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Bacterial pyoderma is second only to flea allergy dermatitis as a cause of canine skin disease. In areas of the world ecologically less favorable to fleas, pyoderma is the most common canine skin disease. Pyoderma is defined as a pyogenic or pus-producing bacterial infection of the skin. In comparison to other mammalian species, dogs seem uniquely susceptible to both single-event pyoderma and recurrent pyoderma. The reasons for this phenomenon are not known, but may relate to various host factors that could result in enhanced susceptibility to infection. These factors could include the comparatively thin, compact stratum corneum of dogs, the relative lack of intercellular lipids in the canine stratum corneum, the lack of a lipid-squamous epithelial plug in the entrance of canine hair follicles, and the relatively high pH of canine skin.

The diversity of clinical syndromes seen with canine pyoderma is enormous. Classification of pyoderma is most useful based on depth of bacterial involvement as it provides information on diagnosis, differential diagnosis, likelihood of underlying disease, prognosis, and likely response to therapy. Pyoderma may be surface, affecting the stratum corneum and outer epidermis, superficial, involving only the epidermis and the epithelial appendages in the dermis, or deeper, compromising structures in the dermis and the deep, subjacent fatty tissue.

As we gain knowledge about canine skin infections, we realize that most infections seem to be secondary to either underlying disease or other underlying factors that somehow increase the likelihood of infection. Few pyoderma are ‘primary’ and do not have underlying causes or triggers. If underlying causes are not found, it is likely that recurrence will follow seeming cure. This recurrence suggests that the initial infection was not ‘primary’ but more likely was secondary to undiagnosed underlying disease or unrecognized triggering factors.

Superficial pyoderma are seen more frequently than deep pyoderma. As infection proceeds deeper into hair follicles, follicular rupture leads to a granulomatous foreign body tissue response. Deeper infections require a more aggressive diagnostic and therapeutic approach. *Staphylococcus intermedius* is by far the most common pathogen in canine pyoderma. Much less commonly, *Staphylococcus aureus* and *Staphylococcus schleiferi* may cause canine skin infection. Gram-negative organisms such as *Proteus sp.*, *Pseudomonas sp.*, and *Escherichia coli* are more likely to be secondary invaders in deep pyoderma. Rarely *Pseudomonas aeruginosa* and other gram-negative organisms can be the sole pathogen. Unusual staphyloccocal infection or gram-negative organisms are more likely to be more resistant to various antibiotics.

Both treatment failure and recurrence of infection commonly are associated with lack of recognition of factors that influence prognosis and complicate management of all pyoderma. The most common complicating factors include inappropriate initial therapy, unidentified coexisting and underlying skin diseases, and external environmental factors such as poor owner compliance.

Inappropriate initial therapy include errors in antibiotic selection, dosage, and duration of therapy. If cytology shows infection to be due to cocci and antibiotic choice is empiric, an antibiotic must be selected with a known spectrum of activity directed against *Staphylococcus intermedius*. Lack of response should initiate culture and sensitivity. Under-dosing leads to diminished therapeutic efficacy and overdosing is more likely to cause adverse reactions and needlessly increases expense. Under-dosing is common in larger dogs and overdosing is more common in small dogs. Systemic antibiotics should be utilized for a minimum of 3 weeks for superficial and 6 weeks for deep pyoderma. In general, antibiotics should be continued for a minimum of 1 week beyond apparent clinical cure in superficial pyoderma and 3 weeks beyond clinical cure for deep pyoderma.

Unidentified persistent underlying skin diseases that may complicate the initial management of pyoderma or lead to recurrence of infection include non-parasitic allergic skin diseases (canine atopic dermatitis, food allergy), parasitic allergic skin diseases (flea allergy dermatitis, sarcoptic acariasis, cheyletiellosis), demodicidosis, endocrine diseases (hypothyroidism, hyperglucocorticoidism - primary or iatrogenic), diseases of cornification (‘primary seborrhea’), genodermatoses affecting the hair follicles or adnexa (folicular dysplasia, color dilution alopecia, sebaceous adenitis), other infectious skin diseases (*Malassezia dermatitis*), occult neoplasia (solar-induced squamous cell carcinoma), and immunodeficiency - (congenital, acquired).

External environmental factors that markedly influence therapeutic success include owner compliance, loss of drug via vomition, and unexpected drug inactivation. Owner compliance is largely unexplored in veterinary medicine. In human medicine, it has been published that only 40% of prescriptions are even filled and only 40% or less of medication received is taken appropriately! Based on studies performed in human medicine, it is likely that compliance is enhanced when drugs are dispensed that need to be administered only once daily. This may contribute to a perceived enhanced efficacy in once-daily antibiotics such as enrofloxacin, marbofloxacin and ormetoprim-potentiated sulfadimethoxine. Twice-daily products such as cephalexin, lincomycin, and clindamycin also may offer advantages over antibiotics requiring administration three times daily.

The management of deep pyoderma offers additional challenges. Deep follicular inflammation commonly leads to follicular rupture and furunculosis. Granulomatous foreign body response directed against free keratin from the root sheath and hair shaft fosters the scar tissue formation and sequestered pyogranulomas. Consequently, the dual problems of infection and foreign body granulomas coexist. Unidentified or unsuccessfully managed persistent underlying skin diseases are much more likely to be present with deep pyoderma. Additional challenges include antibiotic dosage problems, the impact of sequestered foci of infection, inactivation of the antibiotic by pus and inflammatory products, and the possibility of unidentified mixed bacterial infection with aerobic or anaerobic organisms.

Unidentified or unsuccessfully managed persistent underlying skin diseases that most commonly complicate the management of canine deep pyoderma include demodicosis, hypothyroidism, iatrogenic hyperglucocorticoidism (especially associated with long-term management of allergic skin diseases), genodermatoses affecting the hair follicles or adnexa such as color dilution alopecia and sebaceous adenitis, occult neoplasia such as solar-induced squamous cell carcinoma, and either congenital or acquired immunodeficiency.

Occult demodicosis is a common undiagnosed initiator of deep pyoderma. Unexplained pyoderma in unusual locations such as the head and face should cue the clinician to look for
demodicosis. Index of suspicion for demodicosis may be low in small long hair coated breeds. Hair loss is not a prime sign of demodicosis in these breeds that have long anagen hair cycles.

Hypothyroidism may allow bacterial infection to invade deeper into the skin. Contributors to immune surveillance deficits such as hypothyroidism should be investigated in any dog with unexplained deep infection or infection that becomes more generalized than most pyoderma.

Iatrogenic hyperglucocorticoidism is a common and subtle occurrence noted in the long-term management of allergic skin diseases and other non cutaneous diseases. All dogs receiving long-term oral or parenteral corticosteroids and small dogs (less than 8kg.) receiving topical, oral or ophthalmic corticosteroids should be suspected of iatrogenic hyperglucocorticoidism if pyoderma is unexplainably widespread or invades more deeply than expected.

Genodermatoses affecting the hair follicles or adnexa such as color dilution alopecia and sebaceous adenitis are underdiagnosed initiators of deep pyoderma. Any anatomic defect in hair follicles predisposes to both superficial and deep folliculitis. Color dilution alopecia is seen most commonly in blue and fawn Doberman Pinschers but has been reported in many other breeds. Breed predilections for sebaceous adenitis, another follicular genodermatosis, have been noted for Standard Poodles, Samoyeds, Akitas, and Vizslas. The disease also has been reported in other breeds.

Solar-induced skin disease in regions of the world with intense solar exposure is underdiagnosed. It occurs in non-pigmented and lightly haired skin exposed repetitively to excessive ultraviolet light. Affected dogs commonly are sunbathers. Multiple stages of premalignant change (solar keratosis) and malignant transformation to invasive squamous cell carcinoma occur concurrently. Dalmatians, Whippets, Italian Greyhounds, Greyhounds, American Staffordshire Terriers, Bull Terriers, Beagles, and Basset Hounds are at increased risk.

Congenital or acquired immunodeficiency may initiate deep pyoderma or make cure more difficult. Acquired immunodeficiency may be seen in conjunction with underlying diseases such as neoplasia (especially lymphosarcoma) or immunosuppressive therapy.

Most antibiotic dosages recommended for the treatment of pyoderma are largely empiric. Clinicians commonly use the same dosages of antibiotics for both superficial and deep infection. This can lead to the belief in increased resistance of S. intermedius. Flexible dosage recommendations for different infections should lead to greater awareness of under-dosing of dogs with deep pyoderma.

In deep pyoderma, sequestered foci of infection impede antibiotic penetration, and keratin debris from ruptured hair follicles encourages foreign body granulomatous response. Granulomatous inflammation prevents antibiotic access to sites of infection. Antibiotics such as penicillins that require microbial replication for activity are less likely to be effective when necrotic tissue and obstructed drainage routes create conditions that are no longer favorable for bacterial multiplication. Consequently, higher antibiotic dosages are warranted in the management of chronic deep pyoderma.

Unidentified mixed bacterial infection with anaerobic as well as aerobic organisms is largely unexplored in the study of canine pyoderma. Recent data in human medicine suggests that anaerobic bacteria may play a larger role in deep infections that respond slowly or poorly to antibiotic therapy.

Clinicians confronted with canine deep pyoderma should always ask themselves the question, “Why?” If an underlying management error or an undiagnosed underlying disease is present, success in managing deep pyoderma is low.

Successful management of all deep pyoderma requires systemic antibiotic therapy. Topical antibacterial shampoo therapy commonly is used as an adjunct in the management of deep pyoderma to speed recovery, improve patient well-being and attitude, encourage owners, and potentially prevent recurrence. Immunomodulatory therapy is used less frequently and usually is an attempt to prevent or diminish the frequency of recurrent superficial infection. Extended regimens of antibiotics are used as a last resort in the management of frustrating recurrent infection.

The basic principles of successful systemic antibiotic therapy including selection of an appropriate antibiotic, the establishment of an optimal dosage, and the maintenance of that dosage for enough time to ensure cure rather than transient remission. Surface lesions in deep pyoderma commonly heal more rapidly than deeper lesions, although sequestered foci of infection may not be visible. Antibiotic selection can either be empiric or based on bacterial culture and susceptibility testing. An antibiotic chosen empirically should have a known spectrum of activity directed against S. intermedius and, should not be inactivated by Beta-lactamases.

Bactericidal antibiotics are recommended for deep pyoderma and when immunosuppression is confirmed or suspected. Pustules or fistulous tracts should be recultured if S. intermedius has not been isolated as the primary pathogen. If multiple isolates are not sensitive to one oral antibiotic, an antibiotic that is effective against S. intermedius should be instituted since staphylococci create a tissue milieu favorable to the replication of secondary bacteria invaders.

Antibiotics most likely to be successful in the management of deep pyoderma include cephalaxin, cefadroxil, enrofloxacin, marbofloxacin, clindamycin, oxacillin, and clavulanate-potentiated amoxicillin. More resistant S. intermedius and gram-negative isolates are seen more commonly in referral practices than in general practice, and resistant bacterial populations are identified most frequently in deep pyoderma.

Chronic, deep pyoderma requires antibiotics penetration as sequestered foci of infection and scarring prevent antibiotic access to the site of infection. First generation cephalosporins such as cephalaxin and cefadroxil offer good to very good penetrating ability. Uptake of enrofloxacin by macrophages was shown to concentrate that antibiotic at the site of deep granulomatous infection thus leading to potent tissue-penetrating abilities. Similar attributes may apply to other new fluoroquinolones. Fluoroquinolones also offer the advantages of once-daily dosing, activity against both S. intermedius and gram-negative secondary invaders, and diminished likelihood of resistance. Once-daily dosing with fluoroquinolones is strongly recommended because the bactericidal effect is concentration rather than time dependent.

Antibacterial shampoos are used as adjunctive therapy in the management of deep pyoderma. Antibacterial shampoos aid in debridement, encourage drainage, and decrease pain. The mechanisms of action is to decrease surface bacterial counts and to limit bacterial recolonization, hopefully diminishing the likelihood of recurrent infections. Improvement in patient attitude and owner encouragement are additional benefits. Antibacterial shampoos contain benzoyl peroxide, benzoyl peroxide and sulfur, chlorhexidine, ethyl lactate, or triclosan. Twice-weekly antibacterial shampoos are the most common recommendation. More aggressive topical therapy is beneficial for the management of deep pyoderma. After clipping, dogs...
benefit from daily antibacterial shampoos or twice-daily whirlpools. Chlorhexidine is added to warm water. Although labor intensive, whirlpools remain an under-employed but highly beneficial modality of topical therapy for deep pyoderma.

All dogs with pyoderma should be re-evaluated within 2 to 3 weeks. If substantial improvement is not noted, the clinician should consider factors that may have complicated management. Owner compliance to the appropriate dosage and drug loss through vomiting, inactivation by food, or malabsorption are common reasons for failure. Referral to a veterinary dermatologist should be considered each time that clinical failure occurs.

SELECTED REFERENCES