

## **Don't shave unless you have to!**

By Gregory P. Nowinski, MD

### **Clipping and depilatories are more effective in lowering infection risk**

Prepping a patient for surgery frequently involves removing the hair around the surgical site. Studies have shown a direct link between surgical site infections and hair removal, although questions remain about the best method to use.

The Surgical Care Improvement Project (SCIP)—a national quality partnership of organizations focused on improving surgical care by significantly reducing surgical complications—has developed recommendations for hair removal methods that can help reduce the occurrence of surgical site infections, a complication that develops in 2 percent to 5 percent of operated patients each year. These recommendations are listed in [Table 1](#).

#### **What's the best method?**

Appropriate removal of hair does help prevent surgical site infections. Shaving has traditionally been the most common method used to prepare the skin before surgery. But the best method of removing hair is debatable.

Razors can rapidly remove hair from the surgical field, but may result in small cuts and abrasions. This minor skin damage can provide an area where bacteria flora can multiply and potentially infect the surgical incision site.

An alternative to using razors is powered surgical clippers. Clippers mechanically trim the hair close to the skin, effectively removing it from the field, and avoid the skin trauma caused by the sharp blade of a razor. A study of open heart surgery patients showed a significant decrease in deep infections in individuals whose hair was removed by clippers compared to those whose hair removal was done with a razor. Reviews of other randomized controlled trials have confirmed this finding. When hair needs to be removed, it should be clipped instead of shaved.

Using depilatories—creams that remove the hair from the surgical site via a chemical, rather than a mechanical, action—may be even more effective in lowering infection rates. Although depilatory creams are easy to apply and avoid mechanical trauma to the skin, they are costly and may generate a sensitivity reaction at the surgical site.

#### **When's the best time?**

Timing of hair removal may also have an effect on infection rates. At least one study comparing infection rates when patients were shaved the night before surgery versus the day of surgery showed that preparing the skin closer to the time of surgery resulted in significantly lower infection rates, although this has not been confirmed.

### **Is it even necessary?**

In some cases, leaving the hair intact at the surgical site may be the best option. A prospective randomized study in spinal surgery patients demonstrated lower infection rates in unshaved patients than in shaved patients.

The Centers for Disease Control and Prevention recommends that hair should not be removed from the surgical site unless it is necessary to facilitate the surgical procedure. Unless you need to remove hair from the surgical area to see what you're doing, the best course of action may be to leave it alone.

### **Other ways to reduce surgical site infections**

Surgical site infections remain a major source of postoperative morbidity in patients undergoing orthopaedic surgery. These complications can clearly compromise patient outcomes and also increase the cost of healthcare delivery. Payors and consumers looking for measures of quality of care are increasingly monitoring compliance by healthcare workers and hospitals with the evidence-based practice guidelines developed by SCIP.

Several measures have been established to decrease the number of surgical site infections. Current performance measures for surgical site infection prevention include the following:

- appropriate timing, selection, and duration of prophylactic antibiotics
- glucose management
- maintenance of normothermia
- employment of appropriate hair removal methods

A collaborative effort of 56 hospitals involving more than 35,000 cases found that surgical infections decreased (27 percent reduction rate) as compliance with infection prevention practices increased.

*Gregory P. Nowinski, MD, is in private practice in Troy, Mich. He can be reached at [gnowinski@comcast.net](mailto:gnowinski@comcast.net)*

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6300 North River Road Rosemont, Illinois 60018-4262 Phone 847.823.7186 Fax 847.823.8125

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## Duration of prophylactic antibiotics

By Laura J. Prokuski, MD

Surgical site infection is a problem that has recently come under increased scrutiny. The U.S. Centers for Disease Control and Prevention (CDC) estimates that approximately 500,000 surgical site infections occur annually in the United States. Surgical site infections are a major cause of increased health care costs, as well as patient morbidity and mortality.<sup>1</sup>

An orthopaedic surgical site infection can lead to an extended hospitalization and prolonged antimicrobial use. True bone infection is difficult to eradicate. Infected and devitalized bone must be debrided. Implants are commonly removed to eradicate a nonviable biofilm where organisms can evade antibiotics. After the infection is controlled, skeletal reconstruction is often required. Antimicrobials must be given for a prolonged period of time to control the contamination. The prolonged administration of antibiotics magnifies their adverse effects, including allergic reactions, organ toxicity and bone marrow suppression.

### Preventing infections

Perioperative antibiotic prophylaxis is effective in reducing the rate of surgical site infections in orthopaedic surgery, particularly in joint replacements and closed fracture care. Optimal prophylaxis requires that a safe, effective antimicrobial be administered on a timely basis that allows effective levels in tissue during the procedure and that the antimicrobial be discontinued when the patient is no longer receiving a benefit.

However, errors in the use of prophylactic antibiotic occur frequently. Selection of the correct antibiotic, appropriate timing of its administration and the correct duration of its use are important in preventing surgical site infections, while minimizing side effects such as toxicity and antibiotic-resistance in local organisms.

The selection of an antimicrobial agent should take into account the common organisms related to particular surgical site infections, duration of action, antimicrobial spectrum, adverse reactions and cost. In orthopaedic surgery, first- or second-generation cephalosporins such as cefazolin or cefuroxime are commonly used. (See "[Selecting an appropriate prophylactic antibiotic agent](#)," *Bulletin*, June 2005.)

The antimicrobial should be administered within 60 minutes prior to incision to ensure adequate tissue concentrations at the operative site. Redosing during long procedures may be required to maintain tissue concentrations of the antimicrobial. (See "[Timing of prophylactic antibiotics in TJA](#)," *Bulletin*, August 2005.)

The proper duration of antibiotics used in a prophylactic manner is usually short. The majority of published evidence demonstrates that continuing to administer antibiotic prophylaxis beyond wound closure is not necessary. Studies comparing single-dose prophylaxis to multiple-dose prophylaxis have not shown any benefit from the additional doses. Limiting the administration of antibiotics to within the first day after surgery promotes cost containment and limits the opportunity for antibiotic toxicity and the development of antibiotic resistance in local organisms.

No evidence exists that continuing prophylactic antibiotics until all catheters and drains have been removed will lower infection rates.<sup>1</sup> In total joint arthroplasty and hip fracture surgery, drain use is controversial. Drains have been associated with infection, retained foreign bodies and soft tissue problems. Over time, there is increased bacterial colonization of the drain tip and migration of skin flora into the wound.<sup>2-4</sup> The current recommendation by the Centers for Medicare and Medicaid Services and CDC's Surgical Infection Prevention Project is to discontinue the antimicrobial agent within 24 hours postoperatively.<sup>1</sup>

### Summary

The use of prophylactic antibiotics has been proven to decrease the rate of surgical site infections in elective orthopaedic surgery cases. The selection of the correct antibiotic and timing its administration to ensure adequate tissue concentrations during the procedure are important factors

in the efficacy of these agents. The duration of antimicrobial use should not exceed 24 hours after the incision is made.

Laura J. Prokuski, MD, is an assistant professor in the department of orthopaedics and rehabilitation at the University of Wisconsin Hospital and a member of the AAOS Infections Committee. She can be reached at [prokuski@orthorehab.wisc.edu](mailto:prokuski@orthorehab.wisc.edu)



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## **Fight infections: Engage in hand-to-hand combat**

From the AAOS Patient Safety Committee

### **Surgeons should lead by example: Follow hand hygiene guidelines**

The concept of good hand hygiene is familiar to all healthcare workers, particularly surgeons, who are meticulous about scrubbing before operating. Good hand hygiene, however, should extend beyond the operating theater into hospital rooms and office settings.

The recent surge of media attention to methicillin-resistant *Staphylococcus aureus* (MRSA) and the arrival of cold and flu season underscore the importance of consistently practicing good hand hygiene. Hand washing with soap and water is common, but alcohol-based hand sanitizers and other antimicrobial preparations are also available for use. An added benefit of hand hygiene is a reduction in absenteeism due to illness, which may help to keep clinics and operating room schedules running smoothly.

Although many resources exist to encourage increased compliance in your institution, the most powerful tool available to surgeons may be leadership by example. Following are some tips and quick statistics on hand hygiene:

- The main mode of transmission of MRSA to other patients is through human hands, especially healthcare workers' hands. Without appropriate hand hygiene such as washing with soap and water or using an alcohol-based hand sanitizer, bacteria can spread when healthcare workers touch patients.
- Clean hands are the single most important factor in preventing the spread of dangerous germs and antibiotic resistance in healthcare settings.
- The Centers for Disease Control and Prevention (CDC) recommends the use of alcohol-based hand rubs by healthcare personnel for patient care because they significantly reduce the number of microorganisms on the skin, are fast acting, and cause less skin irritation than soap and water.
- More widespread use of products such as alcohol-based hand rubs, which improve adherence to recommended hand-hygiene practices, will promote patient safety and prevent infections.
- In 2004, poor compliance with hand-hygiene requirements was recognized as potentially contributing to the inability to control MRSA transmission. In an Australian study, use of alcohol chlorhexidine handrub was mandated for existing and visiting staff to the intensive

care unit (ICU), and its use was actively promoted by all ICU staff. Following the implementation of the campaign, the average monthly acquisition of MRSA in the unit dropped from 15.2 patients per 1000 occupied bed days (OBD) to 3.2 patients per 1000 OBD.

- At another Australian hospital, a series of interventions—including the introduction of an antimicrobial gel to the ICU and a hospital-wide MRSA surveillance feedback program that used statistical process control but not active surveillance cultures—was implemented over a 2 year period. The interventions resulted in a hospital-wide reduction in new patients with MRSA; the pre-intervention rate of 3.0 cases per 100 patient admissions dropped to 1.7 cases per 100 patient admissions during the intervention period.

### **Transmission of pathogens**

According to the CDC, the number of organisms (*S. aureus*, *Proteus mirabilis*, *Klebsiella* species and *Acinetobacter* species) present on intact areas of the skin of certain patients can vary from 100/cm<sup>2</sup> to 10<sup>6</sup>/cm<sup>2</sup>.

Documented studies have shown that healthcare workers may contaminate their hands (or gloves) merely by touching inanimate objects in patient rooms.

One study found that *S. aureus* could be recovered from the hands of 21 percent of ICU personnel and that 21 percent of physician carriers and

5 percent of nurse carriers had more than 1,000 colony-forming units on their hands. Serial cultures revealed that 100 percent of healthcare workers carried gram-negative bacilli at least once, and 64 percent carried *S. aureus* at least once.

### **Adherence to hand hygiene**

Adherence of healthcare workers to recommended hand-hygiene procedures has been poor, with mean baseline rates of 5 percent to 81 percent, and an overall average compliance rate of 40 percent.

[Figure 1](#) illustrates the hand-hygiene compliance rate among healthcare workers during a study conducted at two hospitals in Quebec. Compliance ranged from 32 percent to 81 percent over a 5-year period. Evidence revealed fluctuating compliance patterns for the duration of the study. Hand-washing opportunities were categorized by hospital ward, type of personnel, isolation precautions, and type of care procedure. Hand washing and alcohol-based gel use methods, including friction time, were also recorded.

Healthcare workers are often in the spotlight, encouraging the public to make hand washing part of their daily routine. Even school children are getting involved in the hand-hygiene campaign. During National Hand Washing Week, held the first week of December, students perform science projects and act out skits on the subject, and even vie for the title of "Hand Washing Champion" by keeping a record of who washes their hands the most.

*The AAOS Patient Safety Committee is chaired by Robert L. Brooks, MD. Questions can be directed to staff liaisons Katherine Sale ([sale@aaos.org](mailto:sale@aaos.org)) or Juleah Joseph ([joseph@aaos.org](mailto:joseph@aaos.org)).*

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6300 North River Road Rosemont, Illinois 60018-4262 Phone 847.823.7186 Fax 847.823.8125

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## Hand hygiene guidelines for orthopaedists

*Hand washing is the single most important means to prevent the spread of infection*

**By David B. Carmack, MD**

The concept of cleansing hands with an antiseptic agent probably emerged in the early 19th century. As early as 1822, a French pharmacist demonstrated that solutions containing chlorides of lime or soda could eradicate the foul odors associated with human corpses and that such solutions could be used as disinfectants and antiseptics.

In 1961, the U.S. Public Health Service produced a training film that demonstrated hand washing techniques recommended for use by health-care workers (HCW). In 1988 and 1995, guidelines for hand washing and hand antisepsis were published by the Association for Professionals in Infection Control (APIC). In 1995 and 1996, the Healthcare Infection Control Practices Advisory Committee (HICPAC) recommended that either antimicrobial soap or a waterless antiseptic agent be used for cleaning hands upon leaving the rooms of patients infected with multidrug-resistant pathogens.



Although the APIC and HICPAC guidelines have been adopted by the majority of hospitals, adherence of HCWs to recommended hand washing practices has remained low.

### Defining terms

- Alcohol-based hand rub: An alcohol-containing preparation designed for application to the hands for reducing the number of viable microorganisms on the hands. In the United States, such preparations usually are 60 percent to 95 percent ethanol or isopropanol.
- Antimicrobial soap: Soap (detergent) containing an antiseptic agent.
- Antiseptic agent: Antimicrobial substances that are applied to the skin to reduce the number of microbial flora.
- Antiseptic hand rub: Applying an antiseptic hand-rub product to all surfaces of the hands to reduce the number of microorganisms present.
- Detergent: Detergents (surfactants) are compounds that possess a cleaning action.
- Waterless antiseptic agent: An antiseptic agent that does not require use of exogenous water. After applying such an agent, the hands are rubbed together until the agent has dried.

### Transmission of pathogens

Transmission of health-care-associated pathogens from one patient to another via the hands of HCWs requires the following sequence of events:

- Organisms present on the patient's skin, or that have been shed onto inanimate objects in close proximity to the patient, must be transferred to the hands of HCWs.
- These organisms must then be capable of surviving for at least several minutes on the HCW's hands.
- Handwashing or hand antisepsis by the worker must be inadequate or omitted entirely, or the agent used for hand hygiene must be inappropriate.
- The HCW's contaminated hands must come in direct contact with another patient, or with an inanimate object that will come into direct contact with the patient.

Health-care-associated pathogens can be recovered not only from infected or draining wounds, but also from frequently colonized areas of normal, intact patient skin. The perineal or inguinal areas are usually most heavily colonized, but the axillae, trunk and upper extremities (including the hands) also are frequently colonized. The number of organisms (*Staphylococcus aureus*, *Proteus mirabilis*, *Klebsiella* species and *Acinetobacter* species) present on intact areas of the skin of certain patients can vary from 100/cm<sup>2</sup> to 10<sup>6</sup>/cm<sup>2</sup>.

Patients with diabetes, those undergoing dialysis for chronic renal failure and those with chronic dermatitis are likely to have areas of intact skin colonized with *S. aureus*. In one study, Agar fingertip impression plates were used to culture bacteria; the number of bacteria recovered from fingertips ranged from 0 to 300 colony-forming units (CFUs). Duration of patient-care activity was strongly associated with the intensity of bacterial contamination of HCWs' hands. HCWs can contaminate their hands with gram-negative bacilli, *S. aureus*, enterococci, or *Clostridium difficile* by performing "clean procedures" or touching intact areas of the skin of hospitalized patients.

Other studies also have documented that HCWs may contaminate their hands (or gloves) merely by touching inanimate objects in patient rooms. One study found that *S. aureus* could be recovered from the hands of 21 percent of intensive-care-unit personnel and that 21 percent of physician carriers and 5 percent of nurse carriers had more than 1,000 CFUs of the organism on their hands. Serial cultures revealed that 100 percent of HCWs carried gram-negative bacilli at least once, and 64 percent carried *S. aureus* at least once.

### Preparations for hand hygiene

Plain (non-antimicrobial) soap: The cleaning activity of these agents can be attributed to their detergent properties, which result in removal of dirt, soil and various organic substances from the hands. Plain soaps have minimal, if any, antimicrobial activity.

- Alcohols: The antimicrobial activity of alcohols can be attributed to their ability to denature proteins. The ideal volume of product to apply to the hands is not known.
- Chlorhexidine: The antimicrobial activity of chlorhexidine is likely attributable to attachment to—and subsequent disruption of—cytoplasmic membranes, resulting in precipitation of cellular contents.
- Chloroxylenol: The antimicrobial activity of para-chloro-meta-xyleneol (PCMX) may be attributable to inactivation of bacterial enzymes and alteration of cell walls.
- Hexachlorophene: Hexachlorophene can inactivate essential enzyme systems in microorganisms. It is bacteriostatic.
- Iodine and iodophors: Iodine molecules rapidly penetrate the cell wall of microorganisms and inactivate cells by forming complexes with amino acids and unsaturated fatty acids, resulting in impaired protein synthesis and alteration of cell membranes.
- Quaternary ammonium compounds: These compounds are primarily bacteriostatic and fungistatic, although they are microbicidal against certain organisms at high concentrations.
- Triclosan: Triclosan enters bacterial cells and affects the cytoplasmic membrane and synthesis of RNA, fatty acids and proteins.

### Hand hygiene by HCWs

Adherence of HCWs to recommended hand-hygiene procedures has been poor, with mean baseline rates of 5 percent to 81 percent (overall average: 40 percent).

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David B. Carmack, MD, is a member of the AAOS Infections Committee. He can be reached at [dcarmack@emh.org](mailto:dcarmack@emh.org)

### Recommendations

#### 1. Indications for handwashing and hand antisepsis

- Hands that are visibly dirty or contaminated with proteinaceous material or are visibly soiled with blood or other body fluids should be washed with either a non-antimicrobial soap and water or an antimicrobial soap and water.
- If hands are not visibly soiled, an alcohol-based hand rub should be used for routine decontamination in all other clinical situations.
- Decontaminate hands before having direct contact with patients.
- Decontaminate hands after contact with a patient's intact skin (such as when taking a pulse or blood pressure or lifting a patient).
- Even if hands are not visibly soiled, they should be decontaminated after contact with body fluids or excretions, mucous membranes, non-intact skin and wound dressings.
- Decontaminate hands if moving from a contaminated body site to a clean body site during patient care.
- Decontaminate hands after contact with inanimate objects (including medical equipment) in the immediate vicinity of the patient.
- Decontaminate hands after removing gloves.
- Wash hands with a non-antimicrobial soap and water or with an antimicrobial soap and water before eating and after using a restroom.
- No recommendation can be made regarding the routine use of non-alcohol-based hand rubs for hand hygiene in health-care settings. This is an unresolved issue.

#### 2. Hand hygiene techniques

- When decontaminating hands with an alcohol-based hand rub, apply the product to palm of one hand and rub hands together, covering all surfaces of hands and fingers, until hands are dry. Follow the manufacturer's recommendations regarding the volume of product to use.
- When washing hands with soap and water, wet hands first with water, apply an amount of product recommended by the manufacturer to hands, and rub hands together vigorously for at least 15 seconds, covering all surfaces of the hands and fingers. Rinse hands with water and dry thoroughly with a disposable towel. Use towel to turn off the faucet.
- Multiple-use cloth towels of the hanging or roll type are not recommended for use in health-care settings.

#### 3. Surgical hand antisepsis

- Remove rings, watches and bracelets before beginning the surgical hand scrub.
- Remove debris from underneath fingernails using a nail cleaner under running water.
- Use either an antimicrobial soap or an alcohol-based hand rub with persistent activity before donning sterile gloves to perform a surgical procedure.

- When using an antimicrobial soap, scrub hands and forearms for the length of time recommended by the manufacturer, usually 2 to 6 minutes. Long scrub times (10 minutes) are not necessary.
- When using an alcohol-based surgical hand-scrub product with persistent activity, follow the manufacturer's instructions. Before applying the alcohol solution, prewash hands and forearms with a non-antimicrobial soap and dry them completely. After applying the alcohol-based product as recommended, allow hands and forearms to dry thoroughly before donning sterile gloves.

#### 4. Other aspects of hand hygiene

- Do not wear artificial fingernails or extenders if you will have direct contact with patients at high risk (those in intensive-care units or operating rooms).
- Keep natural nails tips less than 1/4" long.
- Wear gloves when you could come into contact with blood or other potentially infectious materials, mucous membranes and non-intact skin.
- Change gloves during patient care if you are moving from a contaminated body site to a clean body site.

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## Laminar air flow in the operating room

*How effective is it in reducing infection?*

**By Richard P. Evans, MD**

Surgical site infection (SSI), a leading complication of surgery, is particularly devastating and expensive to treat when it occurs in orthopaedic implant surgery. With the current trend toward pay-for-performance standards, orthopaedic surgeons must consider taking advantage of all available potential infection control measures. Both airborne bacteria and other sources of bacterial contamination must be reduced to a minimum to achieve optimal SSI rates.

Several studies have shown a reduced infection rate in orthopaedic implant surgeries performed in ultra clean air facilities and body exhaust suits.<sup>1-5</sup> Decades of laminar flow operating room ventilation in combination with other infection control measures have improved infection rates; however, no uniform opinion about laminar flow efficacy has developed.

Laminar air flow results in a statistically significant reduction in airborne bacterial colony forming units (CFU)<sup>4</sup>, but a decrease in infection rates with statistical significance has not been shown. This is due to the number of uncontrolled variables in operating room infection control. The Centers for Disease Control and Prevention (CDC) also confirms that variables during multiple evaluations of laminar flow may have "confounded the associations." Based on this, some authors have disputed the results of studies showing laminar flow efficacy.<sup>6, 7</sup>



Uncontrolled variables include improved air turnover in traditional operating rooms, standardization of prophylactic antibiotics, behavioral change in personnel and awareness and elimination of other vectors of wound contamination. Laminar flow technology itself has evolved through the years.

Improvement of laminar flow technology has presented its own evaluation challenge. This technology has evolved from fiberglass wall packs to High-Efficiency Particulate Air (HEPA) filtration systems. HEPA-filtered laminar air flow can be provided by vertical air-flow systems and by unidirectional horizontal flow from wall-mounted units, with and without curtains or sliding walls. Because each system has its own associated problems of air-flow disruption, newer "exponential laminar flow"

systems have been developed in which the air flow takes the form of an upside-down trumpet. It is difficult to establish specific system comparisons and recommendations, however, because studies that document the merits of any one system do not include system design data.

The use of body exhaust suits in laminar flow theaters provides patients with additional protection from bacterial shedding, hair, exposed skin and mucus membranes of operating personnel.<sup>8, 9</sup> Body exhaust suits may also prevent the patient from contaminating operating room personnel, although this reverse isolation protection is still unstudied.

A continual decrease in general postoperative infection rates—and specifically in total joint arthroplasties—has resulted from the use of laminar flow with body exhaust suits, prophylactic antibiotics, improved surgical techniques and multiple other infection control measures. Because of the simultaneous evolution of multiple factors aimed at reducing intra operative infection, a long-term homologous study with the power to determine the isolated effect of a specific laminar flow system is unlikely. With an infection rate of about 1 percent in orthopaedic implant operations, only a very large homologous series of surgical cases would show statistical significance.

Nevertheless, the literature, as a whole, remains compelling. Many total joint surgeons prefer to use laminar flow and body exhaust suits when they are available.

### Standards

The analysis of surgical laminar air systems worldwide has resulted in specific standards. Examples are the UK Health Technical Memorandum (HTM 2025) in the United Kingdom and territories and the German VDI Standards, both of which are being amended to comply with the International Standards Organization (ISO) 14644.

The CDC suggests that both ultraclean air and antimicrobial prophylaxis can reduce the incidence of SSI in orthopaedic implant operations. Current CDC recommendations include the recommendation to consider performing orthopaedic implant operations in clean air and body exhaust suits.<sup>10</sup>

Additionally, the National Institutes of Health Office of Research Services, Division of Engineering Services, recently concluded that systems that provide laminar flow regimes represent the best option for contamination control in the operating room.<sup>11</sup>

Richard P. Evans, MD, is chief of adult reconstruction surgery at the department of orthopaedics, University of Arkansas for Medical Science. He can be reached at [rpevans@uams.edu](mailto:rpevans@uams.edu)

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## Selecting an appropriate prophylactic antibiotic agent

*Reduce surgical site infections with appropriate prophylactic antibiotic use*

**By Laura J. Prokuski, MD**

Surgical site infections are a major source of postoperative illness, accounting for nearly 25 percent of all nosocomial infections in the United States each year. The Centers for Disease Control and Prevention (CDC) estimate that approximately 500,000 surgical site infections occur annually in the United States.<sup>1</sup>

The National Surgical Infection Prevention Project (SIPP) was initiated in August 2002 as a joint venture between the Centers for Medicare and Medicaid Services and the CDC. By promoting the appropriate selection, timing and duration of administration of prophylactic antibiotics, SIPP seeks to reduce the morbidity and mortality related to postoperative infections in the Medicare population.<sup>2</sup>

Preliminary data from this project indicates that antibiotic prophylaxis is not always administered in a manner that is supported by scientific evidence.<sup>3</sup> Inappropriate use of antibiotics does not prevent postoperative infections, but contributes to antibiotic resistance, increases the risk of adverse reactions, predisposes the patient to infections and increases healthcare costs.

### **Antibiotics in orthopaedic surgery**

Prophylactic antibiotics reduce the incidence of infection after elective orthopaedic surgery. The use of prophylactic antibiotics is considered routine in major orthopaedic procedures such as arthroplasty, spine surgery and fracture repair. The goal of antimicrobial prophylaxis is to prevent intraoperative contamination of the wound by the most probable organisms to be encountered for the particular type of operation.

Optimal prophylaxis ensures that adequate concentrations of an appropriate antibiotic are present in the serum, tissue and wound during the entire time that the surgical wound is open and at risk for bacterial contamination. The antibiotic that is used should be active against bacteria that are likely to contaminate the wound and should be both safe and inexpensive. The selection of antibiotic prophylaxis should have the smallest impact possible on the normal bacterial flora of the patient and the biogram of the institution.<sup>4</sup>

The primary bacteria of concern in clean orthopaedic surgery are organisms found on the skin, primarily *Staphylococcus aureus* and *Staphylococcus epidermidis*. A first-generation cephalosporin, such as cefazolin, can provide adequate coverage against the majority of staphylococci and other gram-positive bacteria by inhibiting cell wall synthesis. Second-generation cephalosporins, such as cefuroxime, have a slightly broader spectrum, covering some gram-negative bacteria while remaining efficacious against gram-positive organisms.

Currently, cefazolin or cefuroxime are the preferred antibiotics used for prophylaxis in patients undergoing elective orthopaedic procedures.<sup>4,5</sup> Both cover the most common contaminating skin organisms and have a long enough half life to provide adequate tissue concentrations over the majority of orthopaedic procedures. Adverse effects are rare, but include rash and anaphylaxis.

A careful history of prior drug allergies should be obtained before surgery. A number of studies have demonstrated that the incidence of true drug allergy is lower than recorded in medical records. For some, formal allergy testing may disprove a questionable allergy and allow the use of recommended cephalosporins for surgical prophylaxis. For those with confirmed  $\beta$ -lactam allergy or serious adverse event with prior administration of penicillin or a cephalosporin, clindamycin or vancomycin may be used as prophylactic agents.<sup>5</sup>

### **Vancomycin use**

Vancomycin should not routinely be used for surgical prophylaxis. Some surgeons justify the use of vancomycin for surgical prophylaxis because an institution has a high level of methicillin-resistant staphylococcus surgical site infections. However, there is no consensus about what constitutes "high" levels of methicillin- resistance in an institution, and no threshold exists that can support the use of

vancomycin prophylaxis routinely in this situation.<sup>4,5</sup> A decision to use vancomycin in this scenario should involve studies of surgical site infection rates for a particular operation and specific infecting organisms, as well as a review of infection prevention practices for compliance and consultation with infectious disease experts.<sup>5</sup>

Vancomycin should be reserved for the treatment of serious infections with  $\beta$ -lactam-resistant organisms and for treatment of infections in patients with a true  $\beta$ -lactam allergy. Vancomycin may be used for surgical prophylaxis in patients with known colonization with methicillin-resistant *Staphylococcus aureus* (MRSA) and with true allergy to  $\beta$ -lactam antimicrobials.<sup>4,5</sup>

The AAOS Advisory Statement "The Use of Prophylactic Antibiotics in Orthopaedic Medicine and the Emergence of Vancomycin-Resistant Bacteria" provides additional information on the appropriate use of vancomycin and steps to reduce the nosocomial spread of *staphylococci* and *enterococci*. It is available [online](#).

### Summary

The antibiotic used for prophylaxis should be carefully selected, consistent with current recommendations in the literature and take into account the issues of resistance and patient allergies. The ideal prophylactic agent is effective against microorganisms at the surgical site. Effective antimicrobial prophylaxis is dependent on adequate concentrations of the drug in tissues throughout the entire procedure. Routine use of vancomycin as a prophylactic agent should be avoided.

The AAOS Advisory Statement on "Recommendations for the Use of Intravenous Antibiotic Prophylaxis in Primary Total Joint Arthroplasty" provides additional information on the appropriate selection, timing and duration of prophylactic agents for total joint arthroplasty. It is available [online](#).

*Laura J. Prokuski, MD, is assistant professor in the department of orthopaedics and rehabilitation at the University of Wisconsin Medical School and a member of the AAOS Infections Committee. She can be reached at [prokuski@orthorehab.wisc.edu](mailto:prokuski@orthorehab.wisc.edu)*

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## Timing of prophylactic antibiotics in TJA

*Recommendations exist, but questions persist*

**By Terry A. Clyburn, MD**

The literature on the timing of a preoperative dose of prophylactic antibiotics is clear and supported by excellent laboratory and clinical studies. The classic 1961 article by Burke, using an animal model, revealed what he termed the "effective period"—a period of about two hours prior to the creation of the wound in which the antibiotic could be administered and still be effective. When the antibiotic was administered outside that window or after the wound became contaminated, it was not effective.

Burke stated "failure to administer the first dose of antimicrobial prophylaxis within the two-hour window of time before incision is associated with a two- to six-fold increase in rates of surgical site infection."<sup>1</sup> Several other authors have concluded that to prevent infection, there must be bactericidal levels in the tissue at the time of surgery.<sup>2,3</sup> Many other studies support antibiotic administration as the single greatest factor in lowering the infection rate in total hip arthroplasty.<sup>4-6</sup>

Despite this body of evidence, questions persist about the appropriate timing of prophylactic antibiotics. There has been some concern that dosing immediately before surgery may not result in adequate bactericidal levels during surgery. Both the National Surgical Infection Prevention Project (SIPP) and the AAOS recommend that antibiotic prophylaxis be initiated one hour prior to incision to maximize the effective period. If vancomycin is used, the dose should be administered two hours prior to incision to accommodate the extended infusion time.



One study reported bone and serum concentrations of five cephalosporins, administered over a five-minute period in the operating room (OR) immediately prior to total hip and total knee procedures, and continued for 48 hours. Researchers noted a trend between the serum concentration and the bone concentration. Antibiotics with greater concentration in bone also had higher serum levels and longer half lives (cefazolin and ceforamide).<sup>7</sup> Another study examined the concentration of cephalothin and cefamandole in serum, bone, synovial fluid and wound drainage in 29 total knee replacements and 28 total hip replacements. The antibiotics were administered with the induction of anesthesia, and high concentrations of antibiotics were found in all samples. The authors concluded: "Because antibiotics penetrate bone rapidly, it is unnecessary to start antibiotics prior to the time of surgery."<sup>8</sup>

### **Tourniquets**

It may be theorized that inflating the tourniquet minutes after administering the antibiotic would

result in a lower dose of antibiotic in the knee area.<sup>9</sup> However; the preponderance of evidence indicates that the bone concentrations of cephalosporin administered in the OR are well above the minimum inhibitory concentration (MIC) for the targeted organisms.

Schurman specifically studied the effect of the tourniquet,<sup>8</sup> finding that concentrations of the same antibiotic at the hip and knee were not significantly different even though a tourniquet was used for the knee replacement procedures. In another analysis of bone concentrations of cephalosporins administered immediately preoperatively, results revealed the bone concentration of cefazolin, which has a half-life of 42 minutes, to be 60 times the MIC for penicillin-resistant *Staphylococcus aureus*.<sup>10</sup>

Yet another study found that the bone concentration of antibiotic was highest 60 minutes after antibiotic administration, and therefore recommended administration of the initial dose in the "anteroom" prior to surgery.<sup>3</sup>

### **On-call to OR**

Another popular option is to order that antibiotics be administered when the patient is "on-call" to the OR, but this practice has been shown to be unreliable. Many factors contribute to the variability of this option, including system problems at hospitals.

Despite the proven need to start antibiotics preoperatively, two studies done in the 1980s show poor compliance.<sup>11,12</sup> One study found that antibiotics were given immediately prior to surgery (within four hours) in only 49 percent of cases and were given more than four hours prior in 10 percent of cases. Furthermore, only 59 percent of 29 total joint cases received antibiotics before surgery.<sup>12</sup> Results of a 1989 study examining priorities in surgical antibiotic prophylaxis led the authors to conclude "...on call dosing is no longer acceptable because it may result in premature administration of the antibiotic regiment and insufficient tissue concentrations of drug during the decisive interval."<sup>13</sup>

It appears that the preoperative dose may be effective if given within the two-hour "effective period" prior to initiation of the surgical incision. However, it has been found that serum, tissue and bone concentrations of antibiotics are adequate and that clinical infection rates are excellent if the antibiotic is initiated in the OR.

There is also no untoward effect of raising the tourniquet shortly after such dosing. These facts, coupled with the problems that exist with control of dosing when antibiotic administration is ordered "on-call" to the OR, suggest that dosing in the OR of cephalosporins under the guidance of the anesthesiologist and the surgeon is preferred.

### **Vancomycin and resistant organisms**

As concern over methicillin-resistant organisms increases, surgeons are using prophylactic vancomycin.<sup>14,15</sup> Vancomycin is normally infused over a period of at least 30 minutes to prevent the development of "red man syndrome."<sup>16</sup> I have pretreated patients with H1 and H2 histamine receptor blockers so as to allow more rapid infusion.

Vancomycin should be infused prior to incision and prior to tourniquet inflation. As Laura J. Prokuski, MD, said in her article on selection of prophylactic agent (*Bulletin*, June 2005), the decision to use vancomycin must be carefully considered and based on an institutional evaluation of the risk of surgical infection with methicillin-resistant *S. aureus* or *S. epidermidis*. If this decision is made, the vancomycin must be ordered in time to be administered over a 30-to-60-minute period, prior to surgery. This requires compliance throughout the preoperative system in the hospital or surgical center.

The AAOS Advisory Statement on "Recommendations for the Use of Intravenous Antibiotic Prophylaxis in Primary Total Joint Arthroplasty" provides additional information on the appropriate selection, timing and duration of prophylactic agents for total joint arthroplasty. It is available on the [AAOS Web site](http://www2.aaos.org/aaos/archives/bulletin/aug05/fline4.asp).

Terry A. Clyburn, MD, is an assistant professor of orthopaedic surgery at the University of Texas

Hospitals and a member of the AAOS Infections Committee. He can be reached at [Terry.A.Clyburn@uth.tmc.edu](mailto:Terry.A.Clyburn@uth.tmc.edu)

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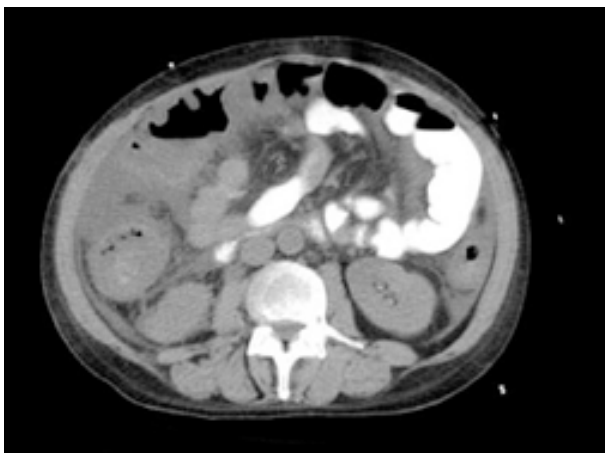
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## Clostridium difficile: An old bug with a new twist

By Calin S. Moucha, MD, and Lisa L. Dever, MD

While orthopaedic surgeons and infectious disease specialists are diligently treating surgical wound infections caused by multidrug-resistant bacteria, an old enemy, *Clostridium difficile*, is causing troubles elsewhere.



*Computed tomography scan image showing diffuse wall thickening of the colon consistent with pseudomembranous colitis in a patient requiring colectomy. Courtesy of Lisa L. Dever, MD*

*C. difficile* infection (CDI), a colonic infection related to antibiotic use, represents a considerable public health threat. In the United States, it is responsible for more deaths than all other intestinal infections combined. A study published this year detected a 23 percent annual increase in CDI hospitalizations in a 6-year period (2000 through 2005). The study estimated that the age-adjusted case-fatality rate for CDI hospitalizations nearly doubled—from 1.2 percent in 2000 to 2.2 percent in 2004.

### Background

Although most antibiotics have been associated with the development of diarrhea, not all such diarrhea is related to CDI. Some antibiotics may increase gastrointestinal motility leading to diarrhea. Others may disrupt the normal colonic flora leading to decreased carbohydrate digestion and result in osmotic diarrhea.

CDI specifically occurs when antibiotic administration leads to the overgrowth of toxin-producing strains of *C. difficile*. It has been estimated that 20 percent to 30 percent of antibiotic-associated diarrhea is due to *C. difficile*. The agents most often implicated include clindamycin and broad-spectrum cephalosporins and penicillins, although any oral, parenteral, or topical antibiotic can lead to the disease. Antibiotics given for surgical prophylaxis have also been associated with CDI ([Table 1](#)).

*C. difficile* is a gram-positive, anaerobic, spore-forming bacillus named in part because early investigators found it difficult to culture. Pseudomembranous colitis (PMC) was first reported in 1893 in a 22-year-old woman who had had gastric polyp resection. In 1943, treatment with penicillin was noted to lead to a lethal, resistant bacterial infection, which, in retrospect, was probably due to *C. difficile*. The first scientific reports of clindamycin-induced CDI were in the 1970s.

### **Risk factors**

Several studies have attempted to identify risk factors associated with CDI. Some of the factors implicated are shown in [Table 2](#). Although many of these factors have been identified in hospitalized patients with CDI, healthy outpatients and peripartum women, populations previously considered to be low-risk, may also acquire CDI.

### **Pathogenesis**

The pathogenesis of CDI is related to colonic mucosal injury and inflammation caused by two potent *C. difficile* exotoxins—toxin A, an enterotoxin, and toxin B, a cytotoxin. CDI can range in severity from mild diarrhea to PMC to toxic megacolon with septic shock and death.

### **Diagnosis**

CDI is diagnosed based on clinical history as well as identification of *C. difficile* toxin in the patient's stool. Symptoms may include diarrhea (often foul-smelling), fever, and abdominal pain. Leukocytosis is not uncommon and may be leukomoid in nature. Hypoalbuminemia may be present when diarrhea is severe. Diarrhea may be absent in some patients, particularly in postoperative patients who are receiving opioid analgesics.

Colonoscopy and computed tomography may be useful to establish the diagnosis of PMC or fulminant disease, but are not required in most patients. The cell cytotoxicity assay is considered the best single test for detection of *C. difficile* toxin, but is not routinely used due to technical issues and cost.

Both enzyme immunoassays (EIA) and enzyme-linked immunosorbent assay (ELISA) tests are commercially available and can detect toxins A and B. Sensitivities of the assays vary widely, however, ranging from 33 percent to 95 percent. Testing multiple stool samples from a patient suspected to have CDI can increase sensitivity. Stool culture is very sensitive in detecting *C. difficile*, but lacks specificity due to the high rate of asymptomatic carriage of the organism among hospitalized patients. Tests used to diagnose newer strains of *C. difficile* are being developed.

### **Hypervirulent strains leading to a new epidemic**

In 2002, investigators from Quebec, Canada, noted an increased number of colectomies performed for CDI. From 1991 to 2003, the incidence of CDI increased four-fold for the entire

region and ten-fold for patients older than 65 years of age.

*C. difficile* strains associated with more severe disease, increased mortality, and higher relapse rates have now been identified throughout the world. Differences between the new strain (known as either BI/NAP1 or 027) and the classic strain include the following:

- increased production of toxins A and B
- production of a unique binary toxin
- fluoroquinolone resistance

Increased use of newer fluoroquinolones and broad-spectrum cephalosporins has been identified as the most likely reason for the emergence of this new epidemic strain.

### **Treatment**

Oral metronidazole and vancomycin are the mainstays of therapy for CDI. Although controversy regarding the optimal treatment for CDI is ongoing, vancomycin is generally reserved for patients with more severe disease and those who have not responded to metronidazole. The efficacy of intravenous metronidazole has not been established. Relapses occur in approximately 25 percent of treated patients. Patients with fulminant disease and toxic megacolon may require a colectomy.

### **Prevention and control**

The Society for Healthcare Epidemiology of America has developed standard recommendations for infection control. These include isolating the patient in a single room with a bathroom; contact precautions; cleansing with bleach; and use of soap and water for hand washing. Alcohol-based hand cleansers do not kill *C. difficile* spores. Judicious use of antibiotics and stringent infection control practices are necessary to prevent CDI.

### **Conclusion**

The incidence of CDI is increasing worldwide. More recently discovered hypervirulent strains have raised concerns among physicians, patients, the media, and members of the legal field. A recent search on Google™ for Web pages containing all the words “*Clostridium difficile*” and “lawyers” revealed 74,900 matches. *Clostridium difficile* is rapidly becoming the other superbug—and one orthopaedic surgeons should be aware of.

When possible, the orthopaedic surgeon should avoid using antibiotics strongly associated with the development of CDI. Unexplainable postoperative leukocytosis, fever, and/or diarrhea should prompt a search for CDI and, in certain instances, empiric treatment with metronidazole. In addition, an explanation of the risk for CDI should be included in discussions with patients undergoing certain orthopaedic procedures, such as treatment of infections, that require antibiotic usage associated with CDI.

*Calin S. Moucha, MD, is a member of the AAOS Patient Safety Committee and assistant professor, division of total joint replacement & reconstruction, department of orthopedics, University of Medicine & Dentistry of New Jersey. He can be reached at [mouchacs@mac.com](mailto:mouchacs@mac.com)*

*Lisa L. Dever, MD, is associate professor, division of infectious diseases, department of medicine, University of Medicine & Dentistry of New Jersey. She can be reached at [deverll@umdnj.edu](mailto:deverll@umdnj.edu)*

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6300 North River Road Rosemont, Illinois 60018-4262 Phone 847.823.7186 Fax 847.823.8125

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