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The Use of Helical Computed Tomography in the Cockatiel

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Computed tomography is a non-invasive diagnostic tool which is becoming more common and increasingly available in veterinary practice. Currently, the literature on the use of computed tomography in avian practice has been primarily focused on medium to large sized birds (Krautwald-Junghanns et al., 1993; Rosenthal et al., 1995; Silverman and Tell, 2010) with few reports about the use of computed tomography in small sized birds such as the cockatiel. The purpose of this paper is to discuss the usefulness, advantages and limitations of helical computed tomography as a diagnostic imaging tool for the cockatiel (*Nymphicus hollandicus*).

Computed tomography

Computed tomography is an imaging modality that utilizes x-rays to produce high detail cross-sectional images. Once acquired, cross-sections can be reformatted to view anatomy in any plane, optimized for soft tissue or fine bone viewing, and reconstructed into a three-dimensional model.

CT offers superior diagnostic imaging compared to conventional radiography as it overcomes the superimposition of overlying structures, and has increased contrast resolution (D'Anjou, 2012).

Modern CT machines, known as helical scanners, allow for continuous x-ray tube rotation and data acquisition as the patient is moved smoothly through the gantry (scanning unit). Helical CT systems are available in single slice, dual slice and multi-slice units depending on how many images are acquired per rotation of the gantry (Saunders and Ohlerth, 2011).

When used for small sized birds such as the cockatiel, a multi-slice helical CT system is preferred as it has rapid acquisition times, less step-like and motion artifact, and improved spatial resolution (Saunders and Ohlerth, 2011; D'Anjou, 2012).

Imaging procedure for the cockatiel

The cockatiel is anaesthetized for the procedure, placed symmetrically in dorsal or ventral recumbency and perpendicular to the gantry. If intravenous contrast is required, intravenous access of the right jugular vein should be obtained at the start of the procedure to avoid re-positioning the patient between pre-contrast and post-contrast scans. Intravenous contrast can be used to highlight soft tissue structures (Van Zeeland et al., 2015).

Skull and upper respiratory tract

Compared to conventional radiography, helical CT is able to provide superior detail of the skull and upper respiratory tract where there is significant superimposition of boney and pneumatic areas (Mackey et al., 2008; Van Zeeland et al., 2015). Major skull bones and finer structures such as the zygomatic arch, nasal septum and hyoid apparatus are able to be identified (Figure 1-6). The quadrate bone is not able to be well appreciated most likely due to limited spatial resolution. Helical CT is able to assess the shape, size and margins of the eyes but the lens are unable to be appreciated. The scleral ossicles are able to be clearly identified with maximum intensity projections (Figure 8). CT has been successfully used in a cockatiel to identify and assess the extent of an intraocular neoplasm before surgical removal (Dineli Bras et al., 2005).

Assessing the extent of disease in the infraorbital sinus can be difficult as endoscopic access is limited and conventional radiography is difficult to interpret due to superimposition (Antinoff et al., 1996). Helical CT is able to demonstrate the choana and major components of the infraorbital sinus except for the mandibular diverticulum, postorbital diverticulum and the connecting cervicocephalic air sac (Figures 1-6). The absence of superimposition and superior contrast resolution allows for assessment of changes in sinus air space volume and bony destruction

(Krautwald-Junghanns et al., 1998; Van Zeeland et al., 2015). Helical CT has been used successfully to highlight the extent of infraorbital sinus involvement in a two year old cockatiel with a history of chronic sinusitis of an undetermined aetiology (Figure 7).

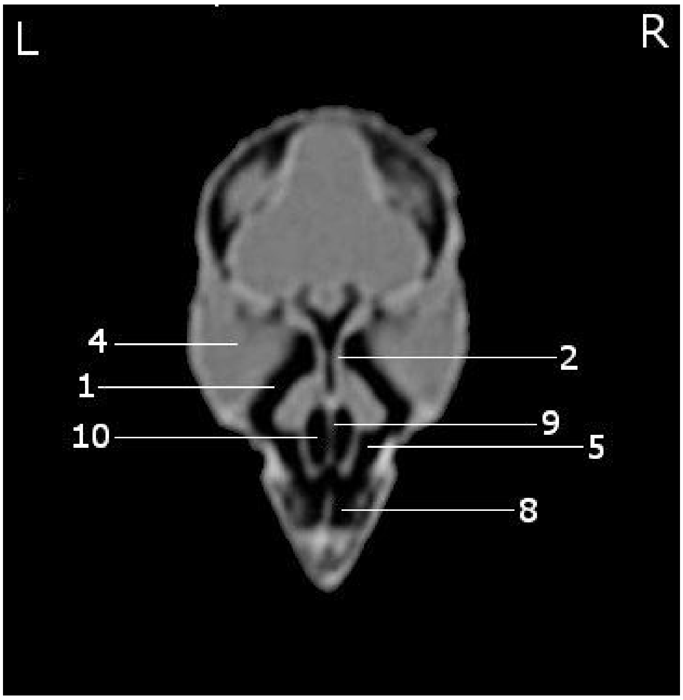

Figure 1. Dorsal CT image of the head of a cockatiel, bone window (WL = 500; WW = 3000). (L) left, (R) right.

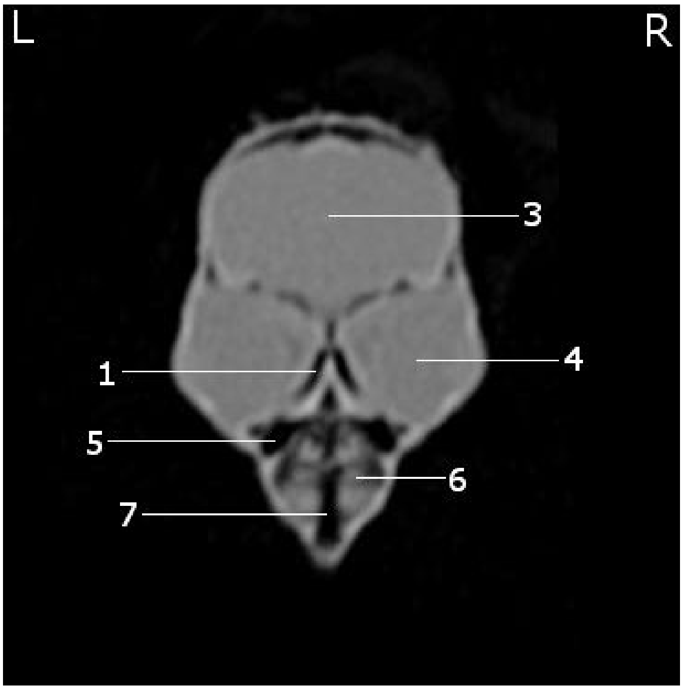

Figure 2. Dorsal CT image of the head of a cockatiel, bone window (WL = 500; WW = 3000). (L) left, (R) right.

Figures 1-2. (1) infraorbital diverticulum of the infraorbital sinus; (2) interorbital septum; (3) cerebrum; (4) eye; (5) preorbital diverticulum of the infraorbital sinus; (6) premaxillary bone; (7) rostral diverticulum of the infraorbital sinus; (8) maxillary chamber of the infraorbital sinus; (9) nasal septum; (10) nasal cavity

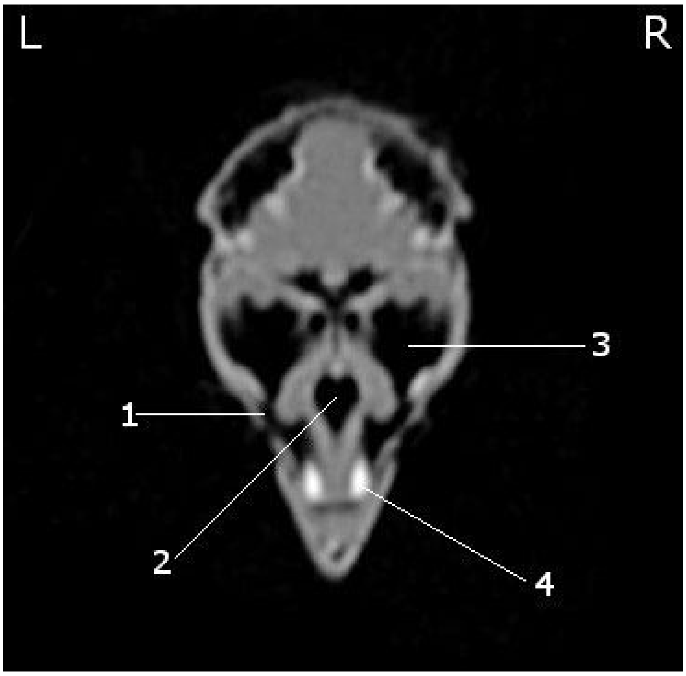

Figure 3. Dorsal CT image of the head of a cockatiel, bone window (WL = 500; WW = 3000). (L) left, (R) right.

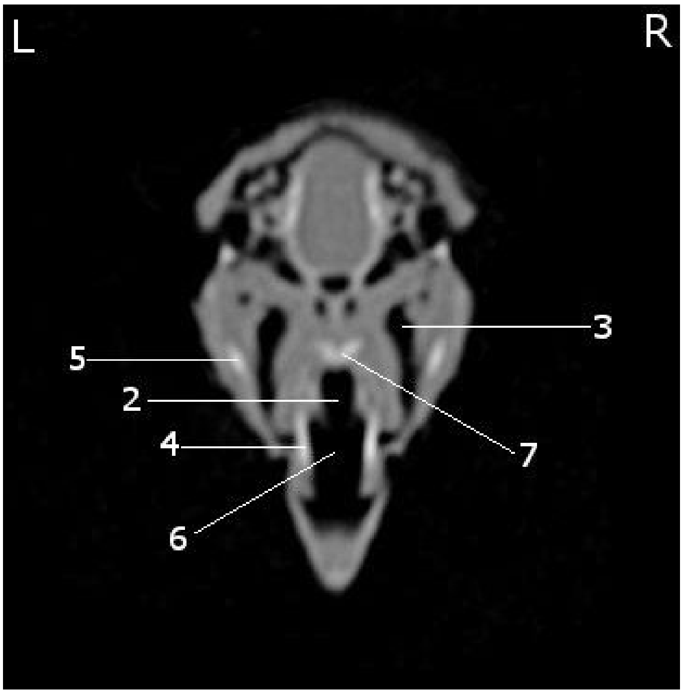

Figure 4. Dorsal CT image of the head of a cockatiel, bone window (WL = 500; WW = 3000). (L) left, (R) right.

Figures 3-4. (1) preorbital diverticulum of the infraorbital sinus; (2) choana; (3) suborbital chamber of the infraorbital sinus; (4) palatine bone; (5) zygomatic arch; (6) oral cavity; (7) pterygoid bone

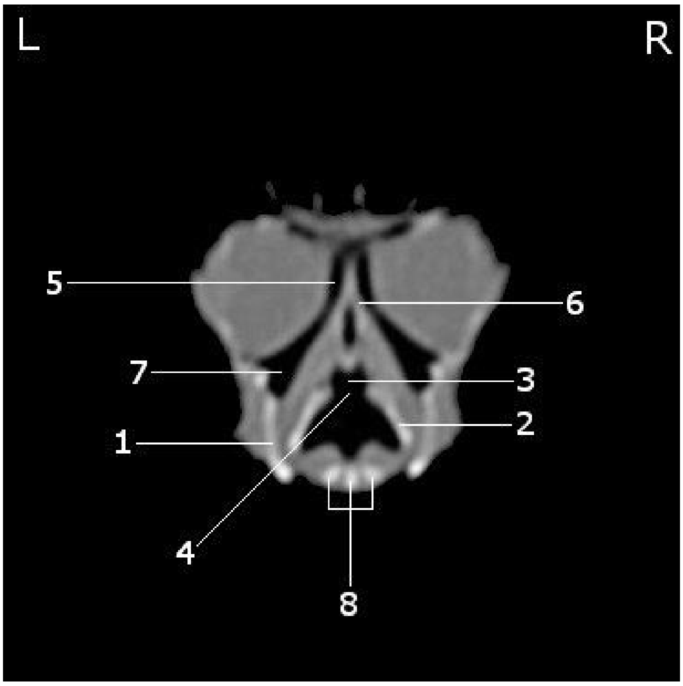

Figure 5. Transverse CT image of the head of a cockatiel, bone window (WL = 500; WW = 3000). (L) left, (R) right.

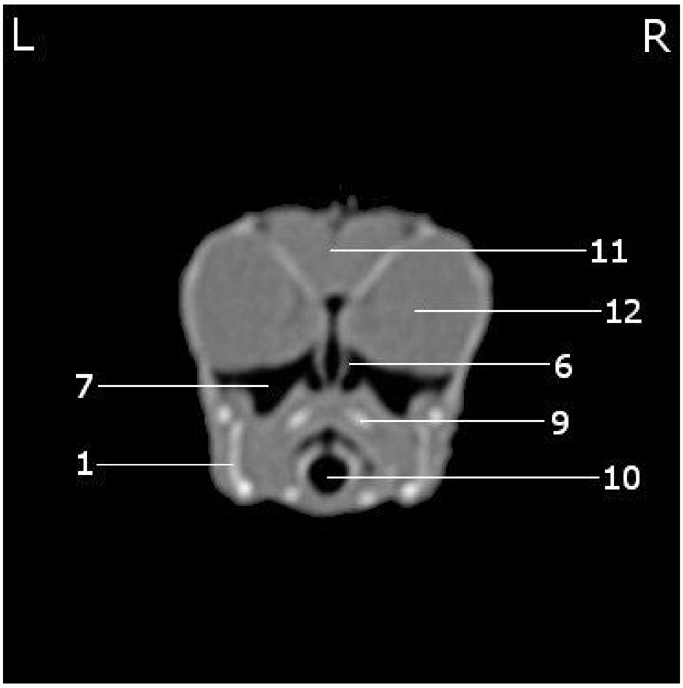

Figure 6**. Transverse CT image of the head of a cockatiel**, bone window (WL = 500; WW = 3000). (L) left, (R) right.

Figures 5-6. (1) mandible; (2) palatine bone (3) nasal cavity; (4) choana; (5) infraorbital diverticulum of the infraorbital sinus; (6) interorbital septum; (7) suborbital chamber of the infraorbital sinus; (8) hyoid bones; (9) pterygoid bone; (10) trachea; (11) cerebrum; (12) eye

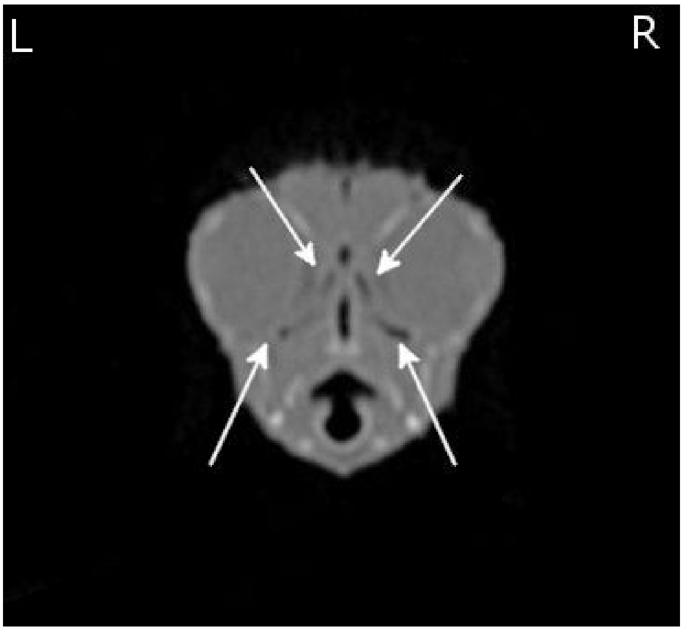

Figure 7. Transverse CT image of the head of a cockatiel with chronic sinusitis, bone window (WL = 500; WW = 3000). (L) left, (R) right. There is loss of air and replacement by soft tissue opacity in the left and right infraorbital diverticulum and suborbital chamber of the infraorbital sinus (arrows).

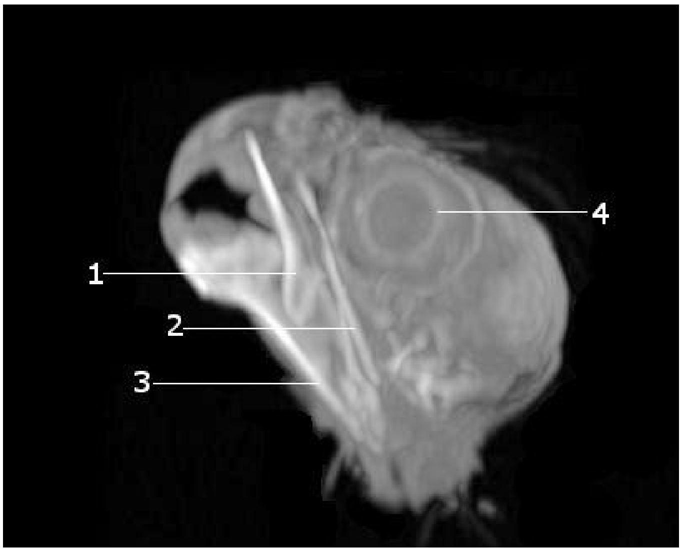

Figure 8. Maximum intensity projection of the skull of a cockatiel, 10mm thick. (1) palatine bone (2) zygomatic arch (3) mandible (4) scleral ossicles

Lower respiratory tract

Computed tomography is more sensitive in detecting lesions of the lower respiratory tract compared to conventional radiography in avian patients (Krautwald-Junghanns, 1992; Krautwald-Junghanns et al., 1993; Krautwald-Junghanns and Pees, 2010). Most of the major lower respiratory structures of the cockatiel are able to be identified on CT including the trachea, bronchi, lungs and most of the air sac spaces (Figures 9-10). The lining of the air sacs and the syrinx are not able to be appreciated. Fine bone reformats provide superior detail of the lower respiratory structures compared to soft tissue reformats.

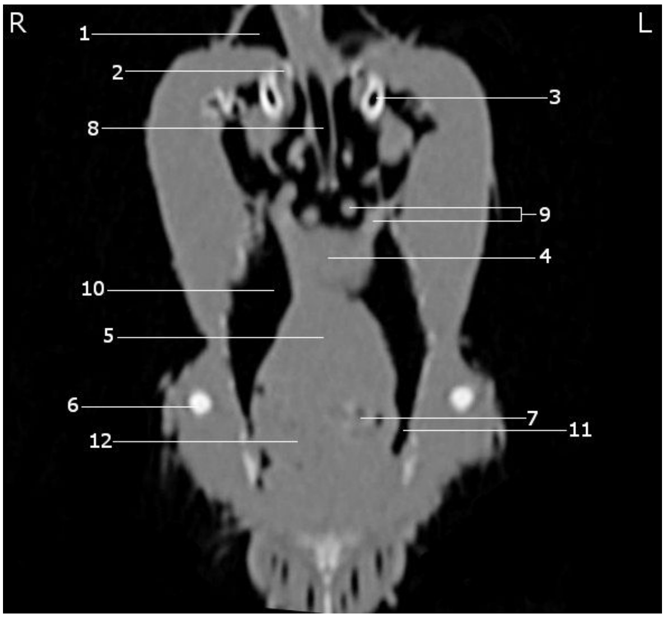

Figure 9. Dorsal CT image of the body of a cockatiel, bone window (WL=500; WW=3000). (L) left, (R) right. (1) clavicular air sac; (2) clavicle; (3) coracoid; (4) heart; (5) liver; (6) femur; (7) ventriculus (8) trachea; (9) great vessels of the heart; (10) thoracic air sac; (11) abdominal air sac; (12) intestines

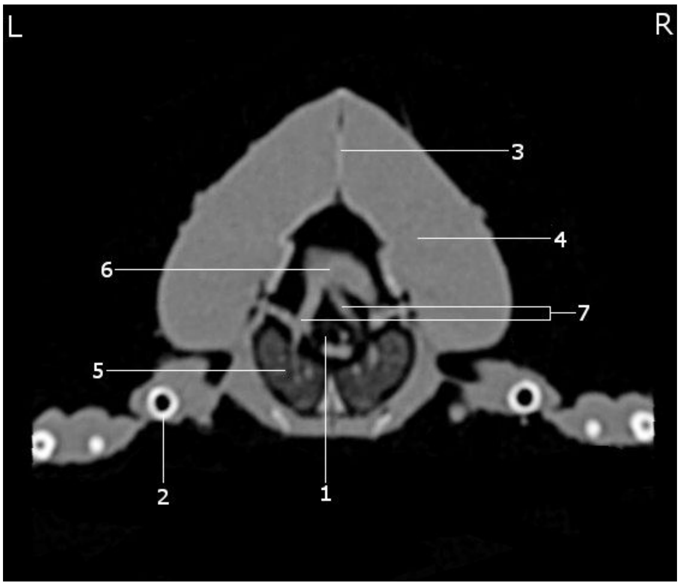

Figure 10. Transverse CT image of the thorax of a cockatiel, bone window (WL = 500; WW=3000). (L) left, (R) right. (1) primary bronchi, level of tracheal bifurcation; (2) humerus; (3) sternum; (4) pectoral muscle; (5) lung; (6) heart; (7) great vessels of the heart

Other coelomic organs

Detail and differentiation of other coelomic organs is variable. Fine bone reformats and soft tissue reformats with intravenous contrast provide the most information.

The location of the ventriculus and proventriculus are easily identified in pre-contrast images due to the presence of granular and/or mineral opacities within them. The ovaries and testes are able to be identified in the female and male cockatiel respectively (Figures 11-12). The spleen is able to be identified and is highlighted by intravenous contrast (Figures 12-13).

The heart and liver are able to be identified in pre-contrast images but the border between these two organs is difficult to appreciate. Intravenous contrast is able to highlight the heart, liver and the border between them. Some of the greater vessels of the heart can be appreciated with fine bone reformats and maximum intensity projections. Left and right ventricles of the heart can be identified in post-contrast images.

The position of the intestinal tract is able to be appreciated but detail of individual loops is poor. The pancreas, ureters, adrenal glands, thyroid glands and cloaca are not able to be clearly identified.

Barium sulphate suspension can be given by gavage tube 60-90 minutes prior to CT examination to provide better differentiation of the gastrointestinal tract (Gumpenberger, 2011). CT has been used successfully in the cockatiel to demonstrate ascites, and a large space occupying mass displacing loops of contrast filled bowel (Gumpenberger, 2011).

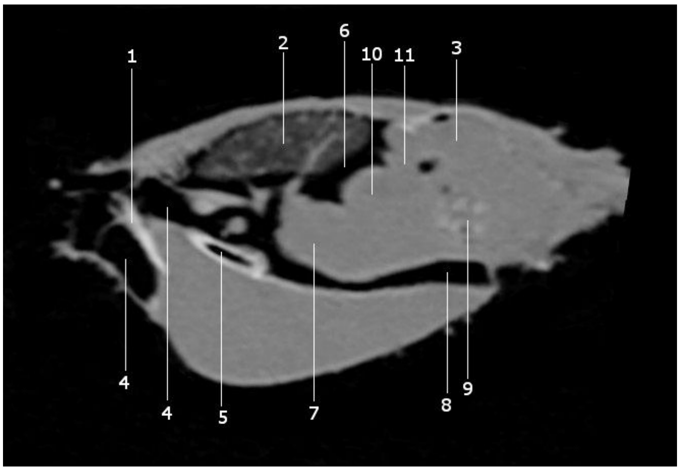

Figure 11. Parasagittal CT image of the body of a female cockatiel, bone window (WL=500; WW=3000).

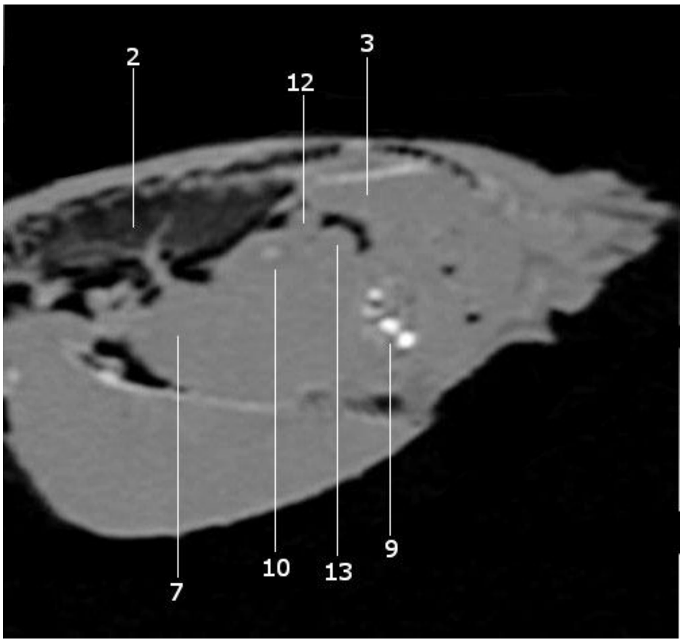

Figure 12. **Parasagittal CT image of the body of a male cockatiel, bone window (WL=500; WW=3000).**

Figures 11-12. (1) clavicle; (2) lung; (3) kidney; (4) clavicular air sac; (5) coracoid; (6) thoracic air sac; (7) heart; (8) abdominal air sac; (9) ventriculus; (10) proventriculus; (11) ovaries; (12) testes; (13) spleen

Skeletal system

Conventional radiography usually provides adequate information for the majority of the skeletal system. In addition to the skull, CT is able to provide more detail of the cockatiel pelvis, shoulder joint and vertebral column which are superimposed by soft tissues and/or other bones (Gumpenberger, 2011; Gumpenberger and Henniger, 2001; Krautwald-Junghanns and Pees, 2010; Van Zeeland et al., 2015). Helical CT is able to clearly identify the vertebral column and its pneumatized chambers in the cockatiel.

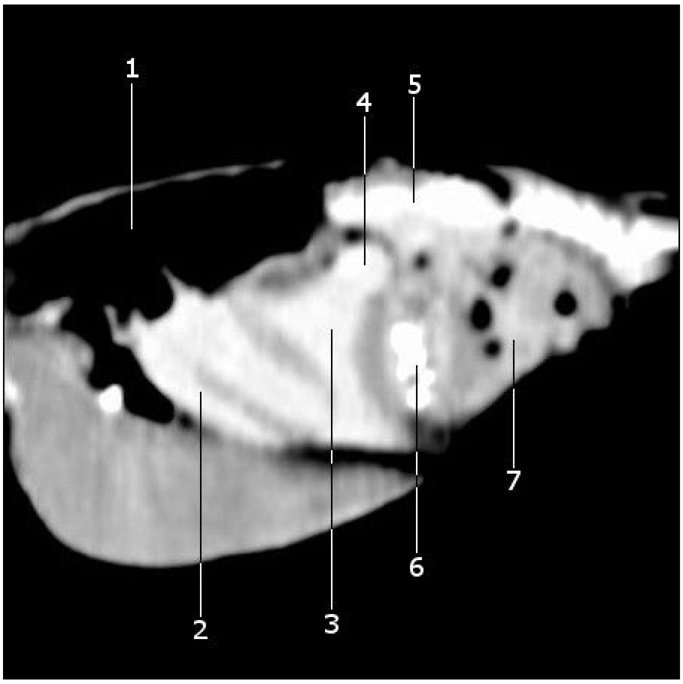

Figure 13. Parasagittal CT image of the body of a male cockatiel with intravenous contrast, soft tissue window (WL=50; WW=250). (1) lung; (2) heart; (3) liver; (4) spleen; (5) kidney; (6) ventriculus; (7) intestines

Limitations and future imaging tools

Currently, the main limitation of using CT in small birds such as the cockatiel is inadequate spatial resolution which limits diagnostic evaluation for abnormalities (Van Zeeland et al., 2015). A newer form of CT called micro-computed tomography has superior spatial resolution compared to conventional CT. However, it is currently used primarily in research and is not readily accessible to veterinary practice. Micro-CT has been successfully used in small mammals such as mice and guinea pigs and has provided superior images compared to conventional CT (Schambach et al., 2010; Souza et al., 2006).

Conclusion

Helical computed tomography is a valuable diagnostic imaging tool for the cockatiel. Compared to conventional radiography, helical CT provides superior anatomic information of the skull, infraorbital sinuses, and upper and lower respiratory tract, which is advantageous for diagnostics. It also provides excellent visualisation of the remaining skeletal structures, especially in areas where there is significant superimposition.

Major coelomic organs including the heart, liver, proventriculus, ventriculus, spleen, kidney and gonads are clearly identified using fine bone reformats. Intravenous contrast provides valuable information by highlighting soft tissue structures and borders between organs. Detail and differentiation of intestinal loops is limited and small coelomic structures are not able to be identified due to limited spatial resolution. The visualisation of the gastrointestinal tract would have been improved by the use of barium sulphate contrast. Hence, when investigating coelomic disease in the cockatiel, administration of intravenous contrast and oral barium sulfate suspension is recommended to improve visualization of coelomic organs.

Although not currently readily available in practice, the use of micro-CT offers a solution to the current spatial resolution limitation of helical CT in the examination of the cockatiel, and would provide higher quality images for diagnostic purposes.

References

Antinoff N, Stefanacci J, Vazquez D, Orosz S, Henrys R, and Janick L (1996). The correlation between CT and the anatomy of the psittacine sinus. Proceedings of the Annual Conference of the Association of Avian Veterinarians. Tampa, Florida. pp 367-368.

D'Anjou, MA (2012). Principles of Computed Tomography and Magnetic Resonance Imaging. In D.E. Thrall (Ed.). Textbook of Veterinary Diagnostic Radiology (6th edition). St Louis, Missouri: Elsevier. pp 50-60.

Dineli Bras I, Gemensky Metzler A J, Kusewitt D F, Colitz CMH, and Wilkie DA (2005). Immunohistochemical characterization of a malignant intraocular teratoid medulloepithelioma in a cockatiel. Veterinary Opthalmology 8, 59-65.

Gumpenberger M (2011). Avian. In T. Schwarz and J. Saunders (Eds.). Veterinary Computed Tomography. Chichester, West Sussex: John Wiley & Sons Ltd. pp 517-532.

Gumpenberger M and Henniger W (2001). The use of computed tomography in avian and reptile medicine. Seminars in Avian and Exotic Pet Medicine 10, 174-180.

Krautwald-Junghanns M-E (1992). Radiology of the respiratory tract and the use of computed tomography in psittacines. Proceedings of the Annual Conference of the Association of Avian Veterinarians. pp 366-373.

Krautwald-Junghanns M-E, Kostka VM and Dörsch B (1998). Comparative studies on the diagnostic value of conventional radiography and computed tomography in evaluating the heads of psittacine and raptorial birds. Journal of Avian Medicine and Surgery 12, 149-157.

Krautwald-Junghanns M-E and Pees M (2010). Computed tomography (CT). In M-E. Krautwald-Junghanns , M. Pees, S. Reese and T. Tully. Diagnostic imaging in exotic pets. Hannover, Germany: Schlütersche. pp 54-63.

Krautwald-Junghanns M- E, Schmacher F and Tellhelm B (1993). Evaluation of the lower respiratory tract in psittacines using radiology and computed tomography. Vet Radiol Ultrasound 34, 382-390.

Mackey EB, Hernandez SJ, Holland M and Frank P (2008). Clinical Tecnhnique: Application of computed tomography in zoological medicine. Jounral of Exotic Pet Medicine 17, 198-209.

Rosenthal K, Stefanacci, J, Quesenberry, K and Hoefer H (1995). Session #5510. Computerized Tomography in 10 cases of Avian Intracranial Disease. Proceedings of the Annual conference of the Association of Avian Veterinarians. Nashville, Tennessee. p. 305.

Saunders J and Ohlerth S (2011). CT physics and instrumentation - mechanical design. In T. Schwarz and J. Saunders (Eds.). Veterinary Computed Tomography. Chichester, West Sussex: John Wiley & Sons Ltd, pp 1-8.

Schambach S, Bag S, Schilling L, Groden C and Brockman MA (2010). Application of micro-CT in small animal imaging. Methods 50, 2-13.

Silverman S and Tell LA (2010). Radiology of birds: An atlas of normal antomy and positioning. St Loius, Missouri: Saunders.

Souza MJ, Greenarce CB, Avenell JS, Wall JS and Daniel GB (2006). Diagnosing a tooth root abscess in a guinea pig (*Cavia porcellus*) using micro computed tomography imaging. Journal of Exotic Pet Medicine 15, 274-277.

Van Zeeland YRA, Schoemaker NJ and Hsu EW (2015). Advances in diagnostic imaging. In BL Speer (Ed.). Current Therapy in Avian Medicine and Surgery. St Loius, Missouri: Elsevier, pp 531-549.