagnosis is based on the presence of two or more signs and symptoms of infection and purulent discharge on the wound or presence of pus cells on microbiological examination.[2] The decision to treat is based on clinical signs and symptoms. The choice of antimicrobial agent is empirical while awaiting culture and sensitivity results. However, they should, when possible, be guided by the microorganism identified in aseptically collected specimen such as wound swab, fluid or tissue.[3]

Approximately 5% of patients who undergo a surgical procedure are reportedly affected by SSI,[4] although a more accurate estimate may be higher due to undetected cases occurring after discharge from hospital. They impact negatively on the patients' quality of life and are highly associated with extended length of hospital stay, persistent surgical complications, mortality and enormous financial burden to healthcare organizations worldwide.[5]

The risks involved in the development of SSIs are complex and may involve the following:

- intrinsic or patient risk factors which are either modifiable (e.g. obesity, alcohol and smoking status, glycaemic control) or non-modifiable (e.g. age, history of skin and soft tissue infections)
- extrinsic factors which are associated with
  - the surgical procedure (e.g. clean or contaminated procedure, complex surgery)
  - the healthcare facility (e.g. ventilation in the operating theatre, sterilization of equipment) and
  - interventions before surgery (e.g. adequate skin preparation and hair removal), during surgery (e.g. quality of surgical hand scrubbing and aseptic technique) and after surgery (e.g. aseptic technique in wound care).[5]

It has been reported that more than 50% of SSIs are preventable. Although surgeons can only modify a limited number of these risk factors, there are multi-modal strategies which can be implemented to reduce the risks of SSIs. Antisepsis, asepsis and skin preparation are important concepts embedded within these preventative strategies and the surgeons' understanding of these concepts and compliance with best practice recommendations are crucial in reducing the risk and burden of SSIs.[5]

Antisepsis, asepsis and skin preparation in the patient's perioperative journey

Antisepsis refers to the process of reducing or inhibiting the growth of microorganisms on the skin or mucous membranes. Products used for antisepsis are called antiseptics. Those which are commonly used in healthcare include hand hygiene products (e.g. soap and hand rubs), preoperative skin disinfectants prior to surgery, surgical hand scrubs, tinctures and mouthwashes.[4]

Asepsis is defined as freedom from pathogenic microorganisms *in sufficient dose* to cause an infection. In keeping with the pathogenesis of wound infection, this offers a more practical and realistic concept of achieving asepsis in any healthcare setting. Aseptic technique refers to methods used to achieve asepsis by preventing contamination of susceptible sites during invasive procedures.[1]

Interventions in preventing and reducing the risk of SSIs can be classified broadly into three periods: preoperative, intraoperative, and postoperative. Safe practice in antisepsis, asepsis and skin preparation is vital during this perioperative journey to reduce the risk of SSIs.

Preoperative period

Prevention on the surgical ward

Hand hygiene is one of the most important practices to prevent healthcare-acquired infections, spread of multi-resistant microorganisms and outbreaks of infection. Hands must be decontaminated at the point of care or where patient care is happening. Correct placement of alcohol based hand rubs or dedicated handwashing sinks near or at the point of care helps improve compliance with handwashing.[6]

Based on the World Health Organization's (WHO) five key moments of hand hygiene, hands must be decontaminated

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immediately before and after patient contact, after contact with the patient environment, before performing procedures requiring clean hands or aseptic technique, and after contact with bodily fluids.[6]

The use of soap and water for hand antisepsis is recommended for visibly dirty or soiled hands and after exposure to blood or bodily fluids, or exposure to spore-forming pathogens. For all other clinical situations, alcohol hand rub can be used for routine hand antisepsis. Wearing of gloves does not provide full protection from hand contamination and inappropriate use does not contribute to reduction of cross-transmission of infections.[6]

Using the correct technique in hand decontamination is important to ensure all hand surface areas are thoroughly decontaminated (Table 1). Wearing of hand jewellery affects hand contamination and hand hygiene technique. Skin under rings has been shown to be more heavily contaminated with pathogenic microorganisms such as Gram-negative bacilli (e.g. *E. cloacae, Klebsiella* spp. and *Acinetobacter* spp.). Staff who wear artificial nails have been proven to have more contamination on their fingertips compared to staff who have natural nails. Rings with a sharp surface and long sharp nails can damage the skin during hand washing or puncture gloves. Removing stoned rings and wrist jewellery and wearing short-sleeved garments or sleeves that can be rolled or pushed up allow thorough hand hygiene to be performed.[6]

WHO hand hygiene techniques

WHO hand hygiene technique using alcohol hand rub (2009, p. 155)[6]	WHO hand hygiene technique using soap and water (2009, p. 156)[6]
Apply a palmful of the product in a cupped hand, covering all surfaces	Wet hands with water; apply enough soap to cover all hand surfaces
Rub hands palm to palm	Rub hands palm to palm
Right palm over left dorsum with interlaced fingers and vice versa	Right palm over left dorsum with interlaced fingers and vice versa
Palm to palm with fingers interlaced	Palm to palm with Backs of fingers to opposing palms with fingers interlocked; fingers interlaced
Backs of fingers to opposing palms with fingers interlocked	Rotational rubbing of left thumb clasped in right palm and vice versa
Rotational rubbing of left thumb clasped in right palm and vice versa	Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa
Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa	Rinse hands with water
Once dry, your hands are safe	Dry hands thoroughly with a single use towel

Table 1

Preoperative showering or bathing

Showering or bathing before surgery reduces concentration of both resident and transient microorganisms present on the skin before surgery. In the UK, the National Institute for Health and Care Excellence (NICE) guidelines[3] and Department of Health's (DH) High impact intervention care bundle for preventing SSIs[2] both recommend preoperative showering or bathing using soap the day before or on the day of surgery.[3] Although there is inconclusive evidence that the use of antiseptic agents in preoperative body washing reduces the rates of SSIs, it is now a well-accepted practice for most hospitals internationally to prescribe them as part of pre-admission shower regime.[2]

Chlorhexidine gluconate (CHG) is a common ingredient of antiseptic body wash. Its level of concentration accumulates on the skin as it binds to skin proteins with repetitive applications but this is reliant on the amount used and the length of time it is left on the skin before rinsing. Cited in the SSI Guidelines by the American College of Surgeons (ACS) and Surgical Infection Society, Edmiston and colleagues' study showed that using a 4 oz volume of a 4% aqueous CHG solution when showering, and leaving the lather on for 1–2 minutes before rinsing resulted on a higher concentration of CHG on the skin surface.[5] Tanner et al.'s study also showed a more effective reduction of colony forming units on the skin of healthy volunteers using CHG compared to using soap and Octenidine.[7] For patients with reduced mobility, 2% CHG impregnated cloths can be used as an alternative. The use of CHG for preoperative showering or bathing must be differentiated from decolonization or suppression therapy required for *Staphylococcus aureus* carriage prior to surgery which is discussed in the next section.[8]

Meticillin-resistant *Staphylococcus aureus* screening and decolonization

Patients who are colonized with meticillin-resistant *Staphylococcus aureus* (MRSA) have a higher risk of MRSA-associated SSIs and worse postoperative outcomes. In the UK, the DH guide for MRSA screening is streamlined to focus on patients who are admitted into highrisk specialities (vascular; renal/dialysis; haematology/oncology/bone marrow transplant; orthopaedics/trauma; cardiothoracic surgery; neurosurgery; and all intensive care units); patients who had previous MRSA carriage; and those who are admitted from units or healthcare environment where MRSA may be endemic such as nursing homes or other hospitals.[9] The result of MRSA screening provides information on the choice of prophylactic antibiotics required to reduce the risk of SSIs.

MRSA screening involves taking a swab of the nose, groin and other potential focal source of infection (e.g. wounds, medical devices). Patients found to be positive to MRSA must receive decolonization or suppression therapy prior to surgery [3,9] Decolonization protocols typically involve a 5-day regime of a daily wash/shower/bath using 4% CHG and twice daily nasal decontamination using mupirocin (unless mupirocin-resistant, then the alternative is CHG with neomycin or naseptin). To be effective, it is suggested that decolonization must take place close to the time of surgery. Nasal decontamination using mupirocin alone has been known to reduce the risk of SSI from *S. aureus* but routine use should be avoided to prevent MRSA developing resistance.[5]

Hair removal

Hair from the operative site should only be removed if it will interfere with the surgery. Hair removal must be performed close to the time of surgery and outside of the operating theatre. Patients must be informed not to shave themselves prior to surgery. If hair removal is required to be done inside the operating theatre, wet clipping can be performed and the hair dispersal controlled by the use of a vacuum unit attached to the clipper. The hair is collected into a single-use filter preventing aerosol plume and saving clean-up time prior to surgery.[2,4,5]

If hair removal is necessary, single-patient hair clippers or electric clippers with single-use heads must be used as they cut the hair close to the skin, but do not touch it, hence avoiding micro-abrasions which disrupt the skin's barrier defence against infection.[4]

Razors are no longer recommended although they are still used for shaving in the scrotal and scalp areas following traumatic injuries.[4]

Depilatory creams have their use but they can be impractical. If patients need to remove hair prior to admission to hospital (e.g. day-care patients) and a clipper is not available or the patient is not able to use one, the use of depilatory cream has been reported to carry less risk than shaving. Caution must be taken for any allergic skin reactions; it must be tested 24 hours before use. It takes at least 15–20 minutes before hair is dissolved.[4]

Skin preparation

The safe practice of skin preparation prior to surgery or 'skin prepping' involves the combination of the appropriate antiseptic solution and effective method of application to reduce both resident and transient microorganisms on the deeper layer of the skin on the intended incision site and the skin surrounding it.[1]

There are mixed recommendations from different expert groups but the majority prefers the use of alcohol-based antiseptic with CHG.[1] The DH high-impact intervention care bundle recommends 2% solution of CHG with 70% isopropyl alcohol. However, there is limited evidence to support that this is more effective than the conventional 0.5% CHG solution available for surgical skin preparation.[4]

In general, the use of skin antiseptics must be avoided on preterm infants due to risks of burns and skin irritation. Caution must be taken when using alcohol-based products for procedures involving direct contact with mucous membranes and inside the ears to avoid vestibular and ototoxicity. Although the incidence rate is low, there have been reports of hypersensitivity, allergic and even anaphylactic reactions to CHG. Sensitivity and allergic reactions have also been reported from the use of povidone-iodine although infrequently because it is less commonly used. Nonetheless, caution must be taken on repeated use for patients with thyroid disorders due to risk of iodine toxicity.[4]

More recently, there has been a move towards using single-use products such as individual sachets of antiseptic solutions and applicators. The use of individual single-use sachets reduces the risk of contaminating multi-use bottles during handling (e.g. contaminating the cap or inside neck of the bottle when pouring the solution). Single-use applicators are supplied in paint-pad style with the right dose of the antiseptic; the attached sponge pad applies the solution onto the skin. Gentle friction is applied when rubbing the skin to penetrate the deeper layers. Potentially, single-use paint-pad applicators can help reduce dosing errors, improve and standardize practice, save time, and reduce waste.[10]

Sterile surgical drapes

Sterile surgical drapes are used to protect the incisional site from contamination. Reusable surgical drapes are made from durable materials (typically chemically-treated knitted cotton blended with polyester), able to withstand multiple cycles of processing and treatment. Disposable surgical drapes are non-woven, typically made from synthetic materials. When used, they should be secured around the operative site and protect the skin underneath from contamination and moisture penetration.[1]

Adhesive incise drapes form part of the sterile field and is applied immediately following skin preparation and prior to incision. A Cochrane review of their use in surgery did not find evidence that they reduce the rate of SSIs. The review found some evidence that they can also contribute to infection.[11] The drape-lift or drape pull-back from the incision site can pose a risk of exposing the wound edge to microorganisms. There has also been some reports of recolonization of the skin under the incise drape after application.[1]

If required, NICE guidelines recommend the use of iodophor-impregnated incise drape unless the patient has a known iodine allergy. Iodine impregnated incise drapes have been found to have high antimicrobial activity against MRSA. Non-iodophor impregnated drapes must not be used routinely for surgery for the purpose of reducing SSIs.[3,4]

Preparation of the surgeon

Surgical hand preparation: surgical hand preparation or scrubbing is different from the hand decontamination using soap and water or alcohol-based hand rub (ABHR) performed outside of the operating theatre as it uses specific surgical antiseptic hand preparation solutions that have proven efficacy in reducing and inhibiting the growth of bacteria on the hands. For this purpose, these antiseptic solutions must comply with the European Committee for Standardization and the American Society for Testing and Materials.[1]

Traditional scrubbing is performed using antiseptic soap solutions containing 4% CHG and either 10% or 7.5% povidone-iodine. Waterless hand rubbing involves the use of ABHR (1% CHG and 61% ethyl alcohol).[1] Prior to surgical scrubbing, nails must be short and free from nail polish; artificial nails and all jewellery must be removed. Hands that are visibly soiled must first be washed with non-medicated soap under running water; debris under the nails can be removed using single-use nail cleaners. Hands must not be scrubbed.[1,12]

When using antiseptic soap solutions, hands and forearms must be scrubbed for the duration recommended by the manufacturer, usually 2–5 minutes. With waterless hand rubbing, hands and forearms must be dry in order to maintain the product's antimicrobial activity. Hence, scrubbing using antiseptic soap and water must not be used in combination with or precede the use of ABHR.[1] Sufficient amount must be applied to hands and forearms for the duration of the waterless rubbing procedure and the length of time recommended by the manufacturer, typically 90 seconds (Box 1). Hands must be washed again with antiseptic solution if they become visibly contaminated.[3]

Surgical scrubbing technique 1

AfPP 'A Guide to Surgical Hand Antisepsis' (2017)[12]

1. Wet hands and forearms and apply appropriate amount of antiseptic solution (recommended by the manufacturer) or apply alcohol-based hand rub onto palms, all areas of the hands and arms to just below the elbow
2. Rub right palm over back of left and vice versa with fingers interlaced
3. Rub palm to palm with fingers interlaced
4. Rotational rubbing backwards and forwards with clasped fingers of right hand into left palm and vice versa
5. Rotational rubbing of right thumb clasped in left hand and vice versa
6. Rub finger tips on palms for both hands
7. Continue with rotating action down opposing arms, working to just below the elbows — do not move back towards wrist. If using ABHR an additional dose may be required here, one for each arm
8. Rinse and repeat steps 1—7 keeping hands raised above elbows at all times.

This wash should now only cover two thirds of the forearms to avoid compromising cleanliness of hands.

Local policy may include repeating these steps a third time but to wrists only.

If using a solution, rinse hands under running water - clean to dirty area. Turn on tap using elbows if necessary. Open gown pack onto a clean surface and take a hand towel. Hands are dried first by placing the opposite hand behind the towel and blotting the skin, then, using a corkscrew movement, to dry from hand to elbow - do not move back down towards wrist. Discard towel. Using a second towel, repeat the process on other hand and forearm before discarding.

If using ABHR, allow hands and forearms to dry completely before donning sterile gloves (WHO 2009, 2016).

Box 1

Surgical gloving: gloves provide a barrier protecting the surgical team from exposure to blood-borne pathogens during surgical procedure. Longer surgical procedures increase the risk of glove puncture. Some techniques contribute to higher incidence of glove perforation (e.g. glove perforation was observed in approximately 57% of major operations involving mass closure technique.[8] Bekele et al. (2017) reported significant higher incidence rate of glove perforation in emergency compared to elective surgery, although this may have been due to the limited experience of surgical residents who performed most of the procedures. First surgeons and scrub nurses had the highest rate of glove perforation; the index and middle fingers of the left handed gloves were the most common puncture sites.[13]

For procedures that carry a high risk of glove perforation, NICE (2016) recommends considering wearing two pairs of sterile gloves.[3] There is evidence that this practice reduces the amount of bodily fluid that could inoculate the surgical staff by wiping off most of the contaminant on the surface of the sharp item. Corresponding inner glove puncture has been seen in less than 50% of outer gloves.[8]

As well as protecting the surgical team from blood-borne pathogens, surgical gloves also contribute to maintaining an aseptic environment during surgery which helps protect the patient from contamination from the surgeon's hands. A study by Hosseini et al., found that the surgeons' hands showed the same or even more contamination 5 hours after surgical scrubbing.[14] Gloves are likely to be contaminated during draping and hence must be changed prior to starting the incision. They are also likely to become permeable after contact with cement, hence a change may be needed prior to contact with implants. The WHO (2009) review did not find any evidence whether the use of double gloving, changing gloves during surgery or the use of specific type of gloves are more effective in reducing the risk of SSI.[1]

Surgical face masks and eye protection (goggles or visors) provide barriers from bodily fluid splashes. Although still referred to as a personal protective equipment (PPE), surgical face masks are not classed as PPE under the European Directive 89/686 because they do not provide the same level of protection as respirators do in the case of smaller airborne droplets or aerosols.[10]

Although surgical face masks were originally developed to protect the patients from SSIs, recent Cochrane review (2016) did not find conclusive evidence to suggest that they reduce incidence of SSIs.[15] However, surgical procedures often carry high risk of splashes and spatter of bodily fluids and wearing of masks and eye protection are essential elements of standard infection control precautions. Their purpose is not only for the safety of the surgical team but for the safety of patients in promoting asepsis by preventing wound contamination during surgical procedures.

Surgical gowns and hair cover: sterile surgical gowns must be worn by the surgical team in preparation for the operation.[3] During physical activity, as much as 10^4 skin scales are shed per minute. Surgical gowns and hair cover help contain the shedding and prevent contamination of the wound and the sterile field.[2]

Gowns must be impermeable, resistant to microbial penetration, made of non-woven fabric to minimize release of particles (non-linting) and allows the wearer to perform the tasks required of the surgery without compromising the sterile field. They must be immediately removed and replaced if contaminated. There is no evidence that links different types of surgical gowns to the incidence or risk of developing SSIs.[16]

Exposed hair of surgical staff during surgery can also pose a risk for SSIs and in recent years have attracted much interest and concern. A study comparing disposable shower cap-like bouffant hats, disposable surgical skullcaps (tie-in-the-back, close-fitting caps) and reusable skullcaps showed no statistical difference in the airborne contamination between disposable skullcaps and bouffant-style hats. However, reusable skullcaps, which had a non-porous crown like the other two, showed lower airborne particle counts and microbial shedding at the sterile field compared to the bouffant hats.[17] To date, there is no definitive

evidence linking the use of either cloth caps or disposable caps in preventing SSIs. There is also no data that links increased incidence of SSIs to exposed skin and hair during surgery. Like surgical gowns, hair cover must be immediately replaced once contaminated.[1]

Preparation of the operating theatre

There are numerous studies supporting the use of laminar airflow or ultraclean ventilation systems (laminar air flow combined with high efficiency particulate air [HEPA] filters) in reducing air contaminants. Surgical procedures which involve implantation of biomedical devices and implants carry higher risk of contamination during surgery.[18]

In orthopaedics, laminar airflow was previously deemed of paramount importance. However, recent evidence shows that laminar airflow may no longer be regarded as a preventative measure for reducing the risk of SSIs. Bischoff et al.'s (2017) systematic review and meta-analysis of 14 studies showed that the risk of SSIs in total hip arthroplasty procedure is not reduced by laminar airflow compared to a conventional theatre.[18] Although the quality of evidence has been found to be low to very low, the most recent WHO Global Guidelines for the Prevention of Surgical Site Infections (2016) recommended that laminar airflow should not be used for arthroplasty procedures for the purpose of reducing the risk of SSIs.[1]

Operating theatre staff must wear appropriately prescribed theatre garments. Scrub suits must not be worn outside the hospital facility and must be covered by an appropriate garment if worn outside the operating theatre department. They must be changed at least daily and replaced when contaminated. Masks should not be worn dangling on the neck.[19]

Any portable electronic device (mobile phones, tablets, bleeps, radios, and computers) must be cleaned and disinfected by an alcohol-related solution before they are allowed into the operating theatre. As much as 98% of these devices have been found to be contaminated with resistant microorganisms such as Gram-negative rods and *S. aureus*.[20]

Traffic from people and materials in and out of the operating theatre has been shown to increase the air contamination and affect the direction of air circulation. Beldi et al. (2009) found that hectic movements, changing of surgical team during the procedure, and presence of 1 or more visitors during surgery were strongly associated with the occurrence of SSI. Doors must not be opened unnecessarily and traffic must be controlled to reduce colony-forming units in the air during surgery.[21]

Preparation of surgical instruments

Decontamination of medical devices and surgical instruments is a complex process but a crucial one in the prevention of SSIs. Guidelines and standards are established at national and international level and the process is validated rigorously at every step.

Cleaning and disinfection: automated cleaning is safer and more efficient than manual cleaning; each cycle involved in the process is validated using physiological and physical parameters compared to protein detectors used in manual cleaning which can be expensive. WHO does not recommend soaking of instruments in disinfectant (0.5% hypochlorite or other disinfectant solution) prior to cleaning. Disinfectants can be deactivated by the presence of organic matter, contribute to antimicrobial resistance to disinfectants, damage the instruments, and pose a hazard risk to workers transporting equipment soaked in such solutions.

Sterilization: the use of steam is the most preferred method globally due to majority of heat–resistant surgical equipment. Pre-vacuum steam sterilizer is widely used for wrapped clean instruments and dry materials required for surgery (e.g. gowns, drapes). Heat and moisture sensitive devices can be sterilized using automated low temperature chemical sterilization. There are also 'flash' sterilization systems that operate at 134°C for 3 −10 minutes to re-process equipment for urgent use.[1]

Intraoperative period

Prophylactic antibiotics

Please see to Surgical antibiotic prophylaxis on pages 19−25 of this issue.

Antisepsis in suturing and wound irrigation

In the last 3 years, significant evidence has been presented to support the use of triclosan-coated sutures compared to regular sutures in reducing the risk of SSI. They are now recommended by the ACS and Surgical Infection Society in clean and clean-contaminated abdominal cases.[5] Independent of the type of surgery, this recommendation has also been included in the WHO Global Guidelines for the Prevention of Surgical Site Infections.[1]

Intraoperative wound irrigation and intra-cavity lavage has been known to reduce the bacterial load on the wound. To date, there are no clear guidelines on the use of antibiotic versus antiseptic solutions for wound irrigation prior to skin closure. Re-disinfection of the surgical wound prior to closure using antiseptics or topical cefotaxime is not recommended for reducing the risk of SSI.[15]

Postoperative period

There is no evidence to support routine use of topical or local antibiotics. However, it may benefit specific procedures such as joint arthroplasty, cataract surgery and breast augmentation; and patient population such as obese patients undergoing abdominal surgery.[5]

Conventional sterile wound dressings on primarily closed surgical wounds are recommended over advanced dressings.[1] More research is required on the use of silver impregnated wound dressing to prevent SSIs. There is also no sufficient evidence that early removal of wound dressing (<48 hours) affects the risk of SSI developing.[5]

Patient showering as early as 12 hours post-surgery does not increase the risk of SSI; practice must be guided by the surgeon's discretion.[5]

Summary

Antisepsis and asepsis are embedded in multi-modal strategies for preventing SSIs. Understanding of these concepts and

compliance with evidence-based interventions are crucial for patient safety in reducing the risk of infection in their perioperative journey. ◆

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