Nosocomial infection (infection acquired after 48 hours of hospitalization, or within 2 weeks of a previous hospitalization) is becoming a problem of global significance. In human hospitals, prevention of nosocomial infection has become paramount, and the emergence of multiple drug resistant (MDR) bacteria has made prevention even more difficult. According to the World Health Organization report on Infectious Diseases; in the United States alone, 14,000 people die each year as a result of multiple drug resistant organisms acquired during hospital stays. This same report emphasizes that the hospital setting is ideal for the development of MDR bacteria due to increased antibiotic use, crowding, and immunocompromised patients. The spread of MDR organisms from the hospital setting to the community has also been identified, as bacteria can transmit resistance genes easily through a population. While MDR bacteria are most commonly selected for in hospitals, they can rapidly become subclinical infections in the healthy population.

There is a widely held misconception that nosocomial infections are simply unavoidable as veterinary medicine moves to the use of more invasive devices. The reality is that 30–70% of nosocomial infections are preventable. This lecture will focus on easily adoptable operating procedures to avoid nosocomial infections.

Nosocomial Infections
Nosocomial infections range from mild to severe, depending on the affected system and resistance of the bacteria. It has been estimated that on average, human nosocomial infections result in a 2.5 times longer length of stay in hospital. A recently published study of 778 patients found that those with nosocomial infections stayed in the ICU an average of 11 days longer than those without. In addition, the treatments are often very expensive in MDR cases, as newer antimicrobials are required. In veterinary medicine, this is of significant importance, since there are often cost limitations and many pets are euthanized because owners cannot afford to pay for the extended hospitalization and antimicrobial treatment.

Nosocomial infections are more common in intensive care units (ICUs) than in general ward populations. This occurs for several reasons: 1) the duration of stay is often longer; 2) invasive medical procedures/devices such as central lines, indwelling urinary catheters, mechanical ventilation, etc., allow entry of opportunistic organisms; 3) patients are often more stressed and immunosuppressed due to illness and/or treatments; and 4) increased use of antimicrobials allows for selection of more resistant bacteria. A dearth of research exists for nosocomial infection in the small animal veterinary patient. The frequent use of antimicrobials in veterinary practice has led to some of the same problems of MDR bacteria as in human medicine. It is possible that nosocomial infection in veterinary patients with MDR bacteria may actually become a reservoir for community infection among other animals and people. Human patients with MDR infections have been shown to act as reservoirs in the community.

Nosocomial infections may arise from endogenous or exogenous sources. Endogenous implies self-infection with a patient’s own bacterial flora. This may occur when the use of broad spectrum antimicrobials affects the balance in the patient’s normal flora, allowing more resistant bacteria to survive and proliferate, while more susceptible organisms diminish. As these organisms are shed in the environment, the relative increase in numbers of MDR organisms increases the probability of an opportunistic nosocomial infection. Exogenous sources can be from the hands of health care workers, use of contaminated equipment or devices, environmental contamination acting as vectors or fomites, and introducing the organism to the infection site.

The bacteria that are most often associated with nosocomial infections include Enterococcus spp., E. coli, Staphylococcus spp., Enterobacter spp., Klebsiella spp., Acinetobacter spp., and Pseudomonas spp. Furthermore, Enterococcus spp., E. coli and Staphylococcus aureus are of increasing concern as they easily acquire resistance determinants and have developed into Vancomycin Resistant Enterococci (VRE), MDR E. coli, and Methicillin Resistant Staphylococcus aureus (MRSA), which have been a problem for many years in human medicine, but are now causing concern in veterinary medicine. Ampicillin resistant enterococci are also very common in veterinary isolates (38/45 [84%] of clinical MDR E. faecium isolates in a prospective study at the Ontario Veterinary College were resistant to ampicillin). While VRE has been reported sparsely in the small animal veterinary literature, MDR E. coli and MRSA have both been associated with nosocomial infection in small and large animal veterinary hospitals.
Types of Nosocomial Infections

Nosocomial infections can present in many sites. The most common nosocomial infections reported in the literature include urinary tract infections (UTIs), bloodstream infections (BSIs), surgical site infections (SSIs), pneumonia, and bacterial diarrheas.5,10

Urinary Tract Infections

In human medicine it is estimated that urinary tract infections are responsible for 40–60% of all nosocomial infections, and of these, 80% can be associated with indwelling urinary catheters.11 Many nosocomial bacteriurias are asymptomatic, yet often caused by highly resistant bacteria. It has been suggested that not treating asymptomatic bacteriuria can allow the patient to become a carrier of MDR bacteria, which can potentially contaminate the hospital environment or other patients.5 Guidelines exist for distinguishing bacteriuria from infections, and the veterinarian must use her own discretion in how either is treated. Studies have identified the duration of catheterization to be the most important risk factor for nosocomial infection. Removing the catheter as soon as is practical may decrease the risk.11 Other measures for preventing or reducing the risk of nosocomial infection have been suggested and include:

1) Follow aseptic technique when placing the catheter.
2) Choose the smallest diameter catheter possible.
3) Connect to a sterile, closed collection system and avoid disconnecting collection system from the catheter.
4) Clean the catheter several times daily, from proximal to distal with an antiseptic solution.
5) Prevent retrograde flow of urine into the bladder from the collection bag.
6) Apply antibiotic ointment to the proximal catheter or use antibiotic impregnated catheters.
7) Keep urine bags and lines wrapped and/or elevated off the floor.
8) Never reinsert a catheter that has migrated out of the urethra.
9) Perform urine culture and susceptibility tests every 48–72 hours the catheter is in place, and upon removal. Do not culture the tip, as it is not reflective of the urine.

It has been suggested where possible to use intermittent catheterization in preference to indwelling catheterization.5 This may be an option for many male dogs depending on their temperament, but not for most cats or female dogs. The frequency of catheterization must also be considered, as an indwelling catheter may be less traumatic and more practical.

Blood Stream Infections

Nosocomial BSIs are most often associated with intravenous catheterization (IVC). While peripheral IVCs are common in veterinary practice, multiple catheters, central lines (jugular catheters, long saphenous and monitoring catheters), and arterial catheters have become a common sight in veterinary ICUs and specialty practices. Serious BSIs are more frequently associated with central venous catheters (CVCs) than with peripheral catheters in human patients, and this is a reflection of the severity of illness and duration of dwell, which can be weeks. As one would expect, prolonged catheterization can predispose the patient to the risk of nosocomial infection if not properly maintained. Scheduled removal and replacement of IVCs (usually at 72 hour intervals) is no longer recommended. The most common route of contamination is migration of skin organisms along the catheter tract in peripheral catheters. In long-term catheters, contamination of the catheter hub is the most common cause of BSI.12

Many recommendations for catheter placement and care have been made in an effort to reduce catheter-associated infections.5,12,13 These include 1) clipping a large area of hair, and trimming excessively long hair around the catheter site, avoiding clipper irritation, and only placing a catheter in an area of unbroken skin; 2) mandatory surgical prep of the area (recommendations for antiseptics vary); 3) thorough hand washing prior to placing the catheter, or for central lines, both hand washing and sterile gloves; 4) making the insertion as atraumatic as possible, and using a new catheter for each attempt; 5) applying a sterile “band-aid” over the insertion site; 6) securing the catheter well to avoid movement and subsequent phlebitis; 7) covering the catheter with a clean, dry dressing and replacing it if it becomes soiled or wet, otherwise changing it every 72–96 hours and visualizing the catheter insertion site for any signs of phlebitis; 8) observing the patient for any signs of discomfort when flushing the catheter, such as chewing or lameness (peripheral IVCs); 9) flushing the catheter with 1U/mL heparinized saline when removing it from IV pump for any period of time (walks, etc.) and ensuring that fluids flow freely and with no discomfort to the patient; 10) not disconnecting the lines from the catheter; 11) changing the lines every 72 hours, every 48 hours for parenteral nutrition or dextrose-containing solutions; 12) removing the catheter if the patient develops an unexplained fever and culturing the catheter tip after very careful removal; and 13) for peripheral
arterial catheters, replacing them as required (not at scheduled intervals) and replacing the continuous flush device and pressure transducer every 72 hours.

**Surgical Site Infections**

Surgical site infections are relatively common in veterinary patients. SSIs include not only incisional infections, but also body cavity infections and osteomyelitis.5 Many factors are implicated in the development of SSIs and include the duration of surgery/anesthesia, ASA status of patient, gender, weight, pre-clipping of hair, number of people in the surgical suite, and prophylactic antimicrobial use.5, 14 Many suggestions for preventing SSIs have been made and include 1) clipping the patient following induction; 2) following strict aseptic technique for prepping, draping, opening instruments, etc.; 3) avoiding unnecessary persons in the surgical suite, all bystanders being capped and masked; 4) doing routine disinfection of the surgical suite; 5) maintaining clean bedding for postsurgical patients, avoiding contact of surgical wounds with the hospital floor; 6) keeping areas around wound drains clean and covered if possible; and 7) using good hygiene when handling surgical wounds, drains, etc.

Many SSIs may not be preventable in the postoperative period; however, using the recommendations above may reduce the infection rate or severity of infection in some patients.

**Nosocomial Pneumonia**

Nosocomial pneumonia has not been studied extensively in veterinary patients. Most of the existing information has been extrapolated from human literature. Nosocomial pneumonia in mechanically ventilated patients is thought to arise following colonization of the oropharynx with MDR organisms, which often occurs during hospitalization. Precautions can be taken to avoid nosocomial pneumonia in mechanically ventilated patients and include: 1) thorough hand washing prior, and preferably wearing gloves while handling the patient’s ET tube, ventilator components or cleaning the patient’s mouth; 2) keeping the patient’s head and upper body elevated to reduce regurgitation; 3) always using sterile ET tubes and changing them as necessary; 4) ensuring that all laryngoscopes, mouth gags, pulse oximeter sensors, or other oral devices are thoroughly disinfected and kept on a sterile drape; 5) ensuring that all filters on the ventilator are in good condition and are changed/sterilized as the manufacturer suggests; 6) using bacteriostatic devices such as HME/filters when practical and changing them frequently; 7) cleaning the mouth and oropharynx every 4-6 hours with a dilute chlorhexidine solution and sterile gauze, paying close attention to the area surrounding the laryngeal folds; 8) culturing any visible exudates on ET tube upon removal; and 9) suctioning the ET tube as necessary using aseptic technique.

Nosocomial pneumonia may be the most difficult infection to prevent, not only because of its etiology, but also due to the severity of illness. Maintaining asepsis and practicing good hygiene when dealing with the patient is of the utmost importance.

**Nosocomial Diarrhea**

Nosocomial diarrhea often occurs in outbreaks of several patients. The 2 most common pathogens are Clostridium difficile and Salmonella spp. Both of these organisms can cause severe hemorrhagic diarrhea and be very debilitating. As well, animals can be asymptomatic carriers, which can serve to contaminate the environment. A reported outbreak at the Ontario Veterinary College affected 48 dogs over a 5-month period. This is the first report of a C. difficile outbreak in dogs, and several successful measures were identified in controlling the outbreak as well as preventing future outbreaks.15 These measures include 1) quarantining all infected animals and taking barrier precautions when handling infected animals; 2) cleaning of floors and cages with 10% bleach solution and using disinfectant footbaths; 3) avoiding bringing in new patients if possible until the outbreak is controlled; 4) considering outside contamination sources such as walking areas; 5) avoiding recontaminating areas by having dogs defecate into plastic bags or onto paper plates so feces do not touch the ground; and 6) doing routine fecal cultures and toxin screenings for diarrheic resident dogs.

Nosocomial diarrheas may be of the most concern to veterinary staff, as they can be zoonotic. They are easily passed from patient to patient, and potential outbreaks must be identified quickly. In human reports, outbreaks have been linked to transmission via the hands of health care workers, another important reason to ensure adequate hand washing. Observations of several diarrheic patients may indicate a need for fecal cultures to be performed.
Nosocomial Surveillance

Volumes of information exist for nosocomial infections in human hospitals. Nosocomial surveillance programs are prominent in many human hospitals, and national nosocomial surveillance programs exist in most developed countries. Due to the potential impact on human health, food animal producers and veterinarians are regulated in many countries. In small animal veterinary medicine, however, a dearth of information still exists, and dissemination of the existing information requires veterinary professionals to be proactive, as no national requirements for surveillance, antimicrobial use, or reporting of nosocomial infections is in place.

Nosocomial surveillance and infection control policies are often in place in larger veterinary centers and teaching hospitals, but rarely in smaller practices. Initiating infection control protocols and nosocomial surveillance is an ideal role for veterinary technicians in smaller practices. By keeping records of positive cultures, a trend of bacterial species might be identified. Further analysis of bacterial isolates might identify a common strain. Ensuring that all staff are familiar with infection control policies may help to reduce nosocomial infection rates. Hand washing between patients has been shown to have dramatic impact on infection rates, but compliance is often an issue. In veterinary clinics, environmental cleaning is often a job given to volunteers and kennel staff, who may not be educated in proper techniques.

Once an MDR infection is suspected (any infection arising after 48 hours of hospitalization is likely MDR), specific infection control protocols must be followed to avoid contamination of the environment, staff, and other patients. These protocols include 1) wearing gowns and gloves when handling patients; 2) keeping hair, jewelry, or any other personal items from coming in contact with the patient; 3) cleaning stethoscopes and other equipment after examination; 4) disposing of bandages, gowns, gloves, or other disposable material in a labeled disposal bag; 5) washing hands after removing gloves; 6) bandaging exposed wounds or drains to reduce environmental contamination; 7) disposing of fluids (urine, drain effusion, etc.) down a drain with running water, then disinfecting; 8) moving the patient if necessary to a lower traffic area, but considering leaving the patient in current housing to avoid contaminating another area; and 9) thoroughly disinfecting the area with a disinfectant known to be effective against the MDR organism.

The use of gloves and gowns is reported to control the spread of resistant organisms from infected to uninfected patients. However, the gloves and gowns must be removed prior to touching equipment or other patients. A rule of thumb is that when the infected patient is touched for the last time, and after disposing of all contaminated material (bandages, body fluids, etc.), the gloves and gown are removed and disposed of in a container, hands are washed, and the patient area is left. By treating any infection as potentially nosocomial and MDR as soon as signs are recognized, and not waiting for culture identification, contamination of the environment, staff, and other patients will be reduced.

Veterinary medicine differs from human medicine in that owners frequently euthanize their pets when they require treatment they cannot afford. When this occurs because of a nosocomial infection, this is even more devastating for both owners and veterinary staff, especially following a prolonged hospital stay. For those infections that can be prevented, it is the responsibility of all veterinary staff to be aware of hospital protocols and use them consistently.

References


