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EVIDENCE-BASED PRACTICES FOR SURGICAL ANTIBIOTIC PROPHYLAXIS: A COMPREHENSIVE REVIEW

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Abstract

Background: This review focuses on evidence-based practices for surgical antibiotic prophylaxis to prevent SSIs. It emphasizes appropriate dosage, timing, and re-dosing, along with the impact of SSIs on patient outcomes and healthcare costs. Guidelines from the CDC, WHO, and local hospitals are vital in reducing SSI risk, considering evidence and patient factors. Epidemiological data on SSIs worldwide is presented, and the choice between single-agent and combination therapy is explored. Timely administration and responsible antibiotic use are discussed, with special considerations for specific patient groups. The importance of antibiotic stewardship in combating resistance is highlighted, underlining the significance of following evidence-based guidelines to prevent SSIs and preserve antibiotic effectiveness.

INTRODUCTION

Surgical-site infection (SSI) refers to an infection that occurs in the area where a surgical procedure took place. The majority of these infections can be avoided by employing appropriate prevention strategies. Presently, SSI is defined as an infection that occurs within 30 days of the operation when no implant is present or within 1 year of the operation if an implant is left in place. They usually happen when bacteria from the patient's flora are introduced into the surgical site during the surgery. The likelihood of infection development depends on factors such as the patient's immune system health, the presence of foreign materials, the level of bacterial contamination in the wound, and the use of antibiotic prophylaxis. Surgical site infections impact around 0.5% to 3% of individuals who undergo surgery and are linked to extended hospital stays compared to patients without such infections.[1]

Surgical Antimicrobial Prophylaxis

Surgical antimicrobial prophylaxis is the administration of antibiotics to prevent surgical site infections. It is important to note that this does not involve preoperative decolonization or treatment of existing infections. When evaluating antibiotic prophylaxis protocols, it is crucial to carefully review the appropriate dosage, timing of the initial dose, and any necessary re-dosing to ensure adherence to best practices.[2]

Importance in Preventing Surgical Site Infections

Initial studies emphasized the significance of anaerobic microflora in postoperative infections, leading to notable advancements in the use of prophylactic and therapeutic antibiotics for surgical patients. Subsequent research focused on identifying risk factors to enhance the prediction of postoperative infection rates.[3] Preventing surgical site infections is essential because they can lead to increased patient morbidity, prolonged hospital stays, additional healthcare costs, and potential complications. By implementing appropriate preventive measures, such as proper hygiene, antibiotic prophylaxis, and aseptic techniques, the risk of surgical site infections can be significantly reduced, improving patient outcomes and overall healthcare quality.[4]

Impact of SSIs on Patient Outcomes

The impact of SSIs on patient outcomes is significant, particularly in terms of healthcare costs and hospitalization duration. SSI can result in increased patient morbidity and mortality, and prolonged hospital stays, and stands as the primary reason for hospital readmissions following surgery.[5] These infections prolong the recovery process, resulting in extended hospitalization durations and affecting the overall quality of patient care. The requirement for reoperation further adds to the increased healthcare costs Effective prevention measures are crucial to mitigate the financial burden and improve patient outcomes in the context of healthcare costs and hospitalization duration.[6]

GUIDELINES RECOMMENDED FOR SURGICAL ANTIBIOTIC PROPHYLAXIS

The guidelines were collaboratively developed by the American Society of Health-System Pharmacists (ASHP), the Infectious Diseases Society of America (IDSA), the Surgical Infection Society (SIS), and the Society for Healthcare Epidemiology of America (SHEA). Major international and national guidelines on surgical antibiotic prophylaxis are essential for reducing the risk of surgical site infections (SSIs) and improving patient outcomes. These guidelines are issued by prominent organizations such as the Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO), the Surgical Care Improvement Project (SCIP), and individual hospital protocols. Recommendations regarding antimicrobial prophylaxis are categorized based on the strength of available evidence. This classification indicates whether there is support for or against the use of prophylaxis but does not pertain to specific details like the choice of antimicrobial agent, dosage, or regimen.[7]

CDC Guidelines

The CDC provides evidence-based recommendations for surgical antibiotic prophylaxis to prevent SSIs. These guidelines emphasize the importance of administering the right antibiotic at the appropriate dose before the surgical incision. They also stress the significance of discontinuing the antibiotic within 24 hours after the surgery's completion, as prolonged use does not reduce infection rates and may contribute to antibiotic resistance.

WHO Guidelines

These guidelines highlight the importance of using a short-acting antibiotic, if needed, and suggest that only a single dose should be administered before the surgical procedure. WHO's approach aims to minimize unnecessary antibiotic exposure, which can help reduce the risk of antibiotic resistance.

Local Hospital Protocols

Individual hospitals often develop their protocols for surgical antibiotic prophylaxis based on a combination of international and national guidelines and their data and expertise. These local protocols take into account the hospital's unique patient population, prevalent pathogens, and antibiotic resistance patterns.[8]

DISCREPANCIES IN GUIDELINES AND THEIR RATIONALE

Variations in guidelines on surgical antimicrobial prophylaxis arise from differences in evidence interpretation, patient populations, surgical procedures, antimicrobial resistance patterns, and resource availability. The rationale includes variations in evidence levels, clinical trial interpretation, balancing benefits and risks, and preferences for broader or targeted coverage. Regularly reviewing multiple guidelines and tailoring prophylactic regimens based on patient needs and local conditions can optimize surgical outcomes while minimizing complications and antibiotic resistance.[9]

EPIDEMIOLOGY OF SURGICAL SITE INFECTIONS

PRESENT DATA PRESENTATION

Epidemiological evidence shows that 2-5% of surgical patients worldwide are affected by surgical site infections (SSIs). The incidence varies between developed and developing countries, with higher rates observed in developing nations. For instance, the United States has an SSI incidence of 2.6%, Germany 1.6%, and various European countries like Italy 2.9%. In contrast, developing countries experience rates up to two times higher than developed nations. Among every 100 patients who undergo surgery, approximately 1 to 3 individuals will experience a surgical site infection (SSI). Annually, around 300,000 SSIs occur, accounting for 17% of all healthcare-associated infections (HAIs) and ranking second only to urinary tract infections (UTIs).[10]

TYPES OF SSIS IN VARIOUS SURGICAL SPECIALTIES

Symptoms of any SSI can include redness, delayed healing, fever, pain, tenderness, warmth, or swelling. Specific types of SSIs have additional signs:

1. Superficial incisional SSI- It may result in pus drainage from the wound, and a culture of the pus helps identify the causative germs.
2. Deep incisional SSI- It may also lead to pus production, and the wound might reopen spontaneously or need surgical reopening to drain the pus.
3. Organ or space SSI- It may exhibit pus discharge from a drain placed in a body space or organ. An abscess, an enclosed area of pus and tissue surrounded by inflammation, could be observed during wound reopening or via special X-ray studies.

ASSOCIATED RISK FACTORS

The risk of an SSI is associated with the type of surgical wound:

1. Clean wounds: Not inflamed or contaminated, and no internal organ involvement.
2. Clean-contaminated wounds: No infection evidence at surgery, but internal organ involvement.
3. Contaminated wounds: Involves operating on an internal organ with spillage of contents into the wound.
4. Dirty wounds: Known infection present at the time of surgery.

Other risk factors for SSIs include surgery lasting over 2 hours, medical conditions, advanced age, overweight, smoking, cancer, weak immune system, diabetes, emergency surgery, and abdominal surgery.[11]

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CHOICE OF ANTIBIOTICS

SURGICAL SPECIALTY	RECOMMENDED ANTIBIOTIC PROPHYLAXIS	TARGET PATHOGENS	ADDITIONAL DOSES	DISCONTINUATION TIME
CARDIAC	Cefazolin OR Vancomycin	S. epidermidis, S. aureus	No additional doses are needed for clean, clean-contaminated procedures	Within 24 hours of the surgical end time for other procedures [12, 13].
GASTROINTESTINAL	For high risk+++: Cefazolin OR If the major reaction to beta-lactams++: Clindamycin plus Gentamicin	Enteric gram-negative bacilli, gram-positive cocci	For high-risk* and major reaction to beta-lactams++:	Within 24 hours of surgical end time [12].
COLORECTAL	Cefoxitin OR Ceftriaxone plus Metronidazole	Enteric gram-negative bacilli, anaerobes, enterococci	If the major reaction to beta-lactams++: Clindamycin plus Gentamicin	-
HEAD and NECK SURGERY	Cefazolin OR If major reaction to beta-lactams++: Clindamycin plus Gentamicin	Anaerobes, enteric gram-negative bacilli, S. aureus	-	Discontinue within 24 hours of surgical end time [12].
NEUROSURGERY	Cefazolin OR Vancomycin	S. aureus, S. epidermidis	-	-
VASCULAR	Cefazolin OR Vancomycin^ OR Clindamycin	S. aureus, S. epidermidis, enteric gram-negative bacilli	-	- [12, 13].
GYNECOLOGIC	Cefoxitin OR Ampicillin plus Metronidazole plus Gentamicin	Enteric gram-negative bacilli, anaerobes, Gp B strep, enterococci	If the major reaction to beta-lactams++: Clindamycin plus Gentamicin	-

SINGLE-AGENT PROPHYLAXIS VERSUS COMBINATION THERAPY

The use of single-agent prophylaxis and combination therapy for surgical site infections (SSIs) is debated. Both approaches can be effective, but the choice depends on surgery type, patient history, and local resistance. Single-agent is preferred for low-risk surgeries, simplifies treatment, and is cost-effective. Combination therapy is considered for high-risk surgeries or when resistance is a concern. Decisions should be based on patient, guidelines, and surgeon's judgment for optimal outcomes while minimizing SSIs. Adherence to evidence-based guidelines and monitoring are crucial in surgical settings.[14]

TIMING OF ADMINISTRATION

ANTIBIOTIC AGENT	INTRAVENOUS DOSE (ADULT DOSE)	INFUSION TIME (MINUTES)	TIMING OF FIRST DOSE (PRE-OPERATIVE DOSE)	INTRAOPERATIVE REDOSING FOR NORMAL RENAL FUNCTION	POST-OPERATIVE
Ampicillin/Sulbactam	50 mg/kg (2 gm) of ampicillin component	30	Begin 60 min or less before the incision	Every 2 hrs	Repeated every 6-8 hours[15].
Cefazolin	30 mg/kg (2 gm, 3 g for pts ≥ 120 kg)	30	Begin 60 min or less before the incision	Every 4 hrs	Repeated every 4 hours [15].
Cefoxitin	40 mg/kg (2 gm)	30	Begin 60 min or less before the incision	Every 2 hrs	Repeated every 2 hours [15].
Cefepime	50 mg/kg (2 gm)	30	Begin 60 min or less before the incision	Every 4 hrs	Repeated every 4 hours [15].
Clindamycin	10 mg/kg (900 mg)	30	Begin 60 min or less before the incision	Every 6 hrs	Repeated every 6 hours [15].
Metronidazole	15 mg/kg (500 mg)	30	Begin 60 min or less before the incision	Every 6 hrs	Repeated every 6 hours [15].
Vancomycin	15 mg/kg	60	Begin 120 min or less before the incision	Every 6 hr	Repeated every 6 hours [15].

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FACTORS THAT MAY AFFECT TIMING OF ADMINISTRATION

The timing of drug administration in surgical site infections depends on pharmacokinetics and the surgical procedure duration.

1. Pharmacokinetics influences how quickly antibiotics reach effective levels, ensuring sufficient concentrations during surgery. Administering antibiotics at the appropriate time before the incision ensures sufficient drug concentrations are present during the surgery to combat potential pathogens.
2. The duration of the surgical procedure also plays a critical role in drug timing. Longer surgeries may require re-dosing to maintain protection. Antibiotics may need to be re-administered during long surgeries to maintain effective drug levels throughout the procedure and into the postoperative period.[16]

DURATION OF PROPHYLAXIS

Properly timing the administration of antibiotics, considering re-dosing when necessary, determining the duration of prophylactic therapy, and adjusting dosages for obese patients are critical factors in preventing surgical site infections. These measures are also essential for promoting responsible antimicrobial use and preserving the effectiveness of antibiotics. It is recommended to administer antibiotics within 30 to 60 minutes before making the surgical incision. Ensuring proper re-dosing of antibiotics is crucial, taking into account the specific antibiotic's half-life. For instance, in the case of cefazolin and cefoxitin mentioned above, multiple administrations may be necessary depending on the procedure's duration. Unless there is a confirmed infection, prophylactic antibiotics should be stopped within 24 hours. However, when it comes to cardiothoracic surgery, there is still ongoing debate about whether the duration of therapy should extend up to 48 hours after the operation.[17]

IMPORTANCE OF LIMITING ANTIBIOTIC USE

Poor practices in infection prevention and control, combined with the inappropriate use of antibiotics, may also accelerate the development of antibiotic resistance. The development of antibiotic-resistant bacteria due to the misuse and overuse of antibiotics has become a significant public health concern. To mitigate this threat, it is crucial to limit unnecessary antibiotic prescriptions and ensure their appropriate use. By doing so, we can slow the emergence of antibiotic-resistant strains, preserving the efficacy of these vital medications and maintaining our ability to effectively treat infections in the long term. Responsible antibiotic use is essential for safeguarding public health and promoting a sustainable approach to managing bacterial infections.[18]

DOSAGE AND ROUTE OF ADMINISTRATION

When it comes to antibiotic prophylaxis for surgical procedures, appropriate dosage regimens are essential to ensure effective infection prevention while minimizing the risk of antibiotic resistance and adverse effects. The choice of antibiotics and their dosing may vary based on the specific surgical procedure, patient factors, and local guidelines. Appropriate antibiotic prophylaxis dosing is crucial for effective infection prevention in surgical procedures, while also minimizing resistance and adverse effects. Common antibiotics like cefazolin, cefoxitin, cefuroxime, and clindamycin are commonly used. Timely administration, usually 30 to 60 minutes before surgery, is essential, with potential re-dosing for prolonged surgeries. Obese patients may require adjusted dosages based on weight. Prophylactic therapy is limited to the peri-operative period, typically discontinued within 24 hours post-surgery if no infection is evident. Adherence to evidence-based guidelines ensures optimal outcomes, reduces surgical site infection risk, and preserves antibiotic efficacy, promoting patient safety and responsible antimicrobial use.[19]

COMPARISON AMONG ORAL, IV, AND TOPICAL ROUTES OF ADMINISTRATION

Route	Advantages	Considerations
Oral	- Convenient and easy for patients to comply with	Suitable for clean surgeries with low infection risk
	- Cost-effective compared to IV administration	- Achieving adequate blood levels may take longer, requiring timely dosing before surgery
Intravenous (IV)	- Rapid and reliable drug absorption into the bloodstream	- Ideal for emergency surgeries or procedures with high infection risk
	- Precise dosing and immediate availability of therapeutic levels	- Requires healthcare professionals' involvement, which may be less convenient for patients
Topical	- Provides localized protection at the surgical site	- Commonly used in clean surgeries targeting specific areas
	- Minimizes systemic side effects and risk of antibiotic resistance	- May not be suitable for surgeries with a higher risk of infection or involving deep tissues

The choice of administration route depends on factors like the type of surgery, infection risk, patient characteristics, and surgeon preferences. Oral administration is convenient and cost-effective but may take longer to achieve adequate blood levels. Intravenous (IV) administration ensures rapid

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and reliable drug absorption, making it suitable for high-risk surgeries but requires healthcare professionals' involvement. Topical prophylaxis offers localized protection and minimizes systemic effects but may not be enough for surgeries with a higher risk of systemic infections.

SPECIAL CONSIDERATIONS

Antibiotic prophylaxis involves administering antibiotics to specific patient populations to prevent infections.

1. In pediatrics, it may be utilized for particular surgeries or conditions to minimize the risk of postoperative infections.
2. In the elderly, antibiotic prophylaxis might be contemplated in certain scenarios to avert infections that could result in severe consequences.
3. Pregnant women might receive antibiotic prophylaxis to hinder the transmission of certain infections to the fetus.
4. Immunocompromised individuals could be prescribed antibiotics to forestall opportunistic infections due to their weakened immune systems. Nonetheless, the utilization of antibiotic prophylaxis should be thoroughly assessed, as it can contribute to antibiotic resistance and other potential risks.[20]

ADVERSE EFFECTS AND ALLERGIC REACTIONS

Antibiotics are known for causing life-threatening immune-mediated drug reactions, which are unintended responses. These reactions can present as anaphylaxis, organ-specific problems, or severe adverse skin reactions. Alongside these serious reactions, prophylactic antibiotics can also result in more common adverse effects like gastrointestinal symptoms (nausea, vomiting, and diarrhea) and allergic reactions, including skin rashes and itching. Patients must be vigilant about these potential side effects and promptly report them to their healthcare providers. Healthcare professionals have a critical role in evaluating the risks and benefits of prophylactic antibiotics and making necessary adjustments to treatment plans to minimize adverse effects while effectively preventing infections.[21]

ANTIBIOTIC STEWARDSHIP

Antibiotic stewardship involves the systematic evaluation and improvement of how healthcare providers prescribe antibiotics and how patients use them. This important initiative aims to ensure the effective treatment of infections, protect patients from the negative consequences of unnecessary antibiotic use, and address the issue of antibiotic resistance.[22]

To promote antibiotic stewardship, the following key elements are essential:

1. Leadership Commitment: Adequate allocation of human, financial, and information technology resources.
2. Accountability: Designating a single leader responsible for program outcomes, with successful experiences suggesting that a physician leader is effective.
3. Drug Expertise: Appointing a single pharmacist leader dedicated to enhancing antibiotic use.
4. Action: Implementation of at least one recommended action, such as systematically evaluating ongoing treatment needs after an initial period (i.e., conducting an "antibiotic time out" after 48 hours).
5. Tracking: Continuous monitoring of antibiotic prescribing practices and resistance patterns.
6. Reporting: Regularly providing information on antibiotic use and resistance to doctors, nurses, and relevant staff.
7. Education: Educating clinicians about antibiotic resistance and optimal prescribing practices.[22]

By distinguishing the culture test and its role in antibiotic selection, it is tabulated as follows

S.NO	ASPECT	DESCRIPTION
1.	Culture Test	The process of examining patient specimens (e.g., blood, urine, sputum) in the laboratory to identify the specific microorganism causing the infection. This information guides the selection of the most appropriate treatment for the patient's condition [23].
2.	Empirical Treatment	Initial antibiotic therapy based on clinical judgment and symptoms, initiated before culture test results are available, to promptly address the infection [23].
3.	Culture and Sensitivity Testing	After identifying the causative microorganism through culture test, sensitivity testing is conducted to assess its response to various antibiotics, identifying effective ones [23].
4.	Targeted Therapy	Healthcare providers use information from culture and sensitivity testing to administer antibiotic therapy that specifically targets the identified microorganism, improving treatment outcomes [23].
5.	Broad-Spectrum Antibiotics	Antibiotics that can effectively target a broad range of microorganisms [23].
6.	Narrow-Spectrum Antibiotics	Specifically target a limited group of microorganisms, reducing the risk of resistance and minimizing disturbance to the body's natural microbiota [23].
7.	De-escalation	As culture and sensitivity results become available, treatment may shift from broad-spectrum to narrow-spectrum antibiotics, ensuring a more targeted approach [23].
8.	Optimizing Antibiotic Course Length	Culture tests aid in determining the appropriate duration of antibiotic treatment to effectively eliminate the infection without promoting resistance [23].

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CONCLUSION

In summary, the prevention of surgical site infections (SSIs) is vital for enhancing patient outcomes and minimizing healthcare expenses. Proper use of antibiotic prophylaxis is a key factor in reducing the risk of SSIs. Evidence-based guidelines, like those from the CDC and WHO, provide valuable insights into selecting the appropriate antibiotics, timing their administration and determining the duration of prophylaxis. Following these guidelines and implementing antibiotic stewardship practices are essential to safeguard the effectiveness of antibiotics and address the worldwide challenge of antibiotic resistance.[24]

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