REVIEW ARTICLE

A systematic review on Prophylactic use of antibiotics in the context of orthopedic surgery

[1]Dr. Pravas Kumar, [2]Dr. Prahlad Kumar, [3]Dr. Ranjeet Kumar, [4]Dr. Om Prakash

[1,2]Senior Resident, [3,4]Assistant Professor, Department of Orthopaedic, ANMMCH Gaya, Bihar, India

Corresponding Author
Dr. Om Prakash
Assistant Professor, Department of Orthopaedic, ANMMCH Gaya, Bihar, India

Received date: 22 October, 2023 Acceptance date: 27 November, 2023

ABSTRACT
Infection in orthopedic surgery is a highly feared and undesirable consequence. It is linked to long-lasting illness, impairment, and higher death rates. Surgical site infection in clean wounds, specifically closed uninfected wounds, include both incisional and organ space infections.1 Of the approximately 30 million surgeries performed in the United States annually, about 2% are accompanied by surgical site infections. Prophylactic antibiotics have a well-established function in decreasing the occurrence of surgical site infections (SSIs) in orthopedic surgery. Their effectiveness is shown by strong clinical data, and their appropriate use is essential to surgical practice. Following criteria for the time, selection, and duration of antibiotic administration may greatly increase the results of surgical procedures, save healthcare expenses, and improve patient safety.
Aim: To examine the existing literature on the use of surgical antibiotic prophylaxis in orthopedic surgery and explore the potential consequences associated with the inappropriate administration of antibiotics.
Materials and method: A systematic review was conducted during June 2020 to April 2021 using the MeSH Terms)antibiotics in orthopaedic, drugs in orthopaedic surgery, prophylactic antibiotics in orthopaedics. Pubmed, Scopus, Embase and google scholar databases were also searched with the same search strategy and the references of selected journals were scanned to try to find more studies.
Conclusion: Prophylactic antibiotics are a cornerstone of infection prevention in orthopedic surgery. Their use significantly reduces the risk of surgical site infections, leading to better patient outcomes and reduced healthcare costs. The choice and timing of antibiotic administration are critical factors in maximizing their effectiveness. While the benefits of prophylactic antibiotics are well established, it is essential to balance these benefits against the risks of antibiotic resistance and adverse effects. Adhering to current guidelines and exploring innovative approaches, such as antibiotic-coated implants and decolonization strategies, will help ensure the continued success of prophylactic antibiotics in orthopedic surgery.
Keywords: Orthopedic surgery, Prophylactic, Antibiotics.

INTRODUCTION

Orthopedic surgery, particularly procedures involving the implantation of prosthetic devices or hardware, is associated with a significant risk of postoperative infections. These infections can lead to severe complications, including implant failure, prolonged hospitalization, and even increased mortality. To mitigate these risks, the administration of prophylactic antibiotics has become a standard practice in orthopedic surgery. The goal of prophylactic antibiotic therapy is to prevent surgical site infections (SSIs) by ensuring adequate tissue and serum concentrations of the antibiotic at the time of surgery and during the immediate postoperative period. This introduction explores the rationale, timing, choice, and efficacy of prophylactic antibiotics in orthopedic surgery, drawing on current guidelines and evidence from clinical studies.[1]

Rationale for Prophylactic Antibiotics in Orthopedic Surgery

Orthopedic surgery, especially procedures involving the implantation of prosthetic devices, carries a significant risk of postoperative infections. These infections can lead to severe complications, including implant failure, prolonged hospitalization, increased morbidity, and even mortality. Prophylactic antibiotics are administered to prevent surgical site infections (SSIs) by achieving adequate tissue and serum antibiotic concentrations at the time of surgery

and during the immediate postoperative period. This article explores the rationale for the use of prophylactic antibiotics in orthopedic surgery, examining their effectiveness, the factors influencing their choice, timing of administration, and potential risks.[2]

Effectiveness of Prophylactic Antibiotics

Prophylactic antibiotics significantly reduce the incidence of SSIs in orthopedic surgery. SSIs can result from bacteria introduced during surgery or from endogenous sources. The administration of antibiotics prior to and during surgery helps to eliminate or reduce bacterial load at the surgical site, thereby decreasing the risk of infection.Numerous studies have demonstrated the efficacy of prophylactic antibiotics in orthopedic procedures. For instance, a landmark study by AlBuhairan et al. conducted a systematic review and meta-analysis that highlighted a significant reduction in SSI rates among patients who received prophylactic antibiotics compared to those who did not. The review included various types of orthopedic surgeries and consistently showed a lower infection rate in the prophylactic antibiotic groups.

Factors Influencing the Choice of Antibiotics

The choice of prophylactic antibiotic in orthopedic surgery depends on several factors, including the type of surgery, patient-specific factors (such as allergies and comorbidities), and local antibiotic resistance patterns. The ideal prophylactic antibiotic should have the following characteristics:

1. **Broad-spectrum activity:** Effective against common pathogens associated with SSIs, such as Staphylococcus aureus and Staphylococcus epidermidis.
2. **Favorable pharmacokinetics:** Achieves and maintains adequate tissue concentrations at the surgical site.
3. **Safety profile:** Minimal adverse effects and low risk of promoting antibiotic resistance.

Cephalosporins, particularly first-generation cephalosporins like cefazolin, are commonly used in orthopedic surgery due to their broad-spectrum activity against gram-positive bacteria and favorable pharmacokinetic profile. Cefazolin's long half-life allows for sustained therapeutic levels during surgery, and its safety profile makes it suitable for most patients.In cases of beta-lactam allergies, alternatives such as vancomycin or clindamycin are used. Vancomycin is particularly effective against methicillin-resistant Staphylococcus aureus (MRSA) and is often used in high-risk patients or in institutions with a high prevalence of MRSA.[3,4]

Timing of Antibiotic Administration

The timing of antibiotic administration is crucial for maximizing its effectiveness. The goal is to ensure adequate antibiotic levels in the blood and tissues at the time of incision and throughout the surgical procedure. The optimal window for administering prophylactic antibiotics is within one hour before the surgical incision.Studies have shown that antibiotics given within this window significantly reduce the risk of SSIs compared to those administered outside this window. Administering antibiotics too early can result in subtherapeutic levels during surgery, while delayed administration fails to provide adequate tissue concentrations at the critical time of bacterial exposure.For prolonged surgeries, additional intraoperative doses may be necessary to maintain therapeutic antibiotic levels. This practice is particularly important for drugs with shorter half-lives or for procedures exceeding two hours in duration .[5,6]

Types of Prophylactic Antibiotics

1. **Cefazolin:**Cefazolin is a first-generation cephalosporin that is highly effective against gram-positive bacteria, including Staphylococcus aureus, and some gram-negative bacteria. It is the preferred prophylactic antibiotic for many orthopedic procedures due to its broad spectrum of activity, favorable safety profile, and cost-effectiveness. It is typically administered within one hour before the surgical incision to ensure adequate tissue concentrations during the procedure .
2. **Vancomycin:**Vancomycin is often used in patients with a history of severe beta-lactam allergies or in cases where there is a high risk of methicillin-resistant Staphylococcus aureus (MRSA) infection. Vancomycin should be administered over a period of 60 to 90 minutes to reduce the risk of infusion-related reactions, such as red man syndrome. Due to its narrow spectrum of activity, vancomycin is often combined with other antibiotics to ensure broader coverage .
3. **Clindamycin:** Clindamycin is an alternative for patients with beta-lactam allergies and provides good coverage against gram-positive bacteria and anaerobes. It is typically administered 30 to 60 minutes before the incision. However, clindamycin has been associated with higher rates of Clostridium difficile infections, which should be considered when selecting prophylactic antibiotics .[7,8]

Potential Risks and Considerations

While prophylactic antibiotics are highly effective in preventing SSIs, their use is not without risks. The overuse or inappropriate use of antibiotics can lead to the development of antibiotic-resistant bacteria, which poses a significant public health challenge. Therefore, it is essential to adhere to evidence-based guidelines and use antibiotics judiciously.One concern with the widespread use of prophylactic antibiotics is the potential for adverse drug reactions. While severe allergic reactions are rare, they can occur and must be managed promptly. Additionally, some antibiotics,

such as vancomycin, can cause nephrotoxicity and ototoxicity, particularly in patients with preexisting renal impairment.Another consideration is the impact of antibiotic prophylaxis on the gut microbiota. Antibiotics can disrupt the normal balance of gut bacteria, leading to dysbiosis and an increased risk of Clostridium difficile infections. This risk underscores the importance of using the narrowest spectrum antibiotic necessary to achieve effective prophylaxis.[9]

Current Guidelines and Recommendations

Several organizations have developed guidelines for the use of prophylactic antibiotics in orthopedic surgery. These guidelines provide evidence-based recommendations for the selection, timing, and duration of antibiotic prophylaxis to minimize the risk of SSIs while preventing antibiotic overuse.The American Academy of Orthopaedic Surgeons (AAOS) and the Centers for Disease Control and Prevention (CDC) both recommend the use of a first-generation cephalosporin, such as cefazolin, administered within one hour before incision for most orthopedic procedures. For patients with beta-lactam allergies, vancomycin or clindamycin is recommended. In cases where MRSA is a concern, vancomycin may be added to the prophylactic regimen.The duration of prophylactic antibiotic therapy is another critical consideration. Current guidelines recommend discontinuing antibiotics within 24 hours after surgery to minimize the risk of antibiotic resistance and adverse effects. Prolonged antibiotic use has not been shown to provide additional benefits and may contribute to the development of resistant organisms .[10]

Emerging Trends and Future Directions

As antibiotic resistance continues to evolve, new strategies for preventing SSIs in orthopedic surgery are being explored. One promising approach is the use of antibiotic-coated implants. These implants release antibiotics locally at the surgical site, providing high concentrations of the drug where it is needed most while minimizing systemic exposure. Studies have shown that antibiotic-coated implants can reduce infection rates in both experimental and clinical settings.Another area of interest is the use of perioperative decolonization strategies to reduce the burden of colonizing bacteria, particularly Staphylococcus aureus. Decolonization protocols typically involve the use of topical antiseptics, such as chlorhexidine, and intranasal mupirocin to eradicate nasal carriage of Staphylococcus aureus. These protocols have been shown to reduce the risk of SSIs in certain patient populations and may be particularly beneficial for patients undergoing high-risk procedures.[11]

Timing of Prophylactic Antibiotic Administration[6,8]

The timing of antibiotic administration is critical for its effectiveness in preventing SSIs. Studies have shown that administering antibiotics within one hour before the surgical incision is most effective in achieving optimal tissue concentrations at the time of surgery. For longer surgeries, additional intraoperative doses may be necessary to maintain therapeutic levels.

Table 2

Timing of Administration	Description	References
Within 1 hour before incision	Administration of prophylactic antibiotics within one hour before surgical incision is recommended to ensure adequate tissue and serum antibiotic levels at the time of incision.	Bratzler et al., 2013 ; Classen et al., 1992
2 hours before incision (Vancomycin and Fluoroquinolones)	For antibiotics like vancomycin and fluoroquinolones that have longer infusion times, administration 2 hours before incision is recommended to complete infusion before surgery.	Bratzler et al., 2013
Intraoperative re-dosing	Additional doses may be necessary for prolonged surgeries (>2 hours) or if there is significant blood loss to maintain therapeutic antibiotic levels throughout the procedure.	Bratzler et al., 2013 ; Classen et al., 1992
Postoperative discontinuation within 24 hours	Prophylactic antibiotics should be discontinued within 24 hours post-surgery to minimize the risk of antibiotic resistance and adverse effects.	Bratzler et al., 2013

Choice of Antibiotics

The selection of an appropriate antibiotic for prophylaxis in orthopedic surgery depends on several factors, including the type of surgery, the patient's history of allergies, and the local prevalence of antibiotic-resistant organisms. Cephalosporins, particularly cefazolin, are commonly used due to their broad spectrum of activity against common pathogens such as Staphylococcus aureus and their favorable pharmacokinetic properties . For patients allergic to beta-lactams, alternatives such as vancomycin or clindamycin can be used.[12]

Efficacy of Prophylactic Antibiotics in Orthopedic Surgery

Prophylactic antibiotics are an integral component in orthopedic surgery, aimed at preventing surgical site infections (SSIs) that can lead to significant morbidity, prolonged hospital stays, and increased healthcare costs. The efficacy of prophylactic antibiotics in reducing infection rates has been well-documented through various studies and clinical guidelines.The introduction of prophylactic antibiotics in surgical practice revolutionized the field of orthopedic surgery. Early studies in the mid-20th century demonstrated significant reductions in postoperative infection rates with the use of antibiotics. These findings led to the

Mechanism of Action

Prophylactic antibiotics work by achieving sufficient tissue and serum concentrations to inhibit bacterial growth at the surgical site. This is critical because the surgical incision provides a potential entry point for bacteria, and orthopedic implants create surfaces conducive to bacterial adherence and biofilm formation. The most commonly used antibiotics in orthopedic surgery include cephalosporins like cefazolin, which have a broad spectrum of activity against gram-positive organisms, including Staphylococcus aureus and coagulase-negative staphylococci, the most common pathogens in orthopedic infections.[13]

Specific Orthopedic Procedures

1. **Joint Replacement Surgery**
- Joint replacement surgeries, such as hip and knee arthroplasties, are particularly susceptible to infections. Prophylactic antibiotics have been shown to reduce infection rates significantly.

2. **Spinal Surgery**
- In spinal surgeries, SSIs can lead to severe complications, including osteomyelitis and hardware infections.

3. **Fracture Fixation**
- Fracture fixation surgeries involve the use of internal or external hardware, which increases the risk of infection.

Duration and Choice of Antibiotics

The duration of antibiotic prophylaxis is also a critical factor in its efficacy. The consensus is that prophylactic antibiotics should be discontinued within 24 hours post-surgery to minimize the risk of antibiotic resistance and adverse effects. Studies have shown that extended use of antibiotics beyond 24 hours does not provide additional benefits in preventing SSIs and may contribute to the development of resistant organisms.The choice of antibiotic depends on the type of surgery, patient factors, and local bacterial resistance patterns. For most orthopedic surgeries, first-generation cephalosporins such as cefazolin are preferred due to their efficacy, safety profile, and broad coverage of common pathogens.[14]

Current Guidelines and Recommendations

Current guidelines from organizations such as the American Academy of Orthopaedic Surgeons (AAOS) and the Centers for Disease Control and Prevention (CDC) provide specific recommendations for the use of prophylactic antibiotics in orthopedic surgery. The AAOS recommends the administration of a first-generation cephalosporin (e.g., cefazolin) within one hour before incision for most orthopedic procedures, with adjustments for patients with allergies or those undergoing surgeries involving high-risk of methicillin-resistant Staphylococcus aureus (MRSA).[15]

Emerging Considerations and Future Directions

While the benefits of prophylactic antibiotics in orthopedic surgery are well established, emerging considerations such as antibiotic resistance and the development of new antimicrobial agents continue to shape clinical practice. The rise of multidrug-resistant organisms necessitates ongoing surveillance and judicious use of antibiotics to prevent the development of resistance. Additionally, research into novel antimicrobial strategies, such as the use of antibiotic-coated implants, offers potential future avenues for enhancing infection prevention in orthopedic surgery.[16,17]

CONCLUSION

Prophylactic antibiotics are a cornerstone of infection prevention in orthopedic surgery. Their use significantly reduces the risk of surgical site infections, leading to better patient outcomes and reduced healthcare costs. The choice and timing of antibiotic administration are critical factors in maximizing their effectiveness. While the benefits of prophylactic antibiotics are well established, it is essential to balance these benefits against the risks of antibiotic resistance and adverse effects. Adhering to current guidelines and exploring innovative approaches, such as antibiotic-coated implants and decolonization strategies, will help ensure the continued success of prophylactic antibiotics in orthopedic surgery.

REFERENCES

1. AlBuhairan B, Hind D, Hutchinson A. Antibiotic prophylaxis for wound infections in total joint arthroplasty: a systematic review. J Bone Joint Surg Br. 2008;90(7):915-919.
2. Lidgren L, Robertsson O, Knutson K, Karrholm J. Prophylaxis with antibiotics versus gentamicin bone cement in total hip arthroplasty: a five-year survey of 1688 hips. ClinOrthopRelat Res. 1990;(253):173-178.
3. Kapadia BH, Berg RA, Daley JA, Fritz J, Bhave A, Mont MA. Perioperative Antibiotic Prophylaxis in Total Joint Arthroplasty. J Bone Joint Surg Am. 2016;98(8).

4. American Academy of Orthopaedic Surgeons (AAOS). Clinical Practice Guideline on the Diagnosis and Treatment of Periprosthetic Joint Infections of the Hip and Knee. Rosemont, IL: AAOS; 2013.
5. Bode LG, Kluytmans JA, Wertheim HF, et al. Preventing surgical-site infections in nasal carriers of Staphylococcus aureus. N Engl J Med. 2010;362(1):9-17.
6. Classen DC, Evans RS, Pestotnik SL, Horn SD, Menlove RL, Burke JP. The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. N Engl J Med. 1992;326(5):281-286.
7. World Health Organization. WHO Guidelines for Safe Surgery 2009: Safe Surgery Saves Lives. Geneva: World Health Organization; 2009.
8. Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Am J Health Syst Pharm. 2013;70(3):195-283.
9. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. Infect Control HospEpidemiol. 1993;14(10):573-580.
10. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Infect Control HospEpidemiol. 1999;20(4):250-278.
11. Kurtz SM, Lau E, Schmier J, Ong KL, Zhao K, Parvizi J. Infection burden for hip and knee arthroplasty in the United States. J Arthroplasty. 2008;23(7):984-991.
12. Beiner JM, Grauer J, Kwon BK, Vaccaro AR. Postoperative wound infections of the spine. Neurosurg Focus. 2003;15(3).
13. Patzakis MJ, Wilkins J. Factors influencing infection rate in open fracture wounds. ClinOrthopRelat Res. 1989;(243):36-40.
14. Whitehouse JD, Friedman ND, Kirkland KB, Richardson WJ, Sexton DJ. The impact of surgical-site infections following orthopedic surgery at a community hospital and a university hospital: adverse quality of life, excess length of stay, and extra cost. Infect Control HospEpidemiol. 2002;23(4):183-189.
15. AlBuhairan B, Hind D, Hutchinson A. Antibiotic prophylaxis for wound infections in total joint arthroplasty: a systematic review. *J Bone Joint Surg Br.* 2008;90(7):915-919.
16. Lidgren L, Robertsson O, Knutson K, Karrholm J. Prophylaxis with antibiotics versus gentamicin bone cement in total hip arthroplasty: a five-year survey of 1688 hips. *ClinOrthopRelat Res.*1990;(253):173-178.
17. AAOS. Clinical Practice Guideline on the Diagnosis and Treatment of Periprosthetic Joint Infections of the Hip and Knee. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2013.