Biosecurity Measures in Clinical Practice

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KEYWORDS

• Hospital-acquired infection • Nosocomial infection • Zoonotic disease • Biosecurity • Fomite • Infection control • Disinfection • Hand hygiene

KEY POINTS

- Veterinary teams should develop biosecurity programs to help prevent spread of infection to other animals and people in a hospital environment.
- Essential components of effective veterinary biosecurity programs include elimination and substitution of pathogens and hazards, engineering controls, administrative controls, and the use of personal protective equipment.
- Hand hygiene is the most effective step for preventing transmission of infectious agents.

INTRODUCTION

Hospitalized companion animals have increased susceptibility for hospital-acquired/nosocomial infections. Such patients typically have compromised immune systems due to a variety of health conditions, and they are potentially exposed to shedding of infectious agents from other animals. Veterinarians have a responsibility to help reduce unintentional disease transmission and to protect both patients and hospital personnel from common biosecurity hazards, including zoonotic infections potentially found in hospital environments. Veterinarians should proactively manage biosecurity risks in hospital, because these threats have an impact on health of veterinary patients and personnel, hospital operations, and client confidence.

ROUTES OF DISEASE TRANSMISSION

In order to persist over long periods of time, pathogens require reservoirs in which they normally reside. Reservoirs can be living organisms or nonliving sites. Regardless of the reservoir, transmission must occur for infection to spread. Transmission from reservoir to patient occurs first. Then, a patient transmits the infectious agent to other susceptible patients or to inanimate objects. Infectious microorganisms are transmitted in veterinary hospitals via 5 main routes[1]:

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Vet Clin Small Anim 50 (2020) 1277–1287
https://doi.org/10.1016/j.cvsm.2020.07.004
vetsmall.theclinics.com

1. Direct contact
2. Indirect contact (also known as fomite transmission)
3. Vector transmission
4. Droplet/airborne
5. Common vehicle

Direct contact transmission occurs when an animal or person comes in direct contact with an infected animal or person. Indirect contact transmission occurs when a susceptible host touches a contaminated, inanimate object, called a fomite, and transfers the contaminated material to a susceptible portal of entry, most commonly mucous membranes, without specific animal-to-human or animal-to-animal contact. Pathogens transmitted indirectly via fomites are a major cause of hospital-acquired infections. Many hospitalized patients are infected with contagious pathogens; as such, surfaces throughout a hospital are more likely to be contaminated with infectious agents. Furthermore, portable items can be contaminated near one patient and then become a source of transmission to patients or personnel in other areas of a hospital.

Transmission also may occur via vectors. Vector transmission occurs when a biological vector (eg, arthropod) acquires a pathogen from 1 animal and transmits it to another. Heartworm disease is a common example of a disease transmitted by a vector (mosquito). Fleas, ticks, and flies are other common biological vectors of disease.

When patients sneeze, cough, bark, and so forth, small droplets containing microorganisms may be propelled through the air, leading to droplet transmission. This form of transmission involves the movement of a pathogen to a new host over a distance of less than 1 m. When the transmitted distance is greater than 1 m, the preferred term is airborne transmission. Dust and fine particles, known as aerosols, can carry pathogens and facilitate airborne transmission. Many droplet exposures are best characterized as medium to large particle aerosols (ie, >100 μm). These aerosols are too large to be inhaled but may cause disease after contact with mucosal or conjunctival surfaces.

Common vehicle transmission applies to microorganisms transmitted by contaminated items, such as food, water, intravenous fluids, medications, blood products used during transfusions, and medical equipment.

Veterinary team members should remember that many diseases affecting dogs and cats are zoonotic in nature, thus posing potential risks to personnel and owners alike. Zoonotic agents may be transmitted via all of the routes discussed previously.[2]

HIERARCHY OF INFECTION CONTROL

A common tactic for addressing infection control in veterinary hospitals is the use of a 5-tier hierarchy pyramid (**Fig. 1**).[3] Top tiers generally are considered more effective than lower ones, and not all tiers are applicable to every situation.

The elimination and substitution tiers describe practices that may be implemented to prevent pathogens from entering hospitals and/or to physically remove them from facilities.[3] For example, pest management practices—including ectoparasite control and prompt disposal of food waste and other materials—are imperative for infection control. Unfortunately, both elimination and substitution—although most effective—also tend to be the most difficult to implement in veterinary hospitals.

Engineering controls are facility constructs designed to help remove pathogens from a veterinary facility and/or enhance adherence to biosecurity protocols.[3] An important consideration should be given to heating, ventilation, and air conditioning.

Administrative controls are hospital policies and procedures designed to address both team member and patient traffic flow when pathogens are suspected or known.[3] Policies to address medical waste disposal are of paramount importance. Another

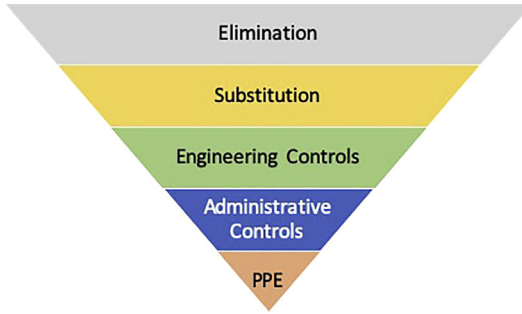

Fig. 1. Five-tier hierarchy of infection control. (*Courtesy of* Centers of Disease Control and Prevention. The National Institute for Occupational Safety and Health (NIOSH). National Institute for Occupational Safety and Health. Hierarchy of controls. Available at https://www.cdc.gov/niosh/topics/hierarchy/default.html. Accessed 6 October 2019.)

essential administrative control is appropriate antimicrobial stewardship.[4] The drafting of policies that promote the judicious use of antimicrobials is necessary to help prevent the development of drug-resistant pathogens. Similarly, protocols to identify high-risk patients (eg, immunocompromised patients) and perform necropsies, use of isolation units, and placement and maintenance of intravenous and urinary catheters all are vital administrative controls in effective biosecurity programs.[4]

Personal protective equipment (PPE) is unique clothing and equipment to protect team members and patients that may be exposed to suspected or known pathogens.[5] The use of PPE helps prevent pathogen exposure and spread.

PRINCIPLES OF INFECTION CONTROL

Every veterinary hospital should develop a comprehensive program for biosecurity control. Management should identify enthusiastic and capable team member(s) to develop and implement specific biosecurity protocols. These individuals should be empowered to recruit other individuals to cultivate staff training programs, create checklists, and generate biosecurity surveillance protocols. Critical components of such programs include the following.

Hand Hygiene

Hand hygiene is the number 1 weapon in preventing the spread of microorganisms and refers to washing with soap and water or using alcohol-based hand rubs containing 60% to 95% alcohol.[6,7] Proper hand hygiene unequivocally removes and kills myriad pathogens without compromising the integrity of the skin. Hand hygiene should be performed[7]

- Before and after contact with a patient and/or animal owner
- Immediately after contact with blood, body fluids, nonintact skin, mucous membranes, or contaminated items (even when gloves are worn during contact)
- Immediately after removing gloves, when moving from contaminated body sites to clean body sites during client care
- After touching objects and medical equipment in the immediate patient care vicinity
- Before eating
- After using the restroom

- After coughing/sneezing into a tissue

When hands are not visibly soiled, use of alcohol gel is the preferred method of hand hygiene. **Boxes 1** and **2** detail recommended protocols for both handwashing and the use of alcohol-based gels.[6,7]

Cleaning and Disinfection

Cleaning and disinfecting environment surfaces, fomites, and medical devices are integral parts of biosecurity programs.[8,9] Every hospital team member needs to understand protocols and processes involved. Teams should define who is responsible for cleaning and disinfecting each surface and piece of equipment in all patient rooms, treatment areas, surgical suites, and public areas. Furthermore, they should develop a schedule for achieving cleaning and disinfection goals.

Different areas of veterinary hospitals pose different levels of biosecurity risk. Human work areas that do not get much animal traffic should be cleaned thoroughly and routinely on a daily basis. Daily disinfection of every surface in these areas of the hospital, however, typically is not needed. In contrast, areas where sick or potentially sick animals are examined and/or treated require more stringent disinfection. Isolation units, intensive care units, and surgical suites require the strictest cleaning and disinfection protocols. Hospital teams are encouraged to develop systems to designate areas of different risk.

Cleaning and disinfecting are 2 distinct processes.[10] Cleaning is the removal of visible foreign material on objects or surfaces and is the first step in environmental sanitation. Disinfection of the inanimate environment decreases the bioburden and limits cross-transmission of pathogens in hospital environments. Most disinfectants are ineffective in the presence of dirt and organic matter.[11] As such, cleaning must occur first before disinfection to effectively remove feces, urine, blood, respiratory secretions, and/or dirt. Proper cleaning/disinfecting is a 4-step process, and gloves and appropriate attire should be worn (**Box 3**).[12]

An ideal disinfectant is one that is broad spectrum, works in any environment, and is nontoxic, nonirritating, noncorrosive, and relatively inexpensive. Unfortunately, no disinfectant is ideal. Therefore, careful consideration of the characteristics of a

Box 1
Recommended handwashing protocol

1. Remove all hand and arm jewelry.
2. Wet hands and forearms with warm water.
3. Add at least 3 mL to 5 mL (1–2 full pumps) of soap to palm of hand.
4. Lather all hand surfaces—pay particular attention to the areas between fingers, backs of hands, underneath fingernails, and thumbs.
5. Rinse under warm water until all soap residue is removed.
6. Dry hands with paper towel or warm air dryer.

Data from Boyce JM, Pittet D. Guideline for Hand Hygiene in Health-Care Settings; recommendations for the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Infect Control Hosp Epidemiol 2002;23(12 Suppl):S3-S40 and Pittet D, Allegranzi B, Boyce K, et al. The World Health Organization Guidelines on Hand Hygiene in Health Care and their consensus recommendations. Infection Control Hosp Epidemiol 2009;30(7):611-622.

Box 2
Recommended protocol for use of alcohol-based hand rub

1. Remove all hand and arm jewelry.
2. Ensure hands are visibly clean.
3. Apply 1 to 2 full pumps (or 2–3 cm diameter pool of product) onto 1 palm.
4. Spread product over all surfaces of hands—pay particular attention to the areas between fingers, backs of hands, underneath fingernails, and thumbs.
5. Rub hands until product is dry (minimum of 15–20 seconds).

Data from Boyce JM, Pittet D. Guideline for Hand Hygiene in Health-Care Settings; recommendations for the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Infect Control Hosp Epidemiol 2002;23(12 Suppl):S3-S40 and Pittet D, Allegranzi B, Boyce K, et al. The World Health Organization Guidelines on Hand Hygiene in Health Care and their consensus recommendations. Infection Control Hosp Epidemiol 2009;30(7):611-622.

disinfectant is essential to select the most useful, effective, and cost-efficient product (**Table 1**).[13,14] Use of the proper concentration of a disinfectant is important to achieve the best results for each situation. Some products have different dilutions depending on the desired use of the product. The product label lists the best concentration to use for each situation.

There are a variety of ways to apply disinfectants.[13] Object surfaces or walls may be treated with a disinfectant solution by wiping, brushing, spraying, or misting. Portable items should be soaked in a container of disinfectant. Appropriate contact times are essential.[14] Disinfectants may vary in the contact time needed to kill versus inactivate microorganisms. Areas being disinfected should be well soaked with the disinfectant selected to avoid drying before the end of the optimum contact time. Some chemicals may have residual activity whereas others may evaporate quickly.

Heat, light, and radiation also may be appropriately used to reduce or eliminate microorganisms in a hospital environment.[15] The use of heat is a one of the oldest physical controls against microorganisms. Although both moist heat (autoclave and steam) and dry heat (flame and baking) can be used to inactivate microorganisms, moist heat is more effective and requires less time than dry heat. Sunlight and UV light can have a detrimental effect on several microorganisms and may be practical methods for inactivating viruses, mycoplasma, bacteria, and fungi, in particular those that are airborne.

Box 3
Four-step process for cleaning and disinfecting

Step 1: mechanical removal of organic material

Step 2: cleaning with soap or general cleaner with subsequent rinsing and drying

Step3: applying disinfectant and allow to sit for the required contact time

Step 4: rinsing disinfectant and drying area well

Data from Quinn PJ, Markey BK. Disinfection and disease prevention in veterinary medicine. In: Block SS, editor. Disinfection, sterilization and preservation. 5th edition. Philadelphia: Lippincott, Williams & Wilkins. 2001; pp1069-1103.

Table 1
Characteristics of selected disinfectants

	Alcohols	Alkalis	Aldehydes	Chlorine	Iodine	Peroxygen Compounds	Phenols	Quaternary Ammonium Compounds	Biguanides
Bactericidal	Y	Y	Y	Y	Y	Y	Y	Y	Y
Viricidal	±	Y	±	Y	Y	Y	Y	Y enveloped	±
Fungicidal	Y	Y	Y	Y	Y	±	Y	Y	N
Sporicidal	N	Y	Y	Y	±	Y	N	Y	N

Abbreviations: ±, variable/limited activity; N, not effective; Y, effective.

Data from Fraise AP, Lambert PA, et al. (eds) Russel, Hugo, & Ayliffe's Principles and Practice of Disinfection, Preservation and Steriliztion, 5th ed. 2013. Ames, IA: Wiley-Blackwell and McDonnell GE. Antisepsis, Disinfection, and Sterilization: Types, Action, and Resistance. 2007. ASM Press, Washington DC.

UV light sterilizing capabilities are limited on surfaces because of its lack of penetrating power. Other forms of radiation are used less frequently but may include the use of microwaves or gamma radiation. Freezing is not a reliable method of sterilization but may help reduce heavy numbers of bacteria.

Performing routine follow-up evaluations of hospital areas is essential to verify pathogens have been destroyed. Visual inspection of cleanliness is important, but bacteriologic samples also should be obtained to determine the efficacy of the cleaning and disinfecting protocols. Failure of these programs may be due to an ineffective disinfectant, careless use of an effective disinfectant, and/or a variety of environmental factors (eg, temperature, relative humidity). The timing of sample collection is important, and the best time to sample is 2 days to 3 days after disinfection. Samples for microbiological testing should not be taken from a wet surface because the disinfectant still may be acting, and disinfectant residues may prevent growth of microorganisms in culture media.

Personal Protective Equipment

PPE includes items, such as gloves, gowns, masks, respirators, goggles, and face shields, used to create barriers that protect skin, clothing, mucous membranes, and the respiratory tract from infectious agents.[16] The items selected for use depend on the infectious agent, type of interaction, and the method of microorganism transmission.

PPE should be donned in the following order[16]:

1. Gown
2. Mask or respirator
3. Goggles or face shield
4. Gloves

The Occupational Safety and Health Administration (OSHA) standards require employers to provide PPE for employees with hazard exposure in the workplace, train employees on the proper use of PPE, and properly maintain, store, and dispose of PPE.

Gowns should be donned if skin or clothing is likely to be exposed to blood or body fluids. Properly fitted gowns should cover the torso fully from neck to knee, arms to the end of wrists, and wrap around the back. They should fasten in back of the neck and waist. Veterinary team members should wear surgical masks/respirators and goggles/face shields if there is a reasonable chance a spray of blood or body fluids may occur to the mouth or nose. A properly fitted mask should have secured ties or elastic bands at the middle of the head and neck. The flexible band should be manipulated to fit the nose bridge, and the mask should fit snugly to the face and below the chin. Googles/face shields should be adjusted to fit over the eyes/face. Gloves should be worn when touching blood, body fluids, nonintact skin, mucous membranes, and contaminated items. Gloves also always should be worn during activities involving vascular and urinary access. They should extend to cover the wrist of an isolation gown.

PPE should be removed immediately after use and should be doffed in proper order to prevent contamination of skin or clothing. The recommended order for doffing PPE is gown first, then shoe covers, followed by gloves, and lastly mask/respirator and goggles/face shield.[16] Any PPE or other disposable items saturated with blood or body fluids, such that fluid may be poured, squeezed, or dripped from the item, should be discarded into a biohazard bag. Any PPE not saturated may be placed directly in the trash.

Needlestick and Sharps Injury Prevention

Literature shows as many as one-third of all sharps injuries occur during disposal.[17] Veterinary medical team members, especially credentialed veterinary technicians, are particularly at risk, because they sustain the most needlestick injuries. The Centers for Disease Control and Prevention estimates 62% to 88% of sharps injuries can be prevented simply by using safer medical devices.[18] Safe handling of needles and other sharp devices are components of standard precautions that are implemented to prevent health care worker exposure to bloodborne pathogens. The Needlestick Safety and Prevention Act mandates the use of sharps with engineered safety devices when suitable devices exit.[19]

Recalling the hierarchy of infection control, a common sense approach for needlestick and sharps injury prevention (from most effective to least effective) is

- Elimination and substitution—whenever applicable and appropriate for patient care, substitute injections by administering medications via another route. Furthermore, jet injectors may be substituted for syringes and needles.
- Engineering controls—use of needles that retract, sheathe, or blunt immediately after use can reduce the incidence of needle/sharp injuries.
- Administrative controls—develop hospital policies that enhance team member knowledge of needle/sharps safety and limit exposure to needle/sharps hazards. Other effective policies include activating safety devices on needles and other sharps immediately after use; discarding used needles immediately after use; eliminating the practices of recapping, bending, and cutting; placing used needles, lancets, or other contaminated sharps in a leak-proof, puncture-resistant sharps container that either is red in color or labeled with a biohazard label; and not overfilling sharps containers.
- PPE—proper use of PPE like goggles, face shields, gloves, masks, and gowns may provide an effective barrier from needle/sharps injuries.

Laundry

Properly laundering reusable blankets, towels, and scrubs is an essential component of effective biosecurity protocols.[20] Veterinary hospitals should have the appropriate equipment to facilitate effective washing and hot air drying of laundry.[20] Special consideration should be given to laundry generated in isolation units, by suspected and known infected animals, and in surgical suites. Ideally, single-use items should be used in isolation units and for patients with suspected or known infectious diseases. Soiled items should be disposed properly in appropriate medical waste receptacles according to local, state, and federal regulations. An alternative approach is to presoak laundry from isolation units and infected animals in diluted bleach (ie, 9 parts water and 1 part bleach) for 10 minutes prior to routine washing and hot air drying.[20] Surgical laundry, including towels and wraps, ideally should be washed and hot air dried separately from other hospital laundry.

Waste Disposal

The Environmental Protection Agency regulates the disposal of products with environmental impact. The OSHA regulates issues associated with potential employee exposure to hazardous substances. Guidance pertaining to products used in the workplace that have an impact on human health is provided by the National Institute for Occupational Safety and Health. The Drug Enforcement Administration regulates the disposal of controlled substances. Veterinary practices that ship hazardous materials are subject to regulation by the Department of Transportation, whereas those that ship

materials via air are subject to regulation by the Federal Aviation Administration. In general, state regulations supersede federal regulations in that they may be more stringent.

Medical waste refers to waste products that are not considered general waste. It is produced from health care premises, such as hospitals, clinics, doctors'/dentists' offices, veterinary hospitals, and laboratories. Regulated medical waste, also known as biohazardous waste, is a subset of medical waste that poses a significant risk of transmitting infection to people. Regulated medical waste generated from veterinary facilities includes sharps waste, animal carcasses, body parts, bedding, and related wastes when animals are intentionally infected with organisms likely to be pathogenic to healthy humans for the purposes of research.

Sharp items should be disposed of in containers that are puncture resistant, leak-proof, closable, and labeled with the biohazard symbol or red in color. Sharps containers should be replaced when filled up to the indicated full line. Items that should be discarded into sharps containers include contaminated items that may easily cause cuts or punctures in the skin, including needles, lancets, broken glass, and rigid plastic vials. Syringes or blood collection tube holders attached to needles also must be discarded still attached to the needles. Similarly, non-sharp disposable items saturated with blood or body fluids should be discarded into biohazard bags that are puncture-resistant, leak-proof, and labeled with a biohazard symbol or red in color. Such items may include used PPE and disposable rags or cloths.

The American Veterinary Medical Association has established best management practices for pharmaceutical disposal.[21] It urges members to

- Follow all applicable federal, state, local, and tribal regulations and guidelines for disposal of all pharmaceutical waste.
- Be knowledgeable of regulations that apply to controlled substances or hazardous, chemotherapeutic, trace chemotherapeutic, mixed, or radiologic waste.
- Maintain close inventory control.
- Avoid pouring/flushing pharmaceuticals down drains or toilets as well as burning pharmaceutical waste, unless permitted by authorities of oversight.
- Segregate waste and utilize appropriate waste brokers, including reverse distributors, whenever possible.
- Train employees on proper disposal of pharmaceutical waste.

SUMMARY

Infection control, biosecurity, and biosafety are essential functions of all veterinary hospitals. Veterinary facilities have a responsibility to protect personnel and clients from exposure to zoonotic disease agents. Hospital teams should develop biosecurity protocols that optimize patient care while concurrently minimizing the risk of hospital-acquired infection. Good biosecurity practices are not the only feature defining excellence in veterinary care, but it is impossible to achieve excellent patient care without employing logical infection control procedures.

DISCLOSURE

Dr C.G. Byers serves as a consultant for Dechra Pharmaceuticals and is a member of the Scientific Advisory Board for Veterinary Recommended Solutions.

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