Introdução à Tomografia Computadorizada (TC) na Clínica de Pequenos Animais

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A tomografia computadorizada (TC) é uma modalidade de imagem que utiliza raios-x e computadores poderosos para construir imagens transversais do paciente. Pode ser pensado como uma combinação das propriedades transversais do ultrassom com a radiografia convencional. A TC está disponível na medicina humana desde meados da década de 1970 e está rapidamente se tornando uma importante ferramenta de imagem na medicina veterinária. Atualmente, está disponível em muitos hospitais universitários e clínicas veterinárias especializadas em todo o mundo.

Historicamente, a TC tem sido usada principalmente para obter imagens do cérebro. Seu uso agora evoluiu para estudar literalmente todas as regiões do corpo. As aplicações comuns incluem a cavidade nasal, crânio, cérebro, coluna vertebral, tórax e estruturas extratorácicas, órgãos abdominais e sistema músculo-esquelético.

O básico

A capacidade de obter imagens transversais é vantajosa porque permite a avaliação de estruturas internas e anatomia que não podem ser vistas em radiografias convencionais devido à sobreposição. Como os raios X são usados para construir a imagem da TC, os veterinários não familiarizados com a TC podem aprender rapidamente a interpretar as imagens da TC usando os princípios básicos da radiologia. Aprender anatomia transversal é a parte desafiadora, já que a maioria de nós não foi treinada para ver a anatomia como fatias de tecido. Livros-texto especializados em TC e anatomia, juntamente com uma lista crescente de literatura de TC veterinária, tornam essa tarefa menos assustadora.

CT images are acquired by placing the patient within the gantry (opening) of the CT scanner. Some form of restraint, sedation or anesthesia is necessary to prevent patient motion during image acquisition. The body part of interest is initially scanned to produce the "pilot" image (a CT-generated radiograph). From this pilot radiograph, image slices of the region of interest are planned. The thickness of the tissue slice is determined by the operator and varies depending on the part of interest. Generally speaking, the narrower the slice thickness (more properly termed slice collimation), the better the image detail. Thicker samples reduce total image acquisition time, however, by covering a larger area per slice. Often, a large region of interest will be scanned using thick collimation (e.g., 10 mm collimation of the abdomen or thorax); narrower slices can then be obtained for better detail of a smaller specific site of pathology or region of interest. The interval (gaps) between slices (if any) is also determined by the operator. Usually, contiguous images are obtained. It is possible to interleave (overlap) images, resulting in greater image detail during multiplanar reconstruction (e.g., images of the cribriform plate for evaluation of tumor extension) or to simply skip intervals of tissue (e.g., high-resolution pulmonary thoracic CT for diffuse disease).

CT images are obtained by a rotating the x-ray tube head around the patient. The tube makes a complete revolution (360°) to obtain one axial (cross-sectional) image (slice) while the CT table is stationary. It takes about 1 second to complete one full revolution. The CT table then advances the patient the predetermined slice interval and the next acquisition takes place.

Newer **spiral CT** scanners (helical CT) have the ability to move the patient through the gantry at a continuous rate while the x-ray tube head rotates continuously around the patient. Advantages of spiral CT include reduced image acquisition time and the ability to reconstruct higher quality images in body planes other than axial, including 3-dimensional images.

The newest generation CT scanners are called **multidetector** (multislice) scanners. They have the ability to obtain multiple slices in one revolution (e.g., 4, 8, 12, 16, 32, 64 or more axial images per revolution) that drastically reduces image acquisition time and allows reconstruction of images in any anatomic plane (including phenomenal 3-D reconstructions) without loss of image detail. Multidetector scanners have revolutionized CT imaging in human medicine. Cost aside, they hold tremendous promise for veterinary applications because complete scans may be made with in a matter of a few seconds, perhaps using only sedation!

As mentioned, CT uses x-rays to acquire data. Because of powerful computers and very sensitive x-ray detectors, CT has the ability to detect and differentiate tissue densities over a very wide range, in striking contrast to conventional radiographs. Tissue densities, known as CT numbers or Hounsfield Units (HU), are quantified and have a range of approximately +3000 to-1000. Pure water has an HU of 0, pure air-1000 and the densest dense bone +2000 or more (depending on the CT scanner). The operator has the ability to view images using various "windows" which include the **width** of the window and the **level** (centering) of the window. This allows adjustment of the image to maximize detail of a particular area (e.g., lung tissue versus mediastinal structures). Since HU values are quantified linear attenuations of the tissue, once an image is obtained, it can be manipulated by adjusting the windows as well as various reconstruction algorithms from a single acquisition. This is in contrast to MRI, in which each image plane acquisition and each type of imaging sequence must be derived from a new scan, greatly increasing imaging time.

The basic composition of a CT image is the pixel and voxel. Each square in the image matrix (viewing monitor) is called a **pixel**, representing a 2-D image of a tiny elongated block of tissue volume called a **voxel** (3-D). Each pixel/voxel can only display one shade of gray. It is the voxel size that determines spatial resolution (the ability to separate two structures of different density).

After the acquisition of standard CT images, it is often beneficial to rescan the patient following intravenous iodinated contrast administration. This allows visualization of specific anatomic structures, detection of some lesions otherwise not seen and can yield useful information regarding the type of pathology present (e.g., walled off abscess, tissue necrosis, neovascularization of some tumors, etc.).

CT is also used in conjunction with radiation therapy. CT images are analyzed by a treatment-planning computer that provides precise locations for therapy portals. This allows much more precise localization of the radiation therapy beam and higher doses to be safely administered.

Skull and Brain

Most practitioners are frustrated when evaluating skull radiographs due to the complexity of the bony structures and the large degree of overlapping structures. CT is now the imaging modality of choice for evaluation of the skull. It allows precise evaluation of the extent and severity of skull trauma, neoplastic conditions of the nasal cavity and bony structures, and diseases of the tympanic bulla and temporomandibular joints. Not only does CT provide superior anatomic detail, image acquisition time is far less than for skull radiography. For example, a nasal CT series takes only several minutes.

As mentioned, CT has been used for many years in evaluation of the brain. CT is most sensitive in the **detection** of mass lesions such as neoplasms (e.g., pituitary tumors, meningiomas, etc.), abscesses and granulomas, but CT cannot reliably determine the type of histopathology present (nor can MRI). CT is less useful in diffuse parenchymal diseases. MRI is vastly superior for detailed evaluation of brain parenchymal disorders and has become the gold standard for neuroimaging in human and veterinary medicine.

Spine

CT is an excellent imaging modality for evaluation of diseases involving the vertebrae, extradural, and intradural/extramedullary spinal cord lesions. Again, MRI should be considered the standard imaging modality for spinal cord disease. CT is routinely used following myelography to further assess the extent of intervertebral disc disease, mass lesions within the spinal canal, and bony lesions resulting from infectious and neoplastic processes. CT is exquisitely sensitive at detection of iodinated contrast material within the subarachnoid space, even when the contrast has faded on conventional myelography radiographs. Myelography is often used to isolate areas of pathology or suspected pathology and CT is then used to evaluate specific areas of the spine. This is an important practical point, as CT examination of the entire spine requires considerable time, especially since small slice collimation should be used because of relatively small patient size and the need for high detail images. Some clinics will perform spinal CT prior to or instead of myelography but this requires good localization of the lesion from clinical and/or radiographic signs.

Thorax

CT is the gold standard for pulmonary imaging in human medicine and is being used much more frequently in veterinary medicine. CT has the resolving power to allow detection of nodules smaller than can be seen on conventional thoracic radiographs. Pulmonary masses can be precisely located and thus CT can aid in surgical planning. It is possible to differentiate pulmonary from pleural or esophageal origin masses. Lung lobe torsions, often difficult to diagnose on radiographs are amenable to CT diagnosis as the bronchus can easily be seen in an abnormal orientation. CT is very sensitive in evaluation of diffuse lung and airway disease. Evaluation of mediastinal disease is also a hallmark contribution of CT, including cranial mediastinal masses, differentiating esophageal pathology, and assessment of hilar lymph nodes.

Anesthetic considerations are important during CT evaluation of the thorax. Foremost, respiratory movement must be managed. Secondly, the lungs must be properly inflated to prevent atelectasis that may mimic pathology. The patient is anesthetized and maintained in sternal recumbency. The lungs are inflated, maintained at 15-20 cm H_2O by positive pressure ventilation with breath holds of 30 seconds safely maintained. Medium-sized patients can be imaged in 2-3 breath holds. A feline thorax may be scanned in one breath hold when a helical CT scanner is used.

Diagnostic scans maybe made in lightly sedate or non-sedated critical patients, allowing that some slices may be compromised by motion. It is under these conditions that multidetector CT will prove invaluable.

Abdomen

All of the abdominal organs can be evaluated with CT. Although ultrasound has made a huge contribution to abdominal imaging, CT is still a valuable adjunct imaging procedure in many cases. One common indication is determination of the origin of mass lesions, sometimes challenging during an ultrasound examination due to the relatively small field of view ultrasound provides (e.g., spleen vs. hepatic, mesenteric vs. intestinal, etc.). CT may be able to detect metastatic disease not seen during an ultrasound examination, especially when intravenous iodinated contrast material is used. CT has recently been used in assessment of portocaval shunts. Assessment of caudal vena cava invasion/thrombus formation by adrenal gland masses is often used prior to surgery. CT has been used for evaluation of pancreatic disease in dogs and cats. CT is very sensitive in detecting and characterizing ectopic ureters and has recently been used to quantify GFR by use of iodinated contrast and HU assessment of renal parenchyma over time.

Musculoskeletal System

CT provides exquisite bony detail and as such is an excellent modality for assessment of skeletal disorders. Bony lesions are often identified on a CT examination that was simply not detectable on radiographs, even in retrospect. In spinal imaging for example, CT is capable of diagnosing early discospondylitis well before radiographic signs are present. The extent of bony neoplasms is better assessed with CT than conventional radiographs and can play a role in treatment planning. The canine elbow has been studied with CT and has been shown to be the most sensitive image modality for assessment of canine elbow dysplasia. The canine shoulder, carpus, stifle, and tarsus have all been studied using CT. Clinical applications include suspected osteochondral (OC) lesions, erosive arthritis, soft tissue neoplasms of joints, lesions of bicipital tendon, etc.

CT is useful in evaluation of soft tissue masses of the extremities. The extent of the mass can be assessed and at times the CT appearance of the mass is characteristic of specific diseases. Examples include lipomas, which have HU values less than the surrounding muscles, and liposarcomas that have a wispy appearance and HU values intermediate between lipomas and soft tissues masses.

While CT is an excellent imaging modality of the musculoskeletal system, it should be noted that MRI is better yet at evaluating soft tissues including joints, menisci, cruciate and collateral ligaments, and articular cartilage.

Speaker Information
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