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Healthcare Associated Infection Control and Biocides





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Foreword
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CHAPTER 3

Antimicrobial Prophylaxis in Surgery

Antimicrobial prophylaxis refers to the prevention of surgical site infection (SSI) complications by using antimicrobial therapy. Certain factors may have a strong impact on SSI rates as follows:

- Attention to basic infection-control strategies
- Surgeon's experience and technique
- The duration of the procedure
- Hospital and operating-room environments
- Instrument-sterilization issues
- Preoperative preparation (e.g. surgical scrub, skin antisepsis, appropriate hair removal)
- Perioperative management (temperature and glycemic control)
- The underlying medical condition of the patient
- Patient-related factors associated with an increased risk of SSI include extremes of age, nutritional status, obesity, diabetes mellitus, tobacco use
- Coexistent remote body-site infections
- Altered immune response
- Corticosteroid therapy
- Recent surgical procedure
- Length of preoperative hospitalization
- Colonization with microorganisms.

The decision to use prophylaxis depends on the cost of treating and the morbidity associated with infection compared with the cost and morbidity associated with using prophylaxis. Antimicrobial prophylaxis is justified for most clean-contaminated procedures. The use of antimicrobial agents for dirty procedures or established infections is classified as treatment of presumed infection, not prophylaxis (Table 3.1).

TABLE 3.1 Treatment with prophylactic and therapeutic antibioticls

Prophylactic antibiotic treatment	• The use of antibiotics before, during, or after a diagnostic, therapeutic, or surgical procedure to prevent infectious complications
Therapeutic antibiotic treatment	• The use of substances that reduce the growth or reproduction of bacteria, including eradication therapy • This term is used to describe antimicrobial therapy prescribed to clear infection by an organism or to clear an organism that is colonizing a patient but is not causing infection

PURPOSE

To reduce the incidence of postoperative SSI as follows:

- Prevent SSI
- Prevent SSI-related morbidity and mortality
- Reduce the duration and cost of health care (when the costs associated with the management of SSI are considered, the cost-effectiveness of prophylaxis becomes evident)
- Produce no adverse effects
- Have no adverse consequences for the microbial flora of the patient or the hospital.

To achieve these goals, an antimicrobial agent should be:

- Active against the pathogens most likely to contaminate the surgical site

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- Given in an appropriate dosage and at a time that ensures adequate serum and tissue concentrations during the period of potential contamination
- Safe
- Administered for the shortest effective period to minimize adverse effects, the development of resistance, and costs.

ETIOLOGY OF SURGICAL SITE INFECTIONS

SSIs are caused by the deposition and multiplication of microorganisms in the surgical site of a susceptible host (Fig. 3.1). There are a number of ways microorganisms colonize and cause infection, including:

- Direct contact, either from another patient, transfer from surgical equipment or the hands of the hospital staff
- Airborne dispersal, surrounding air contaminated with microorganisms that deposit onto the wound
- Self-contamination (also known as endogenous infection)—physical migration of the patient's own normal flora which are present on the skin, mucous membranes or gastrointestinal tract to the surgical site.

Most surgical infection is due to bacterial and, more rarely, fungal infection. Viruses, such as human immunodeficiency virus (HIV) and the hepatitis B and C viruses are important to surgeons because they may contract these diseases from their patients. Due care has to be taken when managing such patients and infection significantly alters the host response to other diseases.

Risk of Infection

The likelihood of developing an SSI depends on a number of factors as the follows:

Patient and Operation Factors

See Table 3.2.

Anesthetic Factors

There are several perioperative factors over which the anesthetist has control and which are associated with SSIs. Normothermia: the maintenance of perioperative normothermia may reduce the incidence of SSIs. The major relation between hypothermia and increased SSI is thought



Fig. 3.1: Infection at surgical sites

TABLE 3.2 Patient and operation factors

Patient	*Operation*
• Age • Nutritional status • Diabetes • Smoking • Obesity • Coexistent infections at a remote body site • Colonization with microorganisms (e.g. *Staphylococcus aureus*) • Immunosuppression (including taking glucocorticoid steroids or immunosuppressant drugs) • Length of preoperative stay • Coexistent severe disease that either limits activity or is incapacitating • Malignancy	• Duration of surgical scrub/skin antisepsis • Preoperative shaving/preoperative skin preparation • Length of operation • Appropriate antimicrobial prophylaxis • Operating room ventilation • Inadequate sterilization of instruments • Foreign material in the surgical site • Surgical drains • Surgical technique including hemostasis, poor closure, tissue trauma • Postoperative hypothermia

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to be a decrease in subcutaneous tissue perfusion mediated by vasoconstriction. Hyperoxia, high inspired oxygen in the perioperative period confers some benefit in reducing the incidence of SSI. Hypoxia and shock are associated with higher rates of SSI. Normoglycemia, it has been well established that patients with diabetes are at increased risk for infections, including SSI. Even in non-diabetic patients, hyperglycemia is associated with an increased morbidity and mortality.

Wound Status

Wound characteristics which increase the risk of SSI include presence of foreign bodies, nonviable tissue in wound, tissue ischemia and hematoma formation. All of these characteristics provide a fruitful bacterial growing environment. Other factors known to promote SSIs are a prolonged preoperative hospital stay (since there is a growing opportunity for the skin to be colonized by pathogens), a long operation time (as it probably increases the extent of both tissue trauma and contamination), and poor surgical techniques. The risk of SSI varies with the type of surgery. Certain types of surgery carry a higher risk of contamination than others and have led to the classification of surgical wounds as: clean, clean-contaminated, contaminated, or dirty.

TABLE 3.3 Different classes of operation

Class	*Definition*
Clean	Operations in which no inflammation is encountered and the respiratory, alimentary or genitourinary tracts are not entered. There is no break in aseptic operating theater technique
Clean-contaminated	Operations in which the respiratory, alimentary or genitourinary tracts are entered but without significant spillage
Contaminated	Operations where acute inflammation (without pus) is encountered, or where there is visible contamination of the wound. Examples include gross spillage from a hollow viscus during the operation or compound/open injuries operated on within four hours
Dirty	Operations in the presence of pus, where there is a previously perforated hollow viscus, or compound/open injuries more than four hours old

Risk Factors that Increase the Rate of SSI

The risk is also related to the amount of contamination with microorganisms, the so-called "class" of the operation (see Table 3.3).

Perioperative antibiotics are generally recommended for clean-contaminated or contaminated operations. "Dirty" operations (e.g. perforated appendectomy) generally require treatment with antibiotics.

Common Surgical Pathogens

The agent chosen should have activity against the most common surgical site pathogens (see Table 3.4).

PROPHYLACTIC ANTIBIOTICS ADMINISTRATION

The preferred route of administration varies with the type of procedure, but for a majority of procedures, IV administration is ideal because it produces rapid, reliable, and predictable serum and tissue concentrations, prophylactic antibiotics should target the anticipated organisms, certain factors should be considered as follows:

Timing of Initial Dose

Successful prophylaxis requires the delivery of the antimicrobial to the operative site before contamination occurs. Thus, the antimicrobial agent should be administered at such a time to provide serum and tissue concentrations exceeding the minimum inhibitory concentration (MIC) for the probable organisms associated with the procedure.

Administration of the first dose of antimicrobial beginning within 60 minutes before surgical incision is recommended. This is a more-specific time frame than the previously recommended time, which was "at induction of anesthesia." Some agents, such as fluoroquinolones and vancomycin, require administration over one to two hours; therefore, the administration of these agents should begin within 120 minutes before surgical incision.

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TABLE 3.4 Types of recommended agents to prevent infection at surgical sites

Type of procedure	*Recommended agents*	*Alternative agents in patients with β-lactam allergy*
Cardiac coronary artery bypass	Cefazolin, cefuroxime	Clindamycin, vancomycin
Cardiac device insertion procedures (e.g. pacemaker implantation)	Cefazolin, cefuroxime	Clindamycin, vancomycin
Ventricular assist devices	Cefazolin, cefuroxime	Clindamycin, vancomycin
Thoracic noncardiac procedures, including lobectomy, pneumonectomy, lung resection, and thoracotomy	Cefazolin, ampicillin-sulbactam	Clindamycin, vancomycin[d]
Video-assisted thoracoscopic surgery	Cefazolin, ampicillin-sulbactam	Clindamycin, vancomycin
Gastroduodenal procedures involving entry into lumen of gastrointestinal tract (bariatric, pancreaticoduodenectomy)	Cefazolin	Clindamycin or vancomycin + aminoglycoside[g] or aztreonam or fluoroquinolone
Procedures without entry into gastrointestinal tract (antireflux, highly selective vagotomy) for high-risk patients	Cefazolin	Clindamycin or vancomycin + aminoglycosideg or aztreonam or fluoroquinolone
Biliary tract—open procedure	Cefazolin, cefoxitin, cefotetan, ceftriaxone, ampicillin-sulbactam	Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone [i]Metronidazole + aminoglycoside or fluoroquinolone
Laparoscopic procedure Elective, low-risk Elective, high-risk	 None Cefazolin, cefoxitin, cefotetan, ceftriaxone, ampicillin-sulbactam	 None Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone [i]Metronidazole + aminoglycoside or fluoroquinolone
Appendectomy for uncomplicated appendicitis	Cefoxitin, cefotetan, cefazolin + metronidazole	Clindamycin + aminoglycoside or aztreonam or fluoroquinolone Metronidazole + aminoglycoside or fluoroquinolone
Small intestine Nonobstructed Obstructed	 Cefazolin Cefazolin + metronidazole, cefoxitin, cefotetan	 Clindamycin + aminoglycoside or aztreonam or fluoroquinolone Metronidazole + aminoglycoside or fluoroquinolone
Hernia repair (hernioplasty and herniorrhaphy)	Cefazolin	Clindamycin, vancomycin
Colorectal	Cefazolin + metronidazole, cefoxitin, cefotetan, ampicillin-sulbactam, ceftriaxone + metronidazole, ertapenem	Clindamycin + aminoglycoside or aztreonam or fluoroquinolone, metronidazole + aminoglycoside or fluoroquinolone
Head and neck—clean	None	None
Clean with placement of prosthesis (excludes tympanostomy tubes)	Cefazolin, cefuroxime	Clindamycin
Clean-contaminated cancer surgery	Cefazolin + metronidazole, cefuroxime + metronidazole, ampicillin-sulbactam	Clindamycin

Contd...

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Type of procedure	*Recommended agents*	*Alternative agents in patients with β-lactam allergy*
Other clean-contaminated procedures with the exception of tonsillectomy and functional endoscopic sinus procedures	Cefazolin + metronidazole, cefuroxime + metronidazole, ampicillin-sulbactam	Clindamycin
Neurosurgery: Elective craniotomy and cerebrospinal fluid-shunting procedures	Cefazolin	Clindamycin, vancomycin
Implantation of intrathecal pumps	Cefazolin	Clindamycin, vancomycin
Cesarean delivery	Cefazolin	Clindamycin + aminoglycoside
Hysterectomy (vaginal or abdominal)	Cefazolin, cefotetan, cefoxitin, ampicillin-sulbactam	Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone Metronidazole + aminoglycoside or fluoroquinolone
Ophthalmic	Topical neomycin-polymyxin B-gramicidin or fourth-generation topical fluoroquinolones (gatifloxacin or moxifloxacin) given as 1 drop every 5–15 minutes for 5 doses[0] Addition of cefazolin 100 mg by subconjunctival injection or intracameral cefazolin 1–2.5 mg or cefuroxime 1 mg at the end of procedure is optional	None
Orthopedic: Clean operations involving hand, knee, or foot and not involving implantation of foreign materials	None	None
Spinal procedures with and without instrumentation	Cefazolin	Clindamycin, vancomycin
Hip fracture repair	Cefazolin	Clindamycin, vancomycin
Implantation of internal fixation devices (e.g. nails, screws, plates, wires)	Cefazolin	Clindamycin, vancomycin
Total joint replacement	Cefazolin	Clindamycin, vancomycin
Urologic: Lower tract instrumentation with risk factors for infection (includes transrectal prostate biopsy)	Fluoroquinolone, trimethoprim-sulfamethoxazole, cefazolin	Aminoglycoside with or without clindamycin
Clean without entry into urinary tract	Cefazolin [the addition of a single dose of an aminoglycoside may be recommended for placement of prosthetic material (e.g. penile prosthesis)]	Clindamycin, vancomycin
Involving implanted prosthesis	Cefazolin ± aminoglycoside, cefazolin ± aztreonam, ampicillin-sulbactam	Clindamycin ± aminoglycoside or aztreonam, vancomycin ± aminoglycoside or aztreonam

Contd...

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Contd...

Type of procedure	*Recommended agents*	*Alternative agents in patients with β-lactam allergy*
Clean with entry into urinary tract	Cefazolin (the addition of a single dose of an aminoglycoside may be recommended for placement of prosthetic material [e.g., penile prosthesis])	Fluoroquinolone, aminoglycoside with or without clindamycin
Clean-contaminated	Cefazolin + metronidazole, cefoxitin	Fluoroquinolone, aminoglycoside + metronidazole or clindamycin
Vascular[p]	Cefazolin	Clindamycin, vancomycin
Heart, lung, heart-lung transplantation Heart transplantation	Cefazolin	Clindamycin, vancomycin
Lung and heart-lung transplantation	Cefazolin	Clindamycin, vancomycin
Liver transplantation	Piperacillin-tazobactam, cefotaxime + ampicillin	Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone
Pancreas and pancreas-kidney transplantation	Cefazolin, fluconazole [for patients at high risk of fungal infection (e.g. those with enteric drainage of the pancreas)]	Clindamycin or vancomycin + aminoglycoside[g] or aztreonam or fluoroquinolone
	Cefazolin	Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone
Plastic surgery		
Clean with risk factors or clean-contaminated	Cefazolin, ampicillin-sulbactam	Clindamycin, vancomycin

Dosing

To ensure that adequate serum and tissue concentrations of antimicrobial agents for prophylaxis of SSIs are achieved, antimicrobial-specific pharmacokinetic and pharmacodynamic properties and patient factors must be considered when selecting a dose.

Weight-based dosing, the dosing of most antimicrobials in pediatric patients is based on body weight, but the dosing of many antimicrobials in adults is not based on body weight, because it is safe, effective, and convenient to use standardized doses for most of the adult patient population. Such standardized doses avoid the need for calculations and reduce the risk for medication errors. However, in obese patients, especially those who are morbidly obese, serum and tissue concentrations of some drugs may differ from those in normal-weight patients because of pharmacokinetic alterations that depend on the lipophilicity of the drug and other factors.

Duration

The shortest effective duration of antimicrobial administration for preventing SSI is not known; however, evidence is mounting that postoperative antimicrobial administration is not necessary for most procedures. The duration of antimicrobial prophylaxis should be less than 24 hours for most procedures. Since prolonged prophylaxis was associated with an increased risk of acquired antimicrobial resistance (cephalosporin-resistant Enterobacteriaceae and VRE) compared with short-term prophylaxis. There are no data to support the continuation of antimicrobial prophylaxis until all indwelling drains and intravascular catheters are removed. Half-lives of selected antibiotics commonly used for Prophylaxis as follows:

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Additional Intraoperative doses

- High antibiotic levels, at the site of incision, for the duration of the operation, are essential for effective prophylaxis
- Patients who experience major blood loss (greater than 1500 mL) should have fluid resuscitation, followed by re-dosing with the recommended prophylaxis regimen for that operation
- For operations lasting more than 4 hours re-dosing may be necessary.

Postoperative Antibiotic Prophylaxis

Studies have shown that giving additional antibiotic prophylaxis after wound closure does not reduce infection rates further. Postoperative antibiotics should only be given to treat active/ongoing infection unless specifically recommended against the surgical procedure (Table 3.5).

Procedure

1. The order forms will be included in the preoperative packet and placed in all relevant

TABLE 3.5 Postoperative antibiotics and doses

Antimicrobial	*Recommended dose*		*Half-life in adults with normal renal function (hours)*	*Recommended re-dosing interval (from initiation of preoperative dose), (hours)*
	Adults	Pediatrics		
Ampicillin-sulbactam	3 g (ampicillin 2g/ sulbactam 1 g)	50 mg/kg of the ampicillin component	0.8–1.3	2
Ampicillin	2 g	50 mg/kg	1–1.9	2
Aztreonam	2 g	30 mg/kg	1.3–2.4	4
Cefazolin	2 g, 3 g for patients weighing ≥120 kg	30 mg/kg	1.2–2.2	4
Cefuroxime	1.5 g	50 mg/kg	1–2	4
Cefotaxime	1 g	50 mg/kg	0.9–1.7	3
Cefoxitin	2 g	40 mg/kg	0.7–1.1	2
Cefotetan	2 g	40 mg/kg	2.8–4.6	6
Ceftriaxone	2 g	50–75 mg/kg	5.4–10.9	NA
Ciprofloxacin	400 mg	10 mg/kg	3–7	NA
Clindamycin	900 mg	10 mg/kg	2–4	6
Ertapenem	1 g	15 mg/kg	3–5	NA
Fluconazole	400 mg	6 mg/kg	30	NA
Gentamicin	5 mg/kg based on dosing weight (single dose)	2.5 mg/kg based on dosing weight	2–3	NA
Levofloxacin	500 mg	10 mg/kg	6–8	NA
Metronidazole	500 mg	15 mg/kg Neonates weighing <1200 g should receive a single 7.5 mg/kg dose	6–8	NA
Moxifloxacin	400 mg	10 mg/kg	8–15	NA

Contd...

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Contd...

Antimicrobial	*Recommended dose*		*Half-life in adults with normal renal function (hours)*	*Recommended re-dosing interval (from initiation of preoperative dose), (hours)*
	Adults	Pediatrics		
Piperacillin-tazobactam	3.375 g	Infants 2–9 months: 80 mg/kg of the piperacillin component Children >9 months and ≤40 kg: 100 mg/kg of the piperacillin component	0.7–1.2	2
Vancomycin	15 mg/kg	15 mg/kg	4–8	NA
Oral antibiotics for colorectal surgery prophylaxis (used in conjunction with a mechanical bowel preparation)				
Erythromycin base	1 g	20 mg/kg	0.8–3	NA
Metronidazole	1 g	15 mg/kg	6–10	NA
Neomycin	1 g	15 mg/kg	2–3 (3% absorbed under normal gastrointestinal conditions)	NA

places, including clinics, to ensure accessibility. The surgical prophylaxis or transplant surgical prophylaxis forms are to be used for all surgical procedures performed.

2. The doctor will complete the order form, including patient allergies. The form will then be given to the pharmacist, who will calculate weight adjustments per patient and if the patient is allergic to the antibiotic that is ordered, the pharmacist will automatically order the option listed on the form for use in the case of allergy.
3. If the doctor does not use the order form (i.e., writes surgical antimicrobial prophylaxis orders on a different form), the pharmacist will inform the physician that an antibiotic will not be dispensed until the form is completed.
4. The Intraoperative Antimicrobial Re-administration Guidelines will be posted in the operating rooms, and the specific re-administration time for a particular case, based on when the pre-operative dose is given, should be written on the wipe boards in the operating rooms by the pharmacy technician.

Recommendation

- Dirty procedures should receive additional postoperative coverage
- Prophylaxis is unnecessary if the patient is already receiving antibiotics that cover likely pathogens
- The timing of antibiotic administration should be adjusted to maximize prophylactic efficacy
- During prolonged procedures, antibiotic prophylaxis should be readministered every 3 hours (with the exception of vancomycin, aminoglycosides, and fluroquinolones)
- Inappropriate prophylaxis is characterized by unnecessary use of broad-spectrum agents and continuation of therapy beyond the recommended time period. These practices increase the risk of adverse effects and promote the emergence of resistant organisms.

PREVENTION OF SSI

Prevention is always better than a cure, and thus a careful assessment of risks related to SSI is paramount. The goal of SSI management is

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Fig. 3.2: Aspesis measures

to prevent or minimize the risk through careful planning. The following factors or methods external to the patient are critical to preventing SSI:

- Operating room (OR) environment and care of instruments; maintenance of positive pressure ventilation of OR, laminar airflow in high risk areas, and sterilization of surgical instruments, sutures etc. according to guidelines.
- Surgical team members educated in aseptic technique; staff with infections excluded from duty and scrubbing up followed by appropriate sterile attire. The following section outlines the evidence regarding hair removal, preparation of the sterile field, and wound closure technique (Fig. 3.2).

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