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Diagnostic imaging of equine neurological disease can be both rewarding and challenging. While very useful for trauma and congenital malformations, conventional radiographic studies lack specificity and sensitivity for one of the more common equine neurological diseases, cervical stenotic myelopathy (CSM). Computed tomography (CT) and magnetic resonance imaging (MRI) are advanced imaging methods that have become standard of care in smaller veterinary patients and in human medicine but their use is limited for equine imaging because of patient size. Nuclear medicine is very sensitive in detecting areas of abnormal bone physiology but is nonspecific and rarely yields a definitive diagnosis. Ultrasound has limited applicability in the diagnosis of equine neurological disease but has been utilized to assist CSF puncture and inject cervical articulations with corticosteroids.

RADIOGRAPHIC INTERPRETATION OF THE SKULL

The complexity of skull anatomy is visually overwhelming, even for specialists. Use of skull symmetry to compare the right to the left side is essential when viewing DV and oblique views. It must be noted that even subtle obliquity of the DV view and small differences in degrees of obliquity between oblique radiographs can yield a visual picture that mimics disease; careful attention to radiographic positioning is essential. The lateral radiograph is best to identify fluid/air interfaces within the sinuses and the oblique and DV views can then be used to differentiate laterality of the fluid.

COMPUTED TOMOGRAPHY OF THE SKULL

CT of the equine skull has proven to be a very useful tool and is complimentary to skull radiography. The cross-sectional nature of CT makes interpretation relatively easy, since there are no interfering overlying structures as when viewing a radiograph. CT typically shows a more extensive nature of radiographically identified lesions, or identifies pathology not seen on radiographs. CT is very useful in assessment of stylotympanohyoid disease and in evaluation of the middle ear. Although relatively rare, CT has been used in the diagnosis of brain abscesses in foals, brain tumors, and nasal tumors that have invaded the cribriform plate. Relatively common incidental findings on CT examination in older horses are choroid plexus cholesteromas and pituitary adenomas. CT examination of seizing horses has been universally unrewarding in this author’s experience.

MAGNETIC RESONANCE IMAGING OF THE SKULL

MRI is vastly superior to CT in differentiation of brain parenchymal pathology and can identify lesions that are not visible on a CT examination. Unfortunately its availability is limited. For suspected bony lesions such as trauma assessment CT is preferred. Undoubtedly, MRI will play a more important role in the diagnosis of equine neurological disease in the future.

RADIOGRAPHY OF THE CERVICAL SPINE

Spinal radiography and myelography are the mainstays of equine cervical spinal imaging as they are universally available and the entire cervical spine can be imaged. While offering greater spatial and contrast resolution, CT and MRI are limited not only in availability, but due to patient size are unable to image the caudal-most cervical spine.

Assessment of cervical spinal radiographs should follow basic radiographic principles of interpretation, including size, shape, margination, position and alignment of the vertebral segments. Recall that bone response to disease is limited to proliferation, lysis, or both. Congenital atlanto-occipital malformation, as seen in Arabian or Arabian-cross foals is a common abnormality
of the occiput and cranial cervical spine. Trauma can produce malalignment of C1-C2, fracture fragments associated with the ligaments of the dens, or dens fractures. The dens of the horse have two sites of ossification, one for the cranial endplate of C2, the other for the dens proper. Prior to osseous union these physis can mimic fractures. Additionally, these growth centers are susceptible to trauma prior to skeletal maturity, so careful attention to alignment is essential when assessing cervical spinal trauma in foals. Fractures and scoliosis of the cervical spine have been reported, and although rare, acute or chronic disc protrusions have been diagnosed by observing a reduction in intervertebral disc space width. Discospondylitis is rarely seen in horses but is diagnosed by vertebral endplate lysis, proliferation, and intervertebral disc space collapse.

One of the most common neurological disorders encountered by the equine practitioner is cervical stenotic myelopathy (CSM; also known as cervical vertebral malformation or CVM). Horses of all ages can be affected, presenting with forelimb and/or hind limb paresis or ataxia. The radiographic manifestations of CSM can be loosely classified into bony vertebral foramen stenosis, vertebral malalignment, and degenerative joint disease of the articular processes.

Mature horses typically present with some degree of articular process degenerative joint disease. Bony proliferation of the articular processes, a result of osteoarthritis from spinal instability and/or osteochondrosis is a very common finding, can be subtle or severe, and involve single or multiple sites. The articular processes become enlarged, sclerotic, and misshapen. The subchondral bone of the articulations becomes sclerotic and the normal smooth linear lucency defined by articular cartilage becomes irregular and narrowed. Bony proliferation of the articular processes infers cervical instability and the potential for bony impingement on the spinal cord.

The cervical spine is assessed for malalignment or subluxation between the vertebral segments ("tipping" of the cranial vertebral body dorsally), resulting in malalignment of the floor of the vertebral foramen. While subtle malalignment is often seen incidentally, marked malalignment in a standing, neutral neck position is usually significant.

In addition to the bony changes described above, congenital or developmental bony stenosis is can be diagnosed as narrowing of the cranial portion of the vertebral foramen relative to the caudal portion vertebral foramen ("funneling"). Abnormal, enlarged caudal vertebral epiphyses can encroach into the vertebral foramen ("endplate flaring"). Caudal extension of the dorsal margin of the vertebral foramen beyond the cranial aspect of the adjacent vertebra is yet another indicator cervical vertebral malformation (see Fig 1).

In 1993, Mayhew, et al reported on the collective use of 6 semi-quantitative radiographic parameters to assess the cervical vertebral malformation in 132 foals. Termed the CVM score, summation of these six parameters yielded a maximum value of 35 points in the most severely affected foals. Values were assigned to vertebral foramen stenosis (10 points maximum), with 5 points maximum to "ski jump" flaring of caudal vertebral endplates, caudal extension of the dorsal arch of the vertebral foramen, angulation between two vertebrae, delayed post-natal ossification of occipital, atlantal, axial, and articular process, and degenerative joint disease. They concluded the CVM score was an accurate procedure for predicting and diagnosing CVM in Thoroughbred foals up to one year of age.

The use of sagittal vertebral foramen ratios to assess bony vertebral foramen stenosis is controversial, yet most practitioners use ratios in an effort to quantitatively assess CSM. The minimum sagittal vertebral foramen height-to-vertebral body height ratio, known as the intravertebral sagittal ratio, was described by Moore, et al in 1994. This value is determined by the height of the cranial portion of the bony vertebral foramen by a line drawn from the dorsal to ventral margins of the vertebral foramen, divided by the maximum height of the cranial portion of the vertebral body. Values in normal horses are generally greater than 0.56. Values of 0.56 to 0.48 are considered marginal and values less than 0.48 are highly suggestive of bony canal stenosis. The intervertebral ratio, described by Hudson, et al in 2005, is made by measuring the distance from the caudodorsal margin of the vertebral foramen of one vertebra to the floor of the cranial vertebral foramen of the adjacent caudal vertebra, divided by the maximum height of the cranial vertebral body. This ratio should be greater than 1.

**MYELOGRAPHY OF THE CERVICAL SPINE**

By default, myelography is the standard for assessment of cervical spinal cord compressive disease in horses. It is a relatively easy technique to perform and the entire cervical spine can be assessed. CT maybe used in conjunction with myelography (CT myelography) but as noted, only the cranial to mid-cervical spine can be reliably imaged in adult horses due to limitations in gantry size. MRI would be the preferred modality in cervical spinal cord assessment but it too is limited by patient size restrictions and is even more limited in availability than CT.
the cervical myelogram is useful in assessment of spinal cord compressive lesions, the sites of which may or may not be suggested by survey radiographs. Several different criteria have been reported to assess extradural compromise of the myelographic contrast column (subarachnoid space). One commonly used criterion for spinal cord compression is that the dorsal subarachnoid space must be reduced in height by at least 50% relative to its greatest height at the level of mid-vertebra, concurrent with some degree of ventral subarachnoid space attenuation. Another criterion is a dorsal subarachnoid space height of less than 2mm. A third report suggests that a 40% reduction in dural diameter, when comparing narrowest to largest dural diameters, is diagnostic for cervical spinal stenosis. A recent report evaluated the accuracy of these methods and concluded that there was poor correlation of myelographic findings with histology except at C6-7, where a 20% reduction in dorsal subarachnoid space height in neutral and flexed positions was highly specific and sensitive for CSM.