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INTRODUCTION

In developed countries, anywhere from 5 to 10% of patients admitted to acute care hospitals acquire an infection which was not present or incubating on admission. The attack rate for developing countries can exceed 25%.

Because of the illnesses, deaths, and added costs related to nosocomial infections, the field of infection control has grown in importance over the last 30 years. Although estimates vary regarding the proportion of nosocomial infections which are preventable, it may be as high as 20% in developed countries and as high as 40% or more in developing countries. Furthermore, in developed countries 5 to 10% of infections acquired in the hospital occur as part of an epidemic or cluster. The figure is larger for developing countries.

The emphasis, however, is that all nosocomial infections, clusters and outbreaks are potentially preventable, and that now, more than ever, opportunities are excellent for risk reduction interventions. At the center if this are the basic principles of good infection control.

Although our discipline, like others, is in constant evolution, this booklet contains the most up to date principles and interventions designed to reduce the rate of nosocomial infections. The chapters herein have been written by international authorities in infection control and hospital epidemiology. They are intended to improve quality of care, minimize risk, save lives, and reduce costs. As our intention is to publish an up to date guide every 2 years, we welcome your comments and thoughts as we proceed with future editions.

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We wish to thank all our colleagues and friends for their contributions.
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CHAPTER 1

IMPORTANCE OF INFECTION CONTROL

Richard P. Wenzel, MD, MSc

Health is a high priority for any society, and infections remain a leading cause of disease globally. Those infections which occur among patients in hospitals and become manifest only after 48 hours of stay are called “nosocomial.” Some prefer the term “healthcare associated” infections. Such nosocomial or hospital acquired infections lead to significant morbidity, mortality and economic burden beyond those expected from the patients’ underlying diseases alone.

In the Western world the nosocomial infection rate is 5–10% or 5–10 infections per 100 patient admissions. In the developing world the rate can be 25% or more. Some hospitals prefer to measure the number of infected people per 100 admissions. Others prefer to add up the total hospital stay in days for all patients over a period of time and report the number of infections per 1000 patient days.

The distribution of infections by anatomic site in acute care hospitals in the developed world is shown below:

- Urinary Tract 35%
- Post-operative Wound 25%
- Bloodstream 10%
- Pneumonias 10%
- Other 20%

In developing countries the distribution may be different, with fewer bloodstream infections since fewer devices are used, more gastrointestinal infections, and a higher proportion of post-operative wound infections.
Mortality
Bloodstream and pulmonary infections carry the highest mortality rates, approximately 25–30% in developed countries. It has been shown that nosocomial infections are equivalent to the 8th leading cause of death in the U.S., even if one examines only nosocomial bloodstream infections. There should be low mortality rates or no deaths following urinary tract or postoperative wound infections. These rates might be expected to be higher for developing nations because of limited resources to manage them, including limited critical care availability.

Importantly, when a patient with a nosocomial infection dies prematurely, there are also years of life lost (YLL) directly due to the infection. For example, if a 40 year old woman whose life expectancy is 60 years dies from a nosocomial infection, her death contributes 20 years of life lost. If 100 similar patients died over a period of one year, then there would be 20 years x 100 patients or 2000 YLL lost due to nosocomial infections that year. In the U.S. it has been estimated that nosocomial bloodstream infections each year lead to 260,000 YLL.

Morbidity
Few studies have examined morbidity directly related to nosocomial infections. However, one thinks of pain, stress, depression or “suffering” when one considers morbidity. With psychological instruments one could systematically measure the days of each, even consider giving a score for each parameter such as scoring pain on a 1–5 scale.

One could also imagine measuring the quality of life, days before return to school or job, or number of doses of pain medication as measures of morbidity. However, little has been done in this area.

Costs
Almost all studies of the economic burden of nosocomial infections have examined only the direct costs of additional hospital stay. For example, in developed countries, patients with nosocomial bloodstream infections stay an extra 10–14 days, presumably for additional therapy. From a hospital administrator’s perspective, there are fixed and variable costs.
The fixed costs include those for heat, air conditioning, lighting, etc. The variable costs are those that increase for each additional day of hospitalization. For example, additional nursing care may be required as the census increases. If the incremental cost of stay—the variable cost above the expected fixed cost of stay—averages $500/day, the additional economic burden is $5,000 to $7,000 for each infection.

Patients with post operative wound infections stay in the hospital twice as long as matched controls without a wound infection. This leads to considerably additional costs. It is generally thought that nosocomial urinary tract infections add 1–3 additional days in the hospital, and nosocomial pneumonias add approximately 9 days to the expected stay compared to matched controls without a nosocomial pneumonia.

There are also “indirect” costs, such as the costs of rehabilitation after hospitalization, the costs of outpatient medications, and costs of followup appointments. Depending on a country’s healthcare reimbursement system, a great deal of the indirect costs might be borne by the patients themselves.

*Table 1.1* below summarizes the ways to measure the impact of hospital-acquired infections:

<table>
<thead>
<tr>
<th>Impact of Hospital Acquired Infections:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mortality</strong> — Number of Deaths per 100 infected Years of Life Lost (YLL) from nosocomial infections per 100 admissions Number of extra hospital days from nosocomial infections</td>
</tr>
<tr>
<td><strong>Morbidity</strong> — Pain and suffering days resulting from an infection</td>
</tr>
<tr>
<td><strong>Costs</strong> — Direct costs of extra hospital days per 100 admissions</td>
</tr>
</tbody>
</table>

### A Quality Issue

An important point is that many view infection control as a key issue in quality of care. In fact, in the developed countries it is the first “success” story in the use of intervention measures to improve patient care in hospitals. Thus, those who espouse quality care should begin with infection control, in part because the outcomes are so serious without control and in part because successful interventions have been developed.
Individual Commitment
In the developed world, it is likely that at least 20% of all hospital acquired infections can be prevented. More could be prevented in the developing world. Most of the interventions are simple and behavioral and relate to the individual healthcare worker: careful hand washing, appropriate isolation and use of gloves where appropriate, and proper use of devices such as the insertion and care of foley bladder catheters. Thus, the link between individual commitment to quality and improved outcomes can be demonstrated for infection control.

System Issues
There are also system issues that need to be addressed for infection control. For example, soap and water have to be available at all times for healthcare workers and placed in convenient locations for easy access. There needs to be a system by which surgical patients receive preoperative antibiotics in the 1–2 hours before the incision, not greater than two hours and never delayed to one after the incision. A system has to be in place to isolate some patients with communicable disease. Very recently the importance of team-based prevention of nosocomial infections has been shown to be valuable when the team utilized evidence-based interventions such as proper hand hygiene, barrier precautions and subclavian site as the preferred one for a central line. The implication of the team approach is that any member of the team of healthcare professionals—physicians or nurses—can ask the physician to restart a bedside procedures if there is a break in sterile technique.

A Societal Issue
Lastly, I would return to the beginning to emphasize that a healthier community can contribute more to its citizens. With fewer infections and their complications, a well society is better able to work, to educate, to contribute to the arts, and to provide a myriad of services that are unavailable to a more ill society. Infection control is a key ingredient to and an essential component of a better functioning and happier society. In the end, proper infection control can make a significant contribution to improving the human condition.
References

Book

Manuscripts
A necessary feature for a successful program in infection control is dedicated leadership that creates a culture for excellence. Without leaders, there are no followers among the management team. Some important attributes of the management team that support the culture for excellence include a knowledge of microbiology, excellent communication skills, and an understanding of the key discipline of epidemiology. Some ability to gather data and perform basic analyses is extremely useful.

Ideally, a trained infectious diseases specialist with some training in infection control would lead the hospital’s program. Such individuals have complementary clinical, microbiological, and epidemiological skills useful in providing the vision and oversight of a high performance team. Since energy and commitment are so critical to success, a hospital may begin with candidates that have these two attributes and select someone with most but not all of the other skills listed above.

Leadership and management are distinct but overlapping skills, useful for any program. The leader is charged with creating the vision, the day-to-day culture, the energy, the ideals and the ethics of a program. The manager is charged with carrying out the vision, making the components of a complex organization function well while meeting all financial budget restrictions. Some leaders have management skills, but the key role of the hospital epidemiologist is to lead!

The team members supporting the hospital epidemiologist may in fact be leaders in their respective fields of nursing epidemiology, microbiology, pharmacy, employee health, biostatistics and epidemiology, and computer support. However, each has a responsibility as a manager in their area of expertise and oversight. They are charged with making the system work. In small hospitals and those with limited resources, a single individual may be charged with more than one of these tasks.
Table 2.1  The Infection Control Team

<table>
<thead>
<tr>
<th>Role</th>
<th>Team Member</th>
<th>Ideal Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leader</td>
<td>Hospital Epidemiologist</td>
<td>Infectious Diseases, microbiology, and infection control communication</td>
</tr>
<tr>
<td>Manager(s)</td>
<td>Microbiologist</td>
<td>Microbiology, interpretation of antibiotic resistance</td>
</tr>
<tr>
<td></td>
<td>Nurse Epidemiologist (infection control practitioner)</td>
<td>Nursing &amp; Epidemiology including surveillance skills, communication</td>
</tr>
<tr>
<td></td>
<td>Pharmacist</td>
<td>Pharmacokinetics and Pharmacodynamics of drugs, especially antibiotics. Education</td>
</tr>
<tr>
<td></td>
<td>Employee Health Director</td>
<td>Infection Control, Vaccine Use</td>
</tr>
<tr>
<td></td>
<td>Biostatistician</td>
<td>Inference statistics and modeling skills</td>
</tr>
<tr>
<td></td>
<td>Computer Technician</td>
<td>Design data base and search features</td>
</tr>
</tbody>
</table>

Functions

The starting point of a good program for infection control is basic surveillance by which rates of infection can be calculated after valid case finding. Most experts prefer prospective surveillance rather than retrospective surveys because of the greater accuracy of the former. Although hospital-wide surveillance is the ideal, with limited resources a program may wish to focus only on nosocomial bloodstream infections because of the high associated mortality and the relative ease with which to identify nonpathogens from pathogens in blood cultures. One could begin surveillance in the microbiology laboratory, and after ruling out all of the contaminants, the physician or nurse epidemiologist could gather clinical data from the infected patients’ charts to be used later in epidemiological analyses.

Alternatively, with limited resources a decision could be made to survey only post-operative (incisional) wound infections because of their high frequency, significant morbidity, and high costs. One could survey all surgical patients only for a fixed period of time after the operation, seeking evidence of infection (pus at the incision site).
The number of infections or infected patients is included in the numerator, and one has various options for the denominator. Thus, various rates can be calculated:

- The number of infections/100 admissions
- The number of infected patients/100 admissions
- The number of infections/1000 patient-days.

The critical point is that for calculation of a rate, the denominator must include the total number of patients at risk. If one is surveying only for post operative wound infections, each month the population at risk, the denominator, would be all patients undergoing operations during that time.

Some of the key functions of an effective infection control program are shown in the Table 2.2 below:

<table>
<thead>
<tr>
<th>Table 2.2: Functions of an Infection Control Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Surveillance</td>
</tr>
<tr>
<td>• Education and feedback to clinicians using surveillance data and antibiogram data by anatomic site</td>
</tr>
<tr>
<td>• Management of proper isolation techniques</td>
</tr>
<tr>
<td>• Provision of either hand washing materials or alcohol-based (waterless) hand cleansing materials</td>
</tr>
<tr>
<td>• Development of standards for management of proper insertion and maintenance of medical devices</td>
</tr>
<tr>
<td>• Monthly meeting of the infection control team</td>
</tr>
</tbody>
</table>

Most of the roles indicated in Table 2.2 rely on excellent education of various members of the healthcare team. Thus, communication skills, and teaching skills specifically, greatly enhance the value of the infection control team.

A key function of the organization that is necessary for its optimal functioning is the monthly infection control meeting. The goals of the monthly meeting are few in number but very important:

- Brief review of surveillance data
- Summary of any epidemic workup
- Review of antibiogram data, listing resistance rates for important antibiotics such as methicillin-resistant *S. aureus*, vancomycin-resistant *E. faecium*, and third generation cephalosporin antibiotic-resistant gram negative rods.
• Review and passage of one new policy or procedure each month. This may sound simple and easy to perform, but it is the most difficult goal for any team, requiring homework, background political work and bold decision making.

**Summary**
The effective infection control program needs a designated leader supported by a team with special skills. Although ideal leadership and management skills are listed above, a hospital with limited resources will need to accommodate the program with interested and dedicated personnel possessing most of the desired skills. The role of surveillance is to provide local data, especially important in education. A monthly infection control meeting for the continued review and development of policies is especially important.

**References**

**Book**

**Manuscripts**
CHAPTER 3

ROLE OF THE MICROBIOLOGY LABORATORY IN INFECTION CONTROL

Mohamed Benbachir, PhD

Key Issue
The microbiology laboratory plays an important role in the surveillance, treatment options, control and prevention of nosocomial infections. The microbiologist is a permanent member of the infection control committee (ICC).

Known Facts
The first task of the microbiology laboratory is accurately, consistently and rapidly to identify the responsible agents to species level and identify their antimicrobial resistance patterns. This has been made easier because of the important progress made in the fields of instruments, reagents and techniques. The quality of the microbiology results is directly linked to the quality of the specimens. Specimens that are not collected and transported properly may lead to misleading results. Since the ICC programmes rely on microbiological results, quality assurance is an important issue.

The microbiology laboratory is a surveillance and early warning system. Laboratory based surveillance is an essential part of the hospital wide surveillance in concert with surveillance based on patient units (e.g., ICU, haematology) and on specific sites of infection (e.g., blood, surgical site). Routine surveillance of nosocomial infections is based both on daily review and on periodic reports of microbiology records. The microbiology laboratory is also a sentinel system. Prompt notification to clinical wards and to ICC initiate epidemiological investigation which may lead to preventive measures to halt the spread of causative microorganisms.

The microbiology laboratory is also involved in the detection and investigation of outbreaks. Comparison (“typing” or “fingerprinting”) of epidemiologically related isolates helps to
determine whether these organisms are related or not and thus essential to confirm the existence of an outbreak. The laboratory must collaborate with the ICC in the investigation of outbreaks. Typing of isolates is also useful during outbreaks to determine the prevalence and mode of spread of strains and to identify reservoirs and carriers.

Antibiotic resistance levels vary widely depending on geographic location and even among hospitals from the same country. Hospital antibiotic policies can be generated only when local information is available. Monitoring the antibiotic susceptibilities of bacteria generates a database which is consulted when writing hospital antibiotic policies. On the other hand the evolution of antibiotic resistance levels is a marker of the quality of infection control in a hospital.

Controversial Issues
Laboratory based surveillance is efficient but incomplete because of the lack of clinical and epidemiological data available in the laboratory and because specimens are not always collected from all cases of nosocomial infections.

The counterpart to the improvement of laboratory performances (detection and typing) is the extra investment needed. A special budget to participate in infection control activities is not always available, especially in developing countries.

Reference typing techniques (e.g., PFGE) are costly, labor-intensive and require interpretation skills. Alternative methods (e.g., Arbitrarily Primed-PCR) lack reproducibility and standardized interpretative criteria. Whether to fingerprint the isolates locally or to send the strains to reference laboratories depends on laboratory staffing and skills, the number of isolates and available budget.

Suggested Practice
A representative of the microbiology laboratory staff must be an active member of the ICC. In many hospitals, the ICC is chaired by a microbiologist, and a key function is to improve collaboration between clinical, laboratory and ICC personnel. If necessary, the microbiologist gives training in basic microbiology to ICC members and provides expertise (e.g., ready to use microbiological strategies to deal with each specific infection control situation, evaluation of resources needed, interpretation of culture results).
The microbiology laboratory staff should implement external and internal quality controls, and participate in continuous education and training to detect recognized, unusual and new phenotypes of resistance. The quality of specimens collection and transport should be maintained in collaboration with clinicians and nursing staff through seminars and procedure books. On the other hand a minimum of epidemiological (e.g., date of hospitalization) and clinical data should accompany the culture orders.

Laboratory records are an important source of information for the ICC. Storage and analysis of information are usually computerized. For laboratories with limited resources, the WHONET software from WHO is a powerful tool which is free of charge, user friendly and can be customized to each laboratory needs.

The microbiology laboratory is responsible for dissemination of this information. All significant laboratory results should be reported as quickly as possible to the clinicians and to the ICC. Some of these results (isolation of *Salmonella*, *Shigella* or *Neisseria meningitidis*, smears showing acid fast bacilli, cultures with multi-resistant bacteria) have a high priority and should be notified immediately by phone.

The microbiology laboratory must issue daily reports of significant microbiology results. This report includes patient’s identification, date of hospitalization, type and date of collection of specimen and culture results. Reports that focus on selected pathogens (e.g., methicillin resistant *Staphylococcus aureus*, vancomycin resistant *Enterococcus*, extended spectrum ß-lactamase producing Enterobacteriaceae, carbapenem resistant *Acinetobacter baumannii* can also be issued. The list of selected pathogens which include bacteria with known epidemic potential and multi-resistant bacteria is established by the ICC and is revised periodically following the epidemiological situation at the institution.

Periodic reports are also useful in that they monitor trends. Data from various time periods should be analysed to study the patterns of infections.

The microbiology laboratory is responsible for the early detection of clusters of microorganisms with the same phenotypic characteristics. Laboratory and epidemiological studies
of suspected outbreaks should be conducted in parallel. During outbreaks the microbiology laboratory collaborates with the ICC to choose the specimens to collect, the isolates to finger-print, and the relevant isolates to store. In some situations, cultures of samples from carriers, from healthcare workers and the environment will be considered. All this work should be done timely.

Surveys of hospital personnel and environment should not be conducted routinely but only to address specific situations.

Biotyping and antibiotic resistance phenotypes are not reliable epidemiological markers. Molecular biology techniques are more discriminatory than phenotypic methods. The use of chromosomal restriction patterns by pulsed field gel electrophoresis is considered the reference technique for typing most bacterial species.

Data on antimicrobial resistance should be periodically available to the medical staff, at least annually. The data should be summarized for each ward or clinical specialty and by anatomic site of infection or type of pathogen. These data are helpful for generating hospital treatment guidelines, which are useful in situations where empirical therapy is often given before the microbiology results are available.

References


In the last twenty-five years, evidence has accumulated that the hospital environment represents an important source of nosocomial pathogens for hospitalized patients. Potential environmental sources of pathogens include air (e.g., *Aspergillus*), water (e.g., *Legionella*), environmental surfaces (e.g., *Clostridium difficile*), medical devices, and many other items in the patient environment.

**Key Issues**
Pathogens may spread from an inanimate environmental reservoir to the patient by one or more routes including airborne, common-vehicle, contact or vector-borne. Airborne transmission describes organisms that have a true airborne phase as part of their pattern of dissemination, such as tuberculosis. In common-vehicle spread, a contaminated inanimate vehicle serves as the mechanism of transmission of the infectious agent to several people. Common vehicles may include ingested food or water; blood and blood products; and infused products such as medications or intravenously administered fluids. In contact spread, the patient has contact with the source and that contact is either direct, indirect, or droplet. Direct contact occurs when actual physical contact occurs between the source and the patient. Indirect contact refers to transmission from the source to the patient through an intermediate object, which is usually inanimate (e.g., endoscopes). Finally, droplet spread refers to the brief passage of an infectious agent through the air when the source and patient are within several feet of each other. Arthropod-borne nosocomial infections have not been reported in the United States.

**Known Facts**
In this section, we will briefly review environmental reservoirs and the pathogens that have been linked with infection in patients admitted to the hospital (*Table 4.1*). We attempt to indicate the strength by which the linkage to human disease has been investigated and the control measures.
<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Associated Pathogens</th>
<th>Transmission</th>
<th>Significance</th>
<th>Prevention and Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Filters</td>
<td>Aspergillus</td>
<td>Airborne</td>
<td>Moderate</td>
<td>Replace soiled filters periodically</td>
</tr>
<tr>
<td>Laundry chutes</td>
<td>Pseudomonas, Staphylococci</td>
<td>Airborne</td>
<td>Low</td>
<td>Proper design and placement, chute doors</td>
</tr>
<tr>
<td>False ceilings</td>
<td>Rhizopus</td>
<td>Airborne</td>
<td>Moderate</td>
<td>Barrier protection during reconstruction</td>
</tr>
<tr>
<td>Fireproof materials</td>
<td>Aspergillus</td>
<td>Airborne</td>
<td>Low</td>
<td>Add fungicide to moist material</td>
</tr>
<tr>
<td>Humidifiers/nebulizers</td>
<td>Acinetobacter, Legionella,</td>
<td>Airborne, Droplet</td>
<td>High</td>
<td>Avoid when possible; use sterile water; disinfect between uses</td>
</tr>
<tr>
<td></td>
<td>Pseudomonas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside construction/</td>
<td>Rhizopus, Aspergillus</td>
<td>Airborne</td>
<td>High</td>
<td>Use at least 95% efficiency filters in hospital; filter all hospital air</td>
</tr>
<tr>
<td>Inadequate ventilation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigeon droppings</td>
<td>Aspergillus</td>
<td>Airborne</td>
<td>Low</td>
<td>Maintain filter efficiency; filter all hospital air</td>
</tr>
<tr>
<td>Inhaled medications</td>
<td>Pseudomonas, Klebsiella,</td>
<td>Inhalation</td>
<td>Moderate</td>
<td>Sterile preparation by pharmacy</td>
</tr>
<tr>
<td></td>
<td>Serratia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Showers</td>
<td>Legionella, Group A Streptococcus</td>
<td>Inhalation</td>
<td>Low</td>
<td>Prohibit with immunocompromised patients</td>
</tr>
<tr>
<td>Ventilators</td>
<td>Pseudomonas</td>
<td>Inhalation</td>
<td>Moderate</td>
<td>Follow current CDC guidelines</td>
</tr>
<tr>
<td>Bronchoscopes</td>
<td>Pseudomonas, Mycobacteria</td>
<td>Contact</td>
<td>High</td>
<td>Pseudoepidemics common; follow disinfection guidelines</td>
</tr>
<tr>
<td>Contaminated germicides</td>
<td>Pseudomonas</td>
<td>Contact</td>
<td>High</td>
<td>Avoid extrinsic contamination and seek verification of manufacturer’s microbicidal efficacy claims</td>
</tr>
<tr>
<td>Dialysis water</td>
<td>GNR</td>
<td>Contact</td>
<td>Moderate</td>
<td>Follow guidelines: dialysate £ 2000 organisms/ml; water £ 200 organisms/ml</td>
</tr>
<tr>
<td>Reservoir</td>
<td>Associated Pathogens</td>
<td>Transmission</td>
<td>Significance</td>
<td>Prevention and Control</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ECG electrodes</td>
<td>S. aureus, GNR</td>
<td>Contact</td>
<td>None</td>
<td>Disinfect after use or use disposable leads</td>
</tr>
<tr>
<td>Elasticized bandages</td>
<td>Zygomycetes</td>
<td>Contact</td>
<td>Moderate</td>
<td>Avoid in immunocompromised patients or over nonintact skin</td>
</tr>
<tr>
<td>Electronic thermometers</td>
<td>C. difficile</td>
<td>Contact</td>
<td>Low</td>
<td>Probe cover, disinfect each day and when visibly contaminated</td>
</tr>
<tr>
<td>Endoscopes</td>
<td>Salmonella, Pseudomonas</td>
<td>Contact</td>
<td>High</td>
<td>Follow proper disinfection procedures</td>
</tr>
<tr>
<td>Faucet aerators</td>
<td>Pseudomonas, Stenotrophomonas</td>
<td>Contact, Droplet</td>
<td>Low</td>
<td>No precautions necessary</td>
</tr>
<tr>
<td>Ice baths</td>
<td>Staphylococcus, Ewingella</td>
<td>Contact</td>
<td>Moderate</td>
<td>Avoid direct contact with ice to cool IV solution/syringes; use closed system for thermodilution</td>
</tr>
<tr>
<td>Intraaortic balloon pump</td>
<td>Pseudomonas</td>
<td>Contact</td>
<td>Low</td>
<td>Add germicide to water reservoir</td>
</tr>
<tr>
<td>Mattresses</td>
<td>Pseudomonas, Acinetobacter</td>
<td>Contact</td>
<td>Moderate</td>
<td>Use intact plastic cover, disinfect cover between patients</td>
</tr>
<tr>
<td>Plaster</td>
<td>Pseudomonas, Bacillus</td>
<td>Contact</td>
<td>Moderate</td>
<td>Use judiciously in immunocompromised patients or over nonintact skin</td>
</tr>
<tr>
<td>Potable water</td>
<td>Pseudomonas, Serratia, non-tuberculous Mycobacteria, Actinetobacter, Legionella</td>
<td>Contact, Droplet, Ingestion</td>
<td>High</td>
<td>Follow CDC and public health guideline</td>
</tr>
<tr>
<td>Pressure transducers</td>
<td>Pseudomonas, Enterobacter, Serratia</td>
<td>Contact</td>
<td>Moderate</td>
<td>Disinfect transducer between patients and replace disposable dome/transducer; use good aseptic technique</td>
</tr>
<tr>
<td>Reservoir</td>
<td>Associated Pathogens</td>
<td>Transmission</td>
<td>Significance&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Prevention and Control</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
<td>------------------</td>
<td>---------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sinks</td>
<td><em>Pseudomonas</em></td>
<td>Contact, Droplet</td>
<td>Low</td>
<td>Use separate sinks for hand washing and disposal of contaminated fluids</td>
</tr>
<tr>
<td>Suction apparatus</td>
<td><em>Klebsiella, Salmonella,</em></td>
<td>Contact, Droplet</td>
<td>Low</td>
<td>Avoid backflow and aerosolization; disinfect between patient use</td>
</tr>
<tr>
<td></td>
<td><em>Pseudomonas, Proteus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermometers (glass)</td>
<td><em>Salmonella</em></td>
<td>Contact</td>
<td>Moderate (rectal)</td>
<td>Disinfect between use</td>
</tr>
<tr>
<td>Tubs for immersion</td>
<td><em>Pseudomonas</em></td>
<td>Contact</td>
<td>Moderate</td>
<td>Add germicide to water; drain and disinfect after each use</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urine-measuring devices</td>
<td><em>Serratia</em></td>
<td>Contact</td>
<td>Moderate</td>
<td>Disinfect between patients, good hand washing</td>
</tr>
<tr>
<td>Water baths</td>
<td><em>Pseudomonas, Acinetobacter</em></td>
<td>Contact</td>
<td>Moderate</td>
<td>Add germicide to water bath or use plastic overwrap</td>
</tr>
<tr>
<td>Electric breast pumps</td>
<td><em>Pseudomonas, Klebsiella,</em></td>
<td>Ingestion</td>
<td>Moderate</td>
<td>Follow guidelines</td>
</tr>
<tr>
<td></td>
<td><em>Serratia</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enteral feeds</td>
<td>GNR</td>
<td>Ingestion</td>
<td>Low</td>
<td>Use sterile commercial feeds or aseptically prepared feeds; refrigerate; minimize manipulation; use closed administration set</td>
</tr>
<tr>
<td>Food&lt;sup&gt;a&lt;/sup&gt;</td>
<td><em>Salmonella, S. aureus,</em></td>
<td>Ingestion</td>
<td>High</td>
<td>Follow local public health guidelines</td>
</tr>
<tr>
<td></td>
<td><em>Clostridia,</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Vibrios,</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>hepatitis A,</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Norovirus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice/Ice machines</td>
<td><em>Legionella, Enterobacter,</em></td>
<td>Ingestion, Contact</td>
<td>Moderate</td>
<td>Periodic cleaning; use automatic dispenser</td>
</tr>
<tr>
<td></td>
<td><em>Pseudomonas, Salmonella,</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidia</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medications (extrinsic)</td>
<td><em>Staphylococcus,</em></td>
<td>Injection, Inhalation</td>
<td>High</td>
<td>Use aseptic technique</td>
</tr>
<tr>
<td></td>
<td><em>Streptococcus,</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GNR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reservoir</td>
<td>Associated Pathogens</td>
<td>Transmission</td>
<td>Significance</td>
<td>Prevention and Control</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------------------------</td>
<td>--------------</td>
<td>--------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Air-fluidized beds</td>
<td>Enterococcus</td>
<td>Contact</td>
<td>Low</td>
<td>Follow manufacturer’s recommendations</td>
</tr>
<tr>
<td>Carpets</td>
<td>—</td>
<td>—</td>
<td>None</td>
<td>Prudent to avoid in areas of heavy soiling</td>
</tr>
<tr>
<td>Flowers</td>
<td>GNR</td>
<td>—</td>
<td>None</td>
<td>Prudent to avoid in the ICU and immunocompromised patients’ rooms</td>
</tr>
<tr>
<td>Fresh vegetables</td>
<td>Aerobic GNRs, Listeria</td>
<td>—</td>
<td>None</td>
<td>Prudent to avoid in immunocompromised patients</td>
</tr>
<tr>
<td>Pets</td>
<td>Malassezia, S. aureus</td>
<td>Contact</td>
<td>Low</td>
<td>Prudent to avoid in hospital setting (except service animals)</td>
</tr>
<tr>
<td>Stethoscopes</td>
<td>Staphylococci</td>
<td>—</td>
<td>None</td>
<td>Prudent to clean periodically with alcohol</td>
</tr>
<tr>
<td>Toilets</td>
<td>GNR</td>
<td>Droplet</td>
<td>Low</td>
<td>Utilize good hand washing</td>
</tr>
<tr>
<td>Medical waste (not sharps)</td>
<td>—</td>
<td>—</td>
<td>None</td>
<td>Follow state and federal regulations</td>
</tr>
<tr>
<td>Eyewash stations</td>
<td>Pseudomonas, Legionella</td>
<td>Contact</td>
<td>Low</td>
<td>Have sterile water available for eye flush</td>
</tr>
<tr>
<td>Toys</td>
<td>Pseudomonas, Rotavirus</td>
<td>Contact</td>
<td>Low</td>
<td>Disinfect toys between patients, avoid water-retaining bath toys</td>
</tr>
<tr>
<td>Computer keyboards</td>
<td>S. aureus, Acinetobacter</td>
<td>Contact</td>
<td>Low</td>
<td>Disinfect periodically, hand wash after use</td>
</tr>
<tr>
<td>Surfaces</td>
<td>VRE, MRSA, C. difficile</td>
<td>Contact</td>
<td>Moderate</td>
<td>Hand wash with soap and water after contact with patient environment, disinfect surfaces</td>
</tr>
</tbody>
</table>

a High, multiple well-described outbreaks due to this reservoir; moderate, occasional well-described outbreaks; low, rare well-described outbreaks; none, actual infection not demonstrated; GNR, gram-negative rods; VRE, vancomycin-resistant Enterococcus; MRSA, methicillin-resistant Staphylococcus aureus

b Modified from 1, 2
Controversial Issues
Few of the aforementioned recommendations (Table 4.1) regarding methods to prevent transmission of pathogens from the environment to patients are based on controlled trials. Rather, the recommendations are based on the success of interventions used to control outbreaks.

There are many unresolved issues associated with the environment that are related either to the degree to which some specific environmental items poses a hazard (e.g., computer keyboards) or to the appropriate control to a known environmental hazard (e.g., routine microbiologic sampling of water for Legionella). Among the unresolved issues in the area of environmental hazards or their control are:

- the risk and benefits of animals used for pet therapy;
- the hazard posed by contaminated personal devices such as stethoscopes, hand-held computers, pagers;
- the hazards associated with bioinformatic devices such as computer keyboards and touch-screen devices;
- the benefit, if any, of surface disinfection;
- the need for protective isolation (including limitation of fresh fruits/vegetables, flowers, potted plants);
- the hazards posed by water decorations such decorative fountains, waterfalls, and aquariums;
- the role of potable water as a source of fungal infections in immunocompromised patients;
- the need to routinely culture potable water for Legionella;
- and whether the hazard posed by multi-dose medication vials is so high that only single dose vials should be used.

Suggested Practice
Fortunately in the past few years, a number of authoritative guidelines have been published that provide scientifically-based recommendations to prevent transmission of nosocomial pathogens to the patient from environmental reservoirs.

- Hand washing before and after patient contact is crucial to prevent transmission of pathogens from the patient’s environment to other patients.
• All hospital construction and renovation must utilize recent guidelines to prevent acquisition of airborne fungi (such as *Aspergillus*) to immunocompromised patients

• Proper cleaning, disinfection/sterilization of reusable medical devices

• Aseptic manipulation of all medications

• Proper surveillance for *Legionella* and institution of control measures in the event of *Legionella* cases

• Surface disinfection of the environment to prevent transmission of methicillin-resistant *S. aureus*, vancomycin-resistant *Enterococcus*, and *C. difficile*

**Summary**

The environment continues to serve as a source of healthcare-associated infections. Key measures to reduce environment associated nosocomial infections include ongoing surveillance; appropriate evaluation of excess cases (epidemics); proper cleaning, disinfection, and sterilization of patient devices and the surface environment; and adherence to recommendations for protecting patients during building renovations and construction. New issues (e.g., computer keyboards, reprocessing prion contaminated medical devices, emerging pathogens such as SARS, monkeypox) will continue to challenge the infection control clinician for the foreseeable future.

**References**


Key Issue
Infectious waste requires special procedures for handling, transport and storage in order to prevent disease transmission to healthcare workers (HCW), waste management workers (WMW), and the community. Treatment of infectious waste is far more costly than that of unregulated waste; therefore, hospitals need to limit the total amount to a strict minimum.

Known Facts
• An array of devices and materials is used in hospitals for patient diagnosis and treatment. Many of these materials have entered into contact with patient blood and body fluids and contain microorganisms. Once discarded, they constitute medical waste and need to be classified and subsequently segregated as infectious or non-infectious waste.
• The classification and segregation of medical waste is often difficult because there is no consensus on what constitutes “infectious waste.” A standard definition is “waste capable of producing an infectious disease.” However, the mere presence of microorganisms is not synonymous with disease, and there is no method available to measure the risk of disease transmission.
• Disease transmission has been reported for occupational exposure to sharps, blood, materials from microbiology and pathology laboratories and waste from infected patients or laboratory animals. Most of these accidents occur in the hospital setting.
• Concentrated cultures of pathogens and contaminated sharps (in particular, needles) are the waste items that represent the most acute potential hazards to health.
Controversial Issues

• How can we determine what kind of medical waste has the potential to cause disease in a susceptible host and requires special handling? There is no straightforward answer, but the infection control practitioner can make the following considerations:

1. Does the waste contain blood, body fluids, or tissue with pathogenic microorganisms in sufficient quantity to produce disease?

• Patients with infectious diseases are much more likely to generate waste containing high numbers of pathogenic organisms. Soiled gauze or suction tubes with sputum from patients with pulmonary tuberculosis or bacterial pneumonia, for example, contain microorganisms that can be transmitted through the airborne route. Diapers with feces from patients infected by enteric pathogens can enter in direct contact with HCW and WMW, or with vectors such as flies that can subsequently contaminate food and water and infect new hosts.

• Because of their capacity to contain high numbers of pathogenic organisms, it is recommended that body organs, and tubes and bags containing blood be treated as infectious waste, independently of the patient’s diagnosis. By contrast, diapers from infants with no enteric disease, sanitary napkins from a normal delivery ward, or feeding tubes from a cardiovascular unit are far less likely to contain pathogenic organisms and can be treated as ordinary residential waste.

2. Does the waste contain cultures of viable and pathogenic microorganisms?

• Cultures from clinical microbiology laboratories contain large numbers of organisms that are commonly pathogenic to humans, and should therefore be treated as infectious. Laboratory specimens (feces, blood, sputum) and contaminated materials (pipettes, tubes, vials) used for the isolation or identification of etiologic agents should also be handled as infectious waste. Conversely, waste from laboratories that sample patients with non-infectious diseases (i.e. clinical chemistry or endocrinology) do not need to be
routinely treated as infectious. Upon deciding whether to classify a certain waste as infectious, the local prevalence of blood-borne infections (hepatitis B, hepatitis C, malaria) and the safety conditions of the final destination of hospital waste need to be considered.

3. Can the waste create a portal of entry for pathogenic organisms into a susceptible host?

- Sharps are the single most frequent cause of occupationally-acquired blood-borne disease in HCW and must always be treated as infectious waste. Sharps include needles, scalpel blades, razor blades, and broken glass. Sharps containing blood should be classified as infectious because the status of the patient is not always known and these provide a portal of entry for pathogens.

- Sharps that do not contain blood (e.g., needles used to administer medications) are also dangerous because they may cause puncture injuries to HCW and WMW that can produce a portal of entry for pathogenic microorganisms.

**Suggested Practice**

- The key step in waste management is to segregate medical waste into infectious and non-infectious. The definition and regulation of “infectious waste” varies by country. Each hospital should develop written procedures for waste management on the basis of national and regional regulations, the prevalence of infectious diseases that can potentially contaminate medical waste and the local infrastructure for processing infectious waste. Hospital staff should receive training for correctly segregating all medical waste and regulations must be strictly enforced.

- In a waste management program, the biologic waste should first be separated from non-biologic waste. Non-biologic waste such as paper, glass, and plastics should be recycled as much as possible and may generate a modest income for the hospital.

- Biologic waste should be segregated into infectious and non-infectious using standard definitions. Non-infectious waste can be collected in regular black bags and treated as
residential waste. Sharp infectious waste must be placed in rigid, puncture and water resistant containers that bear the universal biologic hazard symbol. Incineration is the preferred treatment method for sharps as it eliminates microorganisms and any possibility of puncture wounds.

- Non-sharp infectious waste should be collected in leak-resistant biohazard bags and sent for incineration. Alternatively, it can be decontaminated on site and subsequently discarded as non-infectious waste. On-site decontamination of microbiology laboratory waste is preferred, as this reduces the potential of exposure during the handling of infectious materials. Aerosolization of pathogens from live cultures and stocks should be avoided.

- Garbage bins with black and red bags, as well as the rigid containers for sharps, should be available in sufficient number throughout all patient areas. Infectious waste should be transported within the hospital in carts through specially designed routes. These routes should avoid patient care areas whenever possible.

- Infectious waste should be treated soon after discarding. If transport for off-site incineration is required, it should be temporarily stored in a secure and completely closed storage room.

A summary of the criteria used for medical waste classification by the Centers for Disease Control and Prevention and the Environmental Protection Agency, U.S.A. is shown in Table 5.1 on the next page.

**Summary**

Although the risk of acquiring disease from infectious waste is relatively low, all hospitals need to develop a waste management program. The program should be jointly designed and coordinated by the infection control unit, the hospital engineering staff, and municipal authorities. Medical waste should be classified as infectious only when it contains a sufficient quantity of pathogenic organisms to produce disease and there is a potential within the waste management setting to create a portal of entry into a susceptible host.
Table 5.1 Infectious medical waste requiring special treatment or disposal methods

<table>
<thead>
<tr>
<th>Source or type of medical waste</th>
<th>Classified as infectious</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CDC</td>
</tr>
<tr>
<td>Sharps² (e.g., needles)</td>
<td>Yes</td>
</tr>
<tr>
<td>Microbiology laboratory² (e.g., Petri plates, tubes, bottles with biologic specimens and cultures)</td>
<td>Yes</td>
</tr>
<tr>
<td>Communicable disease isolation²</td>
<td>No</td>
</tr>
<tr>
<td>Pathology laboratory²,³ (tissues, organs)</td>
<td>Yes</td>
</tr>
<tr>
<td>Laboratory waste⁴ (not microbiologic)</td>
<td>No</td>
</tr>
<tr>
<td>Surgery and autopsy waste⁴ (no communicable disease)</td>
<td>No</td>
</tr>
<tr>
<td>Dialysis unit⁴ (patient is not infected with blood-borne agent)</td>
<td>No</td>
</tr>
<tr>
<td>Contaminated equipment⁴</td>
<td>No</td>
</tr>
</tbody>
</table>

¹ As designated by the Centers for Disease Control and Prevention and Environmental Protection Agency, USA.
² Scientific studies document disease transmission from these sources to healthcare workers. Almost no studies document transmission to waste management workers or community-based population; nevertheless, the potential of transmission should be considered.
³ Should be rendered unrecognizable for esthetic reasons, even if patient did not have infectious disease.
⁴ Each hospital should decide on the basis of epidemiological, financial, and safety considerations (see text).


References


It seems to me that reusing disposable devices has an element of poetic justice ingrained, if one can become poetic about economics.
— V.W. Greene

Key Issue
Reutilization of disposable devices is a common practice in most hospitals but there are no well-founded standard guidelines to assure the quality and the safety of this practice.

Known Facts
• Most disposable devices can be reused
• Economic benefits can be obtained by reusing disposables
• Sterilization is a well known and common practice in hospitals
• Infections and malfunction are higher risks if the device is damaged in the re-sterilization process.
• There are diverse studies showing the security of reprocessing a variety of cardiac and urinary catheters, balloon-tipped catheters, guide-wires, implants, needles, surgical instruments, hemodialysers, laparoscopic instruments and pacemakers.
• There is evidence against the reuse of specific items with particular methods, such as Transducer Domes and Esophageal Stethoscopes with ethylene oxide sterilization.
• Risks associated with the reuse of disposable catheters include: infection, pyrogenic reaction, toxicity, particulate contamination, breakage-catheter integrity, catheter biocompatibility, risk for personnel, and risk for the environment.

Controversial Issues
• The selection of the patients to utilize a re-sterilized-device implies an ethical issue that should be resolved in every facility.
• There is a relationship between complexity of disposables and difficulties of sterilization.
• Reuse of disposable increases the risk of exposure of HCW to body fluids and chemicals used for sterilization.
• It is impossible for every single facility to evaluate each item to be reused. In most cases decisions will be made based in published experience.
• Sterilization specialized companies maybe an option.
• Ethical and legal implications should be considered.
• The reuse of disposable masks (N95 respirator) during epidemics or pandemics should be clearly regulated, the American Institute of Medicine do not recommend its reuse but in the case of a pandemic there will a short supply.
• There are many questions and few answers (to many disposables and very few studies), and funding for this research is scarce.

**Suggested Practice**
Reuse of disposables should not be an ad hoc practice or treated casually. A facility committed to the reuse of single-use devices should have an institution-specific policy and work with clear guidelines to ensure the safety of patients.

The American Society for Hospital Service Personnel has published the following guidelines:

1. Review the package labeling and the manufacturer guidelines for use and reprocessing the device.
2. If the manufacturer has not determined reprocessing parameters, obtain information about the material properties (steel, rubber, latex, PVC, etc). Ask the manufacturers if the product can be reprocessed; and if so, ask for recommendations.
3. Establish a list of form and function criteria which the reprocessed device will be expected to meet. These include:
   A.– Physical appearance (color, shape, size, etc) and
   B.– Function (moving parts, tensile strength, flexibility, etc.)
4. Determine if you have the capability to demonstrate that the device can be adequately cleaned according to the material properties and cleaning methods available.
5. Determine if you have the capability to demonstrate that the device can be adequately sterilized according to material properties and sterilizing methods available.

6. Determine if reprocessing of this device is cost justified.

7. For each device, establish a testing protocol that identifies:
   • The quantity of items which must be tested to get an adequate study sample
   • The number of times the device can be reprocessed and still meet the form and function criteria
   • Employee safety considerations
   • The procedures, chemicals, and equipment to be used in reprocessing
   • Process controls, quality assurance monitoring, and documentation
   • Testing of the reprocessed item in simulated use situations
   • The necessity of destructive auditing to identify unacceptable changes to the material properties or the presence of residual toxicity
   • Documentation of testing results
   • A method for labeling the reprocessed device and marking for successive reprocessing episodes

8. Review testing protocols/results with appropriate review groups (administration, infections-control) and the manufacturer

9. Determine need for policies for pricing, informed patient consent, and documentation of the use of reprocessed devices.

10. Periodically review the use and methods.

Other specific recommendations are:

1. Have a procedure to ensure the destruction of pyrogens.

2. Start the cleaning and sterilization process as soon as possible.

3. For angioplasty catheters it is essential to inspect the balloon inflated and deflated before using it.
References


Keywords
Hand hygiene, hand washing, hand antisepsis, hand disinfection, epidemiology, healthcare workers

Key Issues
• Hand hygiene is the cornerstone of infection prevention.
• Healthcare workers’ (HCWs) compliance with hand hygiene practices remains low.
• Enhanced compliance is associated with decreased transmission.

Known Facts
• Appropriate hand hygiene is considered the leading measure to reduce the transmission of nosocomial pathogens in healthcare settings. Its impact on infectious and resistant organisms’ cross-transmission risk is largely recognized in hospitals, schools and day care centers, as well as in community settings.
• Inappropriate hand hygiene practice has been recognized as a significant contributor to numerous outbreaks.
• Several studies have shown the impact of improved hand hygiene on the risk of nosocomial infection and multi-resistant pathogen cross-transmission.
• Normal human skin is colonized with bacteria and harbors mainly two types of bacteria, resident and transient flora. Transient flora colonizes the superficial layers of the skin. It has a short-term survival rate on the skin, but a high pathogenic potential. It is usually acquired by healthcare workers (HCWs) during direct contact with patients or contaminated environmental surfaces adjacent to the patient, and is responsible for most nosocomial infections and spread of antimicrobial resistance resulting from cross-transmission.
The transient flora are amenable to removal by routine hand hygiene. Resident flora are attached to deeper skin layers and have a low pathogenic potential unless introduced into the body by invasive devices. It is also more difficult to remove mechanically. Hand hygiene decreases colonization with transient flora and can be achieved either through hand washing or hand antisepsis (see below).

- The ideal technique for hand hygiene should be quick to perform, reduce hand contamination to the lowest possible level, and be free from significant side-effects on the HCWs’ skin.
- Definitions to be used. Hand hygiene defines either hand washing, hand antisepsis, hand disinfection, antiseptic handwash, or antiseptic handrub. Hand washing refers to the action of washing hands with plain (non-antimicrobial) soap and water. Hand antisepsis refers to either antiseptic hand wash or antiseptic hand rub. Hand disinfection refers to any action where an antiseptic solution is used to clean hands, either with medicated soap or alcohol. Antiseptic hand wash refers to the action of washing hands with water and soap or other detergents containing an antiseptic agent. Antiseptic hand rub refers to the application of a waterless antiseptic (mostly an alcohol-based product) agent to the hands to reduce the number of microorganisms present.
- Major risk factors for noncompliance are identified: factors included belong to the individual HCW (i.e., lack of education, experience, or knowledge of guidelines), the group in which he/she works (i.e., lack of performance feedback, work in critical care or in a high workload situation, lack of encouragement or role model from key staff), and the institution (i.e., lack of existing written guidelines, suitable hand hygiene agents, skin care promotion, hand hygiene facilities, or even lack of culture or tradition of compliance). Furthermore, some HCWs believe that they wash their hands whenever it is recommended, even when observations indicate they do not.
- Among all risk factors for noncompliance identified, time constraint is the most important. In other words, the higher
the demand for hand hygiene, the lower the compliance. Thus, both a facilitated access to hand hygiene and the use of a fast acting agent helps improve compliance.

- Because alcohols have excellent activity and the most rapid bactericidal action of all antiseptics, they are the preferred agents for hygienic hand rub, so-called “waterless hand disinfection.” Of particular importance is the fact that alcohols dry very rapidly, allowing for fast antisepsis. In addition, alcohols are much more convenient for hygienic hand rub than aqueous solutions given their excellent spreading quality and rapid evaporation. Importantly, antiseptic hand rub has no effect on soil, so visibly-soiled hands should be washed with soap and water.

- A system change is required in most healthcare settings to promote alcohol-based hand rub as the new standard for hand hygiene during patient care.

**Controversial Issues**

- Various interventions have been reported to help improve HCW compliance with hand hygiene practices, but most have had short follow-up periods and did not establish if improvements were long-lasting; factors that ensure long-lasting improvement need to be determined.

- Recommendations to improve hand hygiene practices are not all based on scientific evidence. More research is needed.

- Although alcohol-based hand rubs are standard of care, the most suitable hand hygiene agent still needs to be determined.

- Alcohol alone has no lasting effect; whether the addition of antiseptic agents with prolonged activity is needed remains unknown.

- Efficacy and acceptance of hand hygiene products by HCWs are the most important parameters for their choice. Alcohol-based hand rubs are well suited for hand antisepsis for the following reasons: (i) fast-acting; (ii) optimal antimicrobial spectrum including multi-resistant organisms; (iii) no wash basin necessary for their use and easy availability at the bedside; (iv) application does not cause microbial contamination of the HCW’s uniform; (v) no risk of hand contamination by the use of contaminated water;
(vi) no resistance acquisition documented. At equal concentrations, n-propanol is the most effective alcohol, and ethanol the least. The most suitable alcohol type remains to be determined, as well as the need for antiviral activity. Hand hygiene agents with higher alcohol content have been advocated for use in pediatric wards for optimal antimicrobial efficacy against most viruses, but the clinical relevance of such a proposition remains to be validated.

- Factors to be considered for the evaluation of hand hygiene products for potential use in hospitals include their relative efficacy against pathogens, rapidity of action, acceptance and tolerance by HCWs, convenience of use, accessibility, and cost. With alcohol-based agents, the time required for drying may affect efficacy and user acceptance.

- Alcohol-based antiseptics intended for use in hospitals are available as rinses, gels, and foams. Few data are available regarding the relative efficacy of various formulations. Further clinical studies are warranted to determine the relative efficacy of alcohol-based gels and rinses.

- Most antiseptics, including alcohols, have very poor or no activity against bacterial spores; the clinical relevance of this information remains unknown.

- Methods used to assess the antimicrobial efficacy of products differ among studies and countries, and whether or not the efficacy of the agent is to be tested against viral pathogens. Further studies should be conducted at the bedside using standardized protocols to obtain more realistic views of microbial colonization and risk of bacterial transfer and cross-transmission.

- Soaps and detergents are damaging substances when applied to the skin on a regular basis by increasing skin pH, reducing lipid content, increasing transepidermal water loss, and even enhancing microbial shedding. Alcohol-based formulations for hand antisepsis [whether isopropyl, ethyl, or n-propanol, in 60–90% vol/vol] are less irritant on skin than most antiseptic or non-antiseptic detergents; (ii) alcohols with the addition of appropriate emollients are at least as tolerable and efficacious as detergents; (iii) applying emollients to HCWs’ hands is recommended
and may even be protective against cross-infection by keeping the resident skin flora intact; and (iv) hand lotions help to protect skin and may reduce microbial shedding. The drying effect of alcohol can be reduced or eliminated by adding emollients such as glycerol (1 to 3%) or other skin-conditioning agents. Prospective, randomized clinical trials conducted on hospital wards have demonstrated that alcohol-based rinses or gels containing emollients may cause less skin irritation and dryness than commonly-used detergents. The optimal formulation associated with maximal compliance but minimal side effects remains to be determined.

- The application of creams and lotions to protect hands to increase skin hydration and replace altered or depleted skin lipids can contribute to the barrier function of normal skin and reduce skin irritation associated with hand hygiene agents. Regular use of hand cream or lotion can help prevent irritant contact dermatitis and improve skin condition. Further studies are needed to assess the possible interaction between protective hand creams and lotions and antiseptic agents.

- The influence of glove use on compliance with hand hygiene recommendations remains unclear.

- The challenge of hand hygiene promotion consists in implementing tools for HCW behavior change; the optimal strategy to be implemented remains to be determined.

- The most influential components of multimodal intervention strategies for hand hygiene promotion remain to be determined.

- Cost-effectiveness of hand hygiene promotion strategies remains to be assessed.

**Suggested Practice**

Guidelines for hand hygiene in healthcare settings were recently developed by the CDC/HICPAC, SHEA, APIC, and IDSA (available at www.cdc.gov/ncidod/hip/hhguide.htm). Each recommendation was classified in 4 categories. The guideline includes indications for hand hygiene (*Table 7.1*), surgical hand antisepsis, selection of hand hygiene agents,
HCW skin care, HCW education and strategies for motivational programs, administrative measures, and recommended outcome or process measurements.

### Table 7.1 Indications for Hand Hygiene Actions

**A.** Wash hands with a non-antimicrobial/antimicrobial soap and water when hands are visibly soiled or contaminated with proteinaceous material. (IA)

**B.** If hands are not visibly soiled, use an alcohol-based hand rub for routinely decontaminating hands in all other clinical situations described in items 1 through 8 listed below. (IA)

**Decontaminate hands**

1. **before** having direct contact with patients. (IB)
2. **before** donning sterile gloves when inserting a central intravascular catheter. (IB)
3. **before** inserting indwelling urinary catheters, peripheral venous cathethers, or other invasive devices that do not require a surgical procedure. (IB)
4. **after** contact with a patient’s intact skin (as in taking a pulse or blood pressure, or lifting a patient). (IB)
5. **after** contact with body fluids or excretions, mucous membranes, non-intact skin, or wound dressings, as long as hands are not visibly soiled. (IA)
6. **if moving** from a contaminated-body site to a clean-body site during patient care. (II)
7. **after** contact with inanimate objects (including medical equipment) in the immediate vicinity of the patient. (II)
8. **after** removing gloves. (IB)

**C.** Wash hands with antimicrobial/non-antimicrobial soap and water if exposure to *Bacillus anthracis* is suspected or proven. The physical action of washing and rinsing hands under such circumstances is recommended because all hand antiseptics have poor activity against spores.
Footnote to Table 7.1

The CDC/HICPAC system for categorizing recommendations is as follows:

**Category IA.** Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.

**Category IB.** Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale.

**Category IC.** Required for implementation, as mandated by federal and/or state regulation or standard.

**Category II.** Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale.

**No recommendation; unresolved issue.** Practices for which insufficient evidence or no consensus regarding efficacy exist.

- Among indications for hand washing and hand antisepsis (*Table 7.1*), it is worth noting that unless hands are not visibly soiled, the use an alcohol-based waterless antiseptic agent is recommended for routine hand hygiene in all clinical situations (IA). Availability of a hand rub solution at the bedside is recommended to improve compliance.

- Among the parameters designed to enforce HCW education and motivation, the guideline insists on the importance of appropriate teaching and monitoring of HCW compliance with recommended practices and performance feedback. A list of administrative measures to help improve compliance is also proposed. In particular: a) make improved hand hygiene adherence an institutional priority; b) provide appropriate administrative support and financial resources; c) implement a multidisciplinary program that includes a readily accessible waterless antiseptic agent such as an alcohol-based hand rub product. Finally, the guideline also recommends to develop and implement a system for measuring improvements in HCW compliance with recommended hand hygiene practices; a carefully selected process and outcome measures are also proposed.
• Wearing of gloves should not be considered as an alternative to hand hygiene. Hand hygiene is required regardless of whether gloves are used or changed. Recommendations for glove use are: 1) to wear gloves when contact with blood or other potentially infectious materials, mucous membranes, and non-intact skin can be reasonably anticipated; 2) to remove gloves after caring for a patient; 3) to not wear the same gloves for the care of more than one patient; 4) to not wash gloves between patients; and 5) to change gloves during patient care if moving from a contaminated body site to a clean body site.

Summary

Hand hygiene is the cornerstone of infection prevention. Unfortunately, HCWs’ compliance remains low. Improving hand hygiene practices constitutes one of the major challenges of infection control; it is however associated with decreased cross-transmission. Factors adversely affecting HCW compliance with recommended practices include poor access to sinks and hand hygiene materials, time required to perform conventional hand washing with soap and water, time constraint associated with a high intensity of patient care, and a high number of opportunities for hand hygiene per hour of care on a single patient in critical care.

Availability of a hand rub solution at the bedside is recommended to improve compliance. Alcohol-based hand rubbing is currently recommended as the primary tool for hand hygiene action and promotion, because it reduces bacterial counts on hands more effectively than plain or antimicrobial soaps, can be made more accessible than sinks and other hand washing facilities, requires less time to use, and causes less skin irritation and dryness than washing hands with soap and water. Rubbing the hands together until the agent has dried is the essential part of the technique. Both easy access to hand hygiene, and the availability, free of charge, of skin care lotion, appear to be necessary prerequisites for appropriate hand hygiene behavior. The promotion of bedside, antiseptic hand rubs largely contributed to the increase in compliance in several clinical studies. The availability of a hand rub alone
appeared however to be insufficient to obtain sustained improvement with hand hygiene practices. Multimodal strategies that contributed to the success of the promotion campaigns have been designed; they include repeated monitoring of compliance and hand hygiene performance feedback, communication and education tools, reminders in the work environment, active participation and feedback at both individual and organizational levels, and involvement of institutional leaders. A system change is need in most healthcare settings to make hand hygiene action a priority, with alcohol-based hand rub as the new standard of care.

References
CHAPTER 8

ISOLATION OF COMMUNICABLE DISEASES

Bart Gordts, MD, MBA

Key Issue

The combination of standard precautions and isolation procedures represents an effective strategy in the fight against nosocomial transmission of infectious agents. Current CDC-HICPAC proposed guidelines describing the methods and indications for these precautions are straightforward, but effective barriers at the bedside are sometimes still lacking today. Key factors in achieving effective interruption of nosocomial transmission in all hospitals are the availability of the necessary financial and logistic resources as well as the increase in compliance of healthcare professionals (HCPs) with the guidelines. Preventing transmission of infections by means of isolation procedures in a scientific and cost-effective manner represents a challenge to every healthcare institution.

Known Facts

Isolation and barrier precautions aim to reduce or eliminate direct or indirect patient to patient transmission of nosocomial infections that can occur through 3 mechanisms:

1. via contact, which involves skin (or mucosa) to skin contact and the direct physical transfer of microorganisms from one patient to another or via hands of a HCP. Transmission can be direct (skin to skin) or indirect (via a contaminated surface).

2. via respiratory droplets larger than 5μm that do not last very far in the air and usually travel a short distance of less than 1 meter.

3. airborne transmission: particles less than 5μm that remain suspended in the air longer and therefore can travel long distances and infect susceptible hosts several meters away from the source.
Besides patient to patient transmission, nosocomial infections can be of endogenous origin (patient is the source of pathogen causing his infection) or acquired from environmental sources like contaminated water supplies, medical equipment, IV solutions, etc. These infections are not prevented by isolation precautions.

The most cost-effective, simple and feasible way to prevent transmission of pathogens consists in a two-tier approach as described in the CDC-HICPAC guidelines:\(^1\):

1. **Standard precautions** must be taken while caring for all patients. They represent a basic list of hygiene precautions designed to reduce to risk of transmission of bloodborne pathogens and from contact with moist body substances.

2. In addition to standard precautions, extra barrier or isolation precautions are necessary during the care of patients with highly transmissible or epidemiologically important pathogens or with poor hygiene. These practices are designed to interrupt airborne-, droplet- and contact transmission.

Isolation and barrier precautions have also proven successful in limiting the epidemic spread of multiply resistant gram negative bacilli, methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci\(^3\) (VRE). Isolation precautions can also be assumed effective in the fight against nosocomial epidemics caused by vancomycin intermediate or resistant *Staphylococcus aureus*\(^4\) (VISA, VRSA), stably derepressed mutants or extended spectrum beta-lactamase (ESBL) producing enterobacteriaceae (like *Enterobacter* spp.), quinolone- or carbapenem resistant *Pseudomonas aeruginosa* and multi-resistant *Stenotrophomonas maltophilia* and *Acinetobacter* spp.\(^5\)

**Suggested Practice**
All patients receiving care in hospitals or doctor offices, irrespective of their diagnoses, must be treated in such a manner as to minimize the risk of transmission of any kind of microorganisms from patient to HCP, from HCP to patient, and from patient to HCP to patient.
Standard Precautions

Standard precautions apply when contact with ruptured skin or mucous membranes, blood, all body fluids, secretions or excretaions except sweat. They are designed to reduce the risk of transmission from both recognized and unrecognized sources of infection. Among these ‘standard’ precautions, hand hygiene among HCPs constitutes the single most important prevention of nosocomially transmitted infections. HCP’s should wash hands when soiled and disinfect hands when possibly contaminated, irrespective of whether gloves were worn. Hand hygiene should take place immediately after gloves are removed, before and between patient contacts, and any time one handles blood, body fluids, secretions or excretions, or potentially contaminated items or equipment.

Gloves should be worn if touching blood, body fluids, secretions, excretions, mucous membranes, broken skin or contaminated objects. Gloves must be changed between patients and before touching clean sites on the same patient.

A mask and eye protection as well as a gown should be worn to protect mucous membranes, skin and clothing during procedures that are likely to result in splashing of blood, body fluids, secretions, or excretions.

Patients, HCPs or visitors must not be exposed to contaminated materials or equipment. Reusable equipment should be cleaned and sterilized before reuse. Soiled linen should be transported in a (double) bag.

HCPs must protect themselves against bloodborne contamination by carefully handling sharp instruments like needles. When possible, never recap. If recapping is unavoidable, use the one-handed technique or a mechanical device. All used sharps instruments must be placed in designated puncture-resistant containers.

No special precautions are needed for dinner-things since hot water and detergents in hospitals are sufficient to decontaminate these articles. Rooms, cubicles, and bedside equipment should be appropriately cleaned.

In addition to these standard precautions, ‘transmission-based precautions’ must be used for patients known or suspected to be infected with highly transmissible or epidemiologically
important pathogens which can spread by airborne or droplet transmission or by contact with dry skin or contaminated surfaces.

Examples of conditions necessitating isolation precautions and a summary of measures to be taken are shown in Table 8.1 and Table 8.2.

<table>
<thead>
<tr>
<th>Table 8.1 Indications for Standard and Isolation Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Precaution category</strong></td>
</tr>
<tr>
<td>Standard</td>
</tr>
<tr>
<td>Contact</td>
</tr>
<tr>
<td>Droplet</td>
</tr>
<tr>
<td>Airborne</td>
</tr>
</tbody>
</table>

**Contact Precautions**

Contact precautions must be taken when transmission can occur by skin to skin contact and the direct physical transfer of microorganisms as shown in Table 8.1.

Provide a private room, if possible. When not available, cohort patients infected with the same microorganism but with no other infection. Nonsterile gloves should be worn before entering the room. Apply hand washing and hand antisepsis as in standard precautions. Be sure not to touch potentially contaminated surfaces or equipment. Wear a clean, nonsterile gown when entering and remove it before leaving the room. Limit patient transport to the unavoidable and maintain isolation precautions during transport. When possible, limit the use of patient-care equipment to a single patient.
**Droplet Precautions**

Apply droplet precautions for patients infected with pathogens that spread by respiratory droplets larger than 5 µm produced during coughing, sneezing, talking, or during invasive procedures such as bronchoscopy. See conditions in Table 8.1.

Private room as in contact precautions. If unachievable, maintain spatial separation of at least 1 m between the infected patient and other patients and visitors. Special ventilation is unnecessary and the door may remain open. Masks are worn if within less than 1 m of the patient. Limit patient transport to the unavoidable and maintain isolation precautions during transport. When possible, limit the use of patient-care equipment to a single patient.

**Airborne Precautions**

Apply airborne precautions for patients infected with pathogens spread by respiratory droplets smaller than 5 µm produced during coughing, sneezing, talking, or during invasive procedures such as bronchoscopy. See conditions in Table 8.1.

As for the other infections requiring airborne precautions, patients suspected or known to be infected by *M. tuberculosis* should be nursed in a private room where the air flows in the direction from the hall into the room (negative air pressure), with 6 (minimum) to 12 (optimal) changes per hour and appropriate discharge of air outdoors. Negative air pressure can be created by placing a fan in the window and exhausting the air to the outside. High-efficiency filtration is necessary if the air is circulated in other areas of the hospital. Keep the door closed. Cohorting can be done in rare circumstances for patients infected with strains presenting with an identical antimicrobial susceptibility.

Respiratory protection should be worn both by HCPs and visitors when entering the room. The technical requirements for respiratory protection devices remain controversial: CDC guidelines advocate masks with face-seal leakage of ≤10% and filter 1 µm particles for > 95% efficiency (N95). However, a molded surgical mask may be as effective in dealing with nosocomial outbreaks and better complied with because of cost. Avoid transporting patients through other areas of the facility. If transport is unavoidable, the patient should wear a surgical mask that covers mouth and nose.
It is mandatory to maintain isolation until the diagnosis of tuberculosis is ruled out or, when confirmed, the patient is on effective therapy, improving clinically and has three consecutive negative sputum smears excluding the presence of acid fast bacilli. Patients infected with multidrug resistant *M. tuberculosis* should stay in airborne isolation throughout the hospitalization.

### Table 8.2 Summary of Transmission-based Precautions

<table>
<thead>
<tr>
<th>Precaution</th>
<th>Contact</th>
<th>Droplet</th>
<th>Airborne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient room</td>
<td>Private</td>
<td>Private</td>
<td>Private with specific ventilation requirements</td>
</tr>
<tr>
<td>Gloves</td>
<td>Before entering room</td>
<td>—— As in standard ——</td>
<td></td>
</tr>
<tr>
<td>Hand hygiene</td>
<td>——— As in standard, with hand antisepsis ———</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gown</td>
<td>If direct contact with patient or environment</td>
<td>——— As in standard ———</td>
<td></td>
</tr>
<tr>
<td>Masks</td>
<td>Standard</td>
<td>Within 1 meter of patient</td>
<td>Before entering room special requirements</td>
</tr>
<tr>
<td>Other</td>
<td>——— Limit patient transport ———</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Implementation of Isolation Precautions

Hospitals are encouraged to review the recommendations and to modify them according to what is feasible and achievable. The success of transmission prevention in each institution relies on 3 keystones:

- Availability to all HCPs an unambiguous written document describing the indications and procedures for isolation;
- Successful implementation of the procedures through clear objectives and education off all HCPs;
- Monitoring of the compliance with isolation procedures in a continuous improvement program.

Since clear indications and advised practices for isolation procedures are available to date, the further success of transmission prevention further relies upon:

- Accurate and early identification of patients at risk requiring isolation by:
  - availability of unambiguous written criteria for starting and discontinuing isolation;
– initiation of isolation procedure as soon as the infectious disease is suspected;
– active surveillance of risk factors among patients upon admission to the hospital or ward;
– early laboratory diagnosis.

• Effective discharge planning for patients in isolation to be transferred to other healthcare facilities and effective admission planning for patients at risk of carrying infectious agents from other hospitals or nursing homes.

• Increased compliance of patients with the precautions through supportive efforts to facilitate adherence and through education about the mechanism of transmission and the reason for being placed in isolation.

• Instruction and information of visitors about the preventive measures.

• Clear endorsement by hospital management and department heads

References


Key Issue
Critical medical devices must be sterilized and kept from being contaminated before use to avoid infections in patients exposed to them.

Known Facts
- Sterilization can ensure the safe use of invasive medical devices.
- The success of a sterilization procedure must be monitored using physical, chemical and biologic indicators.
- An item should not be used if its sterility is questionable, e.g. if its package is punctured, torn, or wet.

Controversial Issues
- The shelf-life of sterile items remains unclear.
- The procedure for sterilization of prions is still controversial.

Suggested Practice
- Medical devices or patient care equipment that enter normally sterile tissue or the vascular system or through which blood flows are so-called critical items. Examples of critical items are surgical instruments, urinary or vascular catheters, or needles. Critical items pose a high-risk of infection if they are contaminated with microorganisms. Thus, they must be sterile.
- Cleaning, disinfection, and sterilization of patient care supplies should be performed in a central processing department to make quality control easier. The central processing area should be divided into several areas including a cleaning and decontamination area, a packaging area, and areas for sterilization and storage of sterile supplies that are separated by physical barriers. Ideally, the temperature of all areas should be maintained between 18°C and 22°C, the
relative humidity should be maintained between 35% and 70%, and the air flow should be directed from clean areas to relatively soiled areas.

- Because effective sterilization of critical medical equipment depends upon reduction of bioburden, before beginning the sterilization process all items should be thoroughly cleaned. Manual cleaning of contaminated items can expose personnel to blood born pathogens and other potentially harmful microorganisms and should be avoided. Alternatives are ultrasonic cleaning, dishwasher, washer-decontaminator machines, or washer-sterilizers. Disinfectant/detergent agents are used increasingly for presoaking of contaminated items. However, these agents may damage the instruments and, furthermore, personnel may be getting a false sense of security since disinfection cannot be accomplished if gross soilage is present. Thus all items should be considered contaminated and need to be handled with personnel protection equipment (gloves, gowns, face shields if splashing may occur).

- All items to be sterilized should be wrapped or packed to avoid recontamination after the sterilization process. Wrapping materials should

  1. provide a seal of proven integrity,
  2. be free of pinholes,
  3. be durable enough to resist tears and punctures,
  4. not delaminate when opened,
  5. allow printing and labeling,
  6. not generate nonviable particles,
  7. be compatible with the sterilization process, and
  8. be inexpensive, impervious to bacteria, sealable before sterilization, and flexible enough to allow swift wrapping and unwrapping.

Commonly used wrapping materials are 140-thread-count muslin, Kraft paper, nonwoven wraps and paper/plastic peeldown packages. When single-wrapped sterile packages are used the contents may be contaminated from the exterior surface upon opening. Thus items to be sterilized should be wrapped in two thicknesses of paper or nonwoven fabric.
Whichever material is used, all items should be placed loosely as not to hinder contact between the sterilant and the microorganism

- Various methods of sterilization are available for hospitals: steam sterilization, dry heat sterilization, gas sterilization using ethylene oxide, formaldehyde or vapor-phase hydrogen peroxide. Ionizing radiation is another method which is mainly used for industrial sterilization of single-use items. The advantages and disadvantages for each method are summarized in Table 9.1.

- Prions, the causative agent of Creutzfeld-Jacob disease (CJD) and other transmissible spongiform encephalopathies (TSE) exhibit an unusual resistance to conventional sterilization procedures. Items that are contaminated with high-risk tissue (defined as brain, spinal cord, and eyes) from high-risk patients (having known or suspected CJD) should be thoroughly cleaned and decontaminated using alkaline detergents or 1 M NaOH and then sterilized by autoclaving either at 134°C for 18 minutes in a prevacuum sterilizer or at 121°C–132°C for 1 hour in a gravity displacement sterilizer. Items that are impossible or difficult to clean or items that permit only low temperature sterilization should be discarded.

- Monitoring the sterilization process is an essential quality assessment procedure for infection control. Physical monitoring is the observation of sterilizer functioning (e.g., temperature, pressure, time). Any deviation from the expected readings should alert the operator to potential problems. Chemical monitoring describes color or physical change indicators that monitor exposure to sterilizing agents or conditions. Biological monitoring (e.g., using Bacillus stearothermophilus spores for steam sterilizers) is the most important check on sterilizer and should be performed at least weekly. Every load containing implantable objects should be monitored with a spore test. It is recommended that sterilizer loads containing implantables or intravascular devices be quarantined until the spore test has been reported as negative.
<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Sterilization</td>
<td>• Most common sterilization process in healthcare facilities</td>
<td>• Success of sterilization can be impaired by trapped air, grossly wet materials, and decreased steam quality</td>
</tr>
<tr>
<td></td>
<td>• Safe for environment and healthcare workers</td>
<td>• Heat and moisture sensitive components can be damaged</td>
</tr>
<tr>
<td></td>
<td>• Nontoxic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• No aeration necessary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Inexpensive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Short sterilization time</td>
<td></td>
</tr>
<tr>
<td>Dry Heat Sterilization</td>
<td>• Low corrosiveness</td>
<td>• Requires long sterilization time</td>
</tr>
<tr>
<td></td>
<td>• Deep penetration in the material</td>
<td>• Requirements of different countries regarding temperature and cycle time are conflicting</td>
</tr>
<tr>
<td></td>
<td>• Safe for the environment</td>
<td>• Heat-labile components can be damaged</td>
</tr>
<tr>
<td></td>
<td>• No aeration necessary</td>
<td></td>
</tr>
<tr>
<td>100% Ethylene Oxide (ETO)</td>
<td>• Penetrates packaging materials and many plastics</td>
<td>• Requires aeration time</td>
</tr>
<tr>
<td></td>
<td>• Compatible with most medical materials</td>
<td>• Small sterilization chamber</td>
</tr>
<tr>
<td></td>
<td>• Simple to operate and monitor</td>
<td>• ETO is toxic, probable carcinogen, and flammable</td>
</tr>
<tr>
<td></td>
<td>• No aeration necessary</td>
<td>• ETO cartridges need storage in flammable liquid storage cabinet</td>
</tr>
<tr>
<td>Peroxide Gas Plasma Sterilization</td>
<td>• Low process temperature</td>
<td>• Cellulose, linens, and liquids cannot be processed</td>
</tr>
<tr>
<td></td>
<td>• No toxic residuals</td>
<td>• Small sterilization chamber</td>
</tr>
<tr>
<td></td>
<td>• Safe for environment and healthcare worker</td>
<td>• Medical devices with long or narrow lumen cannot be processed</td>
</tr>
<tr>
<td></td>
<td>• Simple to operate, install, and monitor</td>
<td>• Requires synthetic packaging</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>• Formaldehyde is not flammable and explosive</td>
<td>• Potential for residual formaldehyde on the surface</td>
</tr>
<tr>
<td></td>
<td>• Compatible with most medical materials</td>
<td>• Formaldehyde is toxic and allergenic</td>
</tr>
<tr>
<td></td>
<td>• No aeration necessary</td>
<td>• Requires long sterilization time</td>
</tr>
<tr>
<td></td>
<td>• Simple to operate, install, and monitor</td>
<td>• Long processing time due to removal of formaldehyde after sterilization</td>
</tr>
</tbody>
</table>
• An optimal sterile storage area is adjacent to the sterilization area and protects the sterile products against dust, moisture, insects, vermin, and temperature and humidity extremes. Sterile items should be positioned so that packaging is not crushed, bent, compressed, or punctured. The term shelf-life is defined as the period during which sterility can be maintained. In the literature storage times between 2 days and indefinitely have been reported, but in most instances wrapping materials and storage conditions were not considered. In conclusion, loss of sterility is considered event-related (e.g., by the frequency and method of handling and storage area conditions) and not time-related.

• Sterile products transported to the operating rooms and other areas within the hospital should be provided with an additional outer dust-protection cover that can be removed before the items are taken into the clean zone.

• The quality control program of the sterilization procedures should include:
  1. comprehensive and intensive training for all staff assigned to reprocessing procedures,
  2. periodically carrying out of infection control rounds,
  3. a sterilizer maintenance program,
  4. documentation of every sterilization cycle, including type of sterilizer, load identification number, load contents, exposure parameters, operator’s name, and results of monitoring and periodically review of policies and procedures.

**Summary**

• Steam sterilization should be used for all items that will not be damaged by heat, pressure, or moisture.
• Biologic monitoring of sterilization procedures should be performed regularly, e. g. once a week.
• Shelf-life and expiration dating-policies must be based on packaging materials used and facilities for storage.
References
Improperly disinfected medical equipment and devices can harbor microorganisms that cause infection. Environmental surfaces may also play an important role in the transmission of nosocomial pathogens.

**Known Facts**

- **Sterilization** is a procedure that eliminates all living organisms, including bacterial spores, and can be achieved by physical or chemical methods.
- **Disinfection** is a physical or chemical procedure performed on inanimate objects and surfaces that destroys most pathogenic organisms, except bacterial spores. Disinfection can be performed with hot water systems or liquid disinfectants. Healthcare workers must be familiar with the indications and limitations of each disinfectant before using them for processing medical equipment or environmental surfaces. Each compound has a different spectrum of biocidal activity; some are corrosive on metal instruments while others are inactivated in the presence of organic material. Selecting the appropriate disinfectant will reduce risk to the patient and unnecessary expenses for the hospital.

Procedures for the disinfection of medical devices should be based on the type of medical device and the immune status of the patients on whom it will be used. Procedures for the disinfection of environmental surfaces should be based on the patient’s immune status and whether these have a communicable disease, as well as the number of microorganisms present on the particular surface, and the frequency of hand contact.

**Disinfection of Medical Devices**

Medical equipment and devices that require a disinfection procedure are classified into critical, semicritical and non-critical according to the risk they entail for the patient.
• **Critical devices** are instruments that have contact with the blood stream or sterile areas of the body. Examples are IV catheters, surgical instruments, and three-way stopcocks. Because there is a high-risk of acquiring infection if critical devices are contaminated, only sterilization is appropriate for these devices. High-level disinfection may be used in emergency situations for some items that are easily cleaned and have a very low risk of contamination with bacterial spores.

• **Semicritical devices** are those that come in contact with mucous membranes. Examples include endoscopes, ventilator circuits, and Ambu ventilation balloons. Although sterilization is preferable to disinfection, it may be impractical in a busy hospital setting. Moreover, in developing countries with scarce resources, few devices are available for reprocessing. High-level disinfection preceded by meticulous cleaning is acceptable for most semicritical devices, except for those that can potentially harbor bacterial spores.
  – Special caution is required if the devices are intended for immunosuppressed patients. Contaminated ventilator circuits and manual ventilation balloons, for example, have been implicated in fatal *Bacillus cereus* sepsis, meningitis, and pneumonia in neonates.

• **Noncritical devices** are those that come in contact with the patient’s intact skin. Examples are stethoscopes and cardiac electrodes. The risk of acquiring infection from these devices is minimal; thus, low-level disinfection or simple cleaning is sufficient.

**Disinfection of Environmental Surfaces**

• Although scientific studies have documented the capacity of many nosocomial pathogens to survive for weeks or months in the hospital environment, there is a controversy regarding the appropriate treatment of inanimate surfaces in hospitals. With the introduction of molecular typing techniques, there is growing evidence that environmental surfaces can be implicated in the transmission of nosocomial infections. Environmental disinfection appears to be particularly important in the control of *Clostridium difficile*, vancomycin-resistant enterococci (VRE), MRSA, and certain species of *Candida*. For practical purposes, environmental surfaces may be classified into **high-risk** or **low-risk**
according to the patients’ immune status, the microbial load on the surfaces, and the specific pathogen involved.

**High-risk Surfaces**

- High-risk surfaces include those in direct or indirect contact with patients with impaired host defenses, such as those in neonatal, transplant, burn, and hematology-oncology units. In hematology-oncology units, for example, fatal episodes of *Pseudomonas aeruginosa* pneumonia and sepsis in neutropenic patients have been traced to water and drainage systems.

- Surfaces that are repeatedly in contact with blood and body fluids, or are in areas where patients have multiple invasive procedures, such as those in intensive care and hemodialysis units, are also high-risk. Likewise, if patients have communicable diseases, such as pulmonary tuberculosis or varicella-zoster, particular care should be taken with surfaces that have entered in contact with infectious body fluids. These units typically harbor nosocomial pathogens on many of their environmental surfaces that can later serve as reservoirs for transmission. Hepatitis B is a particular risk in hemodialysis units. Although the concentration of HBV on environmental surfaces is not notably high, repeated contact with contaminated surfaces over prolonged periods of time poses a particular risk for patients and personnel.

- Surfaces in busy, crowded wards that have repeated contact with patient secretions, excretions, or hands of personnel, e.g., toilets, bedrails and doorknobs, have a greater bioburden than less frequently touched surfaces such as walls or windows and require correspondingly more frequent disinfection.

- Certain pathogens are able to survive on inanimate surfaces for long periods of time. These inanimate surfaces may contain high numbers of the implicated pathogen and can act as long-term reservoirs during hospital outbreaks. Control of environmental reservoirs are particularly important in the transmission of vancomycin-resistant enterococcus and *Clostridium difficile*. Several studies have also documented a role for the spread of epidemic and endemic *Candida* infections and MRSA. Although *P. aeruginosa* and *A. baumannii* are strongly associated with environmental contamination, the role of inanimate surfaces in the transmission of these gram negative bacilli is unclear.
Surfaces with spills of blood and body fluids are particularly hazardous and require special disinfection procedures. Breakage of suction bottles with bronchial secretions or glass tubes containing blood are examples of accidents that require prompt attention.

**Low-risk Surfaces**

- Low risk surfaces are those that have little or no direct contact with patients (hallway windows and walls) or those that enter in contact with patients with competent immune systems and no communicable infectious disease. Environmental surfaces in Outpatient Clinics, General Pediatrics, Internal Medicine, and Gynecology and Obstetrics wards can be classified in this category.

**Selection of Disinfectants:**

Once the device or surface has been classified, the appropriate disinfectant should be selected. Disinfectants are classified into three levels according to their microbiocidal properties as shown in Table 10.1.

**Controversial Issues**

- Routine disinfection of the hospital environment is unnecessary and expensive. Environmental surfaces play a minor role in the transmission of nosocomial infections in ordinary hospital settings, but can be important for specific pathogens and with immunosuppressed patients. Further research is needed to establish criteria for routine and outbreak situations, according to the pathogen involved.

- Another subject of controversy concerns the choice of sterilization vis-a-vis high-level disinfection of semi-critical items. In each case, certain factors such as patient susceptibility, cost and efficiency need to be considered, but preeminence should be given to patient safety. Medical devices that are difficult to clean or can harbor bacterial spores, such as *B. cereus* or *C. difficile*, should be sterilized whenever possible.

- Reuse of disposable items is commonly practiced in developing countries. Such practices should be used standardized methods to ascertain the proper functioning of the device and the elimination of pathogens after reuse.
Table 10.1. Levels of Disinfectant Action According to Their Spectrum of Microbicidal Activity.

<table>
<thead>
<tr>
<th>Disinfectant Level</th>
<th>Spores</th>
<th>Mycobacteria</th>
<th>Vegetative Cells</th>
<th>Fungi</th>
<th>Nonlipid</th>
<th>Lipid Envelope</th>
</tr>
</thead>
</table>
| **High** (Peracetic acid, glutaraldehyde, chlorine compounds) | +
| +1 Sporocidal activity is achieved after at least 6 hours of exposure. |
| **Intermediate** (Iodine and chlorine compounds, alcohol) | – | + | + | + | ± | + |
| **Low** (Phenols and quaternary ammonium compounds) | – | – | + | ± | ± | + |

+ Killing effect can be expected
- little or no killing effect

Suggested Practice
Each hospital should have a written protocol for cleaning, disinfection, and decontamination procedures developed in conjunction with the infection control practitioner and the medical, nursing and housekeeping staff. Patient safety, cost, and the chemical properties of the disinfectant should all be considered in the selection of procedures. Procedures should seek to reduce handling and maximize safety during the transport of instruments and devices containing patient body fluids. Hospital staff should be appropriately trained and supervised before carrying out disinfection procedures. Each procedure must be appropriately documented and periodic evaluations are advised.

Recommended procedures for the disinfection of medical devices are shown on Table 10.2. When using liquid disinfectants, a sterile water rinse (or at least boiled water) is required to remove residual germicide. This is technically difficult with some equipment (e.g., endoscopes and ventilator circuits) and increases the risk of contamination.

<table>
<thead>
<tr>
<th>Type of device</th>
<th>Recommended procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>Sterilization or high-level disinfection^2</td>
</tr>
<tr>
<td>• Surgical instruments</td>
<td>Steam sterilization</td>
</tr>
<tr>
<td>• Three-way stopcocks</td>
<td>Plasma sterilization, Chemical sterilants</td>
</tr>
<tr>
<td>Semicritical</td>
<td>High-level disinfection^3</td>
</tr>
<tr>
<td>• Endoscopes</td>
<td>Hot water 75–90°C x 20 min</td>
</tr>
<tr>
<td>• Ventilator circuits</td>
<td>2% Glutaraldehyde x 30 min</td>
</tr>
<tr>
<td>• Anesthesia equipment</td>
<td>6–7.5% Hydrogen peroxide x 20 min</td>
</tr>
<tr>
<td>• Laryngoscope blades</td>
<td>0.2–0.35% Peracetic acid x 5 min</td>
</tr>
<tr>
<td></td>
<td>Ortho-phthalaldehyde x 5–12 min</td>
</tr>
<tr>
<td>Noncritical</td>
<td>Intermediate or low level disinfection</td>
</tr>
<tr>
<td>• Stethoscopes</td>
<td>70% Ethyl alcohol</td>
</tr>
<tr>
<td>• EKG electrodes</td>
<td>Quaternary ammonium compounds</td>
</tr>
</tbody>
</table>

1 Thorough cleaning and drying should always precede disinfection procedures.
2 Critical devices should be sterilized. In specific situations, such as an emergency surgical procedure, certain items such as sharp surgical instruments may undergo high-level disinfection for 20–30 minutes.
3 Semicritical devices that are difficult to clean and may lodge bacterial spores should be sterilized. Liquid disinfectants must be thoroughly rinsed with sterile water.
Recommendations for the disinfection of environmental surfaces are shown on Table 10.3; some of them are subject to controversy. Procedures need to be developed for every hospital on an individual basis. The following can be used as a general guideline:

- Large spills require immediate decontamination of the surface with impregnated gauze followed by cleaning and intermediate-level disinfection. Small spills can be managed with cleaning and disinfection of the affected area.
- High-risk surfaces require more frequent cleaning and disinfection than low-risk surfaces. The choice of germicides should be determined by the infection control team. Intermediate-level disinfectants are recommended for the disinfection of surfaces in contact with *C. difficile*, VRE, and MRSA.
- Most low risk surfaces can be cleaned with soap and water. Detergent/low-levels disinfectants may also be considered according to hospital policy. Terminal cleaning of rooms should be performed after each patient discharge.

### Table 10.3 Recommended Procedures for the Disinfection of Environmental Surfaces

<table>
<thead>
<tr>
<th>Type of surface</th>
<th>Recommended procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large spillage of blood, body fluids, and feces</td>
<td>Cover with impregnated gauze 0.5% sodium hypochlorite x 10 min, followed by cleaning and repeat disinfection with 0.05% sodium hypochlorite</td>
</tr>
<tr>
<td>Small spillage</td>
<td>Soak with paper towels, clean and disinfect</td>
</tr>
<tr>
<td>High-risk surfaces</td>
<td>Detergent and water, followed by 0.05% sodium hypochlorite x 10 min OR iodine compounds x 10 min</td>
</tr>
<tr>
<td>Low-risk surfaces</td>
<td>Detergent and water</td>
</tr>
<tr>
<td>Patients with no communicable infectious disease</td>
<td>Quaternary ammonium compounds x 5 min¹</td>
</tr>
<tr>
<td>Immunocompetent patients</td>
<td>Phenol compounds x 5 min¹</td>
</tr>
<tr>
<td>Immunocompeted patients</td>
<td>Use 0.05% sodium hypochlorite for toilets</td>
</tr>
</tbody>
</table>

¹ Low-level disinfectants may be used in certain low risk areas if deemed necessary by infection control team.
**Summary**
Hospital disinfection protocols should include written procedures for both medical devices and environmental surfaces. Each protocol must be based on the biocidal spectrum of the disinfectant and the risk of disease transmission for each device or surface. Reuse of disposable items should only be performed when the sterility and integrity of the device can be reasonably assured.

**References**


CHAPTER 11

THE HEALTHCARE WORKER AS A SOURCE OF TRANSMISSION

Margreet C. Vos, MD, PhD

Key Issue
Within the hospital, healthcare workers (HCWs) are often exposed to infections. Any transmissible disease can occur in the hospital setting and may affect HCWs. HCWs are not only at risk of acquiring infections but also of being a source of infection to patients. Therefore, both the patient and the HCW need to be protected from contracting or transmitting nosocomial infections by using recommended infection control measures.

Known Facts
• The infection control objectives of a hospital should be planned by the infection control committee and occupational health services. The focus of the committee and services must be personal hygiene, monitoring of infectious disease outbreaks and exposures and, after identifying infection risks, institution of preventive measures.
• Prevention of infectious diseases in HCWs serves three purposes: the health of the healthcare worker, the prevention of work restrictions, and the reduction of nosocomial infections. The latter is discussed in this chapter.
• Education is an important factor for improving compliance with guidelines and prevention measures. All HCWs need to know about the risk of infection and the route of transmission of pathogens. Personal hygiene (universal precautions) is the foundation for preventing transmission of infectious diseases to patients.
• Immunization should be used to protect HCWs from infectious agents. Preventing infections in HCWs will also prevent transmission of infections from HCWs to patients.
Prompt evaluation of and institution of appropriate control measures for patients with signs and symptoms of transmissible infectious diseases will reduce the risk of hospital-acquired diseases.

• In deciding the type of infection control procedures needed, one must consider the HCW’s job, risk of exposure, and the suspected infectious pathogen.

A short overview of some of the most important infectious diseases transmitted by HCWs is presented below.

**Skin Infections**

**Scabies.** Scabies is transmitted by direct contact. In case of Norwegian (crusted) scabies, transmission is also through fomites, such as bed linens, floors, walls, furniture, clothes and the air. Symptoms of intense pruritus can develop 2 to 6 weeks after initial infestation. To prevent infection and to prevent a hospital outbreak, a HCW with skin exposure should receive prophylactic therapy, and to prevent reinfection, the household contacts should be treated too. In case of scabies crustosa, contactpatients should be identified and should receive prophylactic treatment. Contactpatients are those who shared the room or were otherwise direct or indirect exposed to skin scales. Immunocompromised patients have a high chance of developing scabies crustosa, which is harder to recognize compared to “local” scabies and more infectious.

**Staphylococcus aureus.** About one-third of the population are persistent nasal carriers of *S. aureus* (SA), one-third are intermittent carriers, and one-third are not carriers. Other sites of colonization are the throat, perineum, skin, axilla, or hair. People with dermal lesions, such as eczema, are more likely to be carriers. Carriers can spread SA to patients, especially those with wounds, or intravascular or other indwelling catheters. Dissemination of SA is by direct or indirect contact or, less commonly, by skin scales. Healthcare workers with lesions caused by SA such as boils (even on an occult body area) or other skin lesions are more likely to transmit infection to others than nasal carriers. HCW’s who are carriers of methicillin-resistant *Staphylococcus aureus* (MRSA) are a high risk to patients, by transmitting MRSA from their hands or nose to
wounds or mucosal surfaces. MRSA seems to spread more easily than MSSA, probably due to selection during antibiotic use and probably not due to the presence of other virulence mechanisms in mecA positive organisms.

During periods of high incidence of staphylococcal disease or epidemics of MRSA, identifying carriers by culturing patients and HCWs is useful and if needed disinfection of the environment. Carriers can be treated with 2% mupirocin ointment and desinfective soap washing. Mupirocin should not be used for longer than 5 days as resistance can develop. Since mupirocin is an important tool to control epidemic spread by eradication of S. aureus from nasal carriers, it should not be used to treat wound infections.

**Group A Streptococcus.** Group A *Streptococcus* (GAS) is a well-known pathogen of the skin and pharynx. Other reservoirs include the rectum and the female genital tract. Major modes of transmission are direct contact and large droplets. An increased incidence of wound infections by GAS should be investigated, focusing on carriage by HCWs. HCW’s with overt infection due to GAS should be restricted from work until 24 hours after adequate therapy has been given or until cultures are proven to be negative. Overall, the risk of transmission of GAS from HCW to patients is considered low.

**Herpes simplex.** Herpes simplex type I can be transmitted from HCWs to patients through primary or recurrent lesions. Most infections are orofacial and transmitted by direct contact. Saliva also can be infectious. Because the main route of transmission is by contaminated hands after direct contact with the lesion, hand washing and disinfection before and after patient contact are the most important methods for preventing transmission to patients. Herpes simplex lesions of the fingers (herpetic whitlow) are an occupational disease of HCWs due to direct exposure to contaminated fluid such as vaginal secretions or skin lesions. Healthcare workers with herpetic whitlow must use gloves to prevent the spread of the herpes virus to patients. When caring for patients at risk of severe infection, such as preterm neonates, patients with severe malnutrition, severely burned, or immunocompromised patients, restriction of work of HCWs with herpes infections can be considered.
Enteric Diseases

**Acute Diarrhea.** Transmission of most microorganisms causing diarrhea in HCWs is by direct or indirect contact. Careful hand washing hygiene, especially after visiting the bathroom, is the most important measure for preventing transmission of these pathogens. Until they are better, healthcare workers with acute infectious diarrhea should not care for patients. Even after resolution of the acute disease, HCWs may still carry enteric pathogens.

HCWs can be asymptomatic carriers of *Salmonella* spp or *Campylobacter* spp during the convalescent period or a protracted period thereafter. Testing for carriage may be unreliable and is therefore usually limited to food handlers, who are more likely to transmit disease to others. Careful hand washing after using the bathroom and before patient contact will prevent the transmission of enteric pathogens from most carriers. Antibiotic treatment is rarely indicated.

In case of norovirus, HCWs can be an important link in outbreaks in the hospital: they bring in the virus, get ill suddenly and spread by vomiting to their colleagues and patients. On the other hand, they can be infected by patients. Patients should be isolated, HCWs should be sent home during active diseases. By PCR diagnosing and monitoring is possible. During an outbreak, hand hygiene should temporarily be by high concentration of alcohol solutions.

**Hepatitis A.** Hepatitis A occurs rather infrequently as a nosocomial infection. Prevention of transmission is through maintaining personal hygiene, especially through hand washing.

Respiratory Diseases

**Common Cold.** The common cold in adults is caused by the parainfluenza virus, adenovirus, rhinovirus, or respiratory syncytial virus. Healthcare workers are important sources of these viruses to patients. In general, to prevent nosocomial transmission from HCWs to patients, infected HCWs should wash or disinfect their hands carefully before patient contact. The use of masks is optional but may be helpful in preventing transmission due to large droplets upon close contact. Routine use of gloves has no additional benefit; even if gloves are used, hands should
be washed after gloves are removed. In most people, viral upper respiratory infections are self-limiting. However, in immunocompromised patients, such as recipients of bone marrow transplants, these infections may progress to severe lower respiratory tract diseases with very high mortality rates. Infection control strategies include identifying, cohorting, and isolating of infected patients and limiting contact of symptomatic HCWs and visitors with at-risk patients. Work restrictions for symptomatic HCWs may be considered.

**Influenza.** Influenza epidemics are well known in hospitals. Transmission occurs from HCWs to other HCWs and patients, and from patients to HCWs and other patients. Hospital infection committees should implement an influenza vaccination program each year, several weeks before the influenza season. There is evidence that vaccination is associated with decreases mortality, the number of febrile respiratory illnesses and days of absence of the HCW. During periods of influenza activity, personnel with acute febrile respiratory infections should not provide care to high-risk patients. The incubation period is 1 day before onset of symptoms and the period of communicability is from 1 day before until 7 day after onset of symptoms. Additionally, profylactic antiviral agents may be used. The hospitals should have written guidelines in case of avian flu in patients and HCWs and in case of pandemic situations.

**Pertussis.** Vaccination of adults with whole-cell *B. pertussis* vaccine is not recommended, because of local and systemic reactions. The acellular vaccine has been used for attempted control of hospital pertussis outbreaks, but clinical effectiveness has not been proven.

**Varicella Zoster.** Varicella zoster virus causes varicella or chickenpox in childhood. After years, due to reactivation, the virus can manifest as skin lesions (zoster or shingles), which may be widely disseminated in immunocompromised patients. Those lesions can be infectious to others through direct contact and cause varicella in susceptible persons.

Varicella is one of the most common hospital-acquired diseases among HCWs. It is a highly contagious disease, and exposure to the virus is common in the healthcare setting.
Most persons with a clear history of chickenpox in childhood are probably immune. Persons with a negative history can be immune but should be tested. Susceptible HCWs can acquire infection after exposure to infectious patients. Nonimmune HCWs exposed to varicella should be excluded from work from day 8 to 21 after contact, to ensure that secondary infection has not occurred. If the HCW develops disease, he/she should be excluded from work until all lesions are dry and crusty. Since such a policy regarding work restriction is very expensive, vaccination of all susceptible workers should be done. A live-attenuated varicella vaccine was licensed for use in the United States, but not in all countries. Vaccination provides approximately 70% protection against infection and 95% protection against severe disease for 7 to 10 years after vaccination. Vaccination of HCW’s is proven to be cost-effective.

**Measles.** Measles is transmitted by the airborne route. The same strategy as has been recommended for varicella-susceptible HCWs can be followed for susceptible HCWs exposed to measles. Prompt identification of HCWs with rash and fever will help prevent further spread of this virus.

**Tuberculosis.** The infection Control Committee should indicate high-risk wards, were HCW’s are routinely screened on tuberculosis. After conversion of the Mantoux test, or positive other newly developed screening tests, profylactic treatment is indicated to prevent open tuberculosis which is contagious for patients. Furthermore, all HCWs reporting symptoms suggestive of tuberculosis should have a medical examination and a chest radiograph. Suggestive symptoms are cough for more than 3 weeks, persistent fever, and weight loss. After identifying an HCW suffering from open tuberculosis, a prompt evaluation of all contacts must be instituted. Stringent measures regarding work restrictions are necessary. Healthcare workers should be receiving effective treatment and have negative sputum smears before returning to work. Bacille Calmette-Guérin (BCG) vaccination should be considered for all tuberculin skin test negative HCWs, unless previously vaccinated, in countries where tuberculosis is endemic or in hospitals where exposure to infectious TB cases is likely.
Bloodborne Diseases
The management of HCWs infected with bloodborne pathogens has been reviewed by the AIDS/TB committee of the Society for Healthcare Epidemiology of America (SHEA). In general, prevention of infection is based on appropriate infection control procedures to avoid blood contact from patient to HCW and from HCW to patient. The major emphasis is on applying blood precautions, practicing hand washing, minimizing contact with blood or blood-contaminated excretions, and handling all blood as potentially infectious. Education concerning bloodborne pathogens for all healthcare workers is recommended, not just those who are already infected.

Hepatitis B. Immunization with the hepatitis B virus (HBV) vaccine is the most important measure to prevent infection of the HCW by HBV. Each hospital must develop an immunization strategy. Healthcare workers with active HBV or those who are carriers of HBV are at risk for transmitting HBV to others. The risk of transmission of HBV is higher than that of the hepatitis C virus or human immunodeficiency virus, as is reflected in 38 outbreaks of HBV by HCW-to-patient transmission in the past 22 years.

Vaginal hysterectomy, major pelvic surgery, and cardiac surgery are associated with HBV transmission despite the use of good infection control procedures. With these surgeries, the chances of needle-stick injuries are presumably greater. Before increased use of infection control interventions, the risk of HBV transmission was also associated with dental procedures. The presence of hepatitis B e antigen (HBeAg) in the HCW concerned in transmission was almost always the case except in one instance. These cases have high numbers of HBV-DNA copies (>10^5 copies/ml) Another route of transmission can be by hepatitis B surface antigen (HBsAg)-positive HCWs with exudative dermatitis on body areas that may come in contact with patients.

In the SHEA position paper, it is recommended that HBeAg-positive HCWs should be restricted from practice of gynecologic or cardiac surgery or performing dental procedures. The risk of transmission to patients, despite appropriate use of infection control measures, was considered to be too high. Treatment of the HBV infection can possibly decrease the
number of copies of HBV-DNA below critical levels. Furthermore, it is recommended that HBV-positive HCWs should double-glove routinely for all procedures in which their blood or body fluids may come in contact with patients.

When patients are exposed to an HCW’s blood or body fluids, testing of the HCW for bloodborne pathogens should be done.

**Human Immunodeficiency Virus (HIV) and Hepatitis C Virus (HCV).** The risk of transmission of HIV is probably 100 times lower than hepatitis B, with that of HCV being somewhere between HIV and HBV. Healthcare workers known to be infected with HIV or HCV are strongly recommended to follow universal precautions as recommended in their hospital to minimize the risk of infection to others. Using double gloves for procedures is recommended. HIV- and HCV-infected HCWs should not be prohibited from patient care activities solely on the basis of their infection. Healthcare workers need not be screened routinely for HIV or HCV infection, except in cases of significant exposure of a patient to the blood or body fluid of an HCW.

**AIDS.** Healthcare workers infected with HIV can be infected with HIV-associated pathogens. In turn, these pathogens can be transmissible to patients. Examples are *Mycobacterium tuberculosis*, varicella zoster, and measles by aerogenic spread and *Salmonella* spp, *Cryptosporidium* spp, and all other enteric pathogens via fecal-oral exposure. For prevention of transmission, see the relevant part of this chapter.

**Vaccine-Preventable Diseases**

Healthcare workers may be exposed to vaccine-preventable diseases and then, after contracting the disease, be infectious to patients. It is recommended that HCWs be vaccinated or have demonstrated immunity to certain vaccine-preventable diseases. The infection control committee of each hospital has to develop policies requiring proof of immunity or, if needed, offer vaccination. Herd immunity of the hospital community cannot be relied on, and unvaccinated HCWs are a potential risk to patients. For HCW’s, the following diseases are vaccine-preventable and can be transmitted to patients during healthcare work; varicella, measles, pertussis, influenza A, hepatitis B, hepatitis A and to some extent tuberculosis.
<table>
<thead>
<tr>
<th>Immunization Available</th>
<th>Work or Patient Contact Restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scabies</td>
<td>Until cleared by medical evaluation</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>Actively draining lesion</td>
</tr>
<tr>
<td></td>
<td>Proven transmission</td>
</tr>
<tr>
<td></td>
<td>With search-and-destroy strategies, MRSA carrier should be restricted until successfully treated</td>
</tr>
<tr>
<td>Group A <em>Streptococcus</em></td>
<td>Until 24 hours adequate therapy, or proven negative cultures</td>
</tr>
<tr>
<td>Herpes simplex</td>
<td>In case of whitlow and caring for immunocompromised patients including neonates</td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>Until 7 days after onset of jaundice</td>
</tr>
<tr>
<td>Common cold viruses <em>(see text)</em></td>
<td>Consider contact restriction with high-risk patients (e.g., bone marrow transplants)</td>
</tr>
<tr>
<td>Influenza</td>
<td>Consider contact restriction with high-risk patients (e.g., bone marrow transplants)</td>
</tr>
<tr>
<td>Varicella</td>
<td>In case of active disease, postexposure in susceptible persons: day 8–21</td>
</tr>
<tr>
<td>Pertussis</td>
<td>In case of active disease</td>
</tr>
<tr>
<td>Measles</td>
<td>In case of active diseases, postexposure in susceptible persons: day 5–21</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>In case of active disease</td>
</tr>
<tr>
<td>HBV</td>
<td>Refer to local regulations: restriction from high-risk procedures.</td>
</tr>
<tr>
<td>HCV</td>
<td>Refer to local regulations</td>
</tr>
<tr>
<td>HIV</td>
<td>Refer to local regulations</td>
</tr>
</tbody>
</table>

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CHAPTER 12

ANTIBIOTIC RESISTANCE

Richard P. Wenzel, MD, MSc

Key Issue
Begun in the 1940s, the antibiotic era is under 70 years’ duration, yet now is challenged by the worldwide increase in the incidence of resistance by microorganisms.

Known Facts

• In the community, penicillin-resistant pneumococci and multidrug-resistant tuberculosis are major public health problems. These organisms also have become significant nosocomial pathogens. A more recent issue is the emergence of community-acquired methicillin-resistant *S. aureus* (CA-MRSA). A more virulent strain of *C. difficile* with higher than usual toxin production has caused epidemics in Canada and the U.S.

• In hospitals throughout the world, there are special problems with methicillin-resistant *Staphylococcus aureus*—both nosocomial and the new strains of CA-MRSA.

• The explosion of infections with vancomycin-resistant *Enterococcus faecium* in hospitals in the United States has been remarkable. Much lower rates have been reported from Europe.

• Resistance of gram-negative rods to quinolones and third generation cephalosporins continues to increase. Some strains of Acinetobacter hospitals are susceptible only to colistin.

• The emergence of strains of *S. aureus* with intermediate levels of resistance to vancomycin (VRSA) has been noted in several countries. These strains have MICs of 8 µg/ml. In 2002, two strains of *S. aureus* with high levels of resistance to vancomycin (VRSA) were reported in the United States. These strains have MICs ≥ 32 µg/ml. As of November 2007, five patients in the U.S. have been identified with infections due to VRSA.
Unless we pay attention to the problem of antibiotic resistance, we will quickly run out of effective therapy. Unfortunately, the problem of resistance comes at a time when fewer pharmaceutical companies are in the business of developing new antimicrobials. Thus, the pipeline of new drugs is limited.

**Controversial Issues**

- The causes of antibiotic resistance are not clearly known, but surely **unnecessary use of antibiotics** is important. Such high use leads to the selection of resistant organisms. Once a patient has a resistant organism, then the possibility exists for transmission to other patients. The initiating problem is the selection of a resistant isolate under the “pressure” of antibiotic usage.

- A second issue is excellent **infection control**—isolation and hand washing—to minimize spread of antibiotic resistant isolates. Exactly what proportion of the level of resistance stems from poor infection control is unclear, but is thought to be higher for Gram positive than Gram negative organisms.

- The third issue relates to the **influx of patients** harboring resistant strains on admission to the hospital. Thus, the issue is a need for quickly identifying patients and isolating them on admission. This requires labeling the charts of patients previously known to be infected with or carriers of antibiotic-resistant pathogen. When the patient enters the hospital, he or she should be automatically placed in appropriate isolation. It remains unclear at what level of resistance it is no longer cost effective to maintain a program of isolation on admission. However, there are some data suggesting its usefulness in controlling the rates of MRSA.

The level of resistance in hospitals to antibiotics can be considered to be influenced by three major parameters: how much enters in institution, how much is selected *de novo* or afterwards, and how much spread as a result of poor infection control. Imagine that one wanted to know what contributed to the current rate of MRSA (*see next page*):
Suggested Practice
Three areas for control of this problem are as follows:

1. Minimize the use of antibiotics to limit the selection and emergence of a resistant clone.

2. Maximize good hand washing and isolation practices to limit transmission of any antibiotic-resistant organisms that may emerge in the hospital to enter with a new patient.

3. Develop systems to identify quickly and isolate immediately all new patients who might be carrying an important antibiotic-resistant pathogen. This may be accomplished by marking the charts of patients previously known to be carriers or by isolating all patients coming from another facility known to have a high number of antibiotic-resistant organisms.

4. Begin to develop policies for changes in both empiral therapy and perioperative prophylaxis should nosocomial strains of CA-MRSA become more prevalent.

References


CHAPTER 13

MANAGING ANTIBIOTIC RESISTANCE: WHAT WORKS IN THE HOSPITAL

Amy L. Pakyz, PharmD, MS and Denise R. Kockler, PharmD, BCPS

Key Issue
Antibiotic resistance in the healthcare setting has emerged as a key factor for impacting patient outcomes and healthcare-related costs. Globally, an increase in the prevalence and transmission of antibiotic-resistant bacteria in hospitals has been reported.1,2 Because of the serious clinical and financial implications of antibiotic resistance, several strategies to control and reduce its burden have been proposed. To date, the most effective strategy includes a multidisciplinary approach that includes core individuals (ie, hospital administrators, Infectious Disease physicians and clinical pharmacists, epidemiologists, and clinical microbiologists) who are responsible for developing, implementing, and monitoring policies, directing active surveillance, conducting prospective audits with intervention, and providing active education.3

Known Facts

• Antibiotic resistance has increased in both community and hospital settings in the past several decades. It is known to be more common in hospitalized settings, primarily in intensive care units, although use of antibiotics in the community setting is often the origin of hospital antibiotic resistance.1
• Nearly every bacterial pathogen has displayed clinically important resistance to antibiotics.1 Mechanisms for resistance include genetic transmission (conjugation, transformation, and transduction) and biological modalities (destruction, transformation, active efflux, and receptor modification).4
• Resistance to antibiotics can be classified as intrinsic or acquired, and can be transmitted vertically or horizontally, with horizontally being the most significant means for emergence and spread.1,5
• Indiscriminate use of antibiotics is a major factor in promoting antimicrobial resistance. Other factors that contribute to the entry of resistant pathogens into hospitals include: the transfer of patients with resistant pathogens from other healthcare facilities; patient-to-patient transfer of pathogens from poor hand hygiene practices; transfer of resistant genes among organisms.²

• Common problem bacterial pathogens include penicillin-resistant *Streptococcus pneumoniae*, methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), multidrug-resistant gram-negative bacilli, and *Clostridium difficile*.¹²⁴

• The burden of antimicrobial resistance includes increased patient-related morbidity and mortality and higher healthcare costs.³

• Adoption of new strategies designed to delay or prevent resistance is crucial since the introduction of new antimicrobial drugs into the market has substantially declined.⁵

• Antimicrobial stewardship and infection prevention and control programs are the two key initiatives employed in combating the emergence and transmission of antibiotic resistance.³⁴

**Controversial Issues**

• Antibiotic cycling is defined as substituting one antibiotic or antibiotic class with similar activity for another during a specified time period. For cycling to be complete, reintroduction of the original antibiotic or antibiotic class must occur.¹
  – Factors such as patient allergies, drug-drug interactions, adverse drug events, restrictive formularies, and differences with national guidelines, impact the success of antibiotic cycling. Trials evaluating antibiotic cycling have reported a protocol non-adherence rate ranging from 10 to 50%, which makes it difficult to isolate the cycling effects on resistance patterns.³
  – Short-term reductions of selection pressure and decreases in resistance to the restricted antibiotic or antibiotic class have been reported when cycling has been applied. Nonetheless, if the resistance determinant is not removed
from the bacterial population when the original antibiotic is reintroduced, selection for the expression of the resistance determinant in the exposed bacterial population will likely occur.³

- Combination antibiotic therapy as a strategy for solely preventing antibiotic resistance is questionable. Bacteria associated with high bacterial burden and frequent mutational resistance (e.g. *Mycobacterium tuberculosis*) has been targeted with combination therapy; however, this practice has not been shown to be effective for other pathogens.³

- Formulary restrictions and pre-authorizations are methods often applied to broad-spectrum antibiotics and those antibiotics associated with rapid resistance.
  - Results of clinical trials have not demonstrated a reduction in the overall emergence of antibiotic resistance among bacteria when restrictions or pre-authorizations have been utilized. Rather, the introduction of new or different antibiotic-resistant bacterial strains within the hospital setting has been reported.³
  - Use of restrictions and pre-authorizations has been successful in specific outbreaks of infection with antibiotic-resistant bacteria, particularly in conjunction with infection control practice and educational activities.³

- More research is needed regarding which specific infection control and prevention practices are most beneficial in the setting of outbreaks with multidrug-resistant organisms. For example, questions remain about when Standard Precautions alone is adequate versus Standard Precautions plus Contact Precautions, with or without active surveillance cultures.⁴

- The optimal circumstances for acquiring active surveillance cultures and for which populations is still unknown.⁴

- As most infection control studies have been conducted in the acute care setting, optimal infection control practices in non-acute healthcare settings such as long term care facilities and smaller rural hospitals are unknown.⁴

- The optimal duration for Contact Precautions for patients infected with multidrug-resistant organisms, especially in the setting of colonized patients has not been established.⁴
• The impact on patient care when patients are placed on Contact Precautions is not fully understood. One study reported that patients on Contact Precautions experience more preventable adverse events, have greater dissatisfaction with their care, and have less documented care than patients not on Contact Precautions.4,6

**Suggested Practice**

**Judicious Use of Antimicrobials:**
The Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America developed a guideline document entitled: Guidelines for Developing an Institutional Program to Enhance Antimicrobial Stewardship.3

Hospitals are encouraged to implement a multidisciplinary antimicrobial stewardship team that includes among its core members an infectious diseases physician and clinical pharmacist with infectious diseases training. Other important members of this team include a hospital epidemiologist, a clinical microbiologist, an information system specialist, and infection control professional.

**Key Strategies: Antimicrobial Selection and Utilization:**
The following are recommended core strategies:

• Prospective audit with intervention and feedback
  – Evaluate prospectively antimicrobial use and providing direct feedback to the prescriber
• Antimicrobial formulary restriction/preauthorization
  – Evaluate antimicrobials for inclusion on hospital formulary and restrict their use through formulary limitation or required preauthorization/justification

The following are recommended elements of an antimicrobial stewardship program depending on an institution’s resources, local antimicrobial use, and antimicrobial resistance problems:

• Education
• Guidelines and clinical pathways
• Antimicrobial order forms
• Streamlining or de-escalation of therapy
• Dose optimization
• Parenteral to oral conversion
Infection Prevention and Control Program:
The transmission and endurance of a problem pathogen in a healthcare institution depends on the patient base, selective pressure from antimicrobial use, and the number of patients colonized or infected with the problem pathogen.

A combination of interventions may need to be employed to prevent and control the spread of problem pathogens. Types of interventions used by institutions may vary depending on the types and significance of problem pathogens, the population of the institution, and available resources.

The Healthcare Infection Control Practices Advisory Committee (HICPAC) developed a guideline document concerning the management of multi-drug resistant organisms in healthcare settings.4

In addition to following Standard Precautions for all patient encounters, the following are some recommended strategies:
- Improvements in hand hygiene
- Use of Contact Precautions in patients with a multidrug-resistant organism until patients are culture-negative
- Active surveillance cultures
- Education
- Enhanced environmental cleaning
- Cohorting of patients
- Decolonization
- Improvements in communication regarding patients with multidrug-resistant organisms between healthcare institutions

Key components of every antimicrobial stewardship and infection prevention and control programs include:
- Administrative support
  - Seek and acquire the support of hospital administration and medical staff leadership for fiscal and human resources
- Ongoing surveillance on a regular interval
  - Measure antimicrobial use and track use
Monitor and track antimicrobial resistance trends (antibiograms) and newly emerging problem pathogens

Measure the effectiveness of interventions

• Education/Feedback
  – Provide educational interventions and training to medical care providers
  – Disseminate information about program outcomes

Additional Preventive Practices:
Guidelines for preventive practices are also included in the Center for Disease Prevention and Control’s Campaign to Reduce Antimicrobial Resistance in Healthcare Settings.7

This initiative focuses on four overall strategies to guide clinicians in an effort to prevent the emergence of drug resistance in hospitals:

• Prevent infection
  – vaccinate (protect)
  – remove indwelling lines

• Diagnose and treat infection effectively
  – target the pathogen
  – consult with the experts

• Use antimicrobials wisely
  – practice antimicrobial control
  – use local data
  – treat infection not colonization
  – treat infection not contamination
  – know when to say “no” to vancomycin
  – **Stop** treatment when infection is cured or unlikely

• Prevent transmission
  – isolate the pathogen
  – **Break** the chain of contagion

Antibiotic resistance is increasing worldwide, and is associated with severe morbidity, mortality, and increased healthcare-related costs. A collaborative practice approach between clinicians, public health practitioners, and administrators needs to be implemented to help manage this serious infectious disease issue.
References


CHAPTER 14

ORGANIZING AND RECORDING PROBLEMS INCLUDING EPIDEMICS

Samuel R. Ponce de León, MD, MSc and Alejandro Macias, MD, MSc

Key Issue
Surveillance is the foundation for organizing and maintaining an infection control program.

Known Facts

- Reviewing patient records, interviewing nurses and physicians, and reviewing microbiology results give the infection control team an accurate view of the frequency and type of nosocomial infections. At the same time, these activities give the infection control team or nurse a highly visible profile to all services and personnel, which can result in changes in clinical practices.

- Frequently visiting the clinical units allows for the early detection of outbreaks (there being no other way to detect an epidemic in the earliest stage) and provides information necessary to maintaining the functioning of the overall program.

- Ongoing surveillance provides the results needed to conduct a continuous evaluation of the interventions begun by the infection control committee. Based on these results, infection control regulations and policies may need to be changed. Surveillance is the most effective way of maintaining continuous improvement.

- Reporting surveillance results is an essential element for an effective infection control program. Reports to clinical services must be regular, periodic, and presented in a non-antagonistic way to encourage change. For infection control activities to succeed, the program must include personnel dedicated exclusively to surveillance.
The frequency of nosocomial epidemics in developing countries is higher than that reported in the United States. This problem can be particularly severe in neonatal intensive care units because:

1. the functioning of these units includes multiple invasive devices without organized procedures and policies to prevent infectious complications; and
2. disposable devices such as catheters, hemodialysis filters, and even needles are reused without appropriate sterilization, a practice that is sometimes unavoidable because of financial considerations.

The organization of a nosocomial infection program should start with a surveillance system. Surveillance is the central activity from which all other related actions are sustained. Passive surveillance is not an accurate or effective method of infection control; surveillance must be active and continuous, in some cases focused on the highest risk areas. The extent (focal or hospital-wide surveillance) of this activity depends on hospital needs and resources.

Hospitals without microbiology laboratory must make every effort to have one to perform, at least, critical test such as blood cultures.

Surveillance provides information on the type of pathogens, the frequency of nosocomial infections, the location of nosocomial infections, and the trends over time. Periodic reports should be brief and clear. If possible, reports should be evaluated monthly at the infection control committee meeting. The results can be given as ratios and incidence (or incidence density, i.e. the number of cases/1000 patient-days) for all nosocomial infections and by site of infection related to the total number of admissions in the period (per month) by service (e.g., intensive care unit, internal medicine, pediatrics, surgery, obstetrics).

Outbreak surveillance in the hospital relies on day-to-day visits to the clinical area, the results of the clinical microbiology laboratory, and spontaneous calls from different wards. The system ideally should detect two or three associated cases as soon as they appear and not after several cases or deaths have occurred.
• Epidemics occur most frequently in intensive care areas. In developing countries, neonatal intensive care units have the highest risk for both nosocomial infections and deaths. These epidemics are most commonly caused by bloodstream infections due to contamination of intravascular lines and infusates. Inappropriate handling and storage of multiple vials for small doses of medications to the neonates, the use of glucose infusions that remain in use open during hours and days, and the lack of hand washing in an overcrowded unit with shortage of personnel and inadequate design are other predisposing factors.

• When confronting an outbreak of nosocomial infection, reports in the literature are a valuable resource for preparing investigation and control.

Controversial Issues

• Definitions of nosocomial infections may be controversial. Definitions must be understood as tools for surveillance and will not always concur with the clinician’s view. For example, a patient with fever for a few hours and positive blood and catheter tip cultures for *Staphylococcus epidermidis* should be recorded as a nosocomial infection even if the clinician does not prescribe specific treatment and the fever disappears with the withdrawal of the line. On the other hand, clinicians tend to diagnose pneumonia more liberally than infection control personnel.

• Definitions must be simple and meet hospital purposes. Hospitals without microbiology support can develop definitions based exclusively on clinical data. The Pan-American Health Organization (PAHO) has published a booklet with clinical definitions. The definitions proposed by Wenzel may be useful for hospitals with limited resources.

Summary

Hospital-wide surveillance is needed to start a program to identify the highest-risk areas. There is a trend to focus surveillance in high-risk areas, specifically intensive care units, because of the efficiency of detecting the most severe nosocomial infections and the most frequent epidemics is very high compared with hospital-wide surveillance. However, for hospitals beginning
surveillance, it may be better to institute a hospital-wide system in order to know the particular characteristics of the institution. This will also facilitate the collection of endemic rates in every ward. With time, surveillance activities may be limited to high-risk areas.

Control of epidemics requires a reinforcement of general measures of infection control. The infection control team should talk to the personnel on the wards, emphasizing hand washing, isolation practices, and stringent adherence to procedural recommendations. Depending on the characteristics of the outbreak, specific recommendations must be given.

A frequent practice when confronting an epidemic is to close the unit and fumigate the area instead of following infection control recommendations. This approach is costly and is not helpful.

**General Recommendations for Surveillance**

- Surveillance must be based on practical definitions.
- Surveillance must be continuous on wards and the microbiology laboratory.
- For every instance of suspected nosocomial infection forms should be filled out recording diagnosis, age, ward, dates of admission and discharge, outcome, type of infection, and etiologic agent.
- Monthly results of surveillance should be reported to the clinical services in a simple format and the results presented at the infection control meeting. Decisions to improve infection control need to be discussed and implemented.

**General Recommendations In Epidemics**

- *An epidemic is an infection control emergency;* measures should be taken as soon as an epidemic is suspected.
- The first step on controlling an epidemic is to reinforce general recommendations of infection control in the ward where the cases are occurring. A case definition is made (e.g., *Enterobacter cloacae* bacteremia in neonates in the neonatal intensive care unit) and then current case rates are compared to previous rates (pre-epidemic period).
- After reviewing cases, additional recommendations should be given to the staff in order to prevent new cases.
From evidences, sound working hypothesis must be established to avoid wrong conclusions and unnecessary closure of medical wards. *Table 14.1* shows some examples of these hypotheses.

- A case-control study should be performed to identify specific risk factors. Maintain frequent communication with the clinical staff in the unit or ward involved and give them all relevant information from your analysis.

| Table 14.1 Evidence-based Working Hypothesis to Study and Control Common Hospital Outbreaks |
|-----------------------------------------------|--------------------------------------------------------------------------------------------|
| **Outbreak**                                  | **Working hypothesis**                                                                     |
| Gram negative bacteremia in neonates          | Contaminated intravenous lines or infusates                                                |
| Candidemia                                    | Contaminated parenteral nutrition solutions                                                |
| Ventilator-associated Gram negative pneumonia | Contaminated respiratory equipment                                                         |
| Streptococcal surgical site infection          | Healthcare worker carrier of Group A streptococcus                                         |
| Tuberculosis                                  | Exposure to TB patient without effective respiratory protection                             |
| Diarrhea in children                          | Exposure to rotavirus (or other viruses) without effective contact precautions              |
| Diarrhea in adults                            | Prolonged use of antibiotics and absence of adequate source control                        |

After the analysis you may be able to identify one or several risk factors and suggest changes to prevent future outbreaks. If not, in most cases the study and interventions should be able to contain the epidemic.

The organization of an infection control program in a hospital with very limited resources requires determination and good relations with the clinical staff. Because cutting costs is a constant goal for most hospitals, explaining the cost benefits of infection control procedures will help gain support for the program. It is worthwhile to calculate the savings and the implicit improvements in quality of care derived from the program.

Maintain good channels of communication. The authorities must feel and know that the program is solving problems.
instead of creating them. The fearful perceptions regarding nosocomial infections must be changed. The attitude of the infection control group should be optimistic and creative; and there is always the possibility of improvement, even if the level you reach is not the same as those reported by others.

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CHAPTER 15

KEEPING THE ENVIRONMENT SAFE WITH LIMITED RESOURCES

Adriano G. Duse, MT, MBBCh, DTM&H, MMed (Microbiology), FCPath (SA)

Key Issues
Ever-increasing budgetary constraints and contracting out cleaning services have resulted in an overall deterioration in hospital hygiene practices in healthcare facilities of many developing countries.

With the exception of immunocompromised patients the healthcare facility environment is rarely implicated in disease transmission.

Although inadvertent exposures to environmental pathogens (e.g., *Legionella* spp. and *Aspergillus* spp.) or airborne pathogens (e.g., *Mycobacterium tuberculosis*) may cause infection in patients and healthcare workers, these can be effectively minimized by infection control strategies.

In addition to reducing potential reservoirs for microorganisms, environmental cleaning has an important aesthetic purpose and is crucial for patient confidence.

Environmental aspects covered in this chapter include air, water, surfaces, carpets, specialized patient-care areas, linen, flowers and waste disposal.

Known Facts

- **Air.** The role of air in the transmission of microorganisms is best discussed on an organism-specific basis. Airborne transmission of *Mycobacterium tuberculosis*, Varicella-zoster, measles and influenza viruses is clearly established, and guidelines to reduce risks of transmission are available (CDC). Shedding or dispersal into the air of Gram positive organisms such as *Staphylococcus aureus* and *Streptococcus pyogenes* in operating theatres or newborn
nurseries has been documented. *Legionella pneumophila* outbreaks have been associated with contaminated cooling towers and *Aspergillus* and other fungal spores are easily dispersed through the air during building constructions/renovations/maintenance.

- **Water.** There are numerous reports in the literature detailing the association of nosocomial infections with medical devices (e.g., respiratory therapy equipment, fiberoptic endoscopes etc.) that have been exposed to contaminated hospital water reservoirs (e.g., potable tap water, sinks, faucet aerators, etc.). Furthermore, environmental water reservoirs have been convincingly associated with infection involving aerosolization from these sources: faucet aerators associated with *Pseudomonas* infections and showerheads associated with *Legionella*. Ice machines have been implicated in the transmission of various pathogens including *Cryptosporidium parvum*.

Several reports have linked hydrotherapy pools and tanks with infection. The combination of organic debris from infected patients and elevated temperatures in these reservoirs favors growth of microorganisms.

- **Carpets.** The evidence that carpets are associated with infection risks is scant. If carpets are installed they should be washable, have waterproof backing and sealed joints, and not be damaged by application of commonly used disinfectants. To prevent fungal growth, wet carpets should be thoroughly dried. It is prudent to avoid carpets in isolation wards, high-traffic zones, and areas with frequent or large-volume blood and other body fluid spillage such as surgical and obstetric wards.

- **Specialized Patient Care Areas.** The role of the operating room environment in causing surgical site infections is dealt elsewhere in this handbook.

The use of ultraclean rooms for certain patient categories in a general hospital remains controversial. These facilities are expensive and do not seem to provide clear benefit.
• **Linen.** Bed linen can become rapidly contaminated with colonized skin scales. Frequent changing is therefore of limited value. Linen should be changed on discharge of the patient or if it becomes soiled, wrinkled, stained or contaminated with potentially infective material. Curtains should be washed if visibly soiled, or on a scheduled (e.g., 6-monthly) basis. Consideration may be given to changing curtains in certain outbreak situations. Linen has rarely been associated with transmission of microorganisms.

• **Plants/Flowers.** Although potted plants and flowers (particularly vase water) are well-established reservoirs of opportunistic pathogens, epidemiological evidence linking these to nosocomial infections is lacking. Since the mechanism for transmission requires that a plant or vase water is handled, hands become contaminated and patient care is subsequently provided, hand washing after handling these items should eliminate the risk of hand contamination.

• **Waste Disposal.** There is no evidence to suggest that most clinical (potentially infectious) waste (with the possible exceptions of microbiological waste and contaminated syringe needles) constitutes a significant public hazard. Household waste contains at least 100 times as many potential human pathogens as clinical waste. Segregation of clinical and domestic wastes in healthcare settings is important to contain costs, and avoid accidents and litigation. In areas where municipal waste disposal is not provided, e.g., in some developing countries and rural areas, burning and burial of waste is common.

**Controversial Issues**

• The extent to which environmental reservoirs contribute to nosocomial infections remains controversial. High levels of hygiene are difficult to defend when there is paucity of scientific evidence to support cleaning practices.

• Use of detergents versus disinfectants for environmental (surfaces, noncritical) cleaning.

• Impact of disinfectant use on the emergence of antimicrobial resistance and need for biocide rotation.

• Microbiological sampling of the environment.
Suggested Practice

General

- Meticulous hand washing is extremely important in preventing the transmission of microorganisms from the environment to patients, since most pathogens that may survive for prolonged periods of time in the environment are most likely to be transmitted by hand transfer. The use of non-aqueous, alcohol-based hand antiseptics is ideally suited to healthcare facilities where hand washing facilities are scant and water is scarce.

- The environment should not be conducive to the multiplication of microorganisms and should be kept dry, clean, well-ventilated and exposed to sunlight. Maintaining surfaces and equipment dry is important, as wet surfaces and equipment promote microbial growth and possible spread of pathogens.

- Cleaning procedures should be defined, applied consistently, and compliance to these validated. Cleaning personnel should be properly trained and responsibility for implementation of cleaning practices needs to be assigned.

- Products used for cleaning and decontamination of the environment should be used according to the hospital policy, manufacturer’s instructions, and available scientific information.

- Infrequently touched (“non-hand-contact”) environmental surfaces should be cleaned with a detergent when visibly soiled and as required to maintain an aesthetically pleasing environment.

- Dedicated non-critical equipment should be used on patients infected with multiply antibiotic-resistant organisms. If this is not possible, shared non-critical items must be cleaned and disinfected between patient use.

Specific Interventions

- **Air.** Good air management is difficult to achieve in many healthcare facilities. An air maintenance programme should be in place and filters should be replaced periodically. Air-related outbreaks of legionellosis or aspergillosis,
particularly in facilities where there are immunocompromised patients, prompt immediate investigation and consultation with a competent engineer. Potential sites of contamination need to be determined and appropriate corrective action must be taken. Patients with an airborne communicable disease (e.g., TB) should be isolated in a single room, if possible, or cohorted. Rooms with good airflow (open windows in many rural hospitals, use of extractor fans to the outside environment, or high volume ventilation greater than six air changes per hour including a good fresh air mix) have a much reduced risk of TB transmission. Use of ultraviolet germicidal irradiation may be considered in designated enclosed areas or booths for sputum induction. In rural healthcare facilities, where engineering controls are lacking, collection of sputum in sunny, open-air environments (outside the building) is advocated.

- **Water.** Legionellosis is an important disease for which an environmental reservoir (warm water in buildings) has been identified and for which specific preventive measures (e.g., water system management, superheating and/or use of biocides such as chlorine and bromine) are well described and advocated.

Hydrotherapy pool water should be adequately filtered and chlorinated, hydrotherapy tanks should be cleaned thoroughly between each treatment and sharing of facilities by patients with open skin lesions should be avoided.

Hemodialysis water has been clearly demonstrated to cause pyrogenic reactions (from endotoxins from Gram negative bacteria) and/or bacteremia. Several types of bacteria are capable of surviving and multiplying in distilled, deionised, reverse osmosis and softened water, all of which may be used in hemodialysis. Water used to prepare dialysis fluid and the dialysate should be sampled monthly and should contain ≤200 colony forming units (cfu)/ml and ≤2000 bacteria/ml respectively. A proposed new standard (RD 52, under development, American National Standards Institute, Association for the Advancement of Medical Instrumentation) recommends that the microbiologic limits for hemodialysis fluids be dropped to ≤200 cfu/ml for
dialysate and that endotoxin levels in both dialysis water and the dialysate should not exceed 2EU/ml). It should be noted that the more stringent standards become the more difficult and impractical it becomes to implement these in developing countries.

Healthcare facilities should develop a routine maintenance programme for water filtration equipment to prevent bacterial overgrowth in filters and replace faulty ones. Water used for hand washing in oncology wards, diluting disinfectants, hemodialysis units, and rinsing semi-critical items, may be heavily contaminated with organisms such as *Pseudomonas* and may pose a risk.

Facilities should be prepared for situations where water is inaccessible (e.g., disaster situations, disruptions in water supply): ready-to-use disinfecting products, that do not require rinsing, must be available.

Water in under-resourced areas can be made safer by solar disinfection using solar box cookers that reach pasteurization temperatures, boiling (10 minutes), chemical disinfection, and filtration.

• **Environmental Surfaces.** Walls and ceilings are unlikely to pose a significant infection hazard and should be periodically cleaned and not be disinfected unless known contamination (e.g., blood splashes) has occurred. Cleaning of floors, without the use of a disinfectant, suffices in most instances. Levels of bacterial contamination on floors can be restored to their original values within 2 hours of cleaning, regardless of whether disinfectants are used or not.

• **Linen.** Although infectious risks associated with linen are low, it should be handled with care both in the ward and in the laundry. Persons handling soiled linen should do so with minimum agitation and must wear gloves. Linen should be transported to the laundry in a sealed bag. Linen from particularly hazardous and transmissible infections (e.g., viral hemorrhagic fevers) should be autoclaved before washing. Linen can be disinfected by heat (70°C for 3 minutes or 80°C for 1 minute) or with an appropriately diluted chlorine solution.
• **Pest Control.** A pest-control strategy in areas like kitchens, cafeterias, laundries, central sterile supply services, operating rooms, and other areas prone to infestation is particularly important in healthcare facilities in developing countries. Screens on windows that open to the outside may be of particular importance in regions where insect vector-borne infections are endemic.

• **Waste Disposal.** Disposal of waste must comply strictly with legislation. Clinical waste must be contained to prevent leakage, and sharps must be discarded into puncture-resistant containers. Disposal strategies include incineration, autoclaving followed by disposal with regular waste, mechanical/chemical disinfection, microwave decontamination, and compacting. Waste such as blood, suctioned fluids, excretions, and secretions can be poured down a sanitary sewer. Alternatives for disposal of medical waste commonly seen in countries with limited resources include: incineration of small amounts of waste in a metal drum, landfills or burial in refuse pits that are securely fenced off to prevent access to human and animal scavengers. Alternating layers of waste and ash help to reduce the smell.

**Dealing with the Controversies**

• **Detergent or disinfectant?** Cleaning with detergent and water is usually adequate for surfaces and items remote from the patient or in contact with healthy, intact skin (“non-critical” items). Thorough cleaning renders most items free of infection risk and safe to handle. Disinfectants should only be used on environmental surfaces where potential risks are identified (e.g., decontamination of potentially infectious spills or of isolation rooms). Wet cleaning and damp dusting procedures are required to ensure that microorganisms are not made airborne from the surfaces that are being cleaned. All cleaning solutions should be changed regularly and cleaning utensils should be thoroughly washed, cleaned and dried before reuse.

Terminal cleaning (when patient is discharged from the room or when isolation is discontinued) should be done as an opportunity to clean areas not routinely accessible.
Currently accepted guidelines should be used for the disinfection and sterilization of semicritical and critical items.

- **Biocide rotation and antimicrobial resistance.** Although there is some laboratory evidence that low-level biocide resistance can be associated with cross-resistance to other biocides and some antibiotics, the significance of these phenomena in the clinical setting remains controversial. Rotation of biocides is probably unnecessary. No evidence is currently available that appropriately and correctly used biocides have resulted in failures (arising from the selection or development of, non-susceptible microorganisms) in the clinical setting. Greater attention directed to cleanliness, hand washing and personal hygiene is much more important.

- **Environmental cultures.** Routine culturing of environment/air is not advocated; it should only be performed when there is an epidemiological indication and for educational or research purposes. Because environmental sampling is costly, overused and misused, it should be conducted only with the approval and under the guidance of a competent infection control practitioner.

**Summary**

Inappropriate use of disinfectants, excessive microbiological sampling of the hospital environment and excessive and complex cleaning policies are neither cost-effective nor conducive to compliance in countries with limited resources. Healthcare facilities in developing countries will find it increasingly more difficult to comply with stringent protocols from developed countries. Adaptation of these protocols to realistically take into account the constraints of local situations and available resources is crucial to the success of environmental infection control programs. Rational, simple protocols based on sound principles of infection control, hand washing, and common sense will go far in minimizing environmental risks of infection.

**References**


CHAPTER 16

PATIENT AREAS

Constanze Wendt, MD, MS

Key Issue
The patient environment harbors a number of potential reservoirs for pathogens.

Known Facts
- Patients do need a clean environment for their uncomplicated recovery.

Controversial Issues
- The extent to which environmental reservoirs contribute to nosocomial infections remains unclear.
- The extent to which germicidal solutions should be used on environmental surfaces as opposed to nongermicidal cleaning methods is also unclear.

Suggested Practice
- Patient areas should be cleaned periodically and after contamination.
- Patient areas should be protected from heavy dust.

Since the writings of Florence Nightingale in the 19th century no one has questioned the need of a clean environment for the uncomplicated recovery of hospitalized patients. However, there is legitimate doubt on the extent to which environmental reservoirs contribute to nosocomial infections.

It has been demonstrated that some parts of the environment have served as reservoir for outbreaks of nosocomial infections, e.g. air filters, insulation materials, or surfaces. Other objects and surfaces known to harbour bacteria, such as flowers, toilets, and medical waste have not been clearly linked to nosocomial infections.
Housekeeping Surfaces
Housekeeping surfaces (floors, walls tabletops) have been associated with outbreaks of vancomycin-resistant Enterococci and methicillin-resistant *Staphylococcus aureus* (MRSA) and more recently with *Clostridium difficile* and Noroviruses. The increasing incidence of such resistant organisms has prompted further discussion on the need for routine surface disinfection, especially in institutions with high rates. However, these special problems do not justify routine disinfection of all hospital floors and furnishings. It has been demonstrated that the rates of nosocomial infections are not significantly different between units cleaned with disinfectants and those units cleaned with detergents. It seems that housekeeping surfaces are contaminated by the patients but not the other way around.

Routine cleaning of housekeeping surfaces with detergents is sufficient in most circumstances. In case of outbreaks, especially outbreaks due to resistant microorganisms found in the environment additional cleaning with a disinfection solution may be indicated. A common reason given for finding environmental contamination with microorganisms can be the lack of adherence to facility procedures for cleaning and disinfection. Monitoring for adherence to recommended environmental cleaning practices is an important determinant for success in controlling transmission of pathogens in the environment. However, disinfecting surfaces is not a substitute for infection control measures to contain the outbreak.

Spills of blood and body substances should be promptly cleaned and decontaminated.

Carpeting and Cloth Furnishings
Carpeting and cloth furnishing may be a source of dust containing microorganisms. They should be avoided were spills are likely and in patient rooms in areas housing immunosuppressed patients. Routine cleaning of carpeting and cloth furnishing should be performed with well-maintained equipment designed to minimize dust dispersion. Wet cleaning should be performed using a method that minimizes the production of aerosols and leaves little or no residues. Carpeting that remains wet for more than 72 hours should be replaced.
Hospital Toilets
Culturing of hospital toilets has demonstrated that frequency and level of contamination is usually low, making the toilets an uncommon source of hospital infections. However, on units for mentally impaired adults, young children, or neurologically impaired patients heavy soiling with feces may occur resulting in cross-infections between patients.

Surfaces of hospital toilets should be cleaned with a disinfecting solution. The bowl should be cleaned with a scouring powder and a brush, but disinfectants should not be poured in the bowl.

Flowers and Plants
Water of cut flowers may yield high numbers of microorganisms including Acinetobacter, Klebsiella spp., Enterobacter spp., Pseudomonas spp., Serratia marcescens, and Flavobacterium. Although it has never been demonstrated that microorganisms from cut flowers or potted plants were linked with nosocomial infections, cut flowers and potted plants should be avoided in rooms of immunocompromised and intensive care unit patients. On other units flowers should be handled by support staff with no patient contact or gloves should be worn for flower handling. Antibacterial agents, e.g. 0.01%–0.02% chlorhexidine or 10ml of 1% hypochlorite can be added to the vase water.

Contaminated Laundry
It is of no question that every patient should have a clean, freshly laundered bed linen. Because it has been demonstrated that the handling of used bed linen may increase the concentration of airborne microorganisms, it has been suggested to disinfect blankets. However, there are no data that would justify the additional cost and workload needed to disinfect blankets.

Soiled linen should be handled as little as possible and with minimum agitation. It should not be sorted or prerinsed in patient care areas. Linens soiled with blood or body fluids should be deposited and transported in bags that prevent leakage.

Construction Projects
The relation between construction projects and fungal infections has been demonstrated frequently. Thus careful control
measures should be performed during These measures should include erection of physical barriers and temporarily shut down of ventilation systems. If possible air flow of ventilation systems should rerouted to protect sensitive areas. Traffic flow patterns for construction personal should be defined and separated from those of patients and healthcare workers.

**Infective Solid Waste**
Infective solid waste may come from patients under isolation precautions, laboratories and from the pathology. Sharp items and blood and blood products should also be considered infective.

There is no evidence that links infective waste with nosocomial infections in patients. Nevertheless, personal handling infectious waste should be informed of the potential health and safety hazard. If necessary, the waste should be transported in sealed impervious containers and stored in areas accessible only to personnel involved in the disposal process.

**Other Reservoirs**
Other possible reservoirs of nosocomial pathogens are summarized in *Table 16.1*.

<p>| Table 16.1 Possible Reservoirs of Infectious Agents in the Environment and Modes of Control |</p>
<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Associated Pathogen</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient Rooms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Air Filters</td>
<td><em>Aspergillus</em></td>
<td>Replace soiled filters periodically</td>
</tr>
<tr>
<td>• False Ceilings</td>
<td><em>Rhizopus</em></td>
<td>Barrier protection during reconstruction</td>
</tr>
<tr>
<td>• Fireproof Material</td>
<td><em>Aspergillus</em></td>
<td>Add fungicide to moist material</td>
</tr>
<tr>
<td>• Air Fluidized Beds</td>
<td></td>
<td>Follow manufacturer’s recommendation</td>
</tr>
<tr>
<td>• Mattresses</td>
<td><em>Pseudomonas</em>, <em>Acinetobacter</em></td>
<td>Use intact plastic cover; disinfect between patients</td>
</tr>
<tr>
<td><strong>Bathroom</strong></td>
<td><strong>Possible Reservoir</strong></td>
<td><strong>Control Measures</strong></td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>• Faucet Aerators</td>
<td><em>Pseudomonas</em></td>
<td>No precautions necessary</td>
</tr>
<tr>
<td>• Sinks</td>
<td><em>Pseudomonas</em></td>
<td>Use separate sinks for hand washing and disposal of contaminated fluids</td>
</tr>
<tr>
<td>• Tub Immersion</td>
<td><em>Pseudomonas</em></td>
<td>Add germicide to water, drain and disinfect after each use</td>
</tr>
<tr>
<td>• Urine-Measuring Device</td>
<td><em>Serratia</em></td>
<td>Disinfect between patients, good hand washing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Routinely Used Medical Equipment</strong></th>
<th><strong>Possible Reservoir</strong></th>
<th><strong>Control Measures</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• ECG Electrodes</td>
<td><em>S. aureus</em></td>
<td>Disinfect after use or use disposable Gram-negative rods leads</td>
</tr>
<tr>
<td>• Stethoscopes</td>
<td>Staphylococci</td>
<td>Prudent to clean periodically with alcohol</td>
</tr>
<tr>
<td>• Electronic Thermometers</td>
<td><em>C. difficile</em></td>
<td>Probe cover, disinfect each day and when visibly contaminated</td>
</tr>
<tr>
<td>• Thermometers (Glass)</td>
<td><em>Salmonella</em></td>
<td>Disinfect between use</td>
</tr>
<tr>
<td>• Plaster</td>
<td><em>Pseudomonas</em>, <em>Bacillus</em>, <em>Clostridia</em>, <em>Cunninghamella</em></td>
<td>Use judiciously in immunocompromised patients or over nonintact skin</td>
</tr>
<tr>
<td>• Elasticized Bandages</td>
<td>Zygomycetes</td>
<td>Avoid in immunocompromised patients or over nonintact skin</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Other Possible Sources</strong></th>
<th><strong>Possible Reservoir</strong></th>
<th><strong>Control Measures</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Chutes</td>
<td><em>Pseudomonas</em>, Staphylococci</td>
<td>Proper design and placement</td>
</tr>
<tr>
<td>• Contaminated Germicides</td>
<td><em>Pseudomonas</em></td>
<td>Avoid extrinsic contamination and seek manufacturer’s microbicidal efficiency verification of claims</td>
</tr>
</tbody>
</table>
Table 16.1 Possible Reservoirs of Infectious Agents in the Environment and Modes of Control (continued)

<table>
<thead>
<tr>
<th>Other Possible Sources</th>
<th>Infectious Agents</th>
<th>Control Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice Baths</td>
<td><em>Staphylococcus</em>, <em>Ewingella</em></td>
<td>Avoid direct contact with ice to cool IV solutions/syringes; used closed system for thermodilution</td>
</tr>
<tr>
<td>Water Baths</td>
<td><em>Pseudomonas</em>, <em>Acinetobacter</em></td>
<td>Add germicide to water bath or use plastic overwrap</td>
</tr>
<tr>
<td>Pigeon Droppings</td>
<td><em>Aspergillus</em></td>
<td>Filter all hospital air; maintain filter efficiency</td>
</tr>
<tr>
<td>Pets</td>
<td><em>Salmonella</em></td>
<td>Prudent to avoid in hospital setting (except seeing-eye dogs)</td>
</tr>
</tbody>
</table>


References


CHAPTER 17

FOOD: CONSIDERATIONS FOR HOSPITAL INFECTION CONTROL

Susan Assanasen, MD, and Gonzalo M.L. Bearman, MD, MPH

Key Issues

• The responsibility of a hospital food service is to provide nutritious and safe food to patients and employees.
• Although food safety has dramatically improved in the last decades, outbreaks of nosocomial gastroenteritis continue to occur worldwide.¹²
• A growing number of hospitalized patients are susceptible to infectious diseases. These include the elderly and immunocompromised hosts. Coupled with mass production of food, the potential exists for large outbreaks of foodborne illnesses.
• Additionally, complex and large-scale production of food and water is a potential target for bioterrorism.
• The outbreaks may result from breakdown in only one-step of food safety control measures.

Known Facts

• Foodborne illnesses can be caused by bacteria, virus, parasites, prions, toxins, or chemical contaminants.
• The clinical presentations are broad and can be quick in onset, such as in toxin mediated outbreaks. Others have long incubation periods, such as hepatitis A, and prion associated diseases.
• Due to highly susceptible and frail populations, such as the elderly, outbreaks of nosocomial gastroenteritis have a higher crude mortality than their community acquired equivalents.²³
• Outbreaks of highly contagious organisms such as norovirus (attack rates>50%) may also affect staff and visitors.
This has resulted in ward closure in up to 44% of reported outbreaks.¹

- Common foodborne pathogens that are easily transmitted through food and can cause severe illness are norovirus, *Salmonella*, *Clostridium perfringens*, *Shigella*, Enterohemorrhagic or Shigatoxin producing *E. coli*, *Campylobacter*, *Listeria monocytogenes*, *Vibrio*, *Yersinia enterocolitica*, *Staphylococcus aureus*, *Hepatitis A virus*, *Giardia*, and *Cryptosporidium*.⁵ Incidence varies according to geographic area, season, and availability of laboratory diagnosis, and change over time.¹²

- Fresh vegetables or fruits have been implicated as vehicles for foodborne pathogens as these products are typically sold to the consumer in ready-to-eat form, do not generally contain preservatives, and rarely undergo any heat processing prior to consumption.

- Noroviruses (formerly called Norwalk-like viruses) are considered the most common cause of sporadic gastroenteritis in developed countries. These are particularly prevalent in nursing homes and hospitals.⁶

- Nosocomial outbreaks caused by noroviruses are difficult to prevent and control due to:
  1. low infectious dose (10–100 viral particles)
  2. very short incubation period (12–48 h)
  3. resistance to inactivation by freezing, heating to 60°C, routine chlorine of water, low pH levels, and treatment with ethanol, or detergent-based cleaners.
  4. multiple routes of transmission, including faecal-oral route and probable respiratory spread via aerosols of vomitus
  5. genetic variability and short-term immunity
  6. prolonged viral shedding after recovery (several weeks)

- Eggs are major vehicles for *Salmonella* infection in humans. Egg-associated salmonellosis is linked to external contamination of the shell during passage through the hen cloaca, and internal contamination by penetration of the bacteria through the eggshell, via microscopic cracks.⁸

- Currently, there are increasing reports of multidrug-resistant zoonotic foodborne infections. Emerging resistance of
Salmonella and Campylobacter species contribute to excess mortality and morbidity in both outbreaks and sporadic cases of illnesses.9

- Listeria monocytogenes is a ubiquitous pathogen and has been recovered in plants, soil, silage, sewage, slaughterhouse waste, human feces (1–10%), animal feces, processing environments, and catering facilities. Although Listeriosis is uncommon, the fatality rate in high-risk individuals (such as pregnant women, older people, and immunocompromised hosts) is as high as 20–50%. The organism can proliferate at –18 to 10°C.10 Consequently, Listeria may be transmitted in foods that have been kept properly refrigerated. Thorough cooking to 75°C can destroy the Listeria. In developed countries, the contamination in ready-to-eat (RTE) meats is primarily due to post-cooking contamination.

- Cryptosporidium, and Giardia are resistant to routine chlorination of water. In 1993, Cryptosporidium caused the largest documented outbreak of gastrointestinal disease in a developed country (estimated 403,000 cases) due to contaminated drinking water supply.11

- Although Clostridium difficile, a common cause of nosocomial diarrhea, is transmitted via contaminated hands and environment, community-acquired C. difficile may be acquired by exposure to spores from soil, contaminated foods, and exposure to household contacts with C. difficile diarrhea.12

- Hazard Analysis Critical Control Point (HACCP) is a systematic approach for the identification, evaluation, and control of potential hazards at every stage of food operation. This system emphasizes the role of continuous problem solving and prevention rather than solely relying on spot-checks of manufacturing processes and random samples of finished food products.13

- HACCP involves major seven principles:
  1. Analyzing hazards
  2. Identifying critical control points (CCPs)
  3. Establishing preventive measures with critical limits for each control point
4. Establishing procedures to monitor the critical control points
5. Establishing corrective actions to be taken when monitoring shows that a critical limit has not been met
6. Establishing procedures to verify that the system is working properly
7. Establishing effective recordkeeping to document the HACCP system

- Currently, HACCP is recognized as an effective food safety assurance system. The success of a HACCP system depends on training and constant supervision of employees in the importance of their role in producing safe foods.
- Although implementation of HACCP system on hospital food service is still voluntary in most countries, several hospitals have adopted these principles to ensure that hospital food is safe for consumption by high-risk patients.
- To provide safe food in hospitals, adherence to HACCP is critical. In a study by the Food and Drug Administration (FDA), important foodborne illness risk factors in US hospitals were:\textsuperscript{14}
  1. Improper holding, time and temperature of the food
  2. Contaminated equipment and inadequate protection from contamination
  3. Poor personal hygiene and lack of adequate toileting and hand washing facilities
- Food-borne bacteria can multiply if food is not maintained at an appropriate temperature (below 5°C or 41°F for refrigeration and above 57°C or 135°F for hot holding), and if there are delays between food preparation and distribution. Enteric viruses are particularly problematic pathogens as they are more resistant to heat, disinfection, and pH changes than enteric bacteria. In addition, viral contamination does not alter the appearance, smell or taste of food. Lastly, viruses can survive for days or weeks on hospital environment.
- Hand washing can effectively reduce the transmission of bacteria and viruses.
Hand washing with soap and water followed by hand drying with paper towels (not hot air dryers) is the standard procedure for hand decontamination in food safety practices. Alcohol-based hand rubs are inferior as these products neither inactivate viral pathogens such as norovirus, nor can destroy the spores of *C. difficile*.

**Controversial Issues**

- Most nosocomial foodborne pathogens are spread by the faecal-oral route. The primary source of outbreaks may be contaminated food/water, and infected/colonized patient, visitor, staff, or food handler. Contact with infected/colonized animals may also cause enteric diseases, especially in immunocompromised hosts.

- Most enteric outbreaks are caused by a single agent, but coinfections may occur, especially if the source is sewage contaminated food or water.

- DNA fingerprinting of foodborne bacteria by PFGE is available for *E. coli* O157:H7, *Salmonella*, *Listeria monocytogenes*, *Shigella*, and *Campylobacter* isolates.

- The CDC estimates that approximately 18–20% of foodborne outbreaks are associated with an infected food worker. Transmission of foodborne pathogens can occur from pre-symptomatic, symptomatic and post-symptomatic food handlers. Transmission of infections is dependent upon the amount of infectious agent excreted, the degree of contamination, the compliance and effectiveness of personal hygiene, the stability of pathogens in food and environment, the virulence of organisms, the food type/amount consumed, cooking process, food preservation techniques, and immune status of patients.

- Outbreak investigations of nosocomial gastroenteritis are complicated and only few illnesses are definitively linked to food.

1. In some situations, it is not clear whether workers are the cause or the victims of enteric outbreaks. This is because some healthcare workers may deny infection or illness for a variety of reasons.
2. Transmission of organisms during outbreaks frequently occurs by multiple sources, including person-to-person contact, contaminated environments (fomites), consumption of contaminated food or water, and airborne inhalation.

**Suggested Practice**

- For the control of foodborne infections in the hospital, it is necessary to:
  1. optimize and standardize methods for the detection of foodborne pathogens;
  2. develop rapid surveillance networks to detect and report outbreaks at an early stage;\(^1^8\)
  3. emphasize the importance of food safety quality control and management systems;
  4. heighten awareness about the presence and spread of these organisms by foodhandlers and promote the good hygienic practices.

- The hospital food service must develop a food safety management system, such as HACCP, that meets food standard requirements. This should be fully reviewed by certified food safety professionals or local, external inspections. All food should be obtained from approved sources in compliance with Federal, State, and local laws and regulations.
  - Foods containing raw or partially cooked eggs, fish, and meat should not be served.
  - Food containing unpasteurized milk and fruit juices should not be served.
  - Pests and flies should be controlled to reduce the risk of food contamination in hospitals.
  - Powdered infant formula (PIF) is not a sterile product. To reduce the risk of infection, the reconstitution of powdered formula should be undertaken by caregivers using good hygienic measures and in accordance with the product manufacturer’s food safety guidelines.\(^1^9\)

- All food handlers must be aware that high standards of personal hygiene are important. In the hospital setting, food handlers also include nurses or domestic staff who distribute or serve meals. Therefore, these personnel should be educated about food hygiene and HACCP.
• Bare hand contact of ready-to-eat foods should be eliminated through the use of gloves, bakery papers and food handling utensils.
• The “touchless or hands free” faucets and paper towel dispensers are preferred to reduce the risk of cross-contamination.
• All food handlers should wash their hands and exposed portions of their arms:20
  1. Before engaging in food preparation, including working with exposed food, clean equipment and utensils, and unwrapped single service and single-use articles
  2. After touching bare human body parts other than clean hands and clean, exposed portions of arms
  3. After using the toilet room
  4. After caring for or handling service or aquatic animals
  5. After coughing, sneezing, using a handkerchief or disposable tissue, using tobacco, eating, or drinking
  6. After handling soiled equipment or utensils
  7. During food preparation, as often as necessary to remove soil and contamination and to prevent cross contamination when changing tasks
  8. When switching between working with raw food and working with ready-to-eat food
  9. Before donning gloves for working with food
  10. After engaging in other activities that contaminate the hands
• All food handlers shall keep their fingernails trimmed, filed, and maintained so the edges and surfaces are cleanable and not rough.
• Food handlers who have direct contact to unwrapped food, clean equipment, utensils, and linens should wear clean outer clothing and wear hair restraints such as hats, hair coverings or nets, beard restraints, and clothing that effectively covers body hair.
• All food handlers with vomiting, diarrhea, jaundice, sore throat with fever, and infected or draining skin lesions must stop working immediately and report to their manager and to the hospital’s Occupational Health Department.20
• Any cuts, wounds, or open sores on the hands and exposed portions of their arms must be completely covered by impermeable bandage. The lesions on other parts of the body must be covered by a dry, durable, tight-fitting bandage.

• Criteria for the return to work of an infected or colonized food handler with a foodborne pathogen are varied. The details are available at http://www.cfsan.fda.gov/~acrobat/fc05-2.pdf.

• Early case identification of foodborne illnesses can prevent further transmissions. Through early detection, the identification and removal of contaminated products from the commercial market can be expedited.

• Physicians should promptly report hospitalized cases of enteric infections to the infection control team and to the appropriate public health authorities. In addition, physicians and other healthcare professionals can help prevent and control foodborne diseases by educating their patients about the risks of foodborne illness, and providing sound advice on safe food-handling and consumption practices.

• Once an outbreak of nosocomial gastroenteritis is suspected, infection control measures should be instituted immediately, prior to the results of confirmatory tests. The three most important actions during an outbreak are:
  1. Effective hand hygiene with soap and drying with hand towels
  2. Isolation of affected patients, restriction of movement of staff, patients and visitors and exclusion of affected staff
  3. Enhanced cleaning of the environment and equipment with appropriate disinfectants, such as sodium hypochlorite at 1000 ppm for suspected norovirus outbreaks, and at 5000 ppm (1:10 dilution of household bleach) for *C. difficile* outbreaks.  

• The IC team should be invited to help in the evaluation of the catering contract, set up quality measures such as HACCP, and participate in the inspection of hospital food handling areas.
In high prevalence areas of Hepatitis A virus (HAV) infections, vaccination should be considered for all food handlers not immune to HAV. Due to the low incidence of HAV infection and high cost of vaccine, mass immunization for all food service workers in the US is not cost effective, except during epidemics.

A low microbial diet is recommended for hematopoietic stem cell transplant (HSCT) recipients for at least 3 months after transplantation and until all immunosuppressive drugs are discontinued. Besides general food safety practices, HSCT recipients should not eat any raw or undercooked meat, seafood, and eggs or foods that might contain them (e.g., certain preparations of hollandaise sauce, Caesar and other salad dressings, homemade mayonnaise, and homemade eggnog). HSCT recipients should avoid contact with animal feces to reduce the risk for toxoplasmosis, cryptosporidiosis, salmonellosis, and campylobacteriosis.

Strain-specific recombinant norovirus-like particles (VLPs) are being evaluated as a potential vaccine for prevention of norovirus infection or illness.

Summary

- Hospital acquired enteric outbreaks, although rare, have been reported.
- Incorporation of HACCP principles at every stage of food handling is crucial for ensuring food safety.
- Food processors, manufacturers, wholesalers, retail outlets, and restaurants play a key role in maintaining the safety of food products and food ingredients.
- Strict implementation of temperature control and hygienic measures is the most important preventive measure in the hospital setting.
- Effective hand washing with soap and water before and after the handling of all foodstuffs is critical for infection control.
- To reduce the fecal oral transmission of gastrointestinal pathogens from the contaminated hospital environment, patients and their families should be educated on proper personal hygiene and sanitation.
References


Key Issue
Hospital water is frequently an overlooked, important and controllable source of nosocomial infections. Numerous outbreaks have been linked to contaminated water. No comprehensive guidelines for preventing water borne infections in hospitals exist. Potable water is still an unmet need in many developing countries.

Known Facts
- Hospital potable water must have <1 coliform bacterium/100 mL. High levels of bacteria in hospital water, dialysate water, sinks, faucets, shower heads has been associated with outbreaks or hand colonization.
- The buildup of biofilms and the corrosion of distribution lines and tank surfaces resulting from poor design or aging of distribution systems and water stagnation are the primary cause of diminished water quality.
- Colonization in more than 30% of hospital water has been associated with cases of Legionnaires’ disease. Hospital water colonization by *Legionella* spp. could be long lasting and associated periodically with outbreaks.
- Risk of illness may be influenced by several factors beside water contamination.
- In developing countries, high levels of water contamination correlating with low levels of chlorination have been linked to bloodstream infections outbreaks by enterobacteria, including *Klebsiella* spp, *Enterobacter* spp
- Patient exposure to waterborne organisms occurs while showering, bathing, drinking, or with the contact of medical equipment (tube feed bags, endoscopes, respiratory equipment) rinsed with tap water.
Controversial Issues

- Use of sterile water for all patients.
- Maintaining high concentration of chlorine to reduce *Legionella* colonization.
- Routine point-of-use water filtration.

Suggested Practice

- A high level of suspicion for cases of water borne infections should be maintained, especially if clusters of infections occur.
- Hospital water should not routinely cultured.
- Water used for dialysis should be sampled monthly, and bacteria must be <200 bacteria/mL.
- Dialysate should be also cultured and similar levels of bacteria must be maintained.
- Use sterile water for rinsing nebulization devices and other semicritical respiratory-care equipment.
- Chloride levels in hospital water should be tested periodically. Chlorination should be tested not only in the incoming tap water, but across the hospital, especially in high-risk areas like intensive care units or where immune-compromised patients exist.
- Hospital tap water should be not given to immunosuppressed patients. Use sterile water instead. If not possible filters or boiling could be a safe alternative.
- Cooling towers should be, if possible, directed away from hospital’s air-intake system, and the design the cooling towers should be such that volume of aerosol drift is minimized. Install drift eliminators and regularly use a effective biocide, according manufacturers recommendations.
- In case of a single confirmed case of nosocomial Legionnaires’ disease, or two possible cases in less than 6 months, begin an epidemiological and environmental investigation. Alert hospital personnel so a high level of suspicion for the detection of new cases is maintained. This prospective surveillance should be maintained at least 2 months after the last case. If there is evidence of continuous transmission, hospital water should be sampled, and potential areas for aerosolized water should be looked. If hospital
water is contaminated with *Legionella* spp., start decontamination procedures:

1. Superheating: flushing outlet for at least 5 minutes with water = 65˚C, (post warning signs at each outlet being flushed to prevent scald injury) or
2. Hyperchlorination: >10 mg/L of free residual chlorine.

- Follow up cultures should be done at 2 weeks intervals for three months to evaluate actions taken. If no further positive cultures are found. Then cultures should be obtained monthly for another 3 months. If positive cultures are found reassess the implemented control measures, modify them accordingly, re-implement decontamination and considerer combinations.

**Summary**

Many bacteria can survive in water and have been linked to nosocomial infections including: *Pseudomonas aeruginosa, Burkholderia cepacia, Serratia marcescens, Citrobacter freundii, Clostridium difficile, Acinetobacter baumani, Flavobacterium meningosepticum, Aeromonas hydrophila, atypical Mycobacteria, Legionella spp*, parasites and virus among others. Furthermore *Salmonella, Vibrio, Rotavirus, Cryptosporidium* and other enteric organisms have been reported in developing countries. In *Table 18.1* some examples of hospital water linked outbreaks are shown:

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Reservoir</th>
<th>Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. paucimobilis</em></td>
<td>water bottles for rising tracheal suction</td>
<td>Pneumonia</td>
</tr>
<tr>
<td><em>S. marcescens</em></td>
<td>water of humidifiers</td>
<td>Pneumonia</td>
</tr>
<tr>
<td><em>M. xenopi</em></td>
<td>hot water taps</td>
<td>Pneumonia</td>
</tr>
<tr>
<td><em>M. chelonae</em></td>
<td>contaminated equipment</td>
<td>Otitis</td>
</tr>
<tr>
<td><em>M. chelonae</em></td>
<td>contaminated water tank</td>
<td>Nasal Septum Cellulitis</td>
</tr>
<tr>
<td><em>L. pneumophila</em></td>
<td>hospital water, cooling towers</td>
<td>Pneumonia</td>
</tr>
<tr>
<td><em>Acinetobacter spp.</em></td>
<td>water bath used to thaw fresh plasma</td>
<td>Bacteremia</td>
</tr>
</tbody>
</table>

*Table 18.1 Examples of Hospital Water-linked Outbreaks*
Table 18.1 Examples of Hospital Water-linked Outbreaks (cont.)

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Reservoir</th>
<th>Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. aeruginosa</em></td>
<td>water bath used to thaw cryoprecipitate, hospital water</td>
<td>Bacteremia, Pneumonia</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>tub water contamination</td>
<td>Folliculitis, Skin Infections</td>
</tr>
<tr>
<td><em>C. difficile</em></td>
<td>bath</td>
<td>Diarrhea</td>
</tr>
<tr>
<td><em>S. maltophilia</em></td>
<td>hospital water</td>
<td>Bacteremia</td>
</tr>
<tr>
<td><em>Cryptosporidium</em></td>
<td>hospital water</td>
<td>Diarrhea</td>
</tr>
</tbody>
</table>

Routine cleaning, disinfection and policies for use and changing of water from potential reservoirs should be implemented and periodically reviewed.

References


CHAPTER 19

LABORATORY AREAS

Betty A. Forbes, PhD

Key Issue

Laboratory workers are exposed to a variety of potential occupational health risks that include infectious materials and cultures. Laboratory-acquired infections are defined as all infections acquired through laboratory activities, regardless of their clinical or subclinical manifestations. Biosafety guidelines have evolved from the efforts of the microbiological and biomedical community to reduce laboratory-acquired infections. The actual risk of a laboratory-acquired infection is difficult to measure because there is no systematic reporting to appropriate government agencies or at a professional society level to monitor the number of laboratory workers that acquire infections associated with the workplace. Collective studies published by Sulkin and Pike reported on over 4000 laboratory-associated infections between 1949 and 1974, with a mortality of 4.1%; these infections were reported from research, diagnostic, and teaching facilities, as well as industries producing biological products. To minimize the risk of laboratory-acquired infections, a program that encompasses a combination of engineering controls (including laboratory design), safe laboratory practices, employee education, personal protective equipment (PPE), and medical measures that include surveillance, risk assessment, vaccination, and postexposure prophylaxis is required. Of significance, the development of such programs to minimize risks associated with the handling and disposal of infectious agents is based on an understanding of the pathogenicity of the agent, host susceptibility, source of infection, and the method of transmission of the infectious agent. Most risks from biological hazards can be reduced through the use of appropriate microbiological procedures and techniques, containment devices and facilities and protective barriers.
Known Facts

- In the published reports of Pike and Sulkin, the ten most common causative agents of infections among laboratory (all types of laboratories including diagnostic laboratories, industrial, research, etc.) workers were *Brucella* spp., *Coxiella burnetii*, hepatitis B virus, *Salmonella typhi*, *Francisella tularensis*, *Mycobacterium tuberculosis*, *Blastomyces dermatitidis*, Venezuelan equine encephalitis virus, *Chlamydia psittaci*, and *Coccidioides immitis*.

- Later surveys in the US from 1978 through 1982, and in 1986, reported an annual incidence of 3 to 3.5 infections per 1,000 laboratory employees per year. Infections, in order of decreasing frequency, included hepatitis B, shigellosis, pharyngitis, cellulitis, tuberculosis, conjunctivitis, and non-A, non-B hepatitis.

- Harding and Byers indicated that clinical diagnostic laboratories accounted for 45% of all laboratory-acquired infections. Laboratory workers, especially those in microbiology, are at greater risk of becoming infected than is the general population.

- The causative incident or source for most laboratory-acquired infections is unknown.

Principal Routes of Laboratory Transmission

**Inhalation**—aerosols are a serious hazard because they are common in laboratory procedures

- Pipetting, blenders, pouring, non-self contained centrifuges, sonicators, vortex mixers, flaming a loop that may generate respirable-size particles (<0.05 mm in diameter) that remain airborne for protracted periods.

- Other materials that can act as droplet nuclei include lyophilized cultures, dried materials on laboratory benches and stoppers and bacterial and fungal spores.

- Procedures and equipment that generate respirable size particles also generate larger size droplets (>0.1 mm in diameter) that can contain multiple copies of an infectious agent. These larger size droplets settle out of the air rapidly, contaminating gloved hands, work surfaces and possibly mucous membranes of the persons performing the procedure.
• Technique can significantly impact aerosol output and dose—experiments show that aerosol burden with maximal aeration is about 200 times greater than aerosol burden with minimal aeration.

**Inoculation**

• Parenteral inoculation of infectious materials with syringe needles or other contaminated sharps such as blades and broken glassware,
• One of the leading causes of laboratory-associated infections

**Contamination of Skin and Mucous Membranes**

• Spills, sprays and splashes into eyes, mouth or nose and hand-to-face actions
• Spills, sprays and splashes on intact or non-intact skin
Contaminated surfaces and equipment

**Ingestion**

• Occurs through mouth pipetting, transfer of organisms to the mouth from contaminated items such as pencils or fingers
• Consumption of food or drink in the laboratory
• Accidental splashes that fall into the mouth

**Levels of Containment**

In general, the strategy for minimizing the occupational exposure of laboratory workers to infectious agents is based on microorganism containment which includes physical factors such as facility design and safety equipment, standard microbiological practices, and administrative controls. Microorganisms encountered and the procedures performed are stratified by risk. The primary risk criteria used to define the four ascending levels of containment, biosafety levels (BSL) 1 through 4 are infectivity, severity of disease, transmissibility and the nature of the work being conducted. Each increasing BSL number implies increased occupational risk from exposure to a microorganism or performance of a procedure and thus, is associated with more stringent control and containment practices:
• Primary containment: provides physical separation of the infectious agent from the laboratory worker
• Primary barriers: strict adherence to microbiological practices and techniques and use of biological safety cabinets (BSCs; Table 19.1), safety centrifuge containers, and PPE (for example, gloves, masks, face shields, coats, gowns, respirators), sharps protection
• Secondary containment: includes facility design and serves as a secondary barrier to protect all works within the facility and protect the outside environment.

| Table 19.1  Classes and types of BSCs |
|-----------------|-----------------|------------------|
| BSC Class | Type of Protection | Miscellaneous Comments |
| I | Personnel and environmental | Partial containment cabinets |
| II A1, A2, B1, and B2 | Personnel, environmental and product | All have HEPA-filtered, vertical laminar airflow. Cabinet types vary by minimum air velocity, exhaust, type of ducting, agents allowed for use (eg. biological, volatile radionucleotides, toxic chemicals) |
| III | Personnel, environmental and product | Totally enclosed with gas-tight construction Provides a physical barrier between the user and the agents for maximum protection |

a Personnel protection: protects personnel from harmful agents used inside the cabinet.
b Environmental protection: protects the environment from harmful agents/contaminants generated or used in the cabinet.
c Product protection: protects products/experiment from contaminants in the room environment and from cross contamination inside the cabinet.

A brief overview of practices and techniques, safety equipment and facilities for recommended BSLs is shown in Table 19.2. In addition, the more common agents that cause laboratory-acquired infections with their corresponding routes of transmission and primary practices, containment and facilities in the laboratory are summarized in Table 19.3. In light of significant national and international events, biosecurity measures have been implemented and subsequently expanded to protect microbial agents from loss, theft, diversion or intentional misuse.
<table>
<thead>
<tr>
<th>BSL</th>
<th>Practices</th>
<th>Primary Barriers and Safety Equipment</th>
<th>Facilities (2º Barriers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Standard microbiological practices: eg. hand hygiene; no mouth pipetting, eating, drinking, smoking, applying cosmetics or storing food; policies for safe handling of sharps; decontaminate work surfaces after completion of work or any spill; universal biohazard symbol signage; pest management program; appropriate training.</td>
<td>- Wear PPE (gloves and/or protective eyewear when indicated).</td>
<td>- Bench tops impervious to water, resistant to heat, organic solvents.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Laboratory chairs covered with non-porous material.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Sink for hand washing.</td>
</tr>
<tr>
<td>2</td>
<td>BSL-1 practice plus: biohazard signs, limited access, ‘sharps’ precautions, biosafety manual defining waste decontamination and medical surveillance, demonstrated proficiency in standard and special microbiology practices before working with BSL-2 agents.</td>
<td>- Class I or II BSCs and other physical containment devices used for all manipulations of agents that result in splashes or aerosols. - PPEs (laboratory coats, gloves, face protection) as needed.</td>
<td>- BSL-1 plus autoclave available.</td>
</tr>
<tr>
<td>3</td>
<td>BSL-2 plus controlled access, decontamination of all waste, protective clothing and baseline serum of laboratory personnel for certain agents (eg. hepatitis B virus).</td>
<td>- Class I or II BSCs and other physical containment devices used for all open manipulations of agents. - PPEs as for BSL-2 plus respiratory protection as needed.</td>
<td>- BSL-2 plus controlled access, self-closing, double door access, air exhaust to outside, negative airflow into laboratory.</td>
</tr>
<tr>
<td>4</td>
<td>BSL-3 plus clothing change before entering and showering on exit, all material decontaminated on exit from facility.</td>
<td>All procedures conducted in class III BSCs or Class I or II BSCs in combination with full body, air-supplied, positive-pressure personnel suit.</td>
<td>- BSL-3 plus separate building or isolated zone, dedicate supply and exhaust, vacuum, and decontamination systems.</td>
</tr>
</tbody>
</table>
## Table 19.3 The More Common Causes of Hospital Clinical Laboratory-Acquired Infections
(Adapted from WHO, 2004 and CDC, 2007 Publications).

<table>
<thead>
<tr>
<th>Agent</th>
<th>Laboratory-Acquired Infections: Sources and Routes of Transmission</th>
<th>Primary Practices, Containment and Facilities</th>
<th>SELECT AGENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Bacillus anthracis</em></td>
<td>Primarily cutaneous anthrax by either direct and indirect contact of broken skin with culture and contaminated surfaces or accidental parenteral exposure.</td>
<td>BSL-2</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Brucella</em> species</td>
<td>Most frequently reported laboratory infection by airborne and mucocutaneous routes. Cases have occurred by sniffing cultures or working on open bench tops aerosols, mouth pipetting, accidental parenteral inoculation, sprays into eyes, nose and mouth.</td>
<td>BSL-2</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Burkholderia mallei</em> and <em>Burkholderia pseudomallei</em></td>
<td>Aerosol and cutaneous exposures usually while handling bacterial cultures.</td>
<td>BSL-2 when handling clinical specimens; BSL-3 whenever infectious aerosols or droplets are generated. Gloves should be worn particularly when working with infectious material.</td>
<td>Yes</td>
</tr>
<tr>
<td><em>E. coli</em> — Shiga toxin producing</td>
<td>Unknown route of transmission but suggested that prolonged survival on stainless steel surfaces and low infectious dose may contribute to laboratory transmission by accidental ingestion.</td>
<td>BSL-2. Gloves should be worn when hands may come in contact with potentially infectious materials.</td>
<td>No</td>
</tr>
</tbody>
</table>
Table 19.3 The More Common Causes of Hospital Clinical Laboratory-Acquired Infections (continued)  
(Adapted from WHO, 2004 and CDC, 2007 Publications).

<table>
<thead>
<tr>
<th>Agent</th>
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<th>SELECT AGENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Franciscella tularensis</em></td>
<td>Tularemia commonly reported laboratory-associated infection by direct contact of skin and mucous membranes with infectious material.</td>
<td>BSL-2 when handling clinical specimens. Laboratory personnel should be informed of the possibility of tularemia when specimens are submitted for diagnostic testing. BSL-3 for all other manipulations or suspect cultures.</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Leptospira</em> species</td>
<td>Ingestion, parenteral inoculation, direct and indirect contact of skin or mucous membranes with cultures or infected tissues or body fluids.</td>
<td>BSL-2. Gloves should be worn when handling cultures.</td>
<td>No</td>
</tr>
<tr>
<td><em>Mycobacterium tuberculosis</em> complex</td>
<td>Primary acquisition by exposure to laboratory-generated aerosols; tubercle bacilli may survive on heat-fixed smears.</td>
<td>BSL-2 for non-aerosol-producing manipulations of clinical specimens. BSL-3 for laboratory activities associated with the propagation and manipulations of cultures.</td>
<td>No</td>
</tr>
<tr>
<td><em>Neisseria gonorrhoeae</em></td>
<td>Rare. Accidental parenteral inoculation and direct or indirect of mucous membranes with contact infectious or contaminated solutions</td>
<td>BSL-2. Gloves should be worn when hands may come in contact with potentially infectious materials.</td>
<td>No</td>
</tr>
<tr>
<td>Agent</td>
<td>Laboratory-Acquired Infections: Sources and Routes of Transmission</td>
<td>Primary Practices, Containment and Facilities</td>
<td>SELECT AGENT</td>
</tr>
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<td>--------------</td>
</tr>
<tr>
<td><em>Neisseria meningitidis</em></td>
<td>Parenteral inoculation, droplet exposure of mucous membranes, infectious aerosol and ingestion.</td>
<td>BSL-2 for specimens and cultures. All sterile-site isolates should be manipulated in a BSC.</td>
<td>No</td>
</tr>
<tr>
<td><em>Salmonella</em> and <em>Shigella</em></td>
<td>Risk primarily from the ingestion of the organism or infectious material (numerous cases of laboratory-acquired infections have resulted from handling proficiency testing strains); less common, parenteral injection.</td>
<td>BSL-2</td>
<td>No</td>
</tr>
<tr>
<td><em>Treponema pallidum</em></td>
<td>Parenteral inoculation, contact with mucous membranes or broken skin with infectious clinical materials.</td>
<td>BSL-2</td>
<td>No</td>
</tr>
<tr>
<td><em>Yersinia pestis</em></td>
<td>Direct contact with cultures and infectious materials, inhalation of infectious aerosols or droplets during manipulation.</td>
<td>BSL-2; BSL-3 for laboratory activities associated with high potential for droplet or aerosol production.</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Blastomyces dermatitidis</em></td>
<td>Inoculation and presumably by inhalation of conidia.</td>
<td>BSL-2; BSL-3 for propagating and manipulating sporulating cultures.</td>
<td>No</td>
</tr>
<tr>
<td>Agent</td>
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<td>Primary Practices, Containment and Facilities</td>
<td>SELECT AGENT</td>
</tr>
<tr>
<td>-----------------------------</td>
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<td>-----------------------------------------------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td><em>Coccidioides immitis</em></td>
<td>Inhalation of arthrospores and accidental percutaneous inoculation.</td>
<td>BSL-2 for clinical specimens; BSL-3 for propagating and manipulating sporulating cultures.</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Histoplasma capsulatum</em></td>
<td>Inhalation of conidia, accidental cutaneous inoculation.</td>
<td>BSL-2 for clinical specimens; BSL-3 for propagating and manipulating sporulating cultures.</td>
<td>No</td>
</tr>
<tr>
<td>Blood and tissue protozoal parasites</td>
<td>Majority of laboratory-acquired infections involved need-stick or other cutaneous exposure to infectious stages through abraded skin.</td>
<td>BSL-2</td>
<td>No</td>
</tr>
<tr>
<td>Intestinal protozoal parasites</td>
<td>Primarily by ingestion.</td>
<td>BSL-2</td>
<td>No</td>
</tr>
<tr>
<td>Trematodes</td>
<td>Primarily through accidental needlesticks and by contamination of mucosal membrane and skin abrasions.</td>
<td>BSL-2</td>
<td>No</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Ingestion of infective eggs or skin penetration by infective larvae.</td>
<td>BSL-2</td>
<td>No</td>
</tr>
</tbody>
</table>
Table 19.3 The More Common Causes of Hospital Clinical Laboratory-Acquired Infections (continued)
(Adapted from WHO, 2004 and CDC, 2007 Publications).

<table>
<thead>
<tr>
<th>Agent</th>
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<th>Primary Practices, Containment and Facilities</th>
<th>SELECT AGENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rickettsial agents – Q fever</td>
<td>Exposure to infectious aerosols and parenteral inoculation.</td>
<td>BSL-2 for non-propagative laboratory procedures.</td>
<td>Yes</td>
</tr>
<tr>
<td>Common blood-borne viruses – hepatitis viruses (A, B, C, and D) and HIV</td>
<td>Parenteral inoculation, droplet exposure of mucous membranes, and contact exposure of broken skin.</td>
<td>BSL-2; BSL-3 may be indicated for activities with potential for droplet or aerosol production, other activities involving concentrations of infectious materials. Gloves should be worn when working particularly with infectious material.</td>
<td>No</td>
</tr>
<tr>
<td>Parvovirus B19</td>
<td>Exposure to infectious aerosols.</td>
<td>BSL-2</td>
<td>No</td>
</tr>
<tr>
<td>Arboviruses and related zoonotic viruses: 597 viruses listed in CDC document.</td>
<td>Exposure to infectious aerosols, inoculation, and/or contact with skin or mucous membranes.</td>
<td>BSL-2 through 4 based on risk assessment derived from information provided by a variety of sources, viral mode of transmission, frequency and severity of laboratory-acquired infections, and the availability of a vaccine.</td>
<td>Many are classified as select agents.</td>
</tr>
</tbody>
</table>
In the US, Select Agent regulations have led laboratory managers, scientists, scientific and institutional leaders and others to implement and improve the security of biological agents and toxins within their facilities; advisory recommendations for biosecurity programs are detailed in the CDC *Biosafety in Microbiological and Biomedical Laboratories (BMBL)*, 5th edition. Agents that could pose as severe threats to animal or plant health (i.e. select agents) are identified in *Table 19.3*. Detailed information regarding biosafety levels that are recommended for specific bacteria, fungus, parasites and viruses can be found in textbooks and a variety of websites such as those listed below:

http://www.cdc.gov/od/ohs/biosfty/bmbl5/bmbl5toc.htm

**Risk Assessment**
The assignment of an infectious agent to a biosafety level must be based on a risk assessment. Occupational risk assessment criteria are influenced by the type of manipulations or activities performed with the agent, the experience of the laboratory worker, and the infectious agent. Thus, each task, procedure, or activity performed in the laboratory must be analyzed for its potential risk to the employee who performs the task. The international community has developed a common risk classification scheme in which infectious agents are categorized into 4 risk groups based on their relative risk to cause laboratory-associated infections. These groups are categorized based on particular characteristics of the infectious agent such as their pathogenicity, infectious dose, mode of transmission, host range, and availability of effective preventive measures and effective treatment. These risk groups were developed to help laboratories determine the best laboratory practices and environmental requirements for containment. Other factors associated with laboratory operations including specimen volume, potential for aerosol generation, quantity and concentration of infectious agents, agent stability in the environment, and type of work proposed should also be taken into consideration.
Administrative Elements of a Safe Clinical Laboratory

- Biosafety, exposure control, and chemical hygiene plans including accidental spills of infectious organisms or release of infectious microorganisms into the laboratory or facility environment
- Comprehensive plan for management and disposal of infectious waste including blood and blood products
- Respiratory protection program
- Personal protective equipment program and procedures
- Provision of medical surveillance for infections that may result from exposure to agents encountered in the performance of routine duties or when early diagnosis reduces the risk of serious consequences of the infection (e.g., rickettsial infections)
- Safety manual that is understood by employees and includes the occupational risks and consequences of infection
- Promotion of safety awareness through training programs and require adherence to safety procedures
- Consistent observance by all workers of proven safety and microbiological practices.
- Documentation and reporting of all occupational injuries, illnesses and incidents of potential exposure
References


Key Issue
A pharmacist can play a pivotal role in reducing infection throughout the hospital. The dissemination of infection from and to the pharmacy can be prevented.

Known Facts
- Infections happen when pharmacological formulations are contaminated with microbes. This may occur during manufacture, or when medications are improperly prepared, handled, stored, or become outdated.
- Contamination may occur within the pharmacy or in other areas of the hospital when healthcare workers finalize the preparation of medications and administer them.
- Contamination of medications and solutions occurs through 3 routes:
  1. Direct contact
  2. Use of contaminated diluents
  3. Air-borne contamination
- Contamination of intravenous fluids is particularly problematic because of the potential to cause serious illness.
- Inappropriate prescribing of antimicrobials is an important cause of drug-resistance. Pharmacists can play a key role in reducing antimicrobial resistance by working with committees to limit prescribing of powerful antibiotics to appropriate indications.
- Inappropriate dosing of antimicrobials can lead to persistent infection or drug resistance. Many pharmacies now monitor antibiotic levels and adjust dosing according to established algorithms.
• Pharmacists often dispense discharge medications to patients. Patient education can ensure that antimicrobials are used properly after discharge.

Controversial Issues
Although national regulatory agencies and hospital committees have set standards for aseptic practices within the pharmacy, the extent to which asepsis needs to be confirmed is controversial. Should all products that are compounded in the pharmacy be tested by culturing samples? Should products obtained from an outside vendor be tested? Due to the emergence of large companies that supply intravenous solutions to multiple hospitals, infections caused by low-level contamination may be scattered over a large number of hospitals. An individual hospital may see only one, which would not normally trigger an investigation within the hospital. Although controversial, a national surveillance system could be developed to monitor bloodstream isolates and, potentially, serve as a means to trace the source of such scattered infections.

Rational use of antimicrobials has been shown to reduce the emergence of resistance pathogens. The pharmacy can play a key role in limiting access to antimicrobials, but controversy exists over how much autonomy should be given to the individual physician. In some cases, a short course of therapy is allowed until laboratory results return. In other cases, medications have been made available only for highly selected indications. Controversy usually arises when policies are perceived to impair a physician’s ability to treat a patient effectively, or when restrictions are perceived as being driven by finances rather than health concerns.

Suggested Practice
• Establish internal pharmacy policies, procedures, and quality control programs to prevent contamination.
• Employees should be trained in aseptic techniques before making preparations or administering medications.
• Limit the activities of staff members who exhibit symptoms of infection.
• If multiple-dose vials are used, each user should be trained in sterile technique and date the vials when opening.
• For products that are reconstituted, only sterile diluents should be used. Utmost care should be taken not to introduce contaminants from the outside of containers into the interior. If liquid is to be injected through a vial membrane, the membrane should be disinfected before being pierced.
• Syringes that are used to inject medications or liquids into the container should be sterile and preferably single-use disposable ones should be used. When syringes must be reused, they must be sterilized in between uses.
• Recommend proper labeling, dating, and storage of sterile products.
• Establish strategies for minimizing the development of resistant strains of microorganisms as well as for optimizing therapeutic outcomes in individual patients. Individual physicians or departments should be involved in the development and implementation of policies that affect them.
• A tracking system should be devised in case of a product recall. The tracking system should allow identification of patients who received potentially contaminated medications.
• Pharmacy areas should be kept clean. Food should not be consumed in areas where medications are handled. Rooms in which medications are prepared should be free of visible dust, and access should be limited.
• Personnel preparing sterile medications should wear clean clothing covers and gloves along with completing periodic competencies ensuring proper aseptic technique. Hands should be washed before and after medications are prepared. Employees should not prepare sterile products if they have rashes or broken skin, especially on their hands. When preparing sterile or potentially toxic solutions such as chemotherapies, laminar airflow hoods are strongly recommended.
• The pharmacy should ensure that medications are appropriately handled and stored throughout the institution. Medications should be stored according to manufacturers’ instructions. All should have an appropriate expiration date printed on the outside of the container. Environmental conditions should be checked periodically including the daily temperature log of refrigerators and the competency of laminar airflow hoods.
• The pharmacy should educate providers to help minimize medication side effects.
• The infection control committee should include representation from the pharmacy.

Summary
The pharmacy has many roles in controlling infection. Clearly, the pharmacy should ensure that medications and solutions are not contaminated. Policies should address training and annual performance evaluation of employees, and they should be reviewed annually to ensure they reflect current practices. Employees with acute respiratory, gastrointestinal, and skin infections should not be permitted to handle medications. To promote rational use of antimicrobials, pharmacists should work closely with hospital committees and physicians, encourage multi-disciplinary collaboration within the health system and evaluate compliance with policies. Importantly, pharmacists often have an opportunity to counsel patients about medication adherence, proper storage and handling of medications/devices, and medical waste disposal. In all of these areas, the pharmacy can have a major impact on the success of an infection control program.

References:
CHAPTER 21

THE OPERATING ROOM

Marie-Claude Roy, MD, MSc

Key Issues
Two to five percent of patients undergoing surgical procedures suffer from surgical site infections (SSIs). These infections continue to burden patients with important morbidity, mortality and immense costs. Because SSIs are primarily acquired during the surgical procedure while the wound is opened, a number of infection control practices merit scrutiny in the OR. The measures presented herein only address environmental and surgical issues as patient-related risk factors are discussed elsewhere.

Known Facts
Most SSIs arise from the patient’s endogenous flora which contaminate the wound by direct contact. Therefore, preparing patients for surgery should aim at decreasing the microbiologic burden of the patient’s bowels, skin, respiratory tract, genital tract, etc …, depending on the procedure being performed. Examples of measures which decrease the microbiologic burden include: showering the patient with an antiseptic soap before surgery, giving antimicrobial prophylaxis immediately before skin incision and applying mupirocin to the nares. Accordingly, the extent of endogenous bacterial contamination at surgery depends on the type of procedure being performed: clean, clean-contaminated, contaminated or dirty. The risk of SSI increases from <2% for the former to as high as 40% for the latter. The traditional wound classification is only a moderate predictor of the risk of SSI because other factors, host and surgical factors, also influence this risk.

Exogenous contamination of wounds is also important in the pathophysiology of SSIs, particularly for clean surgical procedures. Airborne bacteria originating from the patient or the surgical team suffice to create SSI in these types of
procedures, particularly when implants are being placed (e.g., total hip prostheses). Airborne contamination may well affect other clean surgical procedures with long exposure times and large surface areas.

The main source of airborne bacteria in the OR originate primarily from the skin of individuals in the room. The number of persons present in the OR as well as their level of activity, the type of surgery, the quality of air provided, the rate of air exchange, the quality of staff clothing, the quality of cleaning process and the level of compliance with infection control practices all influence airborne contamination. Although these may seem trivial issues for contaminated procedures or dirty procedures, they are very important to consider in clean and clean-contaminated surgery.

**Suggested Practices**

**Environmental Issues**

The surgical suite should be divided into three designated areas: unrestricted, semi-restricted and restricted. Personnel can wear street clothes and there is no traffic limitation in the unrestricted area. A semi-restricted area is limited to authorized personnel only and patients. Surgical attire is recommended as well as headgear in this area. In the restricted area (i.e. ORs, clean core, scrub sink areas), surgical attire and head covering but also masks are required where open sterile supplies or scrubbed persons are present.

For a new construction, the general OR should have a minimum clear area of 400 square feet with ten-foot ceilings. Rooms for cardiovascular, orthopedics, and neurosurgical procedures, which require more personnel and large equipment, should have a minimum clear area of 600 square feet.

Modern operating rooms which meet current air standards in the United States should be virtually free of particles larger than 0.5 µm when no people are in the room. To achieve this, ORs should be equipped with positive-pressure systems to ensure that air travels from ORs to adjacent areas, thus minimizing inflow of air to the room. This positive pressure system is challenged everytime a door is opened.

Ventilation of ORs should filter air at a minimum of 15 changes/hour of which at least three changes should be with
fresh air. In developed countries, this air should be high-efficiency filtered (HEPA). Air should be introduced at the ceiling and exhausted near the floor.

The temperature of ORs should be kept between 18°C and 24°C, with humidity of 30% to 60%.

For hospitals with limited resources where the aforementioned recommendations could not be attained, less expensive strategies to keep air as clean as possible are listed here:

• keep personnel to minimum in the OR during a procedure,
• avoid excessive talking as this creates dispersion of bacteria,
• keep doors and windows closed, and
• keep entries into the OR to a minimum during a procedure.

Cleaning and disinfection of the operating theatre should follow a precise schedule: all horizontal surfaces should be cleaned every morning before any intervention, horizontal surfaces and all surgical items (e.g., tables, buckets) should be cleaned between procedures. At the end of the working day, a complete cleaning of the operating theatre should be performed. Once a week, a complete cleaning of the operating room area, including all annexes such as dressing rooms, technical rooms, cupboards is advisable.

On the other hand, routinely culturing the OR environment is unnecessary because inanimate objects and surfaces are seldom the cause of SSI.

**Preparation of the Surgical Team**

All members of the surgical team who will work on the operating field should scrub arms and hands with chlorhexidine, iodophors or hexachlorophene for at least 5 minutes before the first procedure of the day, and for 2 to 5 minutes between subsequent procedures. The first scrub of the day should include a thorough cleaning underneath fingernails. The use of an alcoholic chlorhexidine solution has a greater residual antimicrobial activity, which could give a theoretic advantage during a long surgical procedure. Hand rubbing with aqueous alcoholic solution may be as effective as traditional hand scrubbing and also better tolerated by the surgical team.

All jewelry should be removed, and artificial nails must not be worn as these are associated with enhanced hand colonization with bacteria and fungi.
After performing the surgical scrub, members of the surgical team should keep hands up and away from the body so that the water runs from the tips of the fingers toward the elbows.

Sterile gloves should be of good quality, as approximately 10% of gloves are inadvertently punctured during surgery. Wearing two pairs of gloves is advisable in orthopedic surgery where as many as 50% of gloves are punctured. Because 30% of glove perforations are invisible, some experts recommend routinely changing gloves in long procedures. Gloves should be changed immediately after any accidental puncture.

The operative site should be scrubbed with a detergent and an antiseptic soap should be applied, working from the proposed operative site outward. Antiseptics recommended for this practice include chlorhexidine, iodophors, and iodine.

Sterile drapes must be placed on the patient and on any equipment included in the sterile field. Once a sterile drape is in position, it must not be moved.

Members of the surgical team entering the OR when an operation is about to begin or already underway should wear a mask and headgear which fully covers hair, sideburns and neckline. Experimental studies using tracer particles have shown that bacteria can be shed from hair, exposed skin, and mucous membranes of both OR personnel and the patient’s skin. This is why we use barriers (masks, gowns, hoods and drapes) in the OR. Although no clinical studies have proved that the use of these barriers have led to a decrease in SSI rates, they are recommended not only for the purpose of reducing shedding of microorganisms in the OR but also as part of standard precautions.

Shoe covers can be replaced by ordinary shoes dedicated exclusively to the operating theater, because no significant difference was found in floor contamination whether personnel wear shoe covers or ordinary shoes. These latter shoes must be easy to wash.

Scrub suits should cover most bare skin to decrease shedding of microorganisms from uncovered skin, because individuals shed up to $10^9$ epithelial cells per day, many of which carry bacteria. This practice should be followed by all personnel working in the OR, not just those working in or near the operating field.
For procedures at high risk of blood contamination, a waterproof apron or gown should be worn.

Meticulous operative techniques reduce the risk of SSI. This may be reflected in shorter durations of procedures which are clearly associated with a lower risk of SSI.

Scheduling dirty cases at the end of the day is a practice which should be abandoned.

Any member of the surgical team who suffers from a skin lesion such as a boil should refrain from working in the OR for such an individual may be dispersing tremendous amounts of bacteria, namely *Staphylococcus aureus*, in the air of the OR. Dermatitis of the hands sometimes caused by glove allergy should also be taken seriously for the same reason.

**Controversial Issues**

ORs equipped with laminar airflow system provide almost sterile air, yet a very few studies show a significant decrease in SSI rates for surgical procedures performed in this type of OR. Furthermore, some of these experiments did not control for the antimicrobial regimen received as surgical prophylaxis, thus precluding any conclusion on the exact role of the laminar flow system. Therefore, at this time no recommendation can be made for the use of laminar flow ventilation in ORs.

The use of brushes or sponges for preoperative asepsis of hands and arms can be replaced by antiseptic soap alone. A few studies demonstrated higher bacterial counts after brushing compared with counts obtained after simple washing with soap. Significant savings may occur by not using sponges.

The association between wearing nail polish by surgical team members and the risk of SSI has not been studied adequately.

The design and composition of surgical attire should minimize bacterial shedding into the environment. Cotton does not reduce airborne contamination because the pore size between threads largely exceeds the size of skin scales. Furthermore, wet cotton fabric allows easy passage of bacteria to the outside of a gown as a result of the surgeon’s sweating or from fluids such as blood. A number of other fabrics (close-woven polyester, disposable non-woven, plastic-membrane) have been tested against strike-through and examined for transfer of
bacteria from skin scales from underneath the clothe. It is not known which type of fabric reduces airborne contaminants while also providing comfort.

Likewise, there are also conflicting data regarding the difference in SSI rates when adhesive plastic drapes are used instead of conventional one (cotton).

No well-controlled studies evaluate whether restricting the use of surgical scrubs to the OR suite or allowing them outside the OR will make a difference on SSI rates. Some hospitals require covering gowns when surgeons/nurses leave the OR still wearing surgical scrubs. It would make sense to change grossly soiled scrubs, scrubs worn while changing dressings on wards between surgical procedures, and probably changing scrubs after wearing them for 8 hours or more. No recommendation can be made on how and where to launder scrub suits.

Any perioperative event that causes vasoconstriction, for example hypothermia or subtle hypovolemia, alters the oxygenation of normal soft tissues, which in turn may result in higher infection rates. Therefore, a number of experts have either given supplemental oxygen or warmed patients during surgical procedures and demonstrated a decrease in SSI rates following colorectal procedures. More information is needed before one can recommend these practices as a mean to decrease SSI rates.

Three of 5 randomized trials conducted in patients undergoing colorectal surgical procedures have proposed that peri-operative transfusion of leucocyte-containing allogenic blood components is an apparent risk factor for SSI. However, because many confounding variables may have influenced this association, there is currently no scientific basis for withholding blood products from patients as a means of reducing SSI risk.

Summary
Preparation of the surgical team and maintaining a clean operating environment are important because a number of intraoperative risk factors contribute to the development of SSIs. Very little has changed over the years concerning the surgical rituals of scrubbing, gowning and gloving perhaps because of a lack of scientific data or for ethical reasons. Many of these rituals still hold today not only for the prevention of SSIs but also for
the protection of the surgical team. In clean surgical procedures, particularly when an implant is inserted, these rituals merit attention because airborne contamination by members of the surgical team from their skin contribute to SSIs. Wearing proper surgical attire, keeping OR doors closed and traffic to a minimum are simple measures that decrease airborne contamination.

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Wong ES. Surgical Site Infections in Infection Control and Hospital Epidemiology, CG Mayhall CG (Ed). Baltimore: Lippincott Williams & Wilkins, 2004.
CHAPTER 22

EMERGENCY ROOM
AND RECEIVING AREAS

Heike von Baum, MD, and
Richard P. Wenzel, MD, MSc

Key Issue
Healthcare workers in emergency rooms and receiving areas need to protect themselves from blood and air-borne infections and also recognize and attempt to isolate quickly all patients with infections posing a risk to nearby personnel, patients and visitors.

Identification and isolation of patients are mandatory in cases where highly contagious infections (like tuberculosis) or exposure to a bioterror agent are suspected.

Known Facts
Universal precautions were promoted by the Centers for Disease Control and Prevention because of the inability to identify patients whose blood contain the hepatitis B or C virus, human immunodeficiency virus, and other pathogens. All blood should be considered potentially contaminated, and efforts should be made to avoid direct contact, mucous membrane exposure, and sharp injuries.

Respiratory protection equipment is justified if caring for patients with suspected or confirmed tuberculosis or other highly contagious air-borne infections (e.g., SARS)

Controversial Issues
• There is no controversy about the potential risk of transmission of blood disease to healthcare workers from patients.
• With respect to isolation, there are few data to show how effective various types of isolation are. Nevertheless, for most types of isolation precautions the costs are low and the rationale based on available knowledge about the mode of transmission.
• The association of ventilation measures in the hospital with tuberculin conversion in healthcare providers is still under investigation. Higher tuberculin conversion rates have been reported among personnel who worked in nonisolation patient rooms with fewer than 2 air exchanges per hour. Guidelines for the prevention of nosocomial transmission of tuberculosis recommend minimum air change rates of 2 to 15 per hour for different patient care areas and activities.

• Only scarce data exist discussing how effective healthcare workers are at identifying patients at risk for transmitting infections. Patients with active pulmonary tuberculosis are often missed at emergency triage, although presenting with typical symptoms and risk factors. It should be evaluated if the emergency department might present an opportunity for earlier diagnosis of tuberculosis.

**Suggested Practice**
- Provide patient information material about hand and respiratory hygiene/cough etiquette in the receiving areas
- Offer materials for adhering to the aforementioned recommendations in waiting areas
- Careful hand hygiene preferably with alcohol based hand rubs before and after each patient encounter.
- Gloves should be worn when contact with body and body fluids is likely.
- Consider isolation gowns if contact with blood or body fluids is anticipated
- Goggles or face masks should be worn if available whenever splashing of blood or body fluids is likely.
- Face masks should be worn whenever an air-borne infection (tuberculosis, SARS) is likely.
- Triage persons should be trained to identify patients with probable transmittable infections.
- Patients who appear unusually ill especially with cough should be isolated (> 3 feet distance) from other patients if possible.
- Consider offering surgical masks or tissues to cover their coughs to coughing patients
• Patients who might have been exposed to yet unknown agents in the course of a bioterror attack should be isolated as soon as possible.
• Efforts should be made to minimize staff flow between isolated and non-isolated patients

**Summary**
Reasonable precautions as adjusted above can minimize transmission of most infections in the emergency room i.e., those transmitted by close contact. Any person who performs tasks involving contact with blood, body fluids or sharps should be vaccinated against hepatitis B. Providing and using a sharp container reduces bloodborne infections by sharp injuries.

There will still exist some risk of air-borne diseases such as those transmitted by droplet nuclei especially influenza, measles and tuberculosis. A room with an exhaust fan in the window will minimize air-borne infections. Where this is not available, excellent ventilation will help.

Occupational exposure to blood or droplets should be reported. Postexposure counselling and therapy, if necessary, should be offered to all clinical personnel.

**References**


Sokolove PE, Rossman L, Cohen SH. The Emergency Department Presentation of Patients with Active Pulmonary Tuberculosis. *Acad Emerg Med* 2000; 7: 1056–1060

CHAPTER 23

HIV INFECTION AND AIDS
IN DEVELOPING COUNTRIES

Philippe Van de Perre, MD, PhD

Key Issues
Less than 20 years after it was first recognized in Africa, HIV infection is already the leading cause of adult deaths in many cities in developing countries, and it has significantly increased childhood mortality. Despite considerable efforts to control the epidemic, HIV continues to spread at a rapid pace in developing countries. Of an estimated 42 million people infected by HIV world-wide as of December 2002, 70% of adults and 90% of children are living in developing countries. More than 3 million died of HIV infection during 2006 alone.

In the last decade, the development of new antiretroviral (ARV) drugs (Table 23.1) and the access to Highly Active Antiretroviral Therapy (HAART) for HIV-infected patients in industrialised countries have been accompanied by a dramatic reduction in HIV-associated mortality. In 2003, for those who have access to ARV drugs, HIV infection should be considered as a manageable chronic illness. However, the vast majority of the 36 million people in developing countries living with HIV/AIDS have no access to HAART.

In 2002, the World Health Organization estimated that out of 6 million people eligible for HAART in developing countries, only 230,000 had access to ARV therapy. Half of them live in Brazil where outstanding efforts have been developed to offer appropriate therapy to all HIV-infected individuals. The global challenge is therefore to scale up access to ARV drugs for all HIV-infected individuals who need it.

Known Facts
• Both HIV type 1 (HIV-1) and HIV type 2 (HIV-2) are circulating in developing countries. HIV-2 which is mostly
spread in West Africa where it co-exist with HIV-1, is less transmissible and less pathogenic than HIV-1. HIV-2 as HIV-1 group O are naturally resistant to non nucleosidic reverse transcriptase inhibitors.

• All groups of HIV-1 (group M, N and O) as well as all genotypic subtypes of HIV-1 group M (subtypes A to K) and Recombinant Circulating Forms (CRFs) are co-circulating in developing countries but regional distribution of groups, subtypes and CRFs varies considerably.

• Transfusion of HIV contaminated blood is still responsible for about 10% of overall transmission events.

• Blood banking organization, selection of blood donors and HIV testing of blood donations are effective in preventing transfusion-associated infections.

• Sexual transmission remains by far the most frequent route of transmission in adults. Sexually Transmitted Infections (STI) are facilitating HIV transmission by sexual intercourses.

• Control of STI at the community level is a cost-effective strategy to prevent sexual transmission of HIV.

• Mother-to-Child Transmission (MTCT) of HIV involves almost exclusively HIV-1 and can occur in utero during labor and delivery and postnatally by breastfeeding. MTCT rate is estimated 20–30% in breastfeeding populations in the absence of prophylaxis.

• Prevention of MTCT by treating HIV-infected pregnant women and their neonates with antiretrovirals is highly efficacious.\(^3\) Efficacy of short perinatal regimens of antiretrovirals (such as a single dose of 200 mg of nevirapine given to the mother during labor and a single dose of 2 mg per kg of body weight given to the infant within 48 hours of birth) is high at the short term but is steadily decreasing if infants born to HIV-1 infected mothers are subsequently exposed to HIV-1 by breastfeeding.

• Susceptibility to acquisition of HIV and clinical course of HIV disease are highly variable and may be determined at the individual level by the existence of genetic factors such as deletions on the genes coding for cellular cofactors for viral entry (such as CCR5) or their promotors.
Table 23.1 Antiretroviral Drugs Available or Under Development

<table>
<thead>
<tr>
<th>Nucléosidic Reverse Transcriptase Inhibitors</th>
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<tbody>
<tr>
<td>- Zidovudine (Retrovir®)</td>
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<tr>
<td>- Didanoside (Videx®)</td>
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<tr>
<td>- Zalcitabine (Hivid®)</td>
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<tr>
<td>- Stavudine (Zerit®)</td>
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<tr>
<td>- Lamivudine (Epivir®)</td>
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<tr>
<td>- Abacavir (Ziagen®)</td>
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<tr>
<td>- Combivir® (Zidovudine-Lamivudine)</td>
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<tr>
<td>- Trizivir® (Zidovudine-Lamivudine-Abacavir)</td>
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<tr>
<td>- DAPD*</td>
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<tr>
<td>- Emtricitabine* (FTC)</td>
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<table>
<thead>
<tr>
<th>Nucléotidic Analogue Reverse Transcriptase Inhibitors</th>
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<tbody>
<tr>
<td>- Ténofovir (Viread®)</td>
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<table>
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<tr>
<th>Inhibitors of Viral Entry</th>
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<tbody>
<tr>
<td>- PRO 542* (inhibitor of viral attachment)</td>
</tr>
<tr>
<td>- AMD-3100* (CXCR inhibitor)</td>
</tr>
<tr>
<td>- SC-351125* (CCR5 inhibitor)</td>
</tr>
<tr>
<td>- T-20 enfuvirtide (Pentafuside, Fuzeon®) (fusion inhibitor)</td>
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<tr>
<td>- T-1249* (fusion inhibitor)</td>
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<table>
<thead>
<tr>
<th>Non-Nucléosidic Reverse Transcriptase Inhibitors</th>
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<tbody>
<tr>
<td>- Névirapine (Viramune®)</td>
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<tr>
<td>- Efavirenz (Sustiva,® Stocrin®)</td>
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<tr>
<td>- Delavirdine (Rescriptor®)</td>
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<tr>
<td>- Emvirine*</td>
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<tr>
<td>- Capravirine*</td>
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<tr>
<td>- TMC120*</td>
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<td>- DPC083*</td>
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<table>
<thead>
<tr>
<th>Protease Inhibitors</th>
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<tbody>
<tr>
<td>- Saquinavir</td>
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<tr>
<td>- Saquinavir-HCG (Invirase®)</td>
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<tr>
<td>- Saquinavir-SGC (Fortovase®)</td>
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<tr>
<td>- Ritonavir (Norvir®)</td>
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<tr>
<td>- Indinavir (Crixivan®)</td>
</tr>
<tr>
<td>- Nelfinavir (Viracept®)</td>
</tr>
<tr>
<td>- Amprenavir (Agenerase®)</td>
</tr>
<tr>
<td>- Lopinavir/Ritonavir (Kaletra®)</td>
</tr>
<tr>
<td>- Tipranavir*</td>
</tr>
<tr>
<td>- BMS-232632* (atazanavir)</td>
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</tbody>
</table>

* drugs in development, not commercially available
• More than 85% of fatal overwhelming infections associated with HIV as well as the first five causes of mortality in HIV-infected African patients (Table 23.2) are potentially amenable to a simple, effective and frequently affordable antiinfectious treatment or prophylaxis, such as the use of cotrimoxazole. The most devastating public health impact of HIV-1 infection on other endemic diseases is on tuberculosis. In sub-Saharan Africa, the annual incidence of tuberculosis is more than 15-fold greater in HIV-infected individuals than in HIV-uninfected individuals.

• Clinical management of HIV-infected patients is based on access of non specific healthcare quality services: diagnosis and treatment of tuberculosis and of other infectious diseases (pneumococcal disease, bacteraemia,). Lifelong HAART should be administered in a patient with HIV associated signs or symptoms and/or with less than 200 CD4+ T cells per µl.

Table 23.2 Principal causes of death in HIV-infected African patients (autopsy study, n = 247; Abidjan, Côte d’Ivoire, 1991)

<table>
<thead>
<tr>
<th>Rank order</th>
<th>Causes of death</th>
<th>Prime cause of death*</th>
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<tbody>
<tr>
<td>1</td>
<td>Tuberculosis</td>
<td>32 %</td>
</tr>
<tr>
<td>2</td>
<td>Bacteremia</td>
<td>11 %</td>
</tr>
<tr>
<td>3</td>
<td>Cerebral toxoplasmosis</td>
<td>10 %</td>
</tr>
<tr>
<td>4</td>
<td>Pyogenic pneumonia</td>
<td>8 %</td>
</tr>
<tr>
<td>5</td>
<td>Pyogenic meningitis</td>
<td>5 %</td>
</tr>
</tbody>
</table>

* Proportion of deaths considered as primarily caused by the given condition.

• Alternative techniques to classical flow cytometry, such as immunomagnetic beads or cyflow technologies, exist to enumerate CD4+ T cells at lower cost and with reasonably good technical performances. Similarly, low cost reliable techniques exist to measure HIV-1 viral load, such as real time PCR and p24 antigenaemia.

• HIV is highly sensitive to physic and chemical environment and to widely used disinfectants. Reinforced hospital hygiene measures are of practical importance to minimize...
the risk of exposure to HIV-containing blood and body fluids in the healthcare settings. Postexposure prophylaxis by means of a combination of ARV [generally two drugs, such as zidovudine (AZT) + lamivudine (3TC), 3TC + stavudine (d4T) or didanosine + d4T, given within 36 hours of exposure, for one month] is highly efficacious in preventing acquisition of HIV-1 infection after accidental exposure to the virus in the healthcare settings. In certain circumstances, a third drug may be required or an adjustment of regimen according to the index patient profile of antiretroviral resistance.

Controversial Issues

- Scaling up access to HAART in developing countries, and monitoring it in terms of adherence, efficacy, tolerance and sustainability remain major challenges. Preliminary data from Brazil, Thailand, Senegal and elsewhere suggest that adherence of HAART-treated patients in well-organized outpatients clinics in developing countries is at least as good as in industrialised countries. The most recommendable way to follow up the biological efficacy of HAART in developing countries is unknown. Several schemes have been proposed: clinical follow up only, clinical follow up and CD4 counts, or same with viral load measurements to detect viral escape.

- In industrialised countries, many deaths observed in HAART treated HIV-infected patients occur in a context of liver failure, due to drug toxicity and/or co-infections with hepatitis C (HCV) or B (HBV) viruses. It is presently unknown if HCV and/or HBV, frequently co-existing in HIV-infected individuals will compromise the long term benefit of HAART in developing countries. Access to new HCV (pegylated interferon alpha, ribavirin) and HBV (3TC, adefovir, emtricitabine) therapies worldwide is also a public health challenge.

- The interactions between HIV infection and other tropical diseases, such as malaria, other parasitosis, or malnutrition, remain largely undetermined.

- Herpes simplex type 2 (HSV2) infection is one of the most endemic STI worldwide and have been suggested to facilitate
sexual transmission of HIV. In countries where HIV and HSV2 are both frequent especially in the younger adult age groups, it has been estimated that half of the newly acquired HIV infections are attributable to a pre-existing HSV2 infection. Since HSV2 infection is amenable to prevention and treatment (antiviral compounds such aciclovir and valaciclovir, as well as candidate vaccines), control of HSV2 may have a dramatic impact on the spread of HIV.

- The consequences of the emergence of HIV-1 resistant mutants in mothers treated with short ARV regimens (mainly Nevirapine) for prophylaxis of MTCT are presently unknown. Are archived resistant mutant viral populations able to compromise the efficacy of further Nevirapine-containing maternal HAART?

- Several studies on prolonged maternal and/or infant ARV prophylaxis during breastfeeding are ongoing in order to determine if it can protects against breastfeeding transmission of HIV-1.

- What is the feasibility, efficacy, compliance and long term effects of prophylaxis of opportunistic infections such as TB prophylaxis by Isoniazide, prophylaxis of bacterial and protozoal infections by cotrimoxazole, or prophylaxis of pneumococcal disease by means of anti-pneumococcal vaccine?

- It is presently unclear if post exposure prophylaxis by means of a combination of ARV is as effective for preventing accidental sexual transmission of HIV-1 as it is for professional exposure in healthcare workers.

**Suggested Practices**

- Prevention and clinical and psychosocial management and a continual struggle against discrimination/stigmatisation are all integral parts of HIV/AIDS control programmes. Each of these components is not sufficient in itself but all are synergistic.

- Voluntary counselling and testing for HIV is the entry point of HIV prevention and care and has to be made available widely.

- In terms of prevention the following strategies should be implemented:
– STI diagnosis and treatment at the community level (based on well validated treatment algorithms);
– Blood bank organization, blood donors’ selection and HIV testing of blood donations;
– Increased accessibility of mother and child to high quality healthcare services (antenatal clinics, basic obstetrical needs, nutritional education) including a thoughtful package of antenatal care. Perinatal prophylactic ARV (such as Nevirapine) in the case maternal HIV infection has been detected antenatally or during labor;
– Reinforcement of available health programmes (TB control, malaria control, expanded programme on immunization, maternal and child care, family planning,...);
– Access of all health professionals to post exposure prophylaxis in case of accidental exposure to blood or body fluids potentially containing HIV and hepatitis viruses.

• In terms of psychosocial and clinical management the following strategies should be implemented:
  – Skilled, acceptable, accessible and sustainable voluntary HIV counselling and testing services;
  – Simple clinical algorithms for clinical management of HIV disease and treatment of infectious episodes by means of available essential drugs and including nutritional support;
  – Decentralised management and community support;
  – New strategies to diagnose and treat TB (such as directly observed therapies);
  – In case of HIV related signs and symptoms and/or of a CD4+ T cell count of less than 200 per ml, a triple combination of ARV drugs has to be given together with a meaningful encouragement for adherence and a careful clinical and biological monitoring (biochemistry in search for drug toxicity, CD4 count and HIV viral load for monitoring of treatment efficacy),
  – In patients not eligible for HAART, prophylaxis of opportunistic infections by antibiotics (such as daily cotrimoxazole), together with a careful monitoring of HIV clinical course is to be implemented.
References


CHAPTER 24

TUBERCULOSIS

Timothy F. Brewer, MD, MPH

Key Issue
Tuberculosis (TB) remains one of the leading causes of preventable deaths in adults worldwide. The vast majority of TB cases and deaths occur in low resource areas. Nosocomial transmission of TB to healthcare workers and patients occurs in both developed and developing countries. Effective infection control practices can reduce the risk of TB transmission in healthcare settings, but education, monitoring and follow-up are needed to insure that healthcare workers follow recommended practices.

Known Facts
• Nosocomial transmission of TB, including multiple-drug resistant tuberculosis (MDR-TB), to healthcare workers and patients has been well-documented in industrialized and low resource countries.
• Healthcare workers in many regions are at increased risk for both latent TB infection and active TB disease compared with the general population.
• Human immunodeficiency virus (HIV) infected healthcare workers and patients co-infected with *Mycobacterium tuberculosis* have a high risk of progressing to active TB.
• Procedures that result in the aerosolization of *M tuberculosis* such as autopsies, bronchoscopy, sputum induction or abscess irrigation have caused TB transmission to healthcare workers.
• Many TB patients, including those with MDR-TB, may be treated in community based settings avoiding the need for hospitalization and the risk of nosocomial transmission.
• Chemoprophylaxis, or treatment of latent TB infection, reduces the risk of active TB.
Effective infection control practices lower the risk of new TB infections in healthcare workers.

**Controversial Issues**

- The benefit of environmental controls such as ultraviolet germicidal irradiation (UVGI) or increasing the number of room air exchanges to >6 per hour in reducing nosocomial transmission of TB is unknown.
- Should all healthcare workers in TB endemic countries be screened for HIV infection?
- Should all healthcare workers in TB endemic countries be offered annual screening for latent TB infection and given treatment for documented conversions?

**Suggested Practice**

**Administrative Controls**

Preventing TB transmission in institutions is based on the early identification, isolation and treatment of patients with active disease. The infection control strategies recommended to prevent TB transmission in healthcare settings depend on the prevalence of active TB in the patient population and the resources available for implementing control programs. Unfortunately, the areas with the greatest need for TB infection control policies often have the fewest resources for creating and maintaining effective control programs.

The first step in preventing TB transmission in healthcare settings is to undertake a risk assessment for TB transmission to healthcare workers and patients. An infection control officer, nurse, or other employee should be identified to be responsible for the implementation and enforcement of TB control policies. Based on the risk assessment, written control policies should be established. Factors influencing the risk of TB transmission include the number of TB patients seen at the facility, the amount of time TB patients spend in different areas such as waiting rooms or wards, the prevalence of HIV among healthcare workers and the population, the healthcare worker’s role in caring for those patients and the measures in place to prevent TB transmission. Once policies have been established and put into place, ongoing enforcement and education for healthcare workers are crucial. Studies have shown that compliance with TB control measures, even among physicians, falls over time...
without continuous education and monitoring. Repeat risk assessments should be undertaken at least once a year to determine if control measure are sufficient and effective.

Many TB patients do not need to be hospitalized for TB diagnosis or treatment. Alternative outpatient sites should be considered where individuals with symptoms suggestive of TB may be evaluated. Patients with cough ≥ 2 weeks, hemoptysis, fever, weight loss or night sweats should be rapidly identified, and if TB is considered likely, kept isolated from other patients until TB has been excluded or the patient started on treatment. Possible strategies include having a separate waiting room or isolation room for patients with possible TB. Patients suspected of having TB should be provided with surgical masks or cloths, and instructed to turn their heads and cover their mouths when coughing to reduce the production of airborne droplet nuclei. If possible, HIV-infected healthcare workers should not be involved in the initial evaluation of individuals with likely active TB. Patient factors associated with TB transmission include: coughing, being smear-positive, having disease of the larynx or lungs, having cavitary disease on chest radiography, and not having been started on effective antituberculous therapy.

Sputum microscopy should be available to quickly determine if symptomatic patients have smear-positive TB. For smear-negative patients, chest radiography may be helpful and should be done where facilities and resources allow. Patients with active TB should be promptly started on effective antituberculous therapy according to treatment guidelines developed by the World Health Organization (WHO), the US Centers for Disease Control and Prevention (CDC), or similar expert group. Routine hospitalization to commence TB treatment is not necessary, and should be reserved for only those patients who otherwise require inpatient care. Cough inducing procedures such as sputum induction and bronchoscopy should be avoided in patients with untreated, active TB.

A TB educational program should be developed for all healthcare workers. This program should include information on TB transmission, recognizing the signs and symptoms of active TB, understanding the interaction between TB and HIV and the control policies in place to prevent TB transmission to healthcare workers and patients.
**Environmental Controls**

TB patients requiring admission to the hospital should be kept isolated from non-tuberculous patients until no longer infectious. In industrialized countries, following the CDC guidelines for the prevention of TB transmission in healthcare settings reduces TB transmission to staff and patients. These guidelines include the administrative controls noted above, as well as environmental controls and the use of personal protection devices by healthcare workers.

TB patients should be kept in airborne infection isolation (AII) rooms until no longer infectious; these rooms are designed so that air flows from the corridor into the room and not from the room to the corridor. Unnecessary transfers around the hospital should be avoided, and TB patients should wear surgical masks when being taken for tests outside their rooms. A window fan exhausting air outside is a relatively inexpensive way to create a negative pressure room, though the effectiveness of this approach in preventing droplet nuclei from spreading is unknown. Air from TB isolation rooms should be exhausted to the outside away from intake fans or waiting areas, or passed through high-efficiency particulate (HEPA) filters before being re-circulated. Effective HEPA filters removed 99.97% of particles ≥ 0.3 µm in diameter. Though the effectiveness of HEPA filters in preventing nosocomial TB transmission is not well established, *M. tuberculosis* droplet nuclei are 1 µm to 5 µm in size and should be removed by filtration.

Though AII rooms are the recommended for hospitalized TB patients in industrialized countries, these facilities are unlikely to be available in TB endemic, low resource areas. If TB patients must be hospitalized in settings where individual isolation rooms are not available, a cohort system can be used. TB patients can be hospitalized with other TB patients with a few caveats. Patients with suspected MDR-TB should be kept isolated from patients with drug-sensitive TB. Hospital-based transmission of MDR-TB to patients on treatment for drug-sensitive TB has occurred.

Additional engineering controls to prevent TB transmission in hospitals include UVGI. The goal of UVGI is to inactivate airborne droplet nuclei. The two most common forms of UVGI
are upper-room air irradiation and duct irradiation. In upper-room air irradiation, the UV lights are directed towards the ceiling away from the patient to reduce the risk skin and eye toxicity while providing germicidal benefit. Duct irradiation is used to disinfect air exhausted from TB isolation rooms. UVGI should not be used in place of airborne infection isolation rooms or HEPA filters.

**Personal Protection**

When possible, personal respirators should be worn by healthcare workers caring for patients with infectious TB. Though a surgical mask is adequate for TB patients to reduce their likelihood of producing droplet nuclei, healthcare workers need to wear N95 respirators to adequately protect themselves from inhaling airborne droplet nuclei. N95 masks filter ≥ 95% of particles 1 µm in size. These respirators need to be individually fit tested to insure that they provide adequate protection.

**Summary**

TB remains one of the leading causes of preventable morbidity and mortality worldwide, with approximately 8.9 million new cases and 1.7 million deaths every year. Ninety-eight percent of the cases and deaths occur in low resource countries. For most of the world, TB control consists of directly observed therapy, short-course (DOTS) for smear-positive TB patients and Bacille Calmette-Guérin vaccination for infants. About one-third of the entire world’s population is estimated to be infected with *M. tuberculosis*, and therefore at risk for developing active TB.

Individuals co-infected with HIV and *M. tuberculosis* are at very high risk for active TB, approximately 3–10 cases per 100 person-years. HIV-infected persons and contacts of active TB cases should be screened for latent TB infection with a tuberculin skin test (TST) or whole blood assay for *M. tuberculosis* and given treatment with isoniazid for 6–9 months if positive. WHO currently recommends chemoprophylaxis (treatment of latent TB infection) for children <5 years old who are household contacts of TB cases and TST-positive HIV-infected persons. Though not currently recommended by WHO, studies support the use of chemoprophylaxis for any person, including
healthcare workers, who has a documented TST conversion after contact with an active TB case.

Institutional TB transmission has occurred in many countries including in the US and Western Europe. It is imperative that all healthcare settings undertake a TB risk assessment, and if necessary, develop infection control policies to prevent the TB transmission. Many administrative steps for TB control, such as improving the evaluation of suspected TB cases, coughing etiquette for TB patients, avoiding unnecessary hospitalizations, and separating TB patients from others may be possible without a large investment in new personnel or equipment. Environmental controls, including AII rooms, may be too expensive for many healthcare settings in TB endemic countries. Window fans and cohorting may reduce TB transmission risk, though these interventions remain unproven at this time.

References
CHAPTER 25

DIARRHEA

Made Sutjita MD, PhD, and Herbert L. DuPont, MD

Key Issues
A diarrheal disease outbreak in healthcare facility may affect patients, healthcare workers, and visitors. Recognizing these risk factors, surveillance, and initiation of prompt infection control management practices will reduce the morbidity and mortality rate.

Known Facts
- Definitions of diarrhea vary but generally include the passage of liquid or watery stools, three or more times per day. Microorganisms that invade or inflame the intestinal mucosa often elicit a febrile response in addition to causing diarrhea. Diarrhea in a patient with unexpected fever should be considered as infectious gastroenteritis regardless of culture results. If a patient is febrile or diarrhea occurs in a patient whose fever has other likely causes, the identification of pathogenic microorganisms is necessary to establish the diagnosis.
- The known incubation period of an infectious agent is important in determining whether a given infection is nosocomial. The interval between the time of admission and the onset of clinical symptom must be longer than the known minimum incubation period of the infectious agent. Alternatively, nosocomial gastroenteritis can be determined if a stool culture obtained shortly before or just after admission is negative for a given pathogenic agent and the agent is subsequently cultured from the patient stool.
- Microorganisms that cause diarrhea outbreaks in the community are also able to cause nosocomial outbreaks in the hospital. Some forms of diarrheal disease, such as food poisoning caused by Bacillus cereus, Clostridium perfringens and Staphylococcus aureus have not been demonstrated to
be directly transmissible from person to person in the hospital. Common bacteria reported to cause nosocomial gastroenteritis include various strains of diarrheagenic *E. coli*, *Salmonella spp.*, *Y. enterocolica*, *V. cholerae*, and most importantly *C. difficile*.

- The most important viral agent implicated is nosocomial. In an epidemiologic investigation in England during the period 2002–03 hospital outbreaks, norovirus was found in 63% of healthcare-associated gastroenteritis outbreaks. Other viruses such as norwalk virus and adenovirus have also been implicated in nosocomial outbreaks. In a childcare setting, enteroviruses, such as polioviruses, have the potential to cause an outbreak in a nonimmune population as does *Giardia lamblia* and the conventional enteropathogens.

- It is important to distinguish between nosocomial diarrhea and infectious nosocomial gastroenteritis. Nosocomial diarrhea or diarrhea of non infectious origin, such as that caused by cathartics, tube feeding, inflammatory bowel disease, surgical resection, and anastomoses, should be differentiated from diarrhea of infectious origin.

- The rate of nosocomial gastroenteritis varies among hospitals and services. The NNIS (National Nosocomial Infections Surveillance) in the USA reported a nosocomial gastroenteritis infection rate of 2.27 per 1000 discharge, for the period of January 1990 through December 1994. Infection rates of nosocomial gastroenteritis in developing countries are not exactly known. Nonetheless, outbreaks are reported with increasing frequency. *Salmonella spp* are the most common cause of nosocomial gastroenteritis in India, Pakistan, and Tunisia.

- Risk factors for nosocomial gastroenteritis can be classified by intrinsic and extrinsic factors. Intrinsic factors include an abnormality in the mucosal defense, such as achlorhydria, impairment of intestinal motility, and alteration of normal enteric flora. Neonates with undeveloped immunity or patients with an immune deficiency state, such as those on immuno-suppressive drugs or with AIDS, are at increased risk to develop nosocomial gastroenteritis. Extrinsic factors
include nasogastric tube feeding while receiving cimetidine, which allows intestinal colonization of bacteria. Such a setting is normally found in an intensive care unit.

- Modes of transmission of infectious agents causing gastroenteritis are typically through the fecal-oral route. The transmission occurs either by contact spread from patient to patient, patient to healthcare worker (HCW), or HCW to patient (either direct or indirect), or through common vehicle spread. Contaminated vehicles such as food, water, medications, or devices and equipment can play a significant role in the transmission of the agents.

**Controversial Issues**

- *Salmonella spp* were reported as the most common cause of nosocomial gastroenteritis in some developing countries but the infection rate of other enteric pathogens is not well known. Without the established mechanism for routinely reporting nosocomial outbreaks, the ‘true’ infection rate of given pathogens is underestimated.

- The availability of “over-the-counter” antibiotics without a physician’s prescription in many developing regions may lead to the development of resistant microorganisms. This often complicates the management of a diarrheal disease outbreak.

**Suggested Practice**

- Effective hand washing is among the most important measures to reduce the risks of transmitting microorganism from one person to another or from one site to another in the same patient. HCWs should wash their hands with a non-antimicrobial soap and water or an alcohol-based waterless antiseptic agent. An anti-microbial soap and water should be used when hands are visibly dirty or contaminated with feces.

- *Clostridium difficile* is the most important cause of nosocomial diarrhea in industrialized countries. If outbreak of *Clostridium difficile*-associated diarrhea is suspected, consider using only soap and water for hand hygiene when caring for diarrhea patients since alcohol-based hand rubs are not effective against spore-forming bacteria.
• Gloves play an important role in reducing the risk of microorganism transmission, and preventing contamination of the hands when touching patients and fomites. Attempts should be made to reduce the likelihood of the hands of the HCW being contaminated with microorganisms from a patient or a fomite and of infecting another patient. In this case, gloves must be changed between patient contacts and hands must be washed after gloves are removed.

• Gowns and other protective apparel provide barrier protection and reduce the likelihood of transmission of microorganisms. Gowns, boots, or shoe covers provide greater protection to the skin when splashes or larger quantities of infective material are present or anticipated. When a gown is worn during the care of a patient infected with an epidemiologically important microorganism, it should be removed before leaving the patient’s environment.

• A private room is important to prevent direct or indirect contact transmission of the microorganism. Whenever possible, a patient with infectious diarrhea is placed in a private room with hand washing and toilet facilities. A sign of “contact isolation” should be placed in front of the door to warn visitors or other HCWs. Patients infected by the same microorganism may share a room (cohorting), provided they are not infected with another potentially transmissible microorganism.

• Limiting the transport of a hospitalized patient with infectious diarrhea may also reduce the opportunities for transmission of the microorganism in the hospital.

• The patient’s room, bed and bedside equipment should be cleaned thoroughly. In a patient with stool positive for VRE (vancomycin resistant enterococci), adequate disinfection of environmental surfaces, i.e., bed rails, tables, carts, commodes, doorknobs, or faucet handles, is indicated. Enterococci are not causing diarrhea, but may cause bloodstream infection in susceptible patients. Enterococci are known to survive in the inanimate environment for prolonged periods of time.
• Urine, feces, and soiled linen should be considered potentially infectious and handled or disposed appropriately as discussed elsewhere. Personnel handling these materials should wear gloves and other protective apparel as described above.

• Use diluted household bleach (1000 ppm sodium hypochlorite or 5 tablespoons of 6% household bleach to 1 gallon water) for disinfecting hard surfaces routinely or after cleaning a soiled area. If possible allow the surfaces to remain wet for 10 minutes then air dry.

Summary
It is important to establish a hospital surveillance program in which clinical patterns of infection are monitored on a regular basis. A “low-budget” surveillance program probably can be carried out by daily review and tabulation of bacteriologic reports from the hospital microbiology laboratory. Both cooperation and effective communication between hospital epidemiology and the microbiology laboratory personnel are essential.

In the addition to the patient population, surveillance must include hospital personnel, particularly food handlers, nurses and other medical staffs. An employee health service or an employee clinic ideally should be easily accessible to each employee. Food handlers, nurses, and ancillary staffs having direct contact with patients should report to employee health service when they experience an episode of diarrhea. In this case, stool cultures should be performed and the ill employee temporarily removed from work until the clinical course of the disease and culture result can be evaluated. Workers should not return to work until their diarrhea is resolved and two stool cultures obtained at least 24 hours apart show negative results.

A nosocomial infectious gastroenteritis outbreak may occur due to the transmission from carriers of a specific pathogenic microorganism. Carriers can be patients or hospital personnel. Surveillance carried out on regular basis should detect any episodes of gastroenteritis among patients and hospital personnel. Temporal clustering of cases should alert infection control personnel to the possibility of an outbreak. Occasionally, an
outbreak may occur due to contaminated vehicle such as food, equipment, or oral medication. If such a vehicle is identified, its removal or disinfection may help to terminate the outbreak.

Patients with infectious gastroenteritis should be discharged from the hospital as soon as their condition allows them to be managed as an outpatient basis.

References
Key Issue
Skin and soft tissue (SST) infections are not uncommon in the hospital setting. In addition to localized complications, skin and soft tissue infections may cause life-threatening bacteremia or a sepsis syndrome.

Known Facts
The most common causative agent is *Staphylococcus aureus*, followed by *Streptococcus pyogenes* and anaerobic gram-negative bacilli. In special populations (diabetic patients, burn wounds), aerobic gram-negative bacilli, including *Pseudomonas aeruginosa*, should be considered. *Staphylococcus aureus* is found in the normal skin, as a transient colonizing organism, often linked to nasal carriage (anterior nares). Pre-existing conditions, such as tissue injury (surgical wounds, trauma, pressure sores) or skin inflammation (dermatitis), as well as other diseases (insulin-dependent diabetes, cancer, chronic renal failure on hemodialysis, intravenous drug abuse, and HIV infection) are well-known risk factors for skin colonization and/or secondary infection by *Staphylococcus aureus*. On the other hand, some common diagnosis, like *Pyoderma gangrenosum*, must always be challenged, because its misdiagnosis (which includes several types of fungal infections) can result in severe complications if not properly treated.

**Staphylococcal Skin Infections**

**Key Issue:** Impetigo is the most common skin infection. It is a superficial primary skin infection, most often caused by *Streptococcus pyogenes* (90%) or *Staphylococcus aureus* (10%) infection. Impetigo may appear as a complication of other skin disorders, like eczema, varicella, or scabies.
**Known Facts:** Often seen in children, impetigo is readily transmitted in households and hospitals. If the diagnosis of impetigo is considered, the increasing frequency of skin disorders in HIV-infected patients should also be remembered.

**Controversial Issues:** The use of several antibiotics (mupirocin, fusidic acid, erythromycin, tetracycline) as topical treatment for impetigo shown to have ~90% efficacy in clinical trials. The use of topical antibiotics decreases bacterial colonization and infection, and promotes faster wound healing. Oral antibiotic treatment (erythromycin, an antistaphylococcal penicillin, amoxicillin + clavulanic acid) has been used with a similar success rate. However, the emergence of multidrug-resistant *S. aureus* strains, including methicillin-resistant *S. aureus* (MRSA), including mupirocin-resistant strains, is a matter of concern. The possible introduction of these strains should be closely monitored in hospitals, notably when topical treatments with agents like mupirocin are widely used for long periods of time.

**Suggested Practice:** Standard hygienic measures and contact isolation procedures should be used in patients with impetigo. This practice must be encouraged, especially in neonatal and pediatric intensive care units, as well as for patients with rashes and HIV infection.

**Staphylococcal Scalded-Skin Syndrome (SSSS)**

**Key Issue:** SSSS is a severe *Staphylococcus aureus* infection with extensive bullae and exfoliation.

**Known Facts:** It occurs in children, but rarely in adults. Several epidemics have been reported in nurseries and neonatal intensive care units (NICU). Its clinical picture is related to the production of a powerful exotoxin by the *S. aureus* strains. Most cases develop acute fever and a scarlatiniform skin rash. Large bullae soon appear, followed by exfoliation. Also known as *toxic epidermal necrolysis*, this disease can be due to other infections or drug reactions.

**Controversial Issue:** The use of corticosteroids alone is not recommended for SSSS.
**Suggested Practice:** The use of an antistaphylococcal penicillin is the antibiotic treatment of choice. Topical treatment includes cool saline compresses.

**Skin and Soft Tissue Infections in Patients with Diabetes**

**Key Issue:** Diabetic patients are at higher risk for developing skin and soft tissue (SST) *Staphylococcus aureus* infections.

**Known Facts:** Hyperglycemic states are linked with a higher nasal and skin carriage rate of *S.aureus*. The impaired cell-mediated immunity of these patients is an important factor.

**Controversial Issues:** Diabetic patients may develop different SST infections. The most severe condition is the acute dermal gangrene syndrome. This syndrome, related to a deep tissue infection and dermal necrosis, is often associated with prior trauma or surgery. It includes two different conditions:

1. **Progressive bacterial gangrene,** a more slowly progressive infection, related to surgical wounds, ileostomy sites, and exit site of drains (intra-abdominal or thoracic), which affects the hypodermis. The patient has a low grade fever or no fever. Local signs of infection are prominent.

2. **Acute dermal gangrene syndrome,** affecting the fascia and producing the complete necrosis of subcutaneous tissue. It is often associated with high fever, sepsis and septic shock. The mortality rate is very high (30%).

Other syndromes include Meleney’s gangrene, where the clinical picture is slowly progressive and without deep fascial involvement, *Fournier’s gangrene*, if the perineal zone is involved, *streptococcal gangrene*, if *Streptococcus pyogenes* is the causative agent, or *nonclostridial anaerobic synergistic myonecrosis* if the muscles are also involved. These SST disorders are nearly always due to polymicrobial infections, with *Streptococcus pyogenes* and *Staphylococcus aureus* being the most commonly isolated microorganisms.

**Suggested Practice:** Systemic antimicrobial treatment based on likely pathogens (including penicillin, antistaphylococcal penicillin, amoxicillin+clavulanic acid, a first or second generation cephalosporin), together with extensive and repeated surgical débridement are needed and must be started early.
**Burn Wound Infections**

**Key Issue:** Burn wound patients and burn wound units are potential portals of entry for nosocomial outbreaks due to MRSA and *Pseudomonas aeruginosa* infections. *Staphylococcus aureus* is responsible for 25% of all burn wound infections, followed by *P. aeruginosa*.

**Known Facts:** The most likely reservoirs for these infections are the hands and nares of healthcare workers (*S. aureus, MRSA*), the burn wound itself and the GI tract of burn patients (*S. aureus, P. aeruginosa*), and the inanimate environment of the burn unit, including the surfaces and/or the equipment (*S. aureus, MRSA, P. aeruginosa*).

**Suggested Practice:** Common standard isolation precautions, together with contact isolation precautions are important to prevent nosocomial infections in burn units. Topical treatment using mafenide acetate, silver sulfadiazine, bacitracin/neomycin/polymyxin, 2% mupirocin, together with systemic, antistaphylococcal and anti-*Pseudomonas* antibiotics should be reserved for documented or clinical infections.

**Pressure Sores (Decubitus Ulcers)**

**Key Issue:** Pressure sores appear in 6% of patients admitted to healthcare institutions (range 3 to 17%), and are the leading cause of infection in long-term care facilities.

**Known Facts:** The prevention of pressure sores includes the control of local factors such as unrelieved pressure, friction, moisture, or systemic factors such as low serum albumin, fecal incontinence, and poor hygienic measures. The infection is polymicrobial, and includes gram-negative bacilli, *Staphylococcus aureus*, *Enterococcus* spp and anaerobes. The average number of isolates in infected pressure sores is four, including three aerobic and one anaerobic bacteria. Pressure sores are sometimes associated with severe systemic complications, including bacteremia, septic thrombophlebitis, cellulitis, deep tissue and fascial necrosis, and osteomyelitis. The development of clinical tetanus is unlikely, although still possible. In patients with bacteremia and pressure sores, the sores were considered to be the source of the bacteremia in half the cases.
Overall mortality was 55%, with approximately 25% of deaths attributable to the infection. Therefore, pressure sores must be considered a potential source for nosocomial bacteremia.

**Suggested Practice:** Antibiotic treatment, together with surgical care and débridement of the sores, is needed. Taking into account the most likely microorganisms, a second-generation cephalosporin is one of the drugs of choice. The combination of a beta-lactam antibiotic with an aminoglycoside, or clindamycin plus an aminoglycoside, or a cephalosporin plus metronidazole are other good therapeutic options.

**Nosocomial Bacteremia Due to SST Infection**

**Key Issue:** Nosocomial bacteremia secondary to SST infections has a low frequency rate. According to National Nosocomial Infections Surveillance (NNIS) data, only 5 to 8% of all bacteremic episodes were secondary to SST infections.

**Known Facts:** Patients with poorly controlled diabetes and cancer are a high-risk group for developing this infection. In one large series from the US National Cancer Institute, 12% of all bacteremic episodes in cancer patients were secondary to SST infection. However, only 6% of those cases were associated with severe neutropenia. In neutropenic patients, *ecthyma gangrenosum* due to *Pseudomonas aeruginosa* SST infection must be considered. Intravenous drug abuse (IVDA) is a worldwide problem. SST infections are common among IVDA, ranging from 6 to 8% of all infections in a large Spanish study. *S. aureus* is the most common microorganism (30% of cases). The common clinical presentations are subcutaneous abscesses, cellulitis, and lymphangitis, most often (60%) located in upper extremities. Bacteremia is one of the most severe and common complications among IVDA, with 40% of all episodes due to *S. aureus*.

**Suggested Practice:** If bacteremia develops in an IVDA, septic thrombophlebitis or endocarditis should be considered, and antibiotic treatment started as soon as possible.
References
Key Issues
Hospital-acquired bloodstream infections (BSIs) are related to diagnostic and therapeutic invasive procedures.

BSIs have been divided into two groups: primary BSIs which occur without any other infectious site with the same organism at the time of BSI diagnosis (positive blood culture) and secondary BSIs, which are subsequent to bacteraemia from another infectious site.

Intravascular catheters are increasingly important causes of primary BSIs. Therefore, prevention and control of nosocomial BSIs are based on prevention of intravascular catheters related infection.

The incidence of BSIs associated with peripheral venous catheters is low. The majority of catheter-related BSIs are associated with central venous catheters.

Known Facts
• If the average rate of catheter-related BSIs is 5.3 per 1000 catheter days in intensive care unit, a total of 250,000 cases in the U.S. have been estimated to occur each year if all hospitals are assessed rather than intensive care units exclusively. The attributable mortality for BSIs is estimated to be approximately 25%. This attributable mortality plus additional hospital days related to nosocomial BSI increase the economic burden expected from the underlying diseases alone.
• The micro-organisms most frequently involved are coagulase-negative staphylococci (37%), Staphylococcus aureus (13%), Enterococci (13%) and Candida species (8%) but also Gram negative bacillary (Enterobacter, Klebsiella, Escherichia coli).
• BSIs due to Gram positive cocci and yeasts are increasing.
Coagulase negative staphylococci used to be routinely considered contaminants of blood culture. However, with the microbiological changes in micro-organisms causing BSIs, one has to be careful in interpretation of coagulase negative staphylococcus in blood culture.

Controversial Issues
Further investigations are required to reach a consensus on the following practices:

- Use of heparin or cortisone in parenteral solutions to reduce the risk of thrombosis
- Use of antibiotic lock prophylaxis
- Guidewire catheter replacement in a regular time period
- Interval for catheter-site exchange
- Frequency of replacement of IV tubing
- Frequency of replacement of catheter-site dressings
- Use of in-line filters
- Use of peripherally inserted central venous catheters
- Use of antibiotic or antiseptic-impregnated central venous catheters.
- Use of sutureless securement devices for central venous catheters

Suggested Practice
Preventive measures used to control BSIs can be summarized as following:

- Education and training of healthcare workers
- Hospital infection control policy with surveillance for intravascular device-related infection.
- Hand hygiene by washing hands with antiseptic-containing soap and water or with waterless alcohol-based gels or foams
- Appropriate barrier precautions during catheter insertion: sterile gloves, gowns, mask, drape (Short peripheral catheters does not necessarily require sterile gloves)
- Do not use topical antibiotic ointment on insertion sites (except when using dialysis catheters)
- Adherence to aseptic catheter-site care (hand washing, anti-sepsis, sterile gloves, sterile dressing)
Disinfection of injection ports before use.

Using Teflon or polyurethane catheters rather than catheters made of polyvinyl chloride or polyethylene

Using peripheral rather than central venous catheter when it is possible

Using subclavian, rather than jugular insertion sites

Replacement of tubings after blood products or lipid emulsions

Removal of catheters as soon as possible

Subcutaneous tunnelling of central venous catheter for long-term use.

Summary

Intravascular device related infection is the major cause of nosocomial BSIs. The incidence of BSIs is increasing with the frequent use of invasive procedures. BSIs are associated to excess length of hospital stay, extra cost and attributable mortality.

Gram positive cocci and yeasts are more frequently isolated and coagulase negative staphylococcus in blood culture is a difficult diagnosis problem.

Education of healthcare workers and their adherence to appropriate intravascular device care procedures are the basis of BSIs prevention.

References


Key Issues

- Intravascular (IV) catheters are frequent sources of bloodstream infections. Their prevention should be part of any infection control program. Reports should be given in number of infections per 1000 catheter days rather than per 100 patients.
- Surveillance for catheter-related bloodstream infections (CR-BSIs) requires few resources compared to other nosocomial infections, but has an important impact on the prevention of the most serious type of nosocomial infections: bloodstream infections.
- Catheter-associated bloodstream infection (CA-BSI) is one in which a central line was in use during the 48-hour period before development of the bloodstream infection and no other obvious source was identified (subset of primary bacteremia). This will overestimate the true incidence of CR-BSIs, but reduces the workload for surveillance.

Known Facts

- IV-catheters are a frequent source for bloodstream infections
- The incidence of infection depends on the catheter type, type of hospital setting (intensive care unit vs ward), the catheter care, underlying diseases of the patient, and the type and resources for the prevention program
- Polyurethane or silicon catheters have a lower risk of complications than others. Triple-lumen catheters have similar risks for infection as have single-lumen catheters, but more lumens are associated with more manipulations
- A common portal of bacterial entry is the insertion site during the first 2 weeks after catheter placement
- After 2 weeks, the hub (the connection between the catheter and the infusing tube) becomes the predominant source of bacterial entry
• Most CR-BSIs are observed in intensive care units or burn units
• Each catheter day adds to the overall risk of CR-BSI: Remove catheters as soon it is clinically possible is a key component for prevention of CR-BSI
• Healthcare education, training and monitoring or insertion, maintenance are paramount to prevent CR-BSIs
• Full barrier precautions with gloves, gown, cap and large drapes prevent early infections
• Hand hygiene, specifically the alcoholic hand rub, must be enforced before placing any catheter
• Infusion time for lipids should not exceed 24 hours, for blood 4 hours
• Routine replacement of intravascular catheters does not prevent catheter-related infections (CRIs).
• Clinical signs and symptoms have a poor sensitivity and specificity for CA-BSIs.

Suggested Practice
Catheters in general
• Perform minimal surveillance by the new definition of catheter-associated bloodstream infections (CA-BSIs vs CR-BSI) due to CVCs at least in intensive care units
• Use only established microbiological methods for the detection of CR-BSIs. Choose catheter type based on expected duration of catheterization, type of infusate (e.g., chemotherapy), and training of staff

General recommendation for the choice of intravenous access
– < 5 days: Peripheral catheter
– 5–10 days: CVC: jugular site preferred: higher rate of infection compared to the subclavian access, but lower non-infectious risk (bleeding, pneumothorax)
– 5–28 days: CVC: Subclavian access site
– Alternative: Percutaneous peripherally inserted CVC (PICC-lines)
– 28 days: tunneled (eg. Hickmann) or totally implanted catheters (e.g., port-a-cath)
- Avoid the femoral access site. Higher risk for infection and thrombosis. Use only as last option for intravascular access.

- Replace catheters that are placed under emergency conditions under poor aseptic conditions, once the hemodynamic condition of the patient has stabilized, but at least within 48 hours.

- Check proper fixation of the catheter, discourage idle catheters

- Do not routinely culture IV catheters

**Antisepsis, dressings and tubing**

- Defatting the insertion site before applying antiseptic solutions is not necessary

- Use alcohol/chlorhexidine to disinfect the insertion site. Chlorhexidine is state-of-the art disinfectant for catheter care.

- Do not insert the catheter before the skin is dry after applying the cutaneous antiseptic

- Infusate tubing: replace not more frequently than ≥ 3 days

- Use clean or sterilized gauze as dressing. Highly-permeable transparent dressings are an expensive alternative, but the insertion site can be visibly checked without changing the dressing.

- Routinely change gauze every two days or transparent dressing every 7 days, or if they do not adhere anymore.

- Minimize numbers of stopcocks attached to the catheter

- Do not use in-line filters

**Peripheral intravenous catheters**

- CR-BSIs by peripheral catheters are always preventable, the incidence of phlebitis (a physicochemical problem) should not exceed 20%

- Do not routinely replace peripheral catheters, but daily check the need for the catheter and the insertion site.

**Central venous catheters**

- Use maximal barrier precautions including gown, sterile or at least new gloves, and large sterile drapes when placing a central-venous line.
• Use guide wire exchange for malfunctioning catheters and in febrile episodes, where the source of infection is unlikely the catheter. A new puncture for a catheter is recommended if the insertion site has evidence of infection (e.g., redness, pus, pain)

• Consider a coated catheter (minocycline-rifampin or chlorhexidine/sulfodiazine), if the patient is at high risk of CR-BSI and the incidence of CR-BSI exceeds 5/1000 catheter days. However, full adherence to simple training in IV insertion, full barrier precautions and chlorhexidine for catheter care can cut CR-BSIs close to zero.

• Use chlorhexidine as disinfectant for the regular care of the insertion site. Octenidine is an alternative in Europe

**Long-term catheters**

• Never replace long-term catheters for diagnostic purposes only. Negative blood cultures taken through the catheter have a very high negative predictive value to rule out CR-BSI in patients with fever of unknown origin. For suspected episodes of CR-BSI, take simultaneously blood cultures through the catheter and by venipuncture if an automated BC system is available (time to positivity: 2 hours difference meets the case definition of CR-BSI).

• Do not administer prophylactic antibiotics before insertion

• CR-BSIs due to coagulase-negative staphylococci can be successfully treated by the antibiotic lock technique (Vancomycin or EDTA-Minocycline). The ethanol lock is a promising alternative.

**Arterial catheters**

• Replace peripheral arterial catheters routinely not more frequently than every 5 days

• Routinely replace disposable or reusable transducers, tubing, continues-flush device and flush solution at 96-hour intervals.

• Minimize manipulations of the pressure monitoring system and use a closed-flush system

• Disinfect the diaphragm before accessing the system or use a stopcock.

• Use disposable transducers
Controversial Issues

- Optimum microbiologic procedure for the diagnosis of CR-BSIs. The roll-plate technique is easy, cheap, and results with >100 CFU are highly predictive for clinically significant colonization or CR-BSI. However, positive results (>15 CFU) are difficult to interpret in the absence of positive blood cultures with the same strain. Sonication is more appropriate for long-term catheters. In the ICU, suspected CR-BSI can be ruled out by negative cultures of the insertion site and hub without removing the catheter.

- Needleless devices reduce the risk for sharp injuries to healthcare workers, but are associated with higher risk for CRIs

- Maximum hang time of other parenteral fluids.

- Routine replacement of CVC after episodes of secondary bloodstream infections from another body site

- Use of impregnated catheters and chlorhexidine sponges in small children

- Treatment of febrile patients with a positive microbiologic for coagulase-negative staphylococci from a removed catheter and negative blood cultures. Treatment is recommended if S.aureus is isolated, even blood cultures are negative.

Summary

Two principal pathways are involved in the pathogenesis of catheter-related infections: First, bacteria can colonize the outer surface of the catheter, migrate from the catheter-skin interface over the external surface of the catheter to the catheter tip. Second, bacteria can colonize the hub, the connection between the infusion set and the catheter followed by migration down the internal surface of the catheter. The insertion site is frequently unremarkable even in established cases. Therefore, the diagnosis of CR-BSIs largely depends on the microbiological result. Methods that only detect microorganisms on the outer surface of the catheter such as the semiquantitative method may underestimate the true incidence of CR-BSIs in long-term catheters. Adequate training of strict asepsis during the insertion, continuous education on care of
the insertion site and surveillance of CA-BSIs allow to reduce the incidence of such infections to <2/1000 catheter days. Coated catheters should only be considered for high-risk patients and/or other strategies have failed to reduce the rate of CR-BSIs <3/1000 catheter days.

References
CHAPTER 29

HOSPITAL-ACQUIRED URINARY TRACT INFECTION

Emanuele Nicastri, MD, PhD and Sebastiano Leone, MD

Key Issues
“The decision to use the urinary catheter should be made with the knowledge that it involves risk of producing a serious disease”. Even through this statement was formulated by Paul Beeson about fifty years ago, it still maintains relevant for both patients and healthcare workers (HCWs). Urinary catheters represent the major risk factor related to the acquisition of the hospital-acquired urinary tract infection (HUTIs). Catheter associated urinary tract infection (CAUTI) is the most common type of hospital-acquired infection, accounting for approximately 40% of such infections and for most of the 900,000 patients with nosocomial bacteriuria in U.S. each year. Each year approximately 96 million urethral catheters are sold world-wide, nearly a quarter of which are sold in the United States. Approximately 30% of initial urinary catheterizations are unjustified, and one-third to one-half of days of continued catheterization are unjustified. Many of these catheters are inserted in the emergency room without a documented order, and providers are not aware that the catheter is in place in 21–38% of cases. The reduction of inappropriate use of indwelling urinary catheter, the use of closed drainage system, and the early removal “as soon as possible” of the catheter already in place, are the main tools to reduce HUTIS. infections and are the second most common cause of nosocomial bloodstream infection

Known Facts
In the United States, between 16% and 25% of hospitalized patients have an indwelling urinary catheter in place. The daily rate of acquiring bacteriuria among hospitalized patients with
urinary catheters is approximately 3% to 10%, and between 10 to 25% of patients with bacteriuria will develop symptoms of UTI. Of patients with a symptomatic UTI, 1–4 % develop bacteraemia and, of these, 13–30 % die.

Micro-organisms causing endemic HUTIs derive from the patient’s own flora or from the hands of HCWs during catheter insertion or manipulation of the collection system. Bacteria can enter the urinary tract in catheterized patients in three ways: introduction of organisms into the bladder at the time of catheter insertion or periurethral route or intraluminal route. HUTIs comprise perhaps the largest institutional reservoir of nosocomial antibiotic-resistant pathogens, the most important of which are multidrug-resistant Enterobacteriaceae other than Escherichia coli, such as Klebsiella, Enterobacter, Proteus, and Citrobacter; Pseudomonas aeruginosa; enterococci and staphylococci; and Candida spp. Urinary tract pathogens such as Serratia marcescens and Pseudomonas cepacia have special epidemiological significance. Since these micro-organisms do not commonly reside in the gastrointestinal tract, their isolation from catheterized patients suggests acquisition from an exogenous source, likely through-out the hands of personnel.

A continuously closed urinary drainage system is pivotal to the prevention of catheter-associated infection. For short-term catheterization, this measure alone can reduce the rate of infection from an inevitable 100% when open drainage is employed to less than 25%. Breaches in the closed system, such as unnecessary emptying of the urinary drainage bag or taking a urine sample, will increase the risk of catheter-related infection and should be avoided. Before manipulating the closed system, hands must be washed with an antiseptic agent and gloves worn.

Studies comparing meatal cleansing with a variety of antiseptic/antimicrobial agents or soap and water demonstrated no reduction in bacteriuria when using any of these preparations for meatal care compared with routine bathing or showering. Meatal cleansing is not necessary and may increase the risk of infection. Daily routine bathing or showering is all that is needed to maintain meatal hygiene. The most important, potentially modifiable risk factor, identified in every study, is
prolonged catheterization beyond 6 days (RR 5.1–6.8); by the 30th day of catheterization, infection is near-universal. Thus, every operative strategy should be aimed to reduce the duration of the urinary catheter at minimum.

The cumulative economic burden is substantial: each HUTI adds approximately $675 to the costs of hospitalization and when bacteraemia develops, this additional cost increases to at least $2800.

**Controversial Issues**

Systemic antimicrobial prophylaxis with trimethoprim-sulfamethoxazole or a fluoroquinolone is likely to reduce the risk of HUTIs for short-term catheterizations in critical care areas. Nevertheless, in this setting this protective effect was demonstrated to be transient and was associated with the selection of antibiotic-resistant bacteria and yeasts. It is difficult to justify antimicrobial therapy of asymptomatic bacteriuria other than for severely immunocompromised patients. The benefits of antibiotic prophylaxis in immunocompetent catheterized patients to prevent largely asymptomatic HUTIs are probably unjustified.

Randomized clinical trials suggest the use of medicated urinary catheters to reduce urinary catheter-related bacteriuria. Small studies has already showed a significant reduction in bacterial HUTIs with the use of catheters impregnated with anti-infective solutions such as nitrofurazone and minocycline combined to rifampin. Catheters coated with minocycline and rifampin had significantly lower rates of gram-positive bacteriuria (7.1% vs. 38.2%; p <0.001). Nevertheless similar rates of gram-negative bacteriuria and candiduria have been reported, and the risk of developing antimicrobial resistance needs to be further investigated. A similar concern on the selective antibiotic drug pressure has been raised with regard to an indwelling urethral catheter coated with gentamicin sulphate on the inner and outer surface. Recently, a multicentre study including 177 patients was conducted to determine the CAUTIs inhibition effect by nitrofurazone-coated catheters. In this study, the incidence rate of CAUTI was lower in the nitrofurazone-coated catheter group compared with the control group. When the catheters were maintained for >5 days but <7 days, the incidence rate of catheter-related infection was statistically significantly
lower in the experimental group compared with that in the control group. Finally, Johnson conducted a meta-analysis of randomized or quasi-randomized clinical trials of antimicrobial urinary catheters to assess the efficacy of these for preventing CAUTIs. The author observed that, compared with control catheters, antimicrobial urinary catheters can prevent or delay the onset of catheter-associated bacteriuria in selected hospitalized patients. However, it is necessary to confirm further the effectiveness of antibiotic-coated catheters over long-term periods.

An alternative option to the use of antibiotic impregnated catheters, coating the catheter surface with an antiseptic, such as a silver compound, could reduce the presence of the biofilm on the surface of the catheter. Silver oxide-coated catheters have demonstrated contradictory results when studied in large, well-controlled trials whereas silver-hydrogel catheter have been shown to inhibit the adherence of microorganisms by slime production to the catheter surface in vitro. Recently, a large randomized clinical trial reported a protective effect particularly in preventing HUTIs caused by either gram-positive organisms, enterococci and staphylococci, and Candida but not by gram-negative bacilli. No increased incidence of HUTIs caused by antibiotic-resistant or silver-resistant microorganisms was reported by using the silver-hydrogel catheter. In 2004, the Cochrane Database of Systematic Reviews published a comprehensive assessment of impregnated catheters intended for short-term use in hospitalized adults. Pooled results indicated that the risk of asymptomatic bacteriuria was significantly reduced in the silver alloy group with less than 1 week catheterization (RR 0.34; 95% CI 0.24–0.52) and, to a lesser degree, with more than 1 week (RR 0.67; 95% CI 0.05–0.90). The risk of symptomatic UTI was lower in the groups with silver alloy catheters (RR 0.60; 95% CI 0.50–0.73). More recently, a prospective crossover study involving 3036 patients evaluated the efficacy of a silicone-based, silver-impregnated urinary catheter found that silicone-based silver-impregnated urinary catheters were not effective in preventing CAUTIs. To summarize, the use of the more expensive, silver-coated catheters to prevent CAUTI is not supported by quality data. However, the maximal benefit can be achieved by using a silver
alloy catheter in those categories of patients receiving the
greatest reduction in CAUTIs based on the evidence, predom-
inantly: postoperative patients requiring catheterization for five
to seven days; intensive care unit patients; and burn patients.

**Suggested Practices**

- Educate HCWs to the appropriate indications of indwelling
  permanent catheters:
  - patients with anatomic or physiologic outlet obstruction,
  - patients undergoing surgical repair of the genitourinary
    tract,
  - critically ill patients who need to measure the daily uri-
    nary output and
- Educate HCWs to the availability of other strategies to
  manage urinary incontinence (for example, condom or
  intermittent catheters and special undergarments);
- Provide patients with adequate information in relation to
  the need, insertion, maintenance and removal of their
  catheter;
- Educate HCWs about the infectious complications and
  patient suffering, associated with urinary catheterization;
- Educate HCWs in the optimum selection of the smallest
  gauge catheter that will promote free urinary outflow;
- Educate HCWs in the correct techniques of catheter inser-
  tion and care;
- Educate HCWs to adopt and maintain the sterile continu-
  ously closed system of urinary drainage;
- Educate HCWs to avoid irrigation unless needed to prevent
  or relieve obstruction;
- Educate HCWs to maintain unobstructed urine flow;
- Maintain adequate urine flow at all times. Ideally, sufficient
  fluid to maintain urine output of greater than 100 ml/h
  should be given if it is not contraindicated by the patient’s
  clinical condition;
- Gravity drainage should be maintained;
- Educate HCWs to minimize the duration of the urinary
  catheter;
- Do not change catheters unnecessarily or as part of routine
  practice;
• Consider the use of catheters with anti-infective surface at least for those patients at high risk of serious complications of catheter-associated bacteriuria;

• Develop the effectiveness of automatic “stop orders” for indwelling urinary catheters; these orders should require that the catheter either be removed or reordered after a specified period of catheterization;

• Use quality-control patient audits to design programs to decrease inappropriate use of indwelling urinary catheters;

• Develop and implement a periodic surveillance system of HUTI;

• Document all procedures involving the catheter or drainage system in the patient’s records;

Summary
The development of a nursing, physician, and laboratory team to review and revise protocols and procedures for better catheter management can promote the proper indications for urinary catheter placement and management. The continuously closed system of urinary drainage is the cornerstone of infection control. Criteria to remove a catheter without a physician’s order when no longer medically necessary can be identified as operative strategy.

Novel urinary catheters impregnated with antibiotic drugs or coated with anti-infective material exhibit antimicrobial activity that significantly reduces the risk of HUTI for short-term catheterizations. They represent the first major advance for preventing HUTIs since the wide-scale adoption of closed drainage system 35 years ago. It remains unclear whether medicated urinary catheters will also lead to decreases in the clinically more important outcomes of catheter-related bacteraemia and mortality. Each medicated catheter exceeds the cost of a standard, non-coated non-impregnated urinary catheter tray. However, when all the clinical and economic costs are accounted for, medicated urinary catheters may provide both clinical and economic benefits in patients receiving indwelling catheterization for 2 to 10 days.

In the future, a major biotechnology effort to reduce the prevalence rate of HUTIs and indeed of all hospital-related
nosocomial infections is likely to be represented by vaccines against important multi-drug resistant micro-organisms such as enteric gram-negative bacilli and staphylococci.

References


Key Issues
Nosocomial pneumonia occurs in 0.4 to 1.1% of hospitalized patients. It is the most common infection in the intensive care units and the second most common cause of nosocomial infection overall. Bacterial colonization of the upper airway followed by microaspiration or macroaspiration into the lungs is considered the primary mechanism for development of nosocomial pneumonia. More than 90% of cases of nosocomial pneumonia are caused by bacteria (Gram-negative bacilli 25–75%, *S. aureus* 15–30%, *S. pneumoniae*, *H. influenzae* and *Streptococcus* sp the remaining cases). Nosocomial pneumonias caused by hospital *Legionella* outbreaks have been also reported. Clinical presentation of nosocomial pneumonia, characterized by fever, leukocytosis and pulmonary infiltrates, resembles other conditions such as congestive heart failure, acute respiratory distress syndrome or pulmonary hemorrhage. There is no readily available method for diagnosis of nosocomial pneumonia. Bronchoscopic and non-bronchoscopic techniques, with quantitative or qualitative cultures, have been develop to obtain a valid sample from the lower respiratory tract. Antibiotic therapy should be started early in the course of the infection and should be broad enough to cover all most likely pathogens. Once the organism is identified, therapy should be narrowed according to the microorganims susceptibility profile. Average mortality in patients with nosocomial pneumonia is between 20%–50%, lower in previous healthy nonintubated patients, and increases up to 60%–100% in patients with significant underlying conditions, suffering acute respiratory distress syndrome or infection caused by a highly virulent microorganism. Implementation of guidelines for preventing, diagnosing and treating nosocomial pneumonia can reduce the mortality and morbidity associated with this condition.
Known Facts

Pathogenesis

Nosocomial pneumonia usually occurs in a setting of impaired defenses, such as recent surgery, sepsis, chronic pulmonary disease, neurologic disease, adults respiratory distress syndrome, trauma, endotracheal intubation, malnutrition or advanced age. Invasive mechanical ventilation is the strongest risk factor for the development of nosocomial pneumonia.

*Streptococcus pneumoniae, Streptococcus* species, *Haemophilus* species, *Neisseria* species, and anaerobic bacteria commonly colonizes the upper respiratory tract of the normal host. However, after 4 days of admission to the hospital, 40% of patients are colonized by gram-negative bacilli.

Factors associated with the risk of colonization by gram-negative bacilli are the following: prior antibiotic use, severe and prolonged illness, intubation tracheostomy, major surgery, tobacco use, malnutrition, diabetes mellitus, coma, nasogastric intubation, alcohol abuse, and pre-existing pulmonary disease.

Nosocomial pneumonia occurs as a result of overt or subclinical aspiration of bacteria colonizing the upper respiratory tract. It has been proven that despite the use of a tracheal cuff, patients with endotracheal or tracheostomy tube may still aspirate. Supine positioning has been shown to be independently associated with ventilator-associated pneumonia because of an increased risk for gastroesophageal reflux and aspiration.

The microbial etiology of nosocomial pneumonia can be predicted to some extent by the moment of acquisition.

Early-onset nosocomial pneumonia (within the 4 days of intubation) is caused by *S. pneumoniae, H. influenzae* and *S. aureus*, being gram-negative bacilli present in less than 20% of cases. Higher incidence of colonization by *S. aureus* have been observed in patients with a history of coma, diabetes mellitus or after influenza infections.

Late-onset nosocomial pneumonia (after 4 days of intubation) is caused by aspiration of gram-negative bacilli. *Pseudomonas aeruginosa, Acinetobacter* species or methicillin-resistant *S. aureus* are specially common in patients previously treated with antibiotics.

Non bacteria or atypical etiologies of nosocomial pneumonia are uncommon, but *Legionella* species can cause nosocomial
pneumonia after contamination of hospital water supply. Virus (respiratory syncitial virus and influenza) can cause nosocomial pneumonia in pediatric patients if proper respiratory precautions are not enforced. Fungal etiology of nosocomial pneumonia (Aspergillus and Candida albicans) is often observed in immunosuppressed patients.

Nosocomial pneumonia can be seeded hematogenously from other infectious sources such as catheters, wounds or urinary tract infections. Patients with sinusitis caused by nasotracheal intubation can spread the infection to the lower respiratory tract.

**Prevention**
Avoiding endotracheal or nasotracheal tubes reduces the possibility of bacterial colonization of the tracheobronchial tree and lower airway aspiration of secretions. The ventilation circuit is also a potential source of contamination of patient’s secretions.

Semi-recumbent patient positioning is a low-cost, low risk approach to preventing ventilator associated pneumonia.

**Diagnosis**
Clinical presentation of nosocomial pneumonia is not specific. Fever, leukocytosis and radiographic infiltrates that can mimic a variety of diseases (malignancy, congestive heart failure, atelectasis, adult respiratory distress syndrome, vasculitis, pulmonary hemorrhage, pulmonary infarction, chemical pneumonitis, pancreatitis and pulmonary contusion).

Clinical scores are in general unreliable predictors of nosocomial pneumonia.

Nosocomial pneumonia is often underdiagnosed in patients with adult respiratory distress syndrome. The overall rate of misdiagnosis is between 29%–38%.

**In Treatment**
Inappropriate initial antibiotic therapy is associated with a higher crude hospital mortality and a trend towards longer use of mechanical ventilation.

Selection of appropriate empirical antimicrobial therapy should be based upon risk factors, local epidemiology and resistance patterns.
Broad spectrum antimicrobial regimens should be used aiming at covering all likely bacterial pathogens. This regimen should be modified and narrowed according culture results.

**Controversial Issues**

**Prevention**

A major aim is to avoid gastric overdistention to prevent to risk of aspiration. Therefore reducing the use of narcotics and anticholinergic drugs and increasing gastric motility with metoclopramide can reduce gastric overdistension. To prevent gastric colonization by bacteria, enteral nutrition should be used only when necessary and through a small bore tube placed in the small bowel instead the stomach. The effectiveness of these interventions awaits validation in clinical trials.

The role of gastric pH in the pathogenesis of ventilator associated pneumonia is still controversial. Bacterial colonization of the stomach is enhanced by drugs that lower the gastric acidity (e.g., histamine H2 agonists, antacids, proton pump inhibitors). The administration of sucralfate onto the stomach has been found to prevent stress ulcers without modifying gastric pH.

The accumulation of contaminated oropharyngeal secretions above the endotracheal tube cuff may contribute to the risk for aspiration. Suctioning of the subglottic region by means of a specially designed endotracheal tube containing a separate dorsal lumen may reduce the risk of aspiration. It may be most effective for patients requiring mechanical ventilation for more than 3 days.

Use of oscillating beds may prevent the development of atelectasis and accumulation of respiratory secretions due to immobility of the patients. Oscillating beds have shown controversial results in surgical patients with neurologic impairments. Tolerability of oscillating beds by conscious patients was poor, in addition, their high cost is another major drawback.

Acidification of enteral nutrition to prevent modification of gastric pH has been proposed as a way to reduce bacterial overgrowth. Although it has been demonstrated that in fact acidified enteral feeding (pH < 3.5) significantly reduced bacterial overgrowth in comparison with nonacidified feeding, its impact on the incidence of nosocomial pneumonia has not been demonstrated.
Selective digestive decontamination (oral and gastrointestinal) using nonabsorbable antibiotic paste or conducting a short course of systemic prophylaxis with antibiotics have produced discordant results. Most meta-analysis showed significant reductions in the incidence of pneumonia among patients receiving selective digestive decontamination and in reductions in mortality in patients who received systemic and topical antibiotic prophylaxis. Nevertheless, the effectiveness of selective digestive decontamination may have over emphasized since an inverse relationship was found between methodological quality of the studies and the benefit of selective digestive decontamination. In addition there are concerns on the emergence of antibiotic resistant bacteria.

Oral decontamination focused only in oropharyngeal colonization prevents oral colonization but it did not show reduction in duration of mechanical ventilation or mortality. In addition, topical antibiotics could interfere the ability to diagnose pneumonia.

**Diagnosis**

The role of screening cultures to predict the etiology of ventilator associated pneumonia is still controversial. It has been suggested that directed antimicrobial therapy should be started when MRSA, *Pseudomonas* spp and *Acinetobacter* were isolated within 72 h. of an episode of ventilator associated pneumonia (predictive values in the range 50–60%).

Preliminary studies showed that direct E-test on respiratory samples predicts results at 18–24 h. comparable to those of standard methods. More studies are needed to confirm these preliminary results.

**Treatment**

There is not enough evidence to prove that quantitative testing of respiratory tract samples is better than empirical therapy and qualitative testing of respiratory tract samples.

Piperacillin/tazobacteam has been compared with cef-tazidime, both used in combination with amikacin, for the treatment of nosocomial pneumonia in the intensive care unit setting. There was no difference in overall efficacy, tolerability and safety between two groups including patients infected with
Pseudomonas aegurinosa. Hospital areas with outbreaks of infections caused by gram-negative bacilli (E. coli, Klebsiella spp) producing extended spectrum beta-lactamases which mediates resistance to cefotaxime-ceftriaxone, ceftazidime and aztreonam, would benefit most from empirical therapy with piperacillin/tazobactam or carbapenems such as imipenem or meropenem.

Linezolid, a new class antibiotic (oxazolidinones), active against MRSA and vancomycin resistant enterococci has been compared with vancomycin, both combined with aztreonam. In a randomized double blind clinical trial carried out in patients with nosocomial pneumonia, clinical and bacteriological cure rates were similar for linezolid and vancomycin. Advantages of linezolid over vancomycin were greater proportion of MRSA eradication, lack of necessity for dose adjustment in renal failure and lack of nephrotoxicity, as well as, the availability of an oral form.

Suggested Practice

Prevention

Hand washing is widely recognized as an important but under-used measure to prevent nosocomial infections. The use of protective gowns and gloves is not recommended for routine prevention of ventilator-associated pneumonia.

Patients receiving mechanical ventilation should be placed in semirecumbent position to reduce the occurrence of aspiration.

Prolonged nasal intubation (>48 h.) should be avoided because of the association between nosocomial sinusitis and ventilation-associated pneumonia.

Strategies proved to be ineffective to prevent ventilator-associated pneumonia are: routine changes of ventilator circuits, dedicated use of disposable suction catheters, routine changes of in-line suction catheters, daily changes of heat and moisture catheters and chest physiotherapy.

Diagnosis

A nosocomial pneumonia should be suspected if two or more of the following clinical features are present: temperature >38°C or <36°C; leukopenia or leukocytosis; purulent tracheal secretions; and decreased PaO2. In the absence of such findings,
no further investigations are required, and observation will suffice. If two or more abnormalities are present, a chest radiograph should be evaluated. If the radiograph shows alveolar infiltrates or an air brochogram sign, or if findings have worsened a microbiological diagnostic procedure or an appropriate empirical therapy should be carried out.

Microbiological quantitative procedures include non bronchoscopic techniques (quantitative endotracheal aspiration, blinded bronquial sampling, mini bronchoalveolar lavage, and blinded sampling with PSB) and bronchoscopic techniques (BAL, PSB, or protected BAL). Bronchoscopic and non-bronchoscopic techniques have shown similar test performances and its choice depends on local factors (expertise, experience and costs).

**Treatment**

Antibiotic treatment should be given early after infection is suspected, and the spectrum of this agent(s) should address all reasonable suspected pathogens. Empirical antibiotic therapy should take into account time of pneumonia onset. Patients with late-onset pneumonia (>5 days of hospitalization) or risk factors should be treated with antibiotic drugs with acceptable antipseudomonal activity. Monotherapy is associated with clinical failures in 15–29% of patients. Possible regimens include: antipseudomonal β-lactam agents (piperacillin/tazobactam, ceftazidime, cefoperazone, aztreonam, imipenem, meropenem), quinolones with reliable antipseudomonal activity (ciprofloxacin) and aminoglycosides (amikacin). A traditional choice in this regard has been an extended-spectrum β-lactam plus and aminoglycoside. Vancomycin or linezolid should be added in intitutions with MRSA. Patients with early onset nosocomial pneumonia and no risk factors can be treated with a second or third-generation cephalosporin, a fluoroquinolone or a β-lactam-β-lactamase inhibitor.

**Summary**

Nosocomial pneumonia is still a leading cause of nosocomial infection mainly in patients with mechanischal ventilation and those undergoing surgery. In the recent years a great effort has
been invested to characterize the risk factors for acquiring nosocomial pneumonia in different settings (trauma patients, patients undergoing surgery and burn patients), and to develop useful diagnostic algorithms for microbiological diagnosis of suspected ventilator-associated pneumonia. Implementation of protocolized treatment guidelines and antibiotic rotation policies have proven to reduce the usage of antimicrobials and the emergence of antibiotic resistant microorganisms. Recent studies on prevention have been directed to avoid invasive ventilation and to reduce macroaspiration of secretions into the lungs in intubated patients. Noninvasive ventilation and suctioning subglottic secretions by means of specially designed endotracheal tubes with an extra port have shown to reduce the incidence of ventilation-associated pneumonia. Further studies are needed to better understand the mechanisms of bacterial colonization and develop successful preventive strategies.

References
CHAPTER 31

**DIPHTHERIA, TETANUS, PERTUSSIS**

Jack Levy, MD

**Key Issues**
Active immunization of the general population is effective to control the transmission of these infections in the community, as well as an eventual risk of infection in the hospital setting.

**Known Facts**
- Diphtheria and pertussis are transmissible from person to person, whereas tetanus is not. Transmission of diphtheria occurs mainly from close contact with secretions from the nose, throat, eye or skin of a patient, according to the site of infection, or with a carrier. Transmission of pertussis occurs by close contact via aerosolized droplets from patients with disease. Transmission of tetanus occurs by introduction of tetanus spores into the organism through a contaminated wound. Tetanus spores can be introduced via the umbilical cord during delivery, causing *tetanus neonatorum*, an important health problem in developing countries.
- Diphtheria, tetanus and pertussis are mainly community acquired infections. The high immunization coverage obtained by local programs in industrialized countries and by the WHO EPI has considerably reduced the global burden of diphtheria, tetanus and pertussis.
- Universal vaccination in infancy against these 3 illnesses is done using a combination vaccine.
- Diphtheria and tetanus vaccines consist of single purified antigens: diphtheria and tetanus toxoids. Diphtheria vaccines used for children until the age of 6 years contain 6.7 to 30 floculation units (Lf) of toxoid, whereas a vaccine with a reduced amount of antigen (not more than 2 Lf) should be used for individuals older than 6 years.
• There are 2 types of pertussis vaccines: whole cell vaccine and acellular vaccines. The initial and most widely used is the whole cell vaccine. This vaccine is highly protective, although there are differences between preparations. However, whole cell pertussis vaccine cannot be administered after the age of 7 years. Acellular vaccines consist of 2 or 3 purified antigens. They are less reactogenic than whole cell vaccines and have demonstrated their protective efficacy in clinical trials. Combination with other vaccines recommended for infant immunization (IPV, Hib and HBV) exist. Acellular pertussis vaccine suitable for adults are being developed. However acellular pertussis-based vaccines remain significantly more expensive than whole cell preparations.

• Long term protection against diphtheria, tetanus and pertussis by vaccination requires primary immunization followed by the administration of booster doses of these vaccines. While diphtheria and tetanus vaccines can be safely administered to adults, pertussis immunization is currently restricted to children. As a consequence, older children and adults with mild or atypical disease remain a source of contamination for young infants who are at highest risk for severe manifestation of the disease. However new generations of acellular pertussis vaccine will open the way to adult immunization.

• Transmission of diphtheria, tetanus and pertussis in the hospital setting, although very rare, can occur. An infected patient can be the source of diphtheria or pertussis transmission whereas contaminated surgical material has been reported as a possible cause of tetanus.

**Controversial Issues**

• Rare severe neurological events leading to permanent brain damage occurring in infancy have been attributed to immunization with whole cell pertussis vaccine in the years 1970s, leading to the interruption of pertussis vaccination programs in some industrialized countries. This has been followed by a recrudescence of pertussis in these countries, thereby demonstrating the role of vaccination in controlling the disease. Whether these neurological events were only
temporally related or caused by vaccination has been a source of controversy. One large case control study performed in England has not established a causal relationship between such neurological events and pertussis vaccination.

- Acellular pertussis vaccines have been demonstrated to be effective in large clinical trials and have been shown to control the disease in countries where they are used in childhood vaccination programs. They are better tolerated than whole cell vaccines. However they are more expensive. As a consequence they are not used in countries with limited resources. In a number of industrialized countries, whole cell pertussis vaccines are still preferred on the basis of cost benefit evaluations and/or because they have demonstrated their effectiveness on the long term.

- Acellular pertussis vaccine formulations designed to be used in adults are being developed. Their role in preventing disease in adults as well as transmission to infants remain to be established.

**Suggested Practice**

- All interventions that allow reaching high vaccine coverage should be promoted (*Table 31.1*). Vaccination schedules vary according to local practice; guidelines are proposed by WHO Extended Program of Immunizations (EPI).

**Table 31.1 Interventions to Reach High Vaccine Coverage Against Diphtheria, Tetanus and Pertussis**

- Universal childhood vaccination against diphtheria, tetanus and pertussis consisting of 3 to 4 doses of combination vaccine starting not later than 3 months of age.

- Administration of a booster dose of diphtheria-tetanus vaccine at the age of 4 to 6 years, combined with acellular pertussis if affordable and of a booster dose of diphtheria-tetanus every 10 years thereafter.

- When managing a wound, review of the history of tetanus immunization and administration of a booster dose of diphtheria-tetanus and human tetanus immune globulins according to previous vaccination and to the severity of the wound.

- In countries where a significant proportion of women of childbearing age are not immunized against tetanus, implementation of vaccination programs of pregnant women according to WHO EPI guidelines.
• Measures to prevent hospital transmission should be implemented. For diphtheria and pertussis, they aim at protecting other patients and hospital personnel. For tetanus, which is not transmissible from person to person, they aim at avoiding the rare case of infection from contaminated hospital material and maintaining adequate standard of care for wound management and obstetrical practice (Table 31.2).

**Table 31.2 Measures to Prevent Hospital Transmission of Diphtheria, Tetanus and Pertussis**

**Diphtheria**
- Patient isolation: standard + droplets / and contact if cutaneous
- Identification of exposed individuals and implementation of the following measures:
  - Throat culture for *C. diphtheriae*, as pharyngeal carriage is possible despite antitoxic immunity,
  - Review of prior history of vaccination, completion of primary program if pending or administration of a booster dose of vaccine appropriate for age if last dose not given within the preceding 5 years,
  - Surveillance for 7 days for evidence of disease, and
  - Antimicrobial prophylaxis with erythromycin for 7 days to previously unimmunized or insufficiently immunized individuals, and to carriers; to be prolonged if carriage not eradicated.

**Tetanus**
- Appropriate wound management: includes cleaning and debridment of the wound if necessary and administration of tetanus (and diphtheria) vaccination and human tetanus immune globulin according to the characteristics of the wound and of the history of previous vaccination.
- Appropriate sterilization of hospital supplies (surgical, injections and sutures material)
- Appropriate obstetrical practices, including sterile umbilical cord cutting

**Pertussis**
- Patient isolation: standard + droplets
- Identification of exposed individuals and implementation of the following measures:
  - Review of prior history of vaccination, completion of primary program if pending or administration of a booster dose of vaccine if younger than 7 years and last dose of vaccine has not been given in the last 3 years,
  - Surveillance for 21 days for evidence of disease, and
  - Antibiotic prophylaxis with erythromycin for 14 days to close contacts regardless of immunization status advocated by most authorities on the basis that vaccine induced protection is not absolute and wanes with time (no booster given after the age of 7 years).
References
Preventing Tetanus, Diphtheria, and Pertussis in Adults: Recommendations of ACIP. MMWR 55, RR-17, 2006.
Key Issue
Measles is caused by rubeola virus, one of the most contagious pathogenic agents known. Despite progress in global immunization, measles remains one of the major infectious causes of mortality in developing countries and is responsible for about 1 million deaths in children each year. The importance of nosocomial transmission of measles varies substantially from one region to another according to local measles epidemiology and to vaccine coverage. Whatever the local incidence of measles, the hospital represents a critical site for cross-infection. Characteristics of hospital care settings present numerous risk factors for measles transmission.

Known Facts
Measles virions remain viable for a few hours when suspended in air. Therefore, cough of infected patients can be an important source of virus for susceptible individuals exposed in confined rooms. Infection has been described without face-to-face contact with an infected subject. Transmission may occur when the contagious individual has left the room up to 2 hours before the arrival of susceptible subjects.

Patients with measles are contagious from 3 to 5 days before the onset of rash and 1 to 2 days before the onset of fever. This highly contagious prodromal phase significantly facilitates the spread of measles in the hospital and complicates control measures. Patients with measles remain contagious until 4 days after the onset of rash.

Even in populations with good vaccine coverage, medical facilities can be the place for transmission of measles to patients and to healthcare workers. Indeed, the hospitals combine the factors of infected children, susceptible persons (e.g., those too young for immunization, debilitated patients), and crowding.
In industrialized countries, most cases of nosocomially-acquired measles are transmitted patient-to-patient. However, non-immune healthcare workers are also often involved. Staff in developed countries who acquire measles most frequently are those in direct contact with patients (physicians, nurses). In contrast, most healthcare workers in developing countries have been definitively immunized by wild viruses during childhood and do not contribute significantly to nosocomial transmission.

Nosocomially infected children have higher case-fatality and complication rates and recover more slowly than community-infected patients. The reason for the increased complications rate in these children is that it tends to occur in young infants and in the presence of underlying disease. In African countries, HIV infection is frequent in hospitalized children and is associated with prolonged measles infection and increased mortality.

Immunization is generally performed in children 9 months of age or older in developing countries and in children 12 months of age or older in industrialized nations. Young non-immune infants are therefore highly susceptible to nosocomial measles. Young children are also at increased risk of nosocomial infection because of frequent contacts with healthcare facilities such as maternal and child healthcare clinics. In addition, young age is an important risk factor for severe illness.

Several studies have suggested that nosocomial transmission is important in developed nations and that attendance at hospital facilities is a significant risk factor for acquiring measles. All types of healthcare settings have been implicated; direct or indirect exposure to measles virus in waiting rooms and in emergency departments has been shown to be a significant risk factor during community outbreaks in the US. Low relative humidity and lack of fresh-air circulation in waiting rooms may facilitate measles transmission.

During outbreaks in developing countries, nosocomial transmission appears to contribute to measles incidence in urban communities. In rural populations, however, no significant level of transmission appears to be linked to hospital contact, especially if vaccination coverage remains moderate.

**Controversial Issue**

Safe and effective measles vaccines that can be administered
before 6 to 9 months or age are needed to reduce the number of susceptible individuals and the burden of disease.

Fears contribute to poor vaccination rates in some parts of the population in industrialized countries. Links between measles vaccination and autism or inflammatory bowel diseases have been proposed. There is now strong scientific evidence against the hypothesis that measles vaccination may be implicated as a causative agent in these two diseases.

It has been suggested that measles infection may prevent the development of atopy in surviving children.

**Suggested Practice**

High rates of measles vaccination coverage need to be maintained in the community. This intervention will minimize the number of susceptible individuals.

A high level of awareness of the dangers of measles must be maintained among medical staff. Healthcare personnel should be informed about the risk of nosocomial transmission of measles to non-immune subjects.

Patients with fever and rash must be cared for with additional respiratory precautions. These subjects should not enter the common waiting areas of healthcare facilities. Where possible, these patients should be taken to a room reserved for respiratory isolation. It is also important that waiting and treatment rooms be adequately ventilated.

For developing countries, WHO recommends that children between 6 months and 9 years of age should be vaccinated against measles upon admission to hospital, even if there is evidence of previous measles immunization. The protection rate of measles vaccination is about 80 to 90% in developing countries. In industrialized countries, only unvaccinated patients need to be vaccinated upon admission.

Various studies have shown that measles vaccination is effective in preventing measles in exposed subjects if vaccination is given within 72 hours of exposure. The vaccine efficacy varied between 68 and 100%.

Gamma globulins should only be used for patients with congenital immune function disorders or during immunosuppressive therapy.

Staff members should be immune to measles. Most adults in developing countries have natural measles immunity.
In industrialized countries, healthcare personnel without adequate measles antibody titers or documented vaccination should be vaccinated.

Summary
Measles is a serious and very contagious disease. Nosocomial transmission of measles remains a threat and may prove to be an important obstacle to the elimination of measles. Maintaining a high coverage or measles vaccination in the community is the most important preventive strategy against the disease. Other helpful interventions to limit nosocomial transmission include: postexposure vaccination, immunization of hospitalized patients, increasing awareness of the clinical presentation of measles in healthcare facilities, and respiratory isolation of suspected or proven cases. Newer, safe vaccines that are more immunogenic in the first year of life and more stable in tropical countries are needed.

References
CHAPTER 33

TRANSFUSIONS

M. Sigfrido Rangel-Frausto MD, MSc, and Samuel R. Ponce de León, MD, MSc

Key Issue
Although life-saving, transfusions are not infrequently are associated with life threatening complications. In the USA alone, between 10–12 million units are transfused every year. There is at least a 1% risk of complications but this risk is higher in other regions. Recent news from Peru and China describe epidemics of HIV related blood transfusion. Complications range from allergic reactions to blood-borne infections. The mortality risk is 1 per 100,000 transfusions. Blood utilization has been the subject of numerous regulations to improve safety, however, these best practices are not often followed in most countries, where lack of resources are associated not infrequently with outbreaks of blood-borne associated infections. Every year at least one country reports compliance-associated problems with the standard practices resulting in epidemic transmission of preventable diseases.

Known Facts
- A high proportion of transfused patients do not need to be transfused; in developing countries transfusion is still indicated to improve “well-being”.
- Half of the deaths associated to transfusion are due to allergic reactions including hemolytic and non hemolytic reactions. Most of hemolytic events are related to human errors.
- Numerous agents have been reported to be transmitted by transfusion (Table 33.1), and it is possible that in the future the number of know pathogens will increase.
• Routine blood screenings for blood-borne pathogens and exclusion of donors in regards of high-risk backgrounds or behaviors have decreased this risk considerably.

• **Close to half of the units transfused in developing countries are not screened for blood-borne pathogens.** Routine scrutiny for Hepatitis and HIV have considerably decreased the risk of those infections. Although such scrutiny has become standard of care in many countries, bacterial scrutiny is still very uncommon particularly in platelets, where the risk of bacterial infections associated to transfusions is not properly addressed.

• Multivariate analysis of risks for blood-stream infections in critically ill patients have reported that packed red blood cell transfusions is an independent risk factor for such infections.

<table>
<thead>
<tr>
<th>Table 33.1 Agents Associated with Transfusion-Associated Infections</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Hepatitis virus</strong></td>
</tr>
<tr>
<td>a) Hepatitis A virus</td>
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<tr>
<td>b) Hepatitis B virus</td>
</tr>
<tr>
<td>c) Hepatitis C virus</td>
</tr>
<tr>
<td>d) Hepatitis D virus</td>
</tr>
<tr>
<td>e) Hepatitis G virus</td>
</tr>
<tr>
<td>f) Cytomegalovirus</td>
</tr>
<tr>
<td>g) Epstein-Barr</td>
</tr>
<tr>
<td><strong>2. Other viruses</strong></td>
</tr>
<tr>
<td>a) Human immunodeficiency 1-2</td>
</tr>
<tr>
<td>b) HTLV I-II</td>
</tr>
<tr>
<td>c) Parvovirus</td>
</tr>
<tr>
<td>d) Colorado tick fever virus</td>
</tr>
<tr>
<td>e) West-Nile virus</td>
</tr>
<tr>
<td>f) Coronavirus-SARS</td>
</tr>
<tr>
<td><strong>3. Spirochetal</strong></td>
</tr>
<tr>
<td>a) Syphilis</td>
</tr>
<tr>
<td>b) Relapsing fever</td>
</tr>
<tr>
<td>c) Lyme disease</td>
</tr>
<tr>
<td><strong>4. Protozoal</strong></td>
</tr>
<tr>
<td>a) Malaria</td>
</tr>
<tr>
<td>b) Babesiosis</td>
</tr>
<tr>
<td>c) Trypanosomiasis</td>
</tr>
<tr>
<td>d) Leishmaniasis</td>
</tr>
<tr>
<td><strong>5. Parasites</strong></td>
</tr>
<tr>
<td>a) Loiasis</td>
</tr>
<tr>
<td>b) Other filariais</td>
</tr>
<tr>
<td><strong>6. Bacterial Infections</strong></td>
</tr>
<tr>
<td>a) Brucellosis</td>
</tr>
<tr>
<td>b) Salmonellosis</td>
</tr>
<tr>
<td>c) Yersinosis</td>
</tr>
<tr>
<td>d) Gram-positive or gram-negative contaminants</td>
</tr>
<tr>
<td><strong>7. Prion Disease</strong></td>
</tr>
</tbody>
</table>
Controversial Issues

- Directed donations increase the risk of post transfusion hepatitis.
- Although maybe not cost effective, autologous blood donation is a safe procedure.
- Transfusion is associated with suppression of the recipient’s immune defenses.
- Low levels of hemoglobin should not be an automatic indication for transfusion.

Suggested Practice

- Always consider alternatives before transfusion.
- Blood banks must have a standardized protocol for screening and interviewing potential donors (Table 33.2).
- Routine screening for syphilis (non-treponemal test), hepatitis (HBsAg, HCV), human immunodeficiency virus (HIV1-2, and HIV-1 p 24 antigen), and human T-leukemia virus (HTLV-I/II) must be performed. In some regions screening for Chagas, HTLV-1 and 2, and malaria should be considered.
- Blood transfusion and the use of derivatives should follow a careful protocol with registration of donor, serological studies, recipient, reasons to be transfused, and amount transfused.
- Platelets should be subject to strict protocols to make sure bacterial contamination has not occurred, including 24–48 hours cultures.
- Blood transfusion reactions or infections must be reported to the blood bank.
- Bacterial infections after transfusion should be followed by culture of the bag and the recipient’s blood.

Table 33.2 American Association of Blood Banks Criteria for Protection of Recipients of Donor Blood

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Appearance of good health in donor</td>
</tr>
<tr>
<td>a)</td>
<td>Temperature of donor &lt;37.5˚C (99.5˚F)</td>
</tr>
<tr>
<td>b)</td>
<td>Permanent exclusion for stigmata of injectible drug use or of</td>
</tr>
<tr>
<td></td>
<td>needle use, even once for illicit drug use</td>
</tr>
<tr>
<td>c)</td>
<td>Deferral for alcoholism</td>
</tr>
<tr>
<td>d)</td>
<td>Deferral 12 months after treatment for syphilis or gonorrhea</td>
</tr>
</tbody>
</table>
### Table 33.2 American Association of Blood Banks Criteria for Protection of Recipients of Donor Blood (continued)

2. Deferral of donor two weeks after attenuated bacterial or viral vaccine receipt, except for 4 weeks after rubella or varicella-zoster vaccine and 1 year after rabies vaccine given for a rabies-prone animal bite

3. Donor referral for 12 months after hepatitis B immune globulin

4. Donor deferral if donor was given potentially infected blood or blood products in the previous 12 months

5. Permanent donor deferral
   a) If history of hepatitis after age 11 years
   b) If HBsAg (confirmed) or anti-HBc positive (positive at two different donations)
   c) If anti-HCV, HTLV-I/II, or HIV-1/2 seropositive
   d) If in a high-risk group for HIV-1/2 infection
   e) If prior donation led to hepatitis, HTLV-I/II, or HIV-1/2 infection in recipient
   f) If received blood in UK or lived for 3 months in UK or six months in Europe (recommendation of the American Red Cross and FDA)

6. Donor referral for 12 months after
   a) Application of a tattoo
   b) Mucous membrane exposure to blood or skin penetration by an instrument contaminated with blood or a body fluid
   c) Household or sexual exposure to a person with hepatitis or confirmed positive test for HBsAg
   d) Sexual contact with a person infected with or at high risk for HIV infection
   e) An ALT determination on one occasion greater than or equal to twice normal or on two occasions abnormal but less than twice normal (practice stopped, but continues at some centers)

7. Donor deferral due to malaria (plasma donations excepted)
   a) Permanent deferral for those after recovery from malaria
   b) 1-year deferral for travelers after return from a malaria endemic areas if asymptomatic
   c) 3-year deferral for immigrants after departure from malaria endemic areas if asymptomatic
Blood borne infections have been decreased considerably after the development of routine testing for the most common transfusion-associated pathogens. Hepatitis B, once being the most common post-transfusional infection is now rarely seen; the actual risk should be is less than 0.002%. Most cases seen today are from donors who are HB-DNA carriers with HBsAg positive and HBcAb negative. Post-exposure prophylaxis with hepatitis B vaccine and hepatitis B immune globin is recommended in those cases. Hepatitis C is now the most common post-transfusional hepatitis, but the use of anti-HBC assay has decreased the risk of hepatitis by 40%, currently less than 0.5 per patient transfused and between 0.03–0.07 per unit. The identification of a new hepatitis virus agent from two patients with a non-A no-B hepatitis, called G virus has been reported. It is a member of the flavivirus family (same family of the HCV) and is also a parenterally transmitted agent. No routine blood test is yet available. Cytomegalovirus associated hepatitis has decreased because of the lower usage of fresh blood transfusions. The storage between 2–6°C decreases the number of leukocytes containing CMV, leukocyte-depleted blood products are an alternative when a high risk CMV-negative is to be transfused. Transfusion-associated HIV disease is now rare with cases secondary to transfusion during the window period (no antibodies detected). That period is about 45 days but can be further reduced to 16 days with the help of a p24 antigen assay, if a PCR is used. This period can be further decreased to 11–13 days, with the actual risk of HIV calculated to be 1 in 450,000 to 1 in 660,000 transfusions. The use of steam, heat, and leukocyte filtration has further reduced the risk of HIV after use of blood-products. Most of the outbreaks reported across the world have been associated with a lack of the recommended protocols.
Numerous outbreaks have been described involving *Pseudomonas* spp, *Salmonella* spp, *Serratia* spp and other gram negatives rods. The isolation of these microorganisms suggests processing contamination. In a recent survey by IDSA only 36% of respondents knew that bacterial contamination of platelets was the most common complication associated.

Transfusions have been linked to immune-suppression. High-risk patients are those with burns of more than 10% and post-surgery. In some studies the risk of tumor recurrence is increased after transfusion, and the longer survival of kidney transplants after transfusions has been reported.

**References**


Key Issue
Mechanical ventilation is the main risk factor for hospital-acquired pneumonia in critically ill patients.

Known Facts
- Ventilator-associated pneumonia (VAP) is a common and highly morbid condition in critically ill patients. Cumulative incidence varies between 10% and 25% among ventilated patients. The crude case-fatality ranges between 10% and 50%, with an excess mortality between 0% and 15%. In surviving patients, it causes substantial morbidity, resource utilization and extends hospital length of stay by at least 4 days.
- Non-invasive ventilation decreases morbidity and mortality by preventing complications and nosocomial infections such as VAP.
- Adequate initial antimicrobial treatment decreases the clinical impact of VAP.
- Intrusion of bacteria into the lower respiratory tract is usually the result of the aspiration of organism from the upper respiratory or gastrointestinal tract. VAP can result when the inoculum is large, the microbes are virulent, and host defenses are impaired.
- Coma, prolonged mechanical ventilation through an endotracheal tube, repeated intubation, and permanent supine position increase the risk of VAP.
- Early-onset VAP accounts for at least 1/3 of pneumonia cases in the critical care setting. This entity should be distinguished from late-onset episodes because of their different microbiologic spectrum, risk factors and outcome. Because the pathogens causing aspiration pneumonia reflect the oropharyngeal microbial flora at time of aspiration, the pathogens that cause early-onset VAP are more likely to
reflect normal oral flora or pathogens responsible for community-acquired pneumonia (*Staphylococcus aureus*, *Streptococcus pneumoniae*, and *Hemophilus influenzae*). Nevertheless, antimicrobial-resistant pathogens may also be involved in early-onset pneumonia, especially in settings with high prevalence of antibiotic overuse.

- Selective digestive decontamination (SDD) has been studied for many years and involves the use of topical oral and intestinal antibiotics, often with a systemic antibiotic added for the first few days of the regimen, with the goal being the elimination of potential pathogens from the gastrointestinal tract and oro-pharynx. With eradication of endogenous bacterial sources, infection may be avoided. SDD may decrease the rate of VAP, but its reduction effect on patient mortality is small. Importantly, the main concern associated with use of SDD remains the development and spread of antibiotic resistance. Overall, the currently available evidence does not support the use of SDD as a preventive strategy on a large scale, especially not in settings with endemic cross-transmission of multi-resistant microorganisms.

- Low or reduced staffing levels have a negative impact on patient safety and healthcare-associated infections in critically ill patients. A substantial proportion of VAP could be avoided if nurse staffing were to be maintained at a higher level.

**Controversial Issues**

- Numerous studies have evaluated the performance of bronchoscopic and non-bronchoscopic procedures for the diagnosis of VAP. Nevertheless, controversy persists about the optimal diagnostic strategy for VAP.

- Fever, leucocytosis, and lung consolidation, hallmarks of pneumonia in otherwise healthy patients, can result from other pathogenic mechanisms in intubated patients, such as pulmonary edema, contusion, atelectasis, pleural effusion, and acute respiratory distress syndrome.

- Invasive techniques to diagnose VAP include protected bronchoalveolar lavage (BAL), non-bronchoscopic (“blind”) BAL and “blind” protected specimen brush. The use of any of these techniques should be encouraged in patients at high-risk
of multiresistant or other difficult-to-treat pathogens. Diagnosis by invasive methods requires a considerable commitment of resources but can potentially reduce cost of care and may lower use of broad-spectrum antibiotics. However, the clinical impact of BAL remains controversial; a recently published study suggests that cultures of tracheal aspirates may offer similar information and diagnostic accuracy for guiding antibiotic therapy without harming patients.

• The interpretation of the sensitivity and specificity of any given sampling technique may be severely hampered by the distorting effect of previous antibiotic exposure on the yield of bacterial cultures. In patients pre-treated with antibiotics, sampling should be performed before introducing a new antibiotic regimen.

• Other unresolved issues for the prevention of VAP include: placing filters in the breathing circuit to collect condensate or bacterial filters in the breathing system; wearing sterile gloves rather than non-sterile gloves when suctioning secretions; use of heat and moisture exchangers versus heater-humidifiers; and use of oscillating beds.

**Suggested Practice**

A number of preventive strategies have been applied and are recommended:

• Education and training of healthcare workers.

• Surveillance of high-risk patients to determine trends and detect outbreaks of VAP within the intensive care unit. Infection rates should be presented to intensive care physicians and nurses on a regular basis.

• Different measures to interrupt exogenous transmission of microorganisms (disinfection and appropriate maintenance of equipment, use of sterile water for rinsing reusable equipment, change of breathing circuits not more than once within 48 hours, periodical drainage of condensate in the tubing of a breathing circuit, gloves for handling respiratory secretions, and alcohol-based hand hygiene for routine patient care).

• After every patient, clean and disinfect or sterilize re-usable components of the breathing system or the patient circuit.
• Routine changing of ventilator circuit tubing is not recommended because of rapid bacterial colonization of tubing which usually occurs within 24 hours of its placement. Less frequent circuit and humidifier changes are less costly and should therefore be considered in mechanically ventilated patients.

• The use of appropriate techniques and microbiologic cultures to diagnose VAP should be encouraged to lower inappropriate antimicrobial prescription and reduce antibiotic overuse.

• Bacterial colonization of the oropharynx with aerobic gram-negative bacilli and microaspiration of these colonized oropharyngeal contents to the lower airways are probably the most important circumstances leading to the development of VAP. A variety of strategies are recommended to prevent aspiration associated with enteral feeding: elevation of the head at an angle of 30°, discontinuation of enteral-tube feeding and removal of devices as soon as possible, and routine verification of the placement of the feeding tube and the patient’s intestinal motility. The pressure of the endotracheal tube cuff should be adequate to prevent the leakage of colonized subglottic secretions into the lower airway. Moreover, periodic “sedation vacations” and daily assessment of readiness to extubate may reduce the duration of mechanical ventilation and the risk of VAP.

• Installation of an effective drainage of subglottic secretions may reduce the risk for aspiration and VAP. Aspiration of subglottic secretions requires the use of specially designed endotracheal tubes containing a separate dorsal lumen that opens into the subglottic region. It is a promising new strategy for VAP prevention and should be considered in patients requiring prolonged (> 3 days) mechanical ventilation. However, these specialized endotracheal tubes should be part of an organized VAP prevention strategy and should not be used in place of such efforts.

• Continuous sedation is an important risk factor for VAP. Therefore, profound sedation should be avoided whenever possible. Early mobilization of surgical patients is essential and post-operative pain should be controlled with judicious use of analgesics.
Summary
Traditional preventive measures for VAP include decreasing risk of aspiration, preventing cross-contamination or colonization via hands of personnel, appropriate disinfection or sterilization of respiratory devices, and education of hospital staff. New measures being investigated involve reducing oropharyngeal colonization by pathogenic microorganisms. However, the benefit of this strategy remains controversial. In contrast, non-pharmacologic methods designed to reduce gastro-esophageal reflux, tracheal aspiration, and direct inoculation of microorganisms into the lower respiratory tract can be applied in a routine way in mechanically ventilated patients and are effective in reducing the incidence of VAP. Effective drainage of subglottic secretions, semi-recumbent positioning in eligible patients and careful handling of the artificial airway such as periodical monitoring of the intracuff pressure are inexpensive and effective measures to prevent VAP. Finally, adequate staffing levels are a key parameter to allow adherence to best practice guidelines and increase patient safety.

References
CHAPTER 35

PREPARING THE PATIENT FOR SURGERY

Helen Giamarellou, MD

Key Issue
Appropriate skin preparation plus antimicrobial prophylaxis can decrease the incidence of both superficial and deep wound infections (surgical site infection) after certain operations.

Known Facts
A preoperative shower, preparation of the skin with antiseptics in the operating room, and a single preoperative dose of a first- or second-generation cephalosporin are extremely important to significantly decrease wound infection rates. Regrettably, several postoperative doses of prophylaxis are generally administered in some medical centers leading to excess cost and the emergence of multiresistant bacteria.

Controversial Issues
• Hair removal from the operative site is still disputed.
• The duration of prophylaxis in the trauma patient is not well defined. Assessment of risk factors in clean operations requires more studies, particularly in breast and hernia surgery where reevaluation of prophylaxis seems to be necessary.
• It has been shown that nasal colonization with Staphylococcus aureus is a risk factor for surgical site infections following cardiothoracic operations but decolonization using topical mupirocin has not been shown to significantly reduce this risk.

Suggested Practice
• A single, full therapeutic dose of antibiotic should be given intravenously immediately before skin incision and simultaneously with the induction of anesthesia, i.e., prior to tissue contamination to ensure effective tissue concentrations.
throughout the operative period. An exception to this rule is cardiac surgery where two doses of antimicrobial seem to be necessary. Antibiotics are most effective when given before inoculation of bacteria. They are ineffective if given three to four hours after the surgical incision.

- In clean-contaminated cases and in clean operations involving the surgical placement of foreign material, cefazolin alone should be administered upon induction of anesthesia and skin incision. In clean contaminated and contaminated operations with entry into the gastrointestinal tract cefazolin plus an agent active against anaerobes should be used. However, administration in contaminated operations is rather therapy than prophylaxis.

- The selection of the appropriate drug should be based on the most likely bacteria to cause infection in each situation. A single drug should be used, whenever possible. Cephalosporins, in particular, cefazolin, is ideal for prophylaxis because of its broad spectrum of activity, the moderately long serum half-life, low toxicity, ease of administration, and low cost. Third-generation cephalosporins are more costly and promote the emergence of resistant strains. In general, they should not be used for routine prophylaxis. Since coverage against both aerobic and anaerobic gram-negative organisms is necessary for colorectal surgery, penetrating abdominal trauma, or primary appendectomy, cefoxitin or cefotetan are recommended as single agents. For patients with beta-lactam allergies, metronidazole plus gentamicin can be used.

- Prophylaxis should not be extended beyond 24 hours following surgery. However continuing prophylaxis until all chest tubes are removed is strongly discouraged. As long as adequate serum drug levels are maintained during the operation, a single dose is as effective as multiple doses.

- In the case of massive hemorrhage, or whenever the duration of an operation exceeds 3 hours, a repeat dose should be given every two to three half-lives.

- Prophylactic antibiotics are indicated in cases of placement of prosthetic materials (e.g., heart valves, vascular grafts, orthopedic hardware) or whenever host-risk factors suggest
the need for prophylaxis as in breast surgery with obesity age > 60 yrs, cancer with immediate breast reconstruction as well as in herniorrhaphy. Since staphylococci are the major threat in infected prostheses, vancomycin instead of cefazolin should be used in institutions with a high predominance of methicillin-resistant strains as well as in β-lactam allergic patients.

Summary
Preparation of patients for surgery aimed at preventing postoperative wound infection is based on appropriate skin preparation and antimicrobial prophylaxis. Nevertheless, appropriate treatment of remote infections before elective operations and adequate control of blood glucose levels perioperatively are also recommended. Decolonization of nasal carriage of S. aureus before placement of foreign material may be proposed.

Decontamination of the skin preoperatively is very important to prevent wound infection, particularly in clean procedures. A preoperative shower with an antiseptic soap seems to reduce the incidence of postoperative infections. Chlorhexidine gluconate was significantly superior when compared to povidone-iodine and triclocarban medicated soap showers. Hair removal at the operative site by shaving, particularly the night before surgery, should be abandoned since shaving produces significant injury. Subsequently, the injured skin sites are colonized and serve as a niche of bacterial contamination of surgical wounds. The risk of wound infections from clippers or a depilatory have been found to be lower than that from shaving and if necessary it should be done immediately before operation. Interestingly, patients with no hair removal may have even lower rates of wound infection. Skin preparation in the operating room should be performed by trained personnel. The prep starts with a careful cleansing of the operative site with a detergent (with or without a degreasing agent). The antiseptic is applied in concentric circles starting at the proposed operative incision site. Chlorhexidine gluconate or an iodophor scrub are usually used.

Wound infection has been defined as purulent discharge from an incision, regardless of whether organisms are cultured. In 1992, the CDC redefined the term as “surgical site infections,”
and divided them into superficial and deep infections. The superficial infections involve only the skin and subcutaneous tissues while deep infections involve at least muscle and fascial layers. Incisions may be contaminated by the patient’s own normal flora or by flora from the environment, including the operative team. Correct surveillance of wound infection extends to 30 days following surgery. In the case of implants, surveillance is extended for up to 1 year.

The traditional surgical wound classification system was established based on the exposure of the incision to bacterial contamination (Table 35.1). Infection was reported in 3.3% of clean wounds, in 10.8% of clean-contaminated, in 16.3% of contaminated, and in 28.6% of dirty wounds. In the Study of the Efficacy of Nosocomial Infection Control (SENIC), a new classification based on patients’ risk assessment rather than wounds was developed. Risk factors included abdominal operations, operations exceeding 2 hours, and having three or more associated discharge diagnoses. Patients with no risk factors were at low risk for infection (1%), those with one factor at moderate risk (3.6%), and those with two or more factors at high risk (8.9 to 27%). The National Nosocomial Infection Surveillance (NNIS) system, in 1991, attempted to redefine risk factors. The following risk factors provided a greater discrimination for the patient at risk of wound infection: (1) a contaminated or dirty wound class; (2) high preoperative risk as defined by an American Society of Anesthesiologists (ASA) preoperative assessment score of three or more; and (3) a duration of operation exceeding the 75th percentile for a given procedure. Long operations generally include greater blood loss, increased complexity, and violations of asepsis. Malnutrition, advanced age, obesity, diabetes mellitus, malignancy, and the use of steroids or immunosuppressive drugs are also risk factors for wound infection.

Appropriate antibiotic prophylaxis reduces morbidity and costs by preventing surgical site infections. However, it should be emphasized that antibiotic overuse and misuse for surgical prophylaxis accounts for as many as half of all antibiotics costs prescribed in US hospitals, and contributes to the emergence of multidrug-resistant microorganisms.
<table>
<thead>
<tr>
<th>Table 35.1 Classification of Surgical Wounds</th>
</tr>
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<tbody>
<tr>
<td><strong>Clean</strong></td>
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<tr>
<td>Elective, not emergency</td>
</tr>
<tr>
<td>No entry into the gastrointestinal, respiratory, or genitourinary tracts</td>
</tr>
<tr>
<td>No signs of acute inflammation or infection</td>
</tr>
<tr>
<td>Nontraumatic</td>
</tr>
<tr>
<td>No violations of aseptic technique</td>
</tr>
<tr>
<td><strong>Clean-Contaminated</strong></td>
</tr>
<tr>
<td>Urgent or emergency case that is otherwise clean</td>
</tr>
<tr>
<td>Entry into the gastrointestinal or respiratory tract without significant contamination</td>
</tr>
<tr>
<td>Biliary tract entered in the absence of infected bile</td>
</tr>
<tr>
<td>Oropharynx or vagina entered</td>
</tr>
<tr>
<td>Genitourinary tract entered in the absence of infected urine</td>
</tr>
<tr>
<td>Minor violation of aseptic technique</td>
</tr>
<tr>
<td><strong>Contaminated</strong></td>
</tr>
<tr>
<td>Nonpurulent inflammation;</td>
</tr>
<tr>
<td>Major contamination following entry into the gastrointestinal or respiratory tracts</td>
</tr>
<tr>
<td>Entrance of genitourinary or biliary tracts in the presence of acute infection</td>
</tr>
<tr>
<td>Fresh traumatic wounds (&lt;4 hours old)</td>
</tr>
<tr>
<td>Chronic open wounds to be grafted or covered</td>
</tr>
<tr>
<td><strong>Dirty</strong></td>
</tr>
<tr>
<td>Penetrating trauma &gt; 4 hours old</td>
</tr>
<tr>
<td>Acute bacterial inflammation or pus encountered</td>
</tr>
<tr>
<td>Perforated viscus encountered</td>
</tr>
<tr>
<td>Traumatic wound with retained devitalized tissue, foreign material, fecal contamination, and/or delayed treatment</td>
</tr>
</tbody>
</table>

**References**


Key Issue
Neonatal sepsis and postpartum endometritis (PPE) can largely be prevented by simple infection control measures. However, in developing countries they still cause substantial morbidity and mortality. Most infections are caused by organisms in the mothers’ vaginal flora.

Known Facts
- The most important microorganisms causing neonatal sepsis are group B streptococci (GBS) and *Escherichia coli*.
- Cleaning of the birth channel with an antiseptic reduces the neonatal infection rate.
- Prevention of infections with GBS can be achieved by screening and treating vaginal colonization during pregnancy. The cost-effectiveness of this strategy depends on the setting.
- Cesarean section is associated with a higher rate of PPE (10–20%) than vaginal delivery.
- Cleaning of the birth canal with a disinfectant during vaginal examinations reduces the risk of PPE.
- Single dose antibiotic prophylaxis reduces the risk for PPE after cesarean section in high-risk patients.
- Although rare, outbreaks of classical childbed fever caused by group A hemolytic streptococci do occur and warrant prompt investigations into the source. This includes searching for carriers.
- During labor there is frequent and uncontrolled contact with blood and other body fluids. Transmission rates of blood borne pathogens are high when preventive measures are neglected.
Controversial Issue
• The value of prophylaxis in women undergoing cesarean section who are not in labor and have intact membranes is unclear.

Suggested Practice
• General infection control measures should be taken before, during and after labor.
• During labor gloves should be worn at all times, and it is advisable to wear gown, mask and eye protection.
• During vaginal examinations the birth canal should be cleaned with a disinfectant.
• In high-risk patients single dose antibiotic prophylaxis should be administered when cesarean section is performed. This should be given directly after the umbilical cord has been clamped.

Summary
The importance of infection control in obstetrics was established when Semmelweis made his historical observations during the second half of the nineteenth century. Currently, in developed countries most infectious complications of delivery are prevented. However, in developing countries neonatal and maternal postpartum morbidity and mortality due to bacterial infections are substantial. In areas with a high prevalence of HIV, the morbidity and mortality rates have been further increased. Simple infection control measures can prevent infectious complications to a large extent. For instance, cleansing of the birth channel with 0.25% chlorhexidine at every vaginal examination before delivery combined with a wipe of the newborn results in a significant decrease of neonatal and maternal infections and neonatal mortality at a cost of less than US$ 0.10 per patient (1).

Neonatal sepsis
The most important pathogens causing neonatal sepsis are group B streptococci (GBS) and Escherichia coli. The newborn is thought to become colonized during the passage of the birth channel. Although disputable, newborn infections which
are acquired during passage of the birth channel are considered nosocomial. Cleansing of the birth channel with an antiseptic, as mentioned above, results in a significant decrease of neonatal infections. Prevention of infections with GBS can be achieved by screening and treating vaginal colonization during pregnancy.

There are two prevention strategies for neonatal GBS sepsis consisting of giving intrapartum antibiotic intravenous prophylaxis to women:

1. Identified as GBS carriers through screening cultures collected at 35–37 weeks’ gestation or to women who develop premature labor or rupture of the membranes before 37 weeks gestation;

2. Who develop one or more of the following risk factors at the time of labor: delivery at <37 weeks’ gestation, membrane rupture for > 18 hours, or intrapartum temperature > 100.4 F.

In both strategies prophylaxis is given to women who had children with GBS sepsis before and to women who had GBS bacteriuria earlier in the course of pregnancy. High dose intravenous penicillin or ampicillin are the drugs of first choice. In patients who are allergic to penicilline, clindamycin is administered.

Postpartum Endometritis (PPE)

PPE is a serious complication of delivery. Microorganisms that are part of the mothers’ endogenous flora cause most infections, and outbreaks are rare. Prevention depends largely on the elimination of risk factors. Cesarean section is associated with a higher rate of PPE than vaginal delivery. In developing countries, there is an ongoing discussion if symphysiolysis should be preferred over cesarean section when the latter is associated with a high PPE rate. Well documented risk factors for PPE after cesarean section include: membrane rupture, labor, low socio-economic status, frequent vaginal examinations. Well documented risk factors for PPE after vaginal delivery include: prolonged membrane rupture, midforceps delivery, anemia, maternal soft tissue trauma, bacterial vaginosis. Cleaning of the birth canal with a disinfectant during vaginal examinations reduces the risk of PPE. Single dose antibiotic prophylaxis
after clamping the umbilical cord, reduces the risk for PPE after cesarean section in high-risk patients. The value of prophylaxis in women undergoing cesarean section who are not in labor and have intact membranes is unclear at present. Despite adequate antimicrobial prophylaxis, the rate of PPE after non-elective cesarean section remains high (10–20%). Although classical childbed fever caused by group A beta-hemolytic streptococci is rare, outbreaks do occur. If so, immediate control measures, including screening for carriers among healthcare workers and other patients, are mandatory.

**Blood borne pathogens during delivery**

Blood borne pathogens are a threat to mother, child and healthcare worker during delivery. Scalp electrodes are contraindicated if the mother is infected with hepatitis B, C or HIV. In mothers with hepatitis B the newborn should be immunized after delivery, and in mothers infected with HIV, antiretroviral therapy during pregnancy reduces the risk of transmission to the newborn. Blood exposure occurs frequently during labor. Gloves are frequently punctured. Needle stick injuries and splashes occur frequently. Therefore, gloves should be worn at all times, and it is advisable to wear gowns, masks and eye protection.

**Herpes Simplex Virus (HSV)**

 Mothers with active genital HSV infections should be handled with barrier precautions. HCW and the mother should wear gloves when touching the infected area or materials (gauzes etc.).

**References**


CHAPTER 37

THE INFECTION HAZARDS OF HUMAN CADAVERS

P.N. Hoffman, BSc, Hon DipHIC, T.D. Healing, MSc, PhD, and S.E.J. Young, FRCP

Key Issue
Cadavers may pose hazards to those handling them. The recently dead may have been infected by a wide range of pathogens, those presenting particular risks include tuberculosis, streptococcal infection, gastro-intestinal organisms, the agents causing transmissible spongiform encephalopathies (e.g., Creutzfeld-Jacob disease), hepatitis B and C, HIV infection, severe acute respiratory syndrome (SARS), hemorrhagic fever viruses, and possibly meningitis and septicemia (especially meningococcal). None of the organisms that caused mass death in the past (e.g., plague, cholera, typhoid, tuberculosis, smallpox) is likely to survive long in burials.

Known Facts
• Most of the micro-organisms that people die of either do not survive for a long time after their host dies or are not readily transmissible in that context.
• Soft tissues remaining on a cadaver could present a risk.
• Long buried bodies reduced to skeletons are not a hazard.
• A possible hazard in old burials is anthrax, which can form resistant spores but this is unlikely and in addition humans are not very susceptible to this type of infection.

Controversial Issues
There have been worries that smallpox might survive in buried bodies, but the risk from minimal residual virus in dry scabs is not considered to present a valid infectious threat. People should not be vaccinated especially to deal with this hazard as the risks of smallpox vaccination greatly outweigh the very slight risk.
**Suggested Practice**

Whether dealing with the recently dead or with old burials, and regardless of which infectious agents may be present, the risk of acquiring infection can be greatly reduced by:

- covering cuts or lesions with waterproof dressings
- careful cleansing of any injuries sustained during procedures
- good personal hygiene
- the use of appropriate protective clothing (*Table 37.1*).

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### Table 37.1 Use of Protective Clothing

**Hands**

**Examination gloves (latex or nitrile).** For handling hazardous material. Wear whenever handling bodies. Should be worn once only and then discarded. Always wash hands after use. Latex provides short-term (10-minute) protection against formaldehyde. Nitrile provides long-term protection.

**Respiratory Protection**

**Filter masks.** Filter mask to EN 149 for specific hazards (e.g., lead dust, fungal spores, and other aerosols).

**Specifically-manufactured surgical masks.** These may provide protection against splashes, particularly if water-repellent, but cannot be as effective as filter masks as their fit to the wearer’s face allows particles to bypass any filtration the mask fabric may offer.

**Cloth surgical masks.** These provide little protection and may give a false sense of security, but are better than nothing.

**Splash Protection**

**Face:** Visor. Protection against hazardous splashes to eyes, nose and mouth (also mechanical protection).

*Respiratory protective masks and cloth or paper surgical masks normally provide splash protection to mouth and nose only. Some surgical masks incorporate a transparent eye-protecting visor.*

**Body:** Apron. Where splashing to body may occur (hygienic preparation, embalming, collection of traumatized bodies, post-mortem examinations). Best worn under gowns or coats if splashing is likely to be profuse.

**Feet:** Rubber Boots. In wet situations (mortuaries, embalming rooms, collecting severe multiple trauma cases).
Whole-Body Protection

**Gowns/coats.** To protect clothing against splashing.

**Coverall with hood.** To protect clothes and hair from impregnation with dusts, spores, etc.

**Other protective clothing.** Safety helmets, boots, safety glasses, and work gloves should be worn as required to protect against mechanical injury.

**Summary**

Most people have little to do with the dead, although they may at some time in their lives need to deal with the cadavers of relatives or friends during burial rituals. Some have jobs that regularly bring them into contact with cadavers, exposing them to the risk of acquiring infections. These include doctors (especially pathologists), nurses, mortuary attendants, forensic scientists, embalmers, funeral directors, religious officials or others who routinely prepare bodies for the funeral or who perform final rites, and members of the emergency services.

In most circumstances the diseased living are a much greater hazard than are the dead, even those who have died of infectious disease. Whilst a person is alive, invading pathogens can multiply and are readily transmitted. The patient is a continuing source of infection. Once the host is dead, most microorganisms stop multiplying and die rapidly.

**The Recently Dead.**

The diseases and organisms which may pose particular risks vary in different parts of the world but include tuberculosis, streptococcal infection, gastro-intestinal organisms, Creutzfeld-Jacob disease, hepatitis and HIV infection, a number of viral infections (particularly viral hemorrhagic fevers such as Lassa, Marburg or Ebola), severe acute respiratory syndrome (SARS), and possibly meningitis and septicemia (especially meningococcal) (Table 37.2). In general, the use of appropriate protective clothing will greatly reduce the risk of acquiring infection but some additional precautions may be advisable for particular infections.
Table 37.2 Infections Where Bagging is Essential, and Viewing, Embalming, and Hygienic Preparation Should Not Be Done

<table>
<thead>
<tr>
<th>Infection</th>
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<tbody>
<tr>
<td>Anthrax</td>
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<tr>
<td>Plague</td>
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<tr>
<td>Rabies</td>
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<tr>
<td>Smallpox</td>
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<tr>
<td>Viral hemorrhagic fevers</td>
</tr>
<tr>
<td>Yellow fever</td>
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<tr>
<td>Transmissible spongiform encephalopathies (e.g., Creutzfeldt-Jakob disease)</td>
</tr>
<tr>
<td>Streptococcal disease (group A)</td>
</tr>
<tr>
<td>Viral hepatitis (B, C, non-A, non-B)</td>
</tr>
</tbody>
</table>

Bagging = placing the body in a leak-proof plastic body bag.
Viewing = allowing the bereaved to see, touch, and spend time with the body prior to disposal.
Embalming = injecting chemical preservatives into the body to slow the process of decay. Cosmetic enhancement of the appearance of the body may be undertaken to improve the appearance for viewing.
Hygienic preparation = cleaning and tidying the body so it presents a suitable appearance for viewing (an alternative to embalming).

**Tuberculosis.**
Opening cadavers of individuals infected with tuberculosis is dangerous and workers in morbid anatomy, pathologists, mortuary technicians and medical students have a high rate of tuberculin conversion. BCG vaccination and an annual chest X-ray is advised for such individuals.

**Meningitis and Septicemia.**
- Meningitis can be caused by a wide range of organisms but only tuberculosis (see above) and meningococci are likely to present a risk.
- Septicemia is a common terminal event and can be caused by many different organisms (often the patient’s own flora) most of which present no hazard. Only cases of meningococcal septicemia or of infection with group A streptococci pose a risk. Life threatening infections with the latter can result from quite trivial injuries.
Gastrointestinal Organisms
Fecal leakage from bodies is very common. All those handling cadavers should:
- Wear gloves and impervious single-use aprons
- Take care not to contaminate their instruments or their working environment
- Wash their hands carefully after procedures and before eating, drinking or smoking.

The bodies of those who have died of diseases such as cholera or typhoid should not be buried in places where they could contaminate water sources.

Transmissible Spongiform Encephalopathies (TSEs)
The causative agents of these diseases are highly resistant to most disinfectants and to heat. They are not killed by formalin, and exposure to sodium hypochlorite containing 20,000 ppm available chlorine (for at least one hour), to 1–2M sodium hydroxide, or steam autoclaving at 134°C for at least 18 minutes result in unreliable decontamination. Only fully trained staff should undertake post mortem examinations in patients thought to be at risk of, or who are known or suspected as having, TSEs. If examination of the brain only is required, the skull should only be opened inside a large plastic bag fitted over the head and neck of the cadaver. If a full post mortem is required, including the removal of viscera and spinal cord, the body should be examined in a high risk autopsy suite.

Hepatitis
- Hepatitis A is transmitted by the fecal-oral route and presents the same hazard as other gastro-intestinal pathogens. A highly effective vaccine is available.
- Hepatitis B is extremely infectious and the incidence of this infection continues to increase in many countries. Staff working in hospital mortuaries, and embalmers, should routinely receive immunization against hepatitis B. The bodies of those who have died of, or were known to be infected with, this virus should be handled only by those wearing full protective clothing.
- Hepatitis C is also highly infectious although probably less so than hepatitis B. It is transmitted by the same routes as hepatitis B, there is no vaccine, and similar precautions to those for hepatitis B should be taken.
HIV
The routes of transmission of hepatitis B and of HIV are similar and the precautions required to prevent the transmission of the former should be adequate to prevent transmission of the latter. HIV is probably about 1000-fold less infectious than hepatitis B and the risk to those handling infected cadavers is therefore proportionately less. HIV can survive for many days post-mortem in tissues preserved under laboratory conditions. Care should be taken when handling unfixed, HIV-infected material from cadavers, or when undertaking post-mortem examinations on those infected with HIV. The embalming the bodies of those known or suspected of being infected is not recommended.

Those infected with HIV are often infected with other organisms (such as mycobacteria) which may be more infectious (albeit less dangerous) than the HIV infection itself.

Viral Hemorrhagic Fevers
Viruses such as Ebola and Marburg are highly infectious and are readily transmitted by contact with infected blood, secretions and organs. Most of the known outbreaks have been nosocomial. Great care should be exercised when dealing with those who have died of such infections. Staff should wear gloves and protective gowns and masks and post mortem examinations should not be carried out. Bodies should be bagged as soon as possible and should be buried with appropriate precautions (see below) or burnt.

Reduction of Risk
Post-mortem Rooms
• Post-mortem rooms should be laid out so that the risks to those working in them are minimised. Provision of proper ventilation, lighting, running water and good drainage is essential.
• Workers must wash their hands after each procedure and before eating (or smoking).
• The environment should be cleaned with a broad spectrum disinfectant daily.
• Instruments should be washed in a washer-disinfector, autoclaved or immersed in a broad-range, non-corrosive disinfectant after initial cleaning. Disinfectant for 20 minutes. There are several reasons for the use of a disinfectant other than hypochlorite:
1. Hypochlorite is corrosive and may damage surfaces or instruments.

2. Chlorine gas can sometimes be released when hypochlorite is used and cleaning large areas may lead to unacceptable levels of chlorine in the air.

3. Formaldehyde is likely to be present in post-mortem rooms (and embalmers premises) and the reaction between hypochlorite and formaldehyde produces a potent carcinogen (bis-chloromethyl ether).

Some hospital post-mortem departments bag all bodies for transfer to funeral directors. This can be counter productive in terms of safety as bagging a body may be the main means by which the hospital can communicate to the funeral director that the body may present special risks. In countries where confidentiality precludes reference to specific infections, the type of risk involved can be identified by attaching labels advising generic precaution types (e.g., enteric, blood borne) to the bag.

**Preparation of the Dead for Funerals.**

- Often only a simple “hygienic preparation” may be carried out, frequently by relatives or religious officials. This usually involves washing the body, dressing the cadaver, tidying the hair and possibly trimming the nails and shaving. Such rapid procedures are frequently followed in many countries, particularly the hotter ones, where burial or other disposal of the cadaver follows death within 24 hours (either for practical or religious reasons). Under these circumstances many pathogens may still be viable but, provided there is considered to be only a low level of risk, then the use of gloves and simple protective clothing and/or good personal hygiene by anyone handling the bodies is an acceptable and effective safety measure.

- In some instances, for example where the person has died of a highly infectious disease such as Ebola or hepatitis B, even hygienic preparation is not safe. A list of such infections is given in Table 37.2.

- Embalming may be undertaken as a means of temporary preservation by reducing microbial activity and slowing decomposition and is usually a straightforward process but the embalming of cadavers which have been in accidents or which have been the subjects of post-mortem examination...
is more difficult. They may be badly damaged and present particular hazards because of damaged bones, bone splinters, and (occasionally) due to sharp items, such as intravenous cannulae, left in the body. Cosmetic work on cadavers may also present hazards if the body has been damaged. There can sometimes be considerable contamination of the body with blood, feces and other body fluids if it is bagged, presenting an extra risk to embalmers and others involved in preparation of the body. This is another reason to avoid universal bagging of bodies by hospitals. Embalming practices such as the open drainage of the vascular system lead to excessive environmental contamination and should be avoided.

- All instruments used for embalming or for preparing bodies for the funeral should be cleaned in hot water and detergent and can be sterilised in an autoclave or disinfected, preferably by a brief boil (five minutes), or by being soaked in a disinfectant after careful cleaning. Disinfectants should be used to clean up any spills of blood or body fluid, single-use gloves being used to protect the hands from contact with the spill. Hands should always be washed after finishing a session.

**Emergency Service Personnel**

- The major hazard facing emergency service personnel is spilt blood and any risk can be greatly reduced by preventing contact with blood (use of gloves, face and eye protection, and protective clothing where necessary).
- Bodies that have been decaying for some time, including those that have been in water for extended periods of time, present little risk. The organisms likely to be present are their own body flora and water or environmental organisms. The use of proper protective clothing and good personal hygiene will protect personnel handling such material.
- Bodies should always be transported to mortuary facilities in waterproof body bags or cleanable, fluid retentive (e.g., fibreglass) temporary coffins.

**Disposal of The Dead**

Each society has its own methods of disposal of the deceased. These must be respected as far as possible although in a few
instances (such as deaths due to highly infectious agents such as Ebola) cremation or deep burial with the cadaver in a leak-proof plastic body bag may be the only safe procedures.

Immediately following disasters where there has been substantial loss of life, there seems to be a tradition to bury or cremate the dead as quickly as possible “to prevent the spread of disease”. In reality however, the dead bodies of disaster victims pose a minimal infectious risk to the survivors. The spectrum of disease amongst the deceased in a rapid onset natural disaster (such as a tsunami) will be the same as that amongst the survivors. Of those deceased that had an infectious disease at the time of their death, the risk that they will disseminate it will be lower than it was during their life and those that did not have an infectious disease offer a negligible risk. The imperative of immediate disposal of the dead diverts resources from searching for and caring for the survivors at a critical time in any rescue operation. It also hampers or prevents the identification of the dead, removing part of the grieving process from their relatives as well as prolonging their uncertainty as to the possible survival of the victims. The legal consequences of lack of identification (e.g., uncertainty of spouses about death of partners, inheritance problems) can cause long-term hardship for the deceased relatives.

If bodies cannot immediately be identified and sufficient temporary mortuary space with refrigeration is not available they should be buried in marked graves with at least one metre of earth over the cadavers (to prevent access by scavengers and pests) to allow subsequent exhumation. Once identified they should be dealt with following the normal religious and social practices of the affected areas as far as possible. Burial sites must be chosen so as to avoid the risks that water sources may be contaminated.

Those handling the bodies should take basic infection control precautions: Impervious gloves, single-use or disinfected after use), impervious apron or coverall, impervious footwear, face protection if splashing likely. Respiratory-protective masks are not necessary. The use of chloride of lime to prevent the spread of infection in these circumstances is to be avoided. It has little effect and is dangerous to those applying it. This applies equally to emergency and non-emergency situations, such as exhumations of graves and crypts.
References

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CHAPTER 38

STREPTOCOCCUS PYOGENES
(GROUP A STREPTOCOCCAL INFECTIONS)

Belinda Ostrowsky, MD, MPH

Keywords
Streptococcus pyogenes, Group A streptococcus, postpartum infections, post surgical infections

Key Issues

• Hand washing is one of the most important infection control practices for the prevention of spread of infection with Streptococcus pyogenes [Group A streptococcus (GAS)]

• One nosocomial postpartum or postsurgical invasive GAS infection should prompt enhanced surveillance and streptococcal isolate storage; two or greater cases caused by the same strain of GAS should prompt an epidemiological investigation that includes the culture of specimens from epidemiologically linked healthcare workers (HCWs).

Known Facts

• Group A streptococci frequently colonize the throats of asymptomatic persons and may also colonize the skin, rectum and vagina.

• Streptococcal disease is ordinarily spread by direct person-to-person contact. In cases of pharyngitis and respiratory infections, droplets of saliva or nasal secretions are the mode of spread. Crowding such as occurs in school or military barracks favors interpersonal spread of the organism in community outbreaks. Fomites can also be a source of transmission.

• A variety of clinical presentations may occur, including pharyngitis, otitis media, quinsy, skin and soft tissue infections (pyoderma, impetigo, erysipelas, and scarlet fever), pneumonia and puerperal fever.
• Most GAS infections are relatively mild illnesses. More recently invasive and serious GAS infections have become concerning.

• Invasive Group A streptococcal infection is defined as isolation of GAS from a normally sterile site (e.g., blood) or by the isolation of GAS from a nonsterile site in the presence of the streptococcal toxic shock syndrome or necrotizing fasciitis.

• Postinfectious complications of GAS infections include Rheumatic Fever with secondary aortic and mitral valve injury and glomerular nephritis. Pharyngeal strains of GAS can result in either syndrome. Infections of the skin are only associated with the acute glomerular nephritis.

• Streptococcal infections should be treated to limit secondary complications.

• Outbreaks of pharyngitis and impetigo in school-age children or in group setting are common.

• Clusters/outbreaks are less common, but have been described mainly in two nosocomial settings, postpartum and postsurgical populations.

Controversial Issues

• No controlled trials have evaluated the effectiveness of chemoprophylaxis in preventing invasive GAS disease among household contacts of persons with invasive GAS infections. Given the infrequency of these infections and the lack of a clearly effective chemoprophylaxis regimen, the available data do not support a recommendation for routine testing for GAS colonization or for routine administration of chemoprophylaxis to all household contacts of persons with invasive GAS at this time.

Suggested Practice

• Standard precautions, including hand washing are the most important infection control practices for the prevention of spread of infection with GAS such as minor/limited skin infections, wounds and burns and endometritis (puerperal sepsis).

• HCWs should wear gloves and gowns for contact with the skin of patients with major lesions, wounds and purulent discharge. Place the patient in a private room. When a private
room is not available, place the patient in a room with a patient(s) who also has infection with the *S. pyogenes* (cohorting). Discard the gloves after use and wash hands thoroughly between patient contacts. Contact isolation may be discontinued after 24 hours of directed antistreptococcal therapy.

- For GAS infections that involve the pharynx and respiratory tract, such as pneumonia and Scarlet Fever in infants and children, HCWs should use standard and droplet precautions, including use of a surgical mask when working within 3 feet of the patient. Logistically, some hospitals may want to implement the wearing of a mask to enter the room of affected patients. Place the patient in a private room. When a private room is not available, cohorting should be used. When a private room is not available and cohorting is not achievable, maintain spatial separation of at least 3 feet between the infected patient and other patients and visitors. Special air handling and ventilation are not necessary, and the door may remain open.

- HCWs who are known or suspected to have infection or colonization of their respiratory tract with *S. pyogenes* should wear a mask to reduce respiratory spread of their organism.

- Attempt to eradicate colonization in those HCWs who are proven sources of outbreaks (description evaluation of cluster/outbreak in nosocomial setting below)

**Discussion**

*Streptococcus pyogenes* (Group A β-hemolytic streptococcus) is a gram-positive, catalase-negative cocci. It can be carried in the pharynx, skin, vagina and rectum asymptomatically. There are a wide variety of clinical presentations of GAS. Although the most common GAS infections are mild (i.e. pharyngitis, skin infections) if left untreated there can be serious secondary sequella, including Rheumatic Fever and glomerular nephritis.

More concerning in recent years is the rise in invasive GAS infections. Invasive GAS infection is defined as isolation of GAS from a normally sterile site (e.g., blood) or by the isolation of GAS from a nonsterile site in the presence of the streptococcal toxic shock syndrome or necrotizing fasciitis.
Worldwide, rates of invasive disease increased from the mid-1980s to early 1990s. Rates of invasive disease have been stable over the last 5 years in the United States. However, there have been increases in the severity of diseases, including those associated with M-1 and M-3 serotypes (emm types 1 and 3). Resistance to erythromycin has increased worldwide.

By estimates from Centers for Disease Control and Prevention (CDC), in the year 2000 there were approximately 8800 cases of invasive GAS and 1000 deaths due to GAS infection in the United States.

Direct contact with patients or carriers and large respiratory droplets are the primary means of acquisition. Disease caused by \textit{S. pyogenes} is most common in late winter and early spring. In the community setting, outbreaks of pharyngitis in school children and other congregate setting are common in these months. Contaminated hands of HCWs are an important means of transmission, particularly outside of the setting of the operating room. Appropriate gloving and good hand washing techniques are important to emphasize in efforts to control an outbreak. The addition of contact precautions for wound, skin and soft tissue and droplet precautions for pharyngeal and respiratory infections in infants and children are appropriate infection control practices. Prompt identification and investigation of an outbreak of nosocomial \textit{S. pyogenes} infection will assist in its control.

In the healthcare setting outbreaks have been described mainly in two populations, postpartum and postsurgical patients. There have also been infections in burn patients (wound), bacteremias in the setting of intravascular catheters device insertion and pneumonias.

There are two recent guidelines (since 2002) that are excellent resources for addressing infection control related to GAS infections and particularly in these high-risk settings, one related to an expert panel meeting by CDC in the United States and the second by Public Health Agency of Canada. Highlighted from these comprehensive guidelines are distilled below.

In 2000, CDC hosted a workshop to formulate recommendations for household contacts of those with invasive GAS infections and for responding to nosocomial clusters, including postpartum and post surgical invasive GAS infections. The recommendations from this panel were published in 2002.
In this CDC expert panel review, a household contact is defined as a person who spent at least 24 hours in the same household as the index patient during the seven days before the onset of the case patient’s symptoms. Review by the committee of two prospective studies that were designed to identify subsequent cases among household contacts (who were observed for a total of 66.5 million person-years) identified only five confirmed cases of subsequent invasive disease. There are no controlled trials that have evaluated the effectiveness of chemoprophylaxis in preventing invasive GAS disease among household contacts of persons with invasive GAS infections. In addition, antimicrobial therapy can have undesirable side effects, including adverse reactions and selection for resistant organisms.

Thus, the committee did not recommend routine screening for and chemoprophylaxis to household contacts. However, they suggested that providers and public health officials may choose to offer chemoprophylaxis to household contacts who are at an increased risk of sporadic disease [HIV infection, diabetes mellitus, varicella zoster (Chicken pox) patients <10 years of age, cancer, heart disease, injection drug use, steroid use, ≥65 years of age] or mortality due to GAS (≥65 years of age). HCWs should routinely inform all household contacts of persons with invasive GAS disease about the clinical manifestations of pharyngitis and invasive GAS infection (e.g., fever, sore throat, and localized muscle pain and emphasize the importance of seeking medical attention if contacts develop such symptoms).

Given the potential for prevention of additional cases, the CDC panel recommended that even one case of postpartum or postsurgical GAS infection should prompt an epidemiological investigation by the hospital’s infection control personnel, which should include enhanced surveillance and storage of GAS isolates from the index patients and any other cases for at least six months. Enhanced surveillance should include one or both of the following: 1) review of microbiological records and autopsy reports from the previous six months and/or 2) review of operative, labor and delivery, and medical records from within the hospital.

If two or greater cases are identified within a 6-month period, they may have a common source of GAS transmission.
Isolates should be compared by an appropriate typing method (i.e., PFGE, serotyping, other molecular methods). Isolates that differ probably are community acquired, but enhanced surveillance should be initiated.

If two cases are found to be caused by the same strain within a 6-month period, screening of HCWs is strongly recommended to prevent further cases of serious infection. If infection-control personnel choose to screen healthcare workers, screening should be considered for HCWs who were present at delivery and for those who perform vaginal examinations before delivery (for postpartum cases) and for all HCWs present in the operating room during surgery and those who change dressings on open wounds (for postsurgical cases). If screening of HCWs is undertaken, sites from which specimens should be obtained and cultured include throat, anus, vagina, and any skin lesions. Screened HCWs may return to work pending culture results. However, HCWs identified as colonized should be suspended from patient care duties until they have received chemoprophylaxis for 24 hours and their streptococcus strains should be compared with patient strains using the same typing methods.

If a HCW is epidemiologically linked to the case patient and the strain the HCW is carrying is the same as the strains isolated from patients, the committee suggests follow-up cultures should be done for the HCW (CDC suggestions 7–10 days after the completion of therapy). If no colonized HCW is identified or if HCWs are colonized with strains unrelated to the outbreak strain, the search for colonized HCWs could be broadened to include those HCWs without immediate epidemiological links to all case patients. This might include, for example, HCWs who had direct contact with most but not all case patients.

The Public Health Agency of Canada published their Guidelines for the Prevention and Control of Invasive Group A Streptococcal Disease in October, 2006. This 26 page resource adds to the previously described US review in that it offers simple and clear definitions, an extensive glossary, review of the literature and references by topic area, and particular sections on GAS infection control and investigation in the childcare and long-term care facilities settings. Two areas of difference from the US guideline relevant for the infection
control community are summarized below.

The Canadian workgroup’s consensus on chemoprophylaxis for contacts was slightly more inclusive than the U.S. guidelines above, in that it does suggest prophylaxis for the closest contacts of confirmed severe cases of GAS infections, including streptococcal toxic shock syndrome, soft tissue necrosis, meningitis, pneumonia, other life-threatening conditions or a confirmed case resulting in death (and did not identify the underlying conditions of the contacts as a factor as strongly as the U.S. guideline).

For the long-term care setting, in addition to strict enforcement of standard infection control precautions, this guideline lays out what may constitute an cluster/outbreak and steps to investigate for and address a potential clusters/outbreaks. It suggests that in this setting 1) an incidence rate of culture-confirmed invasive GAS infections of >1 per 100 residents per month or 2) at least two cases of culture confirmed invasive GAS infection in one month in a facility with fewer than 200 residents or 3) an incidence rate of suggested invasive or non-invasive GAS infection of >4 per 100 residents per month should be an impetus for action.

This guideline suggests when a confirmed case of GAS infection in a long term care facility is identified that the following additional steps should be taken: 1) retrospective chart review of the facility’s residents over the 4–6 weeks prior to the case for other culture confirmed or any suggestive cases of invasive or non-invasive GAS infection and 2) assess the potential sources of infection from outside the facility. If an excess of these infections are identified, then the next steps would be: 1) screen patient care staff for GAS (using a cut off of 100 beds, <100 beds screen all residents, >100 beds screen residents within the same care unit as the case), 3) offer prophylaxis for all those identified with colonization with GAS, 4) question non-patient care staff about recent GAS infection and screen those with positive history 5) obtain genotyping of GAS isolates and “test of care” staff identified and 7) active surveillance for GAS infections for one to two months. If no excess is identified, especially if there is evidence of outside source for the index case, then active surveillance alone for 2–4 weeks to establish absence of additional cases is warranted.
Summary
Hand washing is the cornerstone of infection control for GAS infections. Additional precautions including contact and droplet precautions are appropriate for use by HCWs for specific other presentations of GAS infection. For certain high-risk household contacts of GAS infection, prophylaxis maybe appropriate. For nosocomial GAS infections enhanced surveillance, saving isolates and screening/prophylaxis of epidemiologically-linked HCW in certain setting may aid in prevention of further infections. Some additional surveillance and investigation in the long term care setting may also be appropriate when there is suspicion of cluster/breaks in this setting.

References:
CHAPTER 39

Staphylococcus aureus

Michael P. Stevens, MD, and
Michael B. Edmond, MD, MPH, MPA

Key Issue

Staphylococcus aureus is a major human pathogen that commonly causes nosocomial and community-acquired infections. It is a highly virulent organism that is exhibiting increasing antibiotic resistance.

Known Facts

- Colonization with S. aureus is common. A national, population-based study of non-hospitalized persons in the U.S. found 32% of persons to be colonized with methicillin-susceptible S. aureus (MSSA) and 1% colonized with methicillin-resistant S. aureus (MRSA).
- S. aureus is a major cause of nosocomial infections. It accounts for 12% of all hospital-acquired infections in the United States, 20% of all nosocomial bloodstream infections (at a rate of 1/1,000 admissions) and 18% of ventilator associated pneumonia cases.
- Regarding antimicrobial resistance, S. aureus is typically characterized by its susceptibility patterns to penicillinase-resistant penicillins (e.g., methicillin) and vancomycin.
- The mecA gene encodes for penicillin binding protein 2a (PBP2a) which confers resistance to all β-lactam antibiotics.
- Over half of all S. aureus strains acquired in U.S. healthcare facilities are resistant to methicillin.
- Historically, MSSA strains were mostly acquired in the community, whereas MRSA strains were typically acquired in healthcare facilities. However, there have been increasing reports of MRSA acquired in the community setting.
• Community-acquired MRSA tends to differ from hospital-acquired MRSA in that community-acquired strains are more likely to be susceptible to TMP/SMX and clindamycin.

• Community-acquired MRSA often manifests as skin and soft tissue infections and may be misdiagnosed as a “spider bite.” In some urban areas 60–70% of all skin and soft tissue infections are now due to MRSA.

• Virtually all of the community-acquired strains contain the Panton-Valentine Leukocidin (PVL) gene which is associated with lysis of white blood cells and tissue necrosis. These strains characteristically cause skin and soft tissue infections, often in healthy children and young adults, as well as a severe, multilobar, necrotizing pneumonia that often occurs with or following influenza.

• Classification of MRSA strains into community-acquired and hospital-acquired based on exposure to the healthcare setting is becoming increasingly problematic, since some hospitals are now reporting nosocomial infections due to MRSA strains that are of the “community-acquired” genotype.

• Risk factors for staphylococcal colonization and infection include disruptions of the skin (insulin injections, hemodialysis, allergy therapy, IV drug use, eczema, burns), underlying diseases (respiratory infections, HIV infection), prolonged hospitalization, and exposure to other infected or colonized individuals. However, in many patients with community-acquired MRSA infections, these risk factors are not present.

• >80% of cases of S. aureus bacteremia are caused by endogenous strains (i.e., a strain colonizing the patient is responsible for invasive infection).

• The most common sources of S. aureus bloodstream infection are catheters (46%), skin/soft tissue/bone (27%), lower respiratory tract (11%), and urinary tract (10%).

• Vancomycin intermediate Staphylococcus aureus (VISA), vancomycin resistant Staphylococcus aureus (VRSA), and heteroresistant Staphylococcus aureus (hetero-VRSA) have all been reported.
• The Clinical and Laboratory Standards Institute defines staphylococcal vancomycin minimum inhibitory concentrations (MICs) of \( \leq 2 \, \mu g/mL \) as susceptible, \( 4–8 \, \mu g/mL \) as intermediate, and \( \geq 16 \, \mu g/mL \) as resistant.

• Hetero-VRSA are defined as strains of *S. aureus* that contain subpopulations of vancomycin-resistant daughter cells but for which the MICs of the parent strain are only 1–4 \( \mu g/mL \). These subpopulations typically have MICs 2–8 fold higher than the original clinical isolate. When grown in the absence of vancomycin, the subpopulation of cells reverts back to the lower MIC of the parent strain.

• Patients who develop infection with VISA and VRSA often have serious comorbid disease states such as renal failure and diabetes, a previous history of infections with MRSA, recent vancomycin use, the presence of foreign material (including intravenous catheters and prosthetic devices) and recent hospitalizations.

• Major route of transmission for *S. aureus* is direct or indirect contact; airborne transmission is uncommon.

• Colonized healthcare workers may be the source of outbreaks in the hospital setting.

**Controversial Issues**

• The effectiveness of routine surveillance cultures to detect MRSA colonized patients in order to reduce MRSA infection and colonization in high prevalence settings remains undetermined.

• The role of decolonizing agents in the non-outbreak clinical setting remains undefined.

**Suggested Practice**

**MSSA**

• Use standard precautions.

**MRSA**

• Use contact precautions (gloves and gowns). Enforce hand washing with antiseptic agents (chlorhexidine gluconate or alcohol-based products) for staff, visitors, and infected or colonized patients.
• Provide private room or cohort the infected or colonized patient with other MRSA patients. Offer decolonization with intranasal mupirocin for patients with recurring infections and for colonized personnel.

• Maintain a reference list of MRSA patients so that patients may be placed in contact precautions in the event of readmission.

• If the MRSA patient is transferred, notify receiving healthcare facility.

• No special precautions for home discharge are required; emphasize good hand washing.

**VISA/VRSA**

• Contact precautions, including a private room, are recommended for patients colonized or infected with multi-drug resistant organisms, including VISA, VRSA or hetero-VRSA.

• Minimize the number of people in contact with or caring for the patient. For VRSA patients, limit contact with patient to essential caregivers only.

• Educate all healthcare personnel about the epidemiology of VISA/VRSA and the appropriate infection control precautions.

• Initiate epidemiologic and laboratory investigations with the assistance of the public health department.

• Consult with the public health department before transferring or discharging the patient.

**Summary**

In the community, *S. aureus* is best known as the cause of furuncles and soft tissue infections. In the hospital environment, *S. aureus* may cause life-threatening infections, such as pneumonia, bloodstream or surgical site infections, and is considered one of the most important nosocomial pathogens.

The nares are the usual reservoir for *S. aureus*, but other locations such as moist or hairy body areas, skin defects, wounds, and burns also can become colonized. Methicillin-resistant *S. aureus* carriage may be eradicated with application of topical mupirocin to the anterior nares, although recolonization often occurs. This therapy should be limited to patients...
with recurring MRSA infections or colonized hospital personnel to prevent the development of resistance.

The most common mode of *S. aureus* transmission is direct contact of body surface to body surface. Recently, sexual transmission of MRSA has been described and manifests as folliculitis or abscesses of the pubic, vaginal or perineal areas. The airborne route is less efficient but may occur in patients with *S. aureus* pneumonia or large burn wounds. It has been shown that colonized individuals with viral upper respiratory tract infections may shed *S. aureus* into the air. Transmission via indirect contact with inanimate objects such as instruments can occur, and *S. aureus* can be detected on many surfaces in hospitals, including stethoscopes and laboratory coats.

Strategies for the management of *S. aureus* and especially MRSA colonization or infection must focus on the type of spread. Epidemic outbreaks are successfully handled with prompt application of infection control measures. Application of precautions such as patient isolation, hand washing with antiseptic agents, and glove usage can interrupt the chain of transmission and control the outbreak. Institutions with repeated introduction of MRSA from the community or other facilities are unlikely to be able to eradicate this pathogen.

Vancomycin remains the mainstay of therapy for systemic MRSA infections. For MRSA-associated necrotizing pneumonia some experts recommend the addition of an antibiotic active at the ribosomal level (e.g., rifampin or clindamycin) to terminate toxin production. For relatively minor skin infections, the use of doxycycline or trimethoprim/sulfamethoxazole (TMP/SMX) is typically recommended in addition to incision and drainage of abscesses.

Fortunately, infections due to VISA and VRSA have remained uncommon. In the United States, there have been sixteen cases of infection attributed to VISA, as well as an additional six cases ascribed to VRSA. Importantly, strict compliance with infection control guidelines is necessary to minimize cross transmission within healthcare facilities. When identified, public health departments should be involved in the management of these cases.

Treatment options for VISA and VRSA are few, and clinical experience is limited. Quinupristin-dalfopristin and linezolid...
are bacteriostatic for VISA/VRSA. Newer potential therapies include daptomycin and tigecycline. Susceptibility of VISA/VRSA has also been reported to chloramphenicol, minocycline, tetracycline, doxycycline and trimethoprim/sulfamethoxasole (TMP/SMX). Expert consultation with an infectious diseases specialist should be sought for the management of VISA and VRSA cases.

References


CHAPTER 40

ENTEROCOCCAL SPECIES

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Key Issue
Enterococci are important nosocomial pathogens because: 1) they are normal flora in the human gastrointestinal tract, 2) antimicrobial resistance allows for their survival in an environment with heavy antimicrobial usage, 3) they contaminate the hospital environment and survive for prolonged periods of time, and 4) contamination of the hands of healthcare workers coupled with poor hand washing compliance provides the potential for spread in the hospital.

Known Facts
- Enterococci are common hospital-acquired pathogens, accounting for 14% of nosocomial urinary tract infections and 13.5% of nosocomial bloodstream infections in the ICU setting.
- The organism is of relatively low virulence but may be difficult to treat in the compromised host, particularly when multidrug resistant.
- Resistance to nearly every known antibiotic has been described for various strains of enterococci.
- The vanA gene, which confers high-level vancomycin resistance in enterococci, has been detected in Staphylococcus aureus strains in a small number of patients in the United States.
- Vancomycin resistance due to vanC is intrinsic and found in E. casseliflavus and E. gallinarum. vanC organisms do not appear to be epidemiologically important, and isolation of patients harboring these organisms is not necessary.
- Currently 18% of nosocomial enterococcal bloodstream isolates in the United States are resistant to vancomycin.
However, the two most common species display marked variability in vancomycin susceptibility, with 60% of *E. faecium* and 2% of *E. faecalis* bloodstream isolates resistant to vancomycin.

- Risk factors for acquisition of vancomycin-resistant enterococci (VRE) include prior use of antimicrobial agents (vancomycin, third generation cephalosporins, antianaerobic drugs), length of hospital stay, enteral feedings, intraabdominal surgery, presence of a decubitus ulcer, high colonization pressure, and severity of illness.

- Patient populations at highest risk for VRE colonization and infection include dialysis patients, organ transplant patients, patients with hematologic malignancies, and bone marrow transplant patients. Recent studies have found that approximately 30% of patients following liver transplantation are colonized with VRE, of whom over 25% develop infection. Up to 40% of allogeneic hematopoietic stem cell transplant patients are colonized, of whom over 33% develop VRE bloodstream infections in the early period post-transplant.

- Treatment with antianaerobic drugs has been shown to promote high density colonization.

- Colonization of the GI tract with VRE is typically of long duration, in some cases persisting for years.

- Rectal swab cultures for VRE have suboptimal sensitivity.

- Colonization of healthy healthcare workers in the United States is unusual.

- Risk factors for VRE bacteremia include neutropenia, gastrointestinal colonization, and hematologic malignancy.

- VRE colonization is highly prevalent in some long-term care facilities, which serve as reservoirs of resistant organisms for importation into acute care facilities. However, morbidity due to VRE in the nursing home population is low.

**Controversial Issues**

- Treatment of VRE infections is problematic. Therapy should include drainage of localized infections, when possible. Quinupristin/dalfopristin may be clinically useful for the
treatment of infections due to *E. faecium* but is inactive against *E. faecalis*. Linezolid has good activity against VRE and an advantage is its 100% oral bioavailability, allowing for oral therapy. Quinupristin/dalfopristin and linezolid are bacteriostatic against enterococci, and resistant strains have been detected for both agents. Newer agents with activity against VRE include daptomycin and tigecycline. Daptomycin, a cyclic lipopeptide, is bactericidal against VRE.

- A few reports have described attempts to decolonize the gastrointestinal tract of VRE but results have been suboptimal. Ramoplanin has been shown to suppress carriage of VRE, but following discontinuation of the drug, the organism can again be detected in the stool.

- Infection control controversies include the effectiveness of active surveillance cultures and subsequent isolation of colonized patients to control nosocomial transmission, whether drugs that suppress GI colonization result in decreased nosocomial transmission and whether vancomycin restriction leads to decreased rates of VRE infection and colonization.

**Suggested Practice**

- Prudent use of antimicrobial drugs

- For patients with VRE infection or colonization:
  - Place in private room or cohort with other VRE infected/colonized patients. Gloves and gowns should be worn on entering the patient’s room.
  - Strict compliance with hand washing is critical—a medicated hand washing agent (e.g., chlorhexidine or alcohol-based hand rub) should be used.
  - Noncritical items (e.g., stethoscopes, thermometers, etc.) should be left in the patient’s room.
  - Isolation can be discontinued when three stool cultures, each one week apart, are all negative.
  - Phenolic and quaternary ammonium disinfectants are effective against VRE; however, adequate contact time is essential.
Summary
Enterococci are ubiquitous gram-positive cocci that are part of the normal flora of humans and other animals. Infections caused by enterococci include urinary tract infections, abdominal-pelvic infections, wound (especially decubitus ulcers and diabetic foot) infections, and endocarditis.

Strains of enterococci have acquired resistance to virtually all available antimicrobial agents. In general, antimicrobial resistance has been more problematic for \textit{E. faecium} than \textit{E. faecalis}.

The prevalence of vancomycin resistance among the enterococci has reached high levels. In 1989, less than 0.5% of enterococcal isolates from ICU and non-ICU settings were vancomycin resistant. In 2003, 28.5% of enterococci associated with infections in patients in ICU settings were resistant to vancomycin. However, when stratified by species, \textit{E. faecium} isolates demonstrate a markedly higher proportion of vancomycin resistance than \textit{E. faecalis} isolates.

Numerous case-control studies have evaluated risk factors for the development of colonization and/or infection with VRE. A variety of antimicrobial agents have been implicated and include vancomycin, ceftazidime, aminoglycosides, ciprofloxacin, aztreonam, and antianaerobic drugs. Other risk factors have included severity of illness, length of hospital stay, hematologic malignancy or bone marrow transplantation, and mucositis. Colonization of the GI tract has been shown to be a risk factor for the development of VRE bacteremia. Environmental contamination with VRE is common, especially when the patient has diarrhea.

To control VRE in the hospital setting, we recommend placing colonized/infected patients in a private room. Gloves and gowns should be worn on entering the patient’s room, and strict attention to hand hygiene with a medicated agent is imperative. In addition, there should be no sharing of noncritical items (i.e., BP cuffs, stethoscopes, etc., should remain in the patient’s room). Housekeeping staff should wipe down all horizontal surfaces in VRE patient rooms daily.
In addition to infection control measures, controlling VRE requires prudent use of antibiotics. Vancomycin should be avoided for routine surgical prophylaxis unless high rates of MRSA exist. Vancomycin should also be avoided for the treatment of a single positive blood culture growing coagulase-negative staphylococci if contamination is likely. Vancomycin should not be used for selective gut decontamination or for routine prophylaxis of low-birth weight infants, continuous ambulatory peritoneal dialysis patients, or intravascular catheters.

References
Key Issues

*Streptococcus pneumoniae* (*pneumococcus*) remains a major pathogen for human beings. In recent years, important changes in the epidemiology of pneumococcal infections have been observed:

1. The emergence and spread of multiple antibiotic-resistant pneumococci which make pneumococcal infections difficult to treat;
2. The increasing prevalence of pneumococcal disease in the elderly and in young adults with serious underlying diseases (e.g., HIV-infected patients); and
3. The increasing recognition of pneumococcal infections in hospitalized patients, nursing home residents and other closed institutions. Several of these infections came out as outbreaks due to antibiotic-resistant pneumococcal serotypes (e.g., serotype 23).

Infection control measures for preventing endemic and epidemic pneumococcal infections in hospital settings and nursing home facilities have not been widely considered in the literature.

Known Facts

*Streptococcus pneumoniae* is the leading cause of community-acquired pneumonia, otitis media, sinusitis, exacerbation of chronic bronchitis and adult meningitis. Patients with severe pneumonia or meningitis may have a mortality rate of about 20–30%.

*Pneumococcus* is transmitted from person-to-person by close contact and can colonize the nasopharynx of healthy people. The prevalence of nasopharyngeal colonization varies widely with age as well as environmental and seasonal conditions. Thus, the nasopharyngeal carrier rates in children are
approximately 20–40%, and over 95% of them were initially colonized before the age of 2. The pneumococcal serotypes that colonize the nasopharynx in children show a high rate of antibiotic resistance. In adults, the rates of pneumococcal colonization decrease to approximately 5–10%, and these serotypes are usually less resistant.

Several studies have shown a link between age and susceptibility to pneumococcal infection, with an incidence peak in children aged less than 2 and another one in elderly people. Pneumococcal disease in young adults occurs mainly in patients with underlying conditions (e.g., immunosuppressive diseases, smoking).

Failure to produce antibodies is a determining factor for the susceptibility to pneumococcal infection, and it occurs in patients with multiple myeloma, chronic lymphocytic leukemia and lymphoma, as well as in HIV-infected patients. Patients with splenectomy, diabetes mellitus, malnutrition, chronic renal failure, chronic liver disease, heart failure, chronic obstructive pulmonary disease (CPOD), smoking and high alcohol intake are also at risk of pneumococcal infection.

A previous viral infection in the respiratory tract, mainly due to influenza virus, is a major predisposing condition of pneumococcal pneumonia. Viral infections modify the local defense mechanisms of the respiratory tract contributing to nasopharyngeal colonization and facilitating the entrance of microorganisms into the pulmonary alveolus. Other processes that modify the local defense mechanisms of the respiratory tract such as chronic bronchitis, allergic conditions and toxic inhalation may also predispose to pneumococcal pneumonia.

The pneumococcus can be transmitted among persons in closed institutions. Children attending day care centres have an increased risk of carrying pneumococci (nasopharyngeal colonization) and developing pneumococcal infections. In addition, adults who live with children attending these centres have also an increased risk of pneumococcal disease. The spread of *Streptococcus pneumoniae* leading to colonization or infection has been documented in hospitalized patients (children and adults), in nursing homes residents as well as in persons admitted to military camps and prisons and other closed communities, being likely to cause epidemic outbreaks.
The emergence of antibiotic resistance in *Streptococcus pneumoniae* has become a real problem worldwide. Resistance to beta-lactam agents (penicillins and cephalosporins) as well as to macrolide and, more recently, to the new fluoroquinolones has been increasingly reported. Prior antibiotic use and nosocomial acquisition of the infection are important risk factors for antibiotic-resistant pneumococcal infection.

**Controversial Issues**

Little is known about the prevalence of nasopharyngeal carriage and the modes of transmission of *Streptococcus pneumoniae* among hospitalized patients or nursing home residents. Moreover, there is little information regarding pneumococcal infections occurring in the hospital setting. And it is often difficult to differentiate between endemic nosocomial pneumococcal infections and small outbreaks in hospitals. Studies on serotypes and clones may help to identify the pneumococcal strains causing outbreaks in the hospital.

- While it is well known that healthcare workers (HCWs) can transmit infections to patients, the extent to which this occurs in *Streptococcus pneumoniae* is less appreciated. We can hypothesize the following modes of transmission of *Streptococcus pneumoniae*:
  1. From HCWs to patients by exhaling or coughing the microorganism. This may occur when the HCW is a nasopharyngeal carrier and has close contact with the patient using inadequate precautions; and
  2. From patient to patient by means of contaminated respiratory secretions (sputum or saliva). In this case, HCWs can disseminate the microorganism through contact with contaminated material when using inappropriate barrier precautions (e.g., gloves, gowns, masks); and
  3. From patient to patient by exhaling or coughing the microorganism in overcrowded hospitals and long-term care institutions where space and ventilation are inappropriate.

- Once colonized, hospitalized patients are at risk for pneumococcal infections:
  1. They suffer from serious underlying diseases with impaired immunity, chronic pulmonary conditions, and other debilitating diseases;
2. They receive antibiotics which may select resistant pneumococci, and
3. They undergo instrumentations (e.g., endotracheal or nasopharyngeal tubes) or surgical procedures (e.g., surgery of abdominal cavity, lungs, and head and neck).

- Recent studies of nosocomially-acquired pneumonia have found that *Streptococcus pneumoniae*, among other gram-positive cocci, is increasingly recognised as an important agent. Nosocomial pneumococcal pneumonia can be classified into two categories:

1. Early pneumonia (<5 days) occurs mainly in patients who require emergent tracheal intubation (e.g., head trauma with low level of consciousness). This is usually caused by the own patient’s flora (previous pneumococcal carriers) and the intubation process spreads the pneumococcus into the lower respiratory tract.

2. Late pneumonia (>=5 days) may occur more often in patients undergoing surgery, immunosuppressed and debilitated diseases, as well as in ICUs intubated patients. This is more often caused by drug-resistant pneumococcal strains. Other nosocomial-acquired pneumococcal infections may include: nosocomial sinusitis in patients with nasogastric tube; meningitis after otic surgery or neurosurgery; and post-surgical intra-abdominal infection.

Few data are available regarding the global burden of *Pneumococcus* in nosocomial pathogens. For example, in our institution for adult patients (Hospital Bellvitge, University of Barcelona) we found that among all episodes of pneumococcal bacteremia, 12.1% were nosocomial-acquired (123 of 1013 episodes during 1984–2000). In addition, *Streptococcus pneumoniae* accounted for 1.4% of all nosocomial-acquired bacteremias (123 of 8826 episodes during 1984–2000), and 12.3% of nosocomial-acquired bacteremic pneumonias (79 of 642).

**Suggested Practice**

The hospital epidemiologist and infection control practitioners should know the target population at high risk for pneumococcal infections (*see Controversial Issues*), and identify possible outbreaks caused by multiple antibiotic resistant strains in the
hospital setting. It is fundamental for the Microbiology laboratory to conduct a surveillance of all pneumococcal isolates and their antibiotic susceptibility, and to study, when necessary, serotypes and clones.

Infection control measures for nosocomial-acquired pneumococcal infections have not been widely established. In order to properly implement these measures, we should consider the following:

1. compliance with barrier precautions;
2. prudent use of antibiotics; and
3. use of pneumococcal vaccination.

Although it is thought that transmission of pneumococci in the hospital is uncommon, the application of isolation measures and barrier precautions could be necessary, particularly when an outbreak caused by multiple antibiotic-resistant pneumococcal strain is detected. During an outbreak, these patients should be isolated in a single room, and HCWs should ensure the following infection control measures: appropriate hand washing and correct utilization of gloves, gowns and masks when in contact with respiratory secretions from patients with acute respiratory illness. In addition, disinfection of respiratory equipment should be strengthened.

During an outbreak caused by a multi-resistant pneumococcal strain in a closed institution (e.g., hospital or nursing home), the screening of nasopharyngeal carriers could be appropriate. However, the administration of antibiotics to persons in contact with infected patients to eradicate the carriers is a controversial issue.

Prudent use of antibiotics is essential to prevent the emergence of resistant pneumococcal strains. It has been reported that prolonged use of beta-lactams, particularly at low doses, is associated with carriage of penicillin resistant pneumococci in children. Thus, antibiotics may produce a selective pressure of pneumococci harbouring in the nasopharynx, eliminating the susceptible strains and emerging the resistant ones, mostly concentrated in a few serotypes and clones. The appropriate use of antibiotics is particularly important in the hospital setting, nursing homes and other closed institutions where the emergence and spread of resistant pneumococcal clones is easier.
Prevention of pneumococcal infection by means of vaccination programs is essential. It has been reported that the use of 23-valent pneumococcal vaccine may prevent the development of pneumococcal bacteremia. More recently, it has been shown that the use of conjugate pneumococcal vaccine in children is associated with a decreased incidence of pneumococcal disease. However, it is not well elucidated if these vaccines produce a permanent reduction of carriers or if there would be a replacement with serotypes not included in the vaccine. Future vaccine developments such as the pneumococcal surface protein A may substantially improve the current options.

Summary

*Streptococcus pneumoniae* is increasingly reported as a pathogen causing infections in hospitals and nursing homes. These infections are often due to multiple antibiotic resistant pneumococcal serotypes and are likely to appear as small outbreaks. Therefore, it is mandatory for the Microbiology laboratory to conduct a surveillance of all invasive pneumococcal isolates together with their antibiotic susceptibility and study of serotypes whenever it is necessary.

Currently, there is scarce information about the prevalence of pneumococcal carriers and the transmission mechanisms of *Streptococcus pneumoniae* in hospitals and nursing homes. Besides, infection control measures to prevent endemic and epidemic nosocomial pneumococcal infections have not been properly undertaken. However, compliance with barrier precautions, prudent use of antibiotics in the hospital setting and the administration of pneumococcal vaccine should be strengthened when an outbreak is suspected.

References


Key Issue
Nosocomial legionellosis (also called Legionnaires’ disease) is a serious pneumonia caused by inhalation of *Legionella* in aerosols from a contaminated hospital water system. Prevention should be based on a risk management plan including targeted surveillance for cases, adequate design and maintenance of water distribution system and adherence to appropriate respiratory care practices.

Known Facts
- *Legionella* cause up to 10% of nosocomial pneumonias; depending on the country, surveillance data indicate that 2 to 15% of cases of legionellosis are hospital-acquired. Cases may occur sporadically or as epidemics.
- The majority of cases are caused by *Legionella pneumophila*, with over 80% caused by *L. pneumophila* serogroup 1.
- The mortality is 10–15% and is increased by a delay in diagnosis and starting specific antimicrobial treatment.
- *Legionella* sp are part of the normal flora of fresh water bodies and proliferate to high concentrations as biofilms in man-made hot water systems with a temperature of 25–42°C. Hospitals with contaminated water systems are at increased risk of nosocomial legionellosis.
- Transmission to hospitalized patients occurs most frequently by inhalation of aerosols generated by using outlets (faucets, shower) of a heavily contaminated domestic water system and less commonly by direct bronchial instillation during respiratory care using tap water.
- Risk factors for transmission include the concentration of *Legionella* in water, the virulence of the strain, the extent of aerosol exposure and patient immune status.
• Patients at increased risk are those under immunosuppression, particularly organ transplant recipients, treated with corticosteroids, male, elderly, smokers and those with chronic lung diseases.

• Diagnosis requires the use of special methods, including culture of respiratory secretions on special media, detection of urinary antigen (*L. pneumophila* serogroup 1 mainly), serology and PCR.

• Most outbreaks were reported in hospitals with extensive contamination (>30% positive outlets) and high concentration (>10^3/L) of *Legionella* in water.

• Nosocomial outbreaks can be controlled effectively once the source is identified and adequate water disinfection is carried out (shock treatment followed by long-term suppressive measures)

**Controversial Issues**

• The true incidence of nosocomial legionellosis is unknown due to under-diagnosis and under-reporting.

• The predictive value of monitoring the concentration of *Legionella* in hospital water systems is undefined, due to non-standardization of sampling, wide temporal variation in bacterial concentration over time and variation in patients’ exposure and susceptibility in different institutions. Public authorities in different countries have issued various norms of maximal *Legionella* concentration for hospital water systems (ranging from 10^1 to 10^4 /L).

• The optimal methods of water disinfection including thermal disinfection (>60°C), hyper-chlorination, ultra-violet light, copper-silver ionization, monochloramine and chlorine dioxide treatment have not been defined.

**Suggested Practice**

• Each hospital should develop and implement a *Legionella* Risk Management Plan, with the assistance of Management, Technical Plant, Microbiology and Infection Control departments.
This plan is composed of the following parts: (1) plan & technical description of the water systems, and identification of weak points (eg, temperature below 55°C, stagnation, corrosion); (2) bacteriological survey of *Legionella* contamination of the system; (3) analysis of patients population at risk and surveillance for cases of pneumonia; (4) risk control measures and maintenance of the systems to prevent cases or control transmission after a cluster of cases, if any.

Surveillance for cases of *Legionella* pneumonia should use the combination of at least two diagnostic methods such as culture and urinary antigen tests.

Prevention and control measures should aim at reducing the proliferation of *Legionella* and avoiding the generation of aerosols. Codes of good engineering practice exist in most countries and should be consulted. The main rules are to ensure water temperature < 20°C or > 50°C, regular water circulation and cleanliness of the system.

The selection and operation of a water treatment program including *Legionella* disinfection should be made by competent technical services. Microbiological water monitoring is useful to assess the efficacy of the program.

Respiratory care and flushing of naso-gastric tubing should be done with sterile water.

The detection of sporadic or cluster of cases of nosocomial legionellosis should prompt an immediate investigation to identify the source of contamination. Genotyping *Legionella* isolates from cases and the suspected environmental source is useful to confirm the source. Shut down the suspected source and disinfect it or remove the aerosol producing equipment. Consider general shock treatment of water system if it is extensively contaminated.
References


Key Issue

Clostridium difficile, Salmonella, Campylobacter, Shigella, Escherichia coli, Yersinia enterocolitica, Vibrio cholerae, and Vibrio parahaemolyticus are among the various agents which may cause acute gastrointestinal infections in long-term care facility residents and healthcare workers.

Known Facts

- Clostridium difficile-associated diarrhea (CDAD) a very common nosocomial infection, is associated with substantial morbidity and mortality and imposes an important financial burden on healthcare institutions. Three steps are necessary for the development of CDAD: acquisition of the pathogen (i.e., Clostridium difficile), distortion of the normal fecal flora (usually by antibiotics), and toxin production by the Clostridium difficile strain. Risk is modified by host susceptibility factors including older age, manipulation of the gastrointestinal tract (enemas, surgery), chemotherapy, laxative use, antiperistaltic drugs, length of hospital stay, and rate of endemic disease in the hospital. Clostridium difficile persistently contaminates the hospital environment through the formation of spores that persist for prolonged periods. The hands of hospital workers have been documented to be contaminated frequently by Clostridium difficile following contact with patients who
are asymptomatically colonized or who have CDAD, or by contact with the environment of these patients. *Clostridium difficile* has been transmitted by commodes, bathing tubs for neonates and rectal thermometers.

- Salmonellosis is the most commonly reported foodborne disease resulting from improperly handled animal and poultry products. Ninety-two percent of all cases are due to raw or partially cooked eggs but undercooked poultry, beef, and pork also are significant sources. Contamination may occur either during food processing by contact with animal products/feces, or during food preparation from food handlers. Chronic carriers of *Salmonella* pose a particular risk for transmitting this infection.

- In developing countries, nontyphoid *Salmonella* spp are increasingly important nosocomial pathogens, causing septicemia in children. Most of these *Salmonella* spp are resistant to multiple antibiotics. The dissemination of these resistant strains occurs from person to person. The majority of outbreaks have occurred in neonatal and pediatric wards, but community outbreaks in villages have also been reported.

- *Campylobacter* is one of most commonly recognised causes of bacterial gastroenteritis in man. Raw or inadequately heat-treated milk and inadequately treated water have been incriminated as sources of massive outbreaks of infection. Direct transmission is mainly occupational (farmers, butchers, abattoir workers, poultry processors), but domestic animals can bring infection into ordinary homes. Inter-human transmission has been described infrequently in young children. Nosocomial spread within neonatal units has been observed on rare occasions. The putative causes of these outbreaks were an inadequately disinfected communal baby bath and an incubator that was not disinfected between babies.

- Shigellosis is one of the most common causes of gastroenteritis. Transmission is due to improper hand washing and inadequate toilet facilities and occurs via food items such as soups, salads, and sandwiches; however, person-to-person spread and transmission by flies may also occur, since few
organisms are necessary to cause disease. After ingestion of a very low inoculum (<100) of *shigella* organisms, patients typically present with dysentery and fever. Patients are infectious during the acute infection and until the organism is no longer present in the feces.

- **Enterohemorrhagic *Escherichia coli* (EHEC), particularly *E. coli* serotype O 157:H7, is the leading cause of hemorrhagic colitis and hemolytic uremic syndrome (HUS). EHEC infections have been associated with the ingestion of contaminated hamburgers, milk, water, fruit, and vegetables. However person-to-person transmission is possible.
- **Transmission of enterotoxigenic *E. coli* (ETEC) occurs mainly by food and water. It rarely occurs from person – to person.
- **Enteropathogenic *Escherichia coli* (EPEC) is an infrequent cause of outbreaks of diarrhoea in hospitalised infants.
- **Enteroaggregative *Escherichia coli* is an emergent enteropathogen which has been associated with both nosocomial and community outbreaks worldwide.
- **Vibrio cholerae** is transmitted primarily via contaminated water and by the ingestion of contaminated shellfish. Person-to-person spread is uncommon. Hospital workers rarely contract the disease.
- **Vibrio parahaemolyticus** is a common pathogen in countries where raw and undercooked seafood is consumed. Symptoms can vary but patients usually present with nausea, vomiting, and cramps. Fever and chills sometimes can occur.
- **Yersinia enterocolitica** is a common cause of enterocolitis in children in developed countries. It is characterized by either watery or bloody diarrhoea with abdominal pain and fever. Improperly cooked pork and milk are the main sources of transmission. Nosocomial transmission occurs very rarely.

**Controversial Issues**

- Gastroenteritis caused by bacterial pathogens often may be confused with enteric infections caused by parasitic, fungal, or viral agents.
• The decision whether or not to use antibiotics or antimotility drugs is difficult in the absence of specific laboratory diagnosis of the bacterial pathogens.

• Indiscriminate treatment with antibiotic agents or antimotility drugs may create serious problems by encouraging the development of multi-drug resistant bacteria or chronic carriers.

• The incidence of acute gastroenteritis caused by enteric pathogens is greatly underestimated in many locations because of limited surveillance, limited laboratory facilities to diagnose the common bacterial agents, or both.

**Suggested Practice**

• Most bacterial enteric pathogens are transmitted by direct contact. Effective hand washing practice is the most important measure to prevent transmission. Additional interventions include:
  1. Glove use;
  2. Improvements in hygiene and socio-economic conditions;
  3. Safe water supply and sanitary disposal of fecally contaminated materials;
  4. Environmental interventions including proper disinfection of rectal thermometers between use by different patients, proper disinfection of endoscopes, proper terminal disinfection of rooms and surface disinfection with hypochlorite;
  5. Thorough cooking of food; and

• Food service personnel must be very careful about personal hygiene, working habits, and their health. All healthcare and food service personnel with an acute diarrhoeal illness should stop working until diarrhoea has resolved.

• Antibiotics should not be routinely used to prevent transmission. When antibiotics are used to treat patients, appropriate doses and duration of therapy should be used.

• Adequate laboratory facilities are mandatory allowing all enteric bacteria isolated from nosocomial infections to be well characterized. Establishing a provisional microbiology laboratory is also a valuable tool to investigate and control outbreaks even in remote areas.
Summary
A wide variety of organisms may cause outbreaks in long-term facilities (Clostridium difficile, Salmonella, Campylobacter, Shigella, Escherichia coli O157:H7, and others). Gastroenteritis caused by these different groups of bacteria is a leading cause of morbidity and mortality in developing countries. However, difficulty in identifying certain enteric pathogens in many laboratories leads to marked under-reporting.

The majority of the gastrointestinal pathogens are transmitted through the fecal-oral route. These pathogens can survive in soil, water, and food. Outbreaks are frequently related to ingestion of contaminated food or water and occur more frequently in developing countries. Improvements in hygiene and socio-economic conditions can dramatically reduce the transmission of these organisms.

Many studies from the developing world have emphasized the emerging importance of multidrug-resistant Salmonella spp as nosocomial pathogens in children. The clinical microbiologist should be responsible for the identification of all isolates of nosocomial infections and work effectively with all other members of the infection control committee to identify and control outbreaks.

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CHAPTER 44

PERTUSSIS

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Key Issues

- Pertussis is an acute respiratory tract infection mainly caused by *Bordetella pertussis*, a fastidious gram-negative, aerobic coccobacillus. Pertussis remains an important cause of infant death worldwide and continues to be a public health concern even in developed countries.

- During the prevaccine era and in countries with low pertussis vaccine coverage, pertussis is predominantly an infection of preschool-aged children with superimposed epidemic cycles reported every 2–5 years. Although less than 15% of cases are in infants, deaths are mostly reported in non-immune members of this age group.

- Universal childhood immunization with combined pertussis, diphtheria and tetanus toxoid vaccines in children <7 yr has led to a significant decrease in the number of reported pertussis cases. However, it has had a limited impact on circulation of the organism.

- Since the 1980s, reports of cases among adults and adolescents have steadily increased in several countries even with high childhood vaccination coverage (≥90%). In 2004, approximately two-third of pertussis cases in the USA occurred in adolescents and adults. Pertussis in this age group is typically a mild infection. However, these patients act as reservoirs of disease, frequently exposing young infants who have the highest rates of complications and mortality.

- Adolescent and adult reservoirs may also lead to pertussis outbreaks in various settings, including middle and high schools, sports facilities, summer camps, and healthcare facilities.
• Possible reasons for the increased incidence of pertussis among adolescents and adults include increased recognition of the disease among healthcare personnel (HCP), enhanced surveillance and reporting by public health departments, improved laboratory diagnostics, waning immunity after natural infection or immunization, the use of suboptimal quality of vaccines, and loss of vaccine efficacy due to the emergence of new \( B. \) \textit{pertussis} strains.\textsuperscript{6}

• Although no laboratory standard for the evaluation of pertussis immunity exists, pertussis antibody titers wane approximately 4–12 years after the completion of childhood vaccination, and approximately 7–20 years after natural infection.\textsuperscript{7}

**Known Facts**

• \( B. \) \textit{pertussis} is a uniquely human pathogen.

• Pertussis is transmitted from infected to susceptible individuals primarily through respiratory droplets generated by coughing and sneezing or by direct contact with freshly contaminated inanimate surfaces.

• The infectious dose is unknown, however, the organism is believed to be highly contagious as 70\% to 90\% of susceptible household contacts and 50\% to 80\% of susceptible school contacts will become infected after exposure to an acute case at close range.\textsuperscript{4,8}

• Chronic carriage has not been documented, but transient carriers can be detected following known exposures or during outbreaks.\textsuperscript{9}

• Pertussis is primarily a toxin-mediated disease. Major virulence factors of \( B. \) \textit{pertussis} include filamentous hemagglutinin (FHA), pertactin (PRN), fimbriae (FIM), and pertussis toxin (PT). However, the pathogenesis of pertussis is still incompletely understood.\textsuperscript{10}

• The incubation period of pertussis is 7 to 10 days (range: 5–21 days) yet has been reported to be as long as 6 weeks.\textsuperscript{4}

• Classic pertussis is seen in unimmunized toddlers and children. The clinical course is divided into three stages that last a total of 6–12 weeks. The catarrhal stage consists of nonspecific cold-like symptoms (rhinorrhea, sneezing,
conjunctival suffusion, lacrimation, mild sore throat, mild dry cough, and low-grade or no fever). This stage last approximately 1–2 weeks. The paroxysmal stage usually lasts 1–6 weeks (up to 10 weeks) and is characterized by paroxysms of coughing, inspiratory whoop, and post-tussive vomiting. Subconjunctival hemorrhages and petechiae on the upper body are also common.

- Leukocytosis (15,000–100,000 cells/mm³) due to absolute lymphocytosis is characteristic in unvaccinated children during the late catarrhal and early paroxysmal stages. The chest radiograph appearance may demonstrate perihilar infiltration.¹¹

- Paroxysms gradually decrease in frequency and intensity during the convalescent stage, which generally lasts 2–6 weeks, but can last for few months. Minor exacerbations may occur with superimposed viral respiratory infections.

- Persons with pertussis are most infectious during the catarrhal and early paroxysmal stages. Approximately 80%–90% of patients with untreated pertussis will spontaneously clear the organism from the nasopharynx within 3–4 weeks from the onset of cough. However, untreated and unvaccinated infants can remain culture-positive for ≥6 weeks.¹²

- In partially immunized children and previously immunized adolescents and adults, pertussis is often unrecognized and underreported because of relatively mild clinical course. Pertussis infection in these persons may present as a spectrum from asymptomatic to classic pertussis.

- Adults with disease may not demonstrate distinct stages. The majority of these cases are misdiagnosed as bronchitis, upper respiratory tract infection, and post-infectious cough.¹³

- Approximately 12%–32% of prolonged cough illnesses lasting >6 days in adolescents and adults have serologic evidence of B. pertussis infection.²

- Rates of complications are affected by age, immunization status, and supportive care. Complications of childhood pertussis occur in 5–6% of cases, most frequently in infants aged <6 months. Secondary bacterial pneumonia is the
most common complication (5.2% of all reported pertussis cases).  

- Death due to pertussis in children is rare (0.2%). The vast majority (90%) occurs in children younger than 4 months of age. Pneumonia is the most common cause of death.
- Pertussis-related deaths are rarely reported among adolescents and adults and they only occur in patients with serious underlying medical conditions.

**Controversial Issues**

- Due to wide range of disease expression and differential diagnoses, the diagnosis should be based on a clinical history and laboratory confirmation, such as culture, polymerase chain reaction (PCR), and serology. Several factors may affect the sensitivity, specificity, and interpretation of these tests, including the stage of the disease, antimicrobial administration, previous vaccination or infection, the quality of technique used to collect the specimen, transport conditions to the testing laboratory, experience of the laboratory, contamination of the sample, and use of non-standardized tests. However, a major problem in many resource-limited countries is the lack of available laboratory tests.
- Isolation of *B. pertussis* from nasopharyngeal secretions/aspirate by culture on selective media (Regan Lowe/Bordet Gengou media) has been considered as the “gold standard” of laboratory confirmation because of its highly specific nature. Sensitivity of culture varies and the yield is highest during the catarrhal stage (30–90%). The sensitivity may be less than 3% beyond the first 3 weeks of illness. Cultures can take as long as 2 weeks to confirm growth or report negative result. Although erythromycin resistance is rare (less than 1% in the USA), isolations are still essential for validation of other laboratory tests, and for molecular subtyping in epidemiologic studies.
- The nasopharyngeal specimen should be obtained by aspiration or by use of appropriate swabs such as Dacron swabs. Cotton swabs should not be used because they contain fatty acids that are toxic to *B. pertussis* and calcium-alginate swabs can inhibit PCR results.
• Overall, PCR based methods is more sensitive and rapid than culture, especially after antibiotic therapy has been initiated.\textsuperscript{18} PCR sensitivity varies widely among laboratories, as there is no standardized protocol.

• The sensitivity of PCR methods is also affected by duration of illness, immunization status, and specimen collection. However, PCR test or culture results are still positive in <10% in adults and adolescents with pertussis.\textsuperscript{2}

• Serologic tests using enzyme-linked immunosorbent assay (ELISA) for the detection of antibodies to various components of \textit{B pertussis}, including IgG or IgA antibodies to PT, FHA, PRN, and FIM, exist.\textsuperscript{14} The sensitivity and specificity vary from 57 to 100% in various studies.\textsuperscript{6} However, positive serologic response may result from either infection or vaccination.

• Serologic tests are commonly used in epidemiologic studies and in vaccine efficacy trials. These tests are less helpful during acute illness in young infant, and are difficult to interpret in immunized individuals. Serology is also useful for later diagnosis of prolonged cough in adolescents and adults when results of both PCR and culture are negative. However, delay in obtaining the acute-phase specimen and the implementation of booster immunization in this age group may obscure the benefit of this test.

• Combination of laboratory methods may increase sensitivity but is expensive for routine services.

• Current case definition of pertussis has been developed by CDC and the Council for State and Territorial Epidemiologists (CSTE) in 1997 and by WHO in 2000 for the disease surveillance and the evaluation of vaccine effectiveness.\textsuperscript{19,20}

• A clinical case definition is defined as an acute cough illness lasting $\geq$ 14 days in a person with at least one pertussis-associated symptom (paroxysmal cough, post-tussive vomiting without other apparent cause, or inspiratory whoop). In outbreak settings, a case can be defined as an acute cough illness lasting less than 2 weeks without other symptoms.
• Laboratory criteria include isolation of *B. pertussis* from nasopharynx, positive PCR test or positive paired serology. In the USA, the CDC does not recommend serologic test for the diagnosis of pertussis, because this test is not standardized nationally.4

• Macrolide antibiotics such as erythromycin may prevent or moderate clinical pertussis when given during the incubation period or in the early catarrhal stage. During the paroxysmal stage, antimicrobial drugs will not change the clinical course but can reduce the transmission by elimination of the bacterium from the nasopharynx within 5 days.12

• The effective treatment regimens include: 3 days of azithromycin (10 mg/kg as a single dose); 5 days of azithromycin (10 mg/kg on the first day of treatment and 5 mg/kg once daily on the second day to fifth days of treatment); 7 days of clarithromycin (7.5 mg/kg/dose twice daily, maximum 1 g/day); 7 to 14 days of erythromycin (40 mg/kg/day in 3 to 4 divided doses, maximum 2 g/day); 14 days of erythromycin (60 mg/kg/day in 3 to 4 divided doses, maximum 2 g/day); or 7 days of Trimethoprim/sulfamethoxazole (for patients aged ≥2 months).21 Erythromycin may increase the risk of infantile hypertrophic pyloric stenosis in infants younger than two months. The benefit of diphenhydramine, pertussis immunoglobulin, dexamethasone, or sulbutamol is unclear.22

• In 2005, two tetanus toxoid and reduced diphtheria toxoid and acellular pertussis vaccine products (Tdap) formulated for adolescents and adults were licensed in the USA. Each Tdap contains lower amounts of diphtheria toxoid and lower amounts of some pertussis antigens compared with pediatric formulation (DTaP). Tdap vaccine was licensed as a single-dose booster immunization. The vaccines are well tolerated, with relatively limited local side effects, such as mild pain, redness, and swelling at the injection site.3,4 The availability of Tdap may offer a new opportunity to control pertussis. More information on the Tdap vaccine is available at http://www.cdc.gov/vaccines/vpd-vac/pertussis/default.htm.
• The optimum strategies for pertussis immunization remain uncertain. Most countries have a three-dose primary immunization series starting at 6 weeks to 3 months, usually completed by 6 months. Many schedules include a toddler booster, and many a fourth or fifth dose at 4–6 years of age. Several potential vaccination strategies developed by The Global Pertussis Initiative (GPI) are summarized below.

1. Reinforce and/or improve the current infant and toddler immunization strategy
2. Preschool booster at 4–6 years of age
3. Universal adolescent immunization
4. Universal adult immunization
5. Selective immunization of new mothers, family, and close contacts of newborns (cocoon strategy)
6. Selective immunization of healthcare workers
7. Selective immunization of child care workers

• The decision to recommend additional booster immunization is based on several considerations such as the burden of disease among different age groups, the efficacy and safety of vaccine, cost of vaccine, current schedules of immunization program, and the infrastructure to develop vaccine and to promote vaccination, etc.

• Maternal immunization may reduce the mortality and morbidity of pertussis in infants because of passively acquired antibodies. Current strategies do not include maternal immunization because the information about Tdap in pregnancy is limited. However, the use of Tdap during pregnancy is currently under consideration.

Suggested Practice
• Early diagnosis can lead to more effective control measures.
• Pertussis should be suspected in patients of all ages who have predominant complaint of cough, especially if the following are absent: fever, exanthem or enanthem, hoarseness, tachypnea, wheezes, and rales.
• When pertussis is highly suspected or confirmed, effective antimicrobial against *B. pertussis* must be prescribed immediately for persons who may still be infectious, including
persons aged ≥1 year within 3 weeks of cough onset and infants aged <1 year within 6 weeks of cough onset.

- Standard precautions and droplet precautions are recommended for at least 5 days after initiation of therapy.
- In the ambulatory setting, patients should be also excluded from work and public areas until antibiotic therapy has been taken for 5 days.
- Hospital infection control services should be notified to evaluate the risk of transmission in healthcare facilities.
- Because pertussis is highly contagious, chemoprophylaxis should be given promptly to all close contacts of persons with pertussis in either household or community, regardless of age and vaccination status to prevent disease and subsequent spread.
- The CDC has defined a close contact as someone having face-to-face exposure within 3 feet of a symptomatic patient; someone who has had direct contact with respiratory, oral, or nasal secretions from a symptomatic patient; or someone who has shared the same confined space for more than 1 hour with a symptomatic person.\(^{12}\)
- Optimal doses and duration of antibiotic prophylaxis are uncertain, but most authorities recommend the same regimens for treatment.
- In healthcare setting, HCP who have unprotected exposure to pertussis should also receive prophylaxis, regardless of vaccination status.
- Household members visiting patients with pertussis should be screened for a history of exposure as well as signs and symptoms of the disease. Household members who have respiratory tract symptom within 4 weeks of last exposure to infectious cases should be considered as if they have pertussis.
- Potentially infectious visitors should be excluded until antibiotics have been taken for 5 days.\(^{27}\)
- Children younger than 7 years of age who are exposed to pertussis should also complete their primary vaccination schedule on an accelerated basis. The administration of Tdap to persons 10 through 64 years of age who have been
exposed to a person with pertussis is not contraindicated, but the efficacy of postexposure use of Tdap is unknown.\textsuperscript{8}

- Infection control measures after unprotected exposure are labor intensive, and costly. These measures include identifying contacts among HCP and patients, providing chemoprophylaxis for close contacts, and evaluating, treating, and placing symptomatic HCP on administrative leave until they have received effective treatment.\textsuperscript{6} Infection control professionals and hospital decision-makers should consider potential savings and benefits from implementing Tdap in HCP who have direct patient contact.\textsuperscript{5}

- The information about the effectiveness of Tdap for the prevention and control of pertussis in healthcare facilities is limited. Thus, there is no consensus on the management of pertussis-exposed HCP who received Tdap. Each healthcare facility should consider an appropriate strategy on the basis of available resources and the risks of pertussis transmission.

- Daily monitoring of vaccinated HCP who have unprotected exposure to pertussis for 21–28 days before beginning each work shift might be a reasonable strategy for postexposure management.\textsuperscript{4}


**Summary**

Pertussis remains a challenging disease for physicians, microbiologists, epidemiologists, and policymakers. Despite considerable efforts for the prevention and control of pertussis, it continues to affect persons of all ages worldwide. Strategy to control the disease should include increasing awareness of pertussis, improved diagnostic techniques and surveillance system, and implementation of new vaccine strategies. However, atypical manifestations of pertussis, and the lack of rapid and standardized diagnostic tests make pertussis difficult to diagnose and control. Consequently, vaccination is the only available solution to decrease the incidence of pertussis. In areas where pertussis still poses a serious health problem in
preschool-aged children, the first priority is to reach at least 90% coverage with the primary 3 doses of vaccine in infant. The resurgence of pertussis among adolescents and adults and the availability of Tdap lead to a revision of immunization schedules in several countries. Infection control measures after unprotected exposure are labor intensive, and costly. These measures include identifying contacts among HCP and patients, providing chemoprophylaxis for close contacts, and evaluating, treating, and placing symptomatic HCP on administrative leave until they have received effective treatment. Daily monitoring of vaccinated HCP who have unprotected exposure to pertussis for 21–28 days might be a reasonable strategy for post-exposure management. Infection control professionals and hospital decision-makers should consider potential savings and benefits from implementing Tdap in HCP who have direct patient contact. The information about the effectiveness of Tdap for the prevention and control of pertussis in healthcare facilities is still limited.

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Key Issue
Enterobacteriaceae (other than enteropathogenic *Salmonella*, *Shigella*, and *E. coli*) are important nosocomial pathogens. More than 340 different types of beta-lactamases including extended spectrum beta-lactamases (ESBL) have been characterized in multiresistant Enterobacteriaceae. Multiresistant Enterobacteriaceae have emerged as significant nosocomial pathogens and are frequently isolated from urine, respiratory secretions and wounds.

Known Facts
- In an endemic situation, colonization or infection among hospitalised patients results primarily from the patients’ pre-existing indigenous flora.
- Nosocomial transmission of Enterobacteriaceae frequently involves the hands of healthcare workers or contaminated inanimate surfaces.
- Outbreaks of multiresistant Enterobacteriaceae have been linked to understaffing, overcrowding and poor hygiene practices in the hospital.
- Colonization with Enterobacteriaceae predisposes the hospitalised patient for nosocomial infections.
- Risk factors for acquiring (multiresistant) Enterobacteriaceae are severity of illness, mechanical ventilation and presence of indwelling devices.
- Alcohol-based hand rubs are the most efficacious agents for reducing the number of Enterobacteriaceae on the hands of healthcare providers.
Controversial Issues

- Impact of restriction of defined antibiotic substances on the emergence and spread of multiresistant Enterobacteriaceae in the hospital. Several studies, examined the effect of restricted use of antibiotics partcularly third-generation cephalosporins on the prevalence of resistant Enterobacteriaceae. Restriction of ceftazidime caused a reduction of the prevalence of ceftazidime-resistant Klebsiella spp. isolates but propagated an increase in imipenem use and the emergence of imipenem-resistant Pseudomonas spp.

- Many patients are already colonized with (multiresistant) Enterobacteriaceae at the time of admission to ICUs. Thus it remains controversial whether policies confined to ICUs or selected departments have an impact on the overall prevalence of Enterobacteriaceae

- Detection of ESBL producing Enterobacteriaceae remains a challenge for the microbiology laboratory. Routine methods may fail to identify all ESBL producing strains. Laboratory detection and reporting has to be improved according to the NCCLS guidelines.

Suggested Practice

Prevention of Transmission

1. Strict hand hygiene.
2. Identification and elimination of environmental sources.

Multiresistant Strains

- Isolation of colonized or infected patients.
- Contact precautions: gowns, gloves, and single-use or dedicated equipment.
- Education of staff and evaluation of nursing care practices.
- Increase nurse-to-patient ratio, if feasible.

Outbreak Situation

- Cohort patients and healthcare providers.
- Identify further colonized and/or infected patients.
- Intensify communication with microbiology laboratory.
- Review antibiotic policy of the affected wards.
Prevention of the Evolution of Colonization with Enterobacteriaceae to Infection:

1. Discontinue indwelling devices as soon as possible.
2. Initiate critical assessment of the patient’s antimicrobial therapy.

For specific recommendations concerning enteropathogenic Enterobacteriaceae, bladder catheterisation, ventilators, and preoperative patient care, see the appropriate chapter.

Summary

The predominant genera of Enterobacteriaceae are Escherichia, Klebsiella, Enterobacter, Citrobacter, Proteus, Serratia, Salmonella and Shigella. Enteric pathogens are not discussed in this chapter.

Colonization of the gastrointestinal tract and less frequently the respiratory tract is common in non-hospitalized patients. Colonized patients in the hospital have a significantly increased risk to develop an infection. Nosocomial transmission occurs via the hands of healthcare workers or via contaminated equipment and supplies.

Since 1983, the prevalence of Gram negative rods producing extended-spectrum-β-lactamases (ESBL) has steadily increased. Outbreaks have been described most frequently with ESBL-producing Klebsiella or multiresistant Enterobacter strains, carrying AmpC β-lactamases. Identification of ESBL-producing Enterobacteriaceae remains difficult due to the limited sensitivity of diagnostic standard procedures in the microbiology laboratory.

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CHAPTER 46

PSEUDOMONAS AERUGINOSA

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Key Issue

Pseudomonas aeruginosa is an important nosocomial pathogen that causes serious nosocomial infections and contributes significantly to morbidity and mortality.

Known Facts

P. aeruginosa is an aerobic Gram-negative rod that can be isolated from soil, water, plants, animals and humans, where it is uncommonly encountered as part of the normal transient flora. Human colonization occurs mostly at moist sites such as perineum, axilla and ear. High concentrations of P. aeruginosa, among other pathogens, may also be found in the subungual areas of the hands.

Even though colonization in healthy individuals outside the hospital is rare, colonization rates may exceed 50% in patients with severe burns (skin), on mechanical ventilation (lower respiratory tract), receiving chemotherapy (GI-tract) or antimicrobial agents (any site).

Minimal nutritional requirements, the ability to grow in distilled water, and tolerance against a wide range of physical conditions contribute to the success of this opportunistic pathogen. Hospital reservoirs are predominantly moisture-associated and include sinks, showers, respiratory equipment, IV fluids, disinfectants, food mixers and vegetables. Outbreaks have been traced to a variety of sources including respiratory therapy equipment, endoscopes, contaminated mattresses, disinfectants, contaminated water supplies, iv solutions and environmental sources such pools used for physical therapy or hydrotherapy.

Clinical manifestations include mostly nosocomial or healthcare associated infections such as pneumonia (second most common cause) and lower respiratory tract infection.
(mainly CF patients), UTI (fourth), wound infections (surgical, fourth), bone and joint infections, and bloodstream infection (BSI, seventh), but also infections that are usually community-acquired such as gastrointestinal infections, skin and soft tissue infections, bacterial ceratitis or (“malignant”) otitis externa. \( P. \ aeruginosa \) is the overall fifth most common nosocomial pathogen, with an crude attributable mortality of 28% (ward) to 48% (ICU) in patients with nosocomial bloodstream infection. High and increasing resistance of \( P. \ aeruginosa \) to many commonly used antimicrobial agents leading to multi-drug resistant (MDR) strains often leaves few therapeutic options. Repeated susceptibility testing is warranted, due to the potentially quick development of resistance to certain antimicrobial agents.

This organism is also a major cause of infection in highly compromised patients especially patients with cystic fibrosis (CF), neutropenia (and other immunosuppressive conditions) or severe burns.

**Controversial Issues**
Data on the impact of patient to patient transmission on morbidity due to \( P. \ aeruginosa \) are still limited. The original source of the organism and the mode of transmission are often difficult to assess in an outbreak situation.

**Suggested Practice**
Adherence to standard infection control guidelines should limit the spread of \( P. \ aeruginosa \). However, special attention is warranted in risk-patients and hospital environments with endemic \( P. \ aeruginosa \). Measures include:

- Hand washing between patient contacts using antiseptic agents (e.g., chlorhexidine or alcohol-based disinfectants).
- Wearing gloves when attending a patient, especially in ventilated patients, patients with severe burns and patients known to be colonized with \( P. \ aeruginosa \).
- Mechanical cleaning of all medical equipment before sterilization, especially equipment used for mechanical ventilation, and endoscopes.
- Proper sterilization of all respiratory therapy equipment including nebulizers and resuscitation bags.
• Using sterile fluids for nebulizers and preventing contamination of medication nebulizers and humidifiers.
• Using sterile water instead of tap water to rinse tracheal suction catheters.
• Avoiding the use of stock solutions for preparation of IV fluids.
• Avoiding the re-usage of a previously opened ampoule of water or sodium chloride solution for injection.
• Appropriate handling and storage of medical solutions.
• Monitoring the prevalence of *P. aeruginosa*, especially of MDR strains.
• Detecting and eliminating potential reservoirs of cross-transmission.

If a cluster of infections due to *P. aeruginosa* is detected, potential reservoirs including all medical solutions such as IV fluids and sterile water should be screened in order to quickly detect and eliminate a potential reservoir. High-risk patients such as burn-patients and immunocompromised patients should be monitored closely so that appropriate infection control measures can be implemented early.

**Summary**

*P. aeruginosa* is a major cause of nosocomial infections that affects all patient populations and contributes significantly to morbidity and mortality. Colonization usually precedes manifest clinical infection. *P. aeruginosa* has been found to be an independent predictor of mortality in some studies of nosocomial bloodstream infection.

Outbreaks have been traced to contaminated solutions (tracheal irrigate, mouthwash, iv-fluids), water, disinfectants and inadequately disinfected or sterilized endoscopes, ventilators or grafts but have also been linked to direct transmission via the hospital personnel. Important measures of prevention include the detection and elimination of reservoirs, especially moist areas, the appropriate storage and handling of medical solutions, the monitoring of high-risk patients such as ICU- or burn-patients and the immediate investigation of detected clusters of infections due to *P. aeruginosa*. 

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References


Key Issue
*Helicobacter pylori* is the most prevalent chronic bacterial infection in humans, colonizing approximately 60% of the world’s population.

Known Facts

- *H. pylori* is recognized as a causal factor in duodenal ulcer disease, gastric ulcer disease, and in the development of gastric cancer.
- Most persons infected with *H. pylori* are asymptomatic.
- *H. pylori* is commonly acquired in childhood, and in developing countries the prevalence of *H. pylori* infection is as high as 50% by the age of 5.
- The rate of acquisition is higher in developing countries. In industrialized countries, *H. pylori* transmission has decreased over the last years, but lower socioeconomic status and household hygiene practices are key factors leading to a higher prevalence of colonization.
- Treatment is strongly recommended in peptic ulcer disease and low-grade gastric mucosa-associated lymphoid tissue (MALT) lymphoma when *H. pylori* is present.
- Iatrogenic transmission of *H. pylori* by upper gastrointestinal endoscopy has been documented and is probably underestimated, because a more accurate estimate would require both long-term follow-up of asymptomatic patients and invasive procedures.
- *H. pylori* shows sensitivity to the most commonly used high level disinfectants and, therefore, iatrogenic inoculation of the bacterium by endoscopy is unlikely to occur if appropriate cleaning and disinfection procedures are strictly adopted.
Controversial Issues

• The human stomach is thought to be the natural reservoir of *H. pylori* which seems to spread mainly through person-to-person transmission, either by fecal-oral or oral-oral routes. The dental plaque is also a possible candidate reservoir for *H. pylori*.

• At least three other possible vectors have been suggested as possible routes of transmission: water, food and animals.

• There is no evidence that asymptomatic patients should be treated.

• In developing countries, presumptive treatment seems in most of the cases to be followed by recurrence.

• A potential role of *H. pylori* in dyspepsia without duodenal or gastric ulcers has not been proven so far.

• Whether or not *H. pylori* is involved in extragastric diseases (mainly ischemic heart disease, idiopathic thrombocytopenic purpura and iron deficiency) remains controversial. There is more and more evidence that *H. pylori* plays a role in modulating systemic diseases processes.

• Active or passive immunization will be key for prevention in the future.

Suggested Practice

• Wear personal protective equipment (gloves, gowns, mask and protective eyewear) during potentially contaminating procedures such as endoscopy, exposure to patients’ secretions (feces, vomitus, gastric aspirates), and when possibly contaminated objects (syringes, biopsy forceps, pH electrodes) are handled.

• Strictly observe disinfection procedures of gastrointestinal endoscopes between patients.

• Wash instruments before disinfecting them.

• Use an appropriate disinfectant

• Leave endoscopes in the disinfectant as long as recommended.

• Sterilize biopsy forceps and devices breaching the gastric mucosa, because they are regarded as critical items.
Summary
Overwhelming evidence now confirms that *H. pylori* is a worldwide infection and plays a major etiologic role in the development of chronic superficial gastritis and peptic ulcer disease. *H. pylori* infection is also strongly associated with gastric adenocarcinoma and MALT lymphomas. The bacterium colonizes 25 to 50% of the general population in developed countries while in most developing countries colonization rates can be as high as 80 to 90%, especially in poor socioeconomic and sanitary conditions. Most infected persons tend to be asymptomatic, with only a minority (3–25%) developing peptic ulceration and even fewer gastric cancers.

How exactly *H. pylori* is transmitted and spreads in the community is still unclear. The human stomach is the only substantial reservoir of *H. pylori* that has been identified so far, and the bacterium is believed to spread through person-to-person transmission. Both fecal-oral and oral-oral routes of transmission have been substantiated in different studies. On the one hand, the fecal-oral route is supported by both the presence of *H. pylori* in feces, although rarely detected and epidemiological evidence gathered in developing countries. On the other hand, the presence of the bacterium in gastric juice, dental plaque and saliva supports the assumption of an oral-oral transmission route. Indeed, African mothers feeding their infants with pre-masticated food have been identified as a risk factor for *H. pylori* infection in young children. Nevertheless both routes of transmission may co-exist, and besides, new potential reservoirs of *H. pylori* have now been identified, such as nonhuman primates, cats, flies, and environmental sources such as water.

The third and least common route of *H. pylori* transmission is iatrogenic inoculation of strains from one patient to another through a contaminated endoscope. Fiberoptic endoscopic examination of the gastrointestinal tract is known to result in iatrogenic transmission of infectious agents, such as *Salmonella* spp, *Pseudomonas* spp, *Acinetobacter* spp. Since the proportion of individuals positive for *H. pylori* is about half the world’s population, the potential for endoscopic contamination with *H. pylori* and further iatrogenic transmission is high. In addition, the complex internal design of endoscopes (metal and plastic
components, and fiberoptic glass) makes it difficult to decontaminate them. Several studies have shown that endoscopes and biopsy forceps readily get contaminated after endoscopic examination of *H. pylori*-positive patients. Iatrogenic transmission of the bacterium has been estimated to occur in 4/1000 endoscopies when the infection rate in the population is about 60%. *H. pylori* has been found in vitro to be sensitive to common chemical disinfectants within 15 to 30 seconds, but a strict minimum of 10 min immersion is recommended. It is important to note that cleaning with soap and water and rinsing with alcohol have proved to be insufficient to decontaminate endoscopes and biopsy forceps. Cleaning followed by the use of 2% glutaraldehyde (or automated peracetic acid or chlorine dioxide 30 ppm) has been shown to effectively prevent *H. pylori* transmission.

A number of guidelines describing how to clean endoscopes have been published. Endoscopes are classified by Spaulding as semi-critical items, and should at least undergo high-level disinfection. Accessories such as biopsy forceps that breach the mucosa, are regarded as critical devices and therefore must be mechanically cleaned and then sterilized after each use.

How medical equipment should be disinfected is detailed in Chapter 10, and only a few points related to upper gastrointestinal endoscopy will be described here:

- Every endoscopic procedure should be performed with a clean, disinfected endoscope.
- Endoscopic units must have written guidelines for decontamination.
- As the status of the patient is often not known, all patients should be considered to be potentially contaminated and, hence, the material used to treat them should be subjected to the same procedure.
- Manual brushing of the endoscope surface, valves, all internal channels (they should be thoroughly flushed with water and detergent), and endoscopic accessories (biopsy forceps, pH electrodes), has to be done immediately after each patient to prevent secretions from drying. This step is mandatory before the disinfection process (even if an automated washer is used). Water, mechanical action, and suitable detergents or enzymatic products are used.
• Disinfection: the endoscope should be immersed in 2% glutaraldehyde or other equivalent chemical disinfectant. All channels must be filled with the disinfectant. A 20-minute exposure time is recommended to achieve high-level disinfection. However, if this is impracticable due to turnover pressure and when Mycobacterium tuberculosis is not suspected, an immersion of 10 to 20 minutes is usually considered acceptable (10 minutes being the minimum).

• It is then necessary to rinse the instruments with preferably sterile water, internally and externally to remove all traces of disinfectant, as glutaraldehyde and most chemical disinfectants can have serious side effects. If tap water is used, rinsing the external surface as well as all channels with 70% alcohol and thoroughly drying them with compressed air are recommended.

• In all cases, drying the channels with compressed air will prevent bacteria from growing in a moist environment. The equipment should be stored with care, and it is best to hang the endoscopes to drain any excess water in channels (especially in areas where forced air drying is not possible).

In conclusion, although much more understanding of the exact ways of transmission of *H. pylori* in the community is needed to develop specific guidelines to limit the spread of the infection in the general population, what is clear already is that thorough cleaning and disinfection schedules can prevent iatrogenic transmission of common bacterial (including *H. pylori*) and viral infections from one patient to the next one through contaminated endoscopes.

**References**


Key Issue
The incidence of nosocomial fungal infections has increased in recent years, and antibiotic resistance is an issue in some hospitals.

Known Facts
- The incidence of candidemia is higher in critical-care units than in other parts of the hospital. In developed countries, it is the 4th leading cause of bloodstream infections.
- The overall incidence of nosocomial fungemia has increased, with most cases involving *Candida* species, and many such infections are related to the use of intravascular catheters.
- Most cases of nosocomial fungemia found in intensive care unit patients are not associated with recognized immune defense defects.
- Fungemia is associated with a high short-term mortality rate.
- It is already well documented that *Candida* infections, even candidemia, can be transmitted on the hands of colonized healthcare personnel.
- The evidence for cross infection by *Candida*, particularly in ICUs, has increased in the literature.
- The incidence of *Candida* non-albicans infections is increasing, and they tend to be more resistant to azols than *C. albicans* strains.
- There is a strong relationship between *Candida parapsilosis* fungemia or systemic infection and hyperalimentation using intravascular devices.
• *C. glabrata* has emerged as an important cause of candidemia, especially among neutropenic patients who have received fluconazole prophylaxis.

• Invasive candidiasis is usually caused by dissemination of endogenous *Candida* species that have colonized a patient’s gastrointestinal tract.

• Up to 25% of episodes in the ICU of catheter-related UTI are caused by different species of *Candida*. Candiduria is especially common in patients receiving prolonged urinary catheterization and broad-spectrum systemic antimicrobial agents.

• In breakthrough candidemia, the same risk factors seen in de novo candidemia are encountered, although more frequently. *C. glabrata* and *C. krusei* are the leading causes of breakthrough candidemia in patients with cancer.

• Hospital construction and renovation have been associated with an increased risk for nosocomial fungal infection, particularly aspergillosis, among severely immunocompromised patients.

**Controversial Issues**

• The role of susceptibility testing as a guide to selecting appropriate therapy for all of these infections is still incompletely defined.

• The ideal population of ICU patients who would benefit from antifungal prophylaxis. In part, the existing endemic rate of candidemia is important in decision-making.

• The efficacy of antibiotic prophylaxis for patients who demonstrate colonization with *Candida* is undocumented.

• No antimicrobial regimen has been reported to be clearly effective in preventing aspergillosis. Further studies are needed to determine the optimal strategy for aspergillosis prevention.

• Whether the hospital water-distribution system could be a reservoir for airborne molds that leads to secondary aerosolization of these molds in patient shower facilities.
Suggested Practice

- Proper use of antibiotics and strict protocols for invasive procedures.
- Define therapy based on yeast identification.
- The most important infection control measures for the prevention of fungal colonization of indwelling intravascular catheters are quite similar to those recommended for bacterial infections. Standard practice in the treatment of candidiasis is to remove existing intravascular catheters for patients with candidemia or acute hematogenously disseminated candidiasis, especially in nonneutropenic patients.
- Antifungal therapy is necessary in all cases of vascular catheter-related candidemia.
- Tunneled CVCs or implantable devices should be removed in the presence of documented catheter-related fungemia.
- The removal of all central venous catheters from all patients with candidemia is considered to be standard care.
- Bone marrow allogeneic recipients should be administered antifungal prophylaxis to prevent invasive disease with Candida species during neutropenia. The choice of drug will depend on the level of fluconazole resistance and the risk of aspergillus.
- Hospital construction or renovation areas should have negative air pressure relative to that in adjacent patient care areas, if no contraindications exist for such pressure differential.
- Patients with fungal infections of their catheters should be monitored for dissemination.

Summary

The past three decades have witnessed major changes in hospital populations and in the technology used in healthcare. As a result, there has been an improvement in patient survival; some of these patients are highly susceptible to infection. These patients often have diseases and complications that require the use of invasive techniques for both monitoring and treatment. Fungi are pathogens that can take advantage of these procedures, especially in the compromised host.

Candida and Aspergillus are responsible for the vast majority of hospital-acquired fungal infections. However, several
other species can cause infection in debilitated hospitalized patients such as: *Trichosporum, Fusarium*, etc.

Fungemia is associated with a high short-term mortality rate. The crude mortality is 40%. The attributable mortality due to nosocomial candidemia has been estimated to be half or more of the crude mortality. Several studies have identified risk factors for the development of nosocomial fungemia. Among the clinical characteristics that most consistently increase this risk are neutropenia, use of wide-spectrum antibiotics, bone marrow or solid organ transplant, diabetes, severe burns, premature birth, hyperalimentation, antecedent surgery (especially abdominal surgery), and indwelling catheters. Candidemia generally occurs in patients who are debilitated; other risk factors are renal impairment, and multisite candidal colonization, all of which are common in ICU patients.

It has been well documented that transmission of *Candida* can occur via the hands of colonized healthcare personnel. There have been several outbreaks of candidemia in different population of patients that could be tracked to the presence of the agent in the hands of hospital personnel. The evidence for cross infection by *Candida* has increased in the literature, particularly in ICUs.

There is a strong relationship between *Candida parapsilosis* fungemia, or systemic infection, and hyperalimentation using intravascular devices. In fact, the adherence of *C. parapsilosis* to plastic materials exceeds that of *C. albicans*.

The incidence of the different species of candidemia varies according to hospital and region. There has been great variation in the proportion of cases due to *C. albicans* those due to non-albicans species. As is the case with antibacterial agents, the increasing use of antifungal agents has led to the development of antifungal resistance. The impact of fluconazole resistance for patients in the ICU is that it is associated with an epidemiologic shift away from susceptible species, such as *C. albicans* and *C. parapsilosis*, toward more resistant species, such as *C. glabrata* and *C. krusei*.

The incidence of *Fusarium* spp. infection is increasing, especially among compromised patients. Disseminated fusariosis is an uncommon disease, and the reasons for the increasing
incidence are multiple. Some reports suggest a strong correlation between *Malassezia furfur* sepsis and the use of intravascular catheters.

Despite significant advances in the management of immunosuppressed patients, invasive aspergillosis remains an important life-threatening complication. In the past two decades, the incidence of invasive aspergillosis in this population has continued to increase. Factors that predispose patients to develop invasive aspergillosis include prolonged granulocytopenia, the development of graft-versus-host disease, immunosuppressive therapy, the use of adrenal corticosteroids, and the prolonged impairment of host defenses associated with diseases such as chronic granulomatous disease. Environmental factors also play a key part in the pathogenesis of this infection, and therefore, infection control measures play a critical role in reducing exposure of patients to *Aspergillus*.

**References**


Key Issue
Viral infections are common in the community and can cause a variety of symptoms.

Known Facts
- The diagnosis is based on antigen detection, antibody response, electron microscopy, virus isolation, or polymerase chain reaction, which may be laborious and/or time-consuming. Based on the route of transmission, viral infections can be classified into four categories:
  1. Gastrointestinal Infection;
  2. Respiratory Tract Infection;
  3. Exanthematous Disease (skin lesions, vesicles); and

Gastrointestinal Infection. Gastrointestinal infections are caused by several viruses that can be found in feces, such as: enteroviruses (polioviruses, coxsackieviruses A and B, echoviruses), adenoviruses, rotaviruses, astroviruses, caliciviruses (e.g., norovirus, sapovirus), coronaviruses, hepatitis A virus and hepatitis E virus. Some of these are also found in respiratory secretions (enteroviruses, adenoviruses, coronaviruses, norovirus) and may cause symptoms of an upper respiratory tract infection. Outbreaks were reported in daycare centers, sport facilities, hospitals and nursing homes.
- The route of transmission is predominantly fecal-oral, often via contaminated hands. Transmission of norovirus by aerosol during vomiting appears common. Thus, infection control strategies should focus on contact with fecally contaminated items and include gowns, gloves, and hand hygiene (Table 49.1). In general, masks are not advised but should be worn during close contacts or high-risk procedures.
(e.g., bronchial toilet) and when taking care of vomiting patients with norovirus infections.

- Most infections are mild, self-limiting, and do not require any specific therapy.

**Respiratory Tract Infection.** Symptoms of respiratory tract infections may vary from common cold to life-threatening pneumonia or pneumonitis. The severity of the clinical symptoms is largely dependent on host defenses. Cytomegalovirus, for example, can cause severe pneumonitis in the immunocompromised host whereas most infections are subclinical in the immunocompetent host. Viruses that cause respiratory tract infections include influenza viruses, parainfluenza viruses, respiratory syncytial virus, adenoviruses, enteroviruses, rhinoviruses, human metapneumovirus and coronaviruses (SARS, Chapter 50). Many other viruses can be found in respiratory secretions, such as cytomegalovirus (CMV), Epstein-Barr virus (EBV), herpes simplex virus (HSV), human herpes virus type 6 (HHV-6), measles, mumps, human parvovirus B19, rabies virus, rubella virus, poxviruses, and varicella-zoster virus (VZV).

- Route of transmission is via airborne spread or via contaminated hands. Infection control measures should be aimed at aerosol transmission and direct contact and may include isolation, masks, gowns, gloves, and hand hygiene.

- Influenza virus vaccination should be considered for high-risk patients (for detailed information see the WHO website) and healthcare workers. In case of an outbreak, especially when the strain is not controlled by the vaccine, prophylaxis with amantadine (only influenza A, within 48 hours of exposure) or oseltamivir (influenza A & B) may be useful for both patients and healthcare workers.

**Avian Influenza A:** The risk of nosocomial transmission is low. Standard droplet and contact precautions are recommended. During aerosol generating procedures, eye protection and a respirator as protective as N95 /FFP2 is recommended. Suspected cases should be reported to local health authorities. Post-exposure prophylaxis with oseltamivir can be considered but resistance has been described. Up-to-date information is available on http://www.who.int/csr/disease/avian_influenza/en/index.html.
• In case of exposure to rabies virus, injection of human rabies immune globulin (HRIG) in the exposure site within 24 hours is recommended, followed by vaccination.

**Exanthematous Disease.** Many viral infections can cause exanthema, vesicles, or other skin lesions. The most common viruses are enteroviruses, herpes simplex virus (HSV), human herpes virus type 6 (HHV-6), varicella-zoster virus (VZV), measles, human parvovirus B19, and rubella virus.

• The routes of transmission are via respiratory secretions (all), feces (enteroviruses), urine (congenital rubella) and skin lesions (HSV, VZV, coxsackievirus A). Infection control measures are listed in Table 49.1.

• A combined vaccine for mumps, measles, and rubella (MMR) should be given to children at the age of 12 to 18 months or 6 and 9 months and to susceptible adults when vaccination is not contraindicated.

• Vaccines for mumps, measles, varicella and rubella are live attenuated vaccines and should not be given to severely immunocompromised patients.

• Antiviral therapy is available for HSV and VZV.

• Neonates and susceptible immunocompromised adults and pregnant women who had contact with chickenpox or shingles should be given a dose of varicella-zoster immune globulin (VZIG) within 3 days after exposure. Varicella-zoster immune globulin may not prevent infection but it may reduce the severity of infection.

• Susceptible HCW that have been exposed to VZV should be excluded from work with patients at risk during the incubation period (21 days). Susceptible contacts from patients with chickenpox should be isolated during the incubation period. VZIG lengthens the incubation period!

• Less frequently occurring viruses that can cause nosocomial infections include those causing hemorrhagic fevers such as arenaviruses (Lassa, Machupo, Junin), and Filoviruses (Marburg and Ebola). These viruses require strict isolation because they are transmitted by blood and body fluids (see Bloodborne Infection, page 304).
<table>
<thead>
<tr>
<th>Virus/Infection</th>
<th>Infective Material</th>
<th>Isolation/Precautions</th>
<th>Gown</th>
<th>Gloves</th>
<th>Mask</th>
<th>Single Room</th>
<th>Prevention/Postexposure Prophylaxis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenovirus</td>
<td>resp. secretions, feces</td>
<td>contact</td>
<td>(+)</td>
<td>+</td>
<td>(+)</td>
<td>–</td>
<td>(+) eye protection, + triple therapy</td>
</tr>
<tr>
<td>AIDS/HIV</td>
<td>blood, body fluids</td>
<td>universal</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>(+) eye protection &amp; FFP2/N95 mask in aerosol generating procedures</td>
</tr>
<tr>
<td>Avian influenza</td>
<td>resp. secretions, feces</td>
<td>contact, droplet</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>eye protection &amp; FFP2/N95 mask in aerosol generating procedures</td>
</tr>
<tr>
<td>Astrovirus</td>
<td>feces</td>
<td>enteric</td>
<td>(+)</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>Post-exposure prophylaxis</td>
</tr>
<tr>
<td>Calicivirus</td>
<td>feces</td>
<td>enteric</td>
<td>(+)</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Coronavirus</td>
<td>resp. secretions, feces</td>
<td>contact</td>
<td>(+)</td>
<td>+</td>
<td>(+)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Coxsackie A virus</td>
<td>resp. secretions, feces, lesions, secretions</td>
<td>contact</td>
<td>(+)</td>
<td>+</td>
<td>(+)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Cytomegalovirus</td>
<td>resp. secretions, urine, breast milk</td>
<td>body fluids</td>
<td>–</td>
<td>+</td>
<td>(-)</td>
<td>–</td>
<td>+ avoid contact during pregnancy (+) ganciclovir (anti-CMV-immune globulin)</td>
</tr>
<tr>
<td>Dengue virus</td>
<td>blood</td>
<td>universal</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+ avoid mosquito exposure, repellents</td>
</tr>
<tr>
<td>Enterovirus</td>
<td>resp. secretions, feces</td>
<td>contact</td>
<td>(+)</td>
<td>+</td>
<td>(-)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Hantavirus (e.g., Puumala)</td>
<td>rodent excreta</td>
<td>none</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Hemorrhagic fever</td>
<td>blood, body fluids</td>
<td>strict</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>(+) eye protection, + ribavirin may be useful for Lassa fever</td>
</tr>
<tr>
<td>(Ebola, Marburg, Lassa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatitis A and E viruses</td>
<td>feces</td>
<td>enteric</td>
<td>(+)</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+ vaccination and immune globulin for HAV</td>
</tr>
</tbody>
</table>
Table 49.1 Infection Control Measures for Selected Viral Pathogens (continued)

<table>
<thead>
<tr>
<th>Virus/Infection</th>
<th>Isolation/Infective Material</th>
<th>Precautions</th>
<th>Gown</th>
<th>Gloves</th>
<th>Mask</th>
<th>Prevention/Single Room</th>
<th>Postexposure Prophylaxis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatitis B and D viruses</td>
<td>blood, body fluids</td>
<td>universal</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>(+) eye protection, + vaccination and HBIG</td>
</tr>
<tr>
<td>Hepatitis C, F, G viruses</td>
<td>blood, body fluids (?)</td>
<td>universal</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>(+) eye protection, (-) interferon</td>
</tr>
<tr>
<td>Herpes simplex virus (localized)</td>
<td>lesions, secretions</td>
<td>drainage, lesions, secretions</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>(+) acyclovir</td>
</tr>
<tr>
<td>Herpes simplex virus (disseminated)</td>
<td>lesions, secretions, resp. secretions</td>
<td>contact</td>
<td>+</td>
<td>+</td>
<td>(–)</td>
<td>+</td>
<td>(+) acyclovir</td>
</tr>
<tr>
<td>Herpes zoster virus (localized)</td>
<td>lesions, secretions</td>
<td>drainage, lesions, secretions</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>(–)</td>
<td>(+) VZIG</td>
</tr>
<tr>
<td>Herpes zoster virus (disseminated, varicella)</td>
<td>lesions, secretions, resp. secretions</td>
<td>strict</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>(+) vaccination, VZIG</td>
</tr>
<tr>
<td>HIV/HTLV</td>
<td>blood, body fluids</td>
<td>universal</td>
<td>–</td>
<td>(+)</td>
<td>(+)</td>
<td>–</td>
<td>(+) eye protection, + triple therapy</td>
</tr>
<tr>
<td>Influenza virus</td>
<td>resp. secretions</td>
<td>respiratory</td>
<td>–</td>
<td>(+)</td>
<td>(+)</td>
<td>+</td>
<td>(+) vaccination, amantadine, oseltamivir, zanamivir</td>
</tr>
<tr>
<td>Measles</td>
<td>resp. secretions</td>
<td>respiratory</td>
<td>–</td>
<td>(–)</td>
<td>(+)</td>
<td>(–)</td>
<td>+ vaccination (MMR)</td>
</tr>
<tr>
<td>Metapneumovirus (human)</td>
<td>resp. secretions</td>
<td>respiratory</td>
<td>+</td>
<td>+</td>
<td>(–)</td>
<td>+</td>
<td>+ single room only in children</td>
</tr>
<tr>
<td>Virus/Infection</td>
<td>Isolation/Infective Material</td>
<td>Precautions</td>
<td>Gown</td>
<td>Gloves</td>
<td>Mask</td>
<td>Prevention/Single Room</td>
<td>Postexposure Prophylaxis</td>
</tr>
<tr>
<td>----------------</td>
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<td>-------------</td>
<td>------</td>
<td>--------</td>
<td>------</td>
<td>------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Mumps</td>
<td>resp. secretions</td>
<td>respiratory</td>
<td>–</td>
<td>(–)</td>
<td>(+)</td>
<td>(–)</td>
<td>+ vaccination (MMR)</td>
</tr>
<tr>
<td>Norovirus</td>
<td>resp. secretions, feces, vomit</td>
<td>enteric</td>
<td>(+)</td>
<td>+</td>
<td>(+)</td>
<td>–</td>
<td>+ hand disinfection (!)</td>
</tr>
<tr>
<td>Parainfluenza virus</td>
<td>resp. secretions</td>
<td>contact</td>
<td>–</td>
<td>(+)</td>
<td>(+)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Parvovirus B19</td>
<td>resp. secretions, blood</td>
<td>–</td>
<td>(+)</td>
<td>+</td>
<td>(+)</td>
<td>–</td>
<td>+ avoid contact during pregnancy</td>
</tr>
<tr>
<td>Poliovirus</td>
<td>resp. secretions, feces</td>
<td>(+ )</td>
<td>+</td>
<td>(–)</td>
<td>–</td>
<td>–</td>
<td>+ vaccination</td>
</tr>
<tr>
<td>Rabies virus</td>
<td>resp. secretions, respiratory</td>
<td>–</td>
<td>(+)</td>
<td>+</td>
<td>(+)</td>
<td>–</td>
<td>+ HRIG at exposure site, vaccination</td>
</tr>
<tr>
<td>RSV bronchiolitis</td>
<td>resp. secretions</td>
<td>contact</td>
<td>+</td>
<td>+</td>
<td>(–)</td>
<td>+</td>
<td>+ single room only in children</td>
</tr>
<tr>
<td>Rotavirus feces,</td>
<td>resp. secretions</td>
<td>contact</td>
<td>+</td>
<td>+</td>
<td>(+)</td>
<td>–</td>
<td>+ hand disinfection (!)</td>
</tr>
<tr>
<td>Rubella virus</td>
<td>resp. secretions</td>
<td>contact</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ avoid contact during pregnancy, vaccination (MMR)</td>
</tr>
<tr>
<td>SARS: see Chapter 50</td>
<td>resp. secretions, feces</td>
<td>strict</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ negative pressure room, N-95/FFP-3 or FFP 2 mask, eye protection (goggles or face shield) (+) vaccination, VZIG</td>
</tr>
<tr>
<td>Varicella</td>
<td>resp. secretions, lesions</td>
<td>strict</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ avoid mosquito exposure, vaccination</td>
</tr>
<tr>
<td>Yellow fever</td>
<td>blood</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

+ = advised; (+) = only during high-risk procedures (e.g., bronchial toilet, soiling), high-risk patients, or close contact; (–) = questionable, probably not necessary; – = not necessary
Several arboviruses, such as dengue and yellow fever, and rickettsiae may cause hemorrhagic skin lesions but they are vectorborne, and person-to-person transmission does not occur.

- Hantaviruses may cause hemorrhagic fever with renal syndrome but may also cause a pulmonary syndrome with rapid respiratory failure and cardiogenic shock. Hantaviruses are transmitted via infected rodent excreta. Person-to-person transmission does not occur; therefore, no preventive measures are required.

**Bloodborne Infection.** Hepatitis B virus (HBV), hepatitis C virus (HCV), human T-cell leukemia/lymphoma virus (HTLV), human immunodeficiency virus (HIV), and viral hemorrhagic fevers (VHF) (e.g., Lassa, Marburg, Ebola) are examples of bloodborne infections. Other viral infections that can be transmitted by blood are CMV, EBV and HHV-6 because these viruses persist in leukocytes. Transfusion-related transmission of West-Nile virus has been described.

- Routes of transmission are blood and body fluids, including breast milk. The risk of infection after a needlestick is 5 to 40% for HBV, 1 to 10% for HCV, and <0.5% for HIV. For VHF, exact data on transmission after needlestick accidents are missing, but it is known that high concentration of viruses are found in blood during the febrile period.
- Universal precautions should be taken when handling blood in all patients and attention given to save disposal of needles and sharps.
- Effective postexposure prophylaxis for HBV consists of passive immunization with hepatitis B immune globulin (HBIG) followed by active immunization with recombinant hepatitis B vaccine.
- Interferon prophylaxis after exposure to HCV is questionable.
- Triple therapy with a combination of a protease inhibitor and two nucleoside reverse transcriptase inhibitors is probably useful as HIV postexposure prophylaxis.
- Ribavirin is an effective treatment for Lassa fever and may be useful as prophylaxis for Lassa fever.
Vaccination

- Vaccination is available for polioviruses, hepatitis A, hepatitis B, varicella, influenza, measles, mumps, rubella, and rabies.
- Vaccines for mumps, measles, varicella and rubella are normally live attenuated vaccines and should not be given to severely immunocompromised patients.

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CHAPTER 50

LESSONS FROM SARS

Richard P. Wenzel, MD, MSc

Key Issue
Severe Acute Respiratory Syndrome (SARS) was one of the latest epidemics to challenge infection control experts in the early years of the 21st century. The etiology is a novel coronavirus especially capable of being transmitted in hospitals. Only assiduous infection control practices were effective for control. These important lessons for infection control which are summarized herein. These lessons could be employed in the early management of a new epidemic of respiratory infections when the etiology is initially unknown.

Known Facts
• SARS emerged in the Southern Chinese Province of Guangdong in November 2002, but was not recognized until February 2003. Subsequently, a global epidemic occurred with a crude mortality worldwide of almost 10% but with considerably higher rates in some locales among patients older than 65 years.
• The etiology of SARS is a novel coronavirus that very likely has a natural reservoir in one or more animals indigenous to Southern China, possibly the Himalayan or masked palm civit.
• The incubation period is 2–10 days.
• Half of the victims were healthcare workers.
• The SARS virus spreads primarily via large droplets, thus transmission usually requires close contact. It is possible that occasionally droplet nuclei transmission (airborne) can occur. Furthermore, because the virus is found in the bloodstream early, transfusion-related or sharps injury-associated infection remains a theoretic possibility. Lastly, because the
virus is shed in the stool for approximately 30 days and can 
 survive in the environment for 1–4 days, it is likely that the 
environment plays an important role in some cases of trans-
mission.

• Although steroids and ribavirin have been used empirically 
  for therapy, no efficacy data from controlled studies exist to 
  prove that either drug affects outcome favorably.
• Healthcare workers who failed to use masks properly while 
  managing SARS patients were more likely to become 
  infected than those who used the masks properly.

Controversial Issues

• Recognition of the epidemic was important and much credit 
  goes to the late Carlos Urbani, MD, who alerted the world 
  from his hospital in Hanoi. Of interest, the web-based inter-
  national surveillance system for emerging pathogens— 
  ProMED-mail—had reports of SARS weeks before the 
  World Health Organization (WHO) reported the epidemic.
• There is critical need for all countries to report new epi-
  demics immediately.
• Quarantine, if used, must be employed with care and com-
  passion.
• The WHO showed great leadership by coordinating much 
  of the global response to SARS.
• Because of the fears of healthcare workers, more attention 
  to be paid to psychological support when epidemics affect 
  them and threaten their health and lives.

Suggested Practice

Some of the key points in the management of SARS cases are 
shown in Table 50.1. The wearing of tight-fitting masks, 
preferably N-95 with high filtering ability, is the most essential 
part of infection control protection of healthcare workers. Hand 
washing is also very important for infection control. Double 
gloving is thought to be important. Even if one has used gloves, 
a healthcare worker should wash hands after removing the 
gloves. Gowns and eye protection should be used and hair cov-
ers and shoe covers used if available. If available, place the 
patient in a room with negative air pressure.
Table 50.1 Management of Suspected SARS

Isolate the patient
Place the patient in a private room with negative pressure, if possible.
Wear two pairs of gloves, a gown, masks (N-95 if available), and eye protection
(with face shield, if available, rather than goggles).
Just before leaving the room, remove the gown and top set of gloves in the room.
After leaving the room, wash gloved hands with alcohol, remove face shield and mask, placing both in disposable trash.
Remove and discard the second set of gloves.
Wash hands carefully after removing gloves.
Limit the number of healthcare workers caring for patient.
Limit the number of visitors.

Perform diagnostic studies if possible
To rule out known causes of community-acquired pneumonia and to rule in SARS.

Maintain a clean environment
Use chlorine solutions on bedside counters and on medical equipment that can tolerate the disinfectant, such as IV poles, at least daily.

Provide treatment
Supplemental oxygen for hypoxemia.
Antibacterial agents for community-acquired pneumonia.
Consider a neuraminidase inhibitor for treatment of influenza, if available.
Consider ribavirin (oral formulation: 1.2g every 8 hr; commercially available, intravenous form: 8 mg/kg of body weight every 8 hr) (available through the CDC).
Consider corticosteroids.

Whenever healthcare workers exposed to initially non-isolated patients, it was ideal if they could be furloughed to their homes alone for 10 days before returning to work in the hospital. This may be very important for limiting transmission of SARS within the hospital. Ideally, family members would move to a relative’s home during the 10 day furlough.
Summary
SARS is a new and formidable epidemic that is challenging infection control. Although close contact was necessary for transmission most of the time, the possibility exists for coincident transmission via airborne route and fomites. To contain this novel coronavirus, there is no room for error or relaxation of the highest standards of all features of infection control.

References


Key Issue
Nosocomial parasitic infections are infrequently reported in developed countries. As a result little attention is paid to these infections, which can result in under diagnosis and unwanted delay of installment of proper preventive measures. In developing countries nosocomial outbreaks with parasitic infection probably are more common, but detection is hampered due to the high prevalence of parasitic infections in the population and the limited financial resources.

Known Facts
Nosocomial outbreaks with parasitic infections in hospitals and/or institutions are known for enteric-, blood-, tissue- and ecto-parasites.

- Enteric protozoan parasites known from nosocomial outbreaks are Cryptosporidium, Giardia, Entamoeba histolytica/dispar, Balantidium coli, Cyclospora and Isospora. Cryptosporidium is frequently reported in both patient-pro staff, patient-to-patient, and staff-to-patient nosocomial transmission. High-risk situations can result from patients shedding large numbers of Cryptosporidia oocysts in their stools: immunocompetent individuals in the acute phase of infection and individuals who are severely immunosuppressed: i.e. AIDS patients. Suboptimal hand washing efforts orfomite contamination of environmental surfaces can be involved in transmission. Perinatal nosocomial transmission from mother with Cryptosporidia enteritis to the newborn baby at the time of delivery is possible, as well as respiratory transmission.

- Enteric protozoan parasites are frequently involved in water-associated outbreaks and contamination can be anticipated both in developing and developed countries where...
water treatment is not to the highest standard. Water-associated outbreaks involve frequently Cryptosporidium and Giardia, and less frequent Entamoeba histolytica/dispar, Balantium coli, Cyclospora cayetanensis, Microsporidium species, the tissue parasite Toxoplasma gondii and the free living Acanthamoeba species. Due to the small size and robust nature of the transmission stages of parasites, i.e. cyst, oocyst and spores, removal by water treatment systems is difficult. Infection dose for humans often is small: nine oocyst and 25–100 cysts for respectively Cryptosporidium and Giardia.

• Free-living amoeba in water networks of hospitals have been shown to be an important reservoir of pathogens as Legionella pneumophila. In addition these amoeba serve as reservoir for different mycobacterial species and Alphaproteobacteria, such as Rhodoplanes and Methylobacterium. The ability to multiply in free-living amoeba offer these bacteria protection from biocides and enhances their virulence in humans. Human infection occurs via inhalation of aerosols containing free bacteria or, alternatively, infected amoebae itself could be the infectious particles that bring the pathogens to the longs. In addition to hospital water networks amoebal contamination is also reported from water in oxygen humidifier reservoirs.

• Enteric helminth parasites involved in nosocomial transmission are Enterobius vermicularis, Strongyloides stercoralis and Hymenolepis nana. With these infections direct person-to-person transmission is possible because an intermediate host is not required and eggs (E. vermicularis, H. nana) or larvae (S. stercoralis) are direct mature (infective) in stool. When conditions allow fecal contamination of the healthcare environment (i.e. in recreations areas) and helminth eggs are enabled to mature, other roundworms, as hookworm, trichuris and toxocara species, can also be the source of outbreaks. Patient shedding proglottides of Taenia solium in the hospital environment are a potential important source of infection. Eggs liberated from the proglottides are immediately infectious and can, when swallowed by humans, cause severe pathology of i.e. the central nervous system (cysticercosis).
• Malaria. When hospitals are located in malaria endemic regions, hospitalized patients with malaria can, when gametocytes are present in blood, be the natural source for infections of mosquitoes. After development of the malaria parasites in the mosquito, malaria parasites can be transmitted to other hospitalized patients when physical barriers (windscreens and bed nets) are not in use. In non-endemic countries nosocomial malaria is infrequently observed. However, especially in patients hospitalized with high parasitaemia of P. falciparum, small amounts of blood can result easily in nosocomial transmission to other patients and/or staff. Nosocomial malaria occurs when parasite-infected erythrocytes are transmitted from person to person through blood transfusion, needle stick injury, saline flush, improper use of blood glucometer, contaminated gloves, multidose heparin vials, organ transplantation, contaminated catheters, contrast medium of CT-scans and open wounds.

• Babesia microti, cause of babesiosis and normally transmitted to humans via the tick Ixodes scapularis, can be transmitted nosocomial via blood transfusions. This problem is especially recognised in North America. Current numbers of transfusion-transmitted babesiosis in North America, about 50 /year, likely are (strong) underestimates.

• African trypanosomiasis, normally transmitted by tse-tse flies, can also be transmitted by blood transfusion. This is especially true for patients (donors) in the early phase of infection when parasites circulate in the blood but the patient still appears healthy, a period which can last weeks to months.

• American trypanosomiasis, predominantly transmitted via the bite of and infected triatomid bug in endemic areas, can also be transmitted by blood transfusion. It is the second most common means of acquiring this infection. Transmission by needle stick injury and kidney transplantation has also been recorded.

• Leishmanial parasites causing visceral leishmaniasis can be transmitted by blood transfusion. In blood the parasites are observed in leukocytes. In endemic areas differentiation between visceral leishmaniasis due to arthropod vectored—and blood transfusion infection is difficult.
• Nosocomial transmission of toxoplasmosis most often is due to heart or kidney transplantation and infrequently due to white blood cell transfusions. Laboratory-acquired toxoplasmosis in research personal is not uncommon due to contact with infectious (often cultured) material by skin punctures, eye splashes or open wounds.

• Microfilariae of the blood helminths *Mansonella ozzardi*, *Loa loa*, *Diptetelonema perstans* and *Wuchereria bancrofti* have been observed in blood of asymptomatic donors. No illness or mild disease was recorded in recipients of such blood.

• Head lice infestation, transmitted between humans primarily by direct head-to-head contact, is of low risk as a nosocomial infection apart from close patient-to-patient contact in i.e. pediatric ward playrooms or institutions. Body lice, transmitted via contact with/or exchange of infested clothing or bedding, is of negligible risk in hospital settings in developed countries. This is also true for pubic lice which are transmitted via direct venereal skin-to-skin transfer.

• Scabies, due to the infestation with the itch mite, *Sarcoptes scabei*, is an important cause of nosocomial infections. Especially Norwegian or crusted scabies is an highly contagious infestation, where patients can have thousand of mites on their skin and cause heavily contamination of the patients environment. In primary infection the incubation period, before itching and scratching begins, maybe up to four- till six weeks. This long period often delays outbreaks recognition with further transmitting of mites by asymptomatic contacts. Early symptomatology often starts as papular foliculites with classic burrows of conventional scabies only being observed 3 till 4 weeks later.

• The pigeon mite, *Dermanyssus gallinae*, has been involved in several nosocomial outbreaks. Infection with this mite causes pruritic papular rash which can be misdiagnosed as scabies. Usual source of the mite are pigeon roosts on or near ventilatory ducts or outside air-conditioners.

• Nosocomial infestation of body tissues of humans by larvae of various fly species, myasis, is not uncommon. Myasis results from deposition of eggs of gravid flies in open
wounds, which can develop towards motile larvae within a few days. Myiasis most commonly occurs in hospitals in the tropics and subtropics with open air access to the patient but is also reported in temperate areas during warmer months.

**Controversial Issues**

- Parasitic nosocomial outbreaks in developed countries are infrequently reported which is due to the low prevalence in the population, good food and personal hygiene, adequate water treatment services and proper building constructions. However, infrequent parasitic outbreaks also lowers awareness of these infections and consequently can result in delay of diagnoses and installment of proper preventive measures.

- In the tropics parasitic infections are often abundantly present among the native population. Limited financial resources often result of suboptimal housing/building constructions of hospitals, hygienic practices and water treatment, all factors potential enhancing spread of parasitic infections in the hospital setting. Because of the high background prevalence, outbreaks are difficult to detect.

- Expertise in laboratory diagnoses of parasitic infections is, for various reasons, often limited.

- To prevent drinking water to be contaminated with intestinal parasites, especially *Cryptosporidium* and *Giardia*, is most difficult. Even with high standards of treatment, including physical and chemical disinfection methods, contamination does occur.

- Screening for parasitic infections which potentially can be transmitted by blood transfusion i.e. malaria and American trypanosomiasis (Chagas’s disease), requires locally adapted strategies to take into account both care for the recipient as well as unnecessary waste of blood donations.

**Prevention**

- To prevent nosocomial infection due to enteric parasites, effective hand washing practice and glove use are the most important preventive measures. Other important interventions are summarized in Chapter 43 (*Bacterial Enteric Pathogens*, under Suggested Practice). Time of shedding of
*Cyclospora* and *Isospora* oocysts in stools can be shortened by treatment with co-trimoxazole and *Giardia* by metronidazol or tinidazol. For *Cryptosporidium* no effective treatment is known, with effectiveness of nitazoxanide still to be confirmed. *Cryptosporidium* oocysts can be removed from drinking water by either boiling for one minute or by filtering the water through a filter with a pore size of smaller than one micrometer. Full details are provided by the CDC Preventions Website. *Cryptosporidium* can be inactivated on surfaces or instruments by i.e. 10% formal saline, 5% ammonia for 18 hours or full-strength (12%) commercial bleach for 10–15 min.

- The cornerstone to prevent blood-transfusion-associated protozoal infections, i.e. malaria, trypanosomiasis (African and South American), babesiosis and leishmaniasis, is donor selection using questionnaires and use of screening tests. After a visit to a malaria endemic area blood donors are deferred from blood donation for periods varying from 4–6 months, 3 years or even permanent, depending on the origin of the donor (born and lived in endemic area, European visitor), having experienced febrile episodes in the period after the visit and country of blood donation. In the USA and Canada a deferral time of 12 months after return from an endemic area is applied for blood donors. Use of serological tests for malaria in the tropics are, given the high prevalence of malaria in most countries of little use and deferral on basis of positive antibody tests too drastically can reduce the donor pool. Antigen tests and microscopy can be used instead, but sensitivity of these tests can be insufficient to exclude blood donors with low parasitaemia of malaria (<100 parasites/ul). Routine screening for babesiosis in not in common use.

- To prevent American trypanosomiasis (Chagas’s disease) in endemic the predonation questionnaires, serological tests for *T. cruzi* antibodies and treatment of blood with gentian violet is used, the latter being an effective strategy to prevent nosocomial blood transfusion, in non-endemic countries use of questionnaires for Chagas’s disease are often targeted to special donor groups, i.e. visitors or immigrants.
of South-America. Performing serological screening is no routine in non-endemic countries but is considered in the USA when an FDA licensed test should be available.

- To prevent transfusion-acquired leishmaniasis in some countries (USA, Ireland) donors are deferred for 12 months when they visited endemic countries, especially Iraq. Also, donors with multiply scars and fresh cutaneous leishmanial lesions are deferred. In other countries use of specific questionnaires or antibody testing is not routinely performed.

- Nosocomial infection of toxoplasmosis as a result of heart or kidney transplantation can be expected in case of a toxoplasma seropositive donor and seronegative recipient. Serological testing of both donor and recipient in advance should, in case of mismatch, alert the clinician to potentially life threatening complications. Prophylaxis with pyrimethamine can be provided to the recipient. Alternatively anti toxoplasma treatment can be started when seroconversion and clinical manifestations occur, although clinical symptoms often are non-specific.

- To prevent myasis, efforts are required on two fronts:
  - minimize patient risk factors by keeping wounds and malodorous or draining orifices of the patient clean and covered; and
  - reduce fly populations in the health environment.

- Prompt recognition of scabies followed by immediate implementation of preventive measures is the mainstay for the containment of nosocomial outbreaks. In case of crusted scabies, contact precautions should be strictly implemented including use of disposable gloves, gowns and shoe covers. Local treatment with 5% permethrin cream, applied overnight on two occasions one week apart, is highly effective. Lindane lotion 1% is an effective, cheap alternative but is potentially more toxic. In addition to local treatment in crusted scabies oral treatment with ivermectine at a dose of 200 ugr/kg, repeated after one week, is beneficial.
Summary
Nosocomial parasitic infections can be caused by enteric-, blood-, tissue- and ecto-parasites. Frequency of infection is low in developed countries. From developing countries only few data are available. Proper detection of outbreaks requires adequate diagnosis which, in both settings, often has restrictions. In developing counties outbreaks are difficult to detect due to high background prevalence. Enteric protozoan parasites, malaria, American trypanosomiasis, toxoplasmosis (due to heart and kidney transplants), crusted scabies and myasis are among the most frequent reported nosocomial infections.

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