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The evidence-based way to prevent wound infections

Are some CDC recommendations more equal than others?

Of 72 different ways to prevent surgical site infections, 49 are backed by enough confirmatory science to merit the CDC's strongest recommendation for use in all hospitals. (The 23 other measures in the CDC advisory have not been or cannot be as thoroughly studied.)

How can we apply all possible precautions to every patient wheeled into the OR? The CDC's *Guideline for Prevention of Surgical Site Infections* (formerly termed wound infections) advocates "a systematic but realistic approach" based on the evidence, coupled with awareness that risk of surgical site infection is influenced by characteristics of the patient, operation, personnel, and hospital.

This article reviews key evidence behind a number of the most strongly recommended measures, such as optimal regimens for prophylactic antibiotics, and some of the recommendations for which equally rigorous evidence is lacking.

The CDC's *Guideline* ranks its recommendations according to 4 levels of evidence. A total of 49 recommendations meet the most rigorous evidence standards, and therefore are "strongly recommended for all hospitals." (See *How strong is the evidence?* page 31.)

Many of our infection prevention routines, of course, have been standard ever since Joseph Lister introduced the principles of antisepsis in the late 1860s. Technically, however, some standard infection prevention routines are based on a strong theoretical rationale along with suggestive though not confirmatory science.

By necessity, narrowly defined patient populations and ethical and logistical issues will always limit our ability to obtain confirmatory scientific answers to some questions. For example, wearing gloves vs not wearing gloves fits into that category. Likewise, the evidence on preoperative nutritional support for the sole purpose of preventing SSI does not meet the criteria for the best evidence category, "1A." Yet, nutrition therapy is among the CDC's recommendations, albeit the evidence behind it falls into the "NR" category, "no recommendation; unresolved issue."

The CDC's exhaustive guideline identifies 21 characteristics of patients and operations that influence a patient's risk of surgical site infection (**TABLE 1**), and recommends prevention tactics that are backed by evidence (See *CDC Advisory*, page 27).

The CDC's recommendations are grouped into these sections:

1. Preoperative preparation of the patient, hand/forearm antisepsis for surgical team members, management of infected or colonized surgical personnel, and antimicrobial prophylaxis.

2. Intraoperative ventilation, cleaning and disinfection of environmental surfaces, microbiologic sampling, sterilization of surgical instruments, surgical attire and drapes, asepsis, and surgical technique.

3. Postoperative incision care.

4. Surveillance.

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TABLE 1

21 factors that influence risk of surgical site infection

PATIENT	
1	Age
2	Nutritional status
3	Diabetes
4	Smoking
5	Obesity
6	Coexistent infections at remote body site
7	Colonization with microorganisms
8	Altered immune response
9	Length of preoperative stay
OPERATION	
10	Duration of surgical scrub
11	Skin antisepsis
12	Preoperative shaving
13	Duration of operation
14	Antimicrobial prophylaxis
15	Operating room ventilation
16	Inadequate sterilization of instruments
17	Foreign material in the surgical site
18	Surgical drains
19	Poor hemostasis
20	Failure to obliterate dead space
21	Tissue trauma

Source: Reference 1.

FAST TRACK

Consider canceling elective surgery if there is an untreated remote infection

Preparing the patient

Preoperative risk factors

Infection prevention begins with considering the preoperative risk factors of the patient's condition.

Not all risk factors for surgical site infections can be modified (age, for example), but we should correct whatever we can before scheduling elective surgery.

Minimizing smoking improves postoperative SSI outcomes (EVIDENCE CATEGORY IB).

Weight loss before surgery has not been clearly correlated with improved SSI outcomes (EVIDENCE CATEGORY NR). However, body mass index may influence surgical complication rates, perhaps acting as a surrogate for technical difficulty or impaired wound-healing capacity.[2,3]

Nutrition is being recognized as a key determinant in outcomes, but reports have not established how preoperative parenteral or enteral nutrition influences SSI outcome (NO RECOMMENDATION).[4,5]

Antisepsis in the surgical field

The microbial source for most SSI is the patient's endogenous flora, and the operative field determines the type of flora that will be encountered.

Normal skin flora consist mostly of gram-positive aerobes.

Antiseptic showering before surgery significantly reduces resident skin flora (EVIDENCE CATEGORY IB). Multiple showers with chlorhexidine have been shown to reduce resident bacteria up to 9-fold, but whether that reduces SSI rates is unclear.[6]

Prophylactic eradication of nasal *Staph* colonization (NO RECOMMENDATION). Recent attention has focused on microbial colonization with resistant organisms—and *Staphylococcus aureus* colonization of nares in cardiac surgery patients was found to be a major independent risk factor for surgical site infection.

Prophylactic intranasal mupirocin reduced infection risk in cardiothoracic patients,[7] but preoperative use did not reduce gram-positive SSI rates in digestive tract surgery.[8]

Mupirocin also failed to reduce the wound rates in patients who had a variety of procedures, although the rate of nosocomial *S aureus* infections in the subset of patients with nasal colonization was reduced.[9]

Topical microbicides

Soap-and-water washing removes most debris from skin or other surgical surfaces, but antiseptic solutions reduce resident skin flora populations. The choice of appropriate topical microbicides during surgery can influence SSI rates (EVIDENCE CATEGORY IB).

When selecting an antiseptic, consider the anticipated duration of the case, the epithelial surface to be breeched (mucous membrane vs keratinized skin), and the anticipated flora.

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CDC ADVISORY

Best practices for preventing surgical site infections

Recommended for all hospitals

EVIDENCE CATEGORY IA — Well-designed studies

- Cancel elective surgery if the patient has a remote infection
- Achieve maximal subcutaneous concentration of preoperative antibiotics
- Avoid routine vancomycin and similar agents
- Maintain prophylactic antibiotics for only a few hours after closing incisions
- For high-risk cesarean, administer the prophylactic antimicrobial immediately after the umbilical cord is clamped
- If it is necessary to remove hair, use clippers, not shaving, immediately before the operation.

EVIDENCE CATEGORY IB — Good evidence and expert consensus

- Control glucose levels and avoid perioperative hyperglycemia
- Encourage patients to quit or minimize smoking
- Require the patient to shower or bathe with an antiseptic agent
- Surgical hand hygiene to include scrub to elbows for 2- to 5-min, use sterile towel, keep fingernails short, clean under fingernails
- Use appropriate topical microbicides during surgery
- Pay careful attention to proper surgical technique

We still don't know

NO RECOMMENDATION; UNRESOLVED ISSUE — Evidence is insufficient

- Enhance nutritional support solely to prevent SSI?
- Discontinue or taper steroids if medically permissible?
- Measures to enhance wound space oxygenation?
- Preoperatively apply mupirocin to nares?

The complete *Guideline for Prevention of Surgical Site Infections* is available online at www.cdc.gov/ncidod/hip/SSI/SSI_guideline.htm.[1]

Shaving and hair removal

Hair removal is often necessary, but shaving may cause skin trauma that exacerbates bacterial growth.[10] SSI rates correlate with the time interval between shaving and incision (20% if shaved >24 hours before surgery, 7.1% the night before, and 3.1% in the OR).[11] Thus, the CDC guidelines discourage shaving prior to surgery (EVIDENCE CATEGORY IA).Patients have been known to shave the operative area themselves before surgery, so all patients must be told not to shave themselves before elective surgery.

When hair removal is necessary, preoperative clipping causes minimal skin trauma (EVIDENCE CATEGORY IA).

Preparing the surgical staff

The surgeon's hands

Evidence has shown that 2 minutes of preoperative scrubbing reduces resident flora as effectively as scrubbing for 10 minutes.[1] The recommended scrub should include hands and forearms up to the elbows for 2 to 5 minutes (EVIDENCE CATEGORY IB).

Keep hands away from the body and dry hands with a sterile towel (EVIDENCE CATEGORY IB).

Keep fingernails short (EVIDENCE CATEGORY IB), and clean under each nail at the beginning of each day (EVIDENCE CATEGORY II).

An aqueous alcohol solution is a recent alternative to traditional hand anti-

FAST TRACK

Preop warming of the entire body or local site for 30 minutes can reduce infection risk

TABLE 2

Principles of antimicrobial prophylaxis

Consider these factors:
Risk for developing surgical site infection.
Potential severity of consequences Prosthetic implantation Cardiothoracic or vascular surgery
Agents must be safe, inexpensive, and bactericidal
Appropriate spectrum based on anticipated flora of involved tissues and spaces
Administer so that maximal effect is at time of incision, and re-administer when appropriate
Alter dosage as appropriate for the patient (eg, obesity)

FAST TRACK

Short-duration antimicrobial prophylaxis works best, but should continue for only a few hours after closing the incision

sepsis with chlorhexidine- or povoidone-iodine–based solutions. No difference in SSI rates has been documented between hand-rubbing with an aqueous alcohol solution and traditional scrubbing.[12] A traditional scrub before the first of consecutive cases and after contact with gross contamination is still in order.

Sterile barriers

Sterile barriers in the operating room, indispensable in protecting staff, are federally mandated. Their role in preventing SSI is not clear. Surprisingly, the use of face masks may not contribute to SSI reduction.[13] Head covering, on the other hand, markedly reduces airborne and wound bacterial contamination.[14]

Optimize wound physiology

Maintaining normothermia

Hypothermia is common, particularly in patients who are immunocompromised, at age extremes, or have multiple trauma. Hypothermic vasoconstriction may reduce tissue perfusion and increase risk of infection.

A double-blind study showed that maintaining intraoperative normothermia decreased SSI in colorectal patients from 19% to 6%.[15] Additionally, preoperative warming of the entire body or local site for 30 minutes reduced SSI rates in clean surgical cases.[16]

Wound space oxygenation

Supplemental oxygen in colorectal surgery may correlate with lower infection rates (80% without supplemental oxygen, 30% with).[17] This may improve tissue oxygen tension, which enhances oxidative bactericidal capacity.

However, these findings were not duplicated in patients with higher SSI rates and on supplemental hyperoxia.[18] There are no recommendations for enhancing wound space oxygenation.

Control of glycemia

Cardiothoracic surgery studies have stressed the importance of tight perioperative glycemic control. Coronary artery bypass patients with higher mean perioperative glucose showed a trend toward a higher risk of nosocomial infection, but not specifically SSI.[19] Another study of cardiothoracic patients found an association between higher risk of SSI and both diabetes and postoperative hyperglycemia.[20] Continuous intravenous insulin to maintain a blood glucose <200 mg/dL reduced the incidence of deep sternal wound infections after cardiac surgery, more than subcutaneous insulin protocols.[21]

Remote infections

Remote infections at the time of surgery, such as urinary tract infection or pneumonia, significantly raise the risk of SSI (EVIDENCE CATEGORY IA).

Strongly consider canceling elective surgery if there is an untreated remote infection, especially if implanting bioprosthetic material.

Surgical technique

Careful technique reduces risk of infection.

Breaks in sterile technique and gross spillage of enteric contents raise the risk for SSI through increased bacterial load.

Poor hemostasis, excess tissue trauma, inadequate debridement or dead space obliteration, and inappropriate suture technique raise the volume of unperfused biological matter (EVIDENCE CATEGORY IB).

Timely completion of the operation also minimizes risk. Prolonged operative

time can heighten the risk of breaches in sterile technique. Recommendations call for procedures to be completed within the 75th percentile of standardized operative times.

Antimicrobial prophylaxis

The principles for using preoperative antibiotics include maximal subcutaneous concentration when making the incision (**TABLE 2**) (EVIDENCE CATEGORY IA). This corresponds with intravenous antimicrobial administration within 60 minutes before incision (or within 120 minutes for vancomycin or fluoroquinolones). An additional dose of the antimicrobial agent is indicated if the procedure time exceeds 2 half-lives of the agent.

Institutional policies for antibiotic restriction aimed at curtailing resistant organisms do not appear to change the spectrum of causative microbes in SSI.[22] Short-duration therapy preserves antimicrobial efficacy best, so avoid the routine use of agents such as vancomycin (EVIDENCE CATEGORY IB).

Short duration also applies when antimicrobial prophylaxis is indicated. The CDC recommends extending antimicrobial prophylaxis no more than a few hours after incision closure (EVIDENCE CATEGORY IA). Particular cases may require longer antimicrobial prophylaxis, but prophylaxis beyond 24 hours does not reduce SSI rates and increases the potential for microbial resistance.

While a single dose of broad-spectrum antibiotic may cause *Clostridium difficile* colitis, prolonged duration also raises risk through profound changes in gut flora that favor the emergence of this opportunistic pathogen. ■

How strong is the evidence?

Category IA. Strongly recommended for all hospitals and strongly supported by well-designed experimental or epidemiologic studies.

Category IB. Strongly recommended for all hospitals and viewed as effective by experts in the field and a consensus of Hospital Infection Control Practices Advisory Committee (HICPAC), based on strong rationale and suggestive evidence, even though definitive scientific studies may not have been done.

Category II. Suggested for implementation in many hospitals. Recommendations may be supported by suggestive clinical or epidemiologic studies, a strong theoretical rationale, or definitive studies applicable to some, but not all, hospitals.

No recommendation; unresolved issue (NR). Insufficient evidence or no consensus regarding efficacy.

FAST TRACK

Complete operations within the 75th percentile of standardized operative times

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