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REVIEW

Surgical site infections

Nel DC

Department of Anaesthesia, Chris Hani Baragwanath Academic Hospital, University of Witwatersrand
Correspondence to: *Dorinka Nel, e-mail: neldorinka@gmail.com*

Introduction

Surgical site infections (SSIs) are a worldwide problem that has far reaching implications on patient morbidity and mortality as well as significant financial implications. Worldwide it has an incidence of between 2-5%, with an incidence as high as 20% in colorectal surgery.[1] It is the third most common nosocomial infection, and the most common nosocomial infection amongst surgical patients with up to 38% of nosocomial infections being due to surgical site infections.[6] On average, it increases length of hospital stay by 7-10 days and in America in 2002, it was estimated to cost between $3 000 - $30 000 per incident of a surgical site infection. This cost estimate excluded cost to the patient after discharge from hospital.[1] Patients whose surgery was complicated by a SSI had a 2-11% higher risk of death. In those patients who died, 75% was directly attributable to the SSI.[1]

Definitions

Surgical site infection[2]

Infection that occur in the part of the body where the operation took place. It occurs *within* 30 days post surgery or *up to a year* after the procedure in case of an implant.[2]

Classification:[3]

Superficial

- Infection occurs within 30 days of operation *and*
- Infection is confined to the skin and superficial layers around the incision *and at least one of the following:*
- Purulent discharge with or without laboratory confirmation, from the superficial incision
- Organism found on culture of tissue/pus taken aseptically from the incisional area

Deep

- Infection that occur within 30 days if no implant is in-situ or within a year if implant is in-situ and the infection appears to be related to the operation *and* the infection occurs in the deep tissues of the incision *and at least one of the following:*
  - Purulent drainage from the deep tissues but not from the organ space associated with the procedure
  - A deep incision spontaneously dehisces or is deliberately opened by the surgeon when the patient has at least one of the following symptoms: *fever, pain or tenderness unless culture negative*
  - An abscess or other evidence of infection in the deep tissue is found on clinical examination, re-opening, histopathological or radiological investigation
  - Diagnosis of a deep SSI by a surgeon or attending physician

Organ space SSI

- Infection occurs within 30 days if no implant, or within a year if implant and the infection seems to be related to the operation *and* infection occurs in any anatomical site (Organ/space) other than the incision, which was opened or manipulated during the procedure *and at least one of the following:*
  - Purulent discharge from a drain that was sited through a stab wound into the organ or space
  - Organism isolated from an aseptically collected specimen from the organ or space
  - An abscess or evidence of infection found on examination or re-operation or by histo-pathological or radiological examination
  - Diagnosis of an organ/space SSI made by the surgeon or attending physician

Sepsis[6]

- The presence of *two or more of the following:*
  - Temperature ≥38 °C or ≤36 °C
  - Heart rate ≥90 bpm
  - Respiratory rate ≥20 breaths per min or $PaCO_2$ ≤32 mmHg
  - White cell count >12 000/mm³ or <4 000/mm³ or >10% immature bands
  - Anion gap acidosis
- AND one of the following:
  - Positive blood culture
  - Clinical documentation of purulence or positive culture from any site thought to be causative

Disinfectant

- Substance used on surfaces or instruments that may be colonized with micro-organisms that can cause infection e.g. household cleaners or Biocide® or Cidex®. Typically toxic when applied to living tissue

Antiseptic

- Substance used on living tissues and cells to destroy any type of infection or sepsis. Examples: Alcohol, Chlorhexidine, Iodine compounds or Iodophors

Necrotising fasciitis[13]

- An aggressive soft tissue infection involving the fascia, with a characteristic extensive undermining and tracking along anatomical planes.

Classification of surgical wounds[4]

Scoring systems

NNIS Risk Index[9] (1 point for every factor)

- Class III or IV wounds
- ASA class higher than 2
- Operation duration more than the 75th percentile of the average time for that specific procedure

Table I: Surgical wound classification

Class I/Clean:	An uninfected wound in which no inflammation is encountered and the respiratory, alimentary, genital and uninfected urinary tract is not entered. In addition, clean wounds are primarily closed and if necessary, drained via a closed system. Operative incisional wounds that follow non-penetrating (blunt) trauma should be included in this category if they meet the criteria
Class II/Clean-contaminated	An operative wound in which the respiratory, alimentary, genital or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically operations involving the biliary tract, appendix, vagina and oropharynx are included in this category provided no evidence of infection or major break in sterile technique is encountered.
Class III/ Contaminated	Open fresh accidental wounds. In addition, operations with major breaks in sterile technique (e.g. open cardiac massage) or gross spillage from the GIT or incisions in which acute, non-purulent inflammation is encountered
Class IV/ Dirty-Infected	Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms that caused the post-operative infection had been present at the start of the procedure.

* Garner JS and Simmons

Table II: National nosocomial Infections Surveillance (NNIS)

Type Of Operation	T-Point (hours)	Risk Category			
		0	1	2	3
Colon	3 hours	3.2	8.5	16	22
Vascular	3 hours	1.6	2.1	6.1	14.8
Cholecystectomy	2 hours	1.4	2.0	7.1	11.5
Organ transplant	7 hours	0.0	4.4	6.7	18

Centre for disease control- National nosocomial Infections Surveillance (NNIS) System Report

SCENIC Score[8]

- Abdominal surgery
- Operation more than 2 hours
- Class III or IV wounds
- More than 3 diagnosis at time of discharge from hospital
- Risk score
  - 0 = 1% risk of infection
  - 1 = 3,6% risk of infection
  - 2 = 9% risk of infection
  - 3 = 17% risk of infection
  - 4 = 27% risk of infection

Pathogenesis

$$\text{Risk of SSI}^{4} = \frac{\text{Dose of bacterial contaminant x virulence}}{\text{Resistance of the host patient}}$$

For a SSI to occur, there has to be contamination at the operative site. From the above equation, it can be seen that the size of the inoculum is important. However, the number of organisms necessary to cause infection may be substantially lower if there is any foreign material present. The micro-organisms that cause SSI are usually derived from the skin of the patient or from open viscus. (Endogenous infection)[7]

Exogenous infections are those infections that arise due to micro-organisms from instruments or the theatre environment, from contaminated wounds, traumatic injuries or micro-organisms that gain access to the wounds post-operative.[7] Spread is rarely haematogenous. Some organisms also display factors that increase their virulence. An example is the endotoxin produced by many gram-negative bacteria. This stimulates the production of cytokines. Cytokine production gives rise to the SIRS response that may eventually progress to multi organ dysfunction and even death. The resistance of the host is another important factor. The lower the ability of the body to fight off infection, the higher the risk of getting SSI. In our population with a high incidence of HIV/AIDS and other immunosuppressive conditions, this is of paramount significance. Another high-risk population is the trauma patient. The incidence of infection after major intra-abdominal trauma surgery can be as high as 37% with up to 12% organ space infections.[5] Trauma is associated with a massive activation of the stress response as well as a magnitude of other risk factors for the development of SSI.

Complications associated with surgical site infections[7]

- Longer hospital stay with risk of acquiring other hospital acquired infections like pneumonia
- Require more surgical procedures
- Risk for development of resistance to antibiotics
- Risk for development of necrotizing fasciitis with skin loss
- Risk of losing limb
- Cosmetically unacceptable scars
- Persistent pain/itching
- Restriction of movement
- Emotional well-being can also be compromised

Risk factors for surgical site infections

Patient factors

- Immunocompromised
  - AIDS

- Diabetic
- Malnourished; low serum albumin
- Steroid therapy
- Post-transplant patients
- Alcohol abuse
- Anti-cancer treatment
- Obesity

- Extremes of age
- Trauma patients
- Higher ASA status
- Other source of sepsis e.g. UTI
- Ascites
- Hypocholesterolaemia
- Peripheral vascular disease
- Post-operative anaemia
- Recent surgery
- Skin diagnosis in area of surgery e.g. eczema
- Prolonged pre-operative hospitalization
- Smoking
- Poor personal hygiene

Environmental factors

- Poor ventilation
- Poor temperature control
- Poor humidity control (Should be between 40-60%)
- Low humidity favours distribution of micro-organisms
- High humidity favours proliferation of micro-organisms
- Contaminated beds/linen/surface areas/instruments
- Flies
- Non-compliance to hand washing
- Health care worker harbouring pathogenic organisms
- Contaminated medication
- Inadequate disinfection/sterilization
- Inappropriate hair removal

Anaesthetic risk factors

- Inappropriate antibiotic prophylaxis
- Hypothermia
- Poor glucose control
- Blood transfusion
- Poor oxygenation
- Haemodynamic instability
- Neuraxial anaesthesia decrease the risk of SSI
  - Decrease the inflammatory response Vasodilatation leads to better perfusion and oxygenation

Surgical risk factors

- Prolonged surgical time
- Rough handling of tissue
- Devitalisation
- Excessive use of electrocautery
  - Macrophages need intact viable tissue on which they can migrate to the area of injury
- Poor haemostasis
- Drains/catheters
- Poor technique
- Improper skin preparation
- Emergency surgery
- After hour surgery even if elective
- Braided sutures
- Dead spaces especially in obese patients as fat has a poor blood supply

Microbiology

The organisms most commonly implicated in the development of SSIs are *Staphylococcus Aureus,* the *coagulase negative staphylococci, enterococci* and *E. coli.* A significant number of multidrug resistant micro-organisms are frequently encountered. With no new antibiotics due for release in the nearby future, this is of particular concern. It should be every practitioners' priority to use antibiotics judiciously. Antibiotic stewardship is needed in every institution. Practitioners should work closely with the local microbiology department to establish the local resistance patterns and to identify the most common organisms likely to be encountered. It is also very important to de-escalate from empiric antibiotics as soon as the sensitivity results are available.

Antibiotic prophylaxis

Criteria for the use of systemic preventative antibiotics in surgical procedures[10]

Indications:

- Systemic prophylactic antibiotics should be given when:
- High risk of infection associated with the specific procedure e.g. colonic surgery *or*
- The consequences of infection are unusually severe e.g. joint replacement *or*
- Patient has a high NNIS risk index of more than 1

Important points regarding antibiotics[11]

- Antibiotics should be administered within 1 hour of procedure for bolus antibiotics *or* within 2 hours if the drug needs to be slowly infused.
- Antibiotics should also be administered earlier if a tourniquet is going to be used.
- Select the appropriate antibiotic based on:
  - Surgical procedure
  - Most common pathogens associated with such a procedure
  - Published recommendations
- Should be stopped within 24 hours post-operative
- Prophylaxis after wound closure is unnecessary

Antiseptics

Antiseptic activity against various pathogens is summarised in Table IV.

Alcohol

- Advantages:
  - Rapidly effective
  - Effectiveness only moderately decreases by blood or other organic material
  - Non-staining
  - Less expensive

- Disadvantages:
- Drying effect on skin
- Cannot be used on mucous membranes
- Evaporates quickly-decrease contact time
- Cannot be used when area is dirty
  - Must dry completely to be effective

Chlorhexidine

- Less effective against gram negative bacteria, fungi; and no effect against M.*tuberculosis*
- Effectiveness not decreased by organic material
- Remains effective for 6hours
- Effectiveness can be decreased by hard water, hand creams and soap
- Recommended antiseptic for hand washing and skin preparation
- Must NOT be allowed to come in contact with brain, meninges, eyes or middle ear.

Iodophors

- Solutions that contain iodine in a complex form, making them relative non-toxic and less irritating e.g. povidone iodine
- Can be used on mucous membranes
- Effectiveness reduced by blood/organic material
- Takes more than 2min to release active ingredient; thus wait 2 min between application and incision
- Less persistent activity than chlorhexidine
- Best antiseptic for genital area, vagina and cervix
- Use undiluted

Table III: Likely pathogens per procedure[3]

Procedure	Organisms
Grafts/prosthesis/implants	Staph Aureus, Coagulase negative Staphs
Cardiac	Staph Aureus/CNS
Neuro surgery	Staph Aureus/CNS
Breast surgery	Staph Aureus/CNS
Ophthalmology	Staph Aureus/CNS/Streptococci/Gram negative Bacilli
Orthopaedics	Staph Aureus/CNS/GNB
Non-cardiac thoracics	Staph Aureus/CNS/Strep pneumonia/ GNB
Vascular	Staph Aureus/CNS
Appendix	Staph Aureus/Anaerobes
Biliary tract	GNB/Anaerobes
Colorectal	GNB/Anaerobes. Diverse group of aerobic and anaerobic organisms with up to 15 different species detectable
Gastroduodenal	GNB/Streptococci/Oropharyngeal anaerobes
Head and neck	Staph Aureus/Streptococci
Obstetrics and gynaecology	GNB/Enterococci/Group B Streptococci/ Anaerobes
Urology	GNB

Centre for Disease Control-Guidelines for Prevention of Surgical Site Infection.

Guideline For Infection Prevention And Control: Nice Guidelines 2008[15]

1. Showering
2. Advise patients to take a shower or have a bath using soap on the day of surgery
   - Hair removal
   - Do not routinely remove hair
   - Use clipper rather than razor/blade as micro-abrasions lead to multiplication of bacteria
   - On the day of surgery rather than the day before
3. All staff should wear freshly laundered non-sterile scrub suits
4. Staff wearing non-sterile theatre wear should keep their movements in and out of theatre to a minimum
5. There is no evidence that masks decrease surgical site infections, but should be worn as part of theatre discipline
6. Do not use nasal decontamination with topical antibiotics aimed at eliminating Staph Aureus routinely to decrease the risk of surgical site infections
7. Do not use mechanical bowel preparation routinely to decrease the risk of surgical site infections
8. Operating team should remove hand jewelry before operation
9. Operating team should remove artificial nails and nail polish before operation
10. Maintain normothermia
    - Hypothermia decreases tissue oxygen tension by vasoconstriction
    - Hypothermia decreases leucocyte superoxide production
    - Hypothermia increases bleeding and the need for blood transfusion which is an independent risk factor for the development of SSI
    - Hypothermia increases the length of hospital stay even in uninfected patients
11. Maintain optimal oxygenation during surgery. In particular, give patients sufficient oxygen during major surgery and in recovery to maintain oxygen saturation above 95%
12. Maintain adequate perfusion during surgery
13. Maintain normoglycaemia intra-operative and post-operative

Conclusion

It is the responsibility of each and every health care provider to work towards the prevention of SSI. A team approach is needed that includes the patient, the ward staff, the porters, reception staff, nursing staff, surgeons, anaesthetists, ICU clinicians, cleaners, CSSD staff, laundry staff, maintenance team and the management team of the hospital.

Table IV: Antiseptic activity against various pathogens[12]

Antiseptic	Gram positive	Gram negative	Mycobacterium	Fungi	Virus	Onset of action	Comments
Alcohol	+++	+++	+++	+++	+++	Quick	Must evaporate
Chlorhexidine	+++	++	-	+	+++	Inter*	
Iodine compounds	+++	+++	+++	++	+++	Inter*	Causes skin irritation

* Intermediate Table courtesy of Centre for Disease Control

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PRESS RELEASE

Blood Ebola survivors tested as short-term treatment option

An international research consortium led by the Institute of Tropical Medicine in Antwerp (ITM) will assess whether treatment with antibodies in the blood of Ebola survivors could help infected patients to fight off the disease. If proven effective, this straightforward intervention could be scaled up in the short term and provide an urgently needed treatment option for patients in West Africa.

The researchers receive € 2.9 million of European Union (EU) funding to evaluate the safety and efficacy of treatment with blood and plasma made from the blood of recovered Ebola patients.

A WHO expert meeting in September recommended convalescent blood therapies as one of the most promising strategies meriting urgent evaluation as treatment of Ebola disease. As a result of the current outbreak, there are also substantial numbers of survivors to prepare Ebola plasma.

ITM's **Johan van Griensven**, the project's coordinating investigator, said:

"Blood and plasma therapy are medical interventions with a long history, safely used for other infectious diseases. We want to find out whether this approach works for Ebola, is safe and can be put into practice to reduce the number of deaths in the present outbreak. Ebola survivors contributing to curb the epidemic by donating blood could reduce fear of the disease and improve their acceptance in the communities."

Blood and plasma from recovered Ebola patients has been used in a limited number of patients previously. For example, during the 1995 Ebola outbreak in Kikwit, in the Democratic Republic of the Congo (DRC), seven out of eight patients receiving convalescent whole blood survived. However, whether this was due to the transfusions or to other factors is unclear. There is an urgent need to evaluate this therapy in carefully designed studies according to the highest ethical and scientific standards.

EU Research, Innovation and Science Commissioner **Máire Geoghegan-Quinn** said in today's funding announcement that it is urgent to step up medical research on Ebola. According to Geoghegan-Quinn the selected projects *"enlist the best academic researchers and industry to take the fight to this deadly disease."*

The Wellcome Trust will provide additional support, enabling unparalleled international collaboration across the public, private and not-for-profit sectors to tackle the Ebola emergency.

Jeremy Farrar, Director of the Wellcome Trust, said:

"The Wellcome Trust is delighted to work in partnership with the European Commission to support and help fast-track this critical work. Convalescent serum offers the best potential treatment for Ebola in the short term that could be scaled up if proven effective. Global collaboration of this nature, including clinical researchers and multiple partners from across Europe and West Africa, is both unprecedented and essential if we are to bring the current outbreak under control."

The international research consortium

The € 2.9 million grant from the EU will fund the Institute of Tropical Medicine in Antwerp, University of Liverpool, London School of Hygiene & Tropical Medicine, University of Oxford, Aix-Marseille University, the French Blood Transfusion Service (Etablissement Français du Sang), Institute Pasteur, and the French National Institute of Health and Medical Research.

The consortium also includes the National Blood Transfusion Centre in Conakry (Guinea), the Institut National de Recherche Biomédicale in Kinshasha (DRC), and the Belgian Red Cross-Flanders.

The project, which will start in Guinea in November 2014, is supported and guided by the WHO and the International Severe Acute Respiratory and Emerging Infection Consortium (ISARIC).