Otitis media, or inflammatory disease of the middle ear, in rabbits is commonly reported. Otitis media can be difficult to diagnose in live rabbits because those with otitis media are often subclinically affected unless the disease is associated with otitis externa or interna. Postmortem studies investigating subclinical otitis media in rabbits have indicated prevalences ranging from 11.5% to 32%. With otitis interna, rabbits develop signs of vestibular disease. Reports vary with respect to the prevalence of otitis media in rabbits with vestibular disease: 5.9% in a postmortem study of rabbits with neurologic disease, 24% in an Encephalitozoon cuniculi seroprevalence study, and 63% in a postmortem study of rabbits with vestibular disease. Most of these studies determined prevalence of subclinical and clinical middle ear disease in rabbits at necropsy, not on an antemortem basis, and in meat rabbits or research rabbits, not in domestic rabbits.

Examination of the external ear canal and tympanic membrane has been proposed for diagnosis of subclinical otitis media. However, neither an apparently normal tympanic membrane nor an apparently normal external ear canal excludes the presence of otitis media. In addition, examination of the tympanic membrane can be challenging, especially in rabbits with otitis externa and in lop-eared rabbits. Early diagnosis of otitis media is extremely important because infection can spread to the inner ear (causing vestibular disease due to labyrinthitis) or through the internal acoustic meatus and along the vestibulocochlear nerve to the brain (resulting in severe neurologic signs due to encephalomyelitis). Rabbits with otitis interna develop clinical signs of peripheral vestibular disease, including head tilt, nystagmus, ataxia, or rolling. Facial nerve paralysis and Horner's syndrome can also develop with otitis media or interna in rabbits. Otogenic intracranial infection in humans and in dogs and cats is reported to be rare. However, it is relatively common in rabbits, affecting up to 50% of rabbits with otitis media. In those cases, clinical signs of central vestibular disease may be preceded by signs of peripheral vestibular disease, making distinction between central and peripheral vestibular diseases difficult. The main differential diagnosis for rabbits with central vestibular signs is E cuniculi infection. Even though serologic tests are available for anti–Pasteurella multocida and anti–E cuniculi antibodies, positive results of assays for serum antibodies reflect exposure and do not correlate with active disease caused by either organism.

Owing to the often subclinical signs of otitis media, the difficulty in differentiating otitis media or interna...
from central vestibular disease, and the relatively high prevalence of otogenic intracranial infection, diagnostic imaging is important for evaluation of the middle ear and early identification of middle ear disease in rabbits. Computed tomography allows cross-sectional evaluation of the entire head, including teeth and upper respiratory tract, without superimposition of structures.16-24 Computed tomography is reported to be more sensitive than, and as specific as, radiography for diagnosing and characterizing the severity of middle ear disease in dogs.23 Computed tomographic findings of otitis media in dogs and cats include thickening, irregularity, proliferation, or lysis of the tympanic bulla wall. In addition, a fluid or soft tissue density may be evident within the lumen of the bulla.19,20,22 The use of CT for diagnosis of otitis media in rabbits has been described in the veterinary medical literature.6,7,11,24,27,28 However, the information is descriptive and limited to CT-detected changes in clinical cases of otitis media.

In rabbits with otitis media, the primary infection is believed to be a result of bacteria within the nasopharynx that reach the middle ear via the auditory tube.3,4,10 This pathogenesis is supported by the fact that most infections are caused by P multocida, a respiratory tract pathogen.1,3,4,8,9,11,12,29 In addition, high prevalences of middle ear disease in rabbits with concurrent upper respiratory tract infections have been reported (78%4 and 85%).8 Otitis media also develops secondary to bacterial or parasitic otitis externa.1,3,15,30,31 Otitis externa develops more commonly in lop-eared rabbits, possibly because of abnormal conformation of the external ear canal.15

The purpose of the study reported here was to describe and compare CT abnormalities in the middle ear of domestic rabbits (Oryctolagus cuniculus) that had clinical middle ear disease with those in rabbits without signs of disease (subclinical disease) and to determine the prevalence of otitis media in that species. Because there are multiple possible causes of otitis media in rabbits that are not fully understood, another aim was to evaluate the frequency of proposed predisposing factors of otitis media (upper respiratory tract disease, otitis externa, and lop-ear conformation) in rabbits with subclinical or clinical otitis media and in rabbits with or without otitis media. We hypothesized that CT signs of otitis media are a common finding in rabbits that undergo head CT for reasons other than ear disease, that CT middle ear abnormalities would differ between rabbits with clinical and subclinical otitis media, and that predisposing factors to otitis media would be detected more commonly in rabbits with clinical and subclinical otitis media than in rabbits without otitis media.

Materials and Methods

Case selection—The medical records for rabbits that were evaluated at the Cornell University Hospital for Animals from June 2007 to February 2014 were searched for those that underwent CT of the head. Information collected from each medical record included age, weight, sex, ear conformation, past medical history, reason for visit, and physical examination findings. Rabbits that underwent CT were assigned to 1 of 2 groups according to the reason for their visit. Group 1 included rabbits evaluated because of clinical signs of otitis externa (head shaking, pinnal pruritus, malodorous ears, or, for rabbits with upright ears, holding the affected ears down) or middle ear disease (signs of vestibular disease or facial nerve paralysis). Group 2 included rabbits evaluated for conditions not related to ear disease (dental disease, upper respiratory tract disease, and other conditions of the head region, such as ocular or periocular disease or soft tissue or bone masses).

CT examinations—All head CT examinations were performed after each rabbit was sedated with ketamine (10 mg/kg [4.5 mg/lb]) and diazepam (0.5 mg/kg [0.23 mg/lb], IV) or anesthetized with oxygen delivered via face mask. Computed tomographic scans were obtained with a single-slice axial CT unit (for cases examined between August 2008 and July 2009) or a 16-slice helical CT unit (for cases examined between August 2009 and March 2014). Images were acquired in 0.5- to 1-mm contiguous transverse slices (120 kVp; mAs set automatically) with rabbits positioned in ventral recumbency. Most scans were performed with a soft tissue and bone algorithm (72/88 rabbits), with a few performed with a bone algorithm only (15/88 rabbits) or a soft tissue algorithm only (1/88 rabbits).

Image evaluation—External, middle, and inner portions of the ear were evaluated for each rabbit by a board-certified radiologist (MT) and a radiology resident (RAVH). Image evaluation was performed in chronological order of CT examinations. Reviewers were blinded to the rabbit's group assignment, the reason for head CT, and the other reviewer's interpretation of ear CT-detected changes. Once the image review process was completed, inter-reviewer discrepancies were addressed with collaborative image evaluation during which both reviewers agreed on a single diagnosis. Images were interpreted on a commercial picture archiving and communication system with multiple planes and windows available. The external ear was evaluated for increased attenuation within the canal, thickness of the wall of the external ear canal, mineralization of the auricular cartilages, and presence of a mass or masses within or associated with the external ear canal. The middle ear was evaluated for the presence of attenuating material within the tympanic cavity or increased thickness, irregularity, expansion, or lysis of the tympanic cavity wall. The inner ear was evaluated for sclerosis or lysis of the petrous temporal bone or loss of cochlear semicircular canal definition. Lesions of the external, middle, and inner ear were categorized as absent or present on CT images. In addition, abnormalities in the upper respiratory tract and teeth and other remarkable findings within the head region were recorded.

Follow-up—Information regarding the progression of subclinical middle ear disease in affected rabbits was obtained by follow-up visits or telephone or email contact with the owners or referring veterinarians. When available, findings of a follow-up CT ear examination were also recorded, characterized, and compared with the initial CT findings.

Data analysis—Descriptive statistics were used for data analysis and calculated in spreadsheet software (numeric data) and an online data analysis program.
(categorical data). Numeric data (age and weight) were described as mean ± SD. Categorical data (presence or absence of CT-detected changes of the external, middle, or inner ear; unilateral or bilateral disease; type of lesion present in the middle ear; ear conformation; and upper respiratory tract disease) were described as the frequency of occurrence of each category by group. Depending on sample size, Fisher exact tests or χ² tests were used to determine the association between the type of CT middle ear lesion and reason for visit (groups 1 and 2) and, within group 2, between rabbits with permanent and temporary subclinical middle ear disease. These same tests were used to determine the association between middle ear disease (clinical vs subclinical and presence vs absence) and the proposed middle ear predisposing factors (lop-ear conformation, otitis externa, and upper respiratory tract disease). Values of P < 0.05 were considered significant.

**Results**

**Case selection**—Eighty-eight of 784 rabbits evaluated from June 2007 to February 2014 met the inclusion criteria. Twenty-one (24%) rabbits were evaluated because of ear disease or signs suggestive of ear disease (group 1). Clinical signs in group 1 included clinical otitis externa (n = 6), facial nerve paralysis (3), and signs of vestibular disease (20). The group included 9 (43%) males and 12 (57%) females. These rabbits had a mean ± SD age of 4.4 ± 2.6 years (range, 0.1 to 8 years) and mean weight of 1.9 ± 0.92 kg (4.2 ± 2.0 lb; range, 0.6 to 4.9 kg [1.3 to 10.8 lb]). Sixty-seven (76%) rabbits in group 2 had a mean age of 4.9 ± 2.51 years (range, 0.2 to 11.6 years) and mean weight of 2.26 ± 0.9 kg (5.0 ± 2.0 lb; range, 0.7 to 5.3 kg [1.5 to 11.7 lb]).

**Prevalence of CT-detected middle ear changes**—Twelve of the 21 (57%) rabbits in group 1 had CT abnormalities of the middle ear (Table 1). Among the 20 rabbits with signs of vestibular disease in group 1, 11 (55%) had CT-detected changes consistent with middle ear disease; the other 9 (45%) had no CT-detected changes in the external, middle, or inner ears, and presumptive central vestibular disease was diagnosed. Eighteen of the 67 (27%) rabbits in group 2 had CT abnormalities of the middle ear.

**Characterization of CT abnormalities of the middle ear**—For group 1 rabbits with CT-detected changes of the middle ear, 6 had unilateral changes and 6 had bilateral changes (overall, 18 affected ears; Table 1). All those affected ears had soft tissue attenuating material (ie, increased attenuation) within the tympanic bulla; of the 18 ears, 10 had lysis of the bulla (prevalence, 55%) and 3 had thick tympanic bulla (Figure 1). The 3 rabbits in group 1 with facial nerve paralysis had CT-detected changes of the middle ear. One rabbit had middle ear changes ipsilateral to facial nerve paralysis and no vestibular signs. The other 2 rabbits had bilateral middle ear changes as well as head tilt and facial nerve paralysis ipsilateral to inner ear CT-detected changes. The type and severity of middle ear CT-detected changes in rabbits with facial nerve paralysis were similar to the findings for other rabbits in group 1 that had signs of vestibular disease without facial nerve paralysis.

Five of the group 1 rabbits with signs of vestibular disease and CT-detected changes of the middle ear had unilateral disease and ipsilateral vestibular signs. The remaining 6 rabbits with signs of vestibular disease in group 1, 11 (55%) had CT-detected changes consistent with middle ear disease. Vestibular signs were ipsilateral to the ear with more severe middle ear CT lesions (2 cases) or to the ear with inner ear changes detected with CT (2 cases). The 2 remaining rabbits with vestibular signs had bilateral middle and inner ear disease. Despite similar CT abnormalities and severity of disease for both middle and inner ears, those rabbits had unilateral vestibular signs.

Among the 18 group 2 rabbits with CT evidence of middle ear disease (ie, relevant CT abnormalities) but no clinical signs, 10 had unilateral subclinical disease and 8 had bilateral subclinical disease (overall, 26 affected ears; Table 1). All affected middle ears of rabbits with signs of vestibular disease in group 1, 11 (55%) had CT-detected changes consistent with middle ear disease; the other 9 (45%) had no CT-detected changes in the external, middle, or inner ears, and presumptive central vestibular disease was diagnosed. Eighteen of the 67 (27%) rabbits in group 2 had CT abnormalities of the middle ear.

Table 1—Prevalence of middle, external, and inner ear CT-detected changes in 88 domestic rabbits (Oryctolagus cuniculus) that had clinical middle ear disease and those without signs of middle ear disease (subclinical disease).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rabbits with clinical disease</th>
<th>All</th>
<th>Rabbits with upper respiratory tract disease</th>
<th>Rabbits with dental disease</th>
<th>Rabbits with other problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total No. of rabbits</td>
<td>21/88</td>
<td>67/88</td>
<td>18/67</td>
<td>33/67</td>
<td>16/67</td>
</tr>
<tr>
<td>No. of rabbits with CT-detected middle ear changes (%)</td>
<td>12/21 (57)</td>
<td>18/67 (27)</td>
<td>7/18 (39)</td>
<td>8/33 (24)</td>
<td>3/16 (19)</td>
</tr>
<tr>
<td>No. of rabbits unilaterally affected (%)</td>
<td>6/12 (50)</td>
<td>10/18 (55)</td>
<td>0/7 (0)</td>
<td>7/8 (88)</td>
<td>3/3 (100)</td>
</tr>
<tr>
<td>No. of rabbits bilaterally affected (%)</td>
<td>6/12 (50)</td>
<td>8/18 (44)</td>
<td>7/7 (100)</td>
<td>1/8 (13)</td>
<td>0/3 (0)</td>
</tr>
<tr>
<td>No. of rabbits with CT-detected external ear changes (%)</td>
<td>10/21 (48)</td>
<td>32/67 (48)</td>
<td>11/18 (61)</td>
<td>15/33 (45)</td>
<td>6/16 (38)</td>
</tr>
<tr>
<td>No. of rabbits unilaterally affected (%)</td>
<td>2/10 (20)</td>
<td>3/32 (9)</td>
<td>0/11 (0)</td>
<td>1/15 (7)</td>
<td>2/6 (33)</td>
</tr>
<tr>
<td>No. of rabbits bilaterally affected (%)</td>
<td>8/10 (80)</td>
<td>29/32 (91)</td>
<td>11/11 (100)</td>
<td>14/15 (93)</td>
<td>4/6 (67)</td>
</tr>
<tr>
<td>No. of rabbits with CT-detected inner ear changes (%)</td>
<td>4/21 (19)</td>
<td>2/6 (3)</td>
<td>1/18 (6)</td>
<td>1/33 (3)</td>
<td>0/16 (0)</td>
</tr>
<tr>
<td>No. of rabbits unilaterally affected (%)</td>
<td>2/4 (50)</td>
<td>2/2 (100)</td>
<td>1/1 (100)</td>
<td>1/1 (100)</td>
<td>NA</td>
</tr>
<tr>
<td>No. of rabbits bilaterally affected (%)</td>
<td>2/4 (50)</td>
<td>0/2 (0)</td>
<td>0/1 (0)</td>
<td>0/1 (0)</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA = Not applicable.
remained subclinically affected, CT examination of (range, 2 months to 5 years). For 2 of the rabbits that
tion (median interval after CT examination, 9 months
develop signs suggestive of ear disease after CT examina-
middle ear but no signs of middle ear disease did not
The remaining 12 rabbits with CT abnormalities of the
in comparison with the initial CT findings (Figure 2)
images confirmed the progression of middle ear disease
rabbits that developed persistent vestibular signs, and
indicated a significant association between upright ears
Predisposing factors for middle ear disease—Of the
bits in group 2 had increased attenuation within the
tympanic cavity. The prevalence of bulla lysis was 19%
(5/26), and that of increased bulla thickness was 19%
(5/26). Comparing the prevalence of CT-detected mid-
dle ear changes between the 2 groups, the prevalence of
bulla lysis in rabbits with clinical middle ear disease
(group 1) was significantly (P < 0.001) higher.
One rabbit with subclinical middle ear CT disease was
euthanized by IV injection of pentobarbital sodium
solution during the CT examination because of advanced
dental disease. Follow-up information was available for
all other rabbits with subclinical middle ear disease, with
a median monitoring time after CT examination of 23
months (range, 2 months to 5 years). Five of 17 group 2
rabbits with CT abnormalities of the middle ear eventu-
ally developed temporary (n = 2) or persistent (3) signs
of peripheral vestibular disease after CT (median inter-
val after CT examination, 10 months [range, 3 days to 2
years]). A CT scan of the head was repeated in 2 of the
rabbits that developed persistent vestibular signs, and
images confirmed the progression of middle ear disease
in comparison with the initial CT findings (Figure 2).
The remaining 12 rabbits with CT abnormalities of the
middle ear but no signs of middle ear disease did not
develop signs suggestive of ear disease after CT examina-
tion (median interval after CT examination, 9 months
[range, 2 months to 5 years]). For 2 of the rabbits that
remained subclinically affected, CT examination of
the head was repeated for evaluation of chronic upper respiratory tract disease, and no progression of middle ear lesions
was detected (Figure 3). On comparison of middle ear CT lesions between group
2 rabbits that remained subclinical and rabbits that eventually developed clinical signs of middle ear disease, the preva-
ence of attenuation and thickening of the tympanic bulla was similar. However, rabbits that eventually developed clinical signs had a higher prevalence of bulla lysis, compared with rabbits that remained
subclinically affected (3/5 vs 1/10). Nevertheless, the difference in prevalence of lytic changes of the bulla between these 2
subgroups was not significant (P = 0.262).
The presence of CT-detected changes of the external and inner portion of the ear was also recorded for rabbits in both groups
(Table 1). Four rabbits in group 1 had CT-detected changes in all 3 portions of the ear (external, middle, and inner ear). Both
group 2 rabbits with inner ear CT-detected changes had no vestibular signs before or at the time of CT examination. One rab-
bit remained subclinical for 4 months after CT (but was euthanized by IV injection of pentobarbital sodium solution because of
progression of dental disease). The other rabbit developed vestibular signs ipsilateral to the affected inner ear 3 days after the CT
examination. These signs resolved within 2 days, during which time antimicrobial treatment for an upper respiratory tract in-
fecation was administered. Two years later, the rabbit con-
tinued to have no recurrence of vestibular signs.

Predisposing factors for middle ear disease—Of the
21 rabbits in group 1, 9 (43%) were lop-eared rabbits.
Of the 12 rabbits in group 1 with CT-detected
middle ear changes, 9 had lop ears and 3 had upright
ears. All rabbits with presumptive central vestibular
disease had upright ears. For group 2, the distribution
of lop-eared rabbits (28/67 [42%]) was similar to that
in group 1. Of the 18 rabbits with CT-detected changes
of the middle ear in group 2, 12 had lop ears and 6 had
upright ears. Combining rabbits with clinical or sub-
clinical middle ear disease (30 rabbits), 21 (70%) had
lop ears and 9 (30%) had upright ears. For the 58 rab-
bits with no CT-detected middle ear changes, 16 (28%)
had lop ears and 42 (72%) had upright ears. Although
there was no association between ear position and clini-
cal or subclinical ear disease, there was a significant (P
< 0.001) association between lop ears and presence of
CT-detected changes of the middle ear. The study data
indicated a significant association between upright ears
and presumptive central vestibular disease.

Of the 12 rabbits in group 1 with CT-detected changes
of the middle ear, 10 also had CT abnormalities of the
external ear; 2 had only middle ear changes. No rabbits in
this group had CT-detected changes limited to the exter-
nal ear. For group 2, 15 of the 18 rabbits with CT-detected
middle ear lesions had CT-detected abnormalities of the external ear, with 3 having only middle ear changes. In contrast, 17 of 32 (53%) rabbits with CT-detected external ear lesions had no CT-detected lesions in the middle ears. None of these rabbits developed signs of otitis externa, media, or interna following CT examination. Combining rabbits with subclinical and clinical middle ear disease (30 cases), 25 (83%) rabbits had CT-detected changes in the external ear, and 5 (17%) had apparently normal external ears. For rabbits with no middle ear CT abnormalities (n = 58), 17 (29%) rabbits had CT-detected changes in the external ear, and 5 (17%) had apparently normal external ears. For rabbits with no middle ear CT abnormalities, the prevalence of otitis externa in groups 1 and 2 was the same, there was a significant (P < 0.001) association between otitis externa and presence of CT-detected changes of the middle ear.

Only 3 of 12 rabbits in group 1 with CT-detected changes of the middle ear had a history of upper respiratory tract disease (2 rabbits) or had CT abnormalities of the upper respiratory tract (1 rabbit). For group 2, 7 of 18 rabbits with CT-detected changes of the middle ear had a history of upper respiratory tract disease and had CT abnormalities of the upper respiratory tract.

For group 2 rabbits, prevalences of middle ear disease by reason for head CT were summarized (Table 1). Rabbits with signs of upper respiratory tract disease had a higher prevalence of CT-detected changes of the middle ear, with all rabbits having bilateral disease. However, the difference in prevalence of CT changes of the middle ear with regard to the different reasons for head CT in group 2 rabbits was not significant. Combining rabbits with subclinical and clinical middle ear disease (30 cases), 10 (33%) had CT-detected changes consistent with upper respiratory tract disease or a history of upper respiratory tract disease, and 20 (67%) had neither CT-detected changes within the upper respiratory tract nor a history of upper respiratory tract disease. Among the 58 rabbits with no middle ear changes identified by CT, 20 (34%) had CT-detected changes consistent with upper respiratory tract disease or a history of upper respiratory tract disease, and 38 (66%) had neither CT-detected changes within the upper respiratory tract nor a history of upper respiratory tract disease.

Discussion

The overall prevalence of clinical middle ear disease in rabbits in this retrospective study was 57%. For rabbits with vestibular signs, the prevalence was 55%. Different prevalences (5.5%, 13 24%, 14 and 63%12) of
clinical middle ear disease in rabbits have been previously reported. Among the various studies, these discrepancies are likely attributable to differences in rabbit populations, inclusion criteria, or method of diagnosis of otitis media. For the study that found a prevalence of 24%, diagnosis was based on otoscopic examination findings and radiographic abnormalities. The higher prevalence of middle ear disease reported in the present retrospective study could be due to the increased sensitivity and accuracy of CT for identifying changes of the middle ear, compared with routine radiography, as previously reported. One limitation of the present study and the one by Jeklova et al was that the imaging abnormalities of the middle ear were not confirmed during surgery, by histologic evaluation, or during necropsy. The higher prevalence (63%) of otitis media in the retrospective postmortem study of rabbits with vestibular disease suggests the occurrence of false-negative results with radiography and CT, as reported for dogs with middle ear disease. The prevalence of CT-detected changes of the middle ear in the group 2 rabbits of the present study was 27%. Although this is within the reported prevalence range of 11.3% to 32%, all previous studies of the prevalence of subclinical middle ear disease were based on postmortem findings of meat rabbits or research rabbits.

Computed tomography lesions of the middle ear in rabbits in the present study were similar to those described for dogs, cats, and other rabbits. A strong association was found between the occurrence of bulla lysis and clinical otitis media. This finding was different from a previous report for cats, in which CT findings of the tympanic bulla were similar among cases of clinical and subclinical middle ear disease. In addition, the rabbits in the present study had higher prevalences of increased CT attenuation within the middle ear and bulla lysis and a lower prevalence of increased bulla wall thickness, compared with cats with clinical middle ear disease. In cats, the presence of nasopharyngeal polyps can cause increased CT attenuation within the middle ear. Lysis of the tympanic bulla in dogs and cats occurs with severe middle ear infections, although neoplasia or cholesteatoma can cause similar lesions. Within the middle ear of rabbits, neoplasia, polyps, and cholesteatoma have not been reported.

In the rabbits with clinical middle ear disease in the present study, an equal number of rabbits had unilateral and bilateral middle ear changes identified by CT. A higher prevalence (86%) of bilateral middle ear disease in rabbits with vestibular disease secondary to otitis media has been reported. For most rabbits with clinical middle ear disease in the present study, the body side with vestibular signs was consistent with the side of the CT-detected lesions in the middle or inner ear. In cases of bilateral disease, vestibular signs were ipsilateral to the more severely affected side. These results differ from those of a previous study in rabbits, in which clinical signs were not consistent with postmortem ear evaluation findings. Among the 11 rabbits with peripheral vestibular disease due to middle ear disease in the present study, 6 had no CT evidence of inner ear disease. For dogs and cats, the occurrence of peripheral vestibular signs implies the presence of inner ear disease. It is possible that changes in the inner ear of these rabbits were subtle or limited to the soft tissue portion, which would be more readily detected by CT with contrast agent administration or MRI. In the present study, there was no association between the characteristics of the CT-detected middle ear changes and the occurrence of facial nerve paralysis. Facial nerve paralysis is not specific to ear disease and can develop in rabbits with abscesses or other masses in the nerve pathway.

For rabbits with subclinical middle ear disease (group 2) in the present study, unilateral middle ear changes were more prevalent than bilateral middle ear changes (56% vs 44%). Previous reports describe a higher prevalence of bilateral subclinical otitis media in meat (70%) and research (81%) rabbits. As for other findings, discrepancies in these prevalences may be due to differences in rabbit populations, medical history, or method of diagnosis of otitis media. Two rabbits in group 2 had unilateral CT-detected changes of the inner ear and no vestibular signs before CT examination. In contrast, all rabbits in group 1 with CT-detected changes of the inner ear had persistent vestibular signs. Although it is possible that changes in the inner ear of the group 2 rabbits were limited to the bone structures of the inner ear, CT with contrast agent administration or MRI would have been helpful to more accurately evaluate the soft tissue portion of the inner ear and compare clinical and subclinical inner ear disease.

The clinical relevance of CT abnormalities of the middle ear in rabbits with subclinical disease remains unknown. Seventy-one percent of rabbits with CT-detected changes of the middle ear remained subclinically affected after the CT examination in the present study. The reason for head CT, ear position, or presence of CT-detected external ear lesions was not associated with progression of subclinical ear disease. Rabbits with subclinical middle ear disease that eventually developed vestibular signs had a higher prevalence of bulla lysis, compared with rabbits that remained subclinically affected. Although the association was not significant (perhaps because of the small sample size), the authors recommend close monitoring (including CT examination) of rabbits with subclinical middle ear disease that have lysis of the tympanic bulla revealed by CT.

Three proposed predisposing factors for the development of middle ear disease in rabbits were investigated in the present study: ear position, otitis externa, and upper respiratory tract disease. No significant association was found between ear position and the development of clinical or subclinical middle ear disease. However, the study results supported an association between CT-detected middle ear changes and lop-ear conformation and between central vestibular disease and upright-ear conformation. Similarly, a strong association was evident between external ear and middle ear changes identified by CT. It is unknown whether CT-detected changes within the external ear in rabbits with CT-detected lesions in the middle ear were a cause or consequence of middle ear disease in the rabbits in group 1. It is important to note that no rabbits in group 1 had CT-detected changes of the external ear alone, and 17 of 32 (53%) rabbits with external ear disease, as
evidenced by CT, in group 2 had no abnormal changes in the middle ear.

In the present study, no significant association was found between upper respiratory tract disease and CT-detected changes of the middle ear in rabbits. This finding is different from those of previous reports of a strong association between otitis media and upper respiratory tract disease in rabbits. Middle ear changes without external ear changes were identified by CT in both groups of rabbits. In addition, all rabbits with subclinical middle ear disease with upper respiratory tract disease had bilateral changes. Although these findings might reflect otitis media secondary to inflammation of the auditory tube or translocation of flora from within the nasopharynx, other factors may play a role in the development of otitis media in rabbits with upper respiratory tract disease. These may include the type or pathogenicity of the bacteria colonizing the middle ear, host immunity, and concurrent diseases other than external ear disease and upper respiratory tract infection. The role of viruses, anaerobic bacteria, and fungi in the development of otitis media in rabbits remains unknown. In the present study, all rabbits with CT-detected changes of the middle ear had an increased CT attenuation within the tympanic cavity; thus, primary secretory otitis media, as described in Cavalier King Charles Spaniels, may play a role in the development of middle ear disease in rabbits. Allergic rhinitis, reported as a common cause of otitis media in children, has been anecdotally reported as a cause of otitis media in rabbits. Suppurative otitis media can be induced in rabbits by experimentally altering auditory tube function without the inoculation of bacteria; therefore, chronic inflammation associated with allergic rhinitis could initiate and maintain the hypersecretory state of the middle ear mucosa presumed to be responsible for chronic otitis media. An altered conformation of the skull described in brachycephalic dogs may play a role in the development of middle ear disease in rabbits. This association is well described for humans with craniofacial malformations and for brachycephalic dogs. Additional studies are needed to investigate these proposed predisposing factors for middle ear disease in rabbits.

Owing to the retrospective nature of the present study, inclusion criteria, and method of diagnosis (CT examination), the prevalence of clinical and subclinical middle ear disease determined in this study may not accurately reflect the overall prevalence of ear disease in domestic rabbits. A prospective study with broader inclusion criteria, a detailed client survey, additional diagnostic tests (including otoscopy with cytologic and microbiological evaluation of middle ear exudate samples, CT with contrast agent administration, and MRI), and comparison of images of middle ear changes with surgical and histopathologic findings would provide a better understanding of middle ear disease in pet rabbits.

The intent of the present study was to describe the prevalence and characteristics of CT-detected changes of the middle ear in rabbits with and without signs consistent or suggestive of ear disease (ie, clinically and subclinically affected rabbits). Otitis media–related lesions were frequently detected by CT in rabbits with no signs of ear disease. Increased CT attenuation within the tympanic cavity was seen in all affected middle ears. Lysis of the tympanic bulla was more prevalent in clinical cases of middle ear disease and, although not significantly, was associated with progression of subclinical middle ear disease to vestibular disease. Otitis externa and ear conformation were shown to be important predisposing factors for the development of middle ear disease in rabbits. No strong association was found between the presence of middle ear disease and upper respiratory tract disease, with other factors likely playing a role in this mechanism of middle ear disease. Further studies are needed to investigate the pathophysiologic mechanisms of middle ear disease development and to determine the sensitivity and specificity of CT for the diagnosis of middle ear disease in rabbits.

References