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Diagnosis and treatment of otitis media in dogs and cats

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Otitis media, an inflammatory disease in the middle ear cavity, is a common disease process that goes unrecognized in most veterinary practices. Otitis media in dogs is much more prevalent than previously thought. In dogs, secondary otitis media occurs in approximately 16% of acute otitis externa cases and in as many as 50% to 80% of chronic otitis externa cases [1,2]. The fact that otitis media is present in more than half of canine patients with chronic otitis externa should stimulate a reformulation of the thought process when faced with these cases. Just the common history that the patient has been treated repeatedly for ear infections should alert the veterinarian to think about otitis media as a possibility. Otitis media should also be considered when the veterinarian is presented with a patient showing any neurologic disease affecting the head, including vestibular disease, Horner's syndrome, or facial nerve damage.

The diagnosis of otitis media in dogs can be quite difficult to make because of the long, bent, funnel-shaped conformation of the dog's ear canal, which makes it hard to see the tympanic membrane (TM). In addition, many patients with otitis media have an intact TM, giving the clinician the impression that there is nothing wrong in the middle ear. Most canine patients with otitis media also have chronic otitis externa with pathologic changes to the ear canal that cause stenosis, making visual examination of the TM impossible. It is often theorized that otitis media is an extension of otitis externa that was not treated, improperly treated, or resistant to treatment. The end result is significant damage resulting in porosity to the eardrum over time.

The diagnosis of otitis media in cats may be easier to determine with the otoscope because of their relatively short ear canals. Otitis media in cats most often results as a sequela to respiratory disease; thus, a history of

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sneezing, ocular discharge, or nasal discharge may aid in providing a clue. Some cats with otitis media also have a visible polyp in the ear canal after the ear is cleaned of the dried exudates and mucus. Many feline otitis media patients have a dark, dried, crumbly exudate in the ear canal that mimics an ear mite infestation.

Primary otitis media in cats

In the cat, primary otitis media occurs as a result of infection ascending through the Eustachian tube to the middle ear. An exact mechanism for the development of otitis media in the cat has not been reported, although the bacterial isolates from the bullae of cats with middle ear disease are consistent with respiratory pathogens. It has been hypothesized that chronic viral upper respiratory infection early in life may play a role in initiating otitis media in cats, because these infections and polyps occur in younger cats. This has not been documented with virus isolation studies, however. In one study, tissues from inflammatory polyps were assayed for feline calicivirus and feline herpesvirus-1 by polymerase chain reaction (PCR). Failure to detect either of these viruses suggests that persistence of these viruses is not associated with the development of inflammatory polyps [3]. The presence of these viruses may change the ability of the auditory tube to protect the bulla from infection with other agents, however.

In many species, including human beings, rats, pigs, and cattle, *Mycoplasma* has been reported as an inducing agent in middle ear disease [4]. In addition to the more common streptococci and staphylococci isolated from clinical feline otitis media cases, organisms much more difficult to culture and identify, such as *Mycoplasma* and *Bordetella*, have also been cultured from the middle ear of cats with otitis media [5]. It is unclear what role these upper respiratory bacteria may play in the pathogenesis of feline otitis media. It is also unclear whether anaerobic organisms may be involved when the eardrum is intact and the auditory tube swells, thus sealing these bacteria within the bulla. Cytology or cultures often do not reveal an infectious organism. This raises the question of whether allergy, viruses, or fungi have a role in feline middle ear disease.

Secondary otitis media in cats

The cat can have a secondary otitis media as a result of eardrum damage from ear mites or extension of a polyp through the TM. Nasopharyngeal or inflammatory polyps originate from the middle ear mucosa. A polyp is a pedunculated protruding growth that results from chronic inflammation [6]. Depending on their growth pattern, they can grow through the auditory tube toward the nasopharynx or they may grow through the TM. When found in the external ear canal, the enlarging polyp mass has created

a permanent opening from the external ear canal to the middle ear. The presence of a polyp is usually associated with secondary bacterial otitis media. There is copious mucus and pus produced in these cats. When examined, the external ear canal may show liquid exudates or there may be the presence of a wax-covered mass at the eardrum. Flushing the ear canal thoroughly reveals the fleshy pink to red polyp protruding into the ear canal.

Secondary otitis media in dogs

Exudates and infectious organisms drain into the middle ear from the external ear canal through an eroded or ruptured eardrum and get trapped in the ventral portion of the bulla. Once the medications, chemicals in ear-flushing products, or debris contained within the external ear canal enters the middle ear through an eroded eardrum, tissue reaction of the respiratory epithelial lining of the middle ear begins [7]. This is called secondary otitis media.

The pathogenesis of secondary otitis media in the dog is complex and often multifactorial. Because of the L-shaped configuration of the canine external ear canal, proteolytic enzymes within exudates produced as the result of otitis externa accumulate against the thinnest portion of the eardrum. The resulting inflammation and enzymatic destruction lead to necrosis of the epithelium and supporting collagen, which results in thinning of the TM, causing it to weaken.

Ulceration along the ear canal can extend to the eardrum. The ulcerated tissue leaks serum, which can cause maceration and excoriation of the epithelium. Liberation of bacterial proteases, collagenases, elastases, and lysozymes from phagocytic cells as well as epidermal maceration resulting from the excessive amount of serum in the ear canal disrupts the epithelial layers of the ear canal and can lead to erosion or rupture of the eardrum.

Many cases of acute otitis media can be prevented. Special care in cleaning and attention to fluid pressure, especially with the use of bulb syringes used to flush the external ear canal, can prevent the high pressure from causing an iatrogenic rupture. Removal of exudates by careful flushing and suctioning of the ear canal eliminates the source of destructive enzymes acting on the eardrum. Specific therapy for infectious organisms based on cytology or culture results can shorten the course of the bacterial or fungal disease. Treatment of underlying skin disease, such as atopy, food allergy, and hypothyroidism, may remove or improve primary causes of otitis externa. Proper client education concerning the chronic nature of ear diseases increases owner compliance in allowing frequent rechecks to follow the progress of treatment. Recheck visits allow the veterinarian to examine the eardrum and to make changes in the treatment protocol when therapeutic response is inadequate.

Whether primary or secondary, the resulting inflammation causes the lining epithelium, called the mucoperiosteum, in the bulla to change from

cuboidal to pseudostratified columnar ciliated, leading to an increase in the number of secretory cells and glands, which adds to the quantity of exudate. Chronic inflammation leads to mucosal ulceration and breakdown of the epithelial lining. The lamina propria thickens in response to inflammation, and as vascularity increases, edema and granulation tissue form. As otitis media becomes more chronic, the lamina propria changes to dense connective tissue and bone spicules may develop within it [1].

The cycle of inflammation, ulceration, infection, and granulation tissue formation may continue, destroying the surrounding bone. For example, septic arthritis of the ossicles may cause pain and decreased hearing because of the fusion of these joints. The normal air conduction of sound waves is prevented, and the patient may suffer decreased ability to detect high-pitched sounds. With time, the ossicles are dissolved from osteomyelitis and irreversible hearing deficit occurs.

The exudates and secretions thus formed in the bulla escape into the external ear through the ruptured eardrum and contribute to the exudate already present in the external ear canal. This large amount of liquid fills the ear canal and overflows onto the pinna when the patient shakes its head. If there is a polyp or tumor blocking the outflow of secretions and exudates from the middle ear, significant quantities of inspissated material can be present when the obstruction is removed.

The fluid pressure gradient created by suppurative otitis media and increased mucus secretion prevents the eardrum from completely sealing. As the fluid pressure increases within the bulla, it is pushing against a healing eardrum with a thin tenuous covering. The pressure allows fluid to escape through the path of least resistance, and a small hole remains in the TM. As long as there is a hole in the eardrum, this condition remains in a state of flux (ie, fluid can enter or leave the bulla, carrying infectious materials and exudates in both directions).

When the amount of middle ear secretion and exudate is decreased, when the infection is controlled by therapy, and when the fluid pressure is decreased, the eardrum can heal, and otitis media is resolved. Sometimes, however, the eardrum seals, but the infection is not completely resolved. If the trapped organisms lead to a return of inflammation and secretion, the eardrum can once again bulge or rupture. Patients with otitis media may have had a history of repeated episodes because of this alternating rupture of the TM and subsequent healing. A report by Cole et al [2] demonstrated that 70% of eardrums in documented cases of canine otitis media were intact.

History and clinical signs of otitis media

It is uncommon for a patient to be presented to the veterinarian with a history of acute otitis media. Iatrogenic rupture of the eardrum during ear cleaning can lead to an inflammatory acute otitis media, however. A foreign

body that has become lodged in the ear canal can also cause acute otitis media. For example, plant awns and foxtails often work their way through the eardrum and cause a considerable bacterial infection and inflammatory reaction in the ear canal.

More commonly, a dog with otitis media has a history of recurrent or chronic bacterial external ear infections. The mucous membrane lining the tympanic bulla reacts to foreign substances (eg, infectious organisms, hair, cells, cerumen from the external ear canal, chemicals and pharmaceutics used in the external canal) by producing a purulent exudate and increasing secretion of protective mucus from activated goblet cells. Dogs and cats with otitis media with an open eardrum often have a copious malodorous liquid discharge present when the ear canal is examined with the otoscope. Additionally, it is common to see copious mucoid exudate along the floor of the horizontal canal. Although this material is usually in liquid form, the mucus and pus may be inspissated and dry. Mucus is not produced anywhere along the external ear, but it oozes from the tympanic bulla into the horizontal canal through any rent in the TM. The presence of mucus means that there is a hole in the eardrum.

Some patients produce so much exudate that it overflows onto the periaural region of the face, or in a dog with pendulous ears, there may be dried exudate on the ear flap adjacent to the external opening of the auditory canal. Head shaking to relieve the pain and tickle associated with liquid exudate is common in otitis media. It may be wise to check for otitis media in cases of aural hematoma.

Pain on palpation of the base of the ear canal or pain on manipulation of the pinna should also alert the clinician to otitis media. Some dogs even bite their owners while the owners are trying to administer medication because of the intense pain. Patients with otitis media may also be reluctant to have their mouth opened, and there may be a history of reluctance to chew hard food. This is a result of inflammation, swelling, and pain within the bulla, which is located adjacent to the temporomandibular joint.

When otitis media affects the nerves that course around the base of the ear or through the tympanic bulla, the patient may show something as subtle as keratoconjunctivitis sicca on the ipsilateral side. This results from damage to the palpebral branch of the facial nerve. When otitis media affects the sympathetic nerves from the facial and trigeminal nerves coursing through the middle ear, the patient may show mild signs of Horner's syndrome (enophthalmos, ptosis, and miosis). Some patients may show pain; head tilt; or, with facial nerve palsy, a drooped lip, drooped ear, or loss of the ability to close the eyelid, leading to exposure keratitis [8]. Because the facial nerve courses in and around the ear canal, it is easily affected by swelling, inflammation, and trauma from the dog scratching at the base of the ear. Facial neuropathy should be suspected if there is drooping of the facial muscles and skin or drooling saliva, because the lips and facial muscles cannot create an oral seal. Peripheral vestibular disease with

nystagmus and circling may be evident if the infection and inflammation have affected the inner ear.

An owner may present a patient for a hearing deficit. These cases should be evaluated for otitis media. Fluid in the middle ear dampens hearing. If this fluid is the result of previous flushing, it is usually absorbed within 7 to 10 days and the patient regains the hearing. When the eardrum is ruptured or when the ossicles of the middle ear have sclerosed, air conduction hearing is reduced. High-pitched sound waves cannot be effectively transmitted from the ear canal to the cochlea. If a tumor or a polyp has filled the middle ear, air conduction hearing is eliminated. Bone conduction hearing is usually still present in these patients, and the pet can only hear the lower range of tones (bone conduction hearing can be demonstrated by placing your fingers in your ears and listening to the sounds around you). If there is hearing loss detected, this is usually as a result of bilateral ear disease. Unilateral hearing loss is difficult to assess in animals.

If there is pharyngeal drainage of mucus and exudates resulting from otitis media, the patient may be presented for inspiratory stridor. In these cases, a pharyngeal examination may reveal a nasopharyngeal polyp interfering with breathing or thick mucus draining from the auditory ostium in the nasopharynx covering the caudal pharynx and occluding the airway.

Evaluation of the patient

Otoscopy

Careful examination of the TM in the dog or cat with otitis media requires general anesthesia. It is recommended that the patient have an endotracheal tube placed in case there is a ruptured eardrum. Manipulation or flushing can cause material to drain through the Eustachian tube into the nasopharynx, resulting in aspiration.

If there is significant stenosis of the external ear canal from inflammation or permanent pathologic changes to the ear canal, the eardrum may not be adequately visualized. Patient preparation using potent topical or systemic corticosteroids (prednisone, 1mg/lb daily for 10–14 days and then taper, or dexamethasone, 2 mg/mL, at a rate of 0.1 mg/lb intramuscularly once) may be needed to reduce otic inflammation and allow examination of the TM on a subsequent visit. If permanent changes to the ear canal prevent visual determination of the integrity of the eardrum, other techniques are used to identify disease proximal to the stenosis.

Recently, with the introduction of video otoscopes, it is possible to get a detailed magnified examination of the ear canal and the eardrum. The video otoscope provides excellent lighting at the tip of the tapered probe by transmitting light through the probe by a fiberoptic cable attached to a high-output light source. Once the veterinarian is comfortable looking at normal

eardrums (location, color, clarity, and the normal tension on it), using the TM to diagnose otitis media becomes much easier. If the eardrum remains translucent, the middle ear can be transilluminated with the bright light from the video otoscope and the contents of the middle ear can be visualized.

In obvious cases of canine otitis media, there is no eardrum present. The ear canal is filled with a liquid secretion, often with flecks of material mixed with it. A mucus-filled ear canal may alert the clinician to otitis media. Most patients with chronic otitis externa that has been present for 45 to 60 days have a coexisting otitis media. In otitis externa, purulent exudates and proteolytic enzymes elaborated by inflammatory cells have a caustic effect on the thin epithelium of the eardrum, causing it to become necrotic, weaken, and eventually rupture. When this happens, hair, ceruminous secretions, exudates, and infectious bacteria or yeast organisms in the external ear move into the middle ear. In these patients, it is difficult to visualize any part of the eardrum, because it may not be present at all. Sometimes, only a small ring of granulation tissue may be seen at the annulus fibrosus, where the eardrum attaches to the ear canal. That is where the eardrum was attached. With the otoscope, an otitis media case without suppuration looks like a deep dark hole. The mucosa becomes dark as it becomes hyperemic, and brownish ceruminous exudates fill the bulla.

There is a condition described in dogs called a false middle ear. Obstructions along the horizontal ear canal from hypertrophic or cystic glands, neoplasia, inflammation, or ceruminous plugs increase pressure on the TM, causing it to stretch and bulge into the middle ear cavity. Coupled with poor air movement through the Eustachian tube, negative pressure inside the bulla pulls the eardrum even further into the middle ear cavity. A ''false middle ear'' may develop as a result of the distended membrane ballooning into the bulla. Examination of this ear also shows the absence of an eardrum at the end of the horizontal canal. CT scans of these ears reveal a ''finger'' lesion protruding into the bulla. The invaginating eardrum may collect large amounts of debris from the external canal, such as keratin, wax, and desquamated epithelial cells. The invaginated eardrum forms a cavity, which needs to be flushed out thoroughly. Often misdiagnosed as having otitis media, these patients can be retrospectively diagnosed at a 2-week recheck when the previously unseen eardrum is back in the normal location.

In some cases of otitis media, the eardrum is intact but may look abnormal. It may change color in response to inflammation on the medial side, becoming opaque and gray rather than pearly and translucent. Sometimes, there is fluid behind the eardrum, and examination of the intact TM may indicate that it is bulging into the external ear. Purulent material in the middle ear may be seen as yellow fluid behind the eardrum. Early polyps and tumors in the middle ear may be seen as fleshy masses through the eardrum. Therefore, the presence of an eardrum does not rule out otitis media, particularly in dogs with chronic otitis externa. These dogs may have

had a ruptured eardrum that healed, trapping bacteria and yeast in the tympanic bulla.

Is the eardrum ruptured?

Several techniques have been described to determine the integrity of the TM when it cannot be visualized in an ear with a stenotic external ear canal [9]. A small-diameter 3.5- to 5-French catheter can be inserted into the ear canal until it stops. It is then extended and retracted to get a feel for the rigidity of the "stop." If there is a spongy feel, the eardrum is intact. If there is a definite hard feel to the "stop," the eardrum is ruptured and the catheter is hitting the medial wall of the tympanic bulla. This technique should be practiced on cadaver specimens to acquire the sensitivity.

Tympanometry uses a sensor that measures the compliance of the eardrum in response to sound waves. It is not practical to perform this test in the veterinary clinic because it is still a research tool in animals.

An easy indirect method for determining the integrity of the eardrum is to infuse warmed and extremely dilute povidone iodine solution (or dilute fluorescein solution) into the ear canal with the anesthetized dog or cat positioned in lateral recumbency. If the orange or yellow-green flushing fluid comes out of the nose or if the patient snorts out this solution through the oropharynx when pressure is applied with the flushing fluid, the eardrum is ruptured. The fluid has flowed from the external ear canal through the ruptured eardrum into the tympanic bulla and through the auditory tube into the nasopharynx.

Another technique is to place the patient in lateral recumbency with the suspected ruptured eardrum up and then to fill the ear with warmed saline and insert the tip of the video otoscope into the ear canal. Looking through the clear fluid, if air bubbles rise from the ear canal while the animal breathes, the eardrum is ruptured. Air from the nasopharynx rises through the auditory tube into the tympanic bulla to escape from the middle ear through a ruptured eardrum.

Positive-contrast canalography has been described as a method for detecting a ruptured TM in dogs with otitis media. Dilute iodinated contrast agent at a rate of 2 to 5 mL is instilled into the ear canals of these anesthetized patients while in lateral recumbency with the affected ear up. The author uses 0.3 mL of Hypaque 50% or a similar contrast agent in 2.7 mL of saline. In a stenotic ear canal, a 3.5- or 5-French catheter is threaded into the stenosis if possible. Contrast agent is then infused beyond the stenosis. An open-mouth view of the bullae is then taken using a horizontal x-ray beam. If the eardrum is intact, there is a distinct contrast/air interface at the eardrum. If the eardrum is not intact, the contrast material enters the bulla and there is a continuous column of contrast extending into the bulla.

In normal ears, canalography was more accurate for detecting iatrogenic TM perforation than otoscopy [10]. In clinical otitis media cases, positive-

contrast canalography was positive in most of the cases where the eardrum was determined to be ruptured otoscopically and was positive in other cases in which the eardrum appeared to be intact otoscopically [10].

Myringotomy

To diagnose patients with otitis media, it is sometimes necessary to perform a myringotomy to get a cytology specimen and to allow for culture and antibiotic sensitivity testing on the material trapped behind the eardrum. If there is fluid pressure pushing on the eardrum or negative pressure retracting the eardrum, perforation of the eardrum using a controlled myringotomy incision immediately relieves the intense pain associated with these pressure changes.

To perform a myringotomy, the patient is anesthetized and the external ear canal is thoroughly cleaned with a disinfectant, such as dilute povidone iodine. The ear canal is then dried using suction. A sterile rigid polypropylene catheter is cut to an angle of 60° with a surgery blade to provide a sharp point. A long spinal needle can also be used to puncture the eardrum. The tip of the cut catheter is advanced under good visualization, and the pars tensa is punctured at either the 5-o'clock or 7-o'clock position to remain away from the germinal epithelium and blood vessels overlying the manubrium of the malleus.

Alternatively, a small Buck curette (2 mm) can be used to make a hole in the eardrum. This instrument makes a larger hole in the eardrum and is more difficult to direct to the proper site for puncture. This technique may be used to create a large hole in the eardrum to allow middle ear exudates to drain into the horizontal canal and to prevent pressure gradients from reoccurring. Larger instruments used for myringotomy cause tearing of the eardrum and should not be used.

Many veterinary practices are using carbon dioxide lasers to make the myringotomy incision. A 0.8-mm×180-mm rigid tip or long flexible Teflon tip can be inserted through the working channel of the Video Vetscope (Med Rx, Inc., Largo, FL) and can be advanced to the eardrum. Applying a pulsed low-wattage (3–4 W) laser impulse melts the eardrum. The advantage of laser myringotomy is that the tip does not have to touch the eardrum, so there is less chance of contamination of the bulla with external ear canal material. In addition, the hole made by the laser is circular and takes longer to heal, which is sometimes beneficial in providing drainage.

Fluid under pressure may freely flow into the horizontal canal as the perforation begins, and it should be suctioned to ensure that the myringotomy incision is large enough to accommodate a 3.5- or 5-French catheter. In the case of suppurative otitis media, myringotomy serves to decrease the fluid pressure behind the eardrum. The fluid escapes into the external ear canal and may continue to drain for several days; thus during therapy, the ear canals need to be flushed to remove this debris. The catheter

is advanced through the incised TM and directed ventrally into the bulla, and gentle suction is used to retrieve any material within the bulla. If a spinal needle was used, the stylet is withdrawn before suctioning. If the bulla is dry, 1 or 2 mL of normal saline can be infused into the bulla and then immediately retrieved. This material is submitted for cytology, bacterial culture, and antibiotic sensitivity.

Imaging of the tympanic bulla

Radiographic assessment of the bullae can be helpful in determining the extent of bony involvement and determining if there is increased tissue or fluid filling the bullae. The absence of radiographic changes in the bullae does not rule out otitis media, however, especially in the more acute cases.

In a dog with minimal bony changes, the bullae appear as normal thin, circular, osseous structures medial to the mandibular rami on the rostrocaudal view. If an endotracheal tube is in place, it should be temporarily removed for this view. The cortical outline should be thin, and the middle of the bullae should be radiolucent, because the bullae are filled with air. When the bulla is chronically affected, either the intraluminal or extraluminal bone should show new bone production, proliferation, or bone lysis. If lytic lesions are present, differentials include neoplasia (eg, squamous cell carcinoma) and osteomyelitis. The cartilage of the external canal may have also calcified and may be easily seen on a radiograph. Often, an entire bulla appears radiopaque, because there can be large volumes of thick exudate or tissue growths (neoplasm, polyp, or cholesteatoma) filling the air space. One or both bullae may be affected. If unilateral disease is present, a comparison between the normal bulla and the abnormal bulla makes radiographic assessment of middle ear disease easier.

If large volumes of flushing solution are infused into the ear canal of a dog with a ruptured eardrum before radiographic assessment, a misinterpretation of the radiograph can occur, because the bulla became filled with the flushing fluid and appears radiopaque on the radiograph. One limitation of radiographic evaluation is that old sclerotic lesions in the bulla of aged animals cannot be differentiated from more current proliferative otitis media lesions.

CT of the tympanic bullae, when available, may aid in differentiating bony lesions in the bulla from soft tissue reactions. Many teaching hospitals have access to CT. In the United States, specialty referral centers are acquiring older CT scanners from human hospitals and may be able to provide this type of radiographic examination. CT may be helpful for evaluation of the horizontal ear canal and tympanic bulla when stenosis is present.

MRI of the ear is also being done to assess the middle and inner ear. The endolymph within the cochlea and semicircular canals can provide contrast visible on MRI examinations, which may be useful for evaluating the inner

ear. Extension of infection into the meninges can also be detected by MRI. Therefore, MRI may be useful in patients with neurologic signs relating to middle or inner ear disease. At the present time, this technology is available to veterinary medicine only on a limited basis.

Ototoxicity

When the eardrum is perforated or totally absent, topical medications and the chemicals used in ear cleaners can gain access to the inner ear via the round and oval windows, resulting in neurologic ototoxicity. In addition to topical ototoxicity, many pharmacologic agents are ototoxic when administered parenterally. Careful consideration should be given to the ingredients contained in ear-flushing products and topical or systemic medications before their use. Many manufacturers of otic products are now putting warnings on the label of these products that their use should be avoided if the eardrum is not intact.

In acute otitis media, the thin permeable membranes of the round and oval windows provide easy access into the inner ear for many compounds. Access of ototoxins into the inner ear structures may be enhanced by inflammatory damage to the round window. Enzymes contained in otic exudates can cause maceration of the epithelium covering the round window, increasing its permeability. It is also possible for the round window to become hyperplastic and thickened after long-standing otitis media, providing a barrier to prevent these ototoxins from reaching the inner ear. If there is thick mucus found within the bulla, it may act as a barrier covering the round window, effectively shielding the toxic material from contact. Because the round and oval windows cannot be visually examined, it is difficult to know if the membrane is thinned or thickened. By using nonototoxic products, this issue becomes less important.

Ototoxicity results from damage to the hair cells in the cochlea or in the vestibular apparatus. This results in hearing deficits, vestibular disease, or both. Overt deafness or severe clinical vestibular disease (nystagmus, head tilt, and circling) may be obvious. Subtle changes in hearing or balance may not be detected by the owner or the veterinarian, however.

Many ear-cleaning solutions contain a mixture of ototoxic substances that may gain access to the inner ear, resulting in alterations of vestibular and cochlear function. Of these compounds, chlorhexidine is probably the most toxic, especially in cats. Severe prolonged vestibular signs can be caused by chlorhexidine, and its use in the ears is strongly discouraged.

The aminoglycosides, polymyxins, detergents, and most alcohols routinely used in the treatment of the external ear canal are known to be toxic to the nervous structures of the inner ear [11]. Potentially ototoxic antimicrobial pharmaceutics are present in most topical formulations for treatment of otitis externa. An assessment of the risks of topical use of a drug

or ear-flushing solution that may cause ototoxicity versus the therapeutic benefit must be considered when using these formulations to treat otitis media. For example, the aminoglycoside tobramycin has been shown to be an effective antibiotic for many multidrug-resistant *Pseudomonas* organisms. Although it is an aminoglycoside with potential ototoxic side effects, it is often infused into the bulla to treat the bacterial infection because of its efficacy.

Many common topical antibiotics can cause ototoxicity. Gentamicin, for example, concentrates in the hair cells of the organ of Corti in the cochlea when administered parenterally. It may also cause vestibular signs when administered topically in the middle ear, however. The cell permeability is altered such that the hair cells swell and become deformed. They are rendered rigid and are unable to respond to movements of the endolymph within the semicircular canals. Ataxia, head tilt, and circling can result. A similar situation occurs in the cochlea when neomycin or kanamycin concentrate is administered. The cochlear nerve cells are damaged and cannot respond to vibrations, leading to hearing loss.

There is a short list of products that can be infused into the tympanic bulla without the risk of ototoxicity. Before selecting a product to use in the bulla, a study of the ingredients contained in the preparation should be evaluated to determine the ototoxic potential. For antibiotics, the fluoroquinolones (ciprofloxacin, enrofloxacin, and ofloxacin), aqueous penicillin G, some semisynthetic penicillins (carbenicillin and ticarcillin), and some cephalosporins (ceftazidime and cefmenoxine) are safe to use in middle ear disease [12]. The antifungals clotrimazole, miconazole, nystatin, and tolnaftate can be safely infused. The aqueous forms of the anti-inflammatories dexamethasone and fluocinolone are safe in the middle ear. Most cerumenolytics cannot be used in the bulla. The exception is squalene (Cerumene), which has been shown to be safe. Tris-EDTA is also a safe flushing agent.

Treatment of otitis media

Planning treatment of otitis media requires a stepwise protocol for maximal effect. An organized approach allows the clinician to formulate treatment or to change existing treatment based on observations. The steps outlined provide a framework for treating otitis media:

1. Access middle ear.
2. Perform cytology and bacterial culture.
3. Flush bulla.
4. Infuse topical medications into the bulla.
5. Reduce inflammation with corticosteroids.
6. Administer systemic and topical antimicrobials.
7. Recheck weekly, and retreat two to three times.
8. Consider surgery.

Access middle ear

Accessing the middle ear by otoscopy and myringotomy was discussed previously.

Sample collection

To get a culture or cytology sample from the bulla in an ear without an eardrum, a sheathed catheter is used. A sterile 3.5-French polypropylene urinary catheter is threaded into a 5-French polypropylene urinary catheter. With the closed irrigating ends removed, the 5-French catheter is first threaded through the external ear canal until it reaches the bulla. This acts as a shroud to prevent contamination of the sample with debris from the external ear canal. It should be inserted into the bulla along the floor of the horizontal canal and directed ventrally into the bulla. After this catheter is placed, the 3.5-French catheter is threaded into the 5-French catheter and is extended beyond the cut end. The sample is aspirated with a syringe or suction apparatus using the flanged end of the 3.5-French catheter. If no liquid is in the bulla, 1 mL of sterile saline can be infused and suctioned back. Any fluid or mucus that enters the lumen of the 3.5-French catheter is submitted to the laboratory for cytology and culture and sensitivity testing.

If a myringotomy incision was made with a sharp pointed 5-French catheter, as the incision is made, the catheter is extended into the bulla and the contents are aspirated. The lumen contents are submitted to the laboratory. If a laser myringotomy was made, a sterile catheter is inserted through the hole and a sample is taken.

Cytology and bacterial culture

It is important to obtain samples for cytology and bacterial culture. Many infections are polymicrobial, including mixed infections of bacteria (rods or cocci) and yeasts. Cytology of a middle ear specimen may reveal *Malassezia* yeasts, which would not be reported if only bacterial culture was submitted to the laboratory. Additionally, cytology may not reveal bacteria because they are often protected from the cytology stains by mucus. Many cytologically negative specimens have been reported as culture-positive. In ear disease, laboratory assessment based on culture and sensitivity does not always correlate to clinical response (see section on systemic and topical antimicrobial therapy).

In cats with otitis media and polyps, the most common bacterial organism was *Staphylococcus intermedius*. Other bacteria have been isolated from feline middle ears, including *Pseudomonas*, *Bordetella*, *Bacteroides*, *Fusobacterium*, and *Mycoplasma* [13]. Fortunately, bacterial resistance problems are not usually a feature of feline otitis media. The most common microbes recovered from chronic otitis media in the dog include *Pseudomonas aeruginosa* and *S intermedius* [14]. In one study, one or the

other of these two bacteria was isolated in more than 70% of the cases [2]. Other isolates include *Streptococcus*, *Proteus*, *Klebsiella*, *Escherichia coli*, and some anaerobes. When microbiologic samples from the middle ear were compared with the same bacterial isolates found in the horizontal canal, the antibiotic sensitivity of organisms isolated from the horizontal ear canal was different from that of organisms isolated from the middle ear. This occurred in almost 80% of these cases [2].

Flushing and suctioning the bulla

The most important technique for treating otitis media is probably flushing the bulla. Topical otic medications cannot penetrate through the thick exudate that fills the middle ear during otitis media; thus, this exudate and secretory material must be removed. Additionally, many destructive enzymes that are trapped in the mucoid secretions in the bullae remain in contact with the mucoperiosteum, which prolongs the disease. Hydrating the mucus with the water in flushing solutions makes it less dense and easier to suction.

Using fluid under pressure to irrigate the bulla loosens mucus from the tissue. This material does not stick to the mucous membrane as cerumen sticks to the epithelium in the external ear canal. The fluid the author uses for flushing the bulla is warmed extremely dilute povidone iodine solution in warm tap water. If there is an identifiable bacterial infection, warmed Tris-EDTA is also infused into the bulla. Acidic solutions should be avoided in the middle ear so as to prevent pain and irritation. Using a device that delivers the fluid under high pressure allows the mucus and pus to flush out of the bulla either into the external ear canal, where it can be suctioned out, or through the auditory tube into the throat. The MedRx Earigator (MedRx, Seminole, Florida) (Fig. 1) makes flushing and suctioning the tympanic bulla a simple and efficient procedure. A 5-French or smaller polypropylene catheter connected to the irrigation/suction unit is placed into the 2-mm working channel built into the Video Vetscope (Fig. 2). The entire cleaning process is observed on the video monitor. The catheter is advanced along the floor of the horizontal canal and is directed ventrally into the bulla. A less rigid red rubber feeding tube can be used for flushing, but it may collapse when used for suctioning. Without this equipment, catheter placement and evaluation of the efficiency of cleaning are hard to determine, but that should not deter the attempt to flush the bulla.

Bulla infusion

Removal of the mucus and pus within the tympanic bulla during the treatment of otitis media allows topical medications to penetrate in and around the thickened and folded mucoperiosteum. The use of aqueous formulations of nonototoxic topical antibiotics, steroids, or antifungals placed on the mucoperiosteum hastens recovery from otitis media. Topical

Fig. 1. The Earigator. This flush and suction unit provides adjustable flushing volumes adequate for irrigating the tympanic bulla. Trumpet valves in the handpiece allow flushing and suctioning with one hand.

Fig. 2. To flush the tympanic bulla, a 5-French polypropylene catheter attached to the Earigator is extended through the 2-mm working channel of the video otoscope and directed ventrally into the tympanic bulla.

levels of these drugs may be many times the level that can be achieved using parenteral therapy, even when there is severe hyperemia of the mucoperiosteum. Antibiotic concentrations are high in inflamed tissues, because the increased blood flow allows increased serum levels of antibiotic to perfuse the inflamed tissue. Even these levels may not achieve the minimum inhibitory concentration (MIC) necessary to kill the bacterial target, however.

Infusing drugs into the bulla is an effective method of providing long-acting high-concentration effects. The tympanic bulla in the dog and cat is a deep blind pouch. When the bulla is filled with antibiotic, the fluid cannot escape easily. Because of the small diameter of the swollen auditory tube and its location high on the medial wall of the bulla, drainage from the auditory tube is unlikely. Depending on the amount of eardrum present, fluid has to traverse a jut in the petrous temporal bone, which forms the floor of the horizontal ear canal and extends into the bulla. Fluid escape from the bulla is difficult and requires severe changes in head position to allow drainage through the eardrum. If a myringotomy incision was made, it would be difficult for fluid to escape the middle ear because of the surface tension across the incision. There may be a small movement of the infused antibiotic solution into the external ear canal, which actually may be beneficial, but most of the topical antibiotic solution can remain within the bulla for several days after infusion.

The antibiotic, antifungal, or corticosteroid solution is infused into the bulla through a small catheter placed into the bulla until the fluid overflows into the external ear canal. During the first bulla infusion, less than 1 mL of solution can be infused into the inflamed bulla. The entire procedure of flushing, suctioning, and bulla infusion should be repeated weekly during therapy. With each successive treatment, the mucoperiosteum should retract slightly, increasing the volume of fluid the bulla can accommodate.

Reduce inflammation with corticosteroids

Corticosteroids slow the intense inflammation and exudation found in middle ear disease. As described earlier, the mucoperiosteum undergoes severe pathologic changes in response to inflammation. Corticosteroids can reverse some of the extensive granulation that forms in the bulla, which enhances the ability of topically applied antibiotics to penetrate into the infected tissue. The tympanic cavity is crowded out by this hyperemia and proliferating granulation tissue; thus, the amount of free space within the bulla decreases. Reducing the inflammation helps this lining membrane to retract back toward the bone, increasing the volume within the bulla. When the eardrum heals, this space should refill with air.

Corticosteroids also reduce the amount of mucus produced in the bulla and decrease the viscosity of the secretions from the inflamed mucous membrane in the bulla. Changing the character of the mucus aids in its

removal. Corticosteroids may also function in reducing the swelling in the auditory tube, increasing lumen diameter, which has the beneficial effect of offering limited drainage of mucus into the nasopharynx.

Aqueous topical corticosteroids, such as dexamethasone sodium phosphate (4 mg/mL) or a dimethyl sulfoxide (DMSO)/fluocinolone combination (Synotic) may be infused through a catheter placed into the cleaned and dried bulla. These potent topical anti-inflammatories are not ototoxic. Other potent injectable topical corticosteroids are formulated with ototoxins, such as benzyl alcohol or propylene glycol, or they are in suspension. These should not be used in the bulla.

If there is bacterial or fungal disease and the space in the bulla is needed for antibiotic or antifungal topical therapy, systemic corticosteroids may be used for a few weeks during the recovery phase of otitis media. High initial doses of corticosteroid are required, which mirror those used for other diseases, such as inflammatory bowel disease. Patients should be screened for diabetes, hyperadrenocorticism, demodicosis, and potential pregnancy before using the high doses of corticosteroids. Prednisone or prednisolone, 1 to 2 mg/lb daily for 2 weeks and then decreasing to 0.5 mg/lb every other day, provides high enough levels to decrease inflammation within the bulla. Owners of these animals need to be warned that there will be side effects of prednisone at this high dose. Many owners discontinue the medication when the side effects occur. The author prefers to use a 0.1-mg/lb intravenous dose of dexamethasone (2 mg/mL) at the time of treatment and then to repeat this injection weekly at the recheck appointment if there is significant exudate that needs to be suctioned from the bulla. This has fewer mineralocorticoid-related side effects and prevents the owners from having the choice of stopping the medication. Because many dogs with otitis media also have concurrent otitis externa, systemic corticosteroids aid in reducing the swelling and pain from otitis externa. In addition, they reduce the signs associated with atopic disease, which is a primary cause of otitis externa in the dog.

Systemic and topical antimicrobials

The dilemma facing the clinician treating otitis media is that systemic drug levels may not reach sufficient MIC in the bulla and topical treatment requires frequent applications. Using maximal doses of oral antibiotics along with weekly bulla infusions of a fresh supply of antibiotic increases the therapeutic successes.

Topical antibiotic treatment of otitis media has gained recent favor in veterinary medicine. The use of topicals is based on the high levels of antibiotic that can be placed into the bulla coupled with the poor drainage of the tympanic bulla. Aqueous solutions of nonototoxic antibiotics can be placed directly onto the infected mucoperiosteum. Infused antibiotics can remain in contact with the inflamed granulating middle ear mucosa much

longer, because the fluid filling the bulla cannot readily escape. When topical therapy of otitis media fails, it is usually the result of inability of the antibiotic to get to the bacteria [15]. For example, there may be sequestration of bacteria within folds or pockets of granulation tissue unexposed to the topical antibiotic.

Antibiotic sensitivity patterns are important for treating otitis media when systemic antibiotics alone are used to get levels within the bulla. Unlike topical antibiotics, which can achieve many times the blood MIC, systemic antibacterial therapy for otitis media relies on lower levels of antibiotics arriving in the middle ear hematogenously or through inflammatory cells. Because of the poor blood supply in the external ear canal and middle ear, there is limited diffusion of antibiotic from the serum into the lumen of the ear canal or tympanic bulla. Specific systemic and topical medications for otitis media are discussed in another article in this issue.

Rechecks

With successive recheck visits, the eardrum and the horizontal canal should be examined for fluid, mucus, and pus. If there is fluid within the bulla, it should be flushed out and the bulla suctioned to prepare it for reinfusion. When the weekly examination reveals a dry canal and little liquid within the bulla, the inflammation and infection within the bulla have subsided. At this point, bulla infusion treatments can be discontinued. Subsequent 2-week recheck intervals should reveal a healing eardrum.

Surgery

Medical therapy of otitis media in the author's practice is 75% successful. A small number of chronic otitis media cases require total ear canal ablation and bulla osteotomy in spite of proper medical therapy. Surgical techniques (including options for inflammatory polyp removal) are discussed in another article in this issue.

Summary

Otitis externa/media is commonly found in dogs with chronic ear diseases and in cats with upper respiratory disease and polyps. Diagnosis of otitis media requires attention to history and clinical signs, but it also requires other methods of determining disease within the bulla. If the integrity of the eardrum cannot be determined, assume that there is middle ear disease and proceed accordingly. It is prudent to take necessary precautions to avoid the use of potentially ototoxic ear cleaners or topical medications in suspected otitis media cases. Therapeutic success is possible using systemic and topical treatment within the cleaned bulla. Referral to a dermatology specialist or a radiologist for a CT scan may be indicated in some refractory cases. Surgical intervention may be required to cure these difficult cases.

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