DIAGNOSTIC IMAGING OF UPPER RESPIRATORY TRACT DISORDERS: MRI, CT, AND ULTRASOUND
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Key Points
- The information obtained from advanced imaging of the upper airway aids in decision making in cases of upper airway disease.
- Ultrasonography is a valuable part of a complete laryngeal examination and is an inexpensive, non-invasive procedure.
- MRI and CT allow more complete examination of the airway in some situations but nearly always require general anesthesia and additional cost.

Laryngeal and paranasal sinus diseases are common causes of equine upper airway dysfunction. Although initial evaluation of the upper airway is typically performed using resting endoscopy and radiography, these modalities have limitations. Laryngeal ultrasound, magnetic resonance imaging (MRI), and computed tomography (CT) can offer additional diagnostic information in cases of airway disease, both from a structural and functional standpoint.

Ultrasound

Although ultrasonography yields little information about the interior of the paranasal sinuses, it is a very useful technique to image the laryngeal region. Examination of the larynx can be performed using standard ultrasound equipment suitable for musculoskeletal examinations. A 7-10 megahertz linear or microconvex transducer provides good resolution and adequate penetration. Sedation is often necessary, as it facilitates patient cooperation and relaxation to allow extension of the head permitting access to the laryngeal region. The hair can be clipped or soaked with isopropyl alcohol. The larynx is imaged from the lateral, dorsolateral, and ventral aspects. The lateral window allows evaluation of the arytenoid cartilages, thyroid cartilage, cricoid cartilage, cricoarytenoideus lateralis muscle, and vocalis muscle in longitudinal and transverse planes. By shifting the ultrasound transducer to a dorsolateral window, the lateral portion of the cricoarytenoideus dorsalis muscle is imaged. From the ventral window, the basihyoid bone, vocal folds, thyroid cartilage, and cricoid cartilage are imaged.

Ultrasonography is particularly useful in cases of incomplete or absent arytenoid cartilage abduction, as the most common causes of abnormal arytenoid movement have very different ultrasonographic appearances. In horses with recurrent laryngeal neuropathy, hyperechogenicity of the cricoarytenoideus lateralis, cricoarytenoideus dorsalis, and vocalis muscles (as compared to the contralateral side) suggestive of denervation can be appreciated (Figure 1). This technique is particularly useful in horses with Havemeyer grade II or III resting arytenoid movement when dynamic endoscopy is not performed and treatment decisions are not clear-cut.
Figure 1: Dorsal plane ultrasound images of the left (A) and right (B) sides of the larynx of a horse with left recurrent laryngeal neuropathy. Rostral is to the left of the images. The left cricoarytenoideus lateralis and vocalis muscles (arrows) are hyperechogenic as compared to the same muscles on the right side.

Although arytenoid chondritis is often obvious during resting upper airway endoscopy, endoscopy does not permit complete evaluation of the arytenoid cartilages. Ultrasonography allows examination of more of the arytenoid cartilage, including the interior and the lateral aspect. Normal arytenoid cartilages should have a characteristic “trumpet” shape with uniform echogenicity and smooth margins. Chondritic arytenoid cartilages are enlarged with irregular margins and abnormal echogenicity (Figure 2). The diagnosis of arytenoid chondritis is not always obvious during resting endoscopy. Some horses have equivocal arytenoid cartilage thickening endoscopically in the face of dramatic change ultrasonographically, while others have large axial arytenoid masses that ultrasonographically do not involve the body of the arytenoid cartilage and consist only of the mass. The additional information about the arytenoid cartilage gained from ultrasonography can significantly impact treatment decisions (e.g. decision for arytenoidectomy versus resection of a luminal mass). Clinically, ultrasound allows monitoring of the progression of chondritis after medical therapy and resolution of any peri-laryngeal or intra-cartilage abscessation. If horses are affected bilaterally and are candidates for arytenoidectomy, ultrasound can determine which arytenoid cartilage is enlarged to a greater degree, which can be difficult to determine based on endoscopy alone.
Figure 2: Transverse plane image of the larynx at the level of the arytenoid cartilage. Dorsal is to the left of the image. A is a normal arytenoid cartilage (arrows) while B is a chondritic arytenoid cartilage (arrows) with enlargement, irregular margins, and increased echogenicity.

Anatomic malformations of the larynx have the potential to cause a wide spectrum of clinical signs. While laryngeal dysplasia (also known as fourth branchial arch defect or 4-BAD) has classically been thought of as causing right-sided laryngeal hemiplegia and rostral displacement of the palatopharyngeal arch, this condition can also cause left-sided laryngeal hemiplegia or dorsal displacement of the soft palate in the absence of the classic clinical signs. Horses may be affected on either the left or the right sides, symmetrically or asymmetrically. Ultrasonography can demonstrate the characteristic malformations including a lack of cricothyroid articulation, dorsal extension of the thyroid lamina, and varying degrees of pharyngeal muscle abnormalities (Figure 3). Accurate diagnosis of laryngeal dysplasia is key, especially in cases that present with left-sided laryngeal hemiplegia or dorsal displacement of the soft palate as surgical intervention may not lead to predictable results or resolution of the clinical signs due to the abnormal anatomy involved. Prior knowledge of the abnormal anatomy also assists with pre-operative surgical planning.

Figure 3: Dorsal plane ultrasound images of a normal horse (A) and a horse with laryngeal dysplasia (B). Rostral is to the left of the images. The normal horse has a normal cricothyroid articulation (arrow) while the horse with laryngeal dysplasia lacks a cricothyroid articulation and a gap between the thyroid and cricoid cartilages is present (arrow). C: Dorsal plane MRI image of a horse with unilateral laryngeal dysplasia. One cricothyroid articulation is normal (arrow) and the other is absent (arrowhead). Rostral is to the top of the image.

Magnetic Resonance Imaging and Computed Tomography

Magnetic resonance imaging of the upper airway usually requires general anesthesia as the design of standing magnets does not permit positioning of region at or near isocenter for most equine patients. Positioning of the horse in dorsal recumbency is often easier than lateral recumbency, and the length of the neck should be considered when assessing feasibility of positioning an individual horse at isocenter. A body coil may be used, but a surface coil is preferred and will result in superior image quality. Examinations of the sinonasal or laryngeal regions can generally be completed in 60-90 minutes, depending upon the size of the area examined. Images may be acquired in any geometric plane using a variety of sequences.

General anesthesia is usually required for CT examination, but there are designs that will accommodate a standing, sedated horse. Like MRI, the major limiting factor of CT examination
of the equine upper airway is bore size. Unlike MRI, CT examinations have a rapid acquisition time. This is particularly advantageous when surgical intervention is anticipated, as the surgical procedure can often be completed during the same anesthetic episode. Computed tomography has additional advantages over MRI for many types of pathology in the sinonasal region as the spatial resolution is higher than that of MRI, thinner slices can be obtained in a very short acquisition time, and excellent three-dimensional reconstructions can be created. However, the level of soft tissue detail is generally not as great as that afforded by MRI.

Both CT and MRI can provide valuable diagnostic information in cases of paranasal sinus disease, especially if clinical and radiographic examinations do not provide a definitive diagnosis. Abnormalities such as tooth root abscess, oronasal fistula, ethmoid hematoma, masses, congenital defects, and paranasal sinus cyst can be more readily differentiated from one another. The location and extent of fractures can be appreciated to a much greater degree, especially when three-dimensional CT reconstructions are employed.

In the laryngeal region, MRI and CT can provide a more complete assessment of anatomic malformations than can ultrasonography. Both modalities can demonstrate the characteristic malformations of laryngeal dysplasia, including the presence of rotation of the cricoid cartilage to a more complete degree than is possible using ultrasonography. However, the relative costs of ultrasound versus MRI or CT may need to be taken into consideration when formulating a diagnostic plan.

Although many cases of upper airway disease are straightforward to diagnose, others are not. Ultrasound, MRI, and CT add valuable additional information that can substantially augment the diagnostic work-up and subsequent treatment decisions. Incorporation of ultrasonography as a routine procedure and use of MRI or CT when indicated should be considered in cases of upper airway disease.