Proceeding of the SEVC
Southern European Veterinary Conference

Oct. 17-19, 2008 – Barcelona, Spain

http://www.sevc.info

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Other Companion Animals
Use of CT Scan as an Advanced Diagnostic Imaging Technique

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Diagnostic imaging is one critical component of complete evaluation of the exotic mammal patient. Conventional analogic radiography is certainly the most common, even if the requirement for excellent to optimal quality in small patients can sometimes make it challenging. Endoscopy is a diagnostic imaging technique performed with increasing frequency in exotic mammals. Ultrasonography provides another interesting tool for preoperative evaluation of the mammal patient. Like digital radiology, Computed Tomography (CT) is an advanced radiographic technique within the reach of the exotic mammal practitioner.

COMPUTED TOMOGRAPHY (CT)
Computed tomography (CT) is a radiologic technique which allows acquisition of multiple, parallel cross sectional image slices of the tissues of the patient. The name: “tomography” comes from the greek “tomoś” = to cut, and: “gramma” = letter (in other words, image).

Multiple x-ray exposures are made as an x-ray tube within a gantry rotates around the patient as it moves along the gantry on a couch. The final image is generated by a computer. The concept of “slice” imaging originated from the need to overcome superimposition of imaging that is intrinsic to conventional radiography. Actually, the main, critical difference between CT and traditional radiography is that in the latter, the images of all tissues in the area of interest are superimposed over a single plane.

Also, computed tomography allows virtual reconstructions of the images, making them dynamic and more helpful for the clinical evaluation. Computed tomography was developed in the early 1970s, and the first scanner was used to imaging the human head in 1972. Second, third and fourth generation whole body scanners were developed in late 70s and 80s, modestly improving scan speed and image resolution. In 1987, the first continuously rotating scanner or spiral scanner was produced. This dramatically reduced scan time because image data could be continuously acquired compared to the start-stop motion of single slice scanners. Newer CT scans produce images via the standardized, internationally recognized DICOM format. This can be visualized with basic software, allowing a greater number of visual options.

BASIC OPERATION OF A CT SCANNER
There are two basic differences between conventional radiographs and CT scanning:

- With CT, the x-ray beam traverses a very small volume or "slice" of tissue (generally 1-5 mm., and even less than 1 mm with new spiral scanners) as it moves through an arc of 360 degrees. With conventional radiography, all superimposed tissues are exposed to the x-ray beam.

- With CT, an array of electronic x-ray detectors records the multiple exposures resulting from the interaction between the x-ray beam and the capability of tissues to attenuate incident x-rays. The x-rays exiting the tissues excite the detectors, producing an electrical signal; a computer processes, digitizes and stores the electrical signal. With conventional radiography, a
photosensitive film is impressed by radiation.

CT does not just turn the acquired data to axial images. Data can be reformatted by the computer and displayed also in axial, coronal and lateral planes. This capability is called multiplanar reformation (MPR) and has been made possible by the advent of spiral CT. However, this dynamic, two-dimensional interactive rendering is not the only visual tool provided by spiral CT. Dedicated imaging software programs working with DICOM format allow various reconstruction techniques, including volume rendering (VR) techniques, and shaded surface displays (SSD). So-called volume rendering format (MIP - maximum/minimum intensity projection) can show the entire image volume with certain CT numbers suppressed, in order to emphasize certain anatomical structures. For example, only a map of the pulmonary vasculature can be displayed, with the remainder of the lung suppressed. Even if there is the perception of depth and 3-D effect, the actual image is two-dimensional.

Shaded surface displays present a contoured surface map of the entire image volume. The volume can be rotated on the monitor to allow the observer to visualize any surface. Shaded surface displays have overall limited usefulness because deep structures are masked, but they are very helpful for evaluating abnormalities of the bones. Reformations are very helpful and provide the interpreter a different perspective, but axial slices must always be interpreted before any type volume rendering is performed on the image data.

APPLICATION OF CT FOR EXOTIC COMPANION MAMMALS

The use of spiral CT for exotic mammals is a new discipline, and few references are available. Most recent improvements in CT scans include reduction of scan time, and improved image resolution, factors that make such scans feasible and useful even for small exotic patients. Imaging exotic patients is a challenge mostly because of their small size. The consequence of smaller patient size is production of a smaller image containing a smaller number of pixels which is lower-resolution by default. Because spiral scanners allow very thin slices (even less than 1 mm; but 1 or 2 mm slices are usually enough) and larger image matrices (512 x 512 pixels), resolution is superior to that obtained with most older single slice scanners. Good resolution CT images can be magnified 1.5 to 2.0 times with computer software, allowing better detection of subtle anatomic changes. Despite the fact that the resolution of analog or digital conventional radiology is superior, viewing slices of the patient in sagittal and coronal planes as well as the standard axial plane offers tremendous advantages. Contrast resolution, e.g., the ability to see various soft tissues is also superior with spiral CT scanners. By adjusting image contrast (window level and width) to the anatomic structure of interest, i.e., soft tissue, bone, lung, etc., the problem of low soft to hard tissue ratio in small mammals can be reduced. Even with size limitations, however, very good images can be obtained with the latest generation of CT machines.

Positioning and scanning

As for conventional radiographs, proper positioning for CT is critical. Therefore, deep sedation or anesthesia are essential. Also, pharmacologic restraint reduces breathing artifact, especially in smaller mammals with higher respiratory rate, despite the fact that the scanning time is brief. The patient is commonly positioned in ventral recumbency, with the head elevated slightly and kept horizontal if the head has to be scanned. The endotracheal tube will not create a superimposition as in conventional radiographs because the scanning will be axial. Nevertheless, the connection with the anesthetic circuit can hamper perfect symmetric positioning of the head. Even though the scanning time is short, simple inhalant induction of anesthesia is not an effective option as the mask can not be held in place during scanning, increasing the chance the patient will revive and move. The author prefers an injectable protocol to allow adequate time for positioning, scanning and verification of the CT images.

Before scanning, a scout view is collected in both dorsoventral and lateral projection. Scout projections are standard x-ray images that are used to ensure accurate positioning of the patient for CT scanning. The dorsoventral projection is useful for evaluating bilateral symmetry and the lateral projection is
useful for the selection of the angle of the scan plane. A provisional transverse scan through the tympanic bullae can also be made to check for proper position of the head if desired. The thickness of the slices is selected, as well as the extent of the scan.

**Practical applications**

Preliminary studies focus on the anatomy of the normal and pathologic skull and teeth of rabbits, guinea pigs, and chinchillas. Diagnosis, prognosis and treatment of dental disease and related complications in rabbit and selected rodent species are greatly enhanced with the use of CT.

Radiographs help evaluate structures not visible during the physical exam and inspection of the oral cavity. However, standard radiography has a number of limitations, including inability to demonstrate the real extent of areas of bone loss and osteomyelitis, as it is difficult to impossible to isolate single portions of the skull without superimposition of other bony and soft tissue structures. Computed tomography of the head is an outstanding diagnostic tool that overcomes some of the limitations of standard radiology. The advent of newer CT scanners and the availability of user-friendly post capture image manipulation software makes this modality extremely useful and a practical adjunct to standard radiology.

Standard scanning plane angles have been established for some canine breeds, but there are no standards for exotic animals. Scanning plane angles for the skull images of the rabbit, guinea pig and chinchilla performed by the author are perpendicular to the palatine bone. However, further studies may suggest additional advantageous angles, in particular for the study of the mandible and cheek teeth. Note that this particular scanning angle in these species produces slices that are not parallel to the axis of cheek teeth, therefore each slice, depending on thickness, may intersect more than one tooth.

Other practical applications are for the study of intracavitary masses, for example, thymoma in rabbits. Further studies are needed to establish normal CT anatomy, with and without the use of contrast medium.

**Interpretation of CT Data**

Software for manipulation of DICOM images to volume and surface reconstruction formats readily available. OsiriX is an online freeware currently available to Macintosh users. These products require practice, but are user-friendly and allow veterinarians to readily review CT images from a computer show even demonstrate them to owners.

Traditional axial CT images are challenging to interpret, and require skill and practice. Radiologists agree that axial views and supplemental sagittal, coronal and oblique views are the most critical and sensitive for diagnosis. However, supplemental information comes from 3-D renderings, converting CT data of selected body parts into an image very similar to an image of an anatomical specimen, well within the range of interpretation of a trained clinician. Surface rendering displays are remarkable in their ability to highlight bone abnormalities in patients with dental disease, thus allowing effective planning of the surgical approach. While these displays must not relied upon as the sole modality, they are extremely valuable as an adjunct to traditional radiography.

**References:**