Pyoderma is a common skin disorder in small animal practice. Yet it remains a frustrating disorder as Staphylococcus tends to be an opportunist that takes advantage of compromised skin. Sorting out the diseases which predispose to pyoderma is a critical feature of infection management, yet many pyodermas become recurrent. We often consider underlying diseases, but we may not consider features such as owner and patient compliance, suboptimal dosing, incorrect choice of antibiotic, and an overall reduction in the use of topical therapy. The age of methicillin resistance is now with us in veterinary medicine and we are struggling with how best to deal with this phenomenon, which has plagued physicians for some time. The increase in prevalence of multidrug-resistant bacteria is sadly coupled with decreased antibiotic drug discovery and development, so veterinarians and physicians are coming back to old antibiotics for treatment of resistant bacteria as well as nonantibiotic topical therapy, which is particularly suited for dogs with pyoderma. It is important to realize that the best protection against spread of methicillin-resistant Staphylococcus (MRS) in both humans and dogs is hygiene. Handwashing, the use of alcohol-based hand cleaners, and environmental disinfection do more to reduce the spread of infection than antibiotics can. Infected dogs need lots of baths! The next best protection is to use antibiotics wisely. Modern recommendations include using the highest safe dose the pet can tolerate for only the amount of time it takes to clear the infection. The idea is to kill off susceptible bacteria so rapidly that the host’s defenses can take over; in this way, we prevent selection of resistant strains of bacteria. In this presentation, we will review several cases of pyoderma which illustrate some of the critical features to successful management of this common skin disorder. These proceedings will provide the background information for these cases.

Why Do Dogs Get Pyoderma?
Of all the species with which we work, the dog seems uniquely predisposed to bacterial skin infections. Unlike human-haired skin, dog hair follicles lack the protective lipid plug that blocks the hair follicle opening; in addition, dogs have a thin and relatively disordered stratum corneum with less intercellular lipid. In general, the pH of dog skin is believed to be more alkaline that that of human skin and other domestic animals, with acid pH’s considered to be more antimicrobial. Dogs with underlying skin disorders, such as atopic dermatitis and other allergic skin conditions, disorders of keratinization, endocrinopathies, and parasitic diseases, are more likely to develop staphylococcal skin infections. We know that the skin barrier, represented by the stratum corneum, is one of the first physical and chemical defenses against microbial infection. This barrier is known to be defective in human patients with atopic dermatitis and disorders of keratinization; we now know that this barrier is defective in dogs with atopic dermatitis as well. In addition, preliminary evidence suggests that dogs with atopic dermatitis may have decreased levels of defensins, cationic antimicrobial proteins that defend against bacterial infections as part of the innate immune system.

What Bacteria Cause Pyoderma in Dogs?
The major canine skin pathogen is S. pseudintermedius; however, S. schleiferi, S. aureus, and Pseudomonas aeruginosa also can be identified from canine pyoderma. S. pseudintermedius binds preferentially to canine skin cells compared to human or feline skin cells and this binding is enhanced when the corneocytes are derived from atopic dogs. While not considered as virulent as the human pathogen S. aureus, S. pseudintermedius shares many of its virulent characteristics, including enzyme and toxin production, ability to adhere to matrix adhesive proteins, and ability to form biofilms. Each of these features contributes to the ability of the bacterium to colonize and invade the skin. S. schleiferi was first identified from human clinical specimens in 1988. It has now been identified as the cause of pyoderma and otitis externa in dogs as well. S. aureus, the human pathogen, has been identified in a low percentage of dogs; this bacterium has received a great deal of attention because of the interest in methicillin resistance in humans and the possible zoonotic role that pets might play. Lastly, while not common, P. aeruginosa can also be identified from the skin of dogs, particularly in fold pyodermas and post-grooming folliculitis.

What Are the Clinical Manifestations of Pyoderma?
There are many ways to classify pyoderma, but its depth in the skin is a particularly helpful classification as it can be used to predict the type and duration of therapy.

Surface Pyodermas
Surface pyodermas are those in which the skin surface is colonized by the cocci. Because these bacteria produce toxins, inflammation can result even when they sit on the surface of the skin. The best examples include fold
pyodermas of the face, lips, tail, and axilla. Bacterial overgrowth syndrome (BOG) is also associated with a surface infection; it is characterized by large numbers of bacteria, erythema, pruritus, and malodor. Surface infections are often best treated topically. They are not considered curable because the moisture and occlusive nature of folds predisposes toward recurrence. Surgical excision may be curative in some cases of vulvar fold pyoderma and tail fold pyoderma in English bulldogs.

**Superficial Pyodermas**

Superficial pyodermas include impetigo and folliculitis. Impetigo is the subcorneal pustular disease seen frequently on the abdomen of puppies. This disease may or may not be pruritic, but it is often self-limiting. Topical therapy is often effective in its treatment and is preferred to systemic antibiotic administration. Bacterial folliculitis (infection and inflammation of the hair follicles) is the most common pyoderma seen in dogs. This type of pyodermas has many clinical forms, the features of which may be unique to the individual breed of dog. The earliest form of folliculitis is a follicular papule. With a little magnification and good light, the hair can be observed emerging from the center of these lesions. It is quite rare to see actual pustules in most patients. The lesion progresses as the bacteria spread into surrounding hair follicles. The classic lesion is the epidermal collarette, characterized by a circular area of hair loss with variable redness, crusting, and hyperpigmentation. These lesions may or may not be pruritic. Pruritus is usually quite profound in atopic dogs, however, and pyoderma is one of the factors that escalates itch in these patients. There are specific syndromes we see with folliculitis in certain breeds that are not always recognized. These include short-haired dog pyoderma, often misdiagnosed as urticaria (hives), and superficial spreading pyoderma in collies, Shetland sheepdogs, and other dogs, which may involve a hypersensitivity reaction to the bacteria. Short-haired dog pyoderma occurs in any dog with a short coarse coat. The lesions can erupt quite quickly, leading owners to believe that these lesions are hives or insect bites. As the lesions of folliculitis progress, moth-eaten alopecia develops. Superficial spreading pyoderma is characterized by very large serpiginous lesions which can be very pruritic. Superficial pyodermas can often be treated exclusively with topical therapy, but frequent bathing is required (daily or every other day). This schedule is not acceptable to most owners; therefore, systemic antibiotics are often used to treat superficial pyoderma.

**Deep Pyodermas**

Deep pyodermas are less common and occur as either focal diseases of furunculosis or as generalized furunculosis and/or cellulitis. Furunculosis is a term used to describe a lesion in which the hair follicle ruptures, releasing bacteria and free hair into the dermis. The inflammation that results is robust and visible pus is a characteristic feature. Localized forms of furunculosis are common in the chin of short-coated dogs such as those of the bully breeds, Doberman pinschers, and Great Danes. Furunculosis also occurs on the lateral stifles and other pressure points. Furunculosis is associated also with the syndrome of interdigital pyoderma or interdigital “cyst.” Nasal pyoderma, seen most often in German shepherd dogs and their crosses, is a localized painful disease on the dorsal muscle posterior to the nasal planum; it can be similar in appearance to dermatophytosis. The golden retriever develops furunculosis, which has many of the features of acute pyotraumatic dermatitis; these dogs can become depressed as and when these lesions develop. Generalized furunculosis and cellulitis are not common, but often accompany demodicosis. The inflammation is quite severe and dogs are often systemically ill when infection is deep. German shepherd dogs experience a severe ulcerative pyoderma that is generalized and painful. There are hemorrhagic bullae and ulcers that often lead to the mistaken notion the dogs have an autoimmune disease. Deep pyodermas always require prolonged courses of antibiotic therapy.

**How Do We Diagnose Pyoderma?**

For many dogs, the clinical lesions are distinctive enough to make the diagnosis on physical exam. We nearly always perform cytolgies because staphylococcal infections often coexist with *Malassezia* infections and both need to be treated in order to resolve the skin problem. We also recognize that Gram-negative rods, including *Pseudomonas aeruginosa*, can cause pyoderma in some dogs. Cytologies can be made by pressing a glass slide against a moist lesion, by using clear acetate tape, and by using slides coated with a sticky adhesive (http://www.delasco.com/pcat/1/Veterinary/). Slides can be stained with Diff-Quick; if using tape or sticky slides, the first fixative methanol should not be used. Once stained, the tape will serve as its own coverslip. It is placed on the slide, immersion oil applied, then the slide examined for microbes, keratinocytes, and white blood cells. Usually, a semi-quantitative system is used from 1+ to 4+ to evaluate the number of bacteria or yeast present, but it is important to note that even low numbers of organisms can be clinically significant. Some dogs will actually develop
a hypersensitivity response to bacteria or yeast; therefore, the inflammatory response is profound to low numbers of microbes. The cytology results are used to guide therapy. Culture and sensitivity is recommended for all generalized deep pyodermas and when treatment with two different classes of antibiotic fail to resolve the problem. Methicillin resistance in canine infections is increasing and the sensitivity results are required to pick the correct antibiotic since we don’t have validated methods for empirically picking antibiotics for methicillin-resistant staphylococcal infections in dogs. Moreover, identifying the particular Staphylococcus species involved is important so that we can determine whether the dog is infected with methicillin-resistant S. aureus and may be a source of contagion to humans. While there is some risk when dogs have methicillin-resistant Staphylococcus aureus (MRSA), the important concept to remember is that these dogs most likely got the infection from a human. Methicillin-resistant Staphylococcus pseudintermedius (MRSP) is much less likely to cause human infections, unless a person is very young, very old, or immunocompromised. Even then, the risk is relatively low (see http://www.wormsandgermsblog.com).

How Do We Treat Pyoderma in Dogs?
All dogs with pyoderma should be bathed as part of their therapy. Topical therapy is preferred as the sole therapy for surface pyodermas and for some localized superficial pyodermas as well. For pyodermas in which antibiotics are indicated, we want to choose the correct antibiotic at the correct dose for the correct duration. Many dermatologists believe that the most appropriate first choice antibiotic for canine pyoderma is a cephalosporin, although more narrow spectrum antibiotics such as lincomycin, clindamycin, or Clavamox can be very useful for first time pyodermas in general practice. If a pyoderma fails to resolve with a cephalosporin, it is important to step back and reevaluate the diagnosis and treatment plan. One factor often ignored is whether the antibiotics have been given correctly and for the full course of therapy. Compliance is likely a bigger problem in veterinary medicine than we have realized and lack of compliance is a common factor in the failure of pyoderma to resolve and/or its recurrence. Furthermore, poor compliance allows for the selection of more resistant bacteria, thus contributing to the potential of the development of a methicillin-resistant infection. For this reason, cefovecin has become my first choice antibiotic for the treatment of pyoderma during the initial presentation. This antibiotic allows us to adhere to the concept of keeping the antibiotic levels in the tissue above the minimal inhibitory concentration (MIC) for Staphylococcus pseudintermedius consistently for 14 days. This approach would seem to fit the principles we recommend to avoid the selection of resistant bacteria by treating the pyoderma so aggressively that >99% of the bacteria are killed immediately and the host defenses can eradicate the rest. It should be noted, however, that not all dermatologists advocate for cefovecin as it is a third generation cephalosporin. Recommendations against third generation cephalosporins are based on findings in human hospitalized patients treated with antipseudomonal and anti-Gram-negative cephalosporins. We have no evidence in veterinary dermatology that the use of cefovecin or cefpodoxime is more likely to induce resistance than any other antibiotic we use. Furthermore, cefovecin is the only antibiotic for which we have good evidence for efficacy in canine pyoderma. To me, the advantages outweigh the proposed disadvantages and I am not convinced that we can compare this novel injectable antibiotic to oral antibiotics. We still advocate the use of cefpodoxime, but in my area we find that cephalaxin is becoming less reliable. There is some evidence that the MIC for S. pseudintermedius might be climbing, requiring the use of t.i.d. administration for it to work well, if it works at all. Administering medications every eight hours is difficult to achieve with veterinary patients in a home setting. Most dermatologists will recommend against choosing a fluoroquinolone as a first choice for pyoderma management. There are several reasons for this. First, enrofloxacin in particular has been used extensively in many dogs, often at doses that are suboptimal for Staphylococcus spp. Second, the fluoroquinolones do not seem to be as effective in vivo against Staphylococcus pseudintermedius as predicted by in vitro sensitivities. This is particularly true for older fluoroquinolones such as ciprofloxacin and enrofloxacin. Third, there is concern that fluoroquinolones may actually increase the risk of selecting for resistance. In humans, the relative risk for developing infections with MRSA were highest for those patients treated with fluoroquinolones. Furthermore, the use of older fluoroquinolones, in particular ciprofloxacin, was highly associated with selection for resistance. While we don’t have this evidence for veterinary patients, I think we can all agree that methicillin resistance in veterinary medicine temporally followed the introduction of the use of fluoroquinolones and that many of us see MRSP in dogs with previous fluoroquinolone experience. Ciprofloxacin is a second generation fluoroquinolone as is enrofloxacin; neither is a good first choice for staphylococcal pyoderma at this time. Current recommendations for dosing enrofloxacin suggest that we should use it at 20 mg/kg/day. Ciprofloxacin is not absorbed by at least 20% of dogs so it is not recommended, particularly when MRS is cultured. If a fluoroquinolone is used, marbofloxacin is preferred due to its superior pharmacokinetics for the skin, and it should be dosed at the high end (5.5 mg/kg/day). It has a very long half-life relative to other veterinary fluoroquinolones.
What is Methicillin Resistance and How Do We Recognize It?
Methicillin resistance in Staph is associated with acquisition of a gene, mec A, that incorporates into the bacterial genome and is subsequently passed on to all daughter cells. Mec A codes for a mutated form of penicillin binding protein on the surface of the bacteria. The mutant protein can’t bind any beta-lactam antibiotic and, thus, all penicillins and cephalosporins will be ineffective. The genetic element on which the mec A gene resides can also carry other antibiotic resistance genes and, thus, some *Staphylococcus pseudintermedius* will be resistant to all antibiotics tested. This genetic element will be retained within the Staph as long as antibiotic pressure is present, but in some cases it can slow bacterial growth. If antibiotic pressure is removed, then the bacteria have the capability of exciting the incorporated genetic element and becoming sensitive again. For this reason, it may make the most sense to avoid systemic antibiotic therapy for dogs with superficial pyoderma caused by MRS and focus on aggressive topical therapy. To diagnose methicillin resistance, we must do culture and sensitivity. It is no longer acceptable for your lab to report out coagulase-positive *Staphylococcus* spp. You should demand that the species of the Staph be determined, particularly when the infection is reported as methicillin resistant. Also, it is very important to be precise in our terminology. A methicillin-resistant *Staphylococcus pseudintermedius* is not “MRSA,” but “MRSP.” The term “MRSA” refers specifically to methicillin-resistant *Staphylococcus aureus*, the human pathogen.

How Do We Treat Methicillin-Resistant Pyoderma in Dogs? Topical Therapy is the Key.
Systemic antibiotic therapy for dogs with MRS cannot be picked empirically. Culture and sensitivity is required to know what antibiotic will likely be effective. Given that systemic antibiotic therapy drives the retention of the resistance factors, maybe we need to shift the way we think about superficial pyoderma and use topical antiseptic therapy instead. Topical therapy should be part of the regimen for all dogs with pyoderma. Bathing removes scale, grease, and crust; reduces odor; and makes the dog feel and look better. Furthermore, topical therapy will accelerate the rate to cure and hopefully decrease the length of time oral antibiotic therapy will be required. Most veterinary studies show that chlorhexidine shampoos are superior to other products. We can augment bathing, particularly when it can’t be done daily, by using sprays and wipes in between. In particular, the use of household bleach diluted 1:64 to 1:128 has been recommended, but we lack studies. Clearly, not all dogs with MRS will respond to topical therapy, particularly if the infection is a deep pyoderma. For those dogs, systemic antibiotic therapy will be required and culture and sensitivity will be mandatory. Potentiated sulfas and clindamycin may be used if suggested by C/S. Although we have advocated against the use of tetracyclines for most *Staphylococcus pseudintermedius*, MRSP may revert to sensitive. In those cases, doxycycline or minocycline may be helpful. My experience has been that long courses are required, as these antibiotics are bacteriostatic. The majority of MRSP are sensitive to chloramphenicol, rifampin, and amikacin. Chloramphenicol must be given at 50 mg/kg three times daily, which can result in poor compliance. In addition, most dogs that take this drug will become nauseated or develop vomiting and diarrhea after 30 days of treatment. Lastly, chloramphenicol is a health risk for humans, with the potential to induce aplastic anemia. If dispensed to clients they should be advised to handle the medication carefully. Amikacin is well-tolerated by most dogs, but must be given by injection at 15 mg/kg/day and does have the risk of renal toxicity. Frequent monitoring of the urine for casts and repeated bloodwork (blood urea nitrogen [BUN], creatinine) can make this an expensive option. Rifampin can be used once daily; it is recommended to keep the dose at a maximum of 10 mg/kg/day to reduce potential hepatic side effects.

In Conclusion
We are still struggling with how best to manage pyodermas in the age of methicillin resistance. A very useful resource for current information about MRS, particularly their zoonotic potential, can be obtained at the Worms and Germs blog, coordinated by Dr. Scott Weese and Dr. Maureen Anderson (http://www.wormsandgermsblog.com/promo/services/). At this site, you can download PDF files for your clients that explain these infections and how to handle them. My personal pyoderma manifesto is as follows:

1. Utilize antiseptic topical therapy instead of systemic antibiotics whenever possible.
2. When systemic antibiotics are required, be aggressive and treat with the appropriate dose until the pyoderma is resolved completely. Always couple systemic antibiotics with topical therapy.
3. Avoid the use of fluoroquinolones for staphylococcal pyodermas.
4. Utilize topical therapy to prevent recurrence.
5. Diagnose and treat the underlying cause.

Recommended Reading

