A Review of Equine Imaging
Nancy E. Love DVM, Dip. ACVR

Originally from Chicago, IL, Dr. Nancy Love has been a board certified radiologist since 1991. She was on faculty at the NC State College of Veterinary Medicine for 13 years, and currently works in an office from her home as a Teleradiologist for Antech Imaging Services. She and her husband, Dr. Robert Sills, and their 2 dog reside in Cary. They are both longtime students of Susie Wiedman and Encore Sporthorse, Love riding her Trakhner gelding, Curtain Call and Sills aboard his Dutch Warmblood, Narolby.

Introduction

Unless your horse has had an injury requiring advanced imaging, you may not realize what diagnostic tools are currently available, and hopefully you will never need to know. The reality is that the technology available for veterinary imaging has become increasingly sophisticated. The advances in imaging are not limited to small animal patients such as dogs and cats, horses are also included in this equation. In the not so recent past, horses had been excluded from some imaging techniques due to their large size and the inability to modify equipment to accommodate them. Although there may be limitations to anatomical regions (body parts) that may be examined, imaging tests that are available to the small animal patient are also available to the equine patient as well. In addition to radiography (sometimes referred to as "x-rays"), diagnostic imaging tests available for horses include: Nuclear Scintigraphy, Computed Tomography (also known as CT or "CAT scans"), Magnetic Resonance Imaging (MRI), and Ultrasound. The purpose of this review is to introduce the horse enthusiast to the various imaging techniques available to equine patients, and to increase awareness of possible indications for their use. All imaging modalities described are currently available from local veterinarians and/or the NC State University Veterinary Teaching Hospital.

Conventional Radiography

What is it? X-rays are electromagnetic radiation which is similar to visible light, but has a much shorter wavelength. The x-rays are produced by the interaction of high speed electrons with matter. The production and collision of the electrons with a target occurs within a vacuum tube inside an x-ray machine. The x-rays produced interact with light sensitive film to produce a radiograph (sometimes called an "x-ray"). The same area is imaged from multiple perspectives (at least perpendicular perspectives) to allow the veterinarian to reconstruct a three - dimensional representation of the area.

Equipment There are essentially two types of x-ray machines that are used in equine medicine: a portable unit and a permanent unit. The portable x-ray

machine is the unit that the veterinarian carries on the truck out to the farm to make radiographs. It is relatively lightweight and less powerful than the permanent unit. Portable x-ray machines are good for making images of the extremities (limbs), more distal joints (fetlock ("ankle"), carpus ["knee"], tarsus [hock]), and selected views of the skull and spine. This is not to imply that these are the ONLY regions of the horse that may be imaged using this piece of the equipment, but that these areas are more easily imaged. A permanent unit is generally located at a large referral practice or University Veterinary Teaching Hospital. It is more powerful than the portable unit and is often moved on a complex tract system. Areas that may be imaged include: the thorax (chest), more proximal joints (stifle, shoulder), pelvis, spine and skull. A cassette with special screens that "glow" (generate light) when exposed to x-rays expose the film contained within to generate an image that is then reviewed on a light box. After film is exposed, it is processed in a darkroom with a x-ray film processor.

Strengths Conventional radiography is still the "workhorse" of equine imaging. This imaging technique is good for the evaluation of bones and thorax, the relationship of structures to each other, and to monitor selected disease processes.

Weaknesses Although conventional radiography may be the first imaging test selected, there is a limit as to the size of an area that can be imaged. Conventional radiography of the adult equine abdomen is often unrewarding as is an extremely swollen limb. Some larger areas such as the pelvis may be imaged, but require general anesthesia to obtain good quality images. The critical evaluation of soft tissue structures such as muscle and tendons may be better served using another modality (such as ultrasound or MRI) rather than radiography. If there is a quality control problem or an unexpected abnormality detected, the veterinarian often has to make a return trip to repeat or add views.

Anesthesia For routine evaluations of the limbs or joints, injectable anesthesia (tranquilization) is generally required. Selected examinations such as the spine prior to myelography (a contrast examination to allow visualization of the spinal cord), or the pelvis require general anesthesia.

Patient preparation Generally no special preparation is required. To prevent obscuring certain bones, the shoe must often be removed prior to radiography of the foot. Play-doh may be placed in the grooves of the frog to prevent potentially confusing gas shadows superimposed with bones of the foot on selected views.

Digital Radiography/Computed Radiography

What is it? Digital and computed radiography are no different than conventional radiography. How the information is processed is how these procedures differ from conventional radiography and each other.

Equipment

The same x-ray machines used for conventional radiography are used to obtain digital and computed radiographs.

Digital radiography – a flat plate detector connected to a computer (typically a lap top in the field) is exposed by the x-rays and an image is generated. The image is generally displayed almost immediately on the computer screen after it is obtained. The veterinarian can determine instantly if the quality of the image is acceptable. No more return trips after films are developed to retake selected views!

Computed radiography – a plate with photostimulable phosphor is located in a cassette. The phosphor is stimulated by x-rays and the image is captured by the plate. The cassette containing the plate is run through a special "reader" and a digital image is generated on an attached computer screen. The physical set-up is almost identical to conventional radiography because an x-ray machine and cassette are used. However conventional radiography generates a piece of film and computed radiography generates a digital image.

Strengths The digital format allows images to be manipulated after they are made rather than requiring repeating the entire study. The digital format makes it easier for veterinarians to share information for consultation. The immediacy of the image means that retakes or additional views can be done at the time of the initial visit.

Weaknesses Digital and computed radiography systems are very expensive. However more local veterinarians are using digital radiography in their practices.

The anesthesia, and patient preparation are the same as described for conventional radiography.

Nuclear Scintigraphy

What is it? Nuclear scintigraphy is the administration of a radiopharmaceutical that is specifically targeted to an organ or region of the body followed by imaging the patient to see the distribution of the radioactivity. A radionuclide is a radioactive substance that is "tagged" or attached to a chemical that will go to specific organs or regions of the body. Following the administration of the radiopharmaceutical, the patient is radioactive sending gamma rays {□-rays}out from the body in all directions. □-rays are the same as x-rays, the name indicates a more specific identification of the source of the radiation production. The radiopharmaceutical has a defined period of activity and the patient does not remain radioactive indefinitely. The most commonly used radiopharmaceutical contains a radioactive component called technetium 99m, this substance remains radioactive for approximately 24 hours. It becomes weaker and weaker losing half of it's activity (strength) every 6 hours until it eventually is no longer radioactive. The most common use of nuclear scintigraphy in equine medicine is evaluation of the bones ("bone scan"). This is often the diagnostic test of choice

in a complex lameness case. However, evaluation of soft tissue injury, navicular disease, and infected teeth are also common examinations. Similar to conventional radiography, images from multiple perspectives are made to allow recreation of a three - dimensional presentation of the region.

Equipment The radioactivity that is emitted by the patient is detected by a gamma camera. The patient is placed next to the camera and the □-rays emitted are detected by the camera. The gamma camera is highly movable and can generally be positioned from the top of the horses' head to below the foot. If there is an increase in radioactivity at a selected area this is termed a "hot spot", if there is a decrease in radioactivity it is called a "cold spot". There are permanent and mobile gamma cameras. There is a mobile unit often called a hand held scintillation probe available for equine patients. It will deliver a numerical reading of the radioactivity, while the more permanent gamma camera produces a picture that is processed and stored in a computer. Most permanent gamma cameras are limited to large referral practices and University Veterinary Teaching Hospitals. The mobile units are not commonly used.

Strengths Nuclear scintigraphy is useful for detecting changes in bone that have not yet progressed enough to be seen using conventional radiography. In addition it can be fairly efficient when attempting to identify multiple areas of injury/disease, can be used to demonstrate/confirm soft tissue injury, identification of an abscess, and is useful in anatomically complex regions such as the skull (identification of affected tooth roots). Nuclear scintigraphy can also be used to evaluate physiological processes such as identification of a "mismatch" between air exchange and blood flow in the lungs.

Weaknesses The anatomical detail of the nuclear scintigraphy image is poor compared to the other imaging modalities. Often nuclear scintigraphy is used as a screening tool to identify/confirm the site of interest and then the patient is re-imaged at that site using another imaging tool (commonly radiography) to better visualize the affected region. Since the patient is radioactive for at least 24 hours following administration of the radiopharmaceutical, the patient must remain hospitalized until no longer radioactive. While the patient is radioactive, handling is limited, therefore additional diagnostic tests are not conducted except on an emergency basis.

Anesthesia Injectable anesthesia (tranquilization) is generally required to insure that the horse does not move during the acquisition of the images.

Patient preparation An intravenous catheter may be placed when the radiopharmaceutical is given via the vein, a hoof covering (easy-boots□) may be placed on the feet to prevent possible contamination by radioactive urine.

Computed Tomography (CT)

What is it? The CT scanner functions on principles similar to the conventional x-ray machine. There is an x-ray tube, but the image is recorded by detectors rather than film, and the image is processed and stored by a computer (digital) prior to printing a film image. The images can then be manipulated to display different levels of contrast as well as different anatomical planes. The horse is placed on the CT table (called a gantry) and the area in question passes through the CT scanner (x-ray tube and detectors) in preselected size increments. The CT scanner generally collects the information in small cross-sectional slices (similar to slicing a loaf of bread), these multiple slices are then collectively evaluated.

Equipment CT units that can accommodate horses are permanent structures generally limited to University Teaching Hospitals (however CT units will probably be available in large referral practices sooner rather than later). CT scanners that are used by equine patients are human units with a modified table that can accommodate the increased weight of a horse. The body part that is to be imaged must fit within the defined round opening of the CT scanner (approx. 25 cm). Due to the size limitations of the CT scanner, an entire adult horse cannot be imaged. Areas of the adult horse that can be imaged include: the skull, cranial to midportion of the cervical spine (neck), forelimb from the foot to the mid-humerus, and the hindlimb from the foot through the tarsus (hock). If a foal is smaller than the opening of the scanner, then there are no limitations of what may be imaged.

Strengths The cross-sectional imaging can decrease the anatomical complexity of certain region such as the skull, or the tarsus. CT is very sensitive to changes in mineralization (bone), this feature combined with decreased anatomical complexity of selected regions can simplify preoperative planning for the surgeon. Some CT scanners have three-dimensional recreation capabilities (usually of bony structures), which can make evaluation and the imaging diagnosis easier and more precise. CT also allows the radiologist to see the relationship of structures to each other, to evaluate the region scanned from different perspectives without repeating the study, and the ability to highlight different structures such as bone versus soft tissue. Since the information is stored on the computer many manipulations and measurements can be performed to optimize the examination without having to repeat the study.

Weaknesses Although CT has many strengths, it also has limitations that must be considered when determining the imaging test of choice. Weaknesses of CT when imaging the horse include: the limited availability of facilities that provide equine CT, the necessity of general anesthesia to perform the examination, and the selected anatomical regions that may be imaged.

Anesthesia General anesthesia is required to perform a CT scan.

Patient preparation The shoe must be removed when examining a limb (leg or joint).

Magnetic Resonance Imaging (MRI)

What is it? No radiation is used to generate the image. Nuclei within the cells of the patient produce magnetic fields. The magnetization of the nuclei can be controlled by placing the patient in a magnetic field, passing selected radiofrequencies through the body and then recording the return of the nuclei back to the resting state. The shifting of the nuclei generates an image that can be collected and stored by a computer (sounds like science fiction - doesn't it?). The horse is placed on a table that is modified to accommodate the increased weight and moves through a defined opening (the magnet). A radiofrequency coil is placed over/around the area of interest prior to introduction into the magnet. The physical imaging "set-up" is very similar to CT however CT does not have a radiofrequency coil. The information is collected in preselcted cross sectional size increments. Different radiofrequencies are used to highlight specific regions of interest. A digital image is captured and stored on a computer.

Equipment MRI units are generally housed at University Veterinary Teaching Hospitals. The MRI units may be permanent or mobile depending upon the institution. It is not uncommon for human or veterinary hospitals to have a temporary unit on site once weekly that is housed within in semi-tractor trailer. The limitation with this arrangement is the ability of the table to accommodate the weight of a horse and a trailer that is large enough for a horse to fit comfortably and safely. Most temporary and permanent MRI units are human equipment that has been modified for equine use. Again, similar to the CT scanner, there is a defined opening that the body part in question must fit through, so scans are limited to the same regions that can be imaged using the CT scanner. There is also a standing MRI unit that can be used on the distal limbs (lower leg/foot).

Strengths The anatomical detail produced by MRI is exceptional. MRI is outstanding for the evaluation of soft tissue structures including: the brain, spinal cord, tendons, bursa and joints (capsule and cartilage), however it is not as good for imaging bony structures. Similar to CT, MRI images can be reconstructed in another plane without having to reimage the horse. In addition, the composition of structures imaged can be determined (MR spectroscopy) which can make the diagnosis more specific than other noninvasive imaging techniques.

Weaknesses The limited availability of facilities that provide equine MRI, the necessity of general anesthesia to perform the examination, bones are not imaged well using MRI, and the limited anatomical regions that may be imaged.

Anesthesia General anesthesia is required to perform a MRI examination. Sedation/tranquilization is required for a standing MRI.

Patient preparation The shoe will have to be removed when examining a limb (leg or joint). Patients with metal implants or metal foreign bodies cannot be imaged.

Ultrasonography

What is it? Ultrasound does not use radioactivity to create an image. High frequency sound waves are produced by passing a pulsed electric field through a piezoelectric crystal that is housed in the ultrasound transducer. When the sound waves interact with tissues they send back a signal that is detected by the transducer. The signal is processed by the computer inside the ultrasound machine, and is used to generate an image.

Equipment Ultrasound machines come in all sizes but all are generally mobile. Some machines are better suited to certain examinations than others including: equine tendons, reproduction, cardiac (heart), and abdomen (belly). The transducers (send and receive sound waves) come in different sizes and can penetrate different depths depending on the frequency of the sound wave produced. High frequency transducers do not penetrate well, but provide good detail, conversely lower frequency transducers may penetrate well but do not provide great detail. The veterinarian will select the transducer best selected to the area in question.

Strengths Soft tissues can be imaged and the structure, organization and "texture" of tissue may be evaluated. Organs may be imaged in "real-time", for example it is possible to see the heart beat and blood flow through vessels. Ultrasound is an imaging modality that is easily accessible to most veterinarians and their clients.

Weaknesses When using ultrasound to evaluate the equine patient, bony structures are not easily seen, a thorough examination may be time consuming, it can be difficult to determine the relationship of organs/structures to each other, anatomical detail is poor compared to other modalities, and the quality of the images is highly user dependent.

Anesthesia The examination is generally performed in an awake patient placed in stocks, or after the administration of intravenous anesthesia (tranquilization).

Patient preparation The area that is to be evaluated must be clipped to remove any hair which may interfere with the transmission of the ultrasound waves.

Conclusions

Sophisticated imaging techniques are currently available for the equine patient. As an informed client, you will have a better understanding of procedures your horse may undergo, but more importantly, you may be able to function in a better partnership with your veterinarian as he/she works to provide the best care for your horse!