Proceedings of the European Veterinary Conference Voorjaarsdagen

The Hague, the Netherlands

Next Meeting:
April 19-21, 2017
The Hague, The Netherlands

Reprinted in IVIS with the permission of the Conference Organizers
http://www.ivis.org
IMAGING THE SPINE WITH MRI

MRI has revolutionised spinal imaging but it can be challenging both to perform and to interpret, with very variable results. Poor quality scans lead to missed diagnoses, or worse, to misdiagnoses.

The importance of a thorough neurological examination leading to an accurate neurolocalisation cannot be understated. This is because a considerable number of animals have incidental spinal lesions which are not responsible for the clinical signs, especially at the lumbosacral junction. Clinical signs which may be suggestive of spinal disease can be mimicked by brain, peripheral nerve, muscular/neuromuscular, metabolic or orthopaedic disease.

Advantages of MRI over myelography:
- safer for the patient
- less patient manipulation is required
- multiplanar imaging capability – especially the valuable transverse plane
greatly increased soft tissue information, including of extra-spinal tissue
- can scan the brain too if necessary
- absence of ionising radiation.

Disadvantages of MRI compared with myelography:
- anaesthetic equipment constraints due to magnetic field problems if metallic implants and microchips are nearby
- probably more expensive (insurance?)
- spinal survey takes a long time, especially with low field scanners
- hard to know which vertebrae are involved if a small FOV is used (low field)
- cannot devise reliable protocols so scanning must be an interactive process
- stressed views are harder to perform or are more risky
- interpretation can be hard leading to both false positives and negatives.

MRI and myelography are of approximately equal value:
- time taken for the study
- locating lesions with respect to the spinal cord and meninges
- information about bony components.

Spinal MRI technique
There are so many possible combinations of pulse sequence and image plane (not to mention slice thickness and nuances of slice placement) that it is wise not to have too fixed a protocol but to interpret the study as it proceeds and ‘interrogate’ potential lesions appropriately in an interactive manner. The patient should not be recovered from anaesthesia until a reasonably confident diagnosis has been made.

Patient restraint and positioning
If the patient may be in discomfort from spinal or orthopaedic disease use of analgesia and positioning so as not to stress painful areas will reduce the likelihood of movement during the scan. Use positioning aids (sandbags, cradles and bean bags, soft pads, medical tape and Velcro bands) to get the spine as straight as possible. Traction can be used safely for Type II disc lesions in the neck (‘Wobblers’). Flexion and extension can be used for lumbosacral studies.

Choice of radiofrequency (RF) coil
Choose an appropriate RF coil for the patient size and the nature of the study. The type of coil used will vary with the manufacturer. Usually small patients are scanned in human extremity coils and larger dogs on surface spine coils.

Image planes
The dorsal plane is grossly underused in spinal MRI despite the fact that no-one would contemplate a radiographic study without VD views! Dorsal plane images are valuable for (a) identifying the number of vertebrae and ribs in an area and for detecting transitional vertebrae and asymmetrical ribs, knowledge of which is crucial for surgery in the TL area; (b) using as a localiser for accurate placement of sagittal scans; (c) often for diagnosis anyway; and (d) for showing the craniocaudal length of a lateralised lesion.
The sagittal plane is of course usually the main way of identifying the site of a spinal lesion. It may be possible to acquire a large FOV sagittal series initially and then to scan with a smaller FOV in order to get images of higher resolution once a lesion has been localised, but scanning only with a large FOV results in poor images. Once the number of vertebrae in the thoracic and lumbar segments has been verified on dorsal images the vertebrae and disc spaces can be accurately identified on sagittal images relative to fixed landmarks such as C7 and the LSJ. The coeliac and cranial mesenteric arteries usually lie in an area roughly ventral to L1 and once their exact location has been identified they act as landmarks in subsequent scans (as do areas of distinctive spondylosis, if present).

Having identified a lesion on the sagittal and/or dorsal plane, images in the transverse plane are always used to give further 3D information, especially about the degree of any cord compression. Sometimes, cord swelling or compression appears worse on one plane than on another, but a wise rule of thumb is to believe the transverse images since partial volume averaging artefact is likely to be less than in the sagittal images. If a lesion is suspected but is not evident on other planes, it is still a good idea to obtain transverse images through the area of interest (for example, cervical stenosis may be overlooked on the sagittal plane). For disc disease, even when a lesion appears to be clear on in the sagittal plane it is recommended to obtain transverse images through adjacent disc spaces, or even through all disc spaces throughout the area of clinical neurolocalisation (the latter can be done using single slices). Some users prefer to align transverse images parallel to disc spaces (e.g. in the neck) but it seems much more logical to align perpendicular to the vertebral canal as this will give a more accurate representation of the local degree of cord compression or other deformity.

**Pulse sequences (based on high field MRI)**

Three plane localiser – worth examining closely whilst the first definitive sequence is running as it may show an obvious lesion such as a collapsed disc space, vertebral osteolysis or a thoracic or abdominal mass.

T2W – the ‘workhorse’ sequence for the spine with high field scanners, which in many cases is all that is required. Epidural fat, CSF, hydrated discs and areas of cord pathology are hyperintense, giving high contrast with other tissues. Unfortunately T2W scans of the spine are often poorer with low field scanners.

T1W – generally very good image resolution but lower contrast than T2W scans. CSF is hypointense and often cannot be differentiated from the spinal cord. However, epidural fat remains bright and therefore pathology in the epidural space (such as hydrated, extruded disc material) may be more readily seen using this sequence. Comparison of T1W and T2W images permits differentiation of epidural fat and CSF. T1W scans are also excellent for detecting sclerosis and inflammation within vertebrae.

Contrast-enhanced T1W – useful for neoplasia, meningitis and discospondylitis in particular. Other lesions, such as spinal infarcts and low-grade inflammation may not enhance.

Fat suppression can be used with high field scanners, and T1/C with fat sat is excellent for spinal MRI since epidural fat is suppressed and contrast medium in the vertebral venous sinuses gives a myelographic effect. Fat sat is not possible with low field scanners.

Subtraction – a useful technique for areas of subtle contrast enhancement, which is an alternative if fat sat is not possible, although image quality is poor.

2D gradient echo – T2* GE images give image contrast rather like inverted CT, in which bone, calcified disc material and ligaments are of signal void and soft tissues are of low contrast, medium signal intensity. It is especially helpful for disc disease, discospondylitis, haemorrhage and vertebral trauma.

3D gradient echo – in order to improve image resolution and speed up imaging times, low field scanners make much use of 3D sequences using gradient echo, which can be reformatted in other planes. Also useful in high field, to give thin slices of 1.5mm.

STIR (a fat-suppressed T2W technique) – very sensitive for paraspinal soft tissue inflammation, and when used in the dorsal plane and with a fairly large FOV is often successful in pinpointing the source of poorly-localised pain. Also of value in demonstrating medullary bony lesions, since normal bone marrow fat signal is suppressed and areas of pathology are hyperintense.

MR angiography – angiography may be of value for assessment of the venous sinuses. Diffusion tensor imaging DTI – a specialised MR sequence which determines the direction of water molecule motion, which may be potentially useful to evaluate the spinal cord in dogs.
**Image artefacts**

*Motion blur*
Motion artefact resulting in noise and ghosting can be a problem with spinal scans, especially in the cervicothoracic and thoracic areas where there is both cardiac and respiratory motion. This can be minimised by choosing the phase encoding direction so that the artefact (which is always in the PE direction) is directed away from the area of interest. Sat bands may be placed over the thorax or abdomen and these will also reduce motion artefact. Certain coils are more sensitive to the effects of motion (e.g. quadrature >> surface coils).

*Susceptibility artefact*
Many MR scans of the cervical spine and cervicothoracic junction show signal dropout and image distortion resulting from the presence of a microchip, causing susceptibility artefact (although the identity on the chip is not erased by the magnetic field). In small dogs and in cats this may be sufficiently severe to render the study non-diagnostic. In some cases the chip can be pulled away from the area of interest using a temporary stay suture; if this does not succeed then the chip may have to be located and removed. Fragments of ingesta which are metallic and tiny shards of metal left from previous spinal surgery may have a similar effect, even when they are not visible radiographically.

**Image viewing**
Viewing on a workstation which allows cross-referencing between different planes is highly desirable, as is the facility to view scans in the same plane but using different pulse sequences simultaneously and 'locked' together. Zooming and changing the grey scale are similarly important tools.

Viewing hard copy images is greatly inferior, especially if the image size is small or cross references are not shown. However, hard copies are useful to display in the operating theatre if no viewing console is available.

**Principles of interpretation**
A good knowledge of MRI neuroanatomy and the ability to correlate visible abnormalities with clinical signs is necessary.

1. Identify the planes, pulse sequences and slice thickness.
2. List the exact areas of the spine included in vertebral segments. Do the images include the whole area of potential neurolocalisation (e.g. as far cranially as T3)?
3. Identify deviations from normal in the cord, subarachnoid and epidural spaces, intervertebral disc spaces, vertebrae, paraspinal muscles and other areas included in the FOV. Ensure that lesions are visible on all available planes and sequences in order to exclude the possibility of artefact.
4. Consider the lesions in terms of different features e.g. number, location, size, margination, signal intensity.
5. Formulate a list of differential diagnoses.
6. Assess the significance of the lesions in the light of the clinical signs.
7. Plan further diagnostic tests which may be necessary, such as other imaging, lumbar CSF analysis, serology, electrodiagnostics. For some lesions, follow-up MRI may be helpful to assess progression or regression of a lesion.