

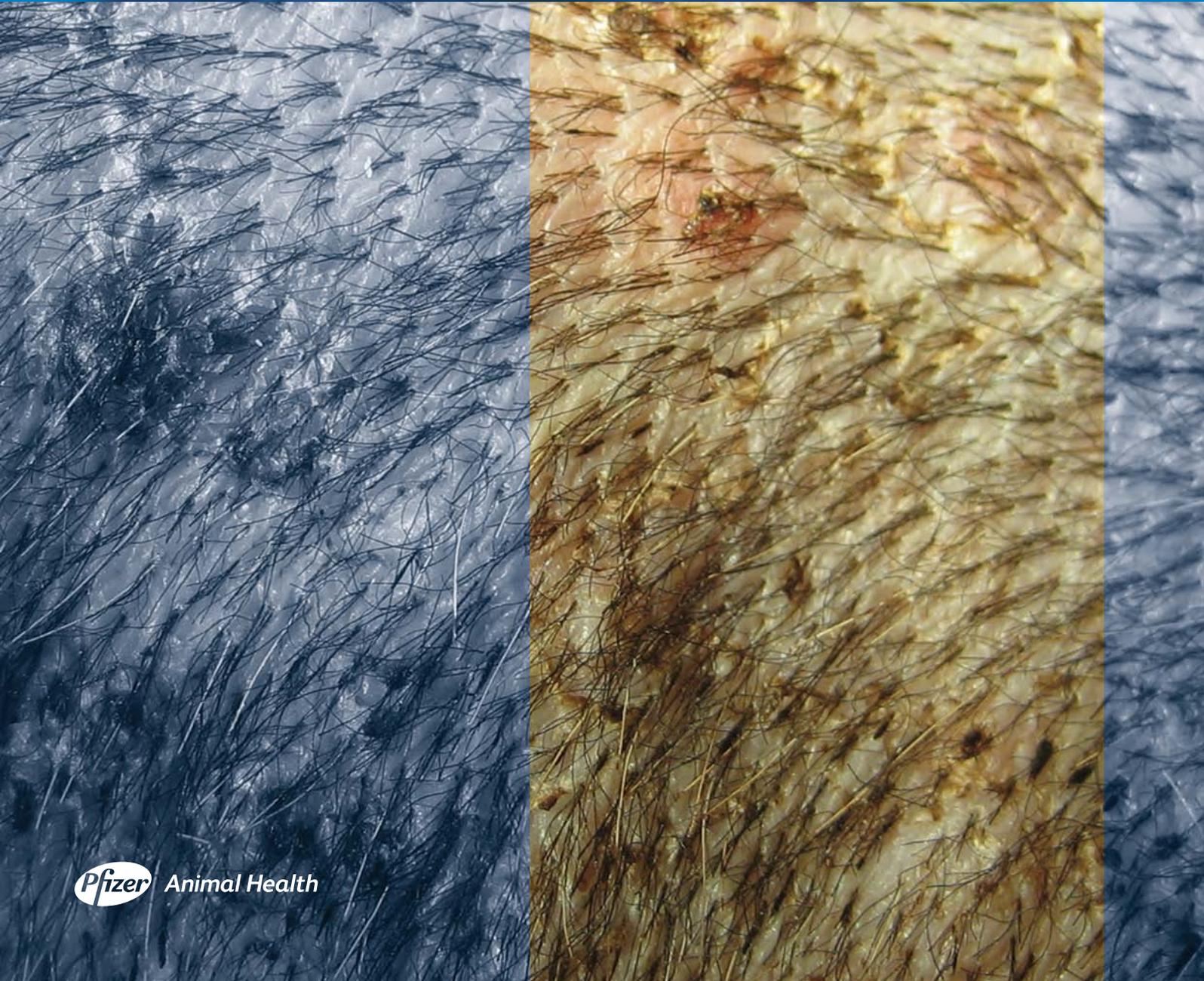


Skin infections in dogs

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Tim Nuttall graduated from the University of Bristol with degrees in Zoology and Veterinary Science in 1992. After three years in general practice he joined the dermatology service at the University of Edinburgh as a resident, where he gained the RCVS Certificate in Veterinary Dermatology and later studied for a PhD in the immunopathogenesis of canine atopic dermatitis. He joined the University of Liverpool in 2001 as a Lecturer, and since 2004 Senior Lecturer in Veterinary Dermatology. With Neil McEwan, Tim has established a busy dermatology clinic and an active research programme studying atopic dermatitis and microbial infections. He is the author of numerous clinical and scientific publications, and presents throughout the world on veterinary dermatology, antibacterial therapy and antibacterial resistance. He has also served on BSAVA and DEFRA scientific committees, is a scientific advisor to the Bella Moss Foundation and is a co-editor of *Veterinary Dermatology*. In his spare time he enjoys mountain biking, hill walking, kayaking and single malt whiskey.



Prof. Dr. Ralf S. Mueller

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Prof. Dr. Ralf S. Mueller graduated in Munich, Germany. He completed his doctoral thesis in 1987, and worked in several large and small animal practices before completing a residency in veterinary dermatology at the University of California, Davis in 1992. In 1992 he moved to Melbourne, Australia to work with his partner and wife Dr. Sonya Bettenay. Together, they created the first, purpose-built specialist practice in Australia. During that time, Dr. Mueller was concurrently consulting and teaching at the Veterinary Teaching Hospital, University of Sydney. In 1999, Dr. Mueller became Assistant Professor in Veterinary Dermatology at the College of Veterinary Medicine and Biomedical Sciences, Colorado State University. In 2004, he accepted a position as Chief of the Veterinary Dermatology Service at the University of Munich, Germany. He has published over 90 studies, articles, book chapters and books and given several hundred seminars, lectures and talks in Australasia, Europe and North America.



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Eric Guaguère graduated from Toulouse University in 1980, and completed a residency in parasitology and dermatology at the same school. He is certified in clinical biochemistry and haematology (1989) and in veterinary dermatology (1993), and a diplomate of the European College of Veterinary Dermatology since 1993. He obtained the French diploma of Specialist in Veterinary Dermatology in 2006. He exclusively works in private referral practice at the Clinique Vétérinaire Saint-Bernard in Lomme (near Lille (France)). He has published about 200 papers in referred journals and has given numerous lectures in Europe, South Africa, and in North and South America in the field of veterinary dermatology specializing in small animal dermatology. He is co-scientific editor of *Practical Guide in Feline Dermatology* (2000) and *Practical Guide in Canine Dermatology* (2006). His main interests are genodermatoses, viral dermatoses, cutaneous manifestations associated with internal diseases in the dog and in the cat, and dermatology of small mammals.

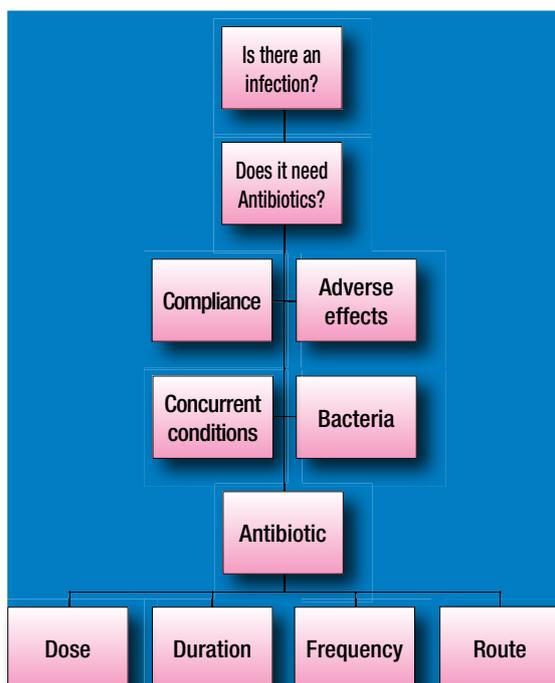


Introduction

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Principles of responsible antibiotic use

This booklet describes in detail the clinical signs and diagnosis of pyoderma. Antibiotics are vital in the treatment of pyoderma, but their use selects for resistance. They must therefore be used responsibly. Remember that cost, availability and medicines legislation may also effect your choice. A useful approach to antibiotic use is:



Is there an infection?

It is important to use history, clinical signs, cytology and culture to determine whether an infection is present, as antibiotics shouldn't be used to treat non-specific clinical signs such as vomiting, coughing, pruritus etc., or to prevent infection except in high risk situations. Clinicians should be able to recognise skin lesions specific for pyoderma, using cytology and culture and sensitivity to confirm clinical suspicions. The latter is not always necessary as most staphylococci have a predictable pattern of antibiotic sensitivity, but is advisable when:

- Cytology reveals rods; antibiotic susceptibility is unpredictable and often limited.
- Empirical antibiotic therapy does not resolve the infection.
- After multiple antibiotic courses.
- Non-healing wounds and post-operative infections.
- Potentially life-threatening infections.

Does the infection require treatment?

Not all infections need systemic antimicrobial therapy – many mild superficial pyodermas resolve once the underlying disease (e.g. atopic dermatitis) is controlled. Focal infections can be managed with topical antibiotics or other antimicrobials.

Label indications and clinical need

Label indications are based on data submitted for registration, and do not necessarily reflect full clinical activity. It is better to base decisions on clinical assessment, cytology and culture, if there is evidence to show that an antibiotic is effective in the required tissue against the target organism, and is safe at the intended dose.

Compliance

Poor compliance can contribute to the emergence of resistance. Generally, it is best with once daily dosing, reduced with twice daily and almost non-existent with more frequent dosing. Parenterally administered drugs such as cefovecin have 100% compliance for the whole dosing interval. Clear written instructions (e.g. use every 12 hours instead of twice daily) and follow-up checks all improve compliance.

Course duration

Treatment should continue to full clinical cure, assessed by clinical examination. This varies – most superficial pyodermas resolve in 2-3 weeks, but some are quicker and others take longer. Full resolution of deep pyoderma can take 4-8 weeks.

First, second and third line drugs

First line drugs include simple penicillins, tetracyclines and sulphonamides. These are no less potent than other antibiotics in the appropriate circumstances (use in pyoderma is often limited by resistance in staphylococci though). Second line drugs include newer products with extended activity, more important for general human and animal use, and more prone to resistance (e.g. broad spectrum β -lactamase resistant penicillins, cephalosporins and macrolides). These should be used where culture and sensitivity or empirical evidence indicates that first line drugs will be ineffective. Third line drugs (fluoroquinolones, anti-Pseudomonas penicillins, ceftazidime, imipenem etc.) are very important to humans and animals, particularly against multi-drug resistant organisms. They should only be used where culture and sensitivity indicates they are necessary.

Skin infections in dogs

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Dermatologic problems are common in small animal practice and comprise more than 20% of the case load. In a recent study bacterial infections were the most frequent cause of skin problems in dogs and cats. Thus, it is essential that the practitioners know about clinical presentations, diagnosis and treatment of such infections in order to provide a high standard of veterinary care.

Resident organisms are bacteria that are found and can proliferate on normal, healthy skin. Common resident organisms in the dog and cat are *Micrococcus* spp., coagulase-negative and -positive staphylococci, α -hemolytic streptococci, *Clostridium* spp. and various Gram-negative aerobes.

Resident flora varies with the location. On hair shafts, staphylococci are found more distally, gram-negative organisms more proximally. *S. intermedius* is a resident organism in the nares, oropharynx and around the anus in dogs. If *S. intermedius* on mucosal carrier sites are eliminated, the cutaneous population decreases markedly, indicating *S. intermedius* is only a transient organism on skin.

Microorganisms frequently seen with bacterial skin disease

● *Staphylococcus* spp.

The most common organism involved in bacterial infections of the canine skin is without doubt *Staphylococcus intermedius*. In a recent study evaluating bacterial pyoderma in more than 100 dogs, *S. intermedius* was isolated

in approximately half of the dogs and in more than one third of the patients it was the sole organism cultured. However, other coagulase-positive staphylococci have been reported in the dog. *Staphylococcus aureus* is the most relevant species in human medicine, but is also isolated from pets. In some laboratories staphylococcal species are not identified and isolates are reported as coagulase-positive staphylococci. However, in light of multiresistant staphylococci and possible transmission of such organisms from humans to their pets or vice versa, species identification is of increasing importance.

In the past, coagulase-negative staphylococci have not been regarded as pathogenic organisms, but *S. epidermidis*, *S. xylosus*, *S. simulans* and *S. hominis* have all been isolated from clinical pyoderma in dogs. Staphylococci may be isolated from the skin and coat of healthy dogs and cats, and thus a positive culture is not necessarily indicative of bacterial involvement in the disease.

Staphylococci produce a number of substances relevant for the pathology seen with infectious processes. Staphylococcal toxins, especially protein A and enterotoxin C, upregulate adhesion molecules on keratinocytes and facilitate the adherence of bacteria, a prerequisite for infection.

In addition, they may serve as superantigens, which can activate T lymphocytes non-specifically and lead to a hugely increased immune response and thus severe inflammation of the skin.

● Gram-negative bacteria

Typically, Gram-negative facultative anaerobic or anaerobic bacteria are not prominent in superficial bacterial infections. In deep infections, these organisms gain more importance. Although staphylococci may cause deep tissue infections (typically as a consequence of a superficial infection), other bacteria may be involved as well. In a recent study evaluating canine deep pyoderma, in more than 30% of the dogs Gram-negative organisms were cultured, and in more than 10% they were exclusively responsible for the infection. In bite abscesses, members of the oral flora such as *Pasteurella multocida* are frequently identified, but anaerobes such as *Fusobacterium*, *Bacteroides*, *Clostridium*, *Peptostreptococcus* and *Porphyromonas* spp. may also be involved.

Skin infections

Healthy dogs and cats do not easily develop skin infections. The cutaneous barrier and the immune system are pillars of a very effective host defence system. If an infection takes place, either one or both of these are defective. Physical trauma is the most common reason for compromised barrier function and frequent consequences of such trauma are abscesses and deep tissue infections. Diseases such as primary seborrhoea, sebaceous adenitis or atopic dermatitis in dogs or severe malnutrition with deficient intake of fatty acids may all compromise the cutaneous barrier.

The immune system may not be completely matured in puppies and young dogs, facilitating diseases such as impetigo, particularly when nutrition is suboptimal or severe endoparasitism occurs. Stress may also be immunosuppressive and in some animals can contribute to the development of skin infections. Immunosuppression due to endocrine diseases such as hypothyroidism or hyperadrenocorticism is seen in middle-aged to older dogs. Despite this multitude of possible predisposing factors, the most common

causes for secondary bacterial infections in small animals are hypersensitivities. With every skin infection a plausible cause must be found and addressed in addition to the antimicrobial therapy to maximize treatment success and prevent recurrences.

Superficial infections

Superficial bacterial infections of the skin are common, particularly in the dog. They can be classified as impetigo, mucocutaneous pyoderma and superficial folliculitis.

Impetigo in the dog is a bacterial disease caused by Staphylococcus organisms and characterised by pustules and epidermal collarettes (ring-like adherent scales that are seen after a pustule ruptures) affecting the sparsely haired ventral areas in young dogs.

Mucocutaneous pyoderma is a bacterial infection characterised by depigmentation, erythema, oedema and/or crusting of the mucocutaneous areas. The presence or absence of pruritus is not a useful clinical clue to differentiate possible hypersensitivities or endocrinopathies as predisposing factors.

Superficial folliculitis is the most common bacterial infection of the dog. It is typically characterised by an infection of the upper part of the hair follicle with *S. intermedius*. The classical lesion is a small pustule with a hair protruding from its centre (a follicular pustule). This is frequently preceded by a follicular papule. With time, hairs are lost and pustules develop into epidermal collarettes. In chronic disease, alopecia, hyperpigmentation and lichenification predominate. In long-coated dogs, initial lesions may be missed and a dull hair coat with increased scaling as a result of the epidermal collarettes may be the first clinical signs.

Deep infections

Deep pyodermas are serious bacterial infections involving deeper tissues. They can be a progression of a superficial infection that was insufficiently or inappropriately treated or did not receive therapy at all. Organisms extend into the deep hair follicle and together with the inflammatory response, cause a break through the follicular epithelium into the dermis and subcutis. Deep infections affecting large areas of the body are typically associated with an underlying disease responsible for a break down in the immune response. In addition to antimicrobial therapy, this disease must be identified and treated to achieve remission of the infection. If however a deep infection is localised, the most common cause is trauma through, for example a bite or a foreign body.

Folliculitis, furunculosis and cellulitis are typically an extension of a superficial infection. An underlying disease is usually present and needs to be diagnosed and treated to achieve good long term results. Demodicosis or dermatophyte kerions are frequently associated with deep bacterial infections.

Subcutaneous abscesses are frequently seen in cats and often due to bite wounds. In dogs, abscesses are rarer and in addition to bite wounds often caused by foreign bodies.

In summary, bacterial infection is a common problem in small animal practice that occurs when the cutaneous barrier function and/or the cutaneous immune system are disturbed. The predisposing factors permitting development of an infection must be identified and addressed in addition to the diagnosis and treatment of the bacteria to achieve an optimal outcome for the patient.

Clinical and diagnostic aspects of canine pyoderma

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Bacterial skin diseases, called “pyoderma”, are the most frequent cause of skin conditions in dogs. They are characterised by their great clinical diversity and the difficulty of both diagnosis and treatment.

Their classification, based on the depth of lesions and the distribution pattern, combines clinical and histopathological features, and is necessary for establishing a prognosis and choosing an appropriate treatment (Table 1). This classification allows us to distinguish surface and superficial pyodermas from deep pyodermas. Generally, pseudo-pyodermas – non-infectious dermatoses with a rapid secondary infection – are included in the category of deep pyoderma. In this article, pseudo-pyodermas will not be considered further.

Table 1: Classification of canine pyodermas

DEPTH	TYPE
Surface/Superficial Pyodermas	Skin fold pyoderma (intertrigo)
	Mucocutaneous pyoderma
	Bacterial overgrowth syndrome
	Impetigo Folliculitis
Deep Pyodermas	Furunculosis Cellulitis
	Pseudo-pyodermas
Juvenile cellulitis	
Eosinophilic furunculosis	
Idiopathic sterile granulomatous panniculitis	

Surface and superficial pyodermas

Surface and superficial pyodermas are the most frequently encountered bacterial skin diseases of the dog. These pyodermas involve the epidermis and/or hair follicles.

The basement membrane is not destroyed by the infectious process. *Staphylococcus intermedius* is the most commonly isolated organism (90% of the cases).



Bacterial folliculitis due to atopic dermatitis in a young male French Bulldog



Superficial pyoderma: epidermal collarette

● Skin fold pyoderma (intertrigo)

Skin fold pyoderma is an inflammatory process with an important bacterial colonization of skin folds: facial, lip, tail, vulvar, mammary, truncal and leg folds. Intertrigo is frequently described in certain predisposed breeds (e.g. Bulldogs, Basset Hounds, Dachshunds, Pugs, Shar pei, Cocker Spaniel) and in obese dogs. Skin folds represent a warm and humid environment, liable to maceration and bacterial colonization.

Clinical signs are characterized initially by erythema, serous exudate followed rapidly by erosions covered with purulent and malodorous crusts. In chronic conditions, skin folds become lichenified and hyperpigmented. These lesions are usually mildly painful and pruritic.



Intertigo of a facial fold in a French bull dog

● Mucocutaneous pyoderma

Mucocutaneous pyoderma is an uncommon bacterial infection of mucocutaneous junctions. German Shepherd dogs are reported to be predisposed. Lips (commissures), more rarely nares, vulva, prepuce and anus are involved.

Clinical signs are characterized initially by erythema and swelling of the lips, and progressively by erosions, fissures, ulcers and crusts. Primary lesions affect the mucocutaneous junction of the lips and not

the lip-fold. Lesions are generally bilateral and symmetrical and often painful.



Mucocutaneous pyoderma of the lower lip in a German Shepherd dog

● Bacterial overgrowth syndrome (BOG)

Bacterial overgrowth syndrome is a frequent skin condition, only described recently. Bacteria (staphylococci) actively multiply only at the skin surface and do not penetrate the epidermis. Bacterial overgrowth syndrome is frequently associated with atopic dermatitis.

Lesions are present initially in moist areas (axillae, neck folds, inguinal areas) and rapidly spread to the ventral thorax, abdomen and perianal area. Clinical signs include generalized erythema, lichenification, scales, alopecia and rapid hyperpigmentation. These cutaneous lesions are malodorous and often very pruritic.



Bacterial overgrowth syndrome
Note the erythema, lichenification and the scales

● Impetigo

Impetigo is a non-follicular superficial pyoderma characterized by large, non-follicular pustules.

Juvenile impetigo is frequently encountered prior to puberty. Clinical signs are characterized by large, numerous non-follicular pustules with an erythematous base, confined to the ventral abdomen, inguinal areas and axillae. These pustules contain a yellowish pus which dries to form honey-coloured crusts after their rupture. Pruritus is minimal to mild.

Adult impetigo is rarely described and always associated with a systemic disease or an underlying skin condition. Pustular impetigo follows repeated micro-trauma (e.g. hunting). Clinical signs are characterized by small non-follicular pustules distributed over the entire body. Bullous impetigo is reported in dogs with hyperadrenocorticism. Clinical signs include fever, large yellowish non-follicular pustules which rapidly develop thick, malodorous crusts.

● Folliculitis

Folliculitis is a follicular superficial pyoderma characterized by follicular pustules (centred on the pilo-sebaceous unit). Bacterial folliculitis has a great clinical diversity: follicular papules and pustules, epidermal collarettes, hyperpigmented macules, nummular (coin-shaped) alopecic patches, scaling and small crusts, and target lesions (central hyperpigmentation and peripheral erythema).



Superficial folliculitis characterized by erythematous papules on the chest in a 15 year old, female mixed breed dog



Bacterial folliculitis: many follicular papules and pustules

Secondary folliculitis is commonly associated with another skin condition or systemic disease. These superficial pyodermas are secondary to structural alterations frequently present with pruritic skin diseases such as allergies. Staphylococci and other bacteria penetrate excoriated areas that may be considered as a portal of entry for infection. Clinical signs are characterized by numerous pruritic follicular papules and pustules rapidly developing into epidermal collarettes, scales and crusts distributed generally over the trunk.



Bacterial folliculitis in a dog with demodicosis

Superficial spreading pyoderma is also called "bacterial hypersensitivity", even if staphylococcal hypersensitivity has not been formally demonstrated in dogs. Clinical signs are characterized by erythema, follicular pustules, target lesions (with a hyperpigmented centre), seborrheic plaques and haemorrhagic bullae. Multifocal hair loss gives the coat a "moth-eaten" appearance. Pruritus is often severe.



Superficial spreading pyoderma: note the target lesions

“**Acral lick dermatitis**” is frequently associated with a deep pyoderma (folliculitis and furunculosis). Clinical signs are located on the carpus and/or tarsus; they are characterized by one or more circumscribed, well-demarcated, erythematous alopecic areas and which rapidly become hard, erosive and weeping plaques. These lesions can become painful.

Pyotraumatic folliculitis is a clinical subgroup of pyotraumatic dermatitis. Large breeds (Labrador and Golden Retrievers, Leonberg, Great Dane, Saint Bernard) are reported to be predisposed. Clinical signs are reported to be indistinguishable from surface pyotraumatic dermatitis and include an oozing oedematous, suppurative painful plaque surrounded by “satellite” follicular papules and pustules.

Deep Pyodermas

Deep pyodermas are characterized by the crossing of the basement membrane by the infectious process into the dermis and sometimes the subcutis. These pyodermas are more rarely encountered but also more severe than superficial pyodermas. Systemic signs such as fever and lymphadenopathy can be observed. In extreme cases, septicaemia can occur.

Staphylococcus intermedius is the pathogenic bacteria most often implicated in deep

pyodermas but other organisms such as *Pseudomonas* spp., *Proteus* spp. and/or *Escherichia coli* are regularly isolated alone or associated with *Staphylococcus intermedius*. In few dogs, *Pseudomonas aeruginosa* can be the primary pathogenic organism implicated in the deep pyodermas.



Deep pyoderma (furunculosis) of a foreleg in a 1 year old, male Doberman

● Furunculosis

Furunculosis is characterized by deep pustules (furuncles) corresponding to the rupture and necrosis of hair follicles. The purulent debris and keratin, free in the tissue, lead to a foreign body reaction with marked inflammation and granuloma formation which is difficult to penetrate.



Furunculosis of the dorso-lumbar area: note the thick, haemorrhagic pus

Acne mainly occurs in young dogs belonging to predisposed breeds (Boxer, Great Dane, Doberman Pinscher, Labrador Retriever). The true pathogenesis is not clearly understood but it is probably different from the pathogenesis in humans.

Localized furunculosis is secondary to repeated trauma. Hair follicle rupture is responsible for a foreign body inflammatory reaction with a rapid secondary bacterial infection.

Interdigital furunculosis is a skin condition particularly often seen in Boxers, Shar peis, and Bulldogs, and is characterized by solitary or multiple furuncles or firm nodules between the digits. Licking, pain and lameness are regularly noticed.



Interdigital furunculosis

Pressure point furunculosis also called “callus pyoderma”, develops due to a constant trauma to the callus. This deep pyoderma mainly occurs in heavy animals, predominantly German Shepherd dogs, Labrador Retrievers and Great Danes. Clinical lesions are confined to certain body areas (elbows, hocks, hips, lateral digits) and include many painful furuncles which rapidly turn into cellulitis.

Generalized furunculosis is rarely encountered and frequently a consequence of poorly treated or untreated generalized folliculitis. Clinical signs include many deep erythematous or haemorrhagic pustules, fistula and thick crusts. These lesions may involve the entire skin surface.

Post-grooming furunculosis has been recently described. This disease usually is due to back-combing, back-clipping or aggressive bathing. Contamination of the shampoo solution by *Pseudomonas* spp. may be also suspected. Clinical signs are characterized by erythematous, oozing and erosive lesions with typical greenish colour.



Furunculosis in a Yorkshire Terrier with demodicosis note the haemorrhage pastules

● Cellulitis

Cellulitis develops from a diffuse, spreading, infectious process that tends to dissect widely through tissue planes affecting the dermis and subcutis. Cellulitis is frequently secondary to furunculosis. Clinical signs often result from the coalescence of furuncles and include a lesional triad: necrosis-fistula formation and suppuration. Generalised signs can be severe and include fever and septicaemia.

Localized cellulitis may develop as a sequela to localized furunculosis.

Pressure point cellulitis develops from pressure point furunculosis. Clinical signs are characterized by deep ulcers, suppuration, fistula and oedema.

Perianal cellulitis is a controversial skin condition. It is probably that perianal cellulitis and anal furunculosis (perianal fistulae) may actually be the same disease in which the bacterial process is secondary.



Perianal cellulitis

Pedal cellulitis is rarely encountered. One or several paws may be affected and show alopecia, erythema, fistula, ulcers and crusts in the palmar and plantar aspects of the interdigital spaces. Pruritus (licking, chewing) and moderate to severe pain (lameness) are frequently noticed.

Generalized cellulitis is a severe deep pyoderma in dogs and may be associated with systemic signs; possible causes are shown in Table 2.

Table 2: Underlying causes of generalized cellulitis

- Demodicosis
- Iatrogenic (glucocorticoids)
- Endocrine disorders: hyperadrenocorticism, hypothyroidism, diabetes mellitus
- Systemic diseases: leishmaniasis, ehrlichiosis, systemic lupus erythematosus
- Tumours



Cellulitis in a German Shepherd dog: note the ulceration and the peripheral hyperpigmentation

Diagnosis

The diagnosis of canine pyoderma is based on the history, a rigorous clinical, general and dermatological examination and diagnostic testing.

● Cytology

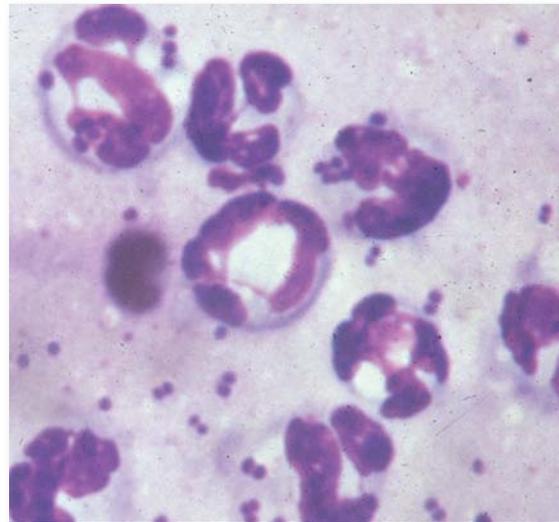
Cytology is easy to perform in general practice. Different methods can be employed (impression smears, scotch tape preparations, swabs). Cytological examination is rapid, inexpensive and simple.

In skin-fold pyoderma, impression smears reveal neutrophils, extracellular cocci or bacilli

and extra- and intracellular, phagocytosed cocci (bacterial colonization).

In Bacterial Overgrowth Syndrome, scotch tape preparations demonstrate numerous extra-cellular cocci. Frequently, *Malassezia* yeast can be observed.

In impetigo and folliculitis, cytological examination of pustular contents show degenerated neutrophils (pale and swollen cells with hypersegmented nuclei) and a few intracellular cocci (bacterial invasion). Extra cellular cocci may also be abundant. However, phagocytosis on the skin surface is of lesser concern than if intracellular bacteria are found in specimens from deep lesions.



Cytology showing intracellular cocci (bacterial invasion)

In furunculosis and cellulitis, cytology rarely reveals the presence of bacteria. In furunculosis, a pyogranulomatous reaction composed of macrophages, plasma cells, eosinophils and neutrophils is noticed.

● Histopathology

Skin biopsies are rarely performed for diagnosing pyoderma.

● Bacterial culture and sensitivity

Bacterial culture and sensitivity should not be systematically performed for diagnosing pyoderma. It is indicated in deep pyodermas, when cytology demonstrates the presence of bacilli or a mixed bacterial flora and when appropriate empirical antibiotic treatment does not lead to clinical remission.

Treatment of skin infections

Part 1: Topical antimicrobial therapy

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Topical therapy is rarely the sole treatment required and more often, is used in association with systemic antimicrobial therapy.

Antimicrobials may be applied to the skin in a variety of formulations: shampoos, gels, creams, ointments and rinses. In general, shampoos are the most widely used, because lesions of pyoderma are often widespread. The dense hair coat of dogs prevents easy application of other topicals directly onto the skin surface and dogs tend to lick off topicals. However, creams or ointments may be useful in localized pyoderma. It must be remembered that it may take weeks or months of treatment to restore skin to normal health.

Antibacterial agents

● Chlorhexidine

Chlorhexidine is the antiseptic used most in veterinary dermatology. It is a synthetic biguanide antiseptic with broad-spectrum antibacterial and antifungal activity. It is effective against most Gram-positive and Gram-negative bacteria, with the possible exception of *Pseudomonas* and *Serratia* strains. It combines rapid effect with good residual activity of at least 24 hours.

Undesirable adverse effects are minimal. Chlorhexidine is non-irritating, non toxic and rarely sensitizing.

Shampoos containing 2 or 4% chlorhexidine are helpful in animals with *Malassezia* overgrowth, and as adjunctive therapy when combined with antibiotic regimens for superficial (impetigo, folliculitis, bacterial

overgrowth), and deep pyodermas (acne, furunculosis, cellulitis). Some shampoos contain chlorhexidine in association with miconazole or ketoconazole. These shampoos are indicated for treating bacterial and *Malassezia* overgrowth. Chlorhexidine shampoos are initially used two to three times weekly, then frequency is decreased based on clinical improvement. Chlorhexidine lotions are indicated in intertrigos as daily applications.

● Benzoyl peroxide

Benzoyl peroxide is a very effective antibacterial agent. It releases nascent oxygen into the skin and benzoyl peroxy radicals cause permeability changes or even rupture of bacterial membranes. Benzoyl peroxide is also keratolytic, antipruritic and degreasing. Sulphur is used in association with benzoyl peroxide in some formulations to increase its keratolytic effect. Benzoyl peroxide reduces sebaceous gland activity. The antibacterial effect at 2.5-5% concentrations has been shown to persist for 48 hours, even in the face of optimal conditions for bacterial growth.

Undesirable adverse effects, such as erythema, cutaneous dryness, pain and pruritus, are not unusual. As a result of its degreasing activity, benzoyl peroxide may lead to dry skin and may occasionally be irritating, especially in dogs with atopic dermatitis. Benzoyl peroxide is applied once to twice weekly and needs to be followed by an emollient bath oil rinse, or alternated with a less drying product. Benzoyl peroxide is also available as a 5% gel used on localized pyodermas, such chin acne and pressure-point pyoderma.

● Iodine products

Iodine is an excellent bactericidal and fungicidal agent. Povidone iodine is iodine complexed with pyrrolidone nitrogen. The iodine is released slowly to the tissues and not impaired by organic debris. The effects last for 4-8 hours. Povidone iodine also has mild degreasing activity. Povidone iodine is found in 2% scrub and shampoo formulations. Polyhydroxydine 1% (Xenodine) is reportedly of greater efficacy against Gram-negative bacteria than povidone iodine solutions.

Undesirable effects associated with iodine usage include irritation (scrotum, external ear), cutaneous dryness and staining of light coloured hair coats.

Iodine products are used for surface or superficial pyodermas, and bacterial and *Malassezia* overgrowth proliferations.

● Ethyl lactate

Ethyl lactate is an antibacterial agent which rapidly penetrates hair follicles and sebaceous glands, where it is hydrolyzed by bacterial lipases into lactic acid and ethanol. The free lactic acid lowers the skin pH. This inhibits bacterial lipases, thereby producing a bacteriostatic activity. Ethanol makes fats soluble and lowers sebaceous secretions. Isolation of pathogenic bacteria from ethyl lactate shows that this shampoo supports bacterial growth.

Undesirable adverse effects are rarely encountered, and include moderate erythema and pruritus. Ethyl lactate shampoo at a concentration of 10% is used for surface and superficial pyodermas.

● Phytosphingosine

Phytosphingosine is a constituent of ceramides and contributes to the cohesion of the stratum corneum. Phytosphingosine, moreover, inhibits skin colonization and infection predominantly with Gram-positive bacteria. Phytosphingosine is incorporated into antiseptic shampoos and lotions with chlorhexidine, hinokitiol, salicylic acid, sulphur and lipidure C. These shampoos

are useful for cornification defects with secondary infections.

● Piroctone olamine

Piroctone olamine is a hydroxy-pyridone compound currently used to treat *Malassezia*-related skin disorders in humans. Broad *in vitro* activity against major veterinary pathogens, including staphylococci and yeasts, has been demonstrated.

Piroctone-olamine (0.5%) is incorporated in diverse shampoos with ammonium-lactate (10%). Recently, a study confirmed its efficacy *in vivo* to reduce clinical signs and control microbial proliferation associated with cornification disorders in dogs.

● Triclosan

Triclosan is a biphenol bactericidal agent which is reported to be effective against methicillin-resistant staphylococci in humans, but appears to be less effective in dogs than benzoyl peroxide as a prophylactic agent against *Staphylococcus intermedius*. It is not effective against *Pseudomonas* spp.

An antiseborrheic shampoo with 0.5% triclosan, salicylic acid and sulphur is available and useful in cornification defects with secondary infections.

● Mupirocin

Mupirocin is an antibiotic with a unique mode of action. A 2% concentration of mupirocin is bactericidal within 24-48 hours in most Gram-positive bacteria, especially *Staphylococcus* spp. Its activity against Gram-negative bacteria is more variable. *Pseudomonas* spp. is particularly resistant to mupirocin. The percutaneous absorption of the 2% ointment is very low. In dogs, it has been shown that mupirocin requires 10 minutes contact with the skin in order to be active.

Undesirable adverse effects are minimal. Indications are: recurrent interdigital abscesses, pressure point pyoderma and chin acne. Twice daily applications are recommended.

● Other antibiotics

Many other potent antibiotics are available in topical form. Ointments containing neomycin, bacitracin, polymyxin B and/or fusidic acid are most commonly used. Adverse effects are variable. Neomycin has the potential of allergic sensitization. Many of these formulations also contain glucocorticoids and their indications are limited mainly to pyotraumatic dermatitis, skin-fold dermatitis and externa otitis.

● General recommendations for topical antibacterial therapy

In order to produce the desired therapeutic effect, antibacterial agents must be in contact with the skin for the prescribed period of time. For most products a contact time of 5-10 minutes is recommended. Particularly with shampoo therapy, owners should be encouraged to time the duration of bathing, so that an adequate duration of contact is ensured. In order to properly hydrate the stratum corneum, the shampoo must be used for at least 10-15 minutes. If contact time is too short and baths are being given frequently, this leads to dehydration of the horny layer, dry skin and a decrease in barrier function. Many problems associated with owner compliance are due to incomplete instructions. Directions must be discussed clearly during the consult and additionally, should be written out or provided in prepared client educational handouts.

In long or densely coated dogs with deep pyoderma and some superficial pyoderma, clipping must be carried out before using warm water soaks and whirlpool baths.

Antiseptic shampoos are usually needed two or three times weekly until the infection is under control. Topical antibacterial therapy is an important adjunct in the management of recurrent superficial and deep pyoderma. It is most helpful when used prophylactically to decrease the severity and frequency of the recurring infection. In most cases of

chronic recurrent pyoderma, antibacterial shampoos must be used at least once a week. Shampooing should be followed by thorough rinsing to decrease undesirable effects such as irritation, erythema, pruritus and scaling. The average duration of rinsing should be 5-10 minutes.

The next article in this series will examine the use of systemic antimicrobial therapy in the management of skin and soft tissue disease.

Treatment of skin infections

Part 2: Systemic antimicrobial therapy

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Systemic antibiotics are frequently used to treat skin and soft tissue infections. Their main advantage is a good distribution and penetration of the antimicrobial drug to the sites of infection. Most systemic antibiotics are available in the form of tablets. However, in some canine and many feline patients, tablet administration may be difficult. Owners may be intermittently absent or too busy to give the medication or forget it altogether, and animals may either refuse or regurgitate it. Thus, it is important to educate the client about the importance of compliance for efficacious treatment. Of course, some antibiotics may also be administered by intravenous and subcutaneous injections.

Due to the short half-life of most injectable antibiotics, they are predominantly used for the treatment of severely sick patients, where oral administration is not possible, absorption questionable and adequate blood concentrations are essential. However, a new injectable cephalosporin, cefovecin, is now available for subcutaneous injection. Serum concentrations of this antibiotic sufficient to treat *S. intermedius* should be maintained for two weeks. The dose and frequency of administration of selected antibiotics as well as their reported adverse effects are given in Table 1.

● Penicillins

Penicillins are not recommended for the treatment of bacterial pyoderma in the dog and cat, as staphylococci are the organisms involved most frequently. Staphylococci

Table 1: Selected antibiotics and their dose

Clavulanic acid/ amoxicilliny q 24 hours	12.5 mg/kg orally q 8-12 hours
Cefalexin	15-30 mg/kg orally q 12 hours
Cefadroxil	10-20 mg/kg orally q 12 hours
Cefovecin	8 mg/kg subcutaneously q 2 weeks
Enrofloxacin	5-20 mg/kg orally q 24 hours
Marbofloxacin	2-5 mg/kg orally q 24 hours
Erythromycin	10-20 mg/kg orally q 8 hours
Lincomycin	15-20 mg/kg orally q 8-12 hours
Clindamycin	5-10 mg/kg orally q 12 hours
Trimethoprim/ sulfadiazin	15 mg/kg orally q 12 hours
Ormethoprim/ sulfadimethoxin	30 mg/kg orall

produce β -lactamases in more than 60% of patients, rendering penicillins useless for the treatment of many staphylococcal infections. Clavulanic acid inactivates β -lactamases and thus extends the efficacy of amoxicillin to β -lactamase-producing bacteria such as staphylococci. A combination of clavulanic acid and amoxicillin has been shown to be efficacious for canine pyoderma. Adverse effects are rare and include allergic reactions.

● Cephalosporins

First generation cephalosporins such as cefadroxil and cefalexin have a good spectrum of activity against Gram-positive organisms such as *S. intermedius*. Resistance of staphylococci against cephalosporins is rare. The efficacy of first generation cephalosporins against Gram-negative organisms is limited and later generations were developed to improve the spectrum against these bacteria. Cefovecin has recently been registered for the treatment of canine and feline bacterial pyoderma in many countries. The *in vitro* activity of cefovecin against more than 2500 isolates from canine and feline bacterial infections was tested and bactericidal activity against most Gram-negative and Gram-positive isolates was reported. In clinical studies, cefovecin was shown to be effective in the treatment of canine and feline skin infections. Due to high plasma protein binding and active resorption in the kidneys, serum concentrations of cefovecin are maintained for a long time. The minimal inhibitory concentration of cefovecin for *S. intermedius* is maintained for 2 weeks, making this is a practical alternative to oral administration of antibiotics.

Cephalosporins are rapidly absorbed and excreted predominantly by the kidneys. Adverse effects are rare; allergic reactions, diarrhoea and/or vomiting may occur.

● Fluoroquinolones

Fluoroquinolones have a broad spectrum of activity. Enrofloxacin has been reported as an effective treatment for canine pyoderma, reaching appropriate concentrations in the skin and accumulating in inflammatory cells. However, an increase in resistance of coagulase-positive staphylococci to enrofloxacin from 1 to 5% has been observed during the decade from its introduction to 2002. Marbofloxacin reportedly was successful in treating most canine pyoderma. Other fluoroquinolones such as ibafloxacin and pradofloxacin have also been reported to be efficacious.

Adverse effects include diarrhoea and vomiting in rare patients; in young growing animals less than 12 months of age cartilage erosions may occur. In cats, blindness has been reported with enrofloxacin at doses greater than 5mg/kg/day and thus this drug should be used at lower doses in the cat or avoided altogether.

● Macrolides and lincosamides

Macrolides (erythromycin) and lincosamides (lincomycin and clindamycin) have been recommended for the treatment of skin infections in small animals. Erythromycin and lincomycin are effective against Gram-positive organisms. Clindamycin also has a high efficacy against anaerobic bacteria. However, an increased rate of resistance is observed in animals that received previous antibiotic therapy. Erythromycin is inactivated by gastric acid and should be given without food. Lincomycin and clindamycin may be administered with food. Adverse effects most commonly involve the gastrointestinal tract. Particularly, erythromycin may cause vomiting in dogs and cats.

● Potentiated sulfonamides

Trimethoprim- or ormetoprim- associated sulfonamides have been used for the treatment of small animal skin and soft tissue infections. Skin concentrations reached are in general effective against coagulase-positive staphylococci. Adverse effects seen with sulfonamides include anorexia, depression, polyuria, polydipsia, vomiting and diarrhoea, personality changes, blood dyscrasias, excessive salivation and others. Sulfonamides are lacrimotoxic. The risk of keratonconjunctivitis sicca, while frequently regarded as idiosyncratic, is associated with body weight. Dogs weighing less than 12 kg are at greatest risk. Weekly Schirmer tear tests are indicated to monitor for decreased tear production, particularly in small dogs on these drugs. Doberman Pinschers have a higher risk of drug reactions to sulfonamides and these drugs should be used with caution in this breed.

● Reasons for failure of antibiotic therapy

If systemic antibiotic therapy fails to eliminate bacteria, there are two main reasons. The most obvious reason of course is resistance of the organism to the antibiotic prescribed. Some bacteria develop resistance more easily than others and particularly Gram-negative bacteria such as *Pseudomonas aeruginosa* or *Escherichia coli* are frequently resistant to antibiotics commonly used for the treatment of skin infections. Bacterial resistance against some antibiotics (particularly erythromycin and clindamycin) is more common in dogs pretreated with antibiotics. Multi-resistant staphylococci have also been reported in veterinary dermatology.

The second main reason for treatment failure is owner compliance. When tablets are prescribed, once daily dosing is more reliably performed than thrice daily administration and long-acting injectable antibiotics administered by the veterinarian avoid this issue altogether. When choosing systemic antibiotic therapy, advantages and disadvantages of the various antibiotics and regimens need to be discussed in detail with the owners. Such discussions should form the basis of choice for antibacterial therapy.

A further factor influencing the therapeutic outcome is diagnosis and successful treatment of the underlying disease. Particularly with recurrent superficial pyoderma secondary to allergies associated with severe pruritus, it is possible to see an active bacterial infection non-responsive to antibiotics that responds to treatment of the underlying disease.



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