A major use of antimicrobial agents in hospitalized children is prophylaxis of postoperative wound infections. In view of this frequent use and the emerging consensus on recommendations for prevention of surgical wound infections, the American Academy of Pediatrics has developed guidelines for surgical antimicrobial prophylaxis in children. Prophylaxis is defined as use of antimicrobial drugs in the absence of suspected or documented infection.

FREQUENCY OF ANTIMICROBIAL PROPHYLAXIS

In an extensive study of patients in acute care general hospitals in Pennsylvania, 36% of antimicrobial courses were initiated for prophylaxis of infection after surgery or an invasive procedure, such as cystoscopy or cardiac catheterization. The prevalence and reasons for antimicrobial use have been studied primarily in general or adult hospitals, but the patterns of use in children are similar to those in adults. Two studies have demonstrated that prophylaxis accounts for approximately 75% of the antibiotic use on pediatric surgical services. These studies and earlier studies by Miles et al and Burke in experimental animals have delineated the principles for effective use of antimicrobial agents in surgical prophylaxis, including choice of drugs and when and how long they are to be given.

INAPPROPRIATE ANTIMICROBIAL PROPHYLAXIS

Prophylaxis has been incriminated as a major cause of inappropriate use of these antimicrobial agents in both adults and children. In 74% of antimicrobial courses given for prophylaxis in the Pennsylvania study, the duration exceeded 48 hours, an interval beyond which continuation has not been proven beneficial. In a study of children less than 6 years old undergoing surgery in which appropriateness of use was assessed on the basis of commonly accepted guidelines, prophylactic antibiotics were administered inappropriately to 42% of children receiving preoperative prophylaxis, 67% of those receiving intraoperative prophylaxis, and 55% of those receiving postoperative prophylaxis. Similarly, in a large pediatric teaching hospital, 66% of antimicrobial agent use on surgical services was considered inappropriate for reasons of the wrong drug, dose, time of initiation, duration, or lack of indication. These findings indicate that the use of antimicrobial agents in children undergoing surgery and other invasive procedures should be subject to periodic review.

GUIDELINES FOR APPROPRIATE USE

Studies documenting the efficacy of systemic prophylaxis in surgical wound infections have been performed in adults. Because the pathogenesis of these infections is the same in children, the principles of surgical prophylaxis in children should be similar. In the absence of studies in children, guidelines recommended by the American College of Surgeons, The Medical Letter, the Veterans Administration Committee on Antimicrobial Drug Use, and Centers for Disease Control provide the only available standards for use of systemic prophylactic antibiotics in pediatric surgical patients. The following general principles are recommended as guidelines with the understanding that studies in children may result in changes and factors unique to children may justify exceptions:

Indications for Prophylaxis

Systemic prophylaxis is indicated when the benefits for prevention of wound infection outweigh the risks of drug reactions and emergence of resistant bacteria. The latter imposes a potential risk not
only for the recipient but also for other hospitalized patients who may develop a nosocomial infection caused by antibiotic-resistant organisms. (1) Procedures in which the benefits justify the risks incurred in antimicrobial prophylaxis are those associated with a significant risk of postoperative infection, and those in which the likelihood may not be great but the consequences of infection can be catastrophic. (2) A determinant of the probability of surgical wound infection is the number of microorganisms in the wound at the completion of the procedure.\textsuperscript{16,17} This concept has led to the classification of surgical procedures (see "Appendix"), based on the estimation of bacterial contamination and risk of subsequent infection, in four categories: clean wounds, clean-contaminated wounds, contaminated wounds, and dirty and infected wounds.

\textit{Clean Wounds.} In clean wound procedures, the benefit of systemic antimicrobial prophylaxis does not justify the potential risk for antimicrobial agents, except in circumstances in which consequences of infection are major and life-threatening, such as implantation of a prosthetic foreign body (for example, insertion of a prosthetic heart valve); open-heart surgery for repair of bacterial contamination; immunocompromised patients, such as those receiving high doses of corticosteroids or chemotherapy for malignancy, and neonates in whom a major body cavity is to be entered. Prophylaxis has been given in these instances, although studies establishing efficacy are lacking. A special circumstance in which systemic antimicrobial agents have been empirically recommended for a clean procedure is in patients with infection at another site.

\textit{Clean-Contaminated Wounds.} In clean-contaminated wound procedures, the degree of contamination is variable, and prophylaxis is limited to procedures with significant risk of wound contamination and infection. Based on data from adults, recommendations for prophylaxis for pediatric patients include the following: many alimentary tract procedures, selected biliary tract operations (eg, with obstructive jaundice); and urinary tract surgery or instrumentation in the presence of bacteriuria or obstructive uropathy.\textsuperscript{14,15,18}

\textit{Contaminated Wounds and Dirty and Infected Wounds.} In contaminated and dirty and infected wound procedures, such as those for a perforated abdominal viscus or a compound fracture, or when a major break in sterile technique has occurred, antimicrobial agents are indicated and considered treatment rather than prophylaxis.

\textbf{When Should Prophylactic Antibiotics Be Given}

Prophylaxis of infection requires effective drug concentrations in tissues during surgical procedures because maximal bacterial contamination occurs intraoperatively. Except for cesarean sections,\textsuperscript{1} antimicrobial agents should be administered (within two hours) before the surgical incision.

\textbf{How Long Should Antibiotics Be Given}

The findings of Stone et al\textsuperscript{19} indicate that a single antimicrobial dose that provides adequate tissue concentration throughout the procedure may be sufficient. A 12-hour limit is desirable in most cases.\textsuperscript{1} These recommendations are based on studies in adults, and may not necessarily apply to all pediatric patients, particularly the neonate. However, inasmuch as the pathogenesis of wound infection does not differ with age, the recommendation for relatively short duration of prophylaxis probably is applicable to patients of all ages. The duration of antimicrobial prophylaxis should not exceed 24 to 48 hours.

\textbf{Which Antibiotics Should Be Given}

The antimicrobial choice is based on knowledge of the common bacteria causing infectious complications after the specific procedure, bacterial susceptibility to the drug, proven efficacy of the drug selected, and its safety. New, costly antimicrobial agents generally should not be used unless prophylactic efficacy has been proven superior to that of drugs of established benefit.

The drugs should be active against the most likely pathogens, but they do not have to be active against every potential organism because effective prophylaxis appears to correlate with a decrease in the total number of pathogens rather than eradication of all organisms. Recommended doses and route of administration are based on the need to achieve therapeutic blood and tissue concentrations throughout the procedure, thus necessitating parenteral (usually intravenous) administration.

\textbf{CONCLUSIONS}

These principles for surgical antimicrobial prophylaxis in children were developed by the Committee on Infectious Diseases in collaboration with the Committee on Drugs and the Section on Surgery. Because the value of systemic antimicrobial prophylaxis in many pediatric surgical procedures has not been established, additional studies in commonly performed surgical procedures in children (eg, insertion of neurosurgical shunts and orthopaedic procedures) are needed. Pediatricians, pediatric surgeons, and surgical specialists should review the prophylactic use of antimicrobial agents as part of the ongoing review of antibiotic use in
their hospitals and use the guidelines given here to develop standards for antimicrobial use.

**APPENDIX**

Definitions of surgical wounds in the classification scheme are as follows:

**Clean Wounds.** These are uninfected operative wounds in which no inflammation is encountered, and neither the respiratory, alimentary, or genitourinary tract nor the oropharyngeal cavity is entered. In addition, they are elective, primarily closed, and if necessary, drained with closed drainage. Operative incisional wounds that follow nonpenetrating (blunt) trauma should be included in this category if they meet the criteria.

**Clean-Contaminated Wounds.** These are operative wounds in which the respiratory, alimentary, or genitourinary tract is entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.

**Contaminated Wounds.** These include open, fresh, accidental wounds, operations with major breaks in sterile technique or gross spillage from the gastrointestinal tract, and incisions in which acute, nonpurulent inflammation is encountered.

**Dirty and Infected Wounds:** These include old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscers. This definition suggests that the organisms causing postoperative infection were present in the operative field before surgery.

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