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SURGICAL SITE INFECTIONS

I Alturki

Moderator: M Ramnarain

UNIVERSITY OF
KWAZULU-NATAL

INYUVESI
YAKWAZULU-NATALI

School of Clinical Medicine
Discipline of Anaesthesiology & Critical Care

CONTENT

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INTRODUCTION [1, 2, 3]

Surgical site infections (SSIs) represent one of the most common perioperative infections worldwide. It has an incidence of 2-5%. It is the most common nosocomial infection amongst surgical patients, and the third most common nosocomial infection.

The Centers for Disease Control (CDC) and prevention estimate that there are 45 million inpatient surgical procedures performed annually in the United States of America. SSIs account for approximately 2 million nosocomial infections in the United States of America each year.

There is considerable financial impact of SSIs on the healthcare system due to increased length of stay in hospital by 7-10 days, increased number of surgical interventions, increased duration of medical therapy, prolonged ICU and High Care Unit admission and increased mortality and morbidity. SSIs can lead to long term loss of function and decrease ability to return to work. It may also cause permanent disability.

Patients with SSIs have a 2-11 times higher risk of death. 75% of deaths among patients with SSI are directly attributable to SSIs. In the United States of America SSIs can cost up to $10 billion per annum.

Table 1. Number of Procedures Reviewed and SSIs Identified 2007-20102

NHSN-Defined Surgical Procedure	No. of Procedures (% of Total)	No. of SSIs (% of Total)
Adult CABG	1988 (9)	66 (11)
Adult craniotomy	3829 (17)	99 (16)
Adult laminectomy	2553 (11)	45 (7)
Adult spinal fusion	4404 (20)	179 (29)
Adult spinal refusion	542 (2)	12 (2)
Cesarean section	2607 (12)	110 (18)
Colon surgery	318 (1)	6 (1)
Hip prosthesis	2204 (10)	37 (6)
Knee prosthesis	3190 (14)	27 (4)
Pediatric spinal fusion or refusion	743 (3)	37 (6)
Total	**22 378 (100)**	**618 (100)**

Abbreviations: CABG, coronary artery bypass graft; NHSN, National Healthcare Safety Network; SSI, surgical site infection.

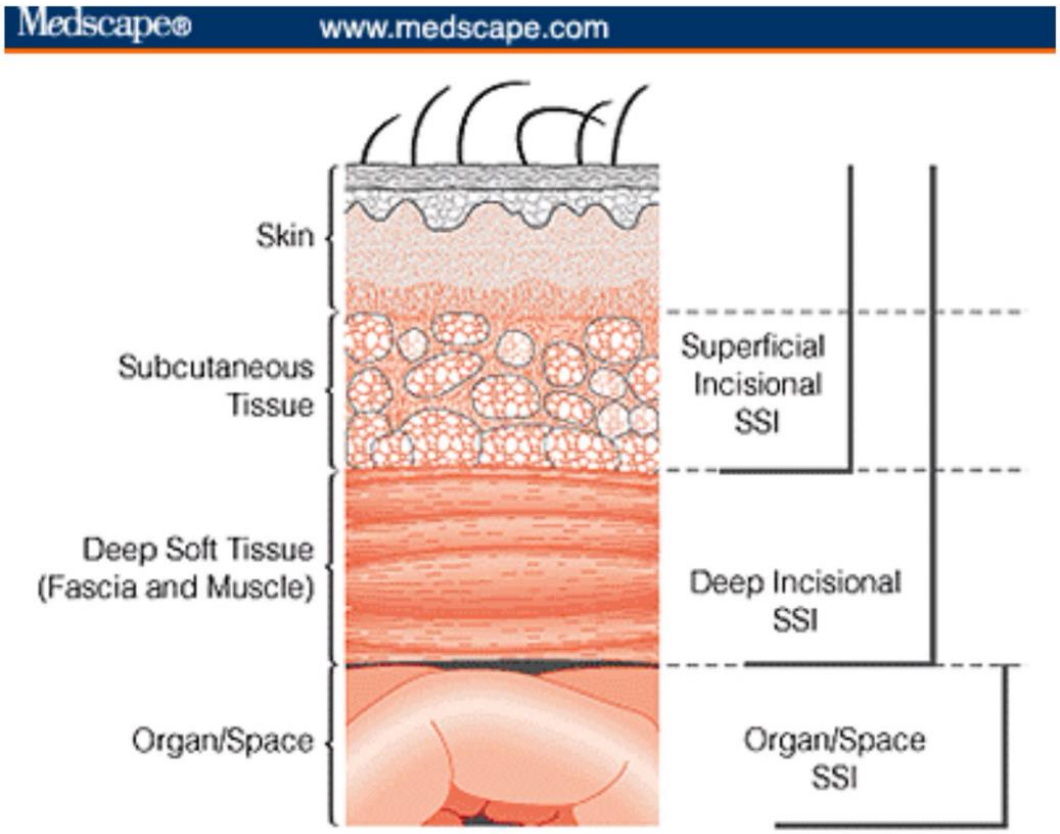
Table 2. Effect of SSIs on Hospitals [2]

	With SSI	Without SSI
Daily charge	7493$	7924$
Length of hospital stay	10.56 days	5.64 days
Readmission /100	51.94	8.19
Profit change	2,268,589 $	

DEFINITION [1, 3, 4]

SSI is an infection that occurs after surgery in the part of the body where the surgery took place. .It occurs within 30 days post-surgery or up to a year in case of an implant.

Diagram 1. The Classification of SSIs. [4]



CLASSIFICATION: [1.3.4]

It is classified as Superficial, Deep and Organ space SSI.

Superficial [1, 3]

Infection is confined to the skin and sub-cutaneous tissue, involving tissue around the incision with at least one of the following:

- Pus or purulent fluid with or without lab confirmation from incision
- Organism found on culture of tissue/pus taken aseptically from the incisional area

Includes at least one of these signs or symptoms:

- Tenderness or pain;
- Localized wound swelling;
- Redness.

Deep [1, 3.4]

Infection that occurs within 30 days if no implant is in-situ or within a year if an implant is in-situ and the infection appears to involve deeper soft tissue layers, beyond or deeper to the superficial layers.

It includes at least one of the following:

- Pus draining from the deep tissues but not from the organ space associated with the surgery;
- The incision spontaneously dehisces or is opened by the surgeon because the patient developed at least one of the following :
  - Fever – temperature of more than 38 degree Celsius;
  - Tenderness or pain (unless wound culture negative);
  - An abscess or evidence of infection in the deep tissue found on clinical examination, re-opening, histopathological or radiological investigation;
  - Diagnosis of a deep SSI by a surgeon or attending physician.

Organ space SSI [1, 3.4]

The infection seems to be related to the operation. The infection occurs in any Organ/space other than the incision, which was initially opened and explored during the procedure with at least one of the following:

- Pus or infected fluid from a drain that was sited through a stab wound into the organ or space;
- Organisms found on an aseptically collected specimen from the organ or space;
- An abcess or evidence of infection seen on examination or re-operation or by histopathological or radiological examination;
- Diagnosis of an organ/space SSI made by the surgeon or attending physician.

It is important to note that SSIs do not include stitch abscesses, episiotomy infection, newborn circumcision scars or infected burn wounds.

CAUSES AND RISK FACTORS OF SURGICAL SITE INFECTIONS [1, 5]

The most common bacterial causes of SSIs include: Staphylococcus; Enterobacteriaceae, Coagulase Negative Staphylococci and Enterococcus species.

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

Therefore the risk of SSI is directly dependent on the dose of the inoculum and the virulence of the organism and inversely proportional to the patient's resistance.

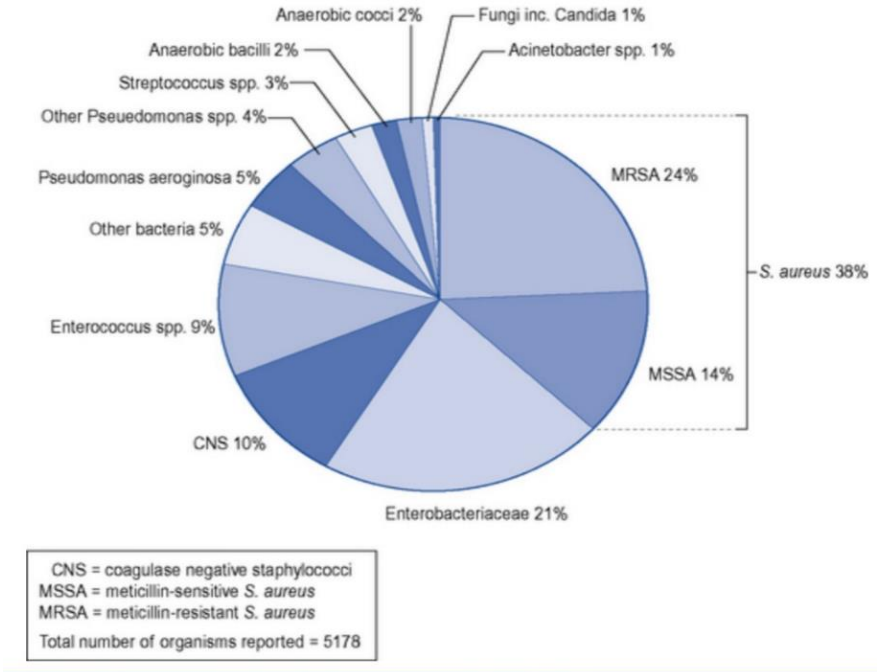
The dose of the bacteria required to cause SSI is more than 100000/gm tissue. In the presence of a foreign body only 100/gm tissue is needed to cause SSI – a substantially lower inoculum size. With surgical sutures in place, the inoculum size is 1000/gm tissue. In the presence of a Polytetrafluoroethylene (PTFE) graft only 10 CFU can cause infection and in the presence of Dextran beads just 1 CFU can cause SSIs.

Germs can infect a surgical wound through various forms of contact.
Exogenous sources of infection include:

- Contaminated caregiver;
- Contaminated surgical instrument;
- Germs in the air – high particle counts in theater or hospital ward environments; and
- Germs found on foreign materials or shrapnel introduced following traumatic injuries.

Endogenous sources of infection include organisms from the patient's skin or from an open viscous.

Diagram 2. Isolated organisms that cause SSIs 2003-2007.[4]



Surgical site infection isolated organisms 2003–2007 (HPA, 2008).

TYPE OF WOUND

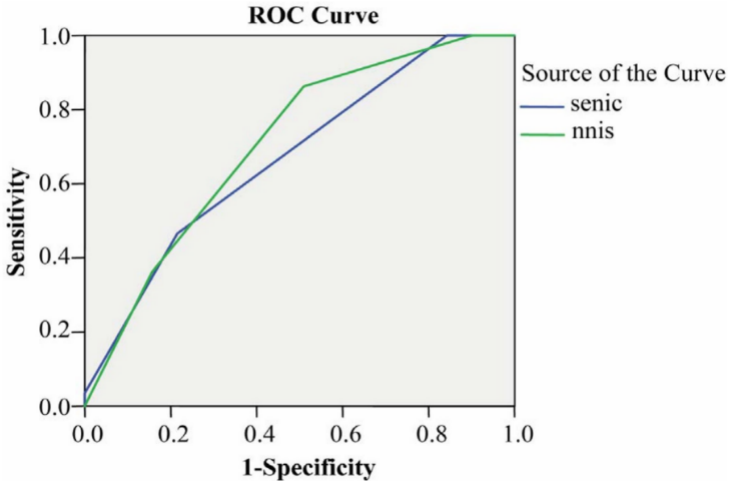
The type of surgical wound can infer likely risk of SSI. Surgical wounds are classified in the following way [1, 3, 4]

Type of wound	Example	Features	Infection rate
Class I Clean	1-Mastectomy 2-Vascular 3-Hernias	1-No hollow viscous entered 2-Primary wound closure 3- No inflammation 4- No breach in aseptic technique 5- elective procedure	2%
Class II Clean contaminated	1-Gastrectomy 2-Hysterectomy	1-Hollow viscous entered but controlled 2- No inflammation 3-primary wound closure 4- minor breach in aseptic technique 5- mechanical drain used	10%
Class III Contaminated	1-Ruptured appendix 2-Emergency bowel resection 3-Biliary tract	1- Uncontrolled spillage from viscous 2- Inflammation 3- Major breach in aseptic technique	18%
Class IV Dirty	1-Intestinal fistula resection	1-untreated , uncontrolled spillage 2-pus in operative wound, 3-open suppurative wound or severe inflammation	42%

SCORING SYSTEMS [6]

There are two validated scoring systems to help predict the risk of SSI. They are the National Nosocomial Infections Surveillance (NNIS) risk index and the Study on the Efficacy of Nosocomial Infection Control (SENIC) Score.

A study by Akin looked at the External Validation of SENIC and NNIS Scores for Predicting Wound Infection in Colorectal Surgery. Neither NNIS nor SENIC were found to be perfect risk indices. However, when compared to each other NNIS is more reliable than SENİC with a ROC value of 0.70 compared to 0.67 respectively. As a result both NNIS and SENIC are reasonably good risk indexes but not perfect. Even when NNIS and SENIC are used together to help predict the risk for SSI they rarely improve the likelihood. [6]



*National Nosocomial Infections Surveillance NNIS risk index. (*1 point for every factor)[6]

- Class III or IV wounds
- ASA class 2 or more
- Duration of surgery greater than the 75th percentile of the average time for that specific surgery

❖ Risk score
0 = 1.5% risk of infection
1 = 2.9% risk of infection
2 = 6.8% risk of infection
3 = 13% risk of infection

Study on the Efficacy of Nosocomial Infection Control SENIC Score .[6]

- Abdominal surgery
- Surgery greater than 2 hours
- Class III or IV wounds
- More than 3 diagnoses 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

THESE ARE OTHER RISK FACTORS FOR SSIS: [1, 3]

Patient factors	*Surgical risk factors*	*Anaesthetic factors*	*Environmental factor*
Immunocompromised -AIDS -DM - Malnourished; -low serum albumin - Steroid therapy - Post-transplant -Alcohol abuse - Anti-cancer treatment – Obesity *Extremes of age* *Trauma* *Higher ASA* *Other sepsis e.g. UTI* *Ascites* *Hypercholestrolaemia* *Peripheral vascular disease* *Anaemia* *Recent surgery* *Skin pathology in area of surgery eg eczema* *Prolonged hospitalisation* *Smoking* *Poor personal hygiene*	• *Prolonged surgical time* • *Rough handling of tissue* • *Devitalisation* • *Excessive use of electrocautery* • *Poor haemostasis* • *Drains/ catheters* • *Poor technique* • *Improper skin preparation* • *Emergency surgery* • *After hours surgery even if elective* • *Braided sutures*	• *Inappropriate antibiotic prophylaxis* • *Hypothermia* • *Poor glucose control* • *Blood transfusion* • *Poor oxygenation* • *Haemodynamic instability* • *Neuraxial anaesthesia decreases the risk of SSI*	• *Poor ventilation* • *Poor temperature control* *Poor humidity control (40-60%)* • *Contaminated beds/ linen/ surface areas/ instruments* • *Flies* • *Non hand washing* • *Health care worker harboring pathogenic organisms* • *Contaminated medication* • *Inadequate disinfection/ sterilisation* •*Inappropriate hair removal*

THE CONSEQUENCES OF SURGICAL SITE INFECTION ARE SERIOUS AND INCLUDE: [1, 3]

- Increased financial burden on the healthcare system;
- Higher mortality;
- Readmission to hospital;
- Increased number of surgical interventions;
- Risk of developing resistance to antibiotics;
- Chronic pain;
- Limitation of movement and restricted mobility;
- Risk of losing a limb;
- Risk of necrotizing fascitis;
- Increased length of hospital stay;
- Cosmetically unacceptable scars.

PREOPERATIVE PREVENTION

Preoperative shower [7]

A systematic review done by Webster et al reviewed 7 Randomised controlled trials for routine preoperative showering and found no differences in outcome when comparing preoperative showering with Chlorhexidine versus no Chlorhexidine. Their article advises that patients do not need to routinely shower with Chlorhexidine preoperatively and may use soap when showering either on the day of surgery or the day before surgery.

Hair (shaving vs clipping) [7, 8]

Routine hair removal is not recommended unless directly interfering with the operative site. In this case then, the use of electrical clippers or disposable clippers for hair removal shows less risk for SSIs than shaving which leads to micro-dermal abrasions. Shaving, increases the risk of SSIs by a factor of 3. Shaving damages the epidermis and causes micro-dermal abrasions which is then more easily colonized by topical flora.

Staff theatre wear [7, 8]

Theatre caps
There is no evidence to support the routine use of theater hats by unscrubbed theater staff.

Face masks
It is recommended that all staff within one meter of the surgical field should wear face masks that must cover both the nose and the mouth.
During intubation Anaesthetists should always wear a face mask for personal protection. Face masks like an N95 mask offer protection to staff from infections like TB.

Foot wear
Overshoes can increase SSIs by contamination of hands when overshoes are donned, removed or adjusted.
Suits, scrubs, gowns [7, 8]

There is little to no evidence linking SSIs to wearing surgical scrubs outside of theater and then returning without changing. All staff should wear specific non-sterile theatre wear in all areas where operations are undertaken. The use of an overcoat outside theater is advisable.

Staff leaving the operating area [7, 8]

Minimizing theater traffic is important, as this affects particle counts. Particle counts are higher in high traffic zones. The theater doors should remain closed at all times, laminar flow is advisable in theater especially for joint implantation surgery.

Nasal decontamination [7]

Use of routine nasal decontamination for eliminating Staphylococcus Aureus to reduce the risk of SSIs is not advisable.

Mechanical bowel preparation [7]

It is not recommended to use mechanical bowel preparation to decrease the risk of surgical site infections, however in colorectal surgery some data show a decrease risk of SSIs but at the expense of fluid and electrolyte imbalances.

Nutrition [9]

Total parenteral nutrition preoperative may increase the risk of SSIs. It is recommended not to delay surgery to provide parenteral nutrition. Two meta-analyses on patients receiving enteral diets containing glutamine and /or arginine preoperatively demonstrated a decrease in SSIs. The decrease in SSIs was found in these patients either when their diets included these amino acids preoperatively or postoperatively.

Smoking [10]

Smoking decreases tissue oxygenation by about 20 mmHg. The risk of SSIs is increased threefold by smoking, this effect reverses quickly after stopping smoking and more profoundly when smoking is stopped at least 4 weeks prior to surgery.

Antibiotic prophylaxis

The principles of antibiotic use [1,3,9,10,11]

1. The surgery should carry a significant risk of infection or cause significant bacterial contamination, these include:
   Class II clean contaminated; class III contaminated; and class IV dirty wounds. For these above classes prophylaxis with antibiotics is mandatory.
   Class I / clean wounds may warrant antibiotic prophylaxis where life or limb are in danger of serious complications following infection.
2. The antibiotic selected must be active against the majority of contaminating pathogens, but it is not necessary to cover all likely pathogens.
3. The antibiotic dose must reach a concentration above the minimum inhibitory concentration for the suspected pathogens in the wound site at the time of incision.
4. The shortest possible course of the most effective and least toxic antibiotic should be considered for prophylaxis.
5. The newer broader spectrum antibiotics ought to be saved for therapy against resistant pathogens and should not be used for prophylaxis.
6. Intraoperative dosing should be repeated if :
   - The duration of surgery is more than 2 half –life's (t ½) of the drug for example 4hrsfor Cefazolin from the first dose;
   - Blood loss is more than 1500 ml.
7. Repeated dosing for prophylaxis - There is no data to support the need for routine subsequent doses for prophylaxis. Repeated dosing should not exceed 24 hours. There is no need to cover drains, tubes and line insertion.
8. Obesity - Dose adjustment in the obese patient is necessary for example the obese patient might require 3 or 4 gram of cefazolin preoperatively.
9. In orthopedic surgery the literature suggests that patients should be screened preoperatively for MRSA and MRSA-positive patients treated before surgical admission in order to reduce the risk of SSI.10
10. Should an orthopedic patient have bacteriuria, the operation should be postponed if the patient is symptomatic and has CFU's >1000.

INTRAOPERATIVE

Anesthetic drugs

Opioids [8]

- Opioids increase the likelihood of SSIs by decreasing the hosts immunity
- Morphine, Fentanyl, Remifentanil, Pethidine associated with immunosuppression. Synthetic opiods may be more immune sparing versus morphine.
- Oxycodone, Hydromorphone, Buprenorphine have no effect on the immune system
- Tramadol has been shown to have immune-enhancing properties.

Volatile gas [8]

- All volatiles depress cellular-mediated immunity, however there is no data to support an increased risk of SSIs with their use.
- The function of neutrophils are inhibited by all volatile agents in a dose dependent fashion.

Nitrous oxide [8]

- The ENIGMA -1 trial showed that avoiding N2O resulted in a decreased incidence of SSIs.

Local anesthetic agent [8, 12]

- Local anesthetics decrease the likelihood of SSIs by inhibiting the growth of both Gram Positive and Gram Negative Organisms such as Staphylococcus Aureus and Pseudomonas.

Neuraxial anaesthesia [8, 13]

- Neuraxial anaesthesia has been shown to decrease the risk of SSIs by two mechanisms:
  1 - Blunts the inflammatory and sympathetic response to surgical incision;
  2 - Improved tissue oxygenation by vasodilatation.

Antiseptic skin preparation (povidone iodine – chlorhexidine) [1, 3, 7]

- Chlorhexidine is the most suitable antiseptic preparation, it has the greatest antimicrobial activity and greater residual activity after single use, but carries a high risk of neuronal toxicity.
- Povidone iodine takes several minutes to be effective, but is inactivated by blood or serum.
- One should ensure that antiseptic skin preparations are dried before use.

Blood transfusion [7, 10]

- The SSIs risk increases with blood transfusions due to decreased the activity of macrophages.
- Blood transfusion is known to cause immunosuppression which can increase risk of SSIs, the risk increases for blood older than two weeks.
- To decrease the risk of the infection when administering blood it is advised to:
  - Use fresh blood for transfusion
  - Use leucocyte depleted blood and
  - Use filters

Checklists [10]

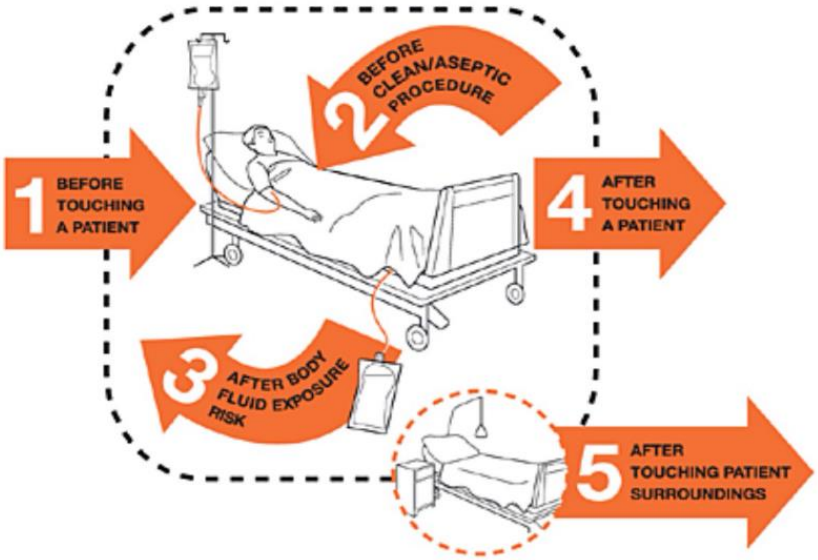
- Several studies have shown an association between the WHO checklist and a reduction in morbidity and mortality
- Perioperative checklists, including a sterility check and the timeous administration of antibiotics both of which are very important steps to decrease SSIs.

Hand decontamination [7, 10]

- Hand washing is one of the most effective precautions to decease the risk of SSIs.
- There is no evidence regarding the effect of equipment such as brushes and sponges.
- Alcohol based hand rub must be used to ensure adequate decontamination between patients.

The WHO five moments of hand hygiene [10]

1. **before touching a patient,**
2. **before clean/aseptic procedures,**
3. **after body fluid exposure/risk,**
4. **after touching a patient, and**
5. **after touching patient surroundings.**



Hypothermia [7, 10]

- Maintained normothermia decreases the risk of SSIs, by decreasing the migration of leukocytes, impairing phagocytosis and cytokine production. T cell antibody production and neutrophil function are negatively affected by a drop in the host's temperature.
- Preventing preoperative hypothermia has been shown to significantly decrease the risk of SSIs more so than the administration of antibiotic prophylaxis.
- It is recommended to use forced air warming devices and warmed IV fluid to prevent both preoperative and intraoperative hypothermia.

Hyperoxia [7, 10]

- Hyperoxia is controversial in the prevention of SSIs
- Higher tissue oxygen tension increases the oxidative killing effects of neutrophils
- Oxidative killing effects are dependent on the tissue perfusion and the amount of oxygen delivered to the tissue
- Several in vitro studies have shown an association between low tissue oxygen tension and increased likelihood of SSIs
- In vivo studies have failed to demonstrate an association between hyperoxia and decreased risk of SSIs
- The PROXI trial failed to show any improved outcome in the hyperoxia group. This was a RCT which included 1400 patients who underwent abdominal surgery. The patients were divided into two groups one receiving either 80% Oxygen (hyperopia group) or the other group where the patients received 30% Oxygen.

Blood glucose control (tight vs liberal) [7, 10]

- Poor blood glucose control preoperatively has been linked to an increased risk of SSIs
- Tight blood glucose control (4.5 and 6mmol/l) decreases the inflammatory response and improves the immunity of the body leading to a decrease in the incidence of SSIs, but increases the risk of hypoglycemic episodes.
- Intensive Insulin therapy has been shown to decrease CRP concentration
- It is recommended that the blood glucose control for perioperative patients be maintained between 4.5 and 10mmol/L.
- Diabetic patients' blood glucose should be monitored regularly intraoperatively and the target blood glucose maintained.

SUMMARY

The role of the anaesthetist in SSI extends to and includes the following points:

- Timeous administration of antibiotic prophylaxis is effective to reduce risk SSIs
- Aim to achieve normoglycaemia
- Aim to achieve Normothermia and prevent hypothermia where possible
- Hyperoxia is controversial
- Neuraxial anaesthesia lowers the incidence of SSIs
- Smoking cessation ideally 4 weeks preop is advocated
- Routine hand washing with antiseptic in between patients is mandatory
- Avoid unnecessary blood transfusions

CONCLUSION

SSI remain to be the most common preventable complication following surgery. We need to do better to decrease the risk of SSIs. Non-antibiotic related factors seem to be as important as antibiotic factors. Despite the use of prophylactic antibiotics and other prophylactic interventions SSIs still occur. The factors associated with SSIs in anaesthesia should be studied more to help decrease the risk of infection.

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