Proceeding of the European College of Veterinary Surgeons Annual Scientific Meeting ECVS

July 4–6, 2013 Rome, Italy

Next Meeting:

July 3-5, 2014 – Copenhagen, Denmark

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Strategies to prevent and interrupt contagious diseases in my surgical practice

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Introduction
Contagious diseases are feared in veterinary hospitals and can be brought in by admittance of an animal suffering from a contagious disease, but probably the most common are hospital-acquired or hospital-associated infections (HAI). The group of contagious diseases concerned contains very different viral, bacterial, parasitic and fungal diseases and some of them are emerging or re-emerging, whereas some are old well established and endemic. They vary tremendously in clinical spectrum and contagiousness. Nevertheless, since hospitalized patients are often debilitated, contagious diseases can more easily spread through a hospital population with a possible bigger clinical impact than on healthy individuals. They can compromise the well being and health of the patient, cause longer hospitalization duration, increased medical costs, higher mortality, economic losses, fear and concern amongst owners, and in some cases temporary closure of the hospital. Moreover, due to close patient contact some diseases with zoonotic potential can even affect their caretakers.

Why should the veterinary world be much more focused on preventing instead of treating contagious diseases?
First of all, the contagion risk has substantially increased over the last decade mainly together with the exponential growth of international and intercontinental transportation of companion animals, horses and food animals. The intensification and scale increase of sport, sales, and breeding events, allows a more intense interaction between transported animals and contagious diseases: travelling animals can spread contagious diseases but they can also come in contact with foreign infectious diseases and attract them due to absence of or poorer protective immunity. In addition, veterinary hospital structures have grown bigger and house larger numbers of patients, meaning increased risk and susceptibility for infectious diseases and their spread. Even though outbreaks in veterinary hospital settings are undoubtedly underreported, there seems to be an emerge and/or re-emerge of pathogens within veterinary hospitals. A survey amongst American veterinary teaching hospitals showed that 82% had identified at least one outbreak of hospital associated disease in the last 5 years, and that 32% of them even demanded closure of the hospital.

Secondly, veterinarians have responsibility and need to protect their hospital, their patients and all people involved. There seems to be an increasing recognition of the need for veterinary hospitals to be accountable for HAI. At the same time, there is a demand from the community that we as veterinarians perform veterinary care that is of better and higher level, not allowing for contagious complications and outbreaks anymore if they can be prevented. Nosocomial infections have been listed in the top 10 reasons for malpractice claims against human hospitals and it is likely that the veterinary community will face the same in the future.

Thirdly, with better diagnostic methods and improved worldwide communication, increased awareness and increased visibility of outbreaks of contagious diseases has developed.

Last but not least, the possibility for zoonotic infections and the emergence of antimicrobial resistance also demands for more strict infection control.

Due to all these changes, the "we have done so for the last 30 years without problems"-culture is no longer acceptable.

This talk will focus on the different transmission routes for infectious diseases and how to interrupt them in a veterinary hospital, with a main focus on surgical patients. For surgical patients, time in the hospital can be divided in a pre-surgical, surgical and post-surgical period; all three of interest regarding spread and/or contamination of infectious diseases. This talk will focus on mainly the pre- and post-surgical period, not the surgical period. Also the subject of multi-resistant bacteria, although integral part of infection control measures, will be more extensively discussed in a later talk.

Transmission routes and transmission-based precautions
Transmission requires 3 elements: a susceptible host with a portal of entry, a source of the infectious agents, and a mode of transmission for the infectious agent. The possible transmission routes with examples and transmission-based precautions are as follows:
Direct contact: from one individual to another.
- Example: FIV, FeLV, rabies, influenza
- Precautions include: limit number of staff with patient contact, cleaning and disinfection of stalls and cages, barrier protection, cover all wounds or draining tracks, promptly clean up any body secretions, use disposable items.

Indirect contact: by fomites, by the environment, airborne, fecal-oral, waterborne. This is mainly applicable to pathogens that remain quite stable outside the host.

Airborne or inhalation: infectious droplets of bacterial or viral particles, either by direct or indirect contact. This route is of interest for surgical patients since they have undergone general anesthesia with inhalation of anesthetics and ventilation.
- Example: Influenza, EHV, FHV, feline calici virus
- Precautions include: avoid overcrowding, increase distance between patients, isolate with separate ventilation system, management of temperature, relative humidity and ventilation, schedule infectious patients at end of day, limit stress and excitement, avoid high pressure washers and dry mopping or sweeping, use wet mopping or filtered vacuum cleaners.

Fecal-oral: ingestion of pathogens shed in feces, either by direct or indirect contact. Environmental contamination plays an important role.
- Example: Salmonella, E. coli, rotavirus, canine parvovirus
- Precautions include: thorough cleaning of all animal-contact items and surfaces, food storage in closed containers with first-in-first-out principle, food storage clean and free of pests, avoid common water supply, barrier protection, promptly clean up feces from areas of patient traffic.

Fomites: transmission via contaminated equipment, clothing, vehicles, etc
- Examples: enteric pathogens, strangles
- Precautions include: hand hygiene, hand free sinks and towel dispensers, change clothes when dirty or contaminated, cleaning equipment, foot hygiene, dedicated work shoes.

Iatrogenic: transmission during medical procedures, especially for surgical patients of importance
- Example: any pathogen via inadequately sterilized equipment and contaminated blood products or medication

Water-borne: indirect transmission via contact with infected water (drinking, swimming, washing)
- Giardia, leptospirosis, pseudomonas

Sexual transmission: via sexual contact or contaminated equipment for reproductive procedures
- Example: contagious equine metritis, equine arteritis virus

Vertical: from mother to offspring
- Example: BVD, EHV, parvovirus

Although not limited, the most important routes for surgical patients are airborne, fecal-oral, fomites, and iatrogenic transmission. Common entry and exit sites for pathogens are the respiratory tract, the skin and the gastro-intestinal tract.

Strategies to interrupt transmission and prevent contagious disease
Most strategies will have their effect upon multiple ways of transmission. Whereas it is sometimes difficult to identify the effectiveness of one single measure on transmission in a clinical setting, different studies have shown that with combinations of infection control measures transmission can be stopped 3,4,7,17.

Infection control measures need to allow for a reasonable flow and function of the hospital. Institutes need to make up their own balance on infection control measures with regards to feasibility, costs, effectiveness, practicality and risks (or accepting certain risks) 18, all dependent on the geographical area, the population of clients and patients and the level of veterinary care offered. The benefit for infection control measures (or the costs of HAI or other contagious diseases) should be weighed against the costs of the implementation of these measures. Even though the costs of some outbreaks can be very high 6,7,13, it remains difficult to estimate the true cost of the impact of infectious diseases in a hospital, especially when it concerns single cases or smaller outbreaks.

Grouping patients with different risks
Not all infectious diseases have the same clinical impact or risk to be transmitted. Therefore classification systems have been developed where each class can have its own specific rules or measures 18. Different levels of separation can be set up ranging from complete isolation to barrier nursing to a simple door closing practice. The levels of clothe and shoe changing, hand and foot hygiene, disinfection and separation from other patients (distance, separate entrance, ventilation system, management of disposals, allowed to go into surgery) depends entirely on the hospital and the type of medical problem.

With regards to contagious patients, it is important to keep in mind that as long as there is a suspicion of a contagious disease, the patient should be treated as contagious until proven otherwise! Therefore one should know how to interpret laboratory findings. It may also be
that the best interest for the hospital is in conflict with the best interest for the individual patient.

Not only groups for contagious patients need consideration about separation, but also non-contagious patients can be considered to have separation levels\(^1\)\(^2\). The bigger the hospital, the easier it is to allocate specific rooms or barns for a specific type of patient or age group.

**Different species**
- Different species should be separated from each other to reduce inter-species spread

**Research animals**
- Healthy research animals should not be housed together with sick patients

**Patients coming for consultations**
- Patients that are coming for consultation only should ideally be separated from hospitalized patients in order to avoid exchange of pathogens and reduce the amount of passage in the hospitalization ward.

**Surgical patients, elective surgery**
- Separate patients that are booked for elective surgeries from those that come for other medical reasons. Patients with for example skin conditions or respiratory diseases can potentially spread their disease and increase the risk of anesthetic or surgical complications for elective surgery patients when hospitalized closely together.

**Neonates**
- Neonates and mother animals have specific needs concerning infection control. Neonates are more at risk for infectious diseases than adults due to their physiologically immature immune system that may be even further dysfunctional due to disease and therefore need infection control for protection. Moreover, a calm environment to deliver and to nurse their newborn is recommended. On the other hand, neonates, broodmares and septicemic calves have been shown to excrete more often *Salmonella*, even without showing clinical signs such as fever or diarrhea\(^1\)\(^2\), and admittance to a equine neonatal intensive care unit was identifies as a risk factor for MRSA colonization\(^2\).

**Colic horses**
- Also colic horses have specific needs. Regardless if they are medical or surgical cases, they are more at risk to excrete *Salmonella* and this can be with or without showing clinical signs such as fever or diarrhea\(^1\)\(^2\). Moreover, especially postoperative cases frequently are immunosuppressed, receive antimicrobial therapy, are fasted, have an IV catheter and can therefore be suggested to be at higher risk for infectious complications such as diarrhea, wound infections, viral infections, thrombophlebitis, etc.

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**General cleanliness and hygiene of the patient, environment and instrumentation**

General cleanliness and hygiene are the basis of good veterinary practice and it will help creating a good image towards your clients. These principles account for all patients, regardless of their infectious status.

**Basic rules regarding cleaning and disinfection**
- Cleaning is necessary before disinfection! Disinfectants are often deactivated by organic material\(^1\)\(^3\).
- Work from clean to dirty or from uncontaminated to contaminated.
- Use the optimal conditions for the disinfectant: good dilution and appropriate contact time according to type of disinfectant and manufacturers instructions. The efficacy of disinfectants can be questioned when products are used with low concentration or with low bactericidal activity, and this might select for less susceptible bacteria\(^2\)\(^3\). True resistance to high concentrations has been described in health care facilities but remains uncommon\(^2\). Concentrations of disinfectants should not be based on minimum inhibitory concentrations (MIC), but on biocidal activity\(^4\).
- Each disinfectant has its own characteristics and spectrum and therefore a disinfectant must be chosen depending on the agent and the circumstances. For example with regards to *Salmonella* organisms, bleach was found to be the most effective disinfectant on the largest number of surfaces tested\(^5\), but another study showed peroxxygen disinfection to be highly efficacious in a clinical setting\(^5\). Parvovirus and rotavirus are difficult to kill pathogens\(^6\).

**The patients**

It speaks for itself that good patient hygiene will contribute to the overall well being of the patient. Dirt, secretions, excretions, urine and feces all can compromise skin health and possibly contain infectious agents. Therefore they should be cleaned off the animal.

**Waste from the patient**

In order to reduce spread of wound infection causing bacteria, the patient’s wound dressings should be put directly into waste disposal bags without touching any surface\(^7\). All dirt, secretions, excretions, urine and feces from the animal expelled in the environment as well as medical waste should be cleaned up and/or disposed. Enough bins for waste disposal should be available throughout a hospital and at strategic places.

**The patients stable or cage**

The stable/cage, the bedding and even the surroundings are frequently touched surfaces by the patient and caregivers and should be clean and regularly disinfected.
Special attention should be paid to drinking and eating equipment since they can be an easy vector of infectious diseases, including MRSA \(^7\), and a source of fungal or bacterial growth. In general, eating and drinking should be optimized in order to provide optimal immunity defense to infectious complications \(^15\).

Environmental surfaces including examination rooms, induction/recovery room, surgical theater and isolation facilities

Although several studies have shown decreasing bacterial loads after cleaning and disinfection in human and veterinary settings \(^7,26\), no study has been able to demonstrate lower infection rates in human hospital settings associated with routine disinfection of surfaces versus cleaning with detergent only \(^27\). As far as the authors are aware, no data is currently available for veterinary settings about its clinical effects.

Nevertheless, it is generally accepted that all rooms used for patient handling and their non medical equipment such as stretchers, chairs, washbowls \(^28\), door handles \(^7,29\) and drains should be cleaned and disinfected regularly \(^25\), because some pathogens, including Salmonella and MRSA can extensively contaminate a hospital setting \(^7,29\). Cleaning efficacy of environmental sites differs greatly, and especially computer keyboards and mice seem more challenging to clean \(^30\).

Faucets need particular attention since they can easily become colonized with *Pseudomonas aeruginosa* and have been identified as sources of HAI in human hospitals \(^31,32\).

Whenever possible, wooden, porous, textured, cracked or pitted materials or surfaces, and rubber mats should be avoided for medical settings since they cannot be disinfected properly \(^7,13,15,28\). Roughened floors can, however, be necessary for safety when dealing with large animals.

Directed mist application of a 4% peroxymonosulfate solution and cold fogging with Virkon S have been demonstrated to be an effective and efficient manner to perform environmental decontamination from *Staphylococcus aureus* and *Salmonella* spp in veterinary settings. These methods are also suggested to be less disruptive than traditional approaches and to potentially minimize microbial contamination in the hard to reach areas \(^33,34\). This approach can be a useful adjunct, not a replacement, to traditional cleaning and disinfection \(^13\). In experimental and clinical human hospital settings, a new disinfectant product with persistent effect, Appeartex, has shown promising results in reducing bacterial loads even one day after application \(^35\).

Separate ventilation systems in surgical theatres and isolation facilities are recommended to avoid airborne spread of pathogens, as described for an EHV outbreak in a veterinary hospital \(^5\).

**Instrumentation or animal contact items**

All medical and non-medical instrumentation should regularly be cleaned and disinfected. Scissors, stethoscopes \(^36\), thermometers \(\text{ref}\), twitches, blood pressure cuffs \(^37\), computer keyboards in treatment areas \(^38\) and anesthetic inhalation machines, pulse oximeter probes \(^22\) have all been reported in literature to be associated with contamination or the spread of pathogens in hospitals and should therefore not be forgotten. When alcohol is used for disinfection it should be applied for the appropriate contact time (15-20min) and allowed to evaporate completely before reuse \(^27\).

**Twitches** can have changeable twitch ropes and be of material easy to clean and disinfect \(^7\).

**Stethoscopes** can be considered as an extension of the hands and cleaning can therefore be suggested at the same frequency as hands \(^39\). Cleaning was found highly effective at removing bacteria and can be done with ethanol based cleansers and isopropyl alcohol \(^36,39\), but in a day those cleaned stethoscopes were contaminated back up to a similar level of bacterial load as never-cleaned stethoscopes in a small animal hospital setting \(^38\). Antimicrobial diaphragm stethoscope covers have been developed but their practical utility can be questioned since stethoscopes with these covers were found to even have higher bacterial loads while used in human hospital than those without these covers \(^36\).

The replacement of rectal thermometers by tympanic ones in human settings has shown important reductions of infections with vancomycin-resistant Enterococcus and *Clostridium difficile* \(^41\). In the veterinary world, thermometers have been recognized to be a potential concern with regards to transmission of multi-resistant enterococci \(^42,43\) and therefore specific thermometer-cleaning protocols can be suggested.

Some non-surgical instrumentation, such as endoscopes and dental equipment, will need cleaning or cleaning and disinfection after each use.

Sterilization of surgical equipment is beyond the scope of this presentation.

**Staff hygiene**

**Eating and drinking**

For their own protection, staff members should not be allowed to eat or drink while in clinical rooms or when handling patients, samples, detergents and disinfectants, chemicals and/or medication. Eating and drinking should only be allowed in dedicated rooms.

**Clothing**

Since uniform contamination may be an important factor in the spread of infections, it is advised that staff wears hospital clothing while in the hospital and specific surgical clothing for use in the surgical theatre \(^7\).

There is currently discussion whether home-laundering of
soiled, but non-contaminated surgical scrubs from human operating room personnel should be allowed. Although logic sense speaks for an increased transmission risk of infectious diseases and that significant higher bacterial counts have been found on home-laundered versus hospital-laundered scrubs 40, home-laundering policies have not been linked with higher surgical site infections or by harmful effects on home environment 45,46. No statistical difference on bacterial counts was found between hospital-laundered scrubs and unused new and disposable scrubs 40. The situation in veterinary surgical theatres is probably different from human settings, and no scientific evidence is currently available about home-laundering of surgical scrubs. When home-laundering is done it is advised to wash surgical attire separately from other laundry and as last and to use bleach, high washing temperatures and a hot air dryer 22,47.

Silver-impregnation of surgical scrubs appeared to be ineffective in reducing bacterial contamination in veterinary settings 48.

**Mobile phones**

Mobile phones of veterinary teaching hospital staff have been found to harbor pathogens, although in a low contamination rate 49. Also in human medicine cell phones are recognized to be a possible transmission route for pathogens in hospital settings and opposite phones are recognized to be a possible transmission route for pathogens in hospital settings 48. The situation in veterinary surgical theatres is probably different from human settings, and no scientific evidence is currently available about home-laundering of surgical scrubs. When home-laundering is done it is advised to wash surgical attire separately from other laundry and as last and to use bleach, high washing temperatures and a hot air dryer 22,47.

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**Hand hygiene (not for surgical preparation)**

Hand hygiene measures are leading measures to personal hygiene and to interrupt transmission cycles. There is convincing evidence that they reduce nosocomial infections in human hospitals as part of multimodal implementation of infection control strategies 52. When their effect is evaluated alone without considering other measures they have only been proved efficacious in a limited amount of studies 53,54, possibly because of lack of appropriate adherence with hand hygiene recommendations 52. Factors for poor compliance or adherence in human settings were amongst others: being a male, doctor status (rather than nurse) 45, working in surgical care unit, working in anesthesiology, wearing gloves 52. Failure to perform and comply with appropriate hand hygiene measures is now considered the leading cause of HAI and outbreaks of multi-resistant organisms 55.

Hand washing (water and antibacterial soaps or water and plain soap), hand rubbing (alcohol based rubs) and glove wearing can protect patient handlers and patients and are recommended in between patients or different procedures. The effect of hand asepsis protocols on HAI rates and removal of pathogens from hands was superior from hand washing with plain water and soap 57. Of the hand asepsis protocols, alcohol-based hand rubs appear to be the most effective at reducing pathogen loads on the hands of health care workers, but hand washing is needed when hands are visibly soiled 13,15,22,52. The use of gloves, although easier to monitor, can provide a false idea of safety and glove removal should be followed by hand washing or disinfection 21,52. Short nails and a healthy skin are suggested to be an integral part of hand hygiene, and therefore provision of hand lotions can be suggested 11.

Hygiene facilities should be easily accessible for staff and available at multiple strategic points and beside all doors and sinks 11, since accessibility of hand hygiene facilities affects the frequency and compliance of hand disinfection by personnel 52,54,91.

Jewelry, including watches, should not be worn not only during surgeries but also normal clinical work 7,52. Extra clocks can be placed and watches to pin on working clothes can be used 7.

Hand hygiene measures amongst veterinarians and their staff are currently poor 90,61, but more and more hand hygiene educational campaigns and protocols are currently instituted 7,61.

**Foot hygiene**

Foot baths and mattresses should not be expected to sterilize footwear, but can reduce the amount of germs on shoes and therefore the spread of infections 62,65. They can be used at sites where infectious status changes. Disinfectants containing peroxygen compounds have showed good effectiveness for footbaths and foot mats in reducing bacterial loads on boots or shoes used in large animal veterinary settings 62,64, whereas quaternary compounds have performed very poorly in footbaths 62. Nevertheless, the disinfectant used should be effective against the specific pathogen, stable in solution and have a short contact time 15. Their success depends on the used disinfectant, the amount of organic debris, the amount of passage, their cleaning frequency and the willingness of the involved people to step in or on them 15. However, if not correctly used or without regular hygienic monitoring footbaths or foot mats may also act as contamination source 65. Removing organic debris from footwear before the use of a foot bath or foot mat with for example a brush and water will minimize the buildup of debris in the foot bath or mat and will increase effectiveness of the disinfectant 15. Although footwear hygiene protocols are generally accepted to be an important aid in reducing risk of transmission, and reduce significantly bacterial loads on boots or shoes 12,44, some questions can be raised on their efficacy, since total bacterial counts and Salmonella enterica isolates recovered from floor surfaces in veterinary hospitals appear not to be affected by them 66,67. In other settings, however, such as an animal research facility, a significantly lower bacterial load obtained from floors was demonstrated after use of disinfectant foot mats or shoe covers, compared to no foot hygiene measures 68.
Plastic overshoes can be used as an alternative in isolation or surgical facilities. Nonetheless, occupational contamination risk during attire and removal is evident.

Unfortunately, no studies relate the use of foot hygiene directly to contamination or infection of surgical sites or patients.

**Limiting passage**

Another main principle is to limit passage through the hospital or the hospitalization barns/wards at several levels: visitors, owners or clients, patients, accompanying animals, insects and vermin. This will limit incoming infectious diseases, and spread of infectious diseases.

Whether a clinic cat should be allowed in a large animal hospital is up for discussion because they can be the only means to keep the rodent population under control. In small animal hospitals, however, it is not recommended to have resident cats since they have been shown to carry multidrug-resistant enterococci and are likely to contaminate the hospital environment.

**Communication and education**

Everybody involved should be aware of and cooperate with the implemented rules, because a single person committing critical errors can undermine all the efforts of the others. Unfortunately, the highest educated medical staff (doctors themselves) has shown to be the least compliant with hygienic measures in hospital surveys, and not showing the good example. Therefore education and training about the pathogens, their transmission and the implemented infection control measures at all levels is a must. It can also be extremely helpful to have written protocols. Although more and more veterinary hospitals are aware of this need and are actively working on it, still few have a formal infection control program.

Veterinary infection control is unfortunately still often reactive instead of proactive.

Also good communication about the infectious status of patients is necessary. It is recommended to use signage and messages on the stable/cage including the measures that need to be taken.

In addition, tracking and documentation of patient movements is crucial to back track the origin of outbreaks of infectious diseases.

**Surveillance and control systems**

Surveillance and controls systems are necessary to establish baseline rates for infection rates, for subsequent assessment of efficacy of infection control protocols, and for rapid identification, intervention and cessation of disease transmission. Surveillance and control systems require reliable and standardized diagnostic tests.

**Regular testing, prospective investigations: active surveillance**

Patients, environment (stables, treatment rooms, surgical theatre), and equipment can be regularly tested for presence of contagious agents. Patients can be systematically sampled on admission in a clinic to monitor for MRSA or Salmonella (standard surveillance or screening).

Sampling of environment and equipment can be performed every so many months to determine if a high bacterial load is present and if sterilization and/or cleaning/disinfection procedures are efficacious.

Of course, extra testing of patients, environment and equipment is warranted after contact with a suspected contagious agent (syndromic surveillance).

Environmental tagging with fluorescent dye may be of use to establish baseline cleaning rates, identify deficiencies in protocols, and help with staff education.

Opting not to perform standard surveillance but only syndromic surveillance has previously lead to late identification of infectious problems and subsequent outbreaks, but standard surveillance is expensive and its need is debatable for low prevalence countries or patient groups. Moreover, standard surveillance might provide a sense of false security with staff handling negative-tested horses with less care. Basic precautions and good cleaning routines should be implemented for every patient irrespective of culture results.

**Retrospective investigations: passive surveillance**

It can be helpful to retrospectively investigate hospital-specific viral and bacterial diagnoses, nosocomial diseases and resistance patterns. Every hospital has their own “in-house” problems and they are important to be recognized.

**Evaluation of infection control protocols**

Developing and maintaining effective infection control programs is a dynamic process. Therefore, infection control protocols need to be evaluated and weaknesses identified and dealt with in order for them to be efficacious in interruption of transmission routes and occurrence of contagious diseases.
References


52. WHO guidelines on hand hygiene. 2009.