Otitis media and interna with or without polyps in cats

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OTITIS MEDIA AND INTERNA WITH OR WITHOUT POLYPS IN CATS: ASSOCIATION BETWEEN MENINGEAL ENHANCEMENT ON POST-CONTRAST MRI, CSF ABNORMALITIES AND CLINICIAN TREATMENT CHOICE AND OUTCOME

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Objectives: To evaluate the association between meningeal enhancement (MgE) and cerebrospinal fluid (CSF) analysis results, their individual association with bacteriology results from affected ear samples, and whether these test results influenced clinicians' therapeutic choice in cats with otitis media and interna (OMI).

Methods: Multicentre retrospective study over an eight-year-period. Cats diagnosed with OMI, with or without a nasopharyngeal polyp, leading to peripheral vestibular signs were included. Only cats for which MRI with post-contrast T1 weighted sequences and CSF analyses were available were included in the study. Cats with intra-axial MRI lesions or empyema were excluded.

Results: Fifty-eight cats met the inclusion criteria. MgE was reported in 26/58 cases of which 9 had an abnormal CSF result (increased total nucleated cell count (TNCC) or total protein); 32/58 cases had no MgE of which 10 showed abnormal CSF results. There was no association between bacteriology results (external ear canal or bulla) and MgE or abnormal CSF results. CSF abnormalities were more commonly detected in acute cases (16/37) compared to chronic cases (3/21), the difference being statistically significant (Fischer test, P = 0.04). Prednisolone was prescribed in 10/16 cases with increased TNCC. Among the 42 cases with normal TNCC, 15/42 received prednisolone, and 13/42 received non-steroidal anti-inflammatory drugs. Various antimicrobial drugs were prescribed in 53/58 cats. Antimicrobial therapy duration was similar regardless of positive bacterial culture (5.58 vs 4.22 weeks), increased TNCC (6.13 vs 4.72 weeks) or MgE (5.33 vs 4.90 weeks).

Conclusion and relevance: No association was found between CSF and MgE results. Furthermore, no association was found between MgE, CSF or bacteriology findings, respectively. In addition, abnormal CSF results might lead the clinician to treat with corticosteroids but did not have any impact on antimicrobial therapy length. CSF abnormalities are seen significantly less frequently in chronic cases. Outcome tended to be poorer when MgE is detected on MRI.

Keywords: Otitis media and interna; Peripheral vestibular signs; MRI, Meningeal enhancement; Cerebrospinal fluid

Introduction

Otitis media and interna (OMI) has been reported to be the cause of cause vestibular signs in 43% to 63% of cats with peripheral vestibular signs (PVS) (1,2). OMI in cats is most commonly associated with inflammation caused by upper respiratory infection that has extended through the auditory tube or a nasopharyngeal polyp (1,3,4). It occurs less frequently as a consequence of an otitis externa or neoplasia. Bacterial isolates from OMI include *Staphylococcus* species, *Streptococcus* species, *Pasteurella multocida*, *Escherichia coli*, *Enterococcus* species and less frequently *Mycoplasma* species, *Corynebacterium* species and other bacterial species (1,4–8). Apart from bacteria, cats can have other infectious agents being involved, especially fungi (*Malessezia*) (8). Occasionally a nasopharyngeal polyp, a non-neoplastic, inflammatory growth that arises from the middle ear or the auditory tube, can be responsible for OMI (1,2,9,10). Diagnosis of otitis media and bacterial infection in the bulla can be reached via cytological and/or bacterial culture of material retrieved via myringotomy or surgical procedure such as bulla osteotomy (1,8,9). Cats with PVS are clinically recognized with the presence of at least one of the following clinical signs: ipsilateral head tilt, jerk nystagmus, tight circling, positional strabismus and/or vestibular ataxia and the absence of any neurologic signs suggestive of intracranial disease. (11–13). PVS reflect the involvement of the inner ear, while presence of facial nerve deficit and/or Horner syndrome indicates the involvement of the middle ear (11–13).

MRI is a sensitive method to diagnose OMI, particularly for inner ear visualization (1,7,14). The fluid composition of endo- and perilymph allows a good visualization of this inner ear part in a fluid sensitive sequence such as T2-weighted (T2W) images or in fluid-attenuated inversion recovery (FLAIR) (14,15). A marked hyperintensity compared to adjacent structures is present on T2W images while a suppression is visible in FLAIR (14,15). Post-contrast T1-weighted images may show abnormality consistent with inflammatory changes in the inner ear. (1) Typical changes raising the suspicion of OMI include isointense material in the bulla on T1W images and hyperintense on T2W images. On post-contrast T1W images, a peripheral enhancement along the inner surface of the tympanic bulla can be observed (7,16). A laminated appearance of the mucosa of the tympanic bulla on T2W images has also been described (17). A reduced signal intensity on T2W or an increase signal intensity on FLAIR images from the intralabyrinthine fluid are MRI finding suggestive of otitis interna (14,16,18). Due to anatomical proximity, intracranial extension of OMI can lead to a meningeal enhancement (MgE) on MRI after intravenous administration of paramagnetic contrast medium (19). Anatomically, perilymph and cerebrospinal fluid (CSF) are connected via the cochlear aqueduct (20). Therefore, CSF analysis is another important diagnostic tool for cats with OMI and is reported to be more sensitive than MRI to identify intracranial inflammatory processes (7,15,21). Thus, an abnormal MRI and/or CSF analysis can provide useful clinical information on the presence of a concurrent meningitis and may influence the therapy.

The relationship between MgE and abnormal CSF in cats with OMI has not yet been investigated, neither have their association with bacteriology results and therapeutic management. The aims of this study were to describe the association between MgE and CSF analysis results, their individual association with bacteriology results from affected ear samples, and the influence of the above with therapeutic choice in cats with OMI. We hypothesize that (a) MgE is associated with CSF abnormalities, (b) positive bacteriology is more common if MgE and/or CSF abnormalities are present and (c) positive bacteriology is associated with the choice and length of antimicrobial and/or anti-inflammatory therapy.

Materials and Methods

Selection criteria

Data were retrospectively collected from six different referral centres across Europe (Vetsuisse-Faculty, University of Bern; University of Veterinary Medicine Hannover, Foundation; Royal Veterinary College London (RVC); School of Veterinary Medicine, University of Glasgow; Queen's Veterinary School Hospital, University of Cambridge, and Royal (Dick) School of Veterinary Studies, University of Edinburgh) over an eight-year-period (January 2012 to December 2020). Only client-owned cats with peripheral vestibular signs that underwent MRI (with post-contrast images) and CSF analysis as part of the diagnostic work up were selected for this study. Inclusion criteria were: (1) clinical signs consistent with peripheral vestibular lesion localisation, (2) a diagnosis of otitis media and interna with or without the presence of a nasopharyngeal polyp based on MRI findings, (3) absence of intra-axial abnormality or imaging findings consistent with empyema on MRI.

Retrospective information collected from the medical records included signalment, history, therapy prior and after referral, side of PVS, MRI and CSF findings, bacteriology results from affected ear, and outcome.

MRI

The MRI images of the skull were obtained under general anesthesia, using anesthetic protocols at the discretion of the anesthesiologist in charge. High-field MRI were used at all institutions (except for one cat) and varied between centres: a Philips Panorama HFO 1.0 T (Philips Medical Systems Nederland B.V., Best, Netherlands) for Bern, a Philips Achieva 3.0 T (Philips Medical Systems, Best, The Netherlands) for Hannover, 1.5T (Intera; Philips Medical Systems, Amsterdam, Netherlands) for RVC, 1.5T (Magnetom Essenza Siemens) for Glasgow, 0.27T (Esaote VetMR Grande, Genova, Italy) or 1.5 T (Phillips Achieva, Phillips Healthcare, Best, Netherlands) for Cambridge and 1.5 T (Intera; Philips Medical Systems, Amsterdam, Netherlands) for Edinburgh. Although MRI protocols varied between centres, in all cats, at least T1-weighted T1W, T2W and T1W post-contrast images were available (IV of 0.2 mmol/kg gadoteric acid [Dotarem; Guebert Laboratories] for Bern and Hannover, IV of 0.1 mmol/kg gadoterate meglumine [Dotarem; Guerbet, Milton Keynes, UK] for RVC, [Gadovist, Bayer] for Glasgow & Cambridge and 0.1 mmol/kg gadopentate dimeglumine [Magnevist, Bayer] for Edinburgh). All MR images had been evaluated by a board-certified veterinary radiologist or a board-certified veterinary neurologist. Information about OMI with or without nasopharyngeal polyp and MgE were collected directly from MRI reports.

CSF analysis

Abnormal CSF was defined as a total nucleated cell count (TNCC) ≥ 5 leukocytes per µL and/or increased total protein > 0.3 g/L for cisterna magna samples and > 0.45 g/L for lumbar samples. Albuminocytologic dissociation was defined as an increase in total protein without an increased TNCC. Neutrophilic (respectively monocytic) pleocytosis is identified if there is > 70% of neutrophils (respectively monocytes) in a CSF with abnormal TNCC. (22)

Medical treatment

Antimicrobials were categorized as first or second line of treatment. First line included amoxiclav, cephalosporin, metronidazole, clindamycin and doxycycline. Second line contained marbofloxacin, enrofloxacin, cefovecine, pradofloxacin and cefixime. (23)

Anti-inflammatory drugs were categorized as steroidal (eg, prednisolone, dexamethasone) or non-steroidal (eg, meloxicam, robenacoxib).

Statistical analysis

The presence or absence of MgE on MRI, the CSF results and bacteriology culture results were compared using a χ^2 test. The choice of therapy based on MgE, CSF and bacteriology results were compared using a χ^2 test or a Fischer's exact test if a group contained less than 5 cats. Duration of therapy was compared using a Student's t-test. Test values were performed two-sided and a value of $P \leq 0.05$ was considered statistically significant. All analyses were performed using R version 3.6.3.

Results

A total of fifty-eight cats met the inclusion criteria. Domestic shorthair cats were the most common breed (32/58 cats). Other breeds were Maine Coon (9), Siamese (4), British Short Hair (2), Burmese (2), Russian Blue (2), Bengal (1), Egyptian Mau (1), Norwegian (1), Ocicat (1), Persian (1), Ragdoll (1), and Snowshoe (1). There were 27 females (four intact, 23 spayed) and 31 males (four intact, 27 neutered; sex ratio male/female = 1.15). The mean age of the cats was 6.9 years (median = 7.3 years, range: 3.7 months to 14.7 years). Half of the cases had left vestibular signs at time of presentation. Clinical signs were acute (≤ 14 days) in 37 cats and chronic (> 14 days) in 21 cats. Medical treatment before presentation was given in 32 cats. Nine cases received antimicrobial therapy alone, eight had an antimicrobial therapy with non-steroidal anti-inflammatory drugs, nine had an antimicrobial therapy with corticosteroids, and two had an antimicrobial therapy, non-steroidal anti-inflammatory drugs, and corticosteroids. Five cats received only corticosteroids and one only a non-steroidal anti-inflammatory drug. All clinical information from cases are available in supplementary material.

Forty-five cats (78%) were diagnosed with OMI alone (without a nasopharyngeal polyp) (Figure 1 (a), 2 (a) and (c)): three based on histology of material obtained from bulla osteotomy, three based on findings during bulla osteotomy, 26 based on otoscopy and cytology results obtained through myringotomy and 13 were suspected on MRI only. The remaining cats (13/58, 22%) were diagnosed with OMI secondary to a polyp (Figure

3 (a) and 4 (a)): six based on histology of material obtained from bulla osteotomy, two based on findings during bulla osteotomy, two based on otoscopy and/or cytology results obtained through myringotomy and two were suspected on MRI only.

Meningeal contrast enhancement was present in 26/58 cases (45%) (Figure 2 (b) and 4 (b)) while 32/58 cases (55%) did not show MgE (Figure 1 (b) and 3 (b)). CSF analysis was abnormal in 19/58 (33%) cats. Eleven of them with only increased TNCC, five with both increased TNCC and total protein and three with albuminocytologic dissociation. Increased TNCC ranged between five and 1205 leukocytes / μL (median = 12) and increased total protein in CSF ranged between 0.34 and 0.77 g/L (median = 0.56). Neutrophilic pleocytosis was seen in nine cases, monocytic pleocytosis was seen in one case and mixed cell pleocytosis in six cases.

Nine of 58 cats (16%) presented both MgE and abnormal CSF (five with only increased TNCC, two with both increased TNCC and total protein and two with albuminocytologic dissociation). MgE was detected in 17/58 cats (29%) with normal CSF. Abnormal CSF was seen in a total of 10/32 cats (31%) without MgE: 6 with only increased TNCC, three with both increased TNCC and total protein and one with albuminocytologic dissociation. No significant association (χ^2 test, $P = 0.79$) was found between CSF results and MgE findings (Table I).

CSF abnormalities were more commonly detected in acute cases (16/37) compared to chronic cases (3/21), the difference being statistically significant (Fischer test, $P = 0.04$), while MgE was similar in acute (15/37) and chronic (11/21) cases. Furthermore, none of the chronic cases presented an abnormal CSF without MgE (Table II). No association was found between the use of anti-inflammatory drugs before MRI and CSF analysis (Table III) or the presence or absence of a polyp (Table IV) and MgE or CSF abnormalities.

Bacterial culture was performed in 45/58 cases. Samples were collected from bulla osteotomy in 13 cases, myringotomy in 28 cases, and external ear canal in four cases. Negative bacterial culture was observed in 33/45 cases, of which thirteen (39%) received antimicrobial therapy before sampling. The percentage of negative bacterial culture was 73% in both acute (21/30) and chronic (11/15) cases.

Twelve cases showed a positive bacterial culture: six for *Staphylococcus* species, three for *Pasteurella* species, one for *Streptococcus canis*, one for *Actinomyces pyogenes* and one with both *Streptococcus equi subspecies zooepidemicus* and *Staphylococcus felis*. Among these cases, seven out of twelve (58%) received antimicrobial therapy before sampling.

The results of the bacterial culture depending on presence/absence of MgE and normal/abnormal CSF findings are summarized in Table V. No statistical association was found between a positive bacterial culture and MgE (χ^2, *P* = 0.82) or CSF results (χ^2 test, *P* = 0.15). One observation was that if no MgE was seen on MRI images and no abnormality was detected on CSF analysis, the likelihood to get a negative ear sample bacterial culture from myringotomy or bulla osteotomy was only about 12% (2/17 cases). One cat had a positive culture from CSF (*Clostridium beijerinkii* and *Enterococcus faecalis*) despite no positive bacterial culture ear sample from myringotomy and clindamycin therapy for three days.

Twenty-five cats received corticosteroids and 13 received non-steroidal anti-inflammatory drugs after diagnosis. Choice of anti-inflammatory drugs according to MgE, CSF or bacteriology findings is summarized in Table VI. No significant difference (χ^2 test, *P* = 0.53 for MgE; Fischer test, *P* = 0.08 for CSF; Fischer test, *P* = 0.62 for bacteriology) was identified although corticosteroids seem to be chosen more often in case of abnormal CSF (11 cases versus 1 case). A total of 54 cats (93%) received antimicrobial therapy after diagnosis. Twenty-six out of 54 (48%) had antimicrobial therapy started prior to referral while it was started by the referral centre after diagnosis in twenty-eight cases (52%). Thirty-nine received first line antimicrobials, seven received second line and eight received both. Duration of antimicrobial treatment depending on MgE, CSF or bacteriology findings are summarized in Table VII. Antimicrobial therapy duration tended to be longer in case of positive culture (5.58 vs 4.22 weeks) or when CSF findings were abnormal (5.83 vs 4.76 weeks), although this difference was not statistically significant (Student's t-test).

Association between CSF results, MgE and outcome are described in table VIII. Good outcome is defined by an improvement of clinical signs (and euthanasia unrelated to the disease after several months). Poor outcome is defined by an absence of improvement or euthanasia. Although cases with MgE tend to have poorer outcome (5/18) than without MgE (3/26), the difference was not statistically relevant (Fischer test, $P = 0.24$). No association was found between outcome and CSF abnormalities (Fischer test, $P = 1$). Bulla osteotomy was performed in 14 cases (8 polyps and 6 OMI), between one and 78 days after diagnosis (median = 5). Delayed bulla osteotomies were due to absence of improvement or relapse of clinical signs after initial medical management. Improvement of neurological signs after surgical management was seen in 11 cases (time of follow-up varies between one and 104 weeks including five cases with more than eight weeks of follow-up), relapse in one (three months after surgery) and three cases were lost to follow-up. None of the surgical cases were euthanized for reasons related to the OMI. Medical management resulted in improvement in 23/44 cases (time of follow-up varies between one and 78 months including 12 cases with more than eight weeks of follow-up). Two cases improved and were euthanized due to unrelated reasons four months and 17 months after diagnosis of OMI respectively due to carcinoma and polyarthritis. Three cases did not improve after one month but owners declined surgery. Four cases were euthanized following diagnosis or several weeks after with no improvement on medical therapy. One case showed intermittent vestibular signs and was euthanized 20 months after diagnosis due to seizure-like episodes. Eleven cases were lost to follow-up.

Discussion

The findings of this study show that in a cohort of 58 cats with PVS diagnosed with OMI, MgE is seen in approximately 50% of cases but only 27% of these cases had an abnormal CSF analysis. There was no association between MgE and abnormal CSF results. Chronic cases had significantly fewer abnormal CSF findings. When a treatment was given, its duration was similar regardless of a positive bacterial culture, abnormal CSF analysis or meningeal enhancement. Cases with MgE tend to have poorer outcome.

The use of MRI to investigate the cause of PVS is common practice in clinical neurology, particularly if concurrent meningitis is suspected. Administration of gadolinium-based contrast medium in MRI has been demonstrated as a more sensitive method to diagnose experimental bacterial meningitis in dogs compared to MRI without contrast or post-contrast CT (23). However, only severe meningeal inflammation at necropsy was correlated with MRI findings while mild inflammation was not detected in MRI leading to the conclusion that the absence of meningeal enhancement does not rule out bacterial meningitis (24). False positive results of diffuse MgE on MRI images without CSF abnormalities have also been previously described (25). MRI also allows a better evaluation of fluid containing inner ear structures than CT and otitis interna can be assessed on T2W images (16,26). More recently, d'Anjou *et al.* (2012) and Keenihan *et al.* (2013) compared MR sequences for detecting MgE in dogs. Post-contrast T1W and

T1W fat suppression were found to be the sequences of choice to detect meningeal inflammation (27,28). In previous studies in cats with OMI, only one case with focal meningitis resembled our population of cats with MgE, without intra-axial lesion or empyema. This case had an abnormal CSF analysis (1). In dogs, few studies describe naturally occurring OMI leading to meningeal enhancement in T1W images after gadolinium administration but no large study focusing on this aspect has been done; therefore its clinical consideration remains unknown (16,29,30).

Despite the first hypothesis that MgE is associated with abnormal CSF findings, a discrepancy between MgE and CSF results was found in 47% of cases. Indeed, MgE was seen more frequently in cases with unremarkable CSF analysis (65%) and abnormal CSF can be found without MgE in up to 31% of cases. To the best of the authors' knowledge, no previous report of cats with OMI evaluated the association between the MRI findings and CSF analysis. In previous reports of cats diagnosed with OMI and intra-axial lesions or empyema on MRI, an abnormal CSF was detected in 22/25 cases in which CSF analysis was performed (1,7,31). MgE was specifically described in one of these studies, where none of the five cats with chronic vestibular clinical signs had a MgE while all of the six acute or subacute cases showed MgE (7). The prevalence of MgE is in contrast with our results, in which 11 of 21 chronic cases and 15 of 35 acute cases showed MgE. When available, abnormal CSF analysis was detected in all acute or subacute cases (5/5) and only in 1 of 4 chronic cases (7). These results reflect our findings with significantly fewer CSF abnormalities in chronic cases. Previous treatment with anti-inflammatory drugs or presence of a polyp did not affect presence/absence of MgE or CSF results.

The second hypothesis was that there would be an association between MgE and/or CSF abnormalities and a positive bacteriology culture. In case of absent MgE and normal CSF, the likelihood of a positive bacterial culture from myringotomy or bulla osteotomy is low (~ 12%). Even if this result is not statistically significant, it could make the clinician aware of the possible need to alter antimicrobial therapy after receiving culture results. Bacteriology results between acute or chronic cases did not different significantly.

We finally hypothesized that positive bacterial culture would influence the choice and length of antimicrobial and/or anti-inflammatory therapy. Due to the retrospective and multicentre aspect of our study, medical management was very variable, making the investigation of the last hypothesis difficult. Generally, a long term (4 to 8 weeks), broad-spectrum antimicrobial therapy or, ideally, a therapy based on *in vitro* antimicrobial sensitivity profile, is recommended to treat OMI in cats and dogs (8). In the current study, duration of therapy was slightly longer in cases of positive bacterial culture than in cases of negative bacterial growth culture (respectively 5.58 weeks vs 4.22 weeks), although the difference was not significant. The similar length of therapy may be due to initial prescription with no improvement of clinical signs or a lack of short-term follow-up by the referring centre. Also, if anti-inflammatory drugs were to be implemented after abnormal CSF results, clinicians tended to use corticosteroids more frequently. These results could reflect a clinicians' preference for corticosteroids in case of CNS inflammation. However, clinicians need to remember about the lack of CSF abnormalities in chronic cases, despite meningeal inflammation.

Culture results from samples taken from the external ear canal have to be interpreted with caution. Common microorganisms can be detected in the tympanic bulla of healthy cats in up to 25% of cases (32). Bacteria have been previously cultured from 48% of healthy canine external ears (33). Moreover, up to 67% of myringotomies performed via video-otoscopy might be contaminated even if microorganisms were detected only in 15.4% of the samples (34). The presence or absence of bacteria on culture should not be considered as critical in formulating a treatment plan as the type of bacteria that are cultured (that is, whether they are likely of external ear canal origin and/or possible iatrogenic contaminants versus a likely cause of middle ear infection). The lack of a cultured infectious agent in our case series with the presumed presence of OMI raises the question of a purely inflammatory mechanism leading to otitis interna.

Age of cats, uni- or bilateral vestibular signs distribution, proportion of OMI with or without polyps and type of bacteria cultured were similar to previously published literature (1,2,13,35). In this cohort cases with identified MgE tend to have poorer prognosis than those without MgE however this difference was not statistically significant, while an abnormal CSF result was not associated with any difference in outcome. This finding might help clinicians to anticipate and maybe adapt the therapy for such cases. Surgical treatment with bulla osteotomy was performed in fourteen cats (24%), including four in which it was performed several weeks after diagnosis. This was different to other published studies in which none of the cases with vestibular signs underwent surgery and up to 30% of otitis media cases without neurological signs received bulla osteotomy (1,4). In another study focusing on OMI in cats with intracranial complications, ventral bulla osteotomy was performed more often (12/18 cases, 67%) (31). Surgically managed cases lead to an improvement of neurological status for all cases (13/13) while medical management showed an improvement in 23/31 cases (74%). These results are slightly better than those for cats with OMI and intracranial complication (31).

There are several limitations to this study. First of all, the retrospective nature is associated with incomplete data and did not allow long term follow-up of cases. A multicentre study with different MRI machines, clinicians and protocols will result in differences in the evaluation of MR images and the clinical management of cases. Concerning case recruitment, cases without MRI and/or CSF analysis were excluded, which may have biased the study population towards potentially more severely affected cases. Clinicians may decide against CSF analyses in those cases where clear MgE is seen on MRI, biasing the population towards a higher number of cases without MgE. A similar bias could also impact the choice of therapy in the cases of the present study. Moreover, the use of medication prior to presentation might have impacted the results of the current study. We decided to exclude all cases presented with intra-axial lesions or empyema on MRI images despite presumed peripheral vestibular lesion localisation as brainstem signs may not be clinically obvious in the neurological examination and might have impacted CSF results (36,37). In dogs, it has been shown that bacterial culture obtained via myringotomy can be contaminated by bacteria from the external ear canal and this could be one limitation for our bacteriology results (34). Time of acquisition in dogs and higher dose of gadolinium in humans may induce false negative meningeal enhancement (28,38). False positive MgE may also occur (25).

Conclusion

In this study, no association was found between MgE and CSF results. Nearly half of the cases (47%) showed a discrepancy between MRI and CSF findings. Additionally, the lack of MgE in MRI does not rule out the presence of a meningitis pathologically. Hence, CSF analysis may be useful to detect the presence of possible concurrent meningitis in cats with OMI. CSF findings and MgE results were not associated with likelihood of a positive or negative middle ear bacterial culture. Abnormal CSF results seemed to influence the clinicians' choice of anti-inflammatory drugs with a preference for glucocorticoids versus non-steroidal anti-inflammatory drugs. Abnormal CSF results were seen less frequently in chronic cases than acute cases in this study. Additionally, the identification of an abnormal CSF analysis did not seem to notably influence the length of antimicrobial therapy, which remains the mainstay for this presumed infectious disease. Outcome tend to be poorer when MgE is detected on MRI.

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Figures

Figure 1 - MRI (Philips Panorama HFO 1.0 T) transverse images in T1W sequence (a) and T1W post-contrast sequence (b) of a cat presented with an otitis media-interna without polyp (*) and without meningeal enhancement.

Figure 2 - MRI (Philips Panorama HFO 1.0 T) transverse images in T1W sequence (a), T1W post-contrast sequence (b) and T2W sequence (c) of a cat presented with a bilateral otitis media-interna without polyp (*), with meningeal and vestibulocochlear nerve enhancement (white arrowhead) and otitis interna (yellow arrowhead).

Figure 3 - MRI (Philips Panorama HFO 1.0 T) transverse images in T1W sequence (a) and T1W post-contrast sequence (b) of a cat presented with an otitis media-interna associated with a polyp (X) and without meningeal enhancement.

Figure 4 - MRI (Philips Panorama HFO 1.0 T) transverse images in T1W sequence (a) and T1W post-contrast sequence (b) of a cat presented with an otitis media-interna associated with a polyp (X) and with meningeal and vestibulocochlear nerve enhancement (white arrowhead).

Supplementary material

The following file is available online: table of cases

Conflict of Interest

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Ethical Approval

The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognised high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in JFMS. Although not required, where ethical approval was still obtained, it is stated in the manuscript.

Informed consent

Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers) for all procedure(s) undertaken (prospective or retrospective studies).

No animals or people are identifiable within this publication, and therefore additional informed consent for publication was not required.