Nosocomial infections increase morbidity and mortality in patients as well as cost to clients. Antimicrobial resistance further complicates nosocomial infections by increasing morbidity, mortality, and cost.

RISK FACTORS
Postoperative patients are among those at highest risk for nosocomial infection because these patients:
- Are frequently fasted
- Have ongoing disease processes
- Undergo procedures in which multiple medical devices are inserted into the body
- Receive drugs that alter the normal physiology of the patient.

All of these factors can modulate a patient’s immune system. Veterinary health care teams must take precautions to minimize the risk of transferring pathogens between patients and maximize their ability to fight infection.

SIGNS OF INFECTION
Patients at risk for nosocomial infections (see Potential Risk Factors for Nosocomial Infection) should be monitored closely for signs of infection, such as:
- Increasing lethargy
- Edema, redness, pain, and/or heat (or fever)
- Discharge from wounds or surgical sites.

POTENTIAL RISK FACTORS FOR NOSOCOMIAL INFECTION

Patient Condition
- Immune deficiency (ie, neutropenia, diabetes mellitus, immunosuppressive drugs)
- Malnutrition
- Open wounds

Patient Environment
- Prolonged hospitalization, surgical preparation, or surgery/anesthesia time

Medical Procedures
- Blood product administration
- Central venous catheterization
- Concurrent antibiotic therapy
- Frequent bandage changes
- Prolonged catheterization (of any type)

Inappropriate Care
- Improper aseptic/sterile technique, care of catheters, and/or tissue handling
- Inexperienced surgeon
Antimicrobial Resistance
Antimicrobial resistance (AMR) occurs when a pathogen develops resistance to 1 or more agents to which the pathogen was previously sensitive. AMR is a growing problem in both human and veterinary medicine. AMR has become more common in nosocomial infections, although the 2 are not synonymous.

AMR often occurs due to inappropriate antimicrobial administration, causing selection for resistant organisms, but can also occur in the face of appropriate antibiotic administration. In the latter case, the gastrointestinal tract is a reservoir for resistant organisms, which can then be transferred from patient to patient.

The rate of AMR in veterinary medicine is largely unknown. In a recent study of 10 private veterinary hospitals, Enterococcus contamination was found at all 10 hospitals, with approximately 20% of the isolates having AMR. Of the AMR isolates:

- About 30% were found on stethoscopes, with 50% of personnel reporting that they almost never cleaned their stethoscopes.
- 6% were found on thermometers, with 30% of hospitals reporting that thermometers were not cleaned between patients.
- 60% were found on cage doors, with 30% of hospitals reporting that cage doors were not disinfected between patients.

Another study showed that 44% of dogs with pyoderma were infected with resistant isolates, mostly Staphylococcus pseudintermedius, which is the most frequently isolated Staphylococcus species in canine and feline patients.

Hand Hygiene
Pathogen transmission in hospitals occurs most often via contaminated hands of health care workers. Although our patients are handled differently than human patients, it is likely that pathogen transmission still occurs frequently via contaminated hands. Therefore, hand hygiene should be a high priority in any health care setting.

Proper hand hygiene consists of hand disinfection:

- **Before**
  - Direct contact with a patient or its environment
  - Placement of any type of catheter
  - Movement from a contaminated to a clean site on a patient

- **After**
  - Direct contact with a patient or its environment
  - Contact with patient bodily fluids
  - Removal of gloves

Disinfection
Disinfection for visibly soiled hands is achieved by (Figure 1):

1. Washing hands in running warm water, with sufficient volume of antimicrobial soap to cover all surfaces of hands/fingers in lather.
2. Rubbing for at least 15 seconds before rinsing.
3. Using paper towels or single-use cloth towels to dry hands.
4. Turning the faucet off using the towel.

Alcohol-based sanitizers are the preferred method of hand hygiene in human medicine and have shown better bactericidal activity than that of soap and water. Hands that require disinfection but are not visibly soiled can be effectively disinfected by:

1. Using a sufficient volume of alcohol-based hand sanitizer to cover all surfaces of hands/fingers.
2. Rubbing for at least 15 seconds before hands are dry.

Gloves
Gloves can be used to prevent gross contamination of the hands, but are not an alternative to proper hand disinfection. Gloves should be worn while handling every patient and hand disinfection should be performed after carefully removing contaminated gloves. Even though clean gloves are used with each patient, hands can become contaminated during glove removal and hand disinfection prevents any transfer of pathogens from one patient to another.
Education

Despite health care workers acknowledging the importance of hand hygiene, compliance rates are very low.\textsuperscript{2,5,6} 

- Recent veterinary studies report hand hygiene compliance to be between 20% to 40%, with 85% of workers feeling they should be washing their hands more frequently.\textsuperscript{7} 
- One veterinary study showed that implementing a comprehensive education program could increase compliance, which is consistent with human data on the same subject.\textsuperscript{5}

The Institute for Healthcare Improvement (IHI) recommends implementing an intervention package consisting of 4 items to increase hand hygiene compliance:

1. **Educate staff on the importance of proper hand hygiene:** Staff should understand why hand hygiene is important and the implications of poor hand hygiene. In-service educational programs, posters, and other literature can be useful as educational tools.

2. **Verify appropriate hand hygiene technique:** Proper technique should be demonstrated to all staff members. Reminders of proper technique may be posted at sinks and other hand hygiene stations (Figure 2).

3. **Ensure hand hygiene is available at point of care:** Ideally, someone is assigned the task of refilling dispensers and ensuring availability of adequate supplies. Checklists may be especially useful for this purpose.

4. **Continually monitor compliance while providing feedback:** Staff should be regularly evaluated on proper technique to ensure ongoing patient safety. Written examinations and direct observation are useful in monitoring compliance.

**SURFACE DISINFECTION**

Additional routes of transmission include contaminated environmental surfaces and equipment.\textsuperscript{3} Proper environmental disinfection is challenging for veterinary teams as patients are not usually confined to a hospital bed.

The appropriate disinfectant is dependent on the surface or device. Disinfectants are divided into 3 categories:

1. **Low level**
2. **Intermediate level**
3. **High level or sterilization.**

**Low-Level Disinfectants**

Low-level disinfectants are used for **noncritical surfaces that touch intact skin or do not come in contact with the patient**, such as floors, tables, food bowls, cages, and stethoscopes.\textsuperscript{7} Examples include:

- 70% isopropyl alcohol
- Quaternary ammonium compounds
- Peroxygen compounds
- 0.05% chlorhexidine
- Sodium hypochlorite (1:100).

While very popular in the veterinary industry, quaternary ammonium compounds have been shown to have poor virucidal and sporocidal activity (despite label claims) and are not recommended for disinfection of contaminated or potentially contaminated surfaces, such as floors.\textsuperscript{7,8} Additionally these compounds are bacteriostatic and can cause pathogens to become disinfectant-resistant.\textsuperscript{7}

**Intermediate-Level Disinfectants**

Intermediate-level disinfectants are used for **semicritical surfaces that will contact mucous membranes or intact skin**, such as laryngoscopes, thermometers, and endotracheal tubes.\textsuperscript{7} Examples include:

- 70% ethanol
- Peroxygen compounds
- 0.5% chlorhexidine
- Sodium hypochlorite (1:10; contact time will be longer compared to low-level use).\textsuperscript{7}

**High-Level Disinfectants**

High-level disinfectants or sterilizers are used for **critical surfaces that enter the bloodstream or a body cavity**, such as intravenous catheters, surgical instruments, and laparoscopes.\textsuperscript{7} Examples include:

- Ethylene oxide gas
- Hydrogen peroxide gas (low-temperature plasma)
- 2% activated glutaraldehyde
- Steam (121°F).


Many disinfectants become unstable after dilution, and must be changed daily, while others may be stable for months.\textsuperscript{7,8} Consultation with your disinfectant manufacturer for stability-in-solution information is recommended.

**Figure 2.** Various methods, such as posting reminders in patient care areas, are useful in promoting proper hand hygiene.
Two percent activated glutaraldehyde is often adequate for critical items that cannot be sterilized.7

**Step-by-Step Disinfection**
Surface disinfection should be a 2-step process consisting of:
1. Organic debris removal
2. Disinfection using appropriate contact time.

However, consideration of proper disinfectants, dilution, and contact times are not sufficient.
• **Prepared scrub gauze and items from cold sterile trays** should be removed by tongs. Weekly sterilization of these items is necessary to prevent multidrug-resistant colonization.7
• **Mop heads and solutions (Figure 3)** should be changed at least twice daily, preferably at the beginning of the day and before final mopping at closing time; sooner if visible soil is present.7
• **Floor drains** should be disinfected weekly with a 1:50 bleach solution.7
• **High-touch surfaces**, such as computers, handsets, mobile phones, door handles, and cage handles, should receive low- or intermediate-level disinfection.
• **Stethoscopes, pulse oximetry probes, Doppler probes, blood pressure cuffs, and other monitoring equipment** must be cleaned between patients and at least once daily. Isopropyl alcohol (70%) is reportedly most effective when proper contact times are observed.3,7
• **Laundry** should be collected in leak-proof containers and washed in hot water (> 160°F) for at least 25 minutes.7 A 1% bleach solution should be used for laundry disinfection, although polyester fabric may be resistant to this form of disinfection, with further disinfection necessary.7

**SURGICAL SUITE**
Special precautions must be made in the surgical suite as these patients may be at high risk for nosocomial infection due to anesthetic-related immune suppression and exposure of tissues (Figure 4). The anesthesia work area can become contaminated, causing spread of resistant bacterial organisms between patients.9

**Area Designation**
• A clean area should be used to store new items and drugs; a dirty area should be used to store items specific to the current patient, such as monitoring equipment and predrawn drugs.
• A plastic bag or tub works well as a dirty area to isolate patient-specific items while maintaining portability throughout the hospital.
• All surfaces and equipment should be disinfected between patients using an appropriate disinfectant and contact time.

**Personnel**
• Surgical personnel should practice barrier precautions, such as gowns, gloves, masks, and face shields specific to that patient, when a known or suspected infectious patient, such as one with a positive culture or zoonotic disease, is in the surgical suite.
• Street clothes should never be worn in the operating theatre. Research has shown that, when compared to street clothes, scrubs reduced airborne *S aureus* levels by 75%.10 Therefore, scrubs should not be worn outside the hospital and surgical personnel should change into clean scrubs before entering the surgical suite.
• The addition of masks and gowns only improved the reduction of *S aureus* levels to 82%, which emphasizes the importance of wearing clean scrubs in the surgical suite.10

**Modifiable Risk Factors**
**Perioperative hypothermia** has been shown to suppress immune function and should, therefore, be avoided in patients.11

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**Figure 3. Effective disinfection is ensured by proper disinfection protocols and care of disinfection equipment.**

**Figure 4. Patients under anesthesia for surgical procedures are at higher risk for nosocomial infection.**
• Using forced-air blankets, heating pads, heat-moisture exchangers, low-flow oxygen, and minimizing surgical preparation time can all reduce the likelihood and severity of perioperative hypothermia.

• Use of forced air blankets, however, should be delayed until final sterile draping of the patient to minimize the likelihood of foreign material or pathogens being blown into the surgical field.

Impaired tissue oxygenation has been shown to delay wound healing and increase infection rates; supplemental oxygen should be provided to all anesthetized patients.13

Shaving patients with a razor has been shown to increase infection rates; patients should be clipped with clippers in the immediate preoperative period if hair removal is necessary.11

Protocols
Prophylactic antibiotics must be present in sufficient concentration in the tissues at time of contamination in order to effectively prevent nosocomial infection.12 The American Society of Health System Pharmacists recommends administration of cefazolin, 20 to 30 mg/kg IV, at induction of anesthesia for most surgical procedures; however, specific veterinary data on the appropriate dosage and frequency of perioperative antibiotics is lacking.12,13

Aseptic technique is essential, and any breach of the sterile field should be immediately brought to the surgeon’s attention.

Surgical instruments should be immediately processed after the procedure, including:14
• Manual scrubbing to remove gross contamination
• Ultrasonic cleaning
• Lubrication, if necessary
• Appropriate sterilization
• Careful inspection to ensure proper function and decontamination.

Minimizing anesthesia and surgery time is likely the most important intervention in preventing nosocomial infections.15

IN SUMMARY
Nosocomial infections and AMR are life-threatening problems for veterinary patients, especially surgical patients. Proper hand hygiene, surface disinfection, and surgical etiquette are essential in minimizing risk and obtaining positive outcomes in veterinary patients. Further research is necessary to determine the rate of nosocomial infection, organisms responsible, risk factors, and recommended interventions for patients at risk.

AMR = antimicrobial resistance;
IHI = Institute for Healthcare Improvement

References

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