Diagnosing disease in reptiles can be a challenge for even the most experienced veterinarian. The clinical signs exhibited by these ectotherms are often subtle and physical findings are seldom pathognomonic. Diagnostic imaging should be part of the clinical evaluation of sick reptiles. Radiology is a common diagnostic tool used in reptile practice and can be instrumental in the identification of disease.

ANATOMICAL CONSIDERATIONS

There are several anatomical differences that make it difficult to obtain quality radiographs of good contrast and detail. The relatively small size of most pet reptiles, coupled with the lack of diffuse body fat often produces images of poor contrast. The presence of thick, highly keratinized scales, osteoderms or shells can severely hinder the x-ray beam, necessitating greater power and a subsequent loss of soft tissue detail.

RADIOGRAPHIC EQUIPMENT

Despite the aforementioned difficulties, most high-capacity radiography units can be set to produce radiographs of diagnostic quality. High-detailed screen-film combinations (e.g. mammography film) are essential to obtain sufficient detail and contrast, especially in smaller animals.

Various agents can be used to improve contrast. Barium sulphate (30%) can be used for gastrointestinal studies, although the authors prefer water soluble iodine compounds such as iohexol for urogenital, vascular, neurologic, and some gastro-intestinal studies. It should not be forgotten that the simple injection of air into the coelom of a lizard can greatly improve the appreciation of pre-ovulatory follicles and other masses.

SNAKES

Restraint & Positioning. Snakes can be difficult to position and restrain for radiographic examinations unless anesthetized. If the purpose of the examination is simply to rule out radiodense foreign bodies, the snake may be allowed to coil in its natural position while the radiograph is taken. If detailed examination of the skeletal, respiratory and digestive system is desired, the snake must be extended. A plastic restraint tube can be utilized for this purpose; however, this often produces some radiographic artifact. In larger snakes, several films will be needed to radiograph the entire length of the body. It is important to properly label each exposure in order to keep track of all the different views. Lateral views are best taken using horizontal beams to avoid displacement artifact of viscera. However, standard laterals with the snake taped in lateral recumbency can be useful especially where horizontal beams are not possible or safe to undertake. The interpretation of dorsoventral views are hindered by the spine and ribs but, in addition to skeletal evaluations, can still be useful when dealing with obvious lesions including eggs, and mineralized masses (Figure 1).

Figure 1. (A) Anesthetized python positioned for lateral, horizontal beam, radiography. (B) Lateral radiograph of a ball python demonstrating multiple soft-tissue opacities within the lung field due to bacterial pneumonia.
**Musculoskeletal System.** Traumatic fractures, metabolic bone diseases, spondylitis/spondylosis, osteomyelitis, and congenital abnormalities are common indications for examining the skeletal system of snakes. Fractured ribs with periosteal bone formation are a common finding in snakes. Another common finding is exuberant vertebral periosteal bone formation and osteomyelitis. On radiographs, this appears as several "fused" vertebrae.

**Digestive System.** Common indications for radiographically evaluating the digestive system include hypertrophic gastritis, foreign body ingestion/impaction, constipation, hepatomegaly and hepatic masses. Contrast studies are useful in diagnosing intestinal obstruction and constipation. In addition, contrast material in the gastrointestinal tract can often outline and help determine the origin of a non-specific intracoelomic mass(es); intraluminal or extraluminal.

**Cardiopulmonary System.** Cardiomyopathy has been reported in snakes, which can be indicated by cardiomegaly on radiographs. Metastatic mineralization of large blood vessels is often apparent around the heart due to the negative contrast afforded by the adjacent lung(s).

The superimposition of other organs such as liver and stomach over the lung fields can make the radiographic interpretation of respiratory disease challenging. Common indications for evaluating the respiratory system are rhinitis, suspected neoplastic and infectious disorders of the trachea and lung, as well as abscesses or granulomas.

**Urogenital System.** The kidneys are not always radiographically evident, unless enlarged or mineralized. Disease processes that can cause renomegaly include renal gout and neoplasia.

Eggs of oviparous species are leathery and poorly calcified, but can often be appreciated on plain radiographs. In viviparous species fetal skeletons become visible as they mineralize late in gestation. The hemipenes of some species may appear mineralized and can be detected radiographically. Common indications for evaluating the reproductive system include dystocia, apparent infertility and reduced fecundity.

**Miscellaneous.** The presence of any swelling is an indication for radiography. Abscesses, which can be extracoelomic or intracoelomic, associated with a specific organ or the coelomic wall, are common findings in snakes.

**LIZARDS**

**Restraint & Positioning.** Small lizards can often be restrained by taping them to the radiography film or table for a dorsoventral view. Placing cotton or gauze over the eyes, and wrapping them with self adhesive tape (VetWrap, 3M Products) will often produce a calm, motionless lizard. Placing a mirror in front of a lizard may distract the animal long enough to take a radiograph. A dorsoventral view can be helpful to identify foreign bodies, intestinal impaction, or coelomic masses. A horizontal x-ray beam provides the preferred view for evaluating the respiratory system. Elevating the body of the lizard on rolled towels or foam pads helps to prevent superimposition of the limbs with the coelomic cavity. The positioning for, and interpretation of, crocodilian radiographs are similar to those employed for lizards.

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**Figure 2.** (A) Positioning of a conscious green iguana for lateral, horizontal beam, radiography – note the use of self-adhesive bandaging to maintain the limbs away from the coelom, and to reduce sensory stimulation. (B) Lateral, horizontal beam, radiograph of a water dragon illustrating the trachea (t), heart (h), lung (Lu), liver (Li), stomach (s), intestines (i), fat bodies (f), and kidneys (k).
Skeletal System. Radiography is useful for the identification of skeletal abnormalities in lizards such as metabolic bone diseases, osteomyelitis, gout, fractures and septic arthritis. Of all the metabolic bone diseases, nutritional secondary hyperparathyroidism is most common. Radiographically, this condition can be manifested as generalized lack of density of all bones, cortical bone thinning and/or pathologic fractures. In addition, fibrous osteodystrophy may manifest as soft tissue swellings of the limbs, in conjunction with lack of cortical bone density of the long bones and spine. Other common radiographic signs of bone disease can include folding or incomplete fractures, chronic luxation of toes and ribs, hypertrophic osteopathy, scoliosis, kyphosis, and/or vertebral fusion. Osteomyelitis tends to be more proliferative than lytic. Bone lysis may be present in cases of bone abscessation.

Digestive System. The anatomy of the different species of lizards must be taken into account when interpreting radiographs of the digestive tract. For example, Green iguanas (Iguana iguana) and Chuckwallas (Saurodalmus obesus) are primarily herbivorous, hind-gut fermenters, and as such, a large, gas-filled, distended sacculated colon can be expected on radiographs. Common indications for evaluating the digestive system of lizards include foreign body ingestion, intestinal impaction, hepatopathy and enteritis. Foreign bodies are common in lizards, especially if housed on substrate they can easily consume. Enteritis is often marked by gas distension of the intestines and/or gastrointestinal ileus. Contrast radiography is helpful in identifying foreign bodies that are not radiopaque. Transit time for contrast media can take days to weeks, depending on the amount of contrast administered, the species of lizard, environmental temperature, and activity of the lizard. An enlarged liver will often displace the intestines and lungs dorsally, or present as a large soft tissue structure obstructing the visualization of the other organs in the mid to caudal coelom.

Respiratory System. Most lizards have sponge-like lungs. However, in some species, the lungs are more sac-like and thus, no reticulations are visible on radiographs. Pneumonia is not uncommon in lizards and can be distinguished by an increased soft tissue opacity of the lungs or distinct fluid lines.

Cardiovascular System. The heart cannot always be fully appreciated as the thoracic girdle and forelimbs may be superimposed over the cardiac silhouette. The descending aorta can be best visualized on a horizontal lateral view coursing from the caudodorsal aspect of the cardiac shadow through the cranial coelom. Given the low incidence of reported cardiac disease in lizards, there is little information on the standards for cardiac size and shape.

Urogenital System. The kidneys of iguanid lizards are mainly located within the pelvic cavity. However, when enlarged they protrude into the caudal coelom. In some lizards like the monitors (Varanus sp.), the gender can be determined by visualizing the calcified hemipenes. One of the primary reasons for radiographing lizards is to evaluate the reproductive system. Dystocia, egg binding and other related reproductive disorders are commonly identified. Lizard eggs may be calcified or leathery. Several round soft tissue objects of approximately equal size with very thin mineralised walls may represent a normal gravid female. If the lizard is depressed, the eggs are over or under mineralised, too large or of irregular size, disease should be suspected.

Miscellaneous. Radiography should be part of the standard investigation for the presence of any soft tissue swelling. Abscesses are common in lizards. It is important to evaluate an abscess radiographically prior to surgical resection to determine the presence of osteomyelitis frequently associated with abscesses, as well as the potential involvement of other major structures.

CHELONIANS

Restraint & Positioning. Fortunately, most chelonia are fairly easy to position and restrain. For vertical beam dorsoventral radiographs, most conscious individuals will remain motionless long enough to permit exposure. Ideally, the head and limbs should be extended from the shell in order to reduce superimposition of the limb musculature on the coelomic viscera. More active animals can be restrained by taping them to the cassette or by placing them in a radiolucent container although this may cause an artifact on films. For lateral horizontal beam radiographs, the chelonian is placed on a central plastron stand. By lifting the animal clear of the ground, the limbs and head will be encouraged to extend but the tortoise will remain immobile. Both left and right lateral projections should be taken with the lateral edge of the shell touching (or as close as possible to) the cassette. The third basic coelomic view is the horizontal craniocaudal (or anterior-posterior) view. Again the chelonian is positioned on a central plastron stand, with the caudal edge of the carapace touching (or as close as possible to) the cassette, with the head facing the x-ray tube and the beam centered on the midline of the cranial rim of the carapace. Radiology of the head and limbs will require their exteriorization from the shell and this will usually require general anesthesia. The use of sandbags, foam and tape will aid positioning. Standard interpretation requires that both true lateral and dorsoventral views be taken – even slight rotation makes interpretation difficult (Figure 3).

Musculoskeletal System. The common musculoskeletal problems that can be detected on radiographs include metabolic bone diseases (often nutritional secondary hyperparathyroidism), shell and limb fractures, dislocations, joint disease and osteomyelitis. Nutritional metabolic bone disease (nutritional secondary hyperparathyroidism) produces characteristic radiographic lesions including; reduced bone density, cortical thinning, and shell (and less commonly limb) thickening as a result of fibrous proliferation. The opacity of the pelvic and pectoral girdles often provides the best assessment of ossification and mineral status. Conversely, soft tissue
mineralization, mineralized gout tophi, or pseudogout may be observed as areas of increased opacity in the periosteal or periarticular areas, or within any visceral tissue. The diagnosis of limb fractures is usually straightforward. Fractures of the shell are more common and may be obvious or subtle and difficult to appreciate on radiographs unless displaced or appropriately sky-lined. The situation is further complicated by the lack of periosteal new bone growth and obvious callus formation, such that a radiolucent line may persist for years in an asymptomatic individual with acquired fibrous fracture stabilization. Following diagnosis and any fracture repair, follow up radiographs should be taken at 10 and 20 weeks to assess the repair, although remodeling is likely to take 12-18 months or more.

Rarely, traumatic joint dislocations can occur as a result of mishandling or predation. Dislocations of the stifle and elbow are easily appreciated but coxofemoral and scapulohumeral dislocations may be more difficult to detect without lateral, dorsoventral and craniocaudal views. Any joint surgery should also be followed up after 6 weeks, 4 months, and 1 year for evidence of degenerative joint disease and arthritis. Chelonia are amongst the longest lived of animals and age related orthopedic disease, namely degenerative joint diseases, are becoming increasingly common. Other causes of degenerative joint disease include articular gout, pseudogout and trauma. Evidence of bone lysis at the articular surfaces and joint swelling are most noticeable. Osteomyelitis is a common presentation in reptiles and tends to be lytic (caseous abscessation) and/or proliferative. There is often gross enlargement and distortion of the local anatomy with loss of corticomedullary definition.

Digestive System. The radiographic appearance of the alimentary tract will depend upon the temperature, nutritional status of the animal, nature of the ingesta, and the period of time elapsed between feeding and radiographic examination. The gastro-intestinal tract of chelonians is shorter than that of mammals but the transit time is also slower. For an overview, a dorsoventral radiograph is most helpful, however the ancillary digestive organs, namely, pancreas and liver are not usually discernible.

Radiodense objects, typically stones or gravel, are often encountered and may be considered significant only if concurrent with clinical signs. Metallic objects are less commonly seen but lead intoxication has been reported. Gastrointestinal ileus due to improper husbandry and diet is common.

The use of gastrointestinal contrast studies can help to differentiate between intestinal and extra-intestinal diseases. These techniques can also help to distinguish between intraluminal (e.g. radiolucent foreign bodies), intestinal (e.g. abscessation, neoplasia) and extraluminal diseases, and aid in the diagnosis of gastrointestinal perforation.
Cardiopulmonary System. The heart is located in the cranial third of the coelomic cavity, resting above the plastron, but is often not radiographically discernible. Radiographic assessment of the lung fields in cases of suspected pulmonary disease is very valuable and effective as, despite the shell, the air provides excellent contrast. The horizontal beam lateral and craniocaudal views are most informative, although severe consolidation can be appreciated on a dorsoventral image.

Lung consolidation due to fibrosis, neoplasia, inflammation or infection is observed as an increase in lung opacity and may be focal or diffuse, unilateral or bilateral. It is important to account for the position of the limbs as the lung volume will be greatly reduced by the head and limbs being withdrawn into the shell. Likewise, the best lung radiographs will be obtained with the head and limbs extended, although this often necessitates sedation or general anesthesia. It is important to realize that increases in lung density are reported as just that, increased soft tissue density. It is impossible to attribute a diagnosis of bacterial pneumonia, pulmonary fibrosis, or neoplasia based solely upon a radiograph.

Urogenital System. The ovaries and oviducts are not radiographically visible but follicular stasis may be inferred from a persistent, mid-coelomic, soft tissue presence. Ovarian necrosis and yolk coelomitis will result in a profound coelomitis but the resultant loss of soft tissue detail can be challenging to identify. The chelonian egg possesses a calcified shell, which is readily identifiable on plain dorsosacional radiographs. Normal eggs are characterized by radiolucent centers and thin, radio-opaque, calcified shells of even thickness. Fractured eggs adopt a folded appearance with loss of the smooth external margins. Eggs that are not laid may remain within the shell glands for prolonged periods of time resulting in thick, but usually even shells. Eggs can also pass into the bladder, where urate deposits accumulate on the surface of cystic eggs to produce an uneven appearance.

The bladder is difficult to evaluate radiographically. In addition, the presence of normal urates are no help as these too are generally radiolucent. However, in cases of cystic calculi, concrete urate accumulations become mineralized and denser, which improves visibility. The kidneys are located in the dorsocaudal aspect of the coelom and are difficult, if not impossible, to identify on plain radiographs. Nephrocalcinosis can delineate the renal parenchyma but, for a better assessment of both the kidneys and the ureters, intravenous urography is required.

References