IMAGING THE POSSIBILITIES

Neil A. Forbes, BVetMed, FRCVS, Diplomate ECAMS,
Great Western Exotics
Swindon, Wilts, UK

RADIOGRAPHY IN BIRDS
Radiography is a noninvasive, safe, and informative diagnostic tool to be used alongside other diagnostic information. A specific diagnosis is rarely made with one element of information alone. Radiographic appearance of ascites, gastrointestinal tract (GIT) obstruction, and cardiomegaly, for example, in birds resembles that of mammals. Radiology (at least two views at right angles, preferably with two different exposure levels) should be performed on all sick patients. Sick birds are often suffering from concurrent diseases; without a comprehensive workup, some diagnoses are likely to be missed. A parrot presented off color and weak with polyuria/polydipsia and discolored cloacal excrement with an abnormal fecal gram stain, might be considered to have a bacterial GIT infection, while a radiograph might reveal heavy metal toxicity.

GETTING THE MOST OUT OF YOUR RADIOGRAPHS
All birds to be radiographed should be anesthetized. Consistent positioning is vital; a restraint device may be useful. High detail (mammography) film (ie, a slow speed film with small crystal size and hence high detail), together with appropriate single screen is essential. A short exposure time (<1/60 sec), light beam diaphragm with a minimized focal area, and a standard focal film distance of 1.05 m should be applied. Avian body radiographs have good natural contrast, so KV should be higher and mAs lower. However, using low exposure, minor inaccuracies become significant. If you increase KV by 10, you must halve the mAs. If your contrast is too great (very black and white), increase your KV and decrease your mAs. If your image is too ‘gray’ (eg, in an ascites case, where the air sacs are lost), then reduce your KV and increase your mAs. As our patients are generally less than 9 cm deep, grids (to reduce scatter) are generally contraindicated, as the benefit achieved is outweighed by the loss of definition created by the grid.

Processing Faults
• Overdevelopment – Film too dark, contrast low
  o Developer too hot
  o Developer too concentrated
  o Developer time too long
• Underdevelopment – Film pale, especially the background
  o Developer too cold
  o Developer exhausted or weak
  o Insufficient time (commonest manual processing fault)

Automatic Processor Faults
• Roller marks, scratches
• Underdevelopment – not warming up
• Overdevelopment – malfunction
• Incorrect chemical concentrations
• Poor dying
• Lost films

Optimizing Results
• Reduce scatter – grids, collimation, lead
• Faster film – screen combinations (although this may cause a loss of resolution, due to larger crystal size)
• Reduce movement blur (use adequate restraint/GA)
• Use of ‘Exposure Charts’ (utilising the lowest KV, the highest MA and the shortest exposure time possible)

While radiographic texts are useful, a file of normal radiographic anatomy should be maintained. When dealing with >9000 species, even the most experienced clinician will not be familiar with the finer points of all species. With the advent of digital photography and email veterinary special interest groups and referral centres, it is now possible to seek a second opinion and seek assistance in interpretation without any delay in interpretation.

POSITIONING
Ventrodorsal (VD) View
The bird is placed in dorsal recumbency, with the keel directed 90 degrees from the cassette. The wings should be extended bilaterally 90 degrees from the body and the legs extended caudally. If wings and legs are each abducted equally, then there is every chance that the radiograph will be level. Position the carina (keel) of the sternum is over lying the spinal vertebrae.

Lateral View
The bird is placed in right lateral recumbency, with superimposition of the acetabula. The wings are both extended dorsally and maintained in place with sand bags or tape. The legs are retracted caudally, with the dependant (lower, ie, right) limb slightly cranial to the non-dependent limb. If positioned correctly, the acetabula, ribs, coracoid, and kidneys are all superimposed contralaterally.
INTERPRETING AVIAN RADIOGRAPHS

Skull
The cranium is fused. There are numerous interconnecting sinuses, the largest of which is the infra-orbital sinus, which is rostro-ventral to the eyes. The upper beak forms a synovial joint with the frontal bone via the articular and quadrate bones. The scleral ossicles form a boney ring, which is visible radiographically (shape shows major inter species variations).

Spine
The avian spine shows major variation from mammals. It may be divided into cervical (parrots 12, swans 25), notarium (fused thoracic, lumbar 1-3), free lumbar (lumbar 4) and synsacrum (fused caudal lumbar and pelvic), plus pygostyle (free caudal). The region of the one free lumbar (typically lumbar 4) vertebræ, is a natural hinging point and the most common area to suffer bruising (which can subsequently lead to an anaerobic environment which may facilitate anaerobic abscess formation), trauma, or spondylisis. So, in conclusion, only the neck, L4 and the tail (pygostyle) are susceptible to damage.

Thoracic Vertebrae
Birds have eight (in parrots) complete ribs.

Thoracic Girdle
The thoracic girdle consists of the clavicle (which fuse bilaterally to form the furcula - wish bone), the coracoid, and the scapula. These three bones form the triosseum, onto which the proximal humerus articulates. The tendon of the supracoracoideus passes through the triosseal canal (created at the pyramidal junction of the three bones). The sternum meets to form the carina (or keel) in the ventral midline. On the wing, the humerus articulates with the ulna and radius. The secondary feathers of the wing insert on the caudal periosteum of the ulna. The ulna and radius articulate with ulna and radius carpal bones at the carpus, which lead to the carpo-metacarpus. The manus has three digits (I - the alula, II - the major metacarpal, III - the minor metacarpal).

Pelvic Girdle
The pelvic girdle consists of the fused ilium and ischium and the unfused pubis.

Heart
The avian heart should be seen lying between the 2nd and 6th thoracic ribs. In psittacines the heart base is best measured at the level of the 5th thoracic vertebrae, should not exceed 50% of the width of the thoracic cavity. On the lateral view the heart length should not (in psittacines), exceed 47% of the length of the sternum. On the VD view the heart - liver silhouette should resemble an 'hour glass' or figure of 8, shape. Macaws have a relatively smaller liver than other psittacines. The liver (coeliomic) outline should lie on or medial to a vertical line ( on VD view) from the scapula to the acetabula. If the coeliomic silhouette is greater this is indicative of 'organomegaly' within the coeliomic cavity (liver, gonad, oviduct, adrenal gland, ascites, etc.).

Atherosclerosis may be apparent by the presence of mineralization in the great vessels cranial to the heart. If not hepatomegally is indicated.

Digestive System Radiography
The crop lies to the right of the midline on the VD view, cranial to the thoracic inlet. The proventriculus is left of the crop on the VD, and dorsal to the liver on the lateral view. The ventriculus often contains grit and is situated caudo-ventral to the proventriculus (except in ostriches in which it is anterior). The intestines occupy the dorso-caudal portion of the abdominal cavity. If the bird is positioned symmetrically and the liver shadow does not appear symmetrical, then a further extension on the left side is indicative for a proventricular dilation. Dilation of any part of the GIT is abnormal (unless the bird is a raptor and the dilation is due to the...
presence of a 'casting,' ie, undigested fibrous matter prior to producing a pellet).

**Dilation of the proventriculus** indicates physical or functional gut dysfunction, (proventricular dilation syndrome [PDS], heavy metal poisoning, any form of infection (bacterial, viral, fungal) of the ventriculus or proventriculus or any form of GIT blockage or obstruction, eg, heavy nematode burdens, foreign bodies, torsions, strictures, or neoplasia.

**Kidney**

The kidney is seen most readily on the lateral view. The cranial lobe of the kidney is apparent below the lumbar spine, just cranial to the acetabulum. The other two lobes of the kidneys are placed sequentially caudal to this one. Just cranial and ventral to the cranial lobe of the lies the gonads. Gonad swelling may be confused with renomegally. Dehydration cause deposition of radio-opaque urates in the kidneys, which can be confused with renal calculi or renal mineralization consequent to hypervitaminosis D. If this is suspected the patient should be given copious fluid therapy and re-radiographed the following day.

**Spleen**

The spleen may on occasion be seen on the lateral view as a spherical object, cranial to the femur, at mid abdominal cavity height, just above the level of the proventriculus. The spleen should not be larger than 1.5x the diameter of the femur. When the spleen is visible, it is typically an indication of splenomegally, the commonest cause being chronic antigenic stimulation, most commonly psitticosis.

Loss of abdominal space will be seen as a loss of the hourglass shape on the VD, and may be seen as a loss of the radiolucent space between the proventriculus and the kidney. Such a finding is synonymous with any abdominal space-occupying lesion, which may be physiological (eg, prior to egg laying with distended oviduct and ovarian follicles), or pathological (eg, egg bound, organomegaly, egg peritonitis, neoplasia). Any space-occupying lesion will expand at the expense of the air sacs.

In any such case GIT barium contrast, will delineate the position of the GIT, in relation to other organs. If plain radiographs show organomegally of unknown cause (while the patient is still anesthetized), a male dog urinary catheter should be measured and marked for appropriate distance (at which the proventriculus should be reached). The catheter is passed per os, via esophagus, crop, distal esophagus to the proventriculus. 6 mL/kg of barium is expressed into the proventriculus, continuing as one gradually removes the catheter. This technique will highlight proventriculus, distal esophagus and crop, with no risk of aspiration, as would be anticipated if the barium where only placed into the crop.

**HIGH-DEFINITION DIGITAL RADIOGRAPHY (HDDR)**

This technique represents a major enhancement in imaging capability, which has been proven to achieve increased diagnostic abilities in both human and veterinary fields. In this system, image creation (generation of an x-ray beam), is identical to conventional radiography, but the creation of the image, and the manner in which this digital image can be manipulated, so as to maximize the diagnostic possibilities varies greatly. In HDDR, film is replaced with x-ray sensitive optical sensors, containing several million pixels. The photo electric converter (pixel), converts the reaction to an electrical impulse which is instantly digitalised. Pixel size will vary with equipment, but is likely to be approximately 100 microns in diameter, which compares with 200 to 400 microns with the highest quality CT scanner. The HDDR system uses a scintillator in place of intensifying screens. The greatest benefit of digital radiology is the opportunity to manipulate the image after initial processing, creating an ability to compensate for exposure errors, or simply to alter the exposure, to enable the detection of different anatomic structures with variable radio density. While a traditional screen/film system only permits a 20-fold change in x-ray exposure (from nothing to totally black), a digital system will permit a 10,000-fold change in exposure, with the ability to manipulate any one image, to see the effect of any exposure within that range, there by allowing one exposure to ‘see all’.

**FLUOROSCOPY**

Fluoroscopy is a valuable additional diagnostic tool that enables real-time radiography to be visualized on a screen. This technique is particularly valuable for assessing GIT motility (in suspect PDS cases), and also for assessing respiratory function in dyspneic birds that one does not wish to anesthetize.

**ULTRASOUND**

Ultrasound (US) is limited in birds (compared with mammals), due to the inability to penetrate air or bone. The most available access point is immediately caudal to the sternum. A scanner probe with a small foot print and high (10–14) MHz is most valuable. Despite these limitations US can be most useful diagnostic tool for noninvasive investigation of heart, liver, gastrointestinal tract, and urogenital system. The information gained by ultrasound, in contrast to radiography, is greatly superior, as indications of texture, consistency, dynamic movements, and functionality can be derived as opposed to simply the size and shape.

**MICRO PET/CT SCAN, COMPUTED TOMOGRAPHY (CT) AND SPIRAL CT**

These techniques are all now of increasing value in referral practices. They are of great value but time constraints prevent inclusion in this talk.

**REFERENCES AND FURTHER READING**

