The Epidemiology of Surgical Wound Infection—Guidelines for Prevention

Dennis G. Maki, M.D.
Selective Antibiotic Therapy in Surgery

Part 5—The Epidemiology of Surgical Wound Infection—Guidelines for Prevention

Part 6—The Use of Prophylactic Antibiotics in Vascular Surgery

Used as directed, these two articles meet the criteria for one hour of Physicians Recognition Award Category 1 credit.

PRETEST: Take the quizzes on pages 19 and 33; insert answers in the pretest columns on the Tests form on page 31.
READ AND STUDY these articles.
POST-TEST: Take the quizzes again; insert answers in the post-test columns.

Part 5

The Epidemiology of Surgical Wound Infection—Guidelines for Prevention

Dennis G. Maki, M.D.

On the average, 3–12% of patients operated on develop a post-operative surgical wound infection. Specific infection rates within this range of averages depend on the type of operation and, given one type, on the hospital in which operations of this type are performed and/or the surgeon who performs them. Wound infection, defined least equivocally as purulent drainage, cellulitis, or a deep abscess, may be clinically inconsequential—a minute stitch abscess, for example. More often, wound infection is associated with local inflammation, fever, and a clinical picture of sepsis, and portends major morbidity, risk of death, prolonged hospitalization, and economic loss.

The present series on Selective Antibiotic Therapy in Surgery provides much information on the microbiology of surgical infections and on the use of antibiotics. It is aimed at bringing about more effective treatment of established infections and also improving the use of antibiotics for prevention (prophylaxis). But the greatest single advance in the history of surgery, asepsis in wound management to prevent infection, was conceived and successfully applied nearly a century before antibiotics were discovered. With rare exception, prevention of disease is far easier than treatment, and is usually more successful. The goals of this article are: (1) to discuss the epidemiology of surgical wound infection, including rational steps to take if an epidemic is suspected, and (2) to review critically specific practices of asepsis aimed at prevention.

Specific measures for prevention of infection of burn wounds are not covered in this review.
The Setting of Surgical Wound Infection. Reduced to basic principles, infection of a surgical wound can be thought of as a complex interaction between three elements (Table 1): microbial contamination of the wound, the intrinsic ability of the patient to ward off introduced microorganisms, and the condition of the wound—primarily reflecting surgical technique. If the patient is basically healthy and tissue damage during operation has been minimal, a surprisingly large inoculum of microorganisms—up to $10^6$ pathogenic bacteria/gm—can be tolerated without infection ensuing. If, on the other hand, the patient is debilitated and highly susceptible, or hematomas, seromas, foreign materials, or large amounts of necrotic tissue have been left in the wound, infection may become almost inevitable, even with very few organisms introduced. Measures intended to prevent wound infection are directed at all 3 of the elements noted but especially the first—i.e., minimizing the number of viable microorganisms entering the wound.

With the exception of traumatic wounds and clean operative wounds (e.g., splenectomy) in which a drain has been left, the vast majority of surgical wound infections derive from microorganisms of endogenous or extrinsic origin introduced into the wound during operation. Wounds from which organisms can be cultured before closure—especially $10^5$ organisms/gm or more—are up to 40 times more likely to become infected than culture-negative wounds. Most surgical wound infections are determined at the time the patient leaves the operating room. The thrust of prevention must therefore be directed at pre- and intraoperative events.

Infection by microorganisms introduced after the wound has been closed is probably rare, unless the wound has a drain. In clean surgery, the presence of a Penrose drain increases the infection rate two- and three-fold. Even in appendectomy, controlled studies from Great Britain suggest that a Penrose wound drain does not contribute to reducing the rate of wound infection and may, in fact, be counterproductive.

While hematogenous seeding of postoperative wounds can be produced experimentally, it is probably uncommon unless prosthetic materials are present, such as artificial heart valves or joints, or ventriculo-systemic shunts.

Sources of Wound Contaminants. Contrary to popular belief, inanimate objects capable of carrying infectious microorganisms (fomites), in the operating room or on the ward postoperatively, are rarely sources of wound pathogens. Even though blood in bypass machines during cardiovascular operations can frequently be shown to contain microorganisms, an association with subsequent infection has not been consistently demonstrable. Most wound contaminants come either from the patient's own skin or from deep organs such as the tracheobronchial tree, the bowel, or the genitourinary tract which have been transected during operation. Patients who are nasal carriers of *S. aureus*, especially if they are immunocompromised, appear to be at greater risk of developing staphylococcal wound infection, usually by their own strains. Patients with an active ongoing infection at the time of operation, such as a urinary tract infection or pneumonia, have a several-fold increased risk of autoinfection of their surgical wounds by the same organisms. Most often, the organisms are introduced during operation, but late hematogenous seeding may also occasionally occur.

Outbreaks of *S. aureus* and Group A streptococcal infections usually derive from a member of the operating team who is asymptomatic but who carries the epidemic strain in skin or anal tissues. But, with the exception of these occasional outbreaks, and possibly in clean-refined surgery, organisms shed by operating room personnel do not appear to be a very common cause of wound infection. Even though punctures of surgical gloves are frequent—occurring in up to 70% of operations—related infection has rarely been demonstrated.

The relative importance of contamination of the wound by ambient airborne microorganisms is a subject of considerable controversy. Counts of airborne microorganisms ranging from 2–10 per cubic ft, are commonly obtained in the operating room in the vicinity of the wound and can be shown to be directly proportional to the number of persons present and the amount of traffic in and out of the room. But, provided there is adequate ventilation (Hill-Burton recommendations: 25 or more room exchanges per hour); there is little evidence that airborne microorganisms contribute significantly to wound infection, despite claims to the contrary. The National Ultraviolet (UV) Study published in 1963 showed that, although the level of airborne contaminants was markedly reduced in UV-irradiated operating rooms, an effect of irradiation on overall infection rates was nonexistent (7.4% vs. 7.5% in non-irradiated rooms) and was only marginal for clean-refined operations (2.9% vs. 3.3%). Impressively low rates of postoperative...
TABLE 1
DETERMINANTS OF SURGICAL WOUND INFECTION
- Microbial Contamination of the Wound
- Host Resistance
- Condition of the Wound

ative wound infections in neurosurgery and orthopedics have been attributed to bacteriologic air control, using either UV irradiation or unidirectional (laminar) flow rooms in which air is recirculated through high efficiency filters ("clean rooms"). However, none of these studies has been adequately controlled. Furthermore, surgeons have reported large experiences with total hip arthroplasty done in operating rooms without unidirectional air flow with rates of wound infection comparable to those reported by proponents of clean rooms. Theoretically, airborne microorganisms are likely to pose the greatest hazard in clean-refined types of surgery (i.e., orthopedic, cardiovascular and neurosurgical operations), and for such procedures, extra measures such as clean rooms might prove beneficial. But air control systems are expensive, require considerable maintenance, and are logistically complicated. Well-controlled studies are needed to determine the benefit-to-cost ratio of these systems.

*Epidemic Wound Infections* (Table 2): Airborne transmission becomes important in the genesis of outbreaks of *S. aureus* or Group A beta-hemolytic streptococcal wound infection. Whereas up to 80% of operating room personnel can be shown to be nasal carriers of *S. aureus* at any one time, only those persons with pyogenic lesions such as a boil or paronychia, or those rare individuals who are "shredders" of staphylococci—often associated with folliculitis, dermatitis, or other chronic skin disorders—pose a hazard. "Common course" outbreaks (a cluster of cases due to one strain over a brief period of time) have been traced to carriers of *S. aureus* or Group A Streptococcus shown to be shedding massive numbers of the epidemic strain from nasopharynx, hair, or anus.

The rare instances where surgical wound infections

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Identified Sources*</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>Human carrier:</td>
</tr>
<tr>
<td><em>Group A Streptococcus</em></td>
<td>nares or hair (<em>S. aureus</em>)</td>
</tr>
<tr>
<td></td>
<td>pharynx (<em>Streptococcus</em>)</td>
</tr>
<tr>
<td></td>
<td>anus (both)</td>
</tr>
<tr>
<td>Gram-negative bacilli</td>
<td>Environmental Source:</td>
</tr>
<tr>
<td><em>Pseudomonas</em> species, <em>Klebsiella</em>, <em>Enterobacter</em> species, <em>Serratia</em>, <em>Acinetobacter</em></td>
<td>irrigating solutions</td>
</tr>
<tr>
<td></td>
<td>disinfectant</td>
</tr>
<tr>
<td></td>
<td>(aqueous benzalkonium or chlorhexadine)</td>
</tr>
<tr>
<td></td>
<td>medications</td>
</tr>
<tr>
<td></td>
<td>local anesthetics</td>
</tr>
<tr>
<td></td>
<td>infusion fluids</td>
</tr>
<tr>
<td></td>
<td>anesthesia equipment</td>
</tr>
<tr>
<td></td>
<td>water source</td>
</tr>
</tbody>
</table>

| *Klebsiella* | Human carrier (very rare) |
| *Pseudomonas aeruginosa*, *Paeclomyces lilacinus* | Contaminated intra-ocular lens |
| *Aspergillus fumigatus* | protheses |
| *Mycobacterium fortuitum (chelonei)* | Contaminated ventilation system |
| | Contaminated porcine heart valves |

* Reported in the literature.
were linked to inanimate sources of contamination in the operating room environment also primarily involved outbreaks. Epidemics of *P. aeruginosa* wound infection have been traced to contaminated disinfectants (aqueous benzalkonium in the United States and aqueous chlorhexidine in Great Britain—neither of which is reliably effective against gram-negative bacilli), to a contaminated shaving brush, and to contaminated local anesthetics. The ability of many Gram-negative bacilli besides *P. aeruginosa*, such as *Klebsiella, Enterobacter* sp., and *Serratia* to survive, and even to multiply, in many solutions such as irrigants, detergents, medications, intravenous fluids, and even tap water should make these sources highly suspect when many wound infections occur caused by the same gram-negative species.

In 1976, outbreaks of *Mycobacterium fortuitum* infections following sternotomy were reported in several states. Intrinsic contamination (i.e., present from the time of manufacture) of some commercial material used intraoperatively was strongly suspected. Also in 1976, multiple lots of one company's porcine xenograft heart valves were shown to be intrinsically contaminated by *M. fortuitum*; one of 8 patients who received a contaminated valve developed infective pericarditis. Since 1975 there have been two outbreaks of septic endophthalmitis following cataract surgery and implantation of intraocular lens prostheses that were traced to intrinsic contamination of one manufacturer's lenses.

Several outbreaks of postoperative infection by *Aspergillus fumigatus* following cardiovascular surgery, involving serious deep infections and in several cases, *Aspergillus* endocarditis, have been ascribed to contaminated ventilation systems in the operating room.

**Host and Therapeutic Factors.** Several large studies, each comprising 15,000 to 21,000 operated patients have identified risk factors predisposing to surgical wound infection (Table 3). Many of these such as the nutritional status of the patient, other infections, corticosteroid or immunosuppressive therapy, the duration of surgery, and the type of surgical knife used, can, in theory, be favorably influenced for elective surgery. The major element not controllable by good aseptic practice and optimal medical preparation of the patient is the technical skill of the surgeon: expeditious but gentle handling of tissues, striving for complete eradication of dead space, thorough debridement of necrotic tissue and contaminating foreign materials, and complete hemostasis—without leaving excessive devitalized tissue in the wound.

**Steps to Take if Epidemic is Suspected**

If an epidemic is suspected, i.e., if there seems to be a significant increase in the wound infection rate above the baseline, the epidemiologic approach should be methodical and thorough, aimed at con-

| TABLE 3 |
| FACTORS INCREASING THE RISK OF SURGICAL WOUND INFECTION* |

<table>
<thead>
<tr>
<th>Host Factors:</th>
<th>Surgical Factors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;60 years</td>
<td>Type of wound:</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>contaminated</td>
</tr>
<tr>
<td>Active infection</td>
<td>dirty</td>
</tr>
<tr>
<td>Obesity</td>
<td>Preoperative hospitalization:</td>
</tr>
<tr>
<td>Steroid therapy</td>
<td>&gt;2 weeks</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1-2 weeks</td>
</tr>
<tr>
<td></td>
<td>Night-time or emergency operation</td>
</tr>
<tr>
<td></td>
<td>Duration of operation</td>
</tr>
<tr>
<td></td>
<td>Shaving operative site</td>
</tr>
<tr>
<td></td>
<td>Electrosurgical knife</td>
</tr>
<tr>
<td></td>
<td>Penrose wound drain</td>
</tr>
</tbody>
</table>

* Excerpted from 2 large multifactorial studies, each encompassing over 15,000 operated patients

firming the existence of an epidemic and defining the reservoirs (or sources) and modes of spread of the epidemic pathogen (Table 4). Control measures are then most likely to be effective.

*Determine Clinical Relevance.* Most outbreaks of surgical wound infection are first suspected on the basis of culture results. It must first be determined that the organisms isolated reflect true infection and not laboratory contamination. If an epidemic is suspected primarily on clinical grounds and especially if cultures of purulent wound discharge are negative or nondiagnostic, it might be advisable to use special media to test for atypical mycobacteria or fastidious bacteria, or even for the presence of toxic materials in solutions or prosthetic materials used surgically.

*Subtyping of Isolates.* One of the most important steps to take if an outbreak is suspected is immediately to retrieve all remaining isolates of the putative epidemic pathogen(s) from the laboratory. It can be very difficult to determine whether an outbreak, even one caused by a single species, is due to a common source without subtyping the isolates: for *S. aureus*, phage typing; Group A streptococci, *P. aeruginosa*, Klebsiella and *Serratia marcescens*, immunotyping; *Proteus mirabilis* and *Serratia*, bacteriocin typing. All relevant isolates, both from cases and from environmental culture surveys, should be saved and sent to a reference laboratory, usually the State Health Department Laboratory or the Center for Disease Control, to be subtyped.

*Determining if Truly an Epidemic.* Many suspected outbreaks are simply fluctuations in the endemic (baseline) rate of wound infection and not actually epidemics. Careful comparison with baseline rates, available if a hospital has an ongoing surveillance program (see below), makes it possible to determine promptly if the increase represents a genuine epidemic and calls, therefore, for an immediate epidemiologic investigation. If surveillance data are unavailable, it may be necessary to do a retrospective chart survey to determine the baseline rate of infection.

*Epidemiologic Investigations.* When an epidemic is suspected, there is often a strong temptation immediately to begin extensive culturing of the operating room environment and of medical personnel. While preliminary culture surveys based on the probable epidemiology of the epidemic organisms (Table 2) are often reasonable, it is equally important to compare the records of epidemic cases and a carefully selected control group (such as uninfected patients who underwent the same operative procedure). Information collected on each case might include demographic parameters, underlying diseases, duration of hospitalization, type of operation and specific operating room used, duration of surgery, operating room personnel—all nurses, surgeons and anesthesiologists who were present—and all drugs, irrigating and intravenous solutions, anesthesia machines and other paraoperative equipment used.

Exposure of all (or most) epidemic cases to one (or more) factor(s) (e.g., the same operating room, a single surgeon or anesthesiologist, one irrigating solution), combined with no (or little) exposure of control cases to the factor(s) constitutes strong presumptive evidence implicating that (those) factor(s) in the causation of the outbreak.

*Selective Culture Studies.* Armed with this information, one may undertake more selective microbiologic studies of the inanimate environment or of medical personnel. In general, culturing of personnel rarely is of value, hence rarely indicated unless *S. aureus* or Group A streptococcal infections have occurred in epidemic numbers. (With these organisms, it is very important also to survey personnel regarding a history of recent supplicative infection.) Empiric widespread environmental culturing is expensive and often fruitless, and even if the epidemic organism is recovered, the findings may be difficult to interpret. But when environmental sampling is directed and complemented by the results of clinical-epidemiologic investigations, the source of the outbreak can often be identified with certainty.

*Control Measures.* Preliminary control measures, based on the probable epidemiology of the epidemic pathogen, are usually implemented before the in-
vestigation is completed. More definitive control measures can be instituted when the probable source of the outbreak has been identified. Continued surveillance will confirm complete control of the epidemic.

If the epidemiologic data and microbiologic studies suggest intrinsic contamination (i.e., during manufacture) of a commercial product, the local and state health authorities, the FDA, and the Center for Disease Control should be informed immediately. Remaining products should be retained for evaluation by these agencies.

Prevention of Surgical Wound Infection

Measures to prevent postoperative wound infection should be directed at eradicating known reservoirs of wound pathogens (e.g., skin disinfection), preventing microorganisms from entering the wound (e.g., gloves, gown, and wound drapes), or eradicating organisms that do get in (e.g., irrigation, prophylactic antibiotics). The following guidelines are epidemiologically consistent and in many instances, are supported by controlled clinical trials.

1. For elective surgery, preoperative hospitalization should be kept as brief as possible. Colonization by nosocomial pathogens (S. aureus in the skin; multiply-resistant gram-negative bacilli in the bowel) increases rapidly with hospitalization exceeding 3–5 days.

2. The patient should be optimally prepared nutritionally and metabolically. Anemia should be treated and the patient's cardiorespiratory status and diabetes stabilized. If feasible, the weight of morbidly obese patients should be reduced before elective surgery. Corticosteroids and immunosuppressive drugs should be tapered and if possible omitted before operation.

3. Ongoing infections such as urinary tract infections and pneumonia should be completely eradicated if possible prior to surgery. This is especially important in patients scheduled to undergo genitourinary surgery; the risk of sepsis following genitourinary manipulation in a bacteruric patient (≥10⁶ organisms/ml of urine) is prohibitively high.

   It is important to recognize that postoperative wound infections comprise less than one-half of all nosocomial infections in surgical patients. Bacterial infections of the catheterized urinary tract, pneumonias deriving from inadequate asepsis during tracheal suctioning or contaminated ventilators, or other inhalation therapy equipment, and septicemias from venous catheters or contaminated infusate account for approximately 70% of all nosocomial infections. These infections are largely preventable by the implementation of simple but highly effective control measure (Table 5).

4. The most important aspects of the surgical scrub are its duration and vigor. (Beyond 5 minutes, however, little additional bacterial removal occurs.) Hexachlorophene and povidone-iodine-containing handwashing agents have been shown to be equally effective. Hexachlorophene has more prolonged antistaphylococcal effect. Isopropyl alcohol, 70%, with or without 0.5% cetly alcohol, is also used in some centers. There are no clinical data to indicate a clearcut superiority of any one agent over all others.

5. For dermgering of the operative site, iodine-containing agents such as 1%–2% tincture of iodine or an iodophor are the most reliable cutaneous antiseptics although, here again, the choice of the agent may not be as important as the vigor of the mechanical cleansing (for at least 2–4 minutes) which must precede application of the dergnering agent. Hexachlorophene and povidone-iodine have been shown to be equally effective in controlled trials. Isopropyl alcohol, 70%, and 1:100 cetlypyridium chloride are also acceptable. An alcoholic solution of chlorhexidine is used widely in Great Britain and Europe, and was recently approved by the FDA for handwashing in this country; however, it has not yet been approved for disinfection of operative wound sites. Aqueous benzalkonium, which is not reliably bactericidal against many gram-negative bacilli, should not be used for preparation of the operative site—outbreaks have stemmed from contamination of this agent during use.

In comparison with the use of a chemical depilatory or not shaving, shaving the operative site has been shown to be associated with a substantially increased incidence of infection. If shaving is desired, it is better done the morning of surgery or, ideally, in the operating room. Several studies have shown that showering with a hexachlorophene-containing soap the night before surgery reduces operative wound infections in clean surgery by 50–75%.

6. A clean scrub suit and head covering—a hood for persons with full beards or long hair—a high filtration surgical mask (synthetic fabric or glass fiber is considerably less permeable than paper
or cloth), and ideally, disposable foot covers should be worn by all individuals entering the operating room.

There is evidence that sterile gowns made of materials that are less permeable than cotton, such as paper or plastic, are associated with less intra-operative contamination of the wound by skin flora of the operating team. Such materials are being used increasingly and are probably of greatest importance in clean-refined surgery. Adhesive plastic skin drapes have not been shown to reduce the rate of wound infection. However, several studies have shown that shielding the wound edges with a disposable plastic wound-(or barrier-)drape held by a flexible ring inserted into the body cavity, confers some protection.

7. Levels of airborne contaminants can be reduced by strictly limiting traffic in and out of the operating suite. An acceptable ventilation system for operating rooms requires at least 25 room exchanges per hour and air filters which are periodically monitored; room air pressure should be positive with respect to the corridor.

Until well controlled studies establish conclusively the efficacy and cost-benefit of forced unidirectional air-flow and UV-irradiation systems in the operating room, their routine use should not be made mandatory. Their major value, if they are to be used, is probably in clean-refined operations.

8. When possible, operations on infected patients should be done last in the day in an operating room designated for contaminated cases. Contaminated cases such as removal of ruptured appendix are associated with a high rate of wound infection. It has been demonstrated in several investigations that substantially fewer wound infections follow certain delayed primary closure or wound irrigation with antibiotic solutions before primary closure than follow primary closure using Penrose wound drains. The entire subject of the efficacy of prophylactic wound drains deserves critical reevaluation. Cruse has presented data showing the use of Penrose drains in clean and clean-contaminated procedures was deleterious and increased the infection rate; however, closed vacuum (suction) drains markedly reduced the rate of wound infection in cholecystectomy (0.8% vs. 2.2% without any drain) and in spinal fusion (0.9% vs. 4.8% without any drain).

9. Well-controlled studies in the past decade have

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**TABLE 3**

<table>
<thead>
<tr>
<th>Infection</th>
<th>Specific Proved Control Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter-related</td>
<td>1. Asepsis at catheter insertion.</td>
</tr>
<tr>
<td>urinary tract</td>
<td>2. Closed sterile drainage.</td>
</tr>
<tr>
<td>infection</td>
<td>3. Dispersal of catheterized patients on the ward.</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>1. Aseptic technique (gloves) during tracheal suctioning.</td>
</tr>
<tr>
<td></td>
<td>2. Assure sterility of ventilators, anesthesia equipment and other apparatus by culture surveillance; use of disposable components when possible.</td>
</tr>
<tr>
<td></td>
<td>3. Judicious use of antibiotics; use of gram-stained smears of sputum to decide whether or not to treat.</td>
</tr>
<tr>
<td>Infusion-related</td>
<td>1. Limit use of plastic catheters.</td>
</tr>
<tr>
<td>septicemia</td>
<td>2. Change peripheral IV catheters every 48-72 hours.</td>
</tr>
<tr>
<td></td>
<td>3. Topical antimicrobial ointment on IV catheter sites.</td>
</tr>
<tr>
<td></td>
<td>4. Change IV delivery systems (tubing and bottles or bags) every 48 hours.</td>
</tr>
<tr>
<td></td>
<td>5. Disposable transducer components for arterial pressure monitoring.</td>
</tr>
</tbody>
</table>
shown conclusively that a brief course of systemic antimicrobics selected for efficacy against anticipated microbial contaminants and begun before operation can augment the effect of the above practices of asepsis and superior surgical technique and further reduce the rate of wound infection, particularly in operations associated with a high risk of intra-operative contamination and subsequent infection. Nevertheless, except in certain high risk orthopedic procedures, the value of systemic prophylaxis in clean-refined surgical procedures such as cardiovascular operations or craniotomy remains unproved. In neurosurgical operations, antimicrobial prophylaxis may be deleterious. A large outbreak of infections by multi-resistant Klebsiella, including meningitis, wound infections, pneumonia and urinary tract infections was linked to heavy use of prophylactic antibiotics in neurosurgical patients and could not be terminated until prophylaxis was completely discontinued.

Recently, preoperative suppression of bowel flora with oral antimicrobial combination such as erythromycin and neomycin has been shown to reduce the rate of wound infections in intestinal operations. Irrigation of the wound or the peritoneal cavity before closure with either topical antimicrobics or an antiseptic (such as an iodophor solution) also appears to have benefit. (Details of administration of antimicrobial prophylaxis and drug regimens are described in other articles of this series.)

10. The single protective measure a hospital has at its disposal to prevent secondary spread of nosocomial pathogens to noninfected patients and medical personnel is to isolate infected patients, i.e., to take precautions to prevent transmission based on the known epidemiology of the pathogen. Patients must remain in isolation until they are no longer infective and, if infected at the time of surgery, they should be segregated from uninfected patients in the recovery room (or, preferably, be placed in a separate recovery room).

Most infected surgical wounds require wound and skin precautions; strict isolation is recommended for large staphylococcal or streptococcal infections where airborne dissemination of these organisms becomes a hazard. Protective isolation may be elected for highly susceptible patients such as individuals who are severely granulocytopenic or who have extensive burns. It is well established that physicians—much more frequently than nurses and other medical personnel—fail to observe isolation precautions. If physicians do not comply with isolation procedures, the entire system aimed at preventing secondary transmission breaks down.

Infected patients comprise an important reservoir for spread of nosocomial pathogens to uninfected patients. Organisms carried on the hands of medical personnel is probably the major mode of transmission of infection to the catheterized bladder, the intubated respiratory tract, and open surgical wounds. In an uncontrolled study at the Montreal General Hospital, a 7-fold drop in surgical nosocomial infections coincided with establishment of an isolated ward segregated from the rest of the hospital. Besides compliance with isolation policy in general, handwashing before and after every manual contact with a surgical patient, especially an infected one, must be mandatory. We have found that 10%–12% of hospital personnel randomly cultured carry S. aureus and up to 63%, enteric gram-negative bacilli or Pseudomonas on their hands. Handwashing reduces the numbers of these organisms and decreases the risk of colonizing susceptible patients.

11. The process whereby infections are identified and tabulated is known as surveillance. Surveillance of all nosocomial infections is required by the Joint Commission on Accreditation of Hospitals and has potential benefits: (1) by defining the profile of infection, it can identify specific problems unique for each institution that may warrant corrective action; (2) it facilitates earlier recognition of outbreaks; and (3) it comprises a means of assessing the efficacy of general and specific measures in controlling infection. Furthermore, disseminating the findings of surveillance—on surgical wound infection rates, for example—increases awareness on the part of surgeons as well as other medical personnel, and improves compliance with infection control practices. Cruse attributed a 50% drop in the rate of operative wound infections in his hospital directly to the feedback effects of surveillance. It should be kept in mind that 20 to 40% of postoperative wound infections do not become manifest until after the patient has been discharged from the hospital. It is probably unnecessary to attempt to identify all of these cases in carrying out surveillance unless an outbreak.
is suspected. Then, especially with *S. aureus* infections, these cases should be identified.

12. In general, there is no need, nor is it advisable, to carry out extensive routine culturing of the operating room environment, especially of floors and other surfaces. Except in a few epidemics, there has been little correlation between environmental contamination and rates of wound infection. Anaesthesia equipment is an exception and should be regularly monitored bacteriologically. Similarly, it is not recommended that operating room personnel be routinely cultured for carriage of *S. aureus* or Group A *Streptococcus*. Neither is it indicated, in the absence of excessive staphylococcal infections, that nasal carriers of *S. aureus* be restricted from the operating room or that attempts be made to eradicate carriage using antibiotics. However, individuals with pyogenic skin infections, chronically draining lesions, or acute pharyngitis (until streptococcal carriage has been ruled out) should be excluded from the operating room. Only if surveillance data show an upsurge in infection rates, especially by one or at most several species, is extensive culturing of the environment or personnel indicated (see Steps to Take if an Epidemic is Suspected). Any person carrying Group A *Streptococcus* should be treated: the conventional regimens for pharyngitis; oral vancomycin for oral carriage refractory to penicillin, if the carrier is the probable source of epidemic infections. Persistent *S. aureus* carriers shown to be a source of wound infections should be restricted from the operating room until an attempt can be made to eradicate carriage; hexachlorophene showers and, for nasal carriers, repeated applications of bacitracin ointment intranasally; for rectal carriers, a course of oral vancomycin. Systemic antibiotics such as cloxacinil are not usually effective in terminating the persistent *S. aureus* carrier state, which is refractory to all forms of therapy. If clinically significant carriage cannot be eradicated, it may be safe to permit a surgeon to resume operating if extra precautions are taken, such as periodic hexachlorophene showers and use of that agent for the scrub, periodic application of intranasal antibiotics, use of extra heavy gowns and a hood, double masking, and double gloving. But, it is imperative to culture that surgeon’s operating room environment during surgery (settling plates placed near the wound) and to maintain close surveillance for infections, to confirm the efficacy of these added measures.

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**Quiz—Part 5**

### Selective Antibiotic Therapy in Surgery

#### The Epidemiology of Surgical Wound Infections

1. Most postoperative surgical wound infections derive from organisms introduced into the wound:
   a. hematogenously.
   b. in the operating room.
   c. from the environment of the ward, after surgery.
   - **Correct answer:** a. hematogenously.

2. Epidemics of staphylococcal or streptococcal wound infection usually derive from:
   a. dirty floors in the operating room.
   b. inadequate ventilation in the operating room.
   c. a human carrier, usually nasopharyngeal or rectal, on the operating team.
   d. a human carrier on the ward.
   - **Correct answer:** a. dirty floors in the operating room.

3. A cluster of wound infections caused by *Pseudomonas aeruginosa* should prompt:
   a. extensive culturing of all personnel in the operating room.
   b. empiric prophylactic gentamicin therapy for all future operations.
   c. critical evaluation and selective culturing of the operating room environment.
   d. a change in the ward’s diet.
   - **Correct answer:** c. critical evaluation and selective culturing of the operating room environment.

4. All of the following are important in prevention of IV catheter-related septicemia except:
   a. limited use of plastic catheters.
   b. changing IV catheter sites every 48–72 hours.
   c. prophylactic systemic antibiotics.
   d. application of topical antimicrobial ointment to catheterization sites.
   - **Correct answer:** d. application of topical antimicrobial ointment to catheterization sites.

5. Which of the following measures is probably of greatest importance in reducing the risk of postoperative surgical wound infections?
   a. using povidone-iodine for preparing the operative site.
   b. handwashing with soap and water.
   c. wearing a resin-coated mask.
   d. wearing disposable gloves.
   - **Correct answer:** a. using povidone-iodine for preparing the operative site.
Infection---Guidelines for Prevention

b. eradicating all active infections preoperatively.
c. using adhesive plastic skin drapes.
d. doing the operation in a special "clean" room, one with forced filtration unidirectional laminar air flow.

6. In regard to Staphylococcus aureus carriage by medical personnel, which is most true:
   a. all operating room personnel should be cultured regularly to detect carriage of S. aureus;
   b. in general, all persons shown to be carrying S. aureus must be restricted from the operating room;
   c. all nasal carriers of S. aureus should receive a course of dicloxacillin;
   d. only persons with active skin infections or draining lesions, or carriers linked to wound infections, need be restricted from the operating room;

7. Which is probably the least important for preventing infection of contaminated wounds (such as removal of a ruptured appendix):
   a. delayed primary closure;
   b. irrigating the wound with a topical antimicrobial solution;
   c. using a Penrose drain;
   d. use of systemic antimicrobial prophylaxis.

8. In regard to isolating infected patients, which is most true:
   a. with availability of effective antibiotics, isolation is archaic and probably only of historical relevance;
   b. compliance with isolation procedures is very important for nurses who have close and repeated contact with the patient, but is un-
   necessary for physicians who have far fewer contacts;
   c. isolation of infected patients is the only practical measure known to prevent spread of infection to uninfected patients and hospital personnel.

DIRECTIONS:
for Questions 9 and 10, which of the 4 answers listed following each question is correct:
   a. only 1, 2, and 3 are correct;
   b. only 1 and 3 are correct;
   c. only 2 and 4 are correct;
   d. only 4 is correct;
   e. all are correct.

9. Which of the following most accurately states the role of "clean" rooms for surgery which employ high volume unidirectional air flow and high efficiency bacterial filters or ultraviolet irradiation:
   1. are probably of marginal value in most types of surgery;
   2. are effective in reducing the concentration of airborne microorganisms in the operating room;
   3. may be of greatest value for refined-clean surgery such as total hip arthroplasty;
   4. have been conclusively shown to reduce the rate of wound infection.

10. If an epidemic of surgical wound infections is suspected, which of the following should be done:
   1. determine the clinical significance of positive culture results;
   2. establish the existence of an outbreak by comparison with baseline infection rates;
   3. examine epidemic and uninfected cases for common exposures;
   4. submit isolates of the epidemic pathogen to a reference laboratory for subtyping.

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Epidemic Wound Infection


Prevention of Other Nosocomial Infections