INFECTION CONTROL: 2008 REVIEW AND UPDATE FOR ELECTRONEURODIAGNOSTIC TECHNOLOGISTS*

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ABSTRACT. In 1995 and 2000, recommendations for infection control in electroneurodiagnostic laboratories were published in this journal (Altman 1995, Altman 2000). This article is an update of those recommendations, reviewing books, journal articles, and information appearing on the Internet from 1995 through 2008. Knowledge of current infection control practices and recommendations is essential for every electroneurodiagnostic technologist, no matter if you work in a hospital, in an ambulatory setting, in an intensive care unit, or in the operating room. All technologists who have direct patient contact are responsible for ensuring effective infection control.

KEY WORDS. Creutzfeldt-Jakob disease, disinfection, hand hygiene, infection control, infectious waste, personal protective equipment, standard precautions, sterilization, transmission-based precaution, variant Creutzfeldt-Jakob disease.

INTRODUCTION

This article is intended to help technologists understand and implement effective infection control practices. Electroneurodiagnostic (END) departments should have infection control policies and procedures that reflect individual needs and clinical situations. The recommendations in this document are based on current infection control practices and knowledge. Since infection control is an active process, technologists need to incorporate new information as it becomes available. There are many organizations devoted to infection control and safety issues that can provide valuable resources to technologists. Most can be accessed through the Internet. The following list is by no means comprehensive but provides a good starting point for current information: Association for Professionals in Infection Control and Epidemiology (APIC), www.apic.org; Society for Healthcare Epidemiology of America (SHEA), www.shea-online.org; Association of periOperative Registered Nurses (AORN), www.aorn.org; Centers for Disease Control and Prevention (CDC), www.cdc.gov; Occupational Safety and Health Administration (OSHA), www.osha.gov; the Environmental Protection Agency (EPA), www.epa.gov; The Joint Commission [formerly known as the Joint Commission for Accreditation of Healthcare Organizations (JCAHO)], www.jointcommission.org; and the World Health Organization, www.who.int.

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Healthcare-associated infection (HAI) has replaced the term nosocomial infection to better reflect the changing patterns in healthcare delivery (CDC 2007a). Patients are found in multiple healthcare settings – home care, ambulatory care, free-standing specialty care sites, long-term care, and hospitals. And patients frequently move among the various settings within a healthcare system. All of this adds to the difficulty in determining the geographic site of exposure to an infectious agent and/or the acquisition of infection (CDC 2007a).

**INFECTION TRANSMISSION**

Infection control practices place emphasis on interrupting the spread of infection at the point of transmission between source and host. For infection transmission to occur there must be a source of infection, a susceptible host, and a transmission pathway.

**Source**

Sources of infection are reservoirs of infectious organisms. The organisms may be bacterial, viral, fungal, or parasitic, but most commonly bacterial or viral. People provide the source for the majority of infectious organisms; however, inanimate objects may also act as reservoirs.

**Host**

Hosts are sites for new infection; they often become new sources of infection. A host needs an opening or gate for an infectious organism to enter. Once inside, the infectious organism may afflict a susceptible host. Factors affecting host susceptibility include age, immune status, underlying disease, and therapeutic treatments or procedures.

**Modes of Transmission**

Transmission pathways allow infectious organisms to leave their sources and connect with new hosts. Infection may be transmitted directly, from source to host; or indirectly, from source, to inanimate object, to host. There are five main routes of transmission: contact, droplet, airborne, common vehicle, and vectorborne (CDC 2007a).

Contact transmission is direct or indirect, and is the most frequent mode of infection transmission. Direct contact transmission occurs when microorganisms are transferred from one person to another person. Indirect contact transmission occurs when the infecting agent is transferred through a contaminated intermediate object (e.g., a toy) or person.

Droplet transmission occurs primarily through coughing, sneezing, talking, or during certain procedures such as suctioning and bronchoscopy. Droplets do not remain suspended in the air but are deposited on conjunctivae, nasal mucosa, or the mouth.

Airborne transmission occurs by dissemination of particles through the air or dust. The particles remain suspended in the air for long periods of time.

Common vehicle transmission refers to infection transmitted by items such as food, water, medications, and equipment.

Vectorborne transmission occurs through animals and insects such as rats and mosquitoes.
STANDARD PRECAUTIONS AND TRANSMISSION-BASED PRECAUTIONS

The CDC (2007a) recognizes two isolation categories, Standard Precautions and Transmission-Based Precautions. Standard Precautions assume that every person is potentially infected or colonized with an organism that could be transmitted. Standard Precautions are used for all patients in all healthcare settings and apply to blood; all body fluids, secretions, and excretions except sweat; nonintact skin; and mucous membranes. Transmission-Based Precautions provide supplemental practices for airborne, droplet, and contact infections. They are used in conjunction with Standard Precautions and for specific patients or conditions that are highly transmissible or significant.

The CDC’s Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Setting 2007 (CDC 2007a) identifies three areas of practice added to the 1996 Standard Precautions: 1) respiratory hygiene/cough etiquette, 2) safe injection practices, and 3) use of masks for insertion of catheters or injection of material into the spinal or epidural spaces via lumbar puncture procedures.

Respiratory hygiene/cough etiquette applies to all persons who enter a healthcare setting including healthcare personnel, patients, and visitors. The respiratory hygiene/cough etiquette recommendations include covering the mouth/nose with a tissue when coughing and prompt disposal of used tissues, using surgical masks on the coughing person when tolerated, hand hygiene after contact with respiratory secretions, and separation (ideally greater than three feet) of persons with respiratory infections in common waiting areas. Healthcare personnel should observe Droplet Precautions and hand hygiene when examining and caring for patients with signs and symptoms of a respiratory infection. Healthcare personnel who have a respiratory infection are advised to avoid direct patient contact.

Safe injection practices recommend sterile, single-use disposable needle and syringe for each injection. Use of single dose vials is preferred over multiple dose vials.

The individual placing a catheter or injecting material into the spinal or epidural space should wear a mask. Bacterial meningitis most likely caused by droplet transmission of oropharyngeal flora into the cerebrospinal fluid is a concern (CDC 2007a).

Standard Precautions

Hand Hygiene. Hand hygiene includes both handwashing with either plain or antiseptic-containing soap and water and the use of alcohol-based products (gels, rinses, foams) that do not require water. If no visible soiling of the hands is seen, alcohol-based products are preferred over plain or antiseptic-containing soap and water due to their superior microbiocidal activity, reduced drying of the skin, and convenience. However, with Clostridium difficile (C. diff) the use of soap and water, rather than alcohol-based products, for mechanical removal of spores from hands is recommended (CDC 2007a). Perform hand hygiene after touching blood, body fluids, secretions, excretions, and contaminated items, whether or not gloves are worn. Perform hand hygiene immediately after gloves are removed, between patient contacts, and when otherwise indicated to avoid transfer of microorganisms to other patients or environments. Perform hand hygiene between tasks and procedures on the same patient to prevent cross-contamination of different body sites.

Gloves. Wear gloves when touching blood, body fluids, secretions, excretions, and contaminated items. Put on clean gloves just before touching mucous membranes and nonintact skin. Change gloves between tasks and procedures on the same patient.
after contact with material that may contain a high concentration of microorganisms. Change gloves after touching the patient and before touching computer keyboards or other mobile equipment that is transported from room to room. Remove gloves promptly after use, before touching noncontaminated items and environmental surfaces, before going to another patient, and perform hand hygiene immediately to avoid transfer of microorganisms to other patients or environments. Clean, nonsterile gloves are adequate in most situations. When gloves are worn with other personal protective equipment, they are put on last.

Mask, Eye Protection, Face Shield. Wear a mask and eye protection or a face shield to protect mucous membranes of the eyes, nose, and mouth during procedures and patient care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions. Masks should be worn by healthcare personnel during procedures requiring sterile technique to protect patients from exposure to infectious agents carried in the healthcare worker’s mouth or nose. Masks are placed on coughing patients to limit the spread of infectious respiratory secretions. Personal eyeglasses and contact lenses are not adequate eye protection.

Gown. Wear a gown to protect skin and to prevent soiling of clothing during procedures and patient care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions. Select a gown that is appropriate for the activity and amount of fluid likely to be encountered. Remove a soiled gown before leaving the patient’s room, and perform hand hygiene to avoid transfer of microorganisms to other patients or environments. Clean, nonsterile gowns are adequate. Do not reuse gowns, even for repeated contacts with the same patient.

Patient Care Equipment. Handle used patient care equipment soiled with blood, body fluids, secretions, and excretions in a manner that prevents skin and mucous membrane exposures, contamination of clothing, and transfer of microorganisms to other patients and environments. Ensure that reusable equipment is not used for the care of another patient until it has been cleaned and disinfected appropriately. Ensure that single-use items are discarded properly.

Environmental Control. Ensure there are adequate procedures for the routine care, cleaning, and disinfection of environmental surfaces, beds, bed rails, bedside equipment, and other frequently touched surfaces.

Linen. Handle, transport, and process used linen soiled with blood, body fluids, secretions, and excretions in a manner that prevents skin and mucous membrane exposures and contamination of clothing, and that avoids transfer of microorganisms to other patients and environments.

Occupational Health and Bloodborne Pathogens. Take care to prevent injuries when using needles, scalpels, and other sharp instruments or devices; when handling sharp instruments after procedures; when cleaning instruments; and when disposing of used needles. Never recap used needles, or otherwise manipulate them using both hands, or use any other technique that involves directing the point of a needle toward any part of the body. Use either a one-handed scoop technique or a mechanical device designed for holding the needle sheath if it is necessary to recap needles or sharps. Do not remove used needles from disposable syringes by hand, and do not bend, break, or otherwise manipulate used needles by hand. Place used disposable syringes and needles, scalpels blades, and other sharp items in appropriate puncture-resistant containers, which are located as close as practical to the area in which the items were used. Place reusable syringes and needles in a puncture-resistant container for transport.
to the reprocessing area. Use mouthpieces, resuscitation bags, or other ventilation devices as an alternative to mouth-to-mouth resuscitation methods.

Patient Placement. Use a single patient room for patients who contaminate the environment or who cannot be expected to assist in maintaining appropriate hygiene or environmental control.

Transmission-Based Precautions

Airborne Precautions. Airborne Precautions are used in addition to Standard Precautions for patients known or suspected to be infected with microorganisms transmitted by airborne droplet nuclei or evaporated droplets that remain suspended in the air. The microorganisms can be dispersed widely by air currents within a room or over a long distance. Examples of illnesses transmitted by airborne microorganisms include measles, varicella, and tuberculosis. Place the patient in an airborne infection isolation room that has monitored negative air pressure, 6 (existing facility) to 12 (new construction/renovation) air exchanges per hour, and appropriate discharge of air outdoors or high-efficiency filtration (CDC 2003). Keep room door closed and the patient in the room. Wear respiratory protection when entering the room of a patient with known or suspected infectious pulmonary tuberculosis. Respiratory protection with National Institute for Occupational Safety and Health (NIOSH) certified N95 or higher level respirator is recommended (CDC 2007a). A user-seal check (“fit check”) should be performed each time a respirator is donned to minimize air leakage around the face. Susceptible persons should not enter the room of patients known or suspected to have measles (rubella) or chickenpox (varicella) if other immune caregivers are available. If susceptible persons must enter the room they should wear respiratory protection. Persons immune to rubella or varicella need not wear respiratory protection. Limit the movement and transport of the patient from the room to essential purposes only. If transport or movement is necessary, minimize patient dispersal of droplet nuclei by placing a surgical mask on the patient. Refer to the Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Settings, 2005 (Jensen et al. 2005) for additional prevention strategies. This document is available on the CDC website.

Droplet Precautions. Droplet Precautions are used in addition to Standard Precautions for patients known or suspected to be infected with microorganisms transmitted by large droplets generated during coughing, sneezing, talking, or during procedures such as suctioning, endotracheal intubation, cough induction by chest physiotherapy, and cardiopulmonary resuscitation. Examples of illnesses transmitted by droplets include influenza, diphtheria, mumps, and rubella. Use a single patient room or place the patient in a room with a patient who has an active infection with the same microorganism but no other infections. Special air handling and ventilation are not necessary and the door may remain open. Wear a mask when coming into contact with the patient. Limit the movement and transport of the patient from the room to essential purposes only. If transport or movement is necessary, minimize patient dispersal of droplet nuclei by placing a surgical mask on the patient.

Contact Precautions. Contact Precautions are used in addition to Standard Precautions for patients known or suspected to be infected with microorganisms transmitted by direct and indirect contact. Transmission may occur when performing care that requires touching the patient (direct contact), or when touching environmental surfaces or patient care items in the patient’s environment (indirect contact). Examples of illnesses transmitted by contact include herpes simplex virus, impetigo, lice, and scabies. Use a single patient room or place the patient in a room with a patient who has active infection with the same microorganism but no other infections.
Wear a gown and gloves when entering the room since the nature of the interaction with the patient cannot be predicted with certainty and contaminated environmental surfaces can transfer microorganisms. Change gloves after having contact with infective material that may contain high concentrations of microorganisms. Remove the gown and gloves when leaving the patient’s environment and perform hand hygiene. After gown removal, ensure that clothing does not contact potentially contaminated environmental surfaces to avoid transfer of microorganisms to other patients or environments. After glove removal and hand hygiene, ensure that hands do not touch potentially contaminated environmental surfaces or items in the patient’s room to avoid transfer of microorganisms to other patients or environments. Limit the movement and transport of the patient from the room to essential purposes only. If transport or movement is necessary, minimize patient contact with others and environmental surfaces. Dedicate the use of noncritical patient care equipment to a single patient to avoid sharing between patients. If use of common equipment or items is unavoidable, then adequately clean and disinfect before use on another patient.

**OSHA BLOODBORNE PATHOGENS FINAL RULE**

The Occupational Safety and Health Administration’s (OSHA) Bloodborne Pathogens Final Rule published in 1991 required healthcare workers to follow specific practices such as wearing gowns and protective apparel under specified circumstances to reduce the risk of exposure to bloodborne pathogens. The Final Rule was revised in 2001 to conform to the Needlestick Safety and Prevention Act and is titled *Occupational Exposure to Bloodborne Pathogens; Needlestick and Other Sharp Injuries; Final Rule* (OSHA 2001). The bulk of the OSHA recommendations for infection control of bloodborne pathogens are incorporated into the guidelines for Standard Precautions.

The Final Rule requires healthcare workers to participate in annual bloodborne pathogen training to reduce the risk of occupational transmission of infectious disease. Online courses titled “Bloodborne Pathogen Training for Healthcare Workers” and “Bloodborne Pathogen Training for Healthcare Supervisors” are available through the ASET website – www.aset.org. These courses are located in the Online Education portal under General Health Studies.

The 2001 Final Rule revision requires that Exposure Control Plans reflect how employers implement new developments in control technology; requires employers to solicit input from employees responsible for direct patient care in the identification, evaluation, and selection of engineering and work practice controls; and requires certain employers to establish and maintain a log of percutaneous injuries from contaminated sharps. OSHA believes engineering controls such as needleless and shielded needle devices can prevent worker exposure to bloodborne pathogens including human immunodeficiency virus (HIV), hepatitis B, and hepatitis C. The 2001 Final Rule is available on OSHA’s website. Noncompliance with the Final Rule can result in significant financial penalties.

**INFECTIOUS WASTE**

Healthcare workers must treat infectious waste in accordance with OSHA and local governing agencies. Infectious waste is a solid waste or mass that may contain pathogens and, if contact with a susceptible host occurs, could result in transmission of an infectious disease. OSHA in its document *Bloodborne Pathogens – 1910.1030* (OSHA 2006) defines infectious waste as follows (state and local regulatory agencies also define infectious waste, and they may provide more stringent definitions):

- Liquid or semiliquid blood or other potentially infectious materials,
• Contaminated items that would release blood or other potentially infectious materials in a liquid or semiliquid state if compressed,
• Items that are caked with dried blood or potentially infectious materials and are capable of releasing these materials during handling,
• Contaminated sharps, and
• Pathological and microbial wastes containing blood or other potentially infectious materials.

Disposal

Healthcare workers need to wear gloves and other protective barriers as appropriate when handling and disposing of infectious waste. Standard Precautions should be observed to prevent contact with blood or other potentially infectious materials. Under circumstances in which differentiation between body fluid types is difficult or impossible, all body fluids should be considered potentially infectious materials (OSHA 2006). Infectious waste must be handled separately from usual trash and treated prior to final disposal and in accordance with local governing agencies and OSHA.

HAND HYGIENE

Hand hygiene is the single most important means of preventing the spread of infection. Wearing gloves does not replace the need for hand hygiene. Using the proper hand hygiene technique is critical to the effectiveness of infection control measures. When using an alcohol-based hand rub, apply the product to the palm of one hand and rub hands together, covering all surfaces of the hands and fingers, until the hands are dry. Follow the manufacturer’s recommendations regarding the volume of product to use. When washing hands with soap and water, wet hands first with water, apply an amount of product recommended by the manufacturer to the hands, and rub hands together for at least 15 seconds. Rinse hands with water and dry thoroughly with a disposable towel. Use the towel to turn off the faucet. Avoid using hot water, because repeated exposure to hot water may increase the risk of dermatitis (CDC 2002).

OSHA (2006) requires all employers to provide handwashing facilities which are readily accessible to employees. When provision of handwashing facilities is not feasible, the employer must provide either an appropriate antiseptic hand cleanser in conjunction with clean cloth/paper towels or antiseptic towelettes.

The CDC (2007a) recommends that artificial fingernails and extenders not be worn by healthcare personnel who have contact with high-risk patients (e.g., patients in ICUs, ORs) due to the confirmed association with outbreaks of gram-negative bacillus and candidal infections. Many healthcare settings have policies that ban artificial nails for all healthcare personnel.

CLEANING AND DISINFECTION

Cleaning

Cleaning is the removal of all visible dust, soil, and any other foreign material. Physical cleaning eliminates large numbers of organisms associated with soiled areas or items. You should follow these guidelines for cleaning:

• Use a detergent (soap) or detergent-disinfectant to clean equipment and instruments according to manufacturer recommendations; not all detergents remove all types of soil.
• Cleaning involves the removal of all dust, organic matter such as blood and tissue, as well as any other residual matter.
• Antiseptic soaps should not be used to clean inanimate objects; they are designed for use on skin and tissue.
• Use of detergent-disinfectants on skin or tissue causes adverse reactions; therefore, gloves are recommended when cleaning with these products.
• Spot clean walls if spills and splashes occur and clean completely when very soiled.
• Clean floors by wet mopping, wet vacuuming, or dry vacuuming. Never dry sweep areas since that causes significant dissemination of microorganisms into the air.
• Clean equipment and furnishings with a clean cloth soaked with detergent or disinfectant-detergent solutions. Peripheral patient care items, e.g., chairs in waiting rooms or curtains in exam rooms, pose very little infection risk.
• Always clean items before disinfecting to remove visible dust, soil, or foreign materials. If items are not thoroughly cleaned, disinfection could be ineffective. Completely disassemble items whenever possible before cleaning.
• Items that touch nonintact skin, mucous membranes, blood and body fluids, or penetrate the body need intermediate- to high-level disinfection or sterilization after cleaning.
• Make sure items are completely dry after cleaning and before packaging or reprocessing for sterilization.
• Important to include computers and digital assistants (PDAs) used in patient care in policies for cleaning and disinfection of non-critical items.

Disinfection

Disinfection involves the destruction of many or all infectious organisms on inanimate objects. The CDC recognizes four levels of disinfection: sterilization, high-level disinfection, intermediate-level disinfection, and low-level disinfection (Rutala and Weber 2004).

Sterilization. In general, sterilization is required to destroy all microorganisms, including bacterial spores. Sterilization is necessary for critical items, which are those that enter tissue or vascular space (e.g., needles, implants, and surgical tools) or those through which blood flows. Critical items have a high risk of infection if contaminated with microorganisms. Critical items should be purchased as sterile or sterilized by steam sterilization (Rutala and Weber 2004). Sterilizers should be routinely tested with biological indicators to ensure that they are working correctly (APIC 2005).

If the product is heat labile, ethylene oxide (ETO), hydrogen peroxide gas plasma, or liquid chemical sterilants may be more appropriate. Steam autoclave sterilization is overall the most effective and least costly form of sterilization but cannot be used with heat- and moisture-sensitive materials. ETO chemical sterilization is highly effective for heat- and moisture-sensitive items. It destroys microorganisms by preventing cell metabolism or reproduction. ETO sterilization is toxic to the environment so must be used in accordance with OSHA and local governing agencies; it is expensive and requires special packaging materials; and the processing time is lengthy and requires aeration for up to 12 hours. Liquid chemical sterilants are a reliable measure of sterilization only if thorough cleaning which removes all organic and inorganic material precedes the treatment, and if proper guidelines for concentration, contact time, temperature, and pH are followed (Rutala and Weber 2004).

High-Level Disinfection. High-level disinfection is appropriate to inactivate the human immunodeficiency virus (HIV), hepatitis B virus (HBV), and mycobacterium
tuberculosis (APIC 2005). High-level disinfection is used for semicritical items that contact mucous membranes or nonintact skin, such as respiratory and anesthesia equipment and endoscopes. Semi-critical items must be free of all but bacterial spores since intact mucous membranes are generally resistant to infection by bacterial spores but susceptible to other microorganisms. Glutaraldehyde, hydrogen peroxide, orthophthalaldehyde (OPA), peracetic acid with hydrogen peroxide, and chlorine have been cleared by the US Food and Drug Administration (FDA) and are dependable high-level disinfectants when guidelines for effective germicidal procedures are followed (Rutala and Weber 2004). The exposure time for most high-level disinfectants varies from 10 to 45 minutes.

Intermediate-Level Disinfection. Intermediate-level disinfection inactivates M. tuberculosis, vegetative bacteria, most viruses and most fungi, but it does not necessarily kill bacterial spores (APIC 2005). Intermediate-level disinfection is appropriate for some semicritical items such as hydrotherapy tanks and thermometers. Sodium hypochlorite (5.25% household bleach) 1:50 dilution (1000 ppm free chlorine), ethyl or isopropyl alcohol (70 to 90%), phenolic germicidal detergent, and iodophor germicidal detergent are recommended to provide intermediate-level disinfection (APIC 2005).

Low-Level Disinfection. Low-level disinfection can kill most bacteria, some viruses, and some fungi, but it cannot be relied on to kill resistant microorganisms (e.g., M. tuberculosis or bacterial spores) (APIC 2005). Low-level disinfection is used for noncritical items. Noncritical items are those that have contact with intact skin. Since intact skin serves as a barrier to most microorganisms, noncritical items require only low-level disinfection. There is very little risk of transmitting infectious agents to patients by means of noncritical items. Ethyl or isopropyl alcohol (70 to 90%), sodium hypochlorite (5.25% household bleach) 1:500 dilution (100 ppm free chlorine), phenolic germicidal detergents, iodophor germicidal detergents, and quaternary ammonium solutions serve as low-level disinfectants. The contact time for low-level disinfection is 10 minutes or less (APIC 2005).

Selection of Disinfectants

The selection of disinfectants involves determination of the level of disinfection required, the impact of the disinfection process on the instruments or devices, the cost of the disinfection method or product, and occupational health or safety risks. The Association for Professionals in Infection Control and Epidemiology, Inc. (APIC) periodically evaluates the selection and use of disinfectants, with the last published review in 2005. The document, Disinfection and Sterilization Principles, can be viewed or downloaded from the APIC website (www.apic.org). Another good reference, and one well worth obtaining if you have responsibility for selecting or managing disinfection or sterilization products or procedures, is A Guide to Selection and Use of Disinfectants (BC Centre for Disease Control 2003). For information regarding specific disinfecting products and manufacturers, the FDA offers a list of sterilants and high-level disinfectants approved for use in reprocessing reusable medical equipment. The list is posted on the FDA website, www.fda.gov/cdrh/ode/gemlab.html.

Factors Affecting Disinfection

In order for disinfection to be effective, you need to closely follow product or procedure recommendations for proper use. Inadequate cleaning prior to disinfection can reduce the effectiveness of a product. The amount of contaminant on the item, if excessive, may require more vigorous disinfection than otherwise expected. Items with complex or multifaceted physical configurations may be difficult to process and may not allow disinfectants to reach all surface areas. The temperature and pH of the disinfecting
process, if inadequate, may adversely affect the end results. The concentration and exposure time of the disinfectant must be followed specifically to achieve the desired level of disinfection. For example, some disinfectants achieve both sterilization and high-level disinfection, with the difference related to the exposure time. Some products require wet contact for a certain period of time to achieve the desired level of disinfection so are not effective as spray mists.

**Determining Appropriate Disinfectant Products or Techniques**

Trying to identify the appropriateness of a disinfectant for a particular situation is often difficult for the inexperienced. Product information on chemical disinfectants may be confusing, incomplete, or hard to understand. When in doubt, you should always contact the product manufacturer or an infection preventionist; however, the following tips may help you wade through your initial review.

Look at the product information to see what actions a product has against microorganisms. For example, look to see if it is a sporicide, sterilant, tuberculocide, viucide, fungicide, and/or disinfectant, and you get an idea about its effectiveness. Since bacterial spores are most resistant to disinfection, products that identify themselves as sporicides or sterilant/disinfectants are usually appropriate for sterilization and high-level disinfection. Products identified as tuberculocides or hospital disinfectants with tuberculocidal activity are usually appropriate for intermediate-level disinfection. Hospital disinfectants without claims for tuberculocidal activity are generally low-level disinfectants. Again, if you are unclear of a product's effectiveness or unsure of your interpretation, you need to contact the manufacturer or an infection preventionist for more specific information.

A look at the chemical family can also help you determine the appropriateness of a product for your situation. For example, quaternary ammonia products are almost always low-level disinfectants. They are good cleaning products for hard surfaces, but should not be used with materials such as cotton or gauze since they absorb the active ingredients and make quaternary products less effective. Hydrogen peroxide is an excellent high-level disinfectant but is highly corrosive to metals. A Guide to Selection and Use of Disinfectants (BC Centre for Disease Control) provides an excellent discussion of the chemical properties and actions of disinfectants including alcohol, chlorine and chlorine compounds, glutaraldehyde, iodophors, peracetic acid, phenolics, and quaternary ammonium compounds.

**Important Guidelines for Liquid Chemical Disinfectant Use**

Read product labels for actions and instructions. A perfectly acceptable disinfection process will fail if not applied for sufficient time or under proper conditions. Thoroughly clean items before disinfection. If articles are not properly cleaned, the disinfection process may be ineffective. Dry items before submerging them to avoid dilution of the disinfectant. Thoroughly rinse and dry items after disinfecting, taking care not to recontaminate. Rinse in sterile water and package in sterile materials if appropriate. Rutala and Weber (2004) recommend rinsing semicritical items in sterile water to prevent contamination with organisms that may be present in tap water. Completely submerge items for the required time; only surfaces in direct contact with the disinfectant solution are affected. Be sure items are open or disassembled whenever possible. Use disinfectants for inanimate objects only. Disinfectants are damaging to the skin so always follow the safety precautions and wear protective equipment as outlined in the material data safety sheet (MSDS). The stronger the disinfectant, the more toxic it is to humans. Use only in well-ventilated areas and follow OSHA guidelines when using glutaraldehyde products.
As a general rule, if exposure times are not documented or unclear; expose items to liquid chemical disinfectants for at least 20 minutes at room temperature for high level disinfection; at least 10 minutes for intermediate level disinfection. In general, the more concentrated the disinfecting product or the longer the exposure of an item to a disinfectant, the more likely that all contaminating microorganisms will be inactivated, but the more likely the item will be damaged. For disinfectants that can be used at various concentrations (e.g., sodium hypochlorite), the more concentrated the product the less time required to achieve a specified level of disinfection.

New disinfectant products continue to be introduced into the healthcare market; therefore, selection and use of disinfectants in the healthcare setting is an active process. Healthcare workers should evaluate product claims based on manufacturer information as well as reports in the scientific literature.

**Sodium Hypochlorite (NaOCl)/Bleach**

Sodium hypochlorite is a chlorine compound that is effective against a broad spectrum of microbes including gram positive and gram negative bacteria as well as viruses. It can be used for high-, intermediate-, and low-level disinfection. Chlorines are inexpensive, fast acting, and offer low levels of toxicity and irritancy to healthcare workers and patients. Sodium hypochlorite is a strong oxidizer that discolors and corrodes metals (especially copper, aluminum, brass, stainless steel, chrome, and silver). The following items apply to use of sodium hypochlorite:

- Devices must be thoroughly cleaned before immersion when using sodium hypochlorite.
- A 1:50 dilution means to add one part bleach to forty-nine parts water; a 1:10 dilution means to add one part bleach to nine parts water.
- Household bleach contains 3 to 6 % usually 5.25%, sodium hypochlorite. The strength varies from one manufacturer to another and gradually decreases over time.
- A Dakin solution is a highly diluted neutral solution of 0.45 to 0.50% sodium hypochlorite and 0.40% boric acid used for cleaning wounds.
- Use only fresh preparations of diluted sodium hypochlorite. As a guideline, bleach dilutions of 1:5 or less should be used within 30 days of mixing. All other dilutions should be used within 24 hours of mixing.
- Pay particular attention to the dilution (strength) of a sodium hypochlorite solution identified as a disinfectant. Dilution directly affects the contact time needed to achieve a specified level of disinfection.

**SPECIFIC ELECTRONEURODIAGNOSTIC INFECTION CONTROL PRACTICES**

The following information contains suggestions for optimal infection control practices in electroneurodiagnostic departments, to be used in conjunction with Standard Precautions; Transmission Based Precautions; hospital or facility wide policies, and OSHA, CDC, FDA, and EPA guidelines. Specific department policies and procedures will vary depending on department settings and clinical situations. Policies and procedures should incorporate optimal practices whenever reasonable.

Electroneurodiagnostic departments should have infection control policies and procedures to supplement hospital or facility infection control manuals. Departmental policies cover specific areas of infection concerns and act as a resource for department employees. Departmental policies do not need to reiterate broad-based hospital or facility infection control practices unless there is special cause to emphasize a particular
area. If broad-based policies do not exist, then the department policy must address general infection control issues.

Department infection control policies and procedures should describe the scope of services provided in the department; the roles and responsibilities of department personnel; policies and procedures specifically related to department infection control; references; dates of review; and signatures of the medical director, department manager, and infection preventionist, as appropriate.

**Gloves and Protective Barriers**

The best policy for use of gloves during electrode application and removal is to require personnel to wear gloves for all patient contacts, regardless of the potential for contact with blood, body fluids, or microorganisms. This universal glove policy eliminates the need for the technologist to make a judgment call regarding potential exposure and eliminates the risk of contamination due to unforeseen risk.

Wear gloves to measure and mark electrode locations, to apply surface electrodes, and to remove electrodes. Many commercially available skin preparation agents contain an abrasive element that scrapes the skin and breaks the surface, potentially exposing technologists to blood and other body fluids (Bild 1997). When using blunted syringe tips to insert electrolyte, there is the risk of abrasion, resulting in potential exposure to blood or other body fluids (Bild 1997, OSET 1999, Cusano et al. 1998).

Wear gloves when inserting, working with, and removing needle electrodes (Schneider 2006).

Remove gloves and perform hand hygiene before touching the END instrument and/or computer keyboard.

Wear gloves and protective barriers when touching potentially contaminated electrodes, thermocouples, CPAP masks; when emptying and cleaning bedpans or urinals; and during transportation and preparation of items for disinfection. Do not touch writing devices, instruments, doors, or other items after handling soiled equipment or when moving from one area to another, until hand hygiene is performed.

Wear gloves and protective barriers when entering surgical suites, handling babies in the nursery or neonatal intensive care area, when entering isolation areas, or when there is anticipated exposure to blood, body fluids, or specific microorganisms.

Wear gloves and protective barriers when using or handling disinfectants.

**Electrodes and Syringe Tips**

Use single use, disposable items whenever possible. Syringe tips and needle electrodes should not be reprocessed if they are sold as disposable items. If reusable, they should be reprocessed only if the cost to reprocess is less than the cost to replace.

When considering disposable versus reusable items, look at the quality of the products, the personnel and time needed for reprocessing, safety, life of the reusable item, cost, reprocessing time for sterilization, frequency of use, problems associated with disposal of products, and storage space. Resterilization of items can be expensive when considering the time required to clean and package items, and the cost of the sterilization method used. Manufacturers state in catalogs and on package inserts: “Sterilization of multiple-use products and their applications and use is the sole responsibility of the user” (Rochester Electro-Medical, Inc. 2008) and “Sterilization efficacy is the user’s responsibility” (Grass Technologies 2008).
Have specific instructions on how to prepare, package, and sterilize reusable needle electrodes if a central reprocessing center does not do this for you. For instance, employees should not handle contaminated sharps with their hands, even if gloved, while cleaning items before sterilization. Departments may want to purchase several pairs of tongs, forceps, or tweezers for employees to grip contaminated items. They can hold contaminated sharps with utensils while rinsing items under cold running water. They can use one utensil to hold a contaminated item while using another to hold a piece of gauze in order to wipe surface dirt from the contaminated item. There are products on the market, such as enzymatic cleaners or vibrating devices, that may be appropriate for cleaning contaminated sharps and do not require physical movement over items; they further reduce the risk for needle stick injuries.

Do not recap needle electrodes unless specific situations warrant such action. If you must recap needles, never use two-handed techniques. There are many methods and devices to protect healthcare workers if recapping between testing sites is necessary. An effective method involves placing the needle cap into a piece of stiff foam attached to a nearby wall or instrument. The foam holds the cap in place and eliminates the need to hold the cap in one hand while recapping with the other. You can also use one hand to scoop the needle into the cap that is placed on a counter or other hard surface.

Do not allow needle electrodes to dangle from headboxes or to be placed on the bedside or nearby tables. Extreme care must be taken when removing and discarding needle electrodes, or when transporting the electrodes to decontamination areas for cleaning and reprocessing. A designated puncture resistant container or tray should be used to collect and transport reusable needle electrodes.

Have easily accessible, prominently labeled, contaminated sharps containers in procedure rooms and on portable instruments for disposal of needles, needle electrodes, and blunted syringe tips.

Do not soak contaminated sharps in sodium hypochlorite or other disinfectants before disposal or reprocessing. At one time this procedure was considered to reduce the potential for infection spread. OSHA (2001) does not recommend this practice currently, and it may even place healthcare workers at additional risk for needlestick injury since workers are required to handle needles more than once. The best method includes immediate disposal of contaminated items in approved contaminated sharps disposal containers or immediate preparation of items for reprocessing.

Report any needlestick incident according to the hospital/facility policy. EEG needle electrodes are solid, not hollow bore needles like injection needles, so there is no column for fluid within the needle (Schneider 2006).

**Electrolyte Products**

Use good judgment when using electrolyte pastes and gels, or any other products, directly from containers. Take care not to contaminate containers with soiled hands, electrodes, or syringes, but also remember that the contents of the containers are not sterile. Skin preparation agents, collodion, and electrolyte paste and gels are usually sold in multi-dose containers. To decrease the risk of cross-contamination, a small amount of the product should be placed into a single use container (Cusano et al. 1998). The unused portion should be disposed of and not reused.

A syringe may be used to insert the electrolyte paste or gel via a blunt tip. The syringe is a single use, disposable item and should be discarded after its use. Do not
change only the tip and reuse the syringe with the electrolyte paste or gel on another patient.

**Surface Electrodes and Airflow Monitors**

Semicritical items are devices that come in contact with mucous membranes or nonintact skin (CDC 2007a). Noncritical items are devices that come in contact with intact skin but not mucous membranes (CDC 2007a). Due to abrading techniques, whether with a commercially available skin prep product or blunted syringe tip, there is the potential to break the skin (Bild 1997, OSET 1999).

The preferred approach to electrode disinfection is to select a product that provides intermediate- to high-level disinfection and use it routinely. As a general rule, electrodes exposed to large amounts of blood or body fluids should undergo high-level disinfection. Those exposed to minor amounts of blood or body fluids can undergo intermediate-level disinfection. Disinfect airflow monitors after each use using an intermediate-level disinfectant.

Most liquid chemicals require contact with an item for a specified amount of time to be effective. This means that electrodes and monitors need to soak in a disinfecting product for the duration of the contact time to achieve a specified level of disinfection. Thoroughly clean electrodes and monitors with detergent and water after removal from the patient and before disinfection. Residual proteinaceous material reduces the effectiveness of the disinfection and sterilization processes (CDC 2007a). Allow to air dry or dry with a clean paper towel before placing in a bath of disinfectant. Depending on the disinfecting product used, you may need to rinse electrodes or monitors with tap or sterile water after disinfection. Do not allow electrodes or monitors to touch the floor, dirty hands, or contaminated areas or substances. Have containers or bags available in recording areas and on portable instruments for transport of contaminated electrodes and supplies to disinfection areas.

**Marking Pencils, Tape Measures, Electrode Wires, Toys, Pulse Oximeter Probes, etc.**

Wipe with a low-level disinfectant after each use. Allow the items to air dry.

**Environment**

Make sure each patient has clean linen. Any item that comes into contact with the patient or becomes soiled needs to be changed before use with the next patient. Determine a cleaning schedule for equipment and furnishings based on frequency and level of use. Equipment needs to be surface cleaned on a regular basis with a low-level disinfectant/detergent. If professional laundry services are not available wash contaminated linens and reusable protective clothing with laundry detergent, household bleach, and hot water. If items cannot be washed in hot water with bleach, an alternative is warm water with a phenolic household detergent. The clothing should be washed and rinsed a second time without the phenolic.

Computer keyboards must be disinfected daily, when visibly soiled, or when they become contaminated with blood. Quaternary ammonium-containing disinfectants can be used without damage to the keyboard (Rutala et al. 2006). Perform a test on one key or an old keyboard to prevent any possible bleaching or discoloring of the keys by the disinfecting agent. If a keyboard cover is used, Rutala et al. (2006) recommend that it should be disinfected daily. Mobile computers used by patients should be disinfected between patients.
Do not allow food or drink in patient testing or disinfection areas. Food and drink should be consumed in designated areas only. Do not apply cosmetics or contact lenses in patient testing or disinfection areas.

**Blood and Body Fluid Spills**

Clean blood and body fluid spills as quickly as possible. Wear gloves and use a disposable paper towel to contain and remove the gross visible material; if there is excessive material, follow the rules for disposal of infectious waste. Clean the entire contaminated surface with an appropriate disinfectant and discard paper towels and gloves in the trash. The CDC (2003) recommends the use of an intermediate-level chemical germicides approved by the EPA. If the surface is nonporous, the CDC (2003) approves the use of a 1:100 dilution of 5.25% sodium hypochlorite (household bleach) for cleaning blood spills if mixed fresh. Gloves and goggles should be worn when preparing and using hypochlorite solutions or other chemical germicides.

**Disinfection**

Acetone is not a cleaning or disinfecting agent. Sufficient quantities of frequently used equipment should be available to allow appropriate time for cleaning and disinfecting between uses. To determine the type and level of disinfection required for electroneurodiagnostic equipment, classify items as critical, semicritical, or noncritical. Determine specific uses for items, and then determine classifications for each specific use. Individual situations or practices may significantly alter the disinfection method for items from one use to another.

Manufacturers of medical devices should supply specific cleaning and disinfecting guidelines, which should be substantiated by research or infection preventionists. If you follow manufacturer suggestions, equipment should last the expected lifetime; however, alternative methods of cleaning and disinfection may be necessary. Check with manufacturers if you have questions or concerns. For instance, if a manufacturer recommends ethylene oxide gas sterilization, and you have only steam autoclave sterilization or liquid glutaraldehyde sterilization, you should talk to the manufacturer about problems you could encounter before attempting an alternative technique.

**Critical Items.** Examples of critical items that require sterilization before and after each use (many of these are currently available as single-use items):

- Needle electrodes (subdermal and EMG)
- Indwelling depth electrodes
- Electrocochleographic (subdural and epidural) electrodes
- Sphenoidal electrodes
- Tympanic electrodes
- Urethral electrodes
- Other items that enter tissue or vascular spaces or that blood flows through

**Semicritical Items.** Examples of semicritical items that require high- to intermediate-level disinfection after each use:

- Surface electrodes (with abrasive skin preparation agent/technique or blunt syringe tip)
- Nasopharyngeal electrodes
• Electroretinogram (ERG) electrodes
• Electrode caps (with abrasive skin preparation agent/technique or blunt syringe tip)
• Nasal/oral thermocouples
• CPAP/BPAP masks and tubing (Hobby 2007)
• Electrodes and all items exposed to nonintact skin or blood and body fluids

Noncritical Items. Examples of noncritical items that require cleaning and/or low-level disinfection after each use:
• Surface electrodes (no abrasive skin preparation agent/technique or blunted syringe tip)
• Electrode cap (no abrasive skin preparation agent/technique or blunted syringe tip)
• Tape measures and calipers
• Marking pencils
• Hair clips and combs
• Earphones
• Stimulator prongs
• Temperature probes that lay on the skin
• Oximeter probes
• Patient toys
• Bed rails
• Headbox and cables
• Any items that have contact with intact skin

Recording in the Operating Room

Electroneurodiagnostic personnel need to be aware of their responsibility in maintaining a relatively sterile operating room environment, and they need to follow policies and procedures that reduce the spread of infection to patients. Technologists should discuss their role in the operating room with the appropriate surgical manager since policies and procedures vary from facility to facility. Questions regarding cleaning and disinfecting of equipment and supplies should be directed to the facility infection preventionist.

Recording in the Nursery or Neonatal Intensive Care Unit

Newborn infants are at increased risk for development of infection, and premature, low-birthweight infants are at greatest risk. Electroneurodiagnostic personnel must follow policies and procedures to reduce the spread of infection when recording in the newborn nursery or neonatal intensive care unit. Because each facility has specific policies and procedures for access to infants, technologists should discuss their role in the specialized units as well as cleaning and disinfecting issues with the nurse manager and facility infection preventionist.

Lice

Electroneurodiagnostic personnel will occasionally discover the presence of head lice on a patient. Lice are insects and anyone, even those with the very best personal hygiene, can have head lice. Lice are most common in school age children and in
recent years lice have become immune to the treatments that have been used in the past (Pollack 2007).

If the patient is an inpatient, the nursing staff should be alerted. Special care should be taken to carefully clean all electrodes and surfaces of the END equipment so as not to spread the insects to the next patient. If the patient is an outpatient, you may want to establish a policy to cancel the appointment and reschedule after the lice have been eliminated.

C REU TZFELDT-J AKOB DISEASE (CJD)

The average worldwide incidence of classic Creutzfeldt-Jakob (CJD) is estimated at approximately one in one million habitants (Liras 2008). In about 85% of patients, CJD occurs as a sporadic disease with no known pattern of transmission. 5% to 15% of patients develop CJD because of inherited mutations of the prion protein gene. These inherited forms include Gerstmann-Strassler-Scheinker syndrome and fatal familial insomnia (CDC 2007b).

CJD can be transmitted via corneal transplants, cadaveric human growth hormones, cadaveric dura mater grafts, cerebrospinal fluid, human pituitary extracts, and inadequately sterilized stereotactic EEG electrodes and neurosurgical equipment used on patients with CJD (CDC 2007b). It is not known whether classic CJD can be transmitted by blood transfusion or contact with blood; experimental results investigating the infectivity of blood have been conflicting (WHO 1999). Kidney, liver, lung, lymph nodes, and spleen are categorized as potentially infective. Body fluids (except cerebrospinal fluid) are not considered even potentially infective at this time. The incubation period (time from exposure to onset of symptoms) varies from two years to many decades.

Standard Precautions are the appropriate choice for all patients. Isolation of patient with CJD is not necessary and they can be nursed in the open ward using Standard Precautions (WHO 1999).

Based on the theoretical potential for blood transmission, the Food and Drug Administration (FDA) requires both the screening of blood donors for family history or clinical symptoms of CJD and the quarantine of plasma derivatives from pooled units from CJD donors (FDA 2002).

Inactivation of CJD

The CJD prion is resistant to sterilization and disinfection by most of the physical and chemical methods in common use.

Invasive Items. Single use, disposable invasive items are strongly recommended for use with patients suspected of or confirmed with a diagnosis of CJD. Use of reusable instruments that penetrate the skin or touch dura mater or other brain tissue, eye, cerebrospinal fluid, or blood from CJD patients or suspects is strongly discouraged since reusable invasive items require special processing (WHO 1999).

When reusable instruments must be used, the instruments should be subjected to the strictest form of decontamination procedure which can be tolerated by the instrument (WHO 1999).

Non Critical Patient Care Items. Because there are no reports of noncritical patient care items (e.g., autopsy tables, floors) being involved in disease transmission, these surfaces may be disinfected with either undiluted sodium hypochlorite or 2N sodium hydroxide at room temperature for one hour (WHO 1999).
Intact Skin. For decontamination of intact skin (not mucous membranes) exposed to CJD infectious body fluids or tissue, wash with soap and abundant quantities of warm water (avoid scrubbing), rinse, and dry (WHO 1999). A one minute exposure of a 1:10 dilution of sodium hypochlorite can be considered for maximum safety (WHO 1999).

Percutaneous Exposure. Great caution must be taken to avoid accidental percutaneous exposure to blood, cerebrospinal fluid, or tissue, particularly brain tissue, of those with suspected or confirmed CJD. If accidental puncture occurs, in addition to Standard Precautions, gently encourage bleeding, wash (avoid scrubbing) with warm soapy water, rinse, dry, and cover with a waterproof dressing (WHO 1999). Report the needlestick according to established procedures for your hospital or healthcare facility.

Tissue Samples. Specimens should be examined in a laboratory or center accustomed to handling high and low infectivity tissues. High infectivity tissue specimens should be examined by experienced personnel (WHO 1999).

Surface Spills. Use disposable cover sheets whenever possible to avoid environmental contamination. Contaminated surfaces can be disinfected by flooding for one hour with sodium hypochlorite followed by water rinses (WHO 1999).

Variant Creutzfeldt-Jakob Disease

Variant Creutzfeldt-Jakob disease (vCJD) is the term assigned to the form of human transmissible spongiform encephalopathy that was first described in the United Kingdom in 1996 (CDC 2007b). vCJD has been found to be associated with consumption of bovine spongiform encephalopathy (BSE) contaminated cattle products (Liras 2008). CJD has different clinical and pathologic characteristics than classic CJD. Patients have a younger median age at death: 28 years versus 68 years with classic CJD, have a longer duration of illness: median 14 months versus 4 to 6 months, have increased frequency of sensory symptoms and early psychiatric symptoms with delayed onset of frank neurologic signs, and have the detection of prions in tonsillar and other lymphoid tissue (CDC 2007a). The EEG abnormalities typically seen in classic CJD are absent in vCJD (Turner 1999).

There have been no reported cases of direct human-to-human transmission of vCJD by casual or environmental contact, droplet, or airborne routes (CDC 2007a, FDA 2007). Bloodborne transmission of vCJD has occurred in the United Kingdom in four patients (Llewelyn et al. 2004, Peden et al. 2004, FDA 2007).

Specific Electroneurodiagnostic Recommendations for CJD, vCJD, or Suspected CJD or vCJD

There is no indication that routine electroneurodiagnostic procedures participate in the transmission of the CJD virus to patients or healthcare personnel. Nevertheless, appropriate precautionary measures are recommended for routine procedures when CJD is suspected or confirmed. Invasive procedures, especially those involving the brain, eye, and cerebrospinal fluid, result in documented risk to patients and healthcare workers and require specific handling and disinfecting procedures.

Surface Electrodes. Single use, disposable electrodes should be considered. If single use electrodes are used, they should be incinerated (WHO 1999). If reusable electrodes are used, the electrodes should be washed to reduce the amount of particulate material. The electrodes should then be sterilized by autoclave at 134°C for 18 minutes or six separate three minute cycles or a hypochlorite concentration of 25,000 ppm available chlorine for one hour may be used (OSET1999).
Needle and Invasive Surgical Electrodes. Use single use, disposable products only. If disposable products are not available, follow instructions for inactivation of CJD for invasive items whenever CJD is suspected or confirmed. For invasive electrodes routinely used in the brain or spinal cord, discuss with the infection preventionist the use of CJD precautions for all invasive electrodes used on patients regardless of the potential for a diagnosis of CJD.

Recording Equipment and Supplies. Ancillary electroneurodiagnostic supplies and equipment such as the headbox and cables, marking pencil, and recording instrument should be wiped down with undiluted bleach or a 1 N sodium hydroxide solution (Altman 2000). If items cannot be disinfected in this manner they should be disposed of and not reused. Single use, disposable tape measures are available and are recommended.

Electrolyte Syringes and Tips. Do not reuse syringes or syringe tips. Dispose of the entire syringe and tip in a contaminated sharps disposal container. Do not remove the syringe tip from the syringe before disposal.

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