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Low-field magnetic resonance imaging of otitis media in two cats: a case report

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ABSTRACT: Otitis media is a common disease in clinical veterinary practice. Although low-field magnetic resonance imaging reports for otitis media in dogs exist, in cats detailed information is missing. Radiography is helpful in diagnosing chronic inflammation, but may be insufficient during the initial phase of inflammation. For this reason, this report describes the magnetic resonance findings in two cats with otitis media. In both cases, middle ear empyema was detected. Magnetic resonance imaging of middle ear disorders in cats should contain pre- and post-contrast T1-weighted sequences in the dorsal and transverse planes, a T2-weighted sequence in the dorsal and transverse planes and a fluid-attenuated inversion recovery sequence in the dorsal or transverse planes. On pre-contrast T1-weighted images, the empyema had an intensity similar to that of brain tissue with a delicate hyper-intensity in the middle. On post-contrast T1-weighted images, the material had non-uniform enhancement in the dorsolateral compartment and circumference enhancement in the ventromedial compartment of the tympanic bulla with a hypo-intense centre. On T2-weighted images, the mass had heterogeneously increased signal intensity to brain tissue, but was less intense than cerebrospinal fluid. In the fluid-attenuated inversion recovery sequence, the pathological lesion was distinctly hyper-intense in comparison to other tissues with a narrow area of increased signal intensity in the middle of the ventromedial tympanic bulla compartment. Magnetic resonance imaging is commonly used for the visualisation of different disorders of the membranous labyrinth and allows the differentiation of chronic hematomas, empyemas and middle and internal ear neoplasia. The recommended magnetic resonance protocol of the middle ear should include pre- and post-contrast T1 sequences in the dorsal and transverse planes, the T2 sequence in the dorsal and transverse planes and the fluid-attenuated inversion recovery sequence in the dorsal or transverse planes.

Keywords: MRI; middle ear; tympanic bulla; empyema; feline

Otitis media is a frequent clinical problem (Remedios et al. 1991). Physical examination of ears is limited to the outer ear and the tympanic membrane (Shell 1988). The examination of the middle and internal ear is possible using such diagnostic modalities as radiology, computed tomography (CT) and magnetic resonance imaging (MRI) (Hoskinson 1993). Although radiography may be useful in diagnosing chronic inflammation, it might not be sufficient in the initial phase of inflammation. For this reason, conventional radiography is not sufficiently sensitive for the diagnosis of middle ear disorders (Remedios et al. 1991; Hoskinson 1993). MRI has replaced radiography and is the technique of choice in the diagnosis of human middle ear disease (Casselman et al. 1994).

Otitis media is a common disease in clinical veterinary practice. Most frequently, otitis media appears as a result of primary inflammation of the external ear or, less commonly, due to auditory tube or haematogenous infection (Remedios et al. 1991). It is a painful disorder with severe symptoms, such as head tilting and shaking, facial paralysis or Horner's syndrome (Shell 1988). The proper diagnosis of otitis media is based on history, clinical presentation and additional visualisation modalities (radiography, CT, MRI; Dvir et al. 2000). Computed tomography is a precise imaging modality for diagnosis of

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otitis media, but is limited in its ability to exclude otitis interna or some masses affecting the vestibulocochlear nerve (Kneissl et al. 2004). Low-field MRI reports for otitis media in dogs exist, but in cats detailed information is missing (Allgoewer et al. 2000; Dvir et al. 2000; Kneissl et al. 2004). This paper describes the MRI findings in two cats with otitis media and includes a protocol for feline ear examination using low-field magnetic resonance.

Case description

Case 1. A three-and-a-half-year-old male Domestic Shorthair cat was presented to the Department of Surgery and Radiology at the University of Warmia and Mazury. The cat had a deformation of the right ear pinna and it showed neurological symptoms: head tilt, protrusion of the third eyelids, ataxia. The immune status was unknown. The general examination revealed chronic right otitis externa with large volume discharge and severe swelling and fibrosis of the auditory canal. It was not possible to investigate the tympanic membrane due to the difficulty in accessing it for otoscopic examination (swelling, purulent discharge). Serological tests for FeLV/FIV, toxoplasmosis were not performed. Complete blood count and serum biochemistry indicated non-significant changes. Radiographic imaging of the middle ear did not reveal any significant abnormal features. Neurological abnormalities were a clear indication for magnetic resonance imaging to examine possible intracranial involvement.

Case 2. A nine-year-old male Domestic Shorthair cat had been treated for otitis externa of the left ear using ear drops with miconazolepolymyxin B sulphate, nitrate, prednisolone acetate (Surolan™, Janssen Pharmaceutica N.V., Belgium) for five weeks. An antibiogram was not performed. The cat had presented intermittent periods of remission, during which no discharge was evident in the external auditory canal. The owner had occasionally observed neurological (head tilt) and behavioural (loss of food while eating, shaking its head, decreased appetite) symptoms. On general examination, the cat appeared normal without neurological symptoms. Moreover, the cat demonstrated pain during examination of the oral cavity, especially when it was open. Otoscopic examination showed otitis externa with purulent discharge near the tympanic membrane, and it could not be determined whether the membrane was intact. Serological tests for FeLV/FIV were negative. Complete blood count and serum biochemistry were normal. Radiography of the middle ear revealed no significant pathological changes.

Magnetic resonance protocol. All images were obtained with a low-field magnetic resonance imaging device (Vet-MR Grande, Esaote, 0.25T, Italy). The investigation was performed with a coil for a small animal (a dual-phase array coil) in dorsal recumbency. During examination, the standard protocol was used, which included pre-contrast: T1-weighted spin echo (SE), T2-weighted fast spin echo (FSE) in transverse, sagittal and dorsal planes, fluid-attenuated inversion recovery (FLAIR) sequence in dorsal plane and post-contrast T1-weighted SE sequences in all planes. The parameters used for each of the sequences are given in Table 1. Post-contrast sequences were acquired after intravenous administration of gadolinium contrast agent at a dosage of 0.2 mmol/kg body weight (Omniscan, GE Healthcare, USA).

On the MRI the first cat showed abnormal content in the right middle ear in all sequences. In pre-contrast transverse, dorsal and sagittal T1-weighted images, the lesion had an intensity comparable to brain tissue with subtle hyper-intensity in the middle of the dorsolateral compartment. The space occupied by this abnormal content was sharply demarcated by the bony borders of the middle ear. In post-contrast T1-weighted images, there was a non-uniform enhancement of the lesion, especially in the dorsolateral compartment and on the rim of the ventromedial compartment of the tympanic bulla with a hypo-intense centre. A circumference enhancement of the ventromedial part was most visible in transverse and sagittal planes. Moreover, transverse T1-weighted contrast-enhanced images had slightly increased signal intensity in the membranous labyrinth (Figure 1). In the T2-weighted images, the lesion had a heterogeneously increased signal intensity to brain tissue, but was less intense than cerebrospinal fluid (CSF). In the FLAIR sequence, the pathological lesion was distinctly hyper-intense compared to other tissues with a narrow area of increased signal intensity in the middle of the ventromedial tympanic bulla compartment (Figure 2). These changes were consistent with otitis media in the middle-ear space and were suggestive of otitis interna.

The pre- and post-contrast MRI protocol for the second case was the same as in the first cat, with an

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Table 1. Summary of the parameters of sequences used in clinical studies

	Sequences	Plane	TR (ms)	TE (ms)	TI (ms)	NEX	Matrix	FOV (mm)	Flip angle	Slice thickness (ms)	Time
Cat 1 pre-/post-contrast	T1-weighted SE	transverse	870	18		2	288 × 200	200 × 200	90°	2	5:53
	T1-weighted SE	dorsal	720	18		2	288 × 200	200 × 200	90°	2	4:52
	T1-weighted SE	sagittal	1050	18		2	288 × 200	210 × 210	90°	2	7:04
	T2-weighted FSE	transverse	4870	90		2	352 × 272	220 × 220	90°	3	6:00
	T2-weighted FSE	dorsal	4010	90		2	352 × 352	220 × 220	90°	3	6:32
	T2-weighted FSE	sagittal	6600	12		1	224 × 224	160 × 160	90°	3	5:16
	FLAIR	dorsal	5060	100	1350	1	192 × 138	160 × 120	90°	3	7:25
Cat 2 pre-/post-contrast	T1-weighted SE	transverse	600	18		2	288 × 200	200 × 200	90°	4	4:03
	T1-weighted SE	dorsal	1010	18		2	288 × 200	200 × 200	90°	4	6:30
	T1-weighted SE	sagittal	400	18		2	288 × 200	210 × 210	90°	4	2:44
	T2-weighted FSE	transverse	4290	90		2	352 × 272	220 × 220	90°	4	5:17
	T2-weighted FSE	dorsal	5440	90		2	352 × 272	220 × 220	90°	4	6:45
	T2-weighted FSE	sagittal	6600	12		2	224 × 224	160 × 160	90°	4	10:32
	GE	transverse	645	20		1	256 × 192	200 × 200	75°	4	2:07

FLAIR = fluid-attenuated inversion recovery, FOV = field of view, FSE = fast spin echo, GE = gradient echo, NEX = number of excitations, SE = spin echo, TE = echo time, TI= inversion time, TR = repetition time

additional gradient echo (GE) weighted sequence, but without a FLAIR sequence (Table 1).

In pre-contrast T1 and GE weighted images of the second cat, the lesion, high in water, was heterogeneously isointense to brain tissue with a poorly visible border, especially in the area of the epitympanic recess and dorsolateral compartment. Septum in the tympanic cavity was poorly seen in pre-contrast and post-contrast T1 and GE weighted images, unlike in the T2 weighted image (Figure 2). The material in T2-weighted FSE sequences was markedly hyper-intense to brain tissue and CSF. The contrast

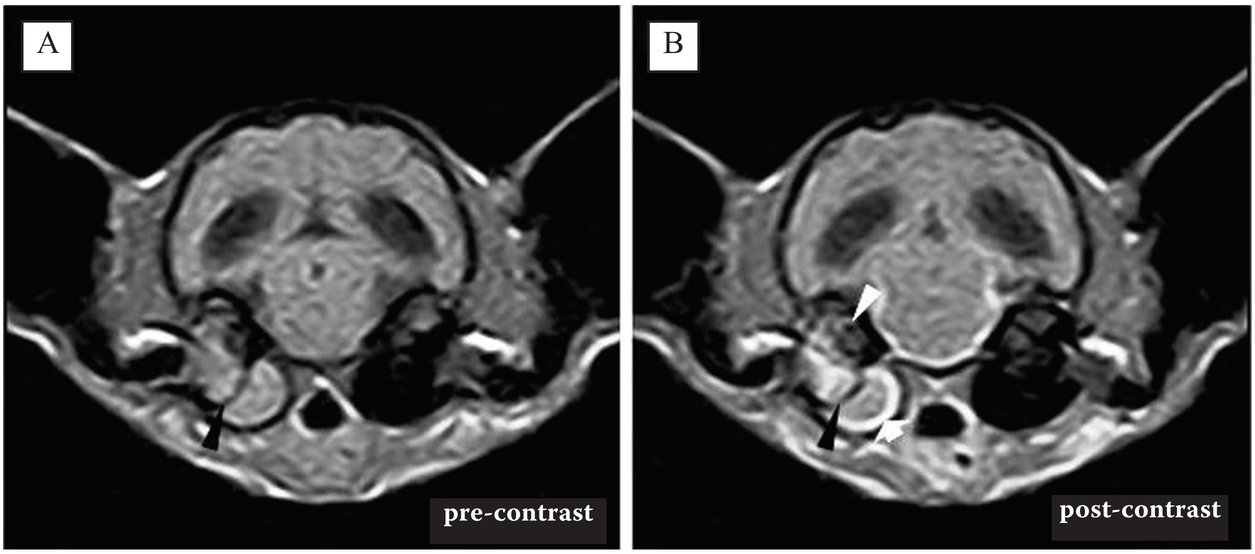

Figure 1. Magnetic resonance imaging at the level of the tympanic bulla. The bony septum dividing the tympanic cavity is well-defined (black arrow head). (**A**) Pre-contrast transverse T1-weighted spin echo image (repetition time (TR) = 870 ms, echo time (TE) = 18 ms). There is a sharply-demarcated mass with intensity comparable to brain tissue and subtle hyper-intensity in the middle of the dorsolateral compartment. (**B**) Post-contrast transverse T1-weighted spin echo image (TR = 870 ms, TE = 18 ms). There is a non-uniform enhancement of mass in the dorsolateral compartment and a rim of increased signal intensity in the ventromedial compartment of the tympanic bulla (white arrow). Moreover, a contrast-enhancement is evident with a slightly increased signal intensity in the area of the membranous labyrinth (white arrow head)

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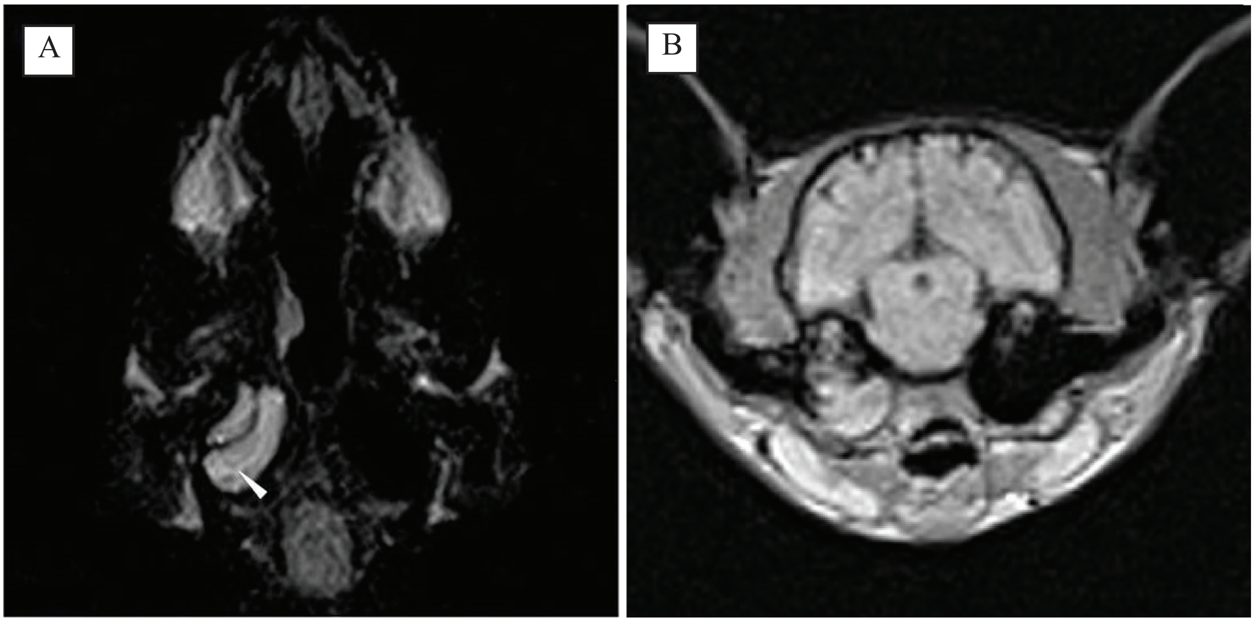

Figure 2. Magnetic resonance of the middle ear. (**A**) Fluid-attenuated inversion recovery sequence in the dorsal plane (repetition time (TR) = 5060 ms, echo time (TE) = 100 ms, inversion time (TI) = 1350 ms). The mass was distinctly hyper-intense compared to other tissues with a narrow area of increased signal intensity in the middle of the ventromedial tympanic bulla compartment. (**B**) The gradient echo sequence in the transverse plane (TR = 645 ms, TE = 20 ms) at the level of the tympanic bulla. There is a mass which is non-homogeneously isointense to brain tissue with a poorly visible border, especially in the area of the epitympanic recess and dorsolateral compartment. Bony septum in the tympanic cavity could not be visualised clearly

enhancement on post-contrast T1-weighted SE sequences was similar to the cat in Case 1. These changes were assessed as a lesion with high water content occupying the middle ear space.

DISCUSSION AND CONCLUSIONS

There is a limited number of reports on the usefulness of MRI in the diagnosis of feline ear diseases (Allgoewer et al. 2000; Mellema et al. 2002; Garosi et al. 2003; Sturges et al. 2006). The otitis of the middle ear is usually problematic for diagnosis (Allgoewer et al. 2000). The peripheral vestibular symptoms are hidden as long as inflammation affects the internal ear (Remedios et al. 1991). Because of the absence of obvious changes, radiography is not helpful in the early diagnosis of middle ear diseases (Allgoewer et al. 2000). Computed tomography is more useful in identification of bony components, whereas MRI allows better identification of soft tissues, nerves, vessels and labyrinthine fluid (Garosi et al. 2003). This paper describes the MRI findings of otitis media in two cats. The conventional MRI protocol of the middle ear should include pre- and post-contrast T1 sequences in the dorsal and transverse planes, the T2 sequence in the dorsal and transverse planes and an additional FLAIR and short tau inversion recovery sequence in the dorsal or transverse planes. The dorsal and transverse planes enable observation of the two sides of the ear, but pathological changes most often affect only one side (Allgoewer et al. 2000). The middle-ear lesion in the first cat in the FLAIR sequence was clearly hyper-intense compared to other tissues with a narrow area of increased signal intensity in the middle of the ventromedial tympanic bulla. In the second cat, this disorder in the GE sequence was heterogeneously isointense to brain tissue with a poorly-visible border, especially in the area of the epitympanic recess and dorsolateral compartment. On T2-weighted images, the pathological lesion had heterogeneously increased signal intensity to the brain tissue, but was less intense than CSF. High water lesions are significantly hyper-intense compared to CSF and are hyper-intense compared to brain tissue on T2-weighted sequences (Tsuchiya et al. 2003). On T1-weighted sequences, empyemas are gently hyper-intense compared to CSF and hypo-intense compared to the cortex (Tsuchiya et al. 2003).

In post-contrast T1-weighted images, there was non-uniform enhancement of the lesion in both pa-

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tients, especially in the dorsolateral compartment and on the rim of the ventromedial compartment of the tympanic bulla with a hypo-intense centre. A circumference enhancement of the ventromedial part was most visible in transverse and sagittal T1-weighted planes (Figure 1). The otitis media is usually characterised by gadolinium enhancement alongside the internal border of the tympanic bulla because of the inherence of vascularised tissues (Allgoewer et al. 2000). The healthy tympanic bulla gives an attenuation signal on all sequences. Free fluid in the middle ear is isointense to the brain on T1-weighted sequences and hyper-intense on T2-weighted sequences (Garosi et al. 2001).

The MRI modality allows the diagnosis of different disorders of the membranous labyrinth. In chronic inner ear inflammation, the fluid which appears in the internal ear suppresses the signal in T2-weighted sequences (Garosi et al. 2001). Labyrinthosis may increase gadolinium enhancement, as a result of inflammation or decrease the haemoperilymphatic obstacle (Vignaud et al. 1995). The first cat with chronic middle ear inflammation on transverse T1-weighted contrast-enhanced images had a slightly increased signal intensity in the membranous labyrinth (Figure 1).

The radiographic modality allows the diagnosis of chronic middle and internal ear disorders, but with low sensitivity (Garosi et al. 2003). CT is more sensitive for middle ear diseases but visualisation of the cerebellum and brainstem is limited by bone artefacts and the technique is not sufficiently sensitive to detect different soft tissue structures (Negrin et al. 2010). MRI allows the differentiation of chronic hematomas, empyemas and middle and internal ear neoplasia (Tsuchiya et al. 2003). Through the MRI modality, it is possible to distinguish between free fluid and solid material (Allgoewer et al. 2000). Final diagnosis of otitis media in cats should be based on an interview, clinical examination, radiography and on MRI analysis.

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