Chapter 40

PRINCIPLES OF INFECTION CONTROL AND PREVENTION DURING MILITARY DEPLOYMENT

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INTRODUCTION

Long-established concepts of infection control, plus those that have achieved prominence since recognition of the bloodborne human immunodeficiency virus (HIV), pose challenges even to fixed health care facilities in peacetime. Medical care under deployed conditions, especially in combat, stretches the feasibility of infection control approaches, yet patients and their providers still deserve the best care that the circumstances allow. During deployments, uncommon and unique infection control hazards must be appreciated by providers who normally work in well-equipped and well-staffed fixed facilities. On the battlefield, infection control must extend from semi-fixed facilities through rapidly mobile units to the warfighter. Medical personnel must recognize that mass casualty situations under fire, biological warfare, challenging logistics, care of non-US patients, natural environmental hazards, and exotic infectious diseases call for innovative adaptations of the US fixed-facility model of infection control. Though much research remains to be done and doctrine to be written, prudent and creative application of basic principles can help achieve successful infection control in the field setting.

Prevention and control of infection in military medical settings is in some respects more important during deployment than it is during more stable operations, such as occur in military hospitals in the United States. Infections that not only cause needless morbidity and mortality and threaten the well-being of other warfighter-patients also put a drain on what may be an already overtaxed health care and medical evacuation system. If key health care providers must be placed under isolation because they have been exposed to diseases such as Crimean-Congo hemorrhagic fever or Lassa fever, health care can be compromised for many current and future patients. Provider anxiety over potential exposure to bloodborne pathogens can also affect performance.

Infection control challenges in the deployed setting may be compounded by higher rates of antibiotic resistance in many overseas settings; greater susceptibility to common infectious diseases such as rubella, mumps, and varicella among some patients from allied forces; the greater possibility of transmissible infections such as tuberculosis among local-hire workers; logistic delays; and bloodborne pathogens. Biological warfare involving a transmissible agent such as smallpox would dwarf any previous infection control concern. These scenarios may be well beyond those envisioned by current US occupational safety standards. Infection control problems arising on deployments may reach back to US-based fixed facilities. The growing emphasis on rapid medical evacuation may result in the importation into the United States of infection control problems, such as previously unknown drug-resistant organisms or exotic emerging infections.

In the civilian sector, the amount of attention paid to controlling the spread of infection in medical facilities is related broadly to the level of general health care. This, in turn, depends on the country's degree of development. At one end of the spectrum, infection control and prevention practices may be ignored by the lower-echelon health care worker; the practices are simply left up to the initiative and concern of individual physicians and nurses. At the other end of the spectrum are facilities that practice all of the Northern American or European models of infection control, complete with surveillance activities and outcome measures.

Since deployment may occur anywhere in the world and since other cultures and geographic areas pose different challenges in infectious disease prevention, general concepts will be the focus of this chapter. Instituting infection control and prevention practices during deployment will present varying levels of difficulty and require varying levels of creativity, depending on the mission, geographic area, logistical support, and beliefs of the local people about health and medicine. Local people who are hired to work for the military medical unit may not understand why certain practices are mandated; they may also be a source of infection or contribute to transmission themselves if, for example, they have undetected tuberculosis or continue to work (to produce income) while they have an enteric illness. Major educational efforts may be necessary for such personnel, with particular attention paid to cultural misunderstandings concerning the transmission of infectious diseases. The challenge to the military medical system while under deployment conditions is not only to improvise in incorporating practices familiar to the US-based practitioner but also to bridge this gap between those practices and local circumstances.

ELEMENTS OF AN INFECTION CONTROL PROGRAM

An effective infection control and prevention program for military and nonmilitary personnel in a deployed environment should be based as much as possible on the same elements and principles that

guide such programs in garrison. Because of the austerity of the deployed environment, though, common sense and creativity may be needed to adjust to the situation at hand. Health care workers must first understand that while infection control principles remain the same, the infection control threat under deployed conditions may be different and more complicated than normal. Health care workers at all levels need to be educated concerning how a deployment scenario may call for particular and even unfamiliar infection control emphases. For example, patient-to-patient transmission of a vector-borne infection such as dengue would not typically be an issue in the controlled environments of a US hospital, but bednets may be essential to protect staff and patients if mosquitoes are present in a deployed hospital with viremic dengue patients.

Infection control encompasses those policies, procedures, and concepts necessary to minimize the transmission of infectious diseases in the health care setting. Successful infection control programs usually have an active multidisciplinary infection control committee; proactive surveillance; effective methods for isolating patients and specimens that pose a risk to others; an occupational health program; policies regarding antibiotic use, aseptic technique, and facility sanitation; and access to at least basic microbiological laboratory support. The underpinning of a successful program is regular education and communication. Infection control must be given emphasis and responsible personnel to be successful.

Infection control policies have to address both facility-acquired and community-acquired infections. Facility-acquired infections, also known as nosocomial infections, are generally defined as those infections that are neither present nor incubating at the time of admission to a facility but develop 48 to 72 hours afterward, unless the infection is clearly related to a procedure or exposure that occurred within the first 48 to 72 hours of hospitalization. Criteria for defining such infections have been outlined by the Centers for Disease Control and Prevention (CDC) and should be used by military personnel.[1] Community-acquired infections are generally considered to be all infections that arise from exposures outside the facility. In this chapter, "facility" refers to any setting in which patients are treated, including hospitals, clinics, or forward treatment areas.

According to Meers,[2] the problems of facility-transmitted infections in developing or war-ravaged countries are 2-fold. The first is communication between the medical personnel and patients. The second is the spectrum of diseases. Some community-acquired infections that are viewed as major problems in the United States are seen as minor problems or everyday occurrences in other nations and cultures (eg, tuberculosis, hepatitis). This can also be true of infections that are transmitted within the facility. An understanding of local attitudes towards infections and infectious diseases may be crucial to the successful prevention of infections in a deployed environment.

THE INFECTION CONTROL COMMITTEE

While most infection control committees are focused on and based in hospitals, on deployment infection control must be addressed at levels extending from the warfighter to supporting hospitals in the United States. This requires layers of infection control management tailored to the size and circumstances of the deployment. For this reason, there is no single model for how to manage infection control efforts in the deployed setting. Individuals should be formally appointed to manage this function.

The committee has several key functions; it formulates theater-specific infection control policies, oversees surveillance activities, develops appropriate medical education, and evaluates the program. This group should also, recognizing resource limitations, advise medical commanders on what infection control programs and settings deserve the highest priority. The frequency of meetings will depend on the maturity of the theater and the complexity of the medical care system being put into place. Efficiency may require meetings by individuals responsible for specific parts of the health care continuum. Membership on the infection control committee, and any subcommittees, should reflect the expertise of clinicians (to include medics), clinical nurses, preventive medicine and environmental science officers, an epidemiologist or a surveillance nurse, the pharmacist, medical regulators involved with moving patients, and laboratorians.

The committee should develop appropriate medical education for all medical personnel, but special emphasis should be placed on education for nurses because of their intense contact with patients and implementation of standard procedures. The committee can also help clinicians in the theater by researching and reporting local antibiotic-resistance patterns. Another important educational focus should be the avoidance of occupational injuries

from contaminated sharps and medical waste. Nonclinicians who may find themselves involved in patient care (eg, first aid and triage personnel, litter carriers) should be taught how to protect themselves from bloodborne infections. Regular feedback of infection control information, including surveillance data, to supported facilities is desirable.

SURVEILLANCE

If a military unit will be stationary for some period of time, a program for nosocomial infection surveillance should be instituted. Ideally, the deployed unit will already have in place policies and procedures for such a program and will only need to implement them. Since microbiological laboratory support may be minimal, if it is present at all, other information about patients (eg, unexplained fevers, new rashes, purulent drainage from wounds) will need to serve as markers for the possible spread of nosocomial infection. Considering that resources are often constrained in the deployment setting, a role of the infection control committee will likely be to prioritize surveillance efforts. This may involve targeting specific high-risk facilities or wards, rotating surveillance of lower-risk wards, and focusing on infections associated with the highest mortality (eg, bacteremia, pneumonia).

One individual should be designated to perform surveillance "rounds" of the patients in the medical treatment facility at least once a week, using patient records, written or oral nursing reports, and pharmacy and laboratory records as primary sources of data and clues as to which patients have nosocomial infections. For example, more scrutiny might be given to those whose records show suggestive antibiotic prescriptions, intravenous catheter sites, wound dressing changes, or abnormal

EXHIBIT 40-1

CASE DEFINITION FOR SUSPECTED EBOLA HEMORRHAGIC FEVER

The following case definition may be useful for surveillance in an area at recognized risk for the emergence of Ebola hemorrhagic fever.

Anyone presenting with fever and signs of bleeding such as:

- Bleeding of the gums
- Bleeding from the nose
- Red eyes
- Bleeding into the skin
- Bloody or dark stools
- Vomiting blood
- Other unexplained signs of bleeding

Whether or not there is a history of contact with a suspected case of Ebola

OR

Anyone living or deceased with:

- Contact with a suspected case of Ebola

AND

- A history of fever, with or without signs of bleeding

OR

Anyone living or deceased with a history of fever

AND

three of the following symptoms:

- Headache
- Vomiting
- Loss of appetite
- Diarrhea
- Weakness of severe fatigue
- Abdominal pain
- Generalized muscle or joint pain
- Difficulty swallowing
- Difficulty breathing
- Hiccups

OR

Any unexplained death in an area with suspected cases of Ebola

Source: Centers for Disease Control and Prevention. *Infection Control for Viral Hemorrhagic Fevers in the African Health Care Setting*. Atlanta: CDC; 1999.

fever curves. Such a program in a deployed unit would not give primary emphasis to the compilation of reports and the calculation of infection rates, although that would be useful information for future deployments, but would rather gain early information on the possible nosocomial clusters or epidemics and prioritize appropriate measures to halt the spread of infection to uninfected patients. The individual performing infection surveillance may also monitor compliance with the military unit's infection control policies and procedures during the course of rounds, possibly using a previously developed checklist.

Surveillance at the point of admission (eg, aid station, clinic, hospital) for patients with certain syndromes or specific diagnoses is indicated. In certain scenarios, the admission of patients who potentially have highly transmissible conditions must be anticipated so that these cases can be isolated rapidly and environmental contamination minimized. Staff involved with the admission process must be alerted to the medical threat for the region and kept informed of up-to-date medical intelligence. It is advisable to have training sessions and standard operating procedures so that patients with conditions such as active tuberculosis and viral hemorrhagic fevers are recognized promptly and safely isolated. Exhibits 40-1 and 40-2 outline case definitions, developed for use in Africa, that may be useful for identifying at the time of presentation patients who may have Ebola fever or Lassa hemorrhagic fever.

The military practice of medical evacuation through echelons of care complicates infection control surveillance since patients may acquire infections in one location and manifest them at another echelon thousands of miles away. The dynamic ebb and flow of casualties further complicates recognition of changes in the rate of infections. Feedback mechanisms should be developed to inform the theater surgeon of clusters or epidemics in evacuated personnel that might have come from theater exposures.

EXHIBIT 40-2

CASE DEFINITION FOR SUSPECTED LASSA HEMORRHAGIC FEVER

Unexplained fever at least 38°C (100.4°F) for 1 week or more

AND

One of the following:

- No response to standard treatment for most likely cause of fever (malaria, typhoid fever)
- Readmitted within 3 weeks of inpatient care for an illness with fever

AND

One of the following:

- Edema or bleeding
- Sore throat and retrosternal pain or vomiting
- Spontaneous abortion following fever
- Hearing loss following fever

Source: Centers for Disease Control and Prevention. *Infection Control for Viral Hemorrhagic Fevers in the African Health Care Setting*. Atlanta: CDC; 1999.

OCCUPATIONAL HEALTH FOR DEPLOYED HEALTH CARE WORKERS

Health care workers in the deployed setting may face particular challenges because of patient care requirements in austere, combat conditions and contact with injured or ill local persons. Care of wounded US forces poses obvious risks, but care of personnel from other countries can be more hazardous. In many overseas areas, prevalence rates of chronic hepatitis B virus carriage exceed 5%.[3] This explains why any member of the military medical departments who could potentially be involved with not only patient care but also triage and patient transport should be fully immunized. In some parts of the world, the HIV infection rates in soldiers exceed 30%.[4] The US military health care system must be prepared to handle a higher risk to health care personnel of inadvertent exposures to HIV and other bloodborne pathogens than would be the case in a typical military fixed facility. Currently recommended prophylactic antiretroviral regimens must be immediately available for use (Table 40-1).[5] US military health care workers should also anticipate the greater possibility of exposure to agents such as measles, rubella, mumps, varicella, hepatitis A, and polio. Whereas the furlough of a susceptible health care provider exposed to varicella in peacetime may be an inconvenience, in a deployed setting such a loss can have a major impact on unit performance. If immunity is in doubt, the health care worker should be screened and, if indicated, immunized. Childhood and military

TABLE 40-1

BASIC AND EXPANDED HIV POSTEXPOSURE PROPHYLAXIS REGIMENS*

Regimen Category	Application	Drug Regimen
Basic	Occupational HIV exposures for which there is a recognized transmission risk	4 wk (28 d) of both zidovudine 600 mg every day in divided doses (ie, 300 mg twice/d, 200 mg three times/d, or 100 mg every 4 h) and lamivudine 150 mg twice/d
Expanded	Occupational HIV exposures that pose an increased risk for transmission (eg, larger volume of blood and/or higher virus titer in blood)	Basic regimen plus either indinavir† 800 mg every 8 h or nelfinavir 750 mg 3 times/d*

*These drug recommendations are current as of August 2000. Because these regimens changed rapidly, the reader is urged to check with the Centers for Disease Control and Prevention for the most up-to-date recommendations at www.cdc.gov.
†Idinavir should be taken on an empty stomach and with increased fluid consumption (ie, drinking six 8 oz glasses of water throughout the day); nelfinavir should be taken with meals.
Source: Centers for Disease Control and Prevention. Public Health Service guidelines for the management of health-care worker exposures to HIV and recommendations for postexposure prophylaxis. *MMWR*. 1998;47(RR-7):1–28.

immunization practices are now associated with high rates of immunity to most of these agents in US forces. However, these agents remain common in some parts of the world. Many members of multinational coalitions, even from some developed countries, are susceptible to some of these agents due to differences in immunization practice.[6]

The likelihood of a US military health care worker being exposed to tuberculosis is significant in certain refugee situations and may necessitate respiratory protection and predeployment and postdeployment screening.[7] The military health care system should also be prepared to provide prophylaxis in the event of exposures to meningococcal and other infections. In addition to these measures, thorough education on basic items such as the need for frequent handwashing and the use of barrier equipment remains central to proper occupational health in the deployed setting.

THREE LEVELS OF INFECTION CONTROL

An infection control program in the deployed setting should be based on three levels of control. First is the prevention of transmission of infection through the faithful practices of handwashing, aseptic technique, and sanitation. Second is the control of sources of contamination by disinfection or sterilization of articles. Third is the protection of uninfected patients and health care workers through the appropriate and judicious use of isolation of patients who have infections, through proper specimen handling, and through the use of other measures such as immunization.

Control Level 1: Sanitary Practices

The first level of control in an infection control program during deployment is the prevention of transmission by thorough handwashing, aseptic technique, and sanitation.

Handwashing in a deployed setting may require creativity but must be enforced. Handwashing is the most single important element in the prevention of infection.[8] It not only prevents transmission of infection between patients but, if done conscientiously, prevents health care workers from becoming casualties themselves. There are at least four methods of providing handwashing facilities in a deployed setting, assuming that the deployed unit is not in a fixed facility with running water.

Handwashing

The preferred handwashing facility in a deployed unit would be a portable sink, in which a foot pump or other pump supplies running water. The second method would be a Lyster bag, or some method of suspending 5-gal cans of water, which would also serve as a source of running water. The third choice would be to use alcohol-based handwashing towelettes that are individual and disposable or

alcohol-based disinfectant waterless hand foams or lotions. This may be the most practical approach for medics and others with very limited resources at their disposal. It should be noted, however, that blood, dirt, and any organic material should be removed with water before using waterless cleaners. There is a problem with this third choice, however, if a residue from the towelettes, foams, or lotions accumulates on the hands. Then the use of soap and water becomes mandatory. The last resort would be a basin of water in which some type of antiseptic (eg, povidine-iodine, chlorhexidine) has been added, accompanied by a basin of clear water for rinsing. It should be emphasized, however, that this "bird bath" is an absolute last resort. As suboptimal as this method is, it will at least remove blood, dirt, and organic matter from the hands, thus allowing personnel to then use a waterless hand antiseptic. The "bird bath" contents, however, need to be changed frequently, perhaps hourly, to prevent the buildup of organic material in the water. Those allergic to the antiseptic may be precluded from using this method.

All of these methods require that three items be available: a water source, soap or antiseptic, and a method of drying the hands. For the lack of a paper towel or other drying material, busy health care workers may dry their hands on their clothing. If supplies of disposable paper towels are interrupted, a cloth "roller towel" could be used for hand drying but only if each person has a clean, unused area on the towel on which to dry their hands.

Various types of soap should be available to the deployed unit. For general patient care, a plain, nonantimicrobial soap can be used. Such a soap can be in almost any form, (ie, bar, leaflets, liquids, powders). Detergent-based products may contain very low concentrations of antimicrobial agents used as preservatives. If bar soap is used, small bars that can be changed frequently and soap racks that promote drainage should be used to minimize microbial growth. Before invasive or surgical procedures, an antimicrobial handwashing agent should be used. Such agents should contain alcohol, povidine-iodine, or chlorhexidine.

Aseptic Technique

Aseptic technique is the next step in this basic level of control. Anything that is used on what is considered a sterile body cavity must be sterile—free of all bacteria and spores. Anything that is used on a body cavity that is normally contaminated with environmental organisms must be at least clean or disinfected.

Aseptic technique is generally divided into two categories: clean technique and sterile technique.[9] Both types must be employed in a deployed environment to the extent possible. Clean technique refers to practices that reduce the number of microorganisms or prevent or reduce transmission of organisms from one person or place to another. It includes handwashing using soap and friction and cleaning patient-care areas from areas requiring the highest level of cleanliness to less-critical areas. Clean technique also refers to the use of physical barriers, such as gloves and gowns, to prevent contact with microbes.

Sterile, or surgical, technique refers to practices designed to render and maintain objects and areas maximally free of microorganisms. This includes such practices as skin antisepsis before the skin is broken for a procedure. It also includes the concept of barriers (eg, sterile drapes, gowns, and gloves used during surgical procedures). In general, clean technique is employed to prevent the transmission of infection from patients to personnel and other patients, and sterile technique is used to prevent the transmission of infection to patients.

Sanitation

Effective sanitation is essential to the control of infections of any type in any setting and is itself a type of clean technique. Removal of microorganisms from environmental surfaces and from equipment and supplies that could transmit them to patients or from personnel to patients is basic to infection prevention. Florence Nightingale wrote:

> The only way I know to remove dust, the plague of all lovers of fresh air, is to wipe everything with a damp cloth. And all furnishings ought to be so made as that it may be wiped with a damp cloth without injury to itself….[10(p89)]

Miss Nightingale's triumphs during the Crimean War have been well-chronicled.[11] She convincingly demonstrated that safe food and water and a clean environment could result in a major decrease in death rates in a military hospital. Those practices are no less important during deployment today than they were at the British military hospital in Scutari, Turkey, during the 1850s.

Sanitation in deployed medical units will generally be accomplished by housekeeping personnel, very probably employed from the local population. Such personnel may have to be taught an appreciation for the level of sanitation needed for a health care area. Housekeeping operations will be directed toward safety and the reduction of direct and indi-

rect transmission of infection from environmental sources. Improper housekeeping can actually spread pathogenic organisms.

There are several basic housekeeping principles that need to be followed. First, some type of disinfectant-detergent should be used for all cleaning, if it can be obtained. At the minimum, plain soap should be used. Second, all horizontal surfaces should be cleaned at least daily and when obviously soiled. Third and finally, all cleaning performed in a facility should employ the "damp-cleaning" method, that is, the materials used to clean the furniture, floors, and other surfaces should be wet with the disinfectant-detergent solution or soap before they are applied to the item being cleaned.

Control Level 2: Disinfection and Sterilization

The second level of infection prevention and control in a deployed environment is the reduction of contamination through the proper disinfection and sterilization of articles. In such an environment, the luxury of presterilized, disposable supplies and equipment may not be available. Consequently, some types of reusable equipment that can be processed by the deployed unit should be maintained. Examples include bedpans and urinals that can be decontaminated and reused.

Spaulding[12] recommends a rational approach to disinfection and sterilization of patient care items, which should be workable for military units during deployment. Spaulding divides the disinfection of patient care items into three categories: critical, semicritical, and noncritical. A basic principle of this method is that all items must be cleaned with some type of soap or detergent and water before being subjected to the next level of processing. The most efficient sterilization process or chemical disinfectant will not work unless the item is cleaned of all organic matter beforehand.

Critical items are those that must be sterilized because they enter a body cavity that is normally sterile. This category includes surgical instruments, urinary and intravascular catheters, and intravenous needles. If presterilized items are not available on deployment, some type of local sterilization procedure must be employed, such as treatment with a chemical sterilizing agent (eg, 2% gluteraldehyde, 6% stabilized hydrogen peroxide). Such sterilizing agents may be available locally or may be brought in from another geographic area. Twenty percent hydrogen peroxide is widely available, and can be diluted to 6%. Cleaning must precede the treatment, and contact time and temperature of the sterilizing solution must be as recommended by the manufacturer. Deployed units that have steam sterilization capability, such as autoclaves or sterilizers, should use them for items such as surgical instruments.

In a deployed setting, there may be situations in which logistics is unable to resupply the military unit with sterile, disposable supplies, such as intravascular tubing or indwelling urinary catheters. There are currently no US government guidelines for the resterilization or reprocessing of such items. It is recommended that rather than attempting resterilization, such devices should be left in place and not routinely changed, as they are in US-based facilities. The possibility of contamination would probably be much greater if reprocessing were attempted using inadequate methods than if the devices were simply left in place until the supply flow was reestablished.

Semicritical items are objects that come in contact with skin or mucous membranes that are not intact. Examples of items in this category would include respiratory equipment, anesthesia equipment, gastrointestinal endoscopes, and thermometers. These objects should, if possible, be free of all microorganisms with the potential exception of bacterial spores. Semicritical items require disinfection, preferably using a chemical such as 2% gluteraldehyde. Wet pasteurization is another method that can work well in a deployed setting. It is hot water disinfection at temperatures below 100°C and involves exposing the equipment to 75°C water for 30 minutes.[9]

Noncritical items are those that come in contact with intact skin and mucous membranes. Examples of these items are bedpans, blood pressure cuffs, crutches, bed rails, linens, food utensils, and furniture. In contrast to critical and semicritical items, most noncritical items can simply be cleaned where they are used and do not need to be transported to a central processing area. Any safe, hospital-approved disinfectant-detergent solution will be adequate to clean these items. If questions arise regarding methods of sterilization or decontamination of items, the military unit's operating room or central supply personnel should be consulted.

Control Level 3: Isolation Procedures

Isolation technique may be difficult in a deployed environment, and creativity may be necessary to solve the problem of disease transmission from a patient to others. The CDC has recommended a two-tiered system of isolation techniques that should function well in a deployed environment.[8]

Standard Precautions

The first tier of this system is termed "standard precautions." The term indicates that every patient who enters a military health care facility of any kind be treated as if he or she were carrying a pathogen that is transmitted through contact with mucous membranes, broken skin, blood, excretions, or body fluids (eg, HIV, a hepatitis virus).[8] Additional precautions may be indicated depending on the specific diagnosis. Standard precautions are designed to reduce the risk of transmission of microorganisms from both recognized and unrecognized sources of infection in facilities. The standard precautions system consists of several basic principles, which should be used by all military health care providers (Exhibit 40-3). These principles address where appropriate and practical the wearing of gloves, gowns, masks or facial protection, eye protection, patient placement, transport of infected patients, care of linen and dishes, routine cleaning, and waste disposal. Some type of barrier "kit" that includes gloves, masks, eye protection, and gowns should be available in all settings, to include military vehicles that transport patients and those that respond to mass casualty situations.

Gloves are worn for three important reasons. First, gloves are worn to provide a protective barrier and prevent gross contamination of the hands when touching blood, body fluids, secretions, excretions, mucous membranes, and nonintact skin. Second, they are worn to reduce the likelihood that microorganisms present on the hands of personnel will be transmitted to patients during invasive or other patient care procedures that involve touching a patient's nonintact skin or mucous membranes. Third, gloves are worn to reduce the likelihood that hands of personnel contaminated with microorganisms from a patient or article will transmit these microorganisms to another patient. Wearing gloves does not replace the need for handwashing because gloves may have small unnoticeable defects or be torn during use, thus allowing hands to become contaminated. Hands may also become contaminated during the removal of gloves. Gloves must be changed between patient contacts.

Whether latex or vinyl gloves are to be used will generally depend upon the task to be performed.[13] Both types protect the health care worker from blood and body fluids. Latex is more flexible than vinyl and, since it conforms to the hands, allows more freedom of movement. Latex gloves have a network of lattices that allow them to reseal tiny punctures automatically, a feature not found in vinyl gloves. Therefore, latex gloves should be used in the following situations: (*a*) when flexibility is needed, such as in phlebotomy, (*b*) when performing tasks that may cause stress on the glove, such as when handling sharp instruments or tape, and (*c*) when the exposure to pathogens may be unknown,

EXHIBIT 40-3

KEY ELEMENTS OF STANDARD PRECAUTIONS

Wash hands with soap (preferably antimicrobial) before and after contact with a patient's blood, body fluids, or contaminated items
Wear clean, thin gloves if there will be contact with blood, body fluids, mucous membranes, or broken skin and change gloves between patients and procedures
Use a mask, eyewear, and a gown if splashes or sprays of body fluids are likely
Handle needles and other sharp instruments safely
Routinely clean and disinfect frequently touched environmental surfaces
Clean and disinfect soiled laundry safely
Isolate patients whose blood or body fluids are likely to contaminate surfaces or other patients
Minimize invasive procedures to avoid the potential for injury or accidental exposure

Source: Centers for Disease Control and Prevention Infection Control Practices Advisory Committee. Guidelines for isolation precautions in hospitals. *Am J Infect Control*. 1996:24:24–51.

such as in surgical, labor and delivery, and disaster areas. For tasks that are unlikely to stress the glove material, vinyl gloves may be worn. Such tasks would typically be performed in outpatient and psychiatric settings.

One problem that may be faced during deployment is the possibility of having to wash or otherwise reprocess disposable latex or vinyl gloves. This problem may arise when supplies of gloves are interrupted. At least one study[14] has examined the ability of three different handwashing agents to reduce bacteria inoculated on gloves. Both 4% chlorhexidine and 70% ethyl alcohol were more effective in removing the bacteria from the gloves than nonantibacterial soap and water. None of the agents, however, removed all of the organisms. Clearly, the optimal practice is to use disposable gloves once and discard them.

For standard precautions, various types of gowns and protective apparel are worn to provide barrier protection and reduce opportunities for transmission of microorganisms to health care personnel and other patients. Gowns or aprons are worn to prevent contamination of clothing and protect the skin of personnel from blood or body fluids. Ideally, disposable gowns with a fluid-resistant front should be used. In a deployed setting, however, such gowns may not be available. Gowns that can be laundered can be used, perhaps with a plastic apron worn underneath. As with other infection control practices in such an environment, ingenuity may be necessary. In some cases, health care workers with an acute, unanticipated need for barrier protection have improvised using plastic trash bags in place of aprons and boots. Gowns and gloves should be changed after dealing with infective material. Nondisposable items, such as respirator masks, should be disinfected after each use. Removal of contaminated aprons, gloves, and other supplies should be done in such as way as to avoid self-contamination or contamination of others or the environment.

Various types of masks, eye protection, face shields, and caps need to be worn when the possibility of splashing of blood, oral secretions, or body fluids exists. A mask that covers both the nose and mouth with goggles or a face shield will provide protection of the health care worker's eyes, nose, and mouth. A surgical mask that fits snugly over the nose and mouth is generally worn to provide protection against the spread of infectious large-particle droplets that are transmitted by close contact and generally travel only short distances (up to 1 m) from infected patients who are coughing or sneezing, such as those with influenza.

Transmission-based Precautions

The second level of precautions that the CDC recommends is for patients with known or suspected highly transmissible or epidemiologically important infectious diseases. These precautions, termed transmission-based precautions, are used in addition to standard precautions. They include airborne precautions, droplet precautions, and contact precautions. Exhibit 40-4 and Tables 40-2 and 40-3 detail the conditions and type of precautions needed for selected militarily-relevant infectious diseases.

Airborne Precautions. Airborne precautions are designed to reduce the risk of airborne transmission of infectious agents, such as measles, varicella (including disseminated zoster), and tuberculosis. Airborne transmission occurs by dissemination of either airborne droplet nuclei (5 μm or smaller) that remain suspended in the air for long periods of time or by dust particles that contain the infectious agent. Microorganisms carried in this manner can be widely dispersed by air currents and may become inhaled by a susceptible host in the same area as the source patient or one a long distance away, depending on environmental factors.

Obviously, the institution of these precautions in a deployed setting can be difficult. Negative pressure rooms will generally not be available, but the placement of a patient with an airborne disease in a small tent (or sealed-off area in a tent) in which the air will not be circulating to other patients and staff is imperative. Tents or other movable facilities can be configured to allow a private area for patients with a transmissible airborne infection.

Some type of respiratory protection must be worn when entering the room or area of a patient with a known or suspected infectious respiratory disease. If the patient has measles or varicella, those who are susceptible to those diseases should not enter the room. It is important to remember that while US service members likely either have natural or vaccine-induced immunity to infections such as these, allied personnel and local-hire workers may have a significantly different pattern of susceptibility.

An area of major concern and controversy has been the selection of respiratory protection equipment for prevention of the transmission of tuberculosis, a disease that may well be present during deployment. Although its efficacy was unproved, a surgical mask was traditionally worn for isolation precautions in hospitals when patients were known or suspected to be infected with microorganisms spread by the airborne route of transmission. The

EXHIBIT 40-4

SYNOPSIS OF TYPES OF PRECAUTIONS AND PATIENTS REQUIRING THE PRECAUTIONS*

Standard Precautions
For all patients

Airborne Precautions (In Addition to Standard Precautions)

For patients known or suspected to have serious illnesses transmitted by airborne droplet nuclei (eg, measles, varicella [including disseminated zoster]†, tuberculosis‡)

Droplet Precautions (In Addition to Standard Precautions)

For patients known or suspected to have serious illnesses transmitted by large-particle droplets (eg, invasive *Haemophilus influenzae* type b disease, invasive *Neisseria meningitidis* disease, pharyngeal diphtheria, mycoplasma pneumonia, pertussis, pneumonic plague, streptococcal [group A] pharyngitis, pneumonia, adenovirus†, influenza, mumps, parvovirus B19, rubella)

Contact Precautions (In Addition to Standard Precautions)
For patients known or suspected to have serious illnesses easily transmitted by direct patient contact or by contact with items in the patient's environment:

- Gastrointestinal, respiratory, skin, or wound infections or colonization with multidrug-resistant bacteria
- Enteric infections with a low infectious dose or prolonged environmental survival (eg, *Clostridium difficile*, respiratory syncytial virus, parainfluenza virus, enteroviral infections in infants and young children)
- Skin infections that are highly contagious or that may occur on dry skin (eg, cutaneous diphtheria); herpes simplex virus (neonatal or mucocutaneous); impetigo; major (noncontained) abscesses, cellulitis, or decubiti; pediculosis; scabies; staphylococcal furunculosis in infants and young children; zoster (disseminated or in the immunocompromised host)†
- Viral/hemorrhagic conjunctivitis
- Viral hemorrhagic infections (Ebola, Lassa, or Marburg)*

*Not a complete listing
†Certain infections require more than one type of precaution
‡See Centers for Disease Control and Prevention. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health care facilities. *MMWR*. 1994;43(RR-13).
Source: Centers for Disease Control and Prevention Infection Control Practices Advisory Committee. Guidelines for isolation precautions in hospitals. *Am J Infect Control*. 1996:24:24–51.

CDC currently recommends that respiratory protection equipment used by health care workers caring for tuberculosis patients should meet the following two basic standards: (1) the ability to filter particles of 1 μm in the unloaded state with a filter efficiency of greater than 95% and (2) the ability to fit the different facial characteristics of personnel.[15] This second recommendation generally means that at least three sizes of masks should be available. Logistic personnel should be able to determine if the masks available meet these minimum requirements. If such masks are not available in a deployed environment, a surgical mask that fits snugly over the nose and mouth should be worn when entering the tent or area where a tuberculosis patient is housed. If the patient must leave the tent or area for any reason, he or she must wear the mask. In fact, it may also be prudent for any patient suspected of having active tuberculosis to wear a mask at all times, even inside the tent because of the difficulty in maintaining negative pressure in that setting.

Droplet Precautions. The next sublevel of isolation precautions is used for diseases that are spread through droplets. Droplet infection is distinct from airborne transmission, and such infections as meningitis, diphtheria, pertussis, influenza, mumps, and rubella are spread in droplets. All of these infectious diseases may be present in a deployed setting. Droplet transmission involves contact of the conjunctivae or the mucous membranes of the nose

TABLE 40-2

TYPE AND DURATION OF PRECAUTIONS NEEDED FOR SELECTED INFECTIONS AND CONDITIONS

Infection/Condition	Precaution Type
Acquired immunodeficiency syndrome	Standard
Amebiasis	Standard
Anthrax, pulmonary	Standard
Arthropod-borne viral encephalitides	Standard/screening
Arthropod-borne viral fevers (eg, dengue, yellow fever)	Standard/screening
Brucellosis	Standard
Campylobacter, cholera, and *Escherichia coli* O157:H7	Standard if continent
Chickenpox	Airborne and Contact
Clostridium perfringens (gangrene)	Standard
Diphtheria, cutaneous	Contact
Enteroviral infections	
Adults	Standard
Infants and young children	Contact
Hantavirus pulmonary syndrome	Standard
Hemorrhagic fevers (eg, Ebola, Lassa)	Contact
Hepatitis, viral	Standard if continent
Influenza	Droplet
Malaria	Standard with screens
Measles (rubeola)	Airborne
Meningitis (*Neisseria meningitidis*)	Droplet
Multidrug-resistant organisms, infections, colonization	
Gastrointestinal	Contact
Respiratory (except pneumococcal)	Contact
Skin (eg, wound, burn)	Contact
Mumps	Droplet
Mycoplasma pneumoniae	Droplet
Pertussis	Droplet
Plague, bubonic	Standard
Plague, pneumonic	Droplet
Rabies	Standard
Rickettsial fevers, tick-borne	Standard
Rubella	Droplet
Strongyloidiasis and hookworm	Standard
Tuberculosis, pulmonary/laryngeal (confirmed or suspected)	Airborne
Zoster in a normal patient	Standard with immune health care workers

Source: Centers for Disease Control and Prevention Infection Control Practices Advisory Committee. Guidelines for isolation precautions in hospitals. *Am J Infect Control*. 1996:24:24–51.

or mouth of a susceptible person with large particle droplets containing microorganisms. Droplets are generated from the infected person or carrier during talking, coughing, and sneezing. Transmission involves close contact, because the droplets usually do not remain suspended in the air and generally travel at most a meter.

Droplet precautions also require that the patient

TABLE 40-3

CLINICAL SYNDROMES OR CONDITIONS WARRANTING ADDITIONAL EMPIRIC PRECAUTIONS TO PREVENT TRANSMISSION OF EPIDEMIOLOGICALLY IMPORTANT PATHOGENS PENDING CONFIRMATION OF DIAGNOSIS

Clinical Syndrome or Condition*	Potential Pathogens†	Empiric Precautions
Diarrhea		
Acute diarrhea with a likely infectious cause in an incontinent or diapered patient	Enteric pathogens‡	Contact
Diarrhea in an adult with a history of recent antibiotic use	*Clostridium difficile*	Contact
Meningitis	*Neisseria meningitidis*	Droplet
Rash or exanthems, generalized, etiology unknown		
Petechial/ecchymotic with fever	*N meningitidis*	Droplet
Vesicular	Varicella	Airborne and Contact
Maculopapular with coryza and fever	Rubeola	Airborne
Respiratory infections		
Cough/fever/upper lobe pulmonary infiltrate in an HIV-negative patient or a patient at low risk for HIV infection	*Mycobacterium tuberculosis*	Airborne
Cough/fever/pulmonary infiltrate in any lung location in an HIV-infected patient or a patient at high risk for HIV infection	*M tuberculosis*	Airborne
Paroxysmal or severe persistent cough during periods of pertussis activity	*Bordetella pertussis*	Droplet
Respiratory infections, particularly bronchiolitis and croup, in infants and young children	Respiratory syncytial or parainfluenza virus	Contact
Infection with Multidrug-resistant Microorganisms		
History of infection or colonization with multidrug-resistant organisms	Resistant bacteria	Contact
Skin, wound, or urinary tract infection in a patient with a recent hospital stay in a facility where multidrug-resistant organisms are prevalent	Resistant bacteria	Contact
Skin or Wound Infection		
Abscess or draining wound that cannot be covered	*Staphylococcus aureus*, group A streptococcus	Contact

*Patients with the syndromes or conditions listed below may present with atypical signs or symptoms (eg, pertussis in neonates and adults may not have paroxysmal or severe cough). The clinician's index of suspicion should be guided by the prevalence of specific conditions in the location, as well as clinical judgment.
†The organisms listed here are not intended to represent the complete, or even most likely, diagnoses, but rather possible etiologic agents that require additional precautions beyond Standard Precautions until they can be ruled out.
‡These pathogens include enterohemorrhagic *Escherichia coli* O157:H7, *Shigella,* hepatitis A virus, and rotavirus.
Source: Centers for Disease Control and Prevention Infection Control Practices Advisory Committee. Guidelines for isolation precautions in hospitals. *Am J Infect Control*. 1996:24:24–51.

be placed in a private tent or area or with another patient who has the same diagnosis. If this is not possible, the patient should be placed at least 1 m from other patients. Health care workers should wear a mask when working within 1 m of the patient. If transport of the patient is necessary, the patient should be masked.

Contact Precautions. All other infections and infectious diseases, whether facility- or community-acquired, may be contained through the next sub-

level of precautions, contact precautions. Contact precautions are designed to reduce the risk of transmission of infections that are spread through direct or indirect contact, such as on health care workers' hands or on fomites (eg, patient-care articles). Contact precautions should be used with patients who have conditions such as diarrhea or skin or wound infections.

Direct-contact transmission involves skin-to-skin contact and physical transfer of microorganisms to a susceptible person from an infected person. Such transmission may occur while turning a patient, giving a patient a bath, or performing other care activities that require close physical contact. Patients who have direct physical contact with each other may also serve as a source of infection. This might happen when convalescent patients help with nursing tasks. The use of gloves is necessary; the use of gowns may also be necessary. Devices for use in mouth-to-mouth resuscitation can be helpful in reducing those associated direct-contact risks.

Patient Isolation and Placement

Appropriate patient placement is an important component of isolation precautions, especially for enteric or respiratory conditions or other conditions requiring contact isolation. As mentioned previously, creativity in using the facilities at hand may be necessary. Of course, the most desirable situation for persons with these types of conditions would be a private accommodation with toilet facilities. Under field conditions, this is not an absolute requirement. For example, if tents are the only housing facilities available, a tent with patients with the same airborne-transmitted diseases should be placed downwind of the main patient-care facility. Sharing of rooms or areas by patients with the same known or suspected diagnosis at the same stage of the disease, also known as cohorting, is especially useful during enteric outbreaks. Grouping respiratory patients with infections due to different etiologies should be avoided to reduce the risk of cross-infections. In the case of patients with a communicable respiratory disease, careful use of exhaust fans may help keep contaminated air from flowing back into common patient-care areas by creating a negative pressure. Signs should be posted indicating the presence of an infectious disease risk and the precautions to be taken for those entering the area. The excreta of individual patients with enteric diseases are normally disposed of in a sanitary sewer and this is usually considered safe, but disinfection may be desirable during an outbreak when the quantity of agents placed into the environment is larger. As in the United States, medical waste should be handled and disposed of appropriately on deployment to avoid infecting others or contaminating the environment.

For some conditions, such as viral hemorrhagic fevers, strict or high-level contact isolation may be indicated. The US standard calls for private negative pressure rooms with anterooms equipped with sinks. Exhaust passes through high-efficiency filters. In the field, such approaches may not be easily achieved short of using plastic-film patient isolators. These isolators have interior spaces below atmospheric pressure, HEPA (high efficiency particulate air) filters for exhaust air, and a lock system for bagging and removing contaminants. As an alternative to an isolator, the medical personnel should be clothed in special suits to provide a microbiological barrier. In addition, these patients should be housed separately from others in another building or at least in a place with separate air flow. For nonmilitary personnel, it may be possible to approach the desired level of isolation by having patients cared for in their homes by trained personnel equipped with protective equipment.

The highest level of personal protection measures, including disposable clothing and microbiological masks, is indicated for strict contact isolation situations. Although the CDC recommends that personnel with known or suspected viral hemorrhagic infections be handled with contact precautions, US military units may be placed under political pressure from foreign governments to severely isolate, and possibly evacuate, such patients. Concern for troops or other personnel succumbing to infectious diseases could initiate the mobilization of the high-containment Aeromedical Isolation Team based at the US Army Medical Research Institute of Infectious Diseases at Fort Detrick, Md. High-containment isolation provides a means by which medical personnel can be physically separated from the patient by a microbiological barrier. The Aeromedical Isolation Team, using the Vickers Patient Isolation System (Figure 40-1), provides such a barrier by enclosing the patient in a negatively pressurized transparent plastic envelope and filtering the exhausted air. Facilities in the form of half-suits or glove-sleeves are provided in the envelope walls of each isolator so patient care procedures can be carried out without breaking the microbiological barrier. The patient could then be safely transported to a facility with the capability of caring for patients with such infectious diseases.

As noted, care of viral hemorrhagic fever patients

Fig 40-1. The Vickers Patient Isolation System
Photograph: Courtesy of Brenda Roup.

necessitates proper clothing. This would include a scrub suit (or a similar inner layer), a thick set of gloves over a thin set, rubber boots or overshoes if the floor is soiled, a surgical or disposable gown with long sleeves and cuffs, a plastic apron, a HEPA-filter or other biosafety mask, a cotton head covering, and eye protection.[16] Personnel with cuts or broken skin on their hands should refrain from direct contact with these patients. After use, protective clothing should be removed carefully and according to a written standard operating procedure to avoid contamination of the provider or environment. The clothing should be disinfected or laundered appropriately. Gloves, boots, and aprons can be disinfected with 1:100 bleach solution. If possible, providers should shower before putting on street clothes.

Decontamination of sewage, disinfection of excreta, and terminal disinfection of patient-care spaces are also indicated for high-level isolation situations, such as with viral hemorrhagic fever patients. Health care providers involved with the care of these patients should be under medical surveillance.

Moving Patients

Limiting the movement and transport of infected patients and ensuring that they leave their tents or areas only for essential purposes reduces the opportunities for transmission of infections in health care facilities. When patient transport is necessary, whether the patient is having a procedure in another area or is being evacuated from the facility, it is important that risk-appropriate barriers are worn or used by the patient to reduce the opportunity for transmission of microorganisms. The barriers used will depend on the route of transmission of the disease. It is also crucial that the personnel in the area to which the patient is to be taken be notified of his or her impending arrival and the special precautions to be used. Patients must also be informed of their responsibilities to prevent the transmission of infections, such as wearing masks.

VECTOR-BORNE DISEASE CONTAINMENT

Vector transmission, while generally not a problem in US-based facilities characterized by screens and central air conditioning, may be a problem during deployment. Standard precautions are recommended for patients with such infections, whether within or outside of the treatment area. Mosquitoes, which transmit various types of encephalitis and dengue fever, as well flies, ticks, fleas, lice, and mites, can be problematic and spread diseases from person to person. For example, patients viremic with the dengue virus during US military operations in Haiti in the 1990s were recognized as a potential threat to other patients in the same treatment facility. Such basic procedures as keeping tent flaps or doors closed and using mosquito bednets that have been impregnated with an insecticide such as permethrin should assist with halting the spread of these and other vector-borne diseases.

HANDLING OF LINEN, SHARPS, SPECIMENS, AND TERMINAL CLEANING

The risk of disease transmission from soiled linen is usually small, even in a deployed setting, if it is handled, transported, and laundered in a manner that avoids the transfer of microorganisms to patients, personnel, and the facility environment. Sanitary and common sense storage and processing of clean and soiled linen will usually be adequate. Laundry practices that include hot water (71°C [160°F] and above), vigorous washing action, and a laundry detergent will remove soil and microorganisms, to include scabies, lice, and the hemorrhagic fever viruses. Placing linen from patients in two bags, commonly known as "double bagging," is not usually necessary, unless the linen is soiled with blood or body fluids and has the potential to leak through the original bag.[9] In caring for patients deserving strict contact isolation, though, linens and contaminated protective clothing should be placed in a bag in the patient's room, the exterior of the bag decontaminated with hy-

pochlorite in an anteroom, and then the decontaminated bag placed into another bag before being taken into clean common space. Hands should also be washed in the transition zone between the patient's room and the clean area. Instruments, such as blood pressure cuffs, for patients in strict isolation should only be used for that one particular patient.

Whatever the infectious disease, no special precautions are needed for decontaminating dishes, glasses, cups, or eating utensils. Either disposable or reusable dishes and utensils may be used for patients on isolation precautions. The combination of hot water and a detergent is sufficient to decontaminate such articles.

The tent or area and furniture of a patient who has been placed on some type of isolation precautions may be cleaned using the same procedures used for other patients. No special "airing" of the area or special procedures need to be used in most cases. However, for surfaces potentially contaminated with excreta, blood, or respiratory tract secretions, thorough cleaning and disinfection is indicated. Enterococci are especially prone to survive on inanimate objects for a long time. Facility waste should be disposed of in accordance with US and local laws.

Sharps safety should be maintained, and sharps should be disposed of in some type of rigid container at the point of use. If possible, sharps containers should be made of a rigid plastic that will not allow the sharps to penetrate the container. The disposal containers may be placed between each patient's bed or secured in some manner to the bed to facilitate rapid and safe disposal. When potentially contagious patient specimens are transported, placement in properly labeled, clear double plastic bags is indicated. To prevent contamination, the outer bag should only be handled with clean hands or a new pair of gloves.

HANDLING OF CADAVERS

A persistent myth is that cadavers pose a serious risk of starting epidemics if they are not buried or burned promptly. This is particularly true after natural disasters. Although dead bodies have been associated with the transmission of certain infections that were present before death, dead bodies resulting from a natural disaster usually do not pose a high priority public health threat. The handling of patients who have died of known or suspected infectious diseases should not present difficulties, but there are several principles to remember. The first is protection for the health care worker while preparing the body. Gloves and gowns, at a minimum, should be worn because of the opportunity for contact with blood and body fluids. The health care worker should also wear a mask if the patient was infected with a respiratory disease when he died. After preparation, the cadaver should be carefully identified as having had an infectious disease, and that disease should be written on the identification tags attached to the body.

According to the CDC, patients who have died as a result of a hemorrhagic fever virus should be handled with contact precautions. Those preparing the body should wear protective clothing as indicated for those working in the patient care isolation area. During the preparation of the body, it and the surrounding area should be sprayed with a 1:10 bleach solution. After placing the body in the body bag, the bag should also be sprayed with this solution and placed in a sealed, leakproof coffin. The coffin exterior should be disinfected and rinsed if contaminated. Those handling the body bag should be suitably protected. The body should then be transported safely for deep burial (at least 2 m deep).[16]

FUTURE RESEARCH

Much infection control doctrine for the deployed setting remains to be written. Considerable research remains to be done regarding the best ways of mitigating risk to combat lifesavers, medics, other health care providers, and patients. Studies should assess the proper role of "waterless" disinfectants in settings where recommended bloodborne precautions cannot be adequately implemented. New diagnostics should be tested and placed far forward to facilitate earlier diagnosis, not only for the benefit of the patient but also to protect those in the patient care and evacuation system. More effective diagnostic algorithms should be tested and employed to rapidly identify patients who should be segregated. Questions about when an exposed health care provider should be put into isolation and when he or she should be given prophylactic medications need to be addressed.

SUMMARY

Each deployed military medical unit, whether a hospital, clinic, or forward treatment area, must ensure that all personnel are familiar with the unit's infection control policies and procedures. Such an orientation should include the location and procurement of equipment and supplies necessary to accomplish required infection control activities. The principles of infection control and prevention in a deployed setting are the same wherever the deployment may be. The institution of the three levels of control should ensure that community-acquired infections are not transmitted to other patients and that facility-acquired infections are kept to a minimum. If logistical support fails or is interrupted, cleanliness in all things is still the goal.

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