
Brian S. Palmeiro, BS; Daniel O. Morris, DVM, DACVD; Staci P. Wiemelt, VMD; Frances S. Shofer, PhD

Objective—To evaluate the outcome of otitis media in dogs after video-otoscopic lavage of the tympanic bulla and long-term antimicrobial drug treatment.

Design—Retrospective study.

Animals—44 dogs with otitis media treated in an academic referral practice.

Procedure—Medical records were reviewed for signalment, duration of ear canal disease, previous medical treatments, dermatologic diagnosis, results of cytologic examination and microbial culture of ear canal exudate, findings during video-otoscopy, medical treatment, days to resolution, and maintenance treatments prescribed. Four independent variables (age, duration of ear canal disease prior to referral, use of corticosteroids in treatment regimens, and infection with Pseudomonas aeruginosa) were evaluated statistically for potential influence on time to resolution.

Results—Mean ± SD (range) duration of ear canal disease prior to referral was 24.9 ± 21.6 (3 to 84) months. Otitis media in 36 dogs resolved after lavage of the tympanic bulla and management; mean ± SD (range) time to resolution was 117 ± 86.7 (30 to 360) days. Time to resolution was not significantly influenced by any variable evaluated. Three dogs were lost to follow-up, and 4 dogs eventually required surgical intervention. Seven of 36 dogs in which otitis had resolved relapsed; 4 required additional lavage procedures.

Conclusions and Clinical Relevance—Results indicate that lavage of the tympanic bulla combined with medical management is an effective and viable option for treatment of otitis media in dogs. (J Am Vet Med Assoc 2004;225:548–553)

Otitis media (inflammation of the tympanic bulla) is a common sequela to severe or chronic otitis externa in dogs. Most cases of otitis media in dogs are believed to be the result of extension of inflammation from the external ear canal to the tympanic bulla via a perforated tympanic membrane; however, it is not uncommon for the tympanic membrane to appear intact on otoscopic examination.

Clinically, the term otitis most often implies the presence of bacterial or fungal infection, although sterile otitis can be associated with masses (tumors, inflammatory polyps, or foreign bodies), parasites, allergic diseases, and irritating chemical or mechanical cleansing regimens. In most instances, infection will result when inflammation in the external ear canal persists, regardless of the inciting cause.

The diagnosis and treatment of chronic infectious otitis media are challenging. Collection of a sample for microbial culture from the tympanic bulla (via myringotomy when necessary) is the most reliable method for diagnosis of infectious otitis media. Microorganisms most commonly isolated in chronic infectious otitis media include Staphylococcus intermedius, Malassezia pachydermatis, and Pseudomonas aeruginosa. Successful medical management of chronic infectious otitis media often requires long-term treatment with systemically administered antimicrobial drugs selected on the basis of results of culture and susceptibility testing.

Lavage of the tympanic bulla via a catheter inserted through the external ear canal is considered an important adjunctive treatment by most veterinary dermatologists. The goal of this procedure is complete removal of inflammatory exudate from the tympanic bulla; however, this is rarely achieved.

The purposes of the study reported here were to evaluate the outcome of chronic otitis media after video-otoscopic lavage of the tympanic bulla and long-term antimicrobial drug treatment in dogs and identify factors affecting prognosis and outcome as measured by time required for resolution of disease.

Criteria for Selection of Cases

A computer-generated search of medical records of all dogs admitted to the Matthew J. Ryan Veterinary Hospital of the University of Pennsylvania for video-otoscopic ear canal examination from January 1998 to May 2002 was performed. Dogs were included in the study if they had infectious otitis media diagnosed via positive results of fungal or bacterial culture of the tympanic bulla, had undergone video-otoscopic lavage of the tympanic bulla and external ear canal under general anesthesia, and had returned for a minimum of 1 follow-up examination after the lavage procedure. For dogs that met the criteria for inclusion, complete analysis of medical records was performed.

Procedures

Historical data, including signalment, duration of ear canal disease prior to referral, location of ear canal disease (unilateral versus bilateral), and previous medical treatments, were recorded for each dog. Clinical data collected at the initial visit (the dermatologic diag-
nosis, results of cytologic examination and microbial culture of ear canal exudate, medications administered prior to video-otoscopic lavage, findings during video-otoscopy; results of microbial culture of the tympanic bulla, medications administered after lavage; cytologic and otoscopic findings at the first and subsequent follow-up examinations; and outcomes (days to resolution and maintenance treatments prescribed at the time of final discharge) were recorded. Because diagnostic imaging of dogs with otitis media is only rarely performed by our dermatology service (when clinical signs or otoscopic findings are suggestive of a mass lesion), results of imaging studies were not included.

Duration of ear canal disease prior to referral was recorded as the number of months. Location of ear canal disease was recorded as bilateral, unilateral (right), or unilateral (left). Previous medical treatments, including corticosteroids (topically or systemically administered), orally administered antimicrobial drugs, ear cleansers, and topically administered antimicrobial drugs, were recorded. Outcomes of prior treatments were collected from a dermatologic history form completed by owners during their initial visits and were recorded as no improvement, mild improvement, or great improvement. When available, duration of prior treatments was also recorded. Dermatologic diagnoses included concurrent atopy (diagnosed by use of criteria of Willemse10), adverse food reaction, and endocrinopathy, whereas infectious disease diagnoses included bacterial or fungal otitis or otitis as a result of a mixed infection.

The day of performance of initial cytologic examination of external ear canal exudate was considered day 0. Cytologic descriptions included the presence of rods, cocci, yeast, or any combination of microorganisms. For some dogs, microbial culture of external ear canal exudate was performed during the initial visit and these results were recorded.

Otoscopy was performed under general anesthesia by use of a fiberoptic otoscope with a video monitor. Findings via video-otoscopy, including tympanic membrane status (intact vs ruptured) and appearance (normal, thickened, opaque) and degree of stenosis of the external ear canal, were recorded. Stenosis was graded as mild, moderate, or severe via interpretation of medical record notes and photographs taken during the otoscopic procedure.

When an intact tympanic membrane in an ear with otitis externa had an abnormal appearance, myringotomy was performed to collect samples from the tympanic bulla for cytologic examination and microbial culture. A sterile spinal needle was passed through a sterilized otoscopic speculum, and the tympanic membrane was punctured. Samples from the bulla in ears in which the tympanic membrane was absent or disrupted were collected in a similar manner by use of a micropipette. The external ear canal was flushed with sterile saline (0.9% NaCl) solution to clear exudates before passage of the speculum. Aerobic bacterial and fungal cultures, but not anaerobic cultures, of samples from tympanic bullae were performed. Results of microbial cultures of samples from tympanic bullae were recorded and microbial susceptibility patterns were compiled when the isolates included P aeruginosa or S intermedia.

To remove exudate in bullae, high through-put lavage was performed. The lavage technique used by our dermatology service involves forcing sterile saline solution or saline solution mixed in equal parts with a mild ceruminolytic cleanser directly into the tympanic bulla through a rigid catheter attached to a 60-mL dose syringe. The catheter is positioned via the working channel in the speculum of the video-otoscope. Care is taken not to form a seal around the speculum so that fluid may be pushed with sufficient force to dislodge exudate from the tympanic bulla without excessive positive pressure that could damage the vestibular and acoustic apparatuses.

Medications that were administered after lavage included orally administered antimicrobial and antifungal drugs, otic cleansers, and topically administered otic medications (anti-inflammatory agents, astringents, and antimicrobial drugs). For dogs that underwent more than 1 follow-up examination, cytologic and otoscopic examination results, relapse of infectious otitis, new treatments, and repeated lavage procedures were recorded.

Final outcome was classified as resolved, not yet resolved, lost to follow-up, or surgically corrected. Otitis externa was considered to have resolved when no abnormalities on cytologic examination of swab specimens of the external ear canal (ie, lack of microorganisms and inflammatory cells) were found and an otoscopic examination revealed a completely reepithelialized external ear canal with absence of exudate and resolution of stenosis of the ear canal caused by edema. Otitis media was considered to have resolved if otitis externa had resolved and clinical signs suggestive of otitis media (ie, pain elicited on palpation of the base of the pinna or opening of the mouth in hyperextension) were absent.17 Because not all ruptured tympanic membranes regenerated and stenosis as a result of fibrosis or glandular hyperplasia persisted in many ear canals, these parameters were not included as criteria for resolution. Time to resolution was defined as the period from day 0 to the day that the dog was prescribed a maintenance treatment program. The maintenance treatment regimen was also recorded.

The potential influence of 4 independent variables on time to resolution was evaluated. Variables included age (< 4 years; 4 to 8 years; and ≥ 8 years), duration of ear canal disease prior to referral (< 12 months; 12 to 23 months; and ≥ 24 months), use of topically or systemically administered corticosteroids or both as part of the treatment regimen, and infection with P aeruginosa versus all other infectious organisms considered as 1 group. To determine whether time to resolution was different in dogs of various ages or with various durations of ear canal disease prior to referral, an ANOVA was used. To determine whether time to resolution differed as a result of corticosteroid treatment or P aeruginosa infection, a Student t test was used. To determine whether certain breeds were overrepresented, the Fisher exact test was used. Where applicable, data are presented as odds ratios (ORs) and 95% confidence intervals (CIs). All statistical evaluations were performed by use of a statistical software package. For all comparisons, a value of $P < 0.05$ was considered significant.

**Results**

Forty-four dogs met all inclusion criteria for the
Forty-two (95%) dogs had a history of bilateral otitis media. Microbial culture of external ear canal exudates yielded positive results for microorganisms or inflammatory cells in 4 (4.5%) ears; yeast and cocci in 4 (4.5%) ears; and no microorganisms were cultured from 28 (31%) samples. Microorganisms isolated included P aeruginosa (39 samples, [43%]), S intermedius (19 [21%]), Enterococcus sp (14 [16%]), Malassezia sp (12 [13%]), Proteus sp (12 [13%]), β-hemolytic Streptococcus sp (11 [12%]), E coli (6 [7%]), Candida sp and coagulase-negative Staphylococcus sp (4 [4%] each), and S simulans and Scopulariopsis sp (1 [1%] each). Antimicrobial susceptibility patterns varied among isolates, especially for P aeruginosa and S intermedius. Of the 39 isolates of P aeruginosa, 7 (18%) were susceptible to enrofloxacin, and 22 (56%) were susceptible to ciprofloxacin. A marbofloxacin disc was not available for antimicrobial susceptibility testing during the study period. Two of 19 isolates of S intermedius were resistant to oxacillin (ie, methicillin resistant), and the same isolates were resistant to enrofloxacin and gentamicin. No significant difference in time to resolution among groups was found.

After the lavage procedure, 40 (91%) dogs were treated with an orally administered antimicrobial drug chosen on the basis of results of antimicrobial susceptibility tests (for antibacterial drugs excluding marbofloxacin) or empirically (for yeast). Eleven (27.5%) dogs were treated with ciprofloxacin, 10 (25%) with marbofloxacin, 8 (20%) with ketoconazole, 4 (10%) with amoxicillin-clavulanic acid, and 3 (7.5%) with cephalexin, 2 (5%) with enrofloxacin, and 1 (2.5%) each with chloramphenicil and cefpodoxime. Two of these 40 (5%) dogs were treated with a combination of ciprofloxacin and ketoconazole. Four (9%) dogs were treated with topical medication only (1% silver sulfadiazine and an acidifying cleanser) because of multidrug-resistant susceptibility patterns that precluded use of an orally administered antimicrobial drug. In 3 of these 4 dogs, otitis resolved, and 1 dog was lost to follow-up on day 33.

Of 36 dogs in which otitis resolved after lavage of the tympanic bulla and medical management, 21 (58%) were treated with corticosteroids as part of their medical management. Three dogs were treated with orally administered prednisone, 15 dogs were treated with a topically administered preparation containing a corticosteroid, and 3 dogs were treated with a combination. All dogs were also treated with a variety of other orally administered and topically administered medications, including antimicrobial drugs and otic cleansers or astringents. No significant difference in time to resolution between dogs that were treated with corticosteroids and dogs that were not was found.
antiseptic cleanser (chlorhexadine),\textsuperscript{5} and 4 (9\%) with Tris-EDTA.\textsuperscript{4} All 44 dogs were also treated with topically administered antimicrobial drugs that were chosen empirically on the basis of results of cytologic examination of external ear canal exudate. Sixteen (36\%) dogs were treated with 1\% silver sulfadiazine\textsuperscript{6} suspended in sterile saline solution or a proprietary aluminum acetate solution;\textsuperscript{7} 13 (30\%) were treated with a 1\% silver sulfadiazine and 2.27\% enroflaxacin\textsuperscript{8} solution, 9 (20\%) were treated with a 1\% miconazole nitrate solution,\textsuperscript{2} 2 (5\%) were treated with a solution of 0.3\% gentamicin sulfate\textsuperscript{9} and 0.05\% dexamethasone in Tris-EDTA,\textsuperscript{2} and 1 (3\%) was treated with a solution of 4\% amikacin sulfate\textsuperscript{10} in Tris-EDTA, and 1 (2\%) was treated with a proprietary product containing DMSO and fluocinolone.\textsuperscript{10}

Cytologic examination of samples from the ear canal collected during the first follow-up examination (3 to 5 weeks after lavage) did not reveal microorganisms in 48 (55\%) ears. Only 1 dog was considered to have attained complete resolution at this time, whereas other dogs with bilaterally negative results on cytologic examination continued to have external ear canal disease that precluded cessation of treatment with antimicrobial drugs.

In 36 (82\%) dogs, otitis resolved after lavage of the tympanic bulla and medical management; mean ± SD (range) time to resolution was 117 ± 86.7 (30 to 360) days. The caregivers of these 36 dogs were given explicit instructions for prophylactic and maintenance treatment at the time of final hospital discharge. Three (7\%) dogs were lost to follow-up before completion of active antimicrobial drug treatment (ie, prior to final discharge with maintenance treatment) on days 628, 371, and 33, respectively. During telephone interviews, the owners of these dogs reported recurrent episodes of otitis that required medical treatment by the referring veterinarian. Four (9\%) dogs required surgical ablation of the external ear canal tissues. Three of these dogs required bilateral total ear canal ablation with either ventral or lateral bulla osteotomy, whereas 1 dog underwent unilateral total ear canal ablation and lateral bulla osteotomy because of the presence of an inflammatory polyp and underwent a ventral bulla osteotomy on the contralateral side because of infectious otitis media. One (2\%) dog had unresolved otitis at the time of data collation and continued with medical treatment.

Eighteen of 36 (50\%) dogs in which otitis resolved were given maintenance programs that consisted of cleansing the ear canal 1 to 3 times/wk with an acidifying cleanser. Sixteen dogs were prescribed similar cleansing regimens and additional application of aluminum acetate astringent 1 to 3 times/wk (8 [22\%] dogs), 1\% silver sulfadiazine in saline solution or aluminum acetate vehicle every 24 to 48 hours (2 [6\%]), 1\% silver sulfadiazine and 2.27\% enroflaxacin in saline solution or aluminum acetate vehicle every 24 to 48 hours (3 [14\%]), or 1\% miconazole nitrate solution every 24 hours (1 [3\%]). One dog owner each was instructed to apply amikacin sulfate in a tromethamine-EDTA flush\textsuperscript{10} twice weekly or cleanse the ear canal with a squalane-based ceruminolytic solution\textsuperscript{10} twice weekly. Dogs prescribed maintenance topical antimicrobial drugs were believed to be at particularly high risk of recurrence of otitis because of poor healing of the tympanic membrane and continued inflammation of external ear canals as a result of allergic disease.

Seven of 36 (19\%) dogs classified as having otitis that resolved returned to the dermatology service 3 to 15 months later with a relapse of bacterial or fungal (or both) otitis. Four of these dogs required a second video-otoscopic lavage under general anesthesia; in 3 dogs, both ears were treated. All 7 of these dogs had been following a maintenance program that involved use of an acidifying otic cleanser 2 to 3 times/wk, and 1 dog's regimen also included twice-weekly application of a 1\% silver sulfadiazine solution. In all dogs, otitis was treated until it resolved, and dogs were once again prescribed maintenance treatments.

**Discussion**

To the authors' knowledge, this is the only retrospective study of management of otitis media in dogs by use of lavage of the tympanic bulla and long-term medical treatment. Results of our study suggest that lavage of the tympanic bulla combined with medical management is effective and remains a viable option for treatment of chronic otitis media in dogs.

The teaching hospital at the University of Pennsylvania is a secondary care facility, and dogs referred to the dermatology service often have long histories of recurrent otitis. We hypothesized that longer duration of disease or advanced age of dogs would independently correlate with longer time to resolution of otitis; however, no significant differences in time to resolution were found among dogs in different age groups or among dogs with various durations of ear canal disease prior to referral.

In addition to the chronic nature of ear canal disease, difficulty in achieving resolution may be associated with uncontrolled primary skin disease (ie, atopy, adverse food reaction, and endocrinopathy), which, if not properly managed, may contribute to the recurrence of otitis and secondary otic infections. Perhaps the most important factor that affects the medical management of infectious otitis, however, is multidrug resistance of bacterial organisms. Resistance of *P. aeruginosa* to fluoroquinolones in particular has become the most common reason for referral of dogs to our dermatology service, and we expected that dogs with infectious otitis caused by *P. aeruginosa* would require a longer course of treatment to achieve resolution; however, no significant difference in time to resolution between dogs with otitis caused by *P. aeruginosa* and those with otitis caused by other infectious organisms was found.

Fluoroquinolones act by inhibiting bacterial DNA-gyrase (ie, preventing DNA supercoiling and synthesis) and are therefore bactericidal. Bactericidal activity is concentration-dependent, and bacterial resistance occurs by rapid gene mutation, especially in the presence of subtherapeutic drug concentrations.\textsuperscript{11} Development of fluoroquinolone resistance by *P. aeruginosa* can occur in vitro with a single exposure of bacteria to the drug.\textsuperscript{11} Fluoroquinolones have good activity against a wide range of gram-negative rods and gram-positive cocci.
antimicrobial drugs and their derivatives. Resistance treatment at home. Examples include meropenem (8 also be administered SC and allow the owner to provide temically administered antimicrobial drugs with activity ed because of the high cost of extended care. Several sys-

nary personnel for indefinite periods are rarely advocat-

and IV administration of antimicrobial drugs by veteri-

istered antimicrobial drugs are limited. Hospitalization bacteria with broad-spectrum resistance to orally admin-

occurrence has become more common in our hospital resistant to methicillin (ie, oxacillin) in our study, their 

of many methicillin-resistant strains to aminoglyco-

sides, fluoroquinolones, fucidic acid, and mupirocin is 

of methicillin is also an emerging problem in veterinary 

which codes for a penicillin-binding protein (PBP2a).

This protein confers intrinsic resistance to all β-lactam antimicrobial drugs and their derivatives. Resistance of many methicillin-resistant strains to aminoglycos-

des, fluoroquinolones, fucidic acid, and mupirocin is also complete. Resistance of Staphylococcus spp to methicillin is implied by its resistance to oxacillin, which is the antimicrobial drug used most commonly in susceptibility testing profiles for Staphylococcus spp. Although only 2 of 19 isolates of S intermediateus were resistant to methicillin (ie, oxacillin) in our study, their occurrence has become more common in our hospital since the completion of this study.

Alternative treatments for otitis media caused by bacteria with broad-spectrum resistance to orally admin-

istered antimicrobial drugs are limited. Hospitalization and IV administration of antimicrobial drugs by veterinary personnel for indefinite periods are rarely advocat-

ed because of the high cost of extended care. Several sys-

temically administered antimicrobial drugs with activity against P aeruginosa, which are labeled for IV use, can also be administered SC and allow the owner to provide treatment at home. Examples include meropenem (8 mg/kg [3.6 mg/lb], q 12 h), ticarcillin (40 to 80 mg/kg [18.2 to 36.4 mg/lb], q 6 h), and cefazidime (30 mg/kg [13.6 mg/lb], q 4 h). For most owners, the cost of these drugs is prohibitive, although they are known to be potentially efficacious.

The final alternative for treatment of otitis media is topical treatment. Of 4 dogs in our study group that received only topical treatment after lavage of the tympanic bulla, otitis completely resolved in 3 dogs and 1 dog was lost to follow-up. Although the numbers in this group were too small to perform statistical analy-

sis, it is our impression (from experience gained with other cases that were not included in our study as a result of specific inclusion criteria used) that topical treatment alone can be quite successful when it follows a thorough lavage of the tympanic bulla.

Silver sulfadiazine has become the most common choice of members of our clinical group for the topical treatment of resistant gram-negative infections. Silver sulfadiazine has been used for > 30 years as a burn-wound protectant in humans and has broad-spectrum antimicrobial activity (most notably against P aerugi-

nos). It does not interfere with reepithelialization and neovascularization of wounds and may enhance wound healing. The spectrum of antimicrobial activity of silver sulfadiazine includes most pathogens associated with otitis (including Staphylococcus sp resistant to methicillin), with the exception of M pachydermatis, against which activity is low. Resistant strains of P aeruginosa have been reported but are extremely rare in the authors’ group practice. Silver exerts its antibac-

terial effect via impairment of bacterial DNA replication and bacterial cell wall damage that leads to osmotic changes. Concentrations as low as 0.02% have 100% efficacy against P aeruginosa and Staphylococcus spp.

Because the mean duration of antimicrobial drug treatment in our study dogs was long, client compli-

ance was critical, and it is our opinion that thorough lavage of the tympanic bulla followed by intensive management by the owner are keys to success. Hazards associated with the lavage procedure include vestibular and auditory dysfunction; however, no dogs in our study had any adverse effects as a result of the lavage procedure.

After lavage, high-volume topical treatment with antimicrobial solutions and otic cleansers, frequent cytologic reevaluation of external ear canal exudate, and otoscopic examinations are required for an indedi-

nite period until resolution of otitis is achieved. We routinely recommend application of 1 to 1.5 mL of a topical antimicrobial solution every 12 hours in medi-

um- to large-breed dogs and application of a high vol-

ume of otic cleanser at least every 48 hours. Once oti-

tis is deemed to be resolved, regular cleansing of affect-

ed ears, with or without regular application of astrin-

gent solutions (such as aluminum acetate solutions), is recommended. In some instances, pulse-dosing every 24 to 48 hours of topical antimicrobial drugs for pro-

phylaxis is required for maintenance of ears at risk for recurring otitis. We routinely choose 1% silver sulfadia-

zine or amikacin in Tris-EDTA for this purpose.

Our study has several limitations. Variations in interpretation of findings of cytologic and otoscopic examinations and in treatment plans were inherent because dogs were managed by several clinicians. The study relied solely on medical records and telephone contacts for all data; incomplete records limited the number of cases for inclusion in the study and assess-

ment of complete data for some study parameters. In addition, only dogs evaluated at a referral practice were included. All dogs had chronic preexisting otic disease, and most had an underlying dermatologic disorder, which precluded standardization of treatment.

Surgical treatment of otitis media and otitis externa that are unresponsive to medical treatment typically involves total or partial external ear canal ablation combined with either lateral or ventral bulla osteotomy for extirpation of the tympanic bulla. Although total exter-

nal ear canal ablation is usually curative for chronic otitis
externa, it may be associated with various postoperative complications, including recurrent infections of the middle ear, Horner syndrome, ipsilateral facial nerve paralysis, head tilt, nystagmus, hearing loss, and keratoconjunctivitis sicca.6,53

Our study group was not compared with a group of surgically treated dogs or a control group that did not undergo lavage of the tympanic bulla prior to medical treatment. Tympanic bulla osteotomy is rarely performed for the sole purpose of extirpation of the bulla at our institution; it is performed as a salvage procedure in combination with total external ear canal ablation for end-stage otitis. Because of the nature of our practice, lavage of the tympanic bulla (rather than surgical extirpation) is recommended for most dogs referred for treatment of chronic otitis media. For the few owners who decline lavage for their dogs, it is our impression that most dogs are quickly lost to follow-up as a result of financial constraints. We concur with anecdotal reports that lavage of the tympanic bulla combined with medical management is an effective and viable option for the treatment of otitis media in dogs, even in chronic cases that involve P aeruginosa.

References