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Preventing surgical site infections

A brief overview of evidence-based measures for Swiss surgeons



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Surgical site infections (SSI) remain a major cause of postoperative morbidity, however, over half of the infections are preventable through evidence-based strategies. This review summarizes key measures applicable to the Swiss surgical setting, structured along the perioperative pathway.

Optimization of patient risk factors, namely preoperative smoking cessation, and screening for and targeting malnutrition are beneficial. In orthopedic implant surgery and cardiac surgery, preoperative *Staphylococcus aureus* decolonization strongly reduces the SSI risk. In colon surgery, oral antibiotic bowel preparation has shown strong protective effects. No shaving for hair removal should be used.

Perioperative antibiotic prophylaxis remains one of the most effective strategies, requiring precise timing and avoidance of unnecessary prolongation or fallback to non-betalactam options.

Highly effective intraoperative measures include skin antisepsis with alcohol-based solutions and maintenance of normothermia.

Postoperatively, strict glycemic control. Outcome surveillance (e.g. with Swissnoso SSI surveillance) with timely feedback and constant process optimization is crucial, and the uptake of the mentioned measures should be monitored, e.g. with Swissnoso SSI intervention module.

Introduction

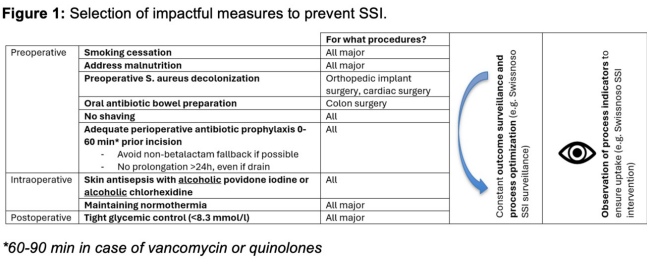
Approximately 0.5% to 3% of patients undergoing surgery will experience infection of the surgical site,¹ and surgical site infections (SSI) contribute with 20–40% to the whole of healthcare-associated infections (according to the Swissnoso point prevalence survey 2023). Clinically, SSI range from

superficial incisional infections presenting with inflammation of the suture, to deep incisional (involving muscle/connective tissue of the incision) and to severe organ/space infections – including foreign-body, prosthetic implant-associated infections and sepsis. They are associated with increased length of hospital stay, reoperations and long-term disability.²

The risk to endure a SSI is influenced by patient-related factors on the one hand: age, comorbidities such as diabetes mellitus, obesity, immunosuppression, malnutrition, carriage of *S. aureus* as well as smoking are known risk factors¹. On the other hand, procedure-related factors such as emergency surgery with potential suboptimal patient preparation as well as complex surgery with longer procedure time increase the SSI risk^{1,3}. Causative pathogens originate predominantly from the patient's microbioma, with skin-colonizing microorganisms constituting the main source in most procedures.⁴ Commonly, procedures are stratified by the presence of microorganisms at the point of procedure according to the CDC Surgical Wound Classification scheme, with the risk of experiencing an organ space SSI increasing in clean/contaminated surgery 6-fold, in contaminated surgery 9-fold and in dirty surgery 18-fold compared to clean surgery⁵. Many prevention measures therefore aim to reduce the dislocation of microorganisms to sterile or semi-sterile compartments of the body.

An estimated 55% of SSI are preventable⁶.

Good surgical technique is an indispensable base of prevention, as it minimizes the amount of avital tissue generated as well as influences procedure times. Nevertheless, as systematic process factors are strong influencers of the SSI risk, prevention requires a multimodal approach encompassing preoperative patient optimization, adherence to aseptic surgical technique, and standardized perioperative infection control measures. This review synthesizes the most relevant evidence-based strategies, emphasizing their applicability in the Swiss surgical context. *Figure 1* gives an overview of the most impactful measures.



Measures to prevent SSI

1. Preoperative Measures

In elective surgery, the preoperative period may be used to optimize modifiable patient-related risk factors. **Smoking cessation** counseling and nicotine replacement therapy in smokers 6–8 weeks prior to surgery reduced infection rates from 23% to 4% in a Danish randomized controlled trial (RCT) in a high-risk orthopedic population⁷. **Screening for and addressing malnutrition** prior to major elective surgery, especially gastrointestinal surgery, is advisable: Preoperative isocaloric and isonitrogenous enteral nutrition support significantly reduce SSI in gastrointestinal surgery, as shown per a meta-analysis (RR 0.64, 95% CI 0.55–0.74)⁸. On the other hand, parenteral nutrition in the preoperative phase failed to confer a benefit in gastrointestinal and cardiac surgery patients⁹.

As mentioned, the skin microbioma is one of the main sources of causative pathogens. Showering or bathing with either soap or a disinfectant containing solution on the day of surgery or the preceding day is advised, based on the fact that it reduces the skin bacterial load; however, pre-operative-showering with chlorhexidine 4% prior to surgery did not significantly reduce SSI¹⁰. *Staphylococcus aureus* is one of the main causative pathogens namely of implant-associated SSI.

Preoperative *Staphylococcus aureus* decolonization using nasal mupirocin and chlorhexidine skin washes 5 days prior surgery was demonstrated to be highly effective (RR 0.42, 95% CI 0.23–0.75) in a landmark trial¹¹. The best effect was found in studies including mainly orthopedic implant surgery and cardiac surgery patients, and less or not detectable in RCTs including mainly general surgery, abdominal surgery or gynecology patients, where *S. aureus* is not the main contributor to SSI¹². In daily practice, the patient process to screen patients and decolonize only in *S. aureus* colonized patients can be complicated and cumbersome. Therefore, the use of *S. aureus* decolonization without screening in all patients prior to undergoing orthopedic implant surgery or cardiac surgery (either implant surgery or sternotomy) is the preferred process by the authors. Skipping of nasal decontamination, thus limiting the decolonization procedure to disinfectant skin washes, results in lower effectiveness¹³.

A comparable reduction (to the mentioned decolonization) in SSI can be achieved in colon surgery by using **oral antibiotic bowel preparation**. Oral neomycin/metronidazole (OR 0.45, 95% CI 0.27–0.77), polymyxin B/tobramycin (OR 0.48, 95% CI 0.30–0.76) and ciprofloxacin/metronidazole (OR 0.41, 95% CI 0.20–0.80) used one day before surgery are options supported by RCT data^{14–18}, ornidazole proved effective in an RCT¹⁹ with suboptimal perioperative prophylaxis; other oral antibiotic bowel preparation regimens such as paromomycin/metronidazole or rifaximin have only been associated with a lower SSI risk in observational studies^{20 21}.

Hair removal is indicated only when its presence interferes with the surgical procedure. In such cases, removal should be performed on the day of surgery using either clippers or a depilatory cream.²² Shaving should be strictly avoided, as it causes microinjuries to the skin and is associated with an increased risk of surgical site infections.²³

Perioperative antibiotic prophylaxis is highly effective in preventing SSI in clean-contaminated, contaminated and dirty surgery, in clean surgery the number needed to prevent is generally only in a reasonable range in the case of implant surgery (in clean non-implant surgery an unreasonably large number of patients have to take prophylaxis to prevent an infection). Antibiotics should be administered 0–60 minutes prior incision (60–90 minutes in case of vancomycin or quinolones), as effectiveness is dependant on the timepoint of application; application after incision is associated with a higher SSI rate²⁴. Whilst the benefit of intraoperative redosing remains uncertain, continuation over 24h is harmful²⁵ and not associated with any benefit even in the presence of a drain²⁶, with the sole possible exception in (ENT) free flap surgery. A Swissnoso sample guideline (https://swissnoso.ch/fileadmin/module/ssi_intervention/Dokumente_D/4_Sample_Guidelines/180816_Sample-Guideline_AMP_de.pdf) might be used as a blueprint for local perioperative prophylaxis guidelines, or freely available institutional prophylaxis guidelines such as <https://antibiotika.insel.ch> provide a detailed blueprint. Recent trial data suggests using prophylaxis also in low risk cholecystectomy²⁷, and using a broader prophylactic spectrum such as piperacillin/tazobactam in high risk pancreatoduodenectomy²⁸. Non-betalactam antibiotics are less preventive, and over 90% of reported penicillin allergies are not true

allergies, therefore a fallback to non-betaactam options in reported non-severe penicillin allergy should be avoided. The use of standardized surgical safety checklists is encouraged, and of particular importance in emergency surgery where processes tend to be less organized, thus, omitting of important process steps are more common ²⁹.

2. Intraoperative Measures

Mainstay of intraoperative SSI prevention is **skin antisepsis**. For intact skin it should be performed with an alcohol-containing disinfectant with remanence, as water-based solutions are less protective³⁰. In a recent Swiss multicenter RCT by the author of this overview, PVP-iodine in alcohol and chlorhexidine in alcohol proved to be equally effective excellent skin disinfectants³¹.

Avoiding hypothermia during surgery (with the exception of few specific indications) is crucial, as temperature monitoring and the use of measures such as forced air warming devices, active body surface warming devices, warming of infusion fluids to maintain normothermia <36°C reduces the SSI risk by a striking 2/3³².

Coated sutures seem to be protective, however a large part of published studies suffer from conflict of interest³³.

Surgeons and operating room staff should avoid transferring their own microbiome onto the surgical field. The use of sterile gowns, hair bouffants and surgical masks, surgical washing or hand disinfection as well as general sterile attire and well trained processes are a reasonable, historical established minimal standard – given the lack of high quality evidence its effect is somewhat difficult to quantify. Zoning concepts in OR tracts are reasonable, however not backed by high quality evidence. Unnecessary door openings are associated with increased SSI rates³⁴.

The use of laminar airflow ventilation in ORs to prevent SSI has been debated³⁵, however a recent Swiss study demonstrated an association of improved OR ventilation with lower rates at least in orthopedic and cardiac procedures³⁶.

3. Postoperative Measures

As around 1/3 of surgical patients suffer from perioperative hyperglycemia, peri- and particularly **postoperative tight glycemic control** (monitoring and maintaining blood glucose below 8.3 mmol/l) reduces the SSI risk by over 1/3 – accordingly at least for major surgery a glucose control protocol should be implemented³⁷.

Incisional wound irrigation with aqueous antiseptics is beneficial³⁸. Sutures should be covered with sterile dressings³⁹. Negative pressure wound therapy seemed to reduce infections mainly in vascular and cardiac surgery in a meta-analysis⁴⁰, whereas a recent RCT found no effect in laparotomy⁴¹, mirroring the findings of the mentioned meta-analysis not demonstrating a relevant benefit for abdominal, obstetric, orthopedic and plastic surgery⁴⁰.

To continuously adapt the SSI prevention strategy, **outcome surveillance** e.g. with the Swissnosso SSI Surveillance module is recommended. To ensure the uptake of SSI prevention measures, we recommend using **implementation bundles** including process parameter observation, such as the Swissnosso SSI intervention module (<https://swissnosso.ch/module/ssi-intervention/ueber-ssi-intervention/das-modul>)

Surveillance itself is associated with a reduction of SSI rates ⁴², nevertheless,

feedback should be given in a timely manner in order to allow analysis of the effect of recent process changes and constant optimization of process factors.

Conclusion

Whilst surgical site infections are associated with increased length of hospital stay, reoperations and long-term disability, over half of them are preventable with a multimodal approach including perioperative process optimization. At least highly effective preventive measures such as *S. aureus* decolonization in orthopedic implant and cardiac surgery, gut decolonization in colon surgery, adequate antibiotic prophylaxis in the hour prior incision without continuation over 24h, avoidance of shaving as hair removal, skin antisepsis with alcoholic chlorhexidine or iodine, maintaining of normothermia and perioperative glycemic control should be implemented without gaps in Switzerland.

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