IMAGING TECHNIQUES FOR THE DIAGNOSIS OF SPINAL DISORDERS IN DOGS AND CATS - A BRIEF INTRODUCTION

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Diagnosis of spinal diseases and their treatment in companion animals have reached enviable limits in western countries. It is unfortunate that in our country most of these conditions still end up causing a lot of pain to the owner and embarrassment to the attending veterinarian.

It is true that we often have to work in circumstances which are highly unfavourable for our professional enhancement compared to our western counterparts. But, we cannot ignore the fact that ours is a fast growing economy and the days that we will see owners demanding treatment for their pets in par with that in western countries is not very far. In fact, the trend is already on in many Indian cities where owners are willing to spend many more times the monetary value of their pets for their health care. Small animal practitioners would already be aware of the effects of 'Animal Planet' and the internet on the awareness among their clients about diseases and their treatment options in their pets. We cannot ignore for too long the expectations our clients place on us with respect to accurate diagnosis and rational treatment of perplexing diseases, of which spinal disorders rank high.

It is unfortunate that most of us are forced by circumstances to limit our diagnostic repertoire to methods of physical examination alone. All attempts should be made to rope in other available diagnostic facilities, so that our diagnostic skills are sharpened and our therapeutic approaches become more rational. It is highly commendable that many veterinarians in our state already make use of human "X-ray labs" to perform radiography on their patients. Some diagnostic labs in other parts of India are willing to offer service of their CT and MRI facilities for animal patients, of course on payment of a premium. This article attempts to discuss in brief the different imaging techniques that would help us to arrive at a definitive diagnosis in diseases of the spinal cord.

1. RADIOGRAPHY

Even after about 110 years since their discovery X-rays play an inevitable role in the diagnosis of spinal disorders. Radiography is still considered the most convenient and economically viable diagnostic aid for spinal patients. In many spinal disorders good quality survey radiographs may help us to arrive at a definitive diagnosis. But, it has to be borne in mind that spinal radiography can be successful only if the fundamental rules of radiography are adhered to. Perfect positioning of the patients and quality radiographs are musts for accurate diagnosis. However, plain radiographs may severely underestimate spinal lesions because of superimposition of overlying structures, insufficient contrast resolution and silhouetting by adjacent tissues of similar density (Jones, 2004).

(i) Survey radiographs

General anaesthesia or heavy sedation helps ideal positioning of the patients. The radiographic projections have to be taken with the animal in perfect lateral or ventro-dorsal position. Sand bags and other positioning aids like belts and ropes help in consistent positioning and minimize exposure to attending personnel.

In lateral projection, ideal radiographs are obtained with the dorsal and ventral midlines equidistant from the X ray film cassette. The axial skeleton has to be extended and the X-ray beam centered over the suspected region of the lesion. The vertebral column has to be straightened and should preferably made to be in a horizontal plane parallel to the cassette by placing soft radiolucent foam pads under the head, neck and lumbar spine. The sagital plane should also be parallel to the film. This can be achieved by keeping the upper legs parallel to the top of the table.

In ventro-dorsal projection, the patient has to be positioned over the cassette on dorsal recumbency with the vertebral column straight and the sagital plane vertical and in line with the central ray. The central X-ray beam should be centered over the suspected region of the lesion. The hind legs should not be over extended. Ideally the femurs should be kept vertical and slightly abducted.

The transition of the anatomical features of the vertebral column is gradual. For evaluation vertebrae and their intervertebral spaces can be considered in units of three as adjacent vertebrae and their respective intervertebral spaces are similar enough to allow comparison to evaluate for deviation from normal. Narrowing and opacification of the intervertebral disc spaces, opacification of the region of the intervertebral foramina or any abrupt deviation or unnatural curve of the line formed by the ventral surfaces of the vertebral bodies or the dorsal spinous processes should be noted. The major conditions that can be diagnosed from plain radiographs are intervertebral disc diseases, fractures and dislocations of the vertebral column, spondyloses, tumours involving the vertebrae etc.

(ii) Myelography

Myelography is a contrast radiographic technique where positive contrast agents are injected into the subarachnoid space and the vertebral column subjected to radiography. It must be performed where survey radiographs fails to indicate the site of lesion. It is very useful to indicate the degree of spinal cord compression.

The contrast agents used for myelography should be non-toxic to the central nervous system, water soluble (miscible with the cerebrospinal fluid), radio-opaque while remaining iso-osmolal, easily and rapidly eliminated from the subarachnoid space and reasonably affordable (Widmer, 1989). Iohexol, iopamidol and metrizamide are contrast agents that fulfil these requirements. Of these, iohexol is considered the best with the least toxic effects to the CNS and untoward incidents being reported with its use (Wheeler and Davies, 1985; Widmer *et al.*, 1992).

The recommended dose of iohexol (preparation containing 240-300 mg of iodine/ml can be used) is 0.25 to 0.5 ml/kg body weight (Wheeler and Sharp, 1994). However, only a maximum of 10 ml per animal can be used in dogs (Sande, 1992).

PROCEDURE FOR MYELOGRAPHY

The most common site used for administration of the contrast agent is the cisterna magna or the cerebello medullary cistern. The skin over the occipital region and the atlas has to be surgically prepared and the dog or cat has to be restrained on lateral recumbency under general anaesthesia. The use of diazepam as a premedicant is recommended because of its anticonvulsant property. Phenothiazine derivatives (like triflupromazine hydrochloride) are not recommended as they reduce the seizure threshold of the central nervous system (Sande, 1992).

The head is turned to an angle of 90^0 from the vertebral column with the nose parallel to the table top. The lateral margins of the wings of the atlas and the external occipital protruberance are palpated. An imaginary line is drawn between the lateral margins of the wings of the atlas and another imaginary line is drawn perpendicular to this line from the external occipital protruberance. The site of puncture is located midway on this perpendicular line. Exactly behind the external occipital protruberance there is a depression in the muscles. If the needle is inserted at this point it will strike the bone. The actual site of puncture is caudal to this.

A 20 or 22G spinal needle (ordinary hypodermic needles can also be used) is advanced perpendicular to the skin and subcutaneous tissue. On further advancement the ligamentum flavum is penetrated and the needle enters the subarachnoid space. If the location is right, cerebrospinal fluid (CSF) starts flowing immediately. The presence of blood in the CSF warrants the removal of the needle and attempting again. An equal quantity of the CSF as the amount of contrast agent required to be injected is removed. The contrast agent is injected slowly with the bevel of the needle facing backwards, with the head of the animal raised. The body has to be kept at an angle of 15 to 20^0 with the head up so that the contrast agent flows caudally. Serial radiographs can be taken depending on the flow of the contrast agent in the subarachnoid space as visualized on the radiographs. In a normal animal the posterior most limit of the subarachnoid space at the lumbosacral joint will be reached in about 10 minutes, if the body is kept suitably tilted. In cases of spinal cord compression, depending on the severity, the column of the contrast agent may stop or get narrowed at the site of lesion.

The procedure, though very useful for diagnostic purpose, cannot be regarded as 100 per cent safe and should be performed with utmost care. Occasionally an animal may suffer from seizures following myelography (Lewis and Hosgood, 1992; Barone *et al.*, 2002). If not performed carefully spinal cord injury and subsequent neurological damage may result from penetration of the spinal cord by the needle.

Myelography may also be performed at the lumbar site. This is usually done at the L_4-L_5 intervertebral space. With the animal on lateral recumbency, after surgical preparation of the skin over the intervertebral space caudal to the one selected for puncture (i.e., L_5-L_6), the needle is advanced until it touches the dorsal spinous process of L_5. Then it is directed along the lateral surface of the spinous process at approximately 45^0 to the top line of the patient. The needle is advanced until it penetrates the ligamentum flavum at the dorsal intervertebral foramen. The bevel of the needle should face cranially or caudally depending on which direction the contrast agent is required to flow (i.e., depending on the suspected site of the lesion). The pressure of out flow as well as the quantity of CSF that can be collected from this site is less than that possible from the cisterna magna.

Normal myelograms may have an elevation and thinning of the contrast column where it passes over the intervertebral discs. But, here the dorsal columns will be wide indicating no spinal cord compression. Leakage of the contrast agent into the epidural space may also produce confusing myelograms. Here two lines of the contrast agent, one is the subarachnoid space and one in the epidural space, can be seen.

Failure of opacification by the contrast agent at a particular level may indicate a diffuse swelling or a space occupying mass that may be compressing the spinal cord at that level. Extradural lesions show the contrast agent moving away from the bone margin and tapering towards the spinal cord (eg., intervertebral disc disease). Intradural extramedullary lesions can be seen as a filling defect with the column of contrast agent tapering towards the spinal cord as well as towards the bony margin of the osseous spinal canal (golf tee appearance). Intramedullary lesions (i.e., those within the spinal cord) like tumours present a myelographic picture where the column of the contrast agent move away from the spinal cord and tapers towards the bony margin.

(iii) Epidurography

Epidurography is performed by injecting a positive contrast agent into the epidural space. Some radiologists consider this as the preferred method for evaluating the lumbosacral region (Feeney and Wise, 1981; Selcer et al., 1988).

(iv) Discography

Here a positive contrast agent is injected into the nucleus pulposus of the intervertebral disc. Usually only a small amount (0.1 to 0.2 ml in a lumbosacral disc) can be introduced. If there is damage to the annulus fibrosus, as in the case of intervertebral disc disease, more of the agent can be injected and its leakage can be visualized in subsequent radiographs. Discography is also useful for diagnosing lumbosacral lesions (Sisson et al., 1992).

2. COMPUTED TOMOGRAPHY (CT)

Computed tomography is a digital imaging modality which uses X-rays and computer processing to produce 'slices' or cross sectional images (along the desired planes) of the structures under study. Here the patient is anaesthetized and placed on a motorized table which then advances the patient through a gantry. A gantry is a ring shaped structure that houses the X-ray tube. The X-ray tube rotates around the patient in the gantry emitting X-rays while detectors on the opposite side of the patient absorb the transmitted X-ray and convert them into electrical signals. These signals are then processed in a computer, unwanted information eliminated and slices of the structures created, which are displayed on a monitor.

The most common spinal disorders that can be studied by CT are intervertebral disc disease, spinal stenosis and spinal masses. Even though CT is less sensitive than Magnetic Resonance Imaging (MRI) for detection of soft tissue abnormalities, it is more sensitive than MRI for detecting soft tissue calcification, cortical bone spurs and degenerative changes in the articular process joints.

Enhancement of the contrast of CT images can be done by performing CT myelography (Wheeler and Sharp, 1994). The quantity of contrast agent (iohexol is the agent of choice) required is reduced to about one quarter of what is required for conventional myelography. If CT is performed following conventional radiography a delay of one to two hours may be allowed to reduce the concentration of the contrast agent by natural dilution and absorption.

A thorough knowledge of the cross sectional anatomy of the soft and hard tissues of the part under study is a must for arriving at an accurate diagnosis from CT images.

3. MAGNETIC RESONANCE IMAGING (MRI)

Magnetic Resonance Imaging uses a strong magnetic field and pulses of high frequency radio waves and interaction of these with hydrogen atoms in the patient's tissue for creating images of the part being studied. The patient is positioned on a motorized table, as in CT, in a gantry in which a strong magnetic field is created. The hydrogen atoms in the patient's body get aligned themselves with the magnetic field. When the tissues are exposed to brief pulses of radiofrequency energy, the hydrogen atoms are knocked temporarily out of alignment. As the hydrogen atoms realign themselves in the magnetic field, they release a weak energy signal. A receiver coil placed near the part under study detects these energy signals, which are then transferred to the MRI computer which converts them into images of varying shades of gray.

Magnetic Resonance Imaging has the greatest potential in visualizing soft tissues. It is said to be most useful for the diagnosis of lumbosacral disease and in detecting parenchymal cord lesions.

4. SCINTIGRAPHY

Scintigraphy can be used to evaluate the functional status of the bone near the spinal cord, i.e., the vertebrae. In this technique a gamma ray limiting radio isotope coupled with a pharmaceutical that concentrates or localizes in specific tissues is injected intravenously. The most commonly used radio isotope is Technetium 99m, which has a short half life period in the body. The pharmaceuticals utilized for scintigraphy of bones are pyrophosphate and methylene diphosphate (Tayal, 1994). A gamma camera detects the gamma rays emitted by the localized radioisotope and converts them into electrical signals. These electrical signals are processed in a computer, converted into an image which indicates the functional status of the part being studied and displayed on a screen. The image is composed of many dots. The areas of high radioactivity are seen as 'hot spots' and those of less activity are seen as 'cold spots'.

Scintigraphy is very useful for the diagnosis of discospondylitis and vertebral tumours (Lamb, 1987).

5. ULTRASONOGRAPHY

This is an imaging technique that uses high frequency sound waves to visualize internal structures of the body. The ultrasonic waves produced by piezo electric crystals are transmitted from a transducer kept in close contact with the surface of the body. The sound waves reflected from the different tissues inside the body are received by the same transducer and converted into electrical signals. These signals are converted into images and displayed on a monitor screen.

The presence of bone and air prevent the visualization of structures underlying them ultrasonographically. But, defects or natural openings on bony structures can be utilized as windows for the visualization of soft structures lying underneath. Spinal cord can be visualized through laminectomy defects, intervertebral foramina, noncalcified intervertebral discs or defects in spina bifida (Cartee et al., 1993; Hudson et al., 1998). The most useful application of ultrasonography for the diagnosis of spinal disorders is in cases of suspected retention of disc fragments, myelomalacia, intraparenchymal neoplasia and dural or spinal cysts. The imaging modalities available for diagnosis of spinal disorders are many. Unfortunately, circumstances prevent them from being utilized optimally as far as veterinary practice in India is considered. Let us hope that in the days to come most of these techniques become less costly and more easily accessible for use in animals. Diagnostic laboratories fully dedicated to animal patients would go a long way to sharpen our diagnostic skills and consequently help us improve the quality of service we can offer to reduce the suffering of our patients. ❑