

# Effect of tympanic cavity evacuation and flushing on microbial isolates during total ear canal ablation with lateral bulla osteotomy in dogs

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**Objective**—To evaluate differences in bacterial numbers, identity, and susceptibility in samples obtained from the tympanic cavity on entry (preflush) and after evacuation and lavage (postflush) and assess perioperative and empiric antimicrobial selection in dogs that underwent total ear canal ablation (TECA) with lateral bulla osteotomy (LBO) or reoperation LBO.

**Design**—Prospective clinical study.

**Animals**—34 dogs.

**Procedure**—TECA with LBO or reoperation LBO was performed on 47 ears. Pre- and postflush aerobic and anaerobic samples were obtained from the tympanic cavity. Isolates and antimicrobial susceptibility patterns were compared.

**Results**—Different isolates (31/44 [70%] ears) and susceptibility patterns of isolate pairs (6/44 [14%] ears) were detected in pre- and postflush samples from 84% of ears. Evacuation and lavage of the tympanic cavity decreased the number of bacterial isolates by 33%. In 26% of ears, bacteria were isolated from postflush samples but not preflush samples. Only 26% of isolates tested were susceptible to cefazolin. At least 1 isolate from 53% of dogs that received empirically chosen antimicrobials postoperatively was resistant to the selected drugs. Anaerobic bacteria were recovered from 6 ears.

**Conclusions and Clinical Relevance**—Accurate microbiologic assessment of the tympanic cavity should be the basis for selection of antimicrobials in dogs undergoing TECA with LBO. Bacteria remain in the tympanic cavity after evacuation and lavage. Cefazolin was a poor choice for dogs that underwent TECA with LBO, as judged on the basis of culture and susceptibility testing results. (*J Am Vet Med Assoc* 2005;227:748–755)

## Total ear canal ablation (TECA) with lateral bulla osteotomy (LBO) is the treatment of choice for end-

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stage otitis externa and media in dogs.<sup>1-4</sup> Many dogs with chronic otitis externa and media have a history of long-term and varied topical and systemic administration of antimicrobials. As an aid in antimicrobial selection, most authors recommend sampling from the middle ear cavity rather than the external ear canal.<sup>1-3,5-9</sup> Recommended duration of antimicrobial administration after TECA with LBO in dogs ranges from 7 to 30 days.<sup>1-4,9,10</sup> Selection of perioperatively administered antimicrobials in dogs undergoing TECA with LBO has not been studied extensively. In 1 report,<sup>6</sup> it was indicated that 70% of isolates from the tympanic cavity of dogs were susceptible to cefazolin, and contamination of subcutaneous tissues with organisms originating from the middle ear was detected in 95% of ears.

Wound infection, wound dehiscence, and chronic fistula development are reported postoperative complications of TECA with LBO.<sup>8,9,11,12</sup> Fistula development can occur 2 or more years after the initial surgery and has been linked to incomplete removal of cartilage, epithelium, or debris from the external or middle ear and recurrent otitis media.<sup>8,9,11,12</sup> No association between immediate or long-term complications and primary closure or passive drainage has been identified in dogs that undergo TECA with LBO.<sup>13</sup> The effect of perioperative antimicrobial use and antimicrobial selection (empiric vs definitive) and use on postoperative complications in dogs undergoing TECA with LBO is unknown.

Studies<sup>5,6</sup> reveal that variable isolates and susceptibility patterns are found in samples from the external ear canal, middle ear, and contaminated subcutaneous tissues of dogs undergoing TECA with LBO. Because of this variety of isolates and susceptibility patterns in dogs with chronic otitis externa and media, choice of appropriate antimicrobials for perioperative and postoperative use is challenging. Resistance of isolates to available orally administered antimicrobials makes it increasingly difficult to properly treat dogs after TECA with LBO.

The purposes of the study reported here were to evaluate differences in bacterial isolate numbers, identity, and susceptibility in samples obtained from the tympanic cavity on entry (preflush) and after evacuation and lavage (postflush) and assess perioperative and empiric antimicrobial selection via susceptibility patterns of isolates in dogs that underwent TECA with LBO or reoperation LBO.

## Materials and Methods

**Dogs and specimens**—Data were collected from 34 dogs (47 ears) referred to the Veterinary Medical Teaching

Hospital for TECA with LBO (44 ears) or reoperation LBO because of fistula development (3 ears). Hair was clipped from all affected ears, and the surgery site was scrubbed with a 4% solution of chlorhexidine gluconate for 5 minutes. A standard TECA with LBO or a reoperation LBO was performed.<sup>1-4</sup> On entry to the tympanic cavity, samples for aerobic and anaerobic culture were obtained by use of a culture swab collection and transport system.<sup>a</sup> Care was taken to avoid touching the swab to skin or subcutaneous tissue. Swabs for aerobic sampling were placed in the transport container, and swabs for anaerobic sampling were placed in anaerobic broth solution (brain heart infusion with added oxyrase enzyme<sup>b</sup>). Debris and epithelium were removed from the tympanic cavity, and copious lavage with 300 to 500 mL of sterile saline (0.9% NaCl) solution was performed until the flush solution appeared clear. Microbial sampling was repeated after tympanic cavity evacuation and lavage. Closure was routine.

**Bacteriologic culture and susceptibility testing**—All samples were sent to the Clinical Microbiology Laboratory, where they were handled and analyzed by the same individuals (KD and RBS). All laboratory procedures followed guidelines provided by the Clinical Laboratory Standards Institute (CLSI, previously the National Committee on Clinical Laboratory Standards). Swabs for aerobic cultures were initially moved into tryptose broth and then streaked on trypticase soy agar plates with 5% sheep blood (blood agar). MacConkey agar was used to isolate gram-negative organisms. Anaerobic samples were streaked onto blood agar and maintained in an anaerobic environment.<sup>c</sup> Isolates were aerotolerance tested after 24 hours to identify strict anaerobes. Plates were incubated at 35°C and kept a minimum of 72 hours, with bacterial growth evaluated every 24 hours. If no growth was observed, plates were discarded after 72 hours. Organisms were identified<sup>d</sup> and aerobic minimum inhibitory concentrations (MICs) were determined, if possible; otherwise, standardized gel diffusion methods (Kirby-Bauer) were used. Standard gram-positive and gram-negative antimicrobial panels were used in most instances (88% of isolates). Extended antimicrobial panels (including cefazolin and imipenem) were used in 12% of isolates at the discretion of the Clinical Microbiology Laboratory. Criteria for selection of isolates for which extended antimicrobial panels were used included initial isolation of *Pseudomonas aeruginosa* (25/41 isolates) or *Escherichia coli* (2/23 isolates). Cefazolin was added to the standard antimicrobial panel for isolates of the last 4 dogs (5 ears, 20 isolates) of this study; imipenem was added to the standard antimicrobial panel for 3 dogs (3 ears, 10 isolates). Isolates assessed as intermediately susceptible were considered resistant for analysis purposes. Mean inhibitory concentrations for anaerobes were evaluated.<sup>e</sup>

**Data analyses**—The microbial population in each ear was assessed via isolate number (determined for gram-positive, gram-negative, and anaerobic bacteria), isolate identity, and drug susceptibility. For isolate number and identity, the number of ears infected with gram-positive, gram-negative, or anaerobic bacteria was determined before and after flushing. The number and percentage of ears for which the microbial population was different in number or identity, after flushing versus before flushing, were determined.

Isolate pairs, defined as an isolate detected in preflush and postflush samples from an ear, were identified. Drug susceptibility was assessed 3 ways. First, the proportion of resistant (including intermediate) versus susceptible isolates was determined in preflush and postflush samples (all ears combined). Second, a susceptibility score, taking into account the total number of isolates as well as the susceptibility of each isolate, was determined for each ear. The susceptibility score

for each ear was the sum of susceptibility scores for each isolate from that ear (preflush and postflush), based on the number of drugs in the antibiogram to which each isolate was designated as susceptible, as follows: 1 = susceptible to  $\geq 80\%$  of drugs in the antibiogram, 2 = susceptible to 50% to 79%, and 3 = susceptible to  $< 50\%$ . Third, the antibiogram for each isolate pair was designated as either the same or different regarding postflush versus preflush samples. For tube dilution procedures, the term *different* indicated that the MIC for at least 1 drug was more than 1 tube dilution different regarding postflush versus preflush samples; for the agar gel diffusion method, the term *different* indicated susceptible versus resistant.

Empiric antimicrobial selection (perioperative [intended to prevent] and therapeutic [intended to treat]) was also evaluated. Selection was considered appropriate if all isolates from the ear were susceptible to the chosen drugs. Selected drugs were evaluated, including cefazolin.

**Statistical analyses**—The total number of isolates and susceptibility scores were compared, regarding preflush versus postflush samples, in each ear by use of a paired *t* test; percentage of isolates designated as resistant was compared regarding preflush versus postflush samples by use of  $\chi^2$  analysis. For all analyses, values of  $P \leq 0.05$  were considered significant.

## Results

Thirty-four dogs (with 47 affected ears) entered the study. Breeds included 14 Cocker Spaniels, 5 mixed-breed dogs, 3 English Bulldogs, 2 Beagles, 2 Shar Peis, and 1 each of Chow Chow, English Springer Spaniel, French Bulldog, Golden Retriever, Irish Wolfhound, Maltese, Mastiff, and Staffordshire Terrier. Fourteen dogs were spayed females, 14 were neutered males, 5 were sexually intact males, and 1 was a sexually intact female. Ages ranged from 1 to 13 years, with a median of 7.5 years. Weights ranged from 4.9 to 94 kg (10.8 to 207 lb), with a median of 15.7 kg (34.5 lb). Duration of clinical signs of otitis externa prior to TECA with LBO ranged from 1 month to 8 years, with a median of 5 years. Twenty unilateral TECAs with LBO, 12 bilateral TECAs with LBO, and 3 reoperation LBOs were studied. One dog underwent both a unilateral TECA with LBO and a reoperation LBO, with results of each procedure included as separate ears.

Of the 34 dogs studied, preflush and postflush aerobic and anaerobic culture results were available for 32 dogs (45 ears), whereas aerobic results only were available for 2 dogs (2 ears). Aerobic isolates ( $n = 230$ ; 118 gram-positive, 112 gram-negative) were cultured from 31 of 34 dogs (44/47 ears), whereas anaerobic isolates (9) were cultured from 5 of 32 dogs (6/45 ears). No isolates were identified in either preflush or postflush samples from 3 dogs (3 ears). Of the 31 dogs (44 ears) with isolates, 7 dogs (10 ears) had only gram-positive isolates, 6 dogs (10 ears) had only gram-negative isolates, and 18 dogs (24 ears) had mixed isolates. In the 12 dogs that underwent bilateral TECA with LBO, isolate number and identity were identical in both ears in only 1 dog.

The number of isolates per ear before flushing ranged from 0 to 8, with a median of 3; the number of isolates per ear after flushing ranged from 0 to 4, with a median of 2. More isolates ( $n = 144$  [60%]; gram-positive [71], gram-negative [68], anaerobes [5]) were cul-

tured in the preflush samples, compared with the postflush samples (95 [40%]; gram-positive [47], gram-negative [44], anaerobes [4];  $P < 0.001$ ). Regarding preflush versus postflush isolate numbers, the overall number of bacterial isolates was decreased by 33%. However, reduction in isolate numbers occurred in only 24 (55%) ears. Nineteen (43%) ears had no change in the number of isolates, and 1 (3%) ear had more isolates after flushing. Only 1 ear had positive preflush (1 anaerobe isolate) but negative postflush results. The isolates recovered from at least one third of the ears were *Proteus mirabilis* (21/47 [45%] ears), *P. aeruginosa* (20/47 [43%] ears), *Streptococcus* spp (20/47 [43%] ears), *Enterococcus* spp (19/47 [40%] ears), and *Staphylococcus* spp (18/47 [38%] ears).

Different isolates were identified in 31 of 44 (70%) ears after flushing, compared with before flushing. An additional 6 of 44 (14%) ears had the same numbers of isolates but different susceptibility patterns. Therefore, a difference in isolates or susceptibility patterns was identified in 37 of 44 (84%) ears. Isolates were identical in number, identity, and susceptibility pattern before flushing and after flushing in 7 (16%) ears. Fifteen isolates that were identified from 12 ears after flushing were not detected before flushing. Twelve isolates were gram-positive, including 6 *Enterococcus* spp. Although the number and identity of isolates varied regarding preflush and postflush results, the proportion of resistant versus susceptible isolates overall did not differ (Table 1).

Seventy-five isolate pairs (34 gram-positive pairs in 19 [43%] ears and 41 gram-negative pairs in 28 [64%] ears) were identified, and 6 (14%) ears had gram-positive and gram-negative isolate pairs. The susceptibility patterns of the antibiograms of 27 isolate pairs were different (preflush vs postflush) in 19 of 44 (43%) ears. Susceptibility scores before flushing ranged from 1 to 17 with a median of 6. Scores after flushing ranged from

0 to 10 with a median of 4. Susceptibility scores were significantly ( $P < 0.001$ ) improved after flushing, compared with before flushing.

In the 3 dogs that underwent reoperation LBO, the number of isolates per ear ranged from 2 to 3. All 3 ears had the same number and identity of isolates before and after flushing. Two ears had 1 isolate pair with different susceptibility patterns to 1 or 4 antimicrobials; all other isolate pairs were identical in susceptibility patterns. In 1 dog for which microbial data of the initial TECA with LBO were available, isolates were compared with those recovered at reoperation LBO and found to be identical in number and susceptibility patterns.

Antimicrobials with overall susceptibility rates  $> 75\%$  to both gram-positive and gram-negative isolates were imipenem, gentamicin, and amoxicillin-clavulanic acid, whereas those antimicrobials with overall susceptibility rates  $< 50\%$  were cefazolin, tetracycline, and trimethoprim-sulfonamide (Table 1). Seventy-four percent of all isolates tested ( $n = 47$ ) were resistant to cefazolin.

**Gram-positive aerobic isolates**—One hundred eighteen gram-positive isolates were identified in 33 ears (Figure 1). Bacterial susceptibilities of gram-positive isolates were determined either by disk diffusion or MIC method, depending on the organism. Organisms isolated included *Staphylococcus* spp ( $n = 34$ ), as follows: *Staphylococcus capitis* (11), *Staphylococcus aureus* (9), *Staphylococcus intermedius* (8), coagulase-positive *Staphylococcus* spp (3), *Staphylococcus epidermidis* (2), and *Staphylococcus simulans* (1); *Streptococcus* spp (32), as follows: *Streptococcus canis* (24), *Streptococcus dysgalactiae* (4), *Streptococcus equi* (2), and  $\alpha$ -hemolytic *Streptococcus* spp (2); *Enterococcus* spp (30); *Arcanobacterium pyogenes* (17); *Bacillus* spp (3); and *Micrococcus* spp (2).

Overall, a difference between the preflush and the postflush samples regarding gram-positive isolate

Table 1—Susceptibility rates (proportion\* [%]) of aerobic bacteria to selected antimicrobials for samples obtained before (preflush) and after (postflush) evacuation and flushing of the tympanic cavity during total ear canal ablation and lateral bulla osteotomy in dogs.

Antimicrobial	Gram-positive isolates			Gram-negative isolates			Total
	Preflush	Postflush	Combined	Preflush	Postflush	Combined	
Imipenem	4/4 (100)	3/3 (100)	7/7 (100)	18/18 (100)	11/11 (100)	29/29 (100)	36/36 (100)
Gentamicin	62/71 (87)	41/47 (87)	103/118 (87)	58/66 (88)	37/42 (88)	95/108 (88)	198/226 (88)
Amoxicillin/clav	70/71 (99)	46/47 (98)	116/118 (98)	35/68 (51)	24/43 (56)	59/111 (53)	175/229 (76)
Doxycycline	40/54 (74)	26/34 (76)	66/88 (75)	ND	ND	ND	66/88 (75)
Chloramphenicol	63/70 (90)	45/47 (96)	108/117 (92)	36/68 (53)	23/43 (53)	59/111 (53)	167/228 (73)
Enrofloxacin	52/71 (73)	31/47 (66)	83/118 (70)	43/62 (69)	30/41 (73)	73/103 (71)	156/221 (71)
Ceftiofur	53/67 (79)	29/44 (66)	82/111 (74)	40/61 (66)	26/40 (65)	66/101 (65)	148/212 (70)
Erythromycin	50/70 (71)	29/46 (63)	79/116 (68)	ND	ND	ND	79/116 (68)
Ticarcillin	ND	ND	ND	38/63 (60)	28/37 (76)	66/100 (66)	66/100 (66)
Cephalothin	55/71 (77)	30/47 (64)	85/118 (72)	36/68 (53)	23/43 (53)	59/111 (53)	144/229 (63)
Amikacin	11/56 (20)	5/33 (15)	16/89 (18)	66/68 (97)	42/42 (100)	108/110 (98)	124/199 (62)
Ampicillin	55/71 (77)	32/47 (68)	87/118 (74)	28/68 (41)	23/44 (52)	51/112 (46)	138/230 (60)
Clindamycin	41/70 (59)	25/46 (54)	66/116 (57)	ND	ND	ND	66/116 (57)
Trimethoprim/sulfa	25/71 (35)	19/47 (40)	44/118 (37)	36/68 (53)	27/44 (61)	63/112 (56)	107/230 (47)
Tetracycline	43/71 (61)	28/46 (61)	71/117 (61)	13/67 (19)	7/42 (17)	20/109 (18)	91/226 (40)
Cefazolin	5/6 (83)	2/4 (50)	7/10 (70)	3/23 (13)	2/14 (14)	5/37 (14)	12/47 (26)
Overall susceptibility	629/894 (70)	391/585 (67)	1,020/1,479 (69)	450/768 (59)	303/486 (62)	753/1,254 (60)	1,773/2,733 (65)

\*Number of susceptible isolates per total number of isolates tested.  
ND = Not done. clav = Clavulanic acid. sulfa = Sulfonamide.

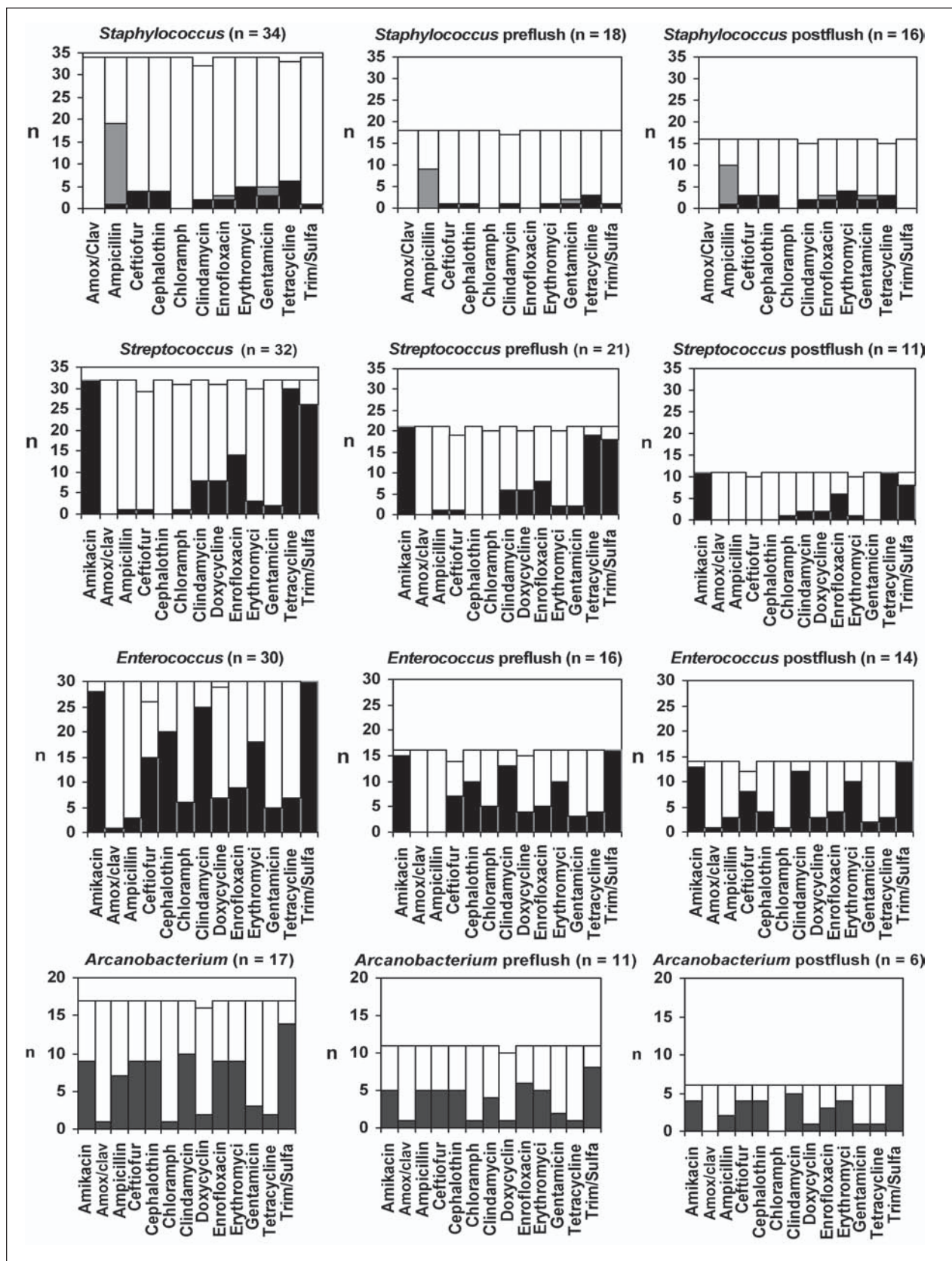


Figure 1—Antimicrobial susceptibility patterns (susceptible [open bars], intermediate [gray bars], resistant [black bars]) of selected gram-positive bacteria isolated from all samples and samples obtained before (preflush) and after (postflush) evacuation and flushing of the tympanic cavity during total ear canal ablation and lateral bulla osteotomy in dogs. Amox/clav = Amoxicillin-clavulanic acid. Chloramph = Chloramphenicol. Erythromyci = Erythromycin. Trim/Sulfa = Trimethoprim-sulfonamide.

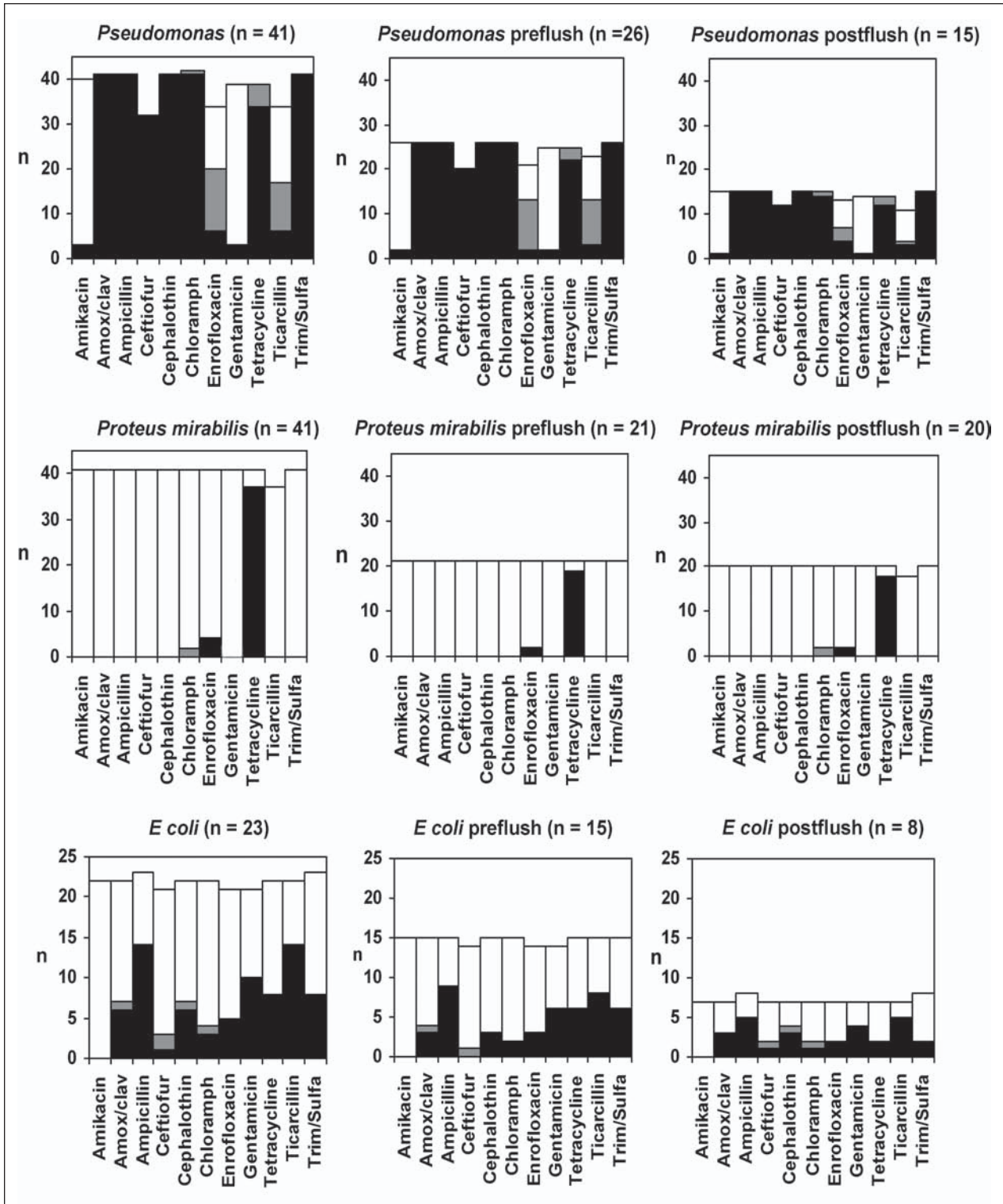


Figure 2—Antimicrobial susceptibility patterns (susceptible [open bars], intermediate [gray bars], resistant [black bars]) of selected gram-negative bacteria isolated from all samples and samples obtained before (preflush) and after (postflush) evacuation and flushing of the tympanic cavity during total ear canal ablation and lateral bulla osteotomy in dogs. See Figure 1 for key.

number, identity, or isolate pair susceptibility patterns was found in 30 of 33 (91%) ears. Additional gram-positive isolates were detected in preflush samples but not in postflush samples in 21 ears; 12 ears had 1 additional gram-positive isolate, 6 ears had 2 additional

gram-positive isolates, and 3 ears had 3 additional gram-positive isolates. Three ears had completely different gram-positive isolates in preflush versus postflush samples. Six ears had gram-positive isolate pairs that had different susceptibility patterns.

Sixteen of 34 (47%) gram-positive isolate pairs had identical susceptibility patterns, whereas 18 (53%) isolate pairs differed in susceptibility patterns to 1 (47%) or up to 4 (53%) antimicrobials. Although the overall proportion of resistant isolates did not differ in preflush versus postflush samples, for 18 isolates, those cultured from preflush samples were susceptible to 1 to 3 antimicrobials, whereas those cultured from postflush samples were resistant to the same antimicrobials. For 16 isolates, those cultured from preflush samples were resistant to 1 to 4 antimicrobials, whereas those cultured from postflush samples were susceptible to the same antimicrobial. The gram-positive isolate most frequently associated with a difference in susceptibility pattern was *S canis* (n = 5). The antimicrobial associated with the most differences (susceptible vs resistant) was enrofloxacin (n = 6).

Antimicrobials with susceptibility rates to gram-positive isolates > 75% were imipenem, amoxicillin-clavulanic acid, chloramphenicol, and gentamicin, whereas those antimicrobials with a susceptibility rate to gram-positive isolates < 50% were amikacin and trimethoprim-sulfonamide.

**Gram-negative aerobic isolates**—One hundred twelve gram-negative isolates were identified from 31 ears (Figure 2). Susceptibility patterns were based on MICs. Organisms isolated included *P aeruginosa* (n = 41), *P mirabilis* (41), *E coli* (23), *Providencia stuartii* (4), *Klebsiella* spp (2), and *Citrobacter* sp (1).

Overall, a difference between the preflush and postflush samples regarding gram-negative isolate number, identity, or isolate pair susceptibility patterns was found in 20 of 31 (65%) ears. Additional gram-negative isolates were detected in preflush samples, compared with postflush samples, in 10 ears; 4 ears had 1 additional gram-negative isolate, 3 ears had 2 additional gram-negative isolates, 2 ears had 3 additional gram-negative isolates, and 1 ear had 4 additional gram-negative isolates. Two ears had additional gram-negative isolates after flushing. Three ears only had gram-negative isolates before flushing. One ear had completely different gram-negative isolates before flushing versus after flushing. Four ears had gram-negative isolate pairs that had different susceptibility patterns.

Thirty-two of 41 (78%) gram-negative isolate pairs had identical susceptibility patterns, whereas 9 (22%) isolate pairs differed in susceptibility patterns to 1 (89%) or 2 (11%) antimicrobials. Although the overall proportion of resistant isolates did not differ regarding preflush samples versus postflush samples, for 4 isolates, those cultured from preflush samples were susceptible to 1 or 2 antimicrobials, whereas those cultured from postflush samples were resistant to the same antimicrobials. For 5 isolates, those cultured from preflush samples were resistant to an antimicrobial, whereas those cultured from postflush samples were susceptible to the same antimicrobial. The gram-negative isolate most frequently associated with a difference in susceptibility pattern was *P aeruginosa* (n = 4). The antimicrobial agent associated with the most differences (susceptible vs resistant) was tobramycin (n = 2).

Antimicrobials with susceptibility rates to gram-negative isolates > 75% were imipenem, amikacin, and

gentamicin, whereas antimicrobials with a susceptibility rate to gram-negative isolates < 50% were cefazolin, tetracycline, and ampicillin.

**Anaerobic isolates**—Nine anaerobic isolates were identified from 6 ears. Gram-positive organisms isolated included *Peptostreptococcus magnus* (n = 3), *Peptostreptococcus anaerobius* (2), and *S intermedius* (2); gram-negative organisms included *Bacteroides vulgatus* (1) and *Propionibacterium granulosum* (1). Five isolates were obtained from the preflush samples and 4 isolates from the postflush samples. No anaerobic isolate pairs were identified. All anaerobic isolates in dogs of this study were susceptible to amoxicillin-clavulanic acid, and ≥ 78% were susceptible to clindamycin, metronidazole, penicillin, and chloramphenicol.

**Antimicrobial selection**—Fifteen dogs (23 [49%] ears) did not receive an antimicrobial perioperatively. Thirteen dogs (17 [36%] ears) received cefazolin after collection of samples for microbial evaluation, whereas 6 dogs (7 [15%] ears) received cefazolin prior to collection of samples. In these 6 dogs, 76% of isolates were gram-positive and 24% were gram-negative. Susceptibility patterns of isolates collected from dogs that received cefazolin prior to or after microbial sampling were similar to those observed in all dogs of this study.

Definitive antimicrobial selection was delayed until culture and susceptibility testing results were available in 17 dogs (23 [49%] ears). Median time to final culture and susceptibility testing results was 3.5 days. Empiric antimicrobial selection in 17 dogs (24 [51%] ears) included amoxicillin-clavulanic acid (n = 7), enrofloxacin (6), clindamycin (1), amoxicillin (1), cephalixin (1), and a combination of ampicillin and enrofloxacin (1) that was changed to amoxicillin-clavulanic acid and enrofloxacin after 24 hours. Nine dogs received antimicrobials to which at least 1 isolate was not susceptible. Seven dogs received antimicrobials to which all isolates were susceptible, and 1 dog received antimicrobials, but no isolates were obtained from that dog.

## Discussion

Microbial evaluation of samples from different anatomic regions of the canine ear has revealed a variety of isolates and susceptibility patterns.<sup>5-7</sup> A 90% difference in isolates and susceptibility patterns between the horizontal ear canal and the middle ear in dogs with chronic otitis has been reported,<sup>5</sup> as has a wide variety of bacterial isolates and susceptibility patterns as well as contamination of the subcutaneous tissues with *E coli* or *S canis* in 94% of dogs that underwent TECA with LBO.<sup>6</sup> Current recommendations for microbial evaluation of dogs undergoing those procedures are to obtain samples on entry to the tympanic cavity prior to administration of antimicrobials.<sup>1,3,5,9</sup>

Bacteria most commonly isolated from dogs of this study differed from those reported in other studies, particularly regarding gram-negative isolates. The most frequently isolated bacteria from dogs of this study were gram-negative (*P aeruginosa* and *P mirabilis*), a finding in contrast to another study<sup>7</sup> in which *Staphylococcus* spp and *Streptococcus* spp were the most

common isolates from tympanic cavities of dogs that underwent TECA with LBO. Similarly, dogs of our study had fewer *S intermedius* isolated than those in the study by Palmeiro et al.<sup>14</sup> The most frequently encountered isolates in our study were resistant to most orally administered antimicrobials against which they were tested. The resistance pattern of *P aeruginosa* isolates from dogs of this study was consistent with those of previous reports.<sup>16-18</sup> The resistance patterns of *Enterococcus* spp and *A pyogenes* isolates from dogs of this study have not been reported previously. Such information supports the recommendation that antimicrobial selection in dogs undergoing TECA with LBO be delayed until culture and susceptibility testing results are available.

This study revealed variation in number and type of isolates from samples obtained before flushing, compared with those obtained after flushing. Reasons for such variation were not determined, but could include contamination with skin bacteria or irrigation and curettage of the tympanic cavity. Because most additional postflushing isolates were gram-positive, such isolates may have originated from the skin during the flushing process. Irrigation and curettage of the tympanic cavity may have exposed different isolates or strains from compartments or pockets within the tympanic cavity. Alternatively, flushing with saline solution may have altered the bacterial population by dilution, although this is not supported by the finding of additional bacterial isolates in the postflushing samples. Growth characteristics of certain isolates (eg, *P mirabilis*, which has swarming characteristics) may have affected isolation of other bacteria.

Variation in susceptibility patterns of isolates from samples obtained before and after flushing was observed. Differences in susceptibility pattern of isolates (susceptible vs resistant) between the preflush and the postflush sample occurred at essentially the same rate; therefore, no pattern could be established. Reasons for such variation in susceptibility patterns, including the potential impact of preoperative or perioperative antimicrobial use, were not clear. Quantitative culturing techniques may have helped define the effect of tympanic cavity evacuation and lavage on bacterial isolation.

The 3 ears that underwent reoperation LBO were comparable to ears that underwent TECA with LBO in number of isolates and susceptibility scores. Interestingly, in 1 dog for which microbial data were available for both the initial TECA with LBO and a reoperation LBO, the same number and susceptibility pattern of isolates were obtained.

The role of anaerobic bacteria in recurrent otitis externa and media is unknown. Cole et al<sup>5</sup> reported 1 anaerobic isolate (*Lactobacillus* sp), but did not specify their method for isolating anaerobes. *Lactobacillus* sp is an aerobic, gram-positive rod that can be a facultative anaerobe.<sup>15</sup> Some strains of *S intermedius* are considered strict anaerobes; therefore, such isolates were included in the anaerobe group for this study.<sup>16</sup> To the authors' knowledge, no other study has reported isolating anaerobic organisms from dogs with recurrent otitis externa and media. Anaerobic bacteria were iso-

lated from the tympanic cavity of some dogs in this study, and such isolation did influence antimicrobial selection in 2 dogs.

Cefazolin has been recommended as a perioperatively administered antimicrobial in dogs because of its favorable pharmacokinetics and efficacy against common wound pathogens.<sup>17-22</sup> Use of cefazolin perioperatively in dogs with recurrent otitis externa and media has been reported.<sup>6</sup> Dogs in our study had a lower susceptibility rate to cefazolin than that reported previously (26% vs 70%).<sup>6</sup> Because cefazolin is not part of the routine susceptibility testing protocol used in the Clinical Microbiology Laboratory, only a small number of isolates (n = 47) were tested against it. Fifty-seven percent (27/47) of isolates were tested against cefazolin as part of standard extended antimicrobial panels, whereas 43% (20/47) of isolates tested were randomly selected after cefazolin had been added to the standard antimicrobial panel. Although cephalothin had an overall susceptibility rate (62%) similar to that reported for cefazolin,<sup>6</sup> cephalothin does not accurately estimate efficacy of cefazolin, particularly against gram-negative isolates. Our findings of a higher susceptibility rate for cephalothin, compared with cefazolin, are in contrast to reports<sup>23,24</sup> that cefazolin should be more effective against gram-negative isolates. Although not all isolates were tested against cefazolin as part of standard antimicrobial panels, the resistance rate, particularly in those isolates frequently encountered (eg, *P mirabilis* and *P aeruginosa*), is of concern. On the basis of results of our study, cefazolin cannot be recommended as the sole antimicrobial in dogs undergoing TECA with LBO. In fact, because of the variability in isolates and susceptibility patterns, no single antimicrobial or combination of antimicrobials can be recommended for perioperative administration in dogs undergoing TECA with LBO for recurrent otitis externa and media.

The impact of appropriate antimicrobial use on incidence of postoperative complications, such as incisional infection or dehiscence, was not determined in this study. No difference in incidence of immediate (during hospitalization) postoperative complications was observed between dogs that received and those that did not receive antimicrobials perioperatively. However, because cefazolin was the only antimicrobial used perioperatively in dogs of this study, its efficacy could be questioned.

Culture and susceptibility testing results usually were available 3 to 4 days after sample submission. Of antimicrobials selected empirically, most were inappropriate selections, as judged by use of susceptibility testing results. Although basing antimicrobial selection on culture and susceptibility testing results involves delay and potential risk, such selection presumably improves the opportunity for therapeutic success.

Susceptibility testing results need to be interpreted with regard to characteristics of the antimicrobials. Nitrofurantoin, for example, although part of the standard susceptibility testing protocol used in our laboratory, only achieves therapeutic concentrations in the urine and is therefore inappropriate for treating recurrent otitis externa and media in dogs. Two dogs in this study received parenterally administered antimicrobials after surgery because of resistance patterns of the isolated

bacteria. Because of the high resistance rate observed in bacteria isolated from dogs with recurrent otitis externa and media, antimicrobials that are not routinely used may need to be included on antibiograms (eg, imipenem). However, selection of new antimicrobials for use in dogs after TECA with LBO should be based on definitive culture and susceptibility testing results.

Our results indicated that antimicrobial options for treating dogs after TECA with LBO are limited. Only 3 orally administered drugs (amoxicillin-clavulanic acid, doxycycline, and chloramphenicol) yielded susceptibility rates > 75% for gram-positive isolates only. Two of these drugs (doxycycline and chloramphenicol) are bacteriostatic in action, and the third has poor tissue distribution (amoxicillin-clavulanic acid).<sup>25</sup> No orally administered drugs yielded susceptibility rates > 75% for gram-negative isolates. Injectable drugs that were tested yielded similar results, and only imipenem (gram-positive and gram-negative isolates) and amikacin and gentamicin (gram-negative isolates only) yielded susceptibility rates > 75%. This information, in association with the observation that most ears of this study yielded mixed isolates, reinforces the need to accurately assess the tympanic cavity of dogs undergoing TECA with LBO by microbial culture and susceptibility testing.

One limitation of this study that may have affected microbial results was the variability in preoperative treatment among dogs. A variety of topically or systemically active antimicrobials was administered to dogs for a variable period prior to surgery. In all but 2 dogs (with facial abscesses), administration of antimicrobials was discontinued at least 2 days prior to microbial evaluation. The ideal time for delay between antimicrobial administration and sample collection remains undetermined in dogs with otitis externa and media.

Samples taken on entry to the tympanic cavity may yield a larger number of bacterial isolates than found in samples taken after flushing; however, samples taken after tympanic cavity evacuation and lavage also are likely to reveal novel isolates. Cefazolin seems to be inappropriate as the sole perioperatively administered antimicrobial in dogs undergoing TECA with LBO for recurrent otitis externa and media. Antimicrobial selection should be based on results of culture and susceptibility testing. Although isolated infrequently, anaerobes in the tympanic cavity may influence antimicrobial selection.

- a. BBL Culture Swab Collection & Transport System, Becton, Dickinson & Co, Sparks, Md.
- b. Oxyrase for broth, Oxyrase Inc, Mansfield, Ohio.
- c. Anaerogen, Key Scientific Products, Round Rock, Tex.
- d. BioMerieux Vitek, Durham, NC.
- e. E-test, Ab-Biodisk, Remel Microbiology Products, Lenexa, Kan.

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