Staphylococcal Pyoderma: An Emerging Problem

Keith A. Hnilica, DVM, MS, DACVD
Elizabeth May, DVM
The University of Tennessee

ABSTRACT:
Staphylococcal pyoderma is the most common skin disease in dogs. Approximately 80% of allergic dogs have a secondary bacterial infection at diagnosis. Canine pyoderma is caused almost exclusively by Staphylococcus intermedius. However, the increasing prevalence of Staphylococcus aureus infections and the emergence of a new species, Staphylococcus schleiferi, require the veterinary community to become more vigilant in preventing zoonosis.

Staphylococcal bacteria are gram-positive cocci commonly found on the skin of most mammals. Most Staphylococcus organisms are innocuous inhabitants and cause few problems. However, several more aggressive (coagulase-positive) staphylococci are frequently associated with cutaneous disease. In dogs, Staphylococcus intermedius is the most common cause of pyoderma; however, Staphylococcus aureus and Staphylococcus schleiferi have been documented and are emerging as common pathogenic species in animals. The potential zoonotic nature of S. intermedius, S. aureus, and S. schleiferi requires increased vigilance by veterinary clinicians.

STAPHYLOCOCCUS INTERMEDIUS
S. intermedius was first reported in 1976. It is almost exclusively pathogenic in dogs; however, it has been recovered from numerous species, including humans and cats. S. intermedius is coagulase positive, making it one of the few pathogenic Staphylococcus spp in mammals. S. intermedius is a normal inhabitant of canine skin; however, in certain diseases, such as atopy, the epidermis demonstrates increased binding affinity, allowing more organisms to colonize the skin (Figure 1). Additional changes in sebaceous gland secretion, apocrine gland secretion, and vasodilation as well as subsequent skin temperature increases all contribute to the development of secondary S. intermedius pyoderma (Table 1). S. intermedius can produce numerous toxins, act as a superantigen, and modulate the immune system, promoting hypersensitivity reactions.

Documented antimicrobial resistance for S. intermedius is prevalent in the literature. Most important, penicillins and tetracyclines are rendered virtually useless because of the high percentage of strains that demonstrate resistance to these compounds. Fortunately, amoxicillin–clavulanic acid, cephalosporins, potentiated sulfonamides, macrolides and lincomides, and fluoroquinolones are usually effective.

Staphylococcus spp can readily develop antibiotic resistance.

Coagulase testing can be used to differentiate between potentially pathogenic coagulase-positive Staphylococcus spp and other gram-positive cocci. Coagulase-positive bacteria theoretically protect the organism by inducing clotting in surrounding tissues, thereby inhibiting normal body defenses such as phagocytosis and antibodies.
resistance, especially if the dose or duration of therapy is inappropriate (see box on page 562). Documented cases of zoonosis are rare.\textsuperscript{1,7,8}

**STAPHYLOCOCCUS AUREUS**

*S. aureus* is a major pathogen in humans but has also been recovered from several animal species, including dogs and cats.\textsuperscript{1,2} *S. aureus* is highly pathogenic and able to rapidly develop resistance to multiple antibiotics through numerous mechanisms (Figure 2). Methicillin-resistant *S. aureus* infections are serious problems in human medicine. The first report of methicillin-resistant *S. aureus* infections are serious problems in human medicine. The first report of methicillin-resistant *S. aureus* associated with the *mecA* gene occurred in 1961.\textsuperscript{18} Nasal carriage of these resistant *S. aureus* strains in humans increases the risk of contagion and nosocomial infections.\textsuperscript{1}

Current infectious disease protocols suggest strict isolation of multidrug-resistant *S. aureus* carriers or individ-

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**Table 1. Changes That Predispose Patients to Secondary Skin Infections\textsuperscript{a}**

<table>
<thead>
<tr>
<th>Normal Function by Skin Region</th>
<th>Pathologic Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Epidermis</strong></td>
<td></td>
</tr>
<tr>
<td>Moisture regulation</td>
<td>Increased moisture. Organisms adhere to and penetrate the skin.</td>
</tr>
<tr>
<td>Turnover every 21 days</td>
<td>Turnover rate changes, preventing normal maturation and exfoliation of cells.</td>
</tr>
<tr>
<td>Essential fatty acids and waxes</td>
<td>The composition changes, decreasing the antimicrobial effect.</td>
</tr>
<tr>
<td>(antimicrobial effect)</td>
<td></td>
</tr>
<tr>
<td>Langerhans’ cells search for antigens, initiating an immune response</td>
<td>Langerhans’ cells may preferentially stimulate an allergic response, which is ineffective against organisms.</td>
</tr>
<tr>
<td><strong>Dermis</strong></td>
<td></td>
</tr>
<tr>
<td>Vessels (temperature regulation)</td>
<td>Vasodilation increases skin temperature, improving the environment for organisms.</td>
</tr>
<tr>
<td><strong>Glands</strong></td>
<td></td>
</tr>
<tr>
<td>Sébum (antimicrobial effect)</td>
<td>Increased production and an altered composition decrease the antimicrobial effect and provide nutrients for yeast.</td>
</tr>
<tr>
<td>Sweat (antimicrobial effect)</td>
<td>Increased production and an altered composition increase skin moisture, improving the environment for organisms.</td>
</tr>
<tr>
<td><strong>Acidity</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increases in pH decrease the antimicrobial effect.</td>
</tr>
<tr>
<td><strong>Salts</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diluted salt concentrations decrease the antimicrobial effect.</td>
</tr>
<tr>
<td><strong>IgA</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decreased IgA production and increased IgG production decrease the antimicrobial effect.</td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pruritus damages the skin and spreads organisms from the mouth to the skin.</td>
</tr>
</tbody>
</table>

Antibiotic Resistance

- Antibiotic resistance has been called one of the world’s most pressing public health problems.
- The number of bacteria resistant to antibiotics has increased in the past decade. Nearly all significant bacterial infections in the world are becoming resistant to the most commonly prescribed antibiotic treatments.
- Repeated and improper uses of antibiotics are primary causes of the increase in drug-resistant bacteria.
- Decreasing inappropriate antibiotic use is the best way to control resistance.
- Antibiotic resistance can cause significant danger and suffering in people [or animals] who have common infections that once were easily treatable. Some resistant infections can cause death.


Staphylococcal pyoderma is the most common skin disease in dogs.

S. schleiferi carriage in the preaxillary area. Growing evidence suggests that S. schleiferi is a pathogenic organism with a propensity for community-based nosocomial infections. In 1990, S. schleiferi coagulans (a coagulase-positive species) was reported in dogs with otitis in Japan. In 2002, the first cases of S. schleiferi skin infections in dogs were reported in the United States. The S. schleiferi isolates demonstrated resistance to multiple antibiotics, including methicillin. S. schleiferi is likely underreported in the United States because most laboratories do not take the additional steps required to differentiate S. schleiferi from other Staphylococcus spp. Additional studies have isolated S. schleiferi in the ears of normal dogs and those with acute and chronic otitis. S. schleiferi is described as a normal element of carnivore skin flora; however, studies to document the prevalence of carriage are lacking. Documented cases of zoonosis and reverse zoonosis have not been reported; however, if both humans and dogs can serve as reservoir species for this opportunistic pathogen, the implications for contagion, zoonosis, and reverse zoonosis are considerable. Unlike S. intermedius and S. aureus, S. schleiferi may be the only multidrug-resistant Staphylococcus sp that normally inhabits both humans and dogs. S. schleiferi is a unique
Staphylococcal pyoderma is almost always caused by changes in normal skin function associated with primary dermatosis—often allergies or endocrine disease.
multidrug resistance (using similar mechanisms as *S. aureus*) and is known to cause infection in humans.\textsuperscript{1,4}

**TREATING PYODERMA**

**The Basics**

The essential components of successfully treating secondary bacterial pyoderma in dogs are proper antibiotic selection and dose and identification and control of all underlying dermatoses (e.g., allergies, endocrinopathy, autoimmune diseases, keratinization defects; see box on page 566). It is important to determine the cause of pruritus (e.g., pyoderma, yeast dermatitis, allergies) rather than immediately treat it with steroids. (Bacterial pyoderma is a common cause of pruritus.) Topical therapy is beneficial in helping to mechanically remove and kill organisms with a nonantibiotic method. Shampoos containing chlorhexidine, benzoyl peroxide, or ethyl lactate are highly effective at reducing the superficial colonization of *Staphylococcus* spp (Table 2).

**Routine Treatments**

The overwhelming majority of first-time bacterial pyodermas in dogs are caused by *S. intermedius*. This organism has demonstrated consistent sensitivity patterns, making empiric antibiotic selection possible (Table 3). Amoxicillin–clavulanic acid and cephalaxin are commonly used antibiotics that demonstrate good efficacy.\textsuperscript{2} Clindamycin, potentiated sulfonamides, and erythromycin also demonstrate consistently good efficacy, although resistance to these drugs is more common than with amoxicillin–clavulanic acid and cephalaxin.\textsuperscript{2}

The antibiotic selected should be used for a minimum of 21 days to eliminate the infection and allow normal antimicrobial function to return to the skin. If inappropriately low doses of antibiotic are used or if the duration of therapy is too short, staphylococci populations are altered so that antibacterial-resistant strains are selected, leading to chronic infections.

**Treatment Failures**

If a patient has been receiving seemingly appropriate doses of antibiotic for an appropriate duration (i.e., a minimum of 21 days) without clinical improvement in lesions associated with a bacterial infection (i.e., alopecic lesions with papular crusting), a resistant *Staphylococcus* infection should be suspected. Other der-
matoses that can mimic pyoderma include demodicosis, dermatophytosis, scabies, and pemphigus. Once these differentials have been eliminated, the skin lesions should be cultured for aerobic bacteria and an antibiotic sensitivity profile conducted to help guide antibacterial selection. In patients with resistant infections, it is especially important to use the highest possible antibiotic dose for a sufficient duration to completely resolve the infection. Antibiotics should be continued for 2 to 3 weeks past complete clinical resolution to ensure that organisms have been eliminated. If antibiotic therapy is discontinued prematurely, resistant *Staphylococcus* populations will be allowed to expand, making additional treatment even more difficult.

For cases of resistant *Staphylococcus* spp, fluoroquinolones are often selected for their perceived increased potency; however, bacterial resistance to them can develop, especially with inappropriately low doses or short durations of use. Resistance to fluoroquinolones seems to be mediated by repeated exposure to suboptimal doses of the antibiotics rather than a single mutation event. This suggests that as long as high doses are used for prolonged durations, fluoroquinolone resistance is unlikely to develop. Unfortunately, fluoroquinolone therapy is expensive when dosed appropriately. This causes many practitioners to prescribe suboptimal doses for shorter than ideal durations, thus increasing the selection of resistant *Staphylococcus* isolates. It is essential that if a patient fails to respond initially or completely, lesions should be cultured for aerobic bacteria and an antibiotic sensitivity panel conducted to appropriately modify the antibiotic protocol.

Secondary bacterial infections have been associated with abnormal function of the skin’s natural antimicrobial defenses (e.g., sebum, pH, epidermal turnover) caused by the underlying skin disease. Allergies (e.g., environmental, food, flea) and endocrinopathy (e.g., hypothyroidism, Cushing’s disease) are the most common primary diseases associated with secondary bacterial pyoderma. Other possible underlying dermatoses include autoimmune skin disease and keratinization defects. Aggressive diagnostic workups should be used to explore the endocrine status and identify allergic disease. Cutaneous biopsies are often useful in determining whether a patient has cutaneous changes typical of an allergy, endocrine disease, autoimmune skin disease, or keratinization defect. When the underlying dermatosis has been successfully controlled, the natural antimicro-

| Table 2. Effective Topical Ingredients for Canine Pyoderma |
| Compound | Benefits | Disadvantages |
| Chlorhexidine | A mild ingredient with excellent antimicrobial activity | — |
| Benzoyl peroxide | A potent degreasing, follicle-flushing shampoo with excellent antibacterial effects | Drying Skin irritation May bleach fabrics |
| Triclosan | A moderately effective antibacterial ingredient added to shampoos | — |
| Ethyl lactate | A mild degreasing, antiseborrheic shampoo with good antibacterial activity | — |
| Mupirocin | Good penetration Good activity against *Staphylococcus* spp | Most appropriate for focal infections |

| Table 3. Antibiotics Used to Treat Staphylococcal Pyoderma

| Drug | Dose |
| Amoxicillin–clavulanic acid | 22 mg/kg q12h |
| Cephalexin | 22 mg/kg q8h or 30 mg/kg q12h |
| Clindamycin | 10 mg/kg q12h |
| Ormetoprim sulfadimethoxine | 27.5 mg/kg q24h (On the first day, give two doses 12 hours apart.) |
| Trimethoprim–sulfonamide | 15–30 mg/kg q12h |
| Enrofloxacin | 10–20 mg/kg q24h |
| Marbofloxacin | 5 mg/kg q24h |
| Orbifloxacin | 7.5 mg/kg q24h |

*These are the authors’ preferred drugs and oral doses. Prolonged use and high doses may cause hypothyroidism, keratoconjunctivitis sicca, and bone marrow suppression.
Key Points for Diagnosing and Treating Canine Pyoderma

- Pyoderma is the most common skin disease in dogs.
- Assume that a patient has pyoderma until it is ruled out.
- To avoid drug resistance, use the highest antibiotic dose possible.
- The antibiotic should always be administered for a minimum of 21 days.
- Secondary pyoderma usually complicates primary skin disorders.
- Controlling pyoderma depends on finding and controlling the primary underlying disease.
- Allergies and endocrinopathies are the most common primary underlying diseases.
- Monitor patients for resistant infections, especially if the infection is not improving.
- Avoid steroid therapy while treating pyoderma.

Emerging Zoonoses

The zoonotic potential of *S. intermedius*, *S. aureus*, and *S. schleiferi* should concern veterinary professionals. All three species can cause disease in dogs and humans; however, *S. aureus* and *S. schleiferi* may be especially important. At the University of Tennessee, *S. aureus* has been isolated from dogs with cutaneous infections: nine cases in 2000, and 15 in 2003. We are aware of three cases in which the family pet was specifically referred to the veterinarian for aerobic bacterial cultures to determine whether it was the source of *S. aureus* causing recurrent infections in a family member. *S. intermedius* has been isolated from pet owners with and without active infections. *S. schleiferi* has the ability to develop multidrug resistance and is known to cause infections in humans and dogs. If the most common skin disease in dogs becomes a zoonotic infection with significant human health implications, it will impact almost every aspect of pet ownership and veterinary care: antibiotic use, isolation of infected patients, canine hospital visitation, guide dog access to public facilities, and owner liability for contagious zoonotic infections.

SUMMARY

Recent reports have identified a new *Staphylococcus* sp, *S. schleiferi*, as a cause of secondary canine pyoderma. This species has exhibited an increasing ability to develop multidrug resistance. Even more alarming are increased reports of *S. aureus*, *S. intermedius*, and *S. schleiferi* causing infections in dogs and humans. This is propelling the veterinary community into a situation very similar to that in human medicine in its attempts to control *S. aureus* and associated multidrug-resistant strains. The days of indiscriminate antibiotic use in veterinary dermatology are rapidly coming to an end.

REFERENCES

ARTICLE #5 CE TEST

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1. Which Staphylococcus sp may be the only one that normally inhabits both dogs and humans?
   a. S. schleiferi
   b. S. intermedius
   c. S. aureus
   d. S. felis

2. Which underlying mechanism causes most staphylococcal pyoderma infections?
   a. the extremely high pathogenicity of the organism
   b. the contagious nature of Staphylococcus spp
   c. altered defensive skin function
   d. excoriation caused by pruritus

3. If an active Staphylococcus infection is not responding to antibiotic therapy, what steps should be taken?
   a. confirm the proper dose and duration of therapy
   b. question the owner about compliance
   c. conduct an aerobic culture and a sensitivity test
   d. all of the above

4. What is the most common reason for antibiotic therapy failure?
   a. antibiotic dose too low and duration too short
   b. improper selection of an antibiotic
   c. inadequate absorption of antibiotics
   d. highly pathogenic and contagious Staphylococcus spp

5. Which antibiotics are considered good first choices for routine pyoderma therapy?
   a. cephalexin or amoxicillin–clavulanic acid
   b. amoxicillin or erythromycin
   c. fluoroquinolones or tetracycline
   d. penicillin or ampicillin

6. When treating pyoderma, which step(s) should be considered essential?
   a. Use a high-dose, long-term antibiotic therapy.
   b. Use a topical antibacterial shampoo to disinfect the skin.
   c. Find and control the underlying disease (e.g., allergy, endocrine disorder).
   d. all of the above

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7. **Why is the mecA gene clinically important?**
   a. It causes resistance to multiple antibiotics.
   b. It can be eliminated with targeted gene therapy.
   c. It is a marker for zoonosis.
   d. Only human bacteria express the gene.

8. **Cases of zoonosis involving ________ have been reported in the literature.**
   a. *S. aureus* and *S. schleiferi*
   b. *S. aureus* and *S. intermedius*
   c. *S. schleiferi* and *S. intermedius*
   d. *S. schleiferi* and *S. aureus*

9. **Why are *S. schleiferi* infections often missed?**
   a. Laboratories do not routinely look for it.
   b. Until recently, *S. schleiferi* was considered insignificant.
   c. *S. schleiferi* is often misidentified as *S. intermedius*.
   d. all of the above

10. **What is the major limitation of fluoroquinolone therapy for routine pyoderma?**
    a. The expense often leads to inadequate doses and durations of therapy.
    b. Fluoroquinolones are ineffective against *Staphylococcus* spp.
    c. Fluoroquinolones have variable absorption.
    d. Fluoroquinolones are a major cause of allergy.