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PREVENTION AND MANAGEMENT OF POSTOPERATIVE INFECTIONS: RATIONAL MODELS OF ANTIBIOTIC THERAPY

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Annotation: Postoperative infections (POIs) remain one of the most urgent complications in surgical practice and significantly influence morbidity, mortality, length of hospital stay and treatment costs. In recent years, the rational use of antibiotic prophylaxis and therapy has been considered the main strategy to prevent bacterial resistance and achieve effective clinical outcomes. This article analyzes modern approaches to prevention and management of postoperative infections, focusing on evidence-based antibiotic therapy, risk factor identification, and optimization of perioperative prevention. The article also provides research methods, results, and practical conclusions on forming rational therapeutic models.

Keywords: Postoperative infections, surgical site infection, antibiotic therapy, antibiotic prophylaxis, rational models, bacterial resistance, perioperative prevention.

INTRODUCTION

Postoperative infections are defined as infections developing within 30 days after surgery (or up to 90 days in the case of implant insertion) and are classified into superficial incisional, deep incisional, and organ/space infections. The occurrence of POIs ranges from 2% to 20% depending on the type of surgery, patient individual risk factors, and adherence to preventive protocols. Despite progressive improvements in surgical asepsis, antisepsis and disinfectants, postoperative infections continue to be a problem due to multidrug-resistant pathogens such as MRSA, ESBL-producing enterobacteria and Pseudomonas aeruginosa. Incorrect and uncontrolled use of antibiotics often leads to microbial resistance and reduces the effectiveness of standard regimens. Therefore, development and application of rational antibiotic therapy models based on standards (CDC, WHO, NICE) is critical.

LITERATURE ANALYSIS

Recent literature shows that rational antibiotic therapy and prophylaxis significantly reduce the incidence of POIs. According to WHO and CDC guidelines, 30–50% of antibiotic usage in surgical departments is unnecessary or irrational. Many studies confirm that prophylactic antibiotics administered within 60 minutes before incision and discontinued within 24 hours post-surgery decrease surgical site infection rates by more than 30%. Literature also focuses on risk stratification: diabetes mellitus, obesity, smoking, long operative time, improper wound care and prolonged catheterization increase infection risk. Modern studies support personalized antibiotic regimens based on local hospital microbiological mapping and antibiogram patterns. Additionally, strict monitoring of antibiotic consumption can effectively control antimicrobial resistance (AMR) trends.

METHODS SECTION

For the methodological basis of this analysis, the following approaches were used:
Systematic literature review of recent guidelines and articles (PubMed, Scopus, WHO publications)
Analysis of clinical protocols for antibiotic prophylaxis in surgery
Comparative evaluation of existing rational antibiotic therapy models
Study of microbiological resistance patterns reported in leading global centers
Research focus: Identify most effective prevention strategies, compare rational therapy models, evaluate antibiotic selection criteria.

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RESULTS SECTION

Postoperative infections, particularly surgical site infections (SSIs), remain a significant challenge in modern surgery, contributing to increased morbidity, prolonged hospital stays, extended antibiotic use, and higher healthcare costs. SSIs account for approximately 20-30% of all healthcare-associated infections, with incidence rates varying from 1-3% in clean procedures to over 20% in contaminated cases. Rational antibiotic therapy emphasizes evidence-based, targeted, and judicious use to prevent infections while minimizing resistance, collateral damage (e.g., Clostridium difficile colitis), and unnecessary exposure.

Key Principles of Rational Antibiotic Therapy

Risk Stratification: Use tools like the National Nosocomial Infections Surveillance (NNIS) system or SENIC score to identify high-risk patients (e.g., obesity, diabetes, immunosuppression, prolonged surgery >2-3 hours).

Timing: Administer prophylactic antibiotics within 60 minutes before incision (120 minutes for vancomycin/fluoroquinolones) to achieve adequate tissue concentrations.

Duration: Limit prophylaxis to <24 hours post-operation for most clean/clean-contaminated surgeries; discontinue immediately after wound closure unless contamination is evident.

Spectrum and Selection: Choose agents covering likely pathogens (e.g., Staphylococcus aureus, Gram-negative rods) based on local antibiograms, procedure type, and patient allergies.

De-escalation in Treatment: For established infections, start broad-spectrum empiric therapy, then narrow based on culture results and sensitivities within 48-72 hours.

Antimicrobial Stewardship: Integrate multidisciplinary programs to audit usage, promote alternatives (e.g., enhanced recovery protocols, negative pressure wound therapy), and avoid overuse.

Classification of Surgical Wounds and Pathogen Profiles

Wound Class	**Description**	**Common Pathogens**	**Prophylaxis Recommendation**
Clean (Class I)	Non-traumatic, no inflammation, respiratory/GI/GU tract not entered	*S. aureus*, coagulase-negative staphylococci	Cefazolin (1-2 g IV); alternatives: vancomycin if MRSA risk
Clean-Contaminated (Class II)	Entry into respiratory/GI/GU tract without significant spillage	Above + Gram-negatives (*E. coli*, *Klebsiella*), anaerobes (*Bacteroides*)	Cefazolin + metronidazole; or cefuroxime
Contaminated (Class III)	Acute inflammation, gross spillage, major break in sterile technique	Polymicrobial (Gram-negatives, anaerobes, enterococci)	Broad: Piperacillin-tazobactam or cefepime + metronidazole
Dirty/Infected (Class IV)	Purulence, perforation, traumatic wound >4 hours old	As above + possible fungi/resistant organisms	Therapeutic: Carbapenems (e.g., meropenem) or vancomycin + broad Gram-negative cover

Prophylactic Models

- Standard Model (ASHP/IDSA/SIS/WHO Guidelines):
  - Agent: First/second-generation cephalosporins (e.g., cefazolin 2 g IV for patients <120 kg; 3 g if ≥120 kg).
  - Redosing: Intraoperatively if surgery >2 half-lives of drug (e.g., every 4 hours for cefazolin) or blood loss >1.5 L.
  - Evidence: Meta-analyses show 50-70% SSI reduction; no benefit from postoperative continuation beyond 24 hours in cardiac/colorectal/orthopedic surgery.

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- MRSA-Endemic Settings: Add vancomycin (15 mg/kg IV) to cefazolin; screen/decolonize with mupirocin nasal ointment + chlorhexidine baths preoperatively.
- Beta-Lactam Allergy: Clindamycin + aminoglycoside/fluoroquinolone; avoid if anaphylaxis history without testing.
- Procedure-Specific:
  - Colorectal: Cefazolin + metronidazole OR ertapenem (single dose); mechanical bowel prep + oral antibiotics (neomycin + metronidazole) reduces SSIs by 40-50%.
  - Orthopedic (Joint Replacement): Cefazolin; cement with antibiotics (e.g., gentamicin) for high-risk.
  - Cardiothoracic: Cefazolin; extend to 48 hours if sternal infection risk.

Management of Established Postoperative Infections

Diagnosis: Use clinical signs (fever >38°C, wound erythema/drainage), imaging (CT/US for deep infections), and microbiology (wound swabs, blood cultures, aspirates). Biomarkers: CRP >100 mg/L or procalcitonin >0.5 ng/mL suggestive.

Empiric Therapy Model:

- Superficial SSI: Oral options if mild (e.g., doxycycline or TMP-SMX for MRSA coverage).
- Deep/Organ-Space: IV broad-spectrum (vancomycin + piperacillin-tazobactam); adjust for ICU/sepsis (add antifungals if candidemia risk).
- Duration: 4-7 days for superficial; 7-14 days for deep (source control essential: I&D, drainage).

Targeted Therapy:

- S. aureus (MSSA): Cefazolin or nafcillin.
- MRSA: Vancomycin (trough 15-20 mcg/mL) or daptomycin.
- Gram-negatives: Ceftriaxone or carbapenems if ESBL suspected.
- Anaerobes: Metronidazole or clindamycin.

Adjuncts: Negative pressure wound therapy (NPWT) reduces bacterial load; hyperbaric oxygen for refractory cases.

Evidence-Based Outcomes and Challenges

- Cochrane Reviews: Prophylaxis reduces SSI risk ratio to 0.40-0.60 across surgeries.
- Resistance Mitigation: Short-course prophylaxis does not increase resistance; prolonged use correlates with MDR emergence (e.g., VRE, CRE).
- Global Models: WHO's Surgical Safety Checklist integrates antibiotic timing checks, reducing SSIs by 30-50% in low-resource settings.
- Emerging Strategies: Preoperative chlorhexidine bathing, triclosan-coated sutures, and microbiome modulation (probiotics) show promise but require more RCTs.

Rational models prioritize prevention over treatment, with prophylaxis as the cornerstone. Local epidemiology must guide choices—regularly update institutional protocols via surveillance data. Consult infectious disease specialists for complex cases to optimize outcomes and stewardship.

DISCUSSION SECTION

It becomes clear that antibiotic therapy is not the only factor in postoperative infection control. In fact, antibiotic therapy is a supportive strategy integrated with surgical technique quality, effective wound management and systemic patient optimization. Overuse and misuse of broad-spectrum antibiotics poses significant danger. Therefore, rational models shift from “empirical wide usage” to “targeted narrow usage”. Another important topic is multidisciplinary teamwork including surgeons, infectious disease specialists, microbiologists, and clinical pharmacists. Developing national and institutional protocols, monitoring adherence, and educating medical staff greatly improve outcomes.

CONCLUSIONS

Rational use of antibiotics remains the cornerstone of postoperative infection control. Correct timing, correct drug choice and correct duration are main principles. Local microbiological data

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must be the basis for antibiotic selection. Preventive measures (asepsis, glucose control, normothermia) strengthen antibiotic efficacy.
Introduce hospital antibiotic stewardship programs in all surgical departments.
Develop individualized antibiotic prophylaxis protocols for each surgery type.
Use narrow-spectrum antibiotics whenever possible.
Regularly update hospital antibiograms and clinical guidelines.
Conduct continuous training for surgeons and nurses on rational antibiotic use.

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