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Virtopsy of a gravid Boa constrictor using computed tomography and magnetic resonance imaging

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Abstract
This article presents radiologic examinations of a deeply sedated Boa constrictor with boid inclusion body disease (BIBD) as an adjunct to the subsequent necropsy. This method is known as virtopsy. The Boa constrictor in the present case was gravid. Computed tomography (CT) allowed for the detailed depiction of a fetal skeleton at the rear end of the adult snake. Furthermore, tiny gas formation was detected inside the cranium of the fetus, which was deemed a radiologic sign for decomposition. Magnetic resonance imaging (MRI) delineated the soft tissue at high resolution. This article illustrates the use of CT and MRI for the examination of a gravid Boa constrictor before necropsy and demonstrates the detection of “normal” postmortem findings leading to the confirmation of fetal death in situ.

1. Introduction

This article describes the radiologic examinations of an infected Boa constrictor that was scheduled for a necropsy. The adult Boa constrictor was positive for boid inclusion body disease (BIBD), i.e., infected with reptarenaviruses (RAVs), due to demonstration of the characteristic intracytoplasmic inclusion bodies in red and white blood cells from the performed blood smears. There is a strong assumption that RAVs, occurring worldwide in constrictor snakes, cause BIBD, which is a progressive disease of constrictor snakes and is characterized by cytoplasmic inclusion bodies in a wide range of cell types. BIBD is an often fatal disease (Hetzel et al., 2013). Due to the poor prognosis of the BIBD-positive status, euthanasia and postmortem examinations were scheduled. Since it was assumed that the infected Boa constrictor was gravid, additional examinations were conducted to reveal possible lesions and to noninvasively determine the state of gravidity. In contrast to most common snakes, which are oviparous, Boa constrictors are viviparous with a true placenta. The embryo of a Boa constrictor develops within the salpinx (uterus). After five to eight months of pregnancy, a female Boa constrictor gives birth to live offspring (Howard, 2011). In the present case, computed tomography (CT) and magnetic resonance imaging (MRI) of the deeply sedated Boa constrictor were performed shortly before the necropsy was conducted. Applying CT and MRI as an adjunct to necropsy is known as a virtual necropsy (Dirnhofer et al., 2006; Ibrahim, Bakar, & Noordin, 2012). To the best of our knowledge, the use of CT or MRI for the examination of a gravid snake has not been presented in the literature.

This article describes the CT and MRI examination of a deeply sedated, gravid Boa constrictor and the in situ examination of a fetus.

2. Material and methods

The Boa constrictor (weight: 4.3 kg, length: 2 m) was deeply sedated by the administration of ketamine (<25 mg/kg) and medetomidine (<0.3 mg/kg).

A CT scan of the entire body was performed using a 128-slice CT (SOMATOM Definition Flash, Siemens Healthcare, Forchheim, Germany) with a detector collimation of 0.6 mm. Parameters: 120 kVp, 250 mAs, 5 mm thick slices, 0.6 mm slice gap. The images were reconstructed with a bone algorithm. A total of 971 images were obtained. The CT data were transferred to a vendor-independent PACS system (OsiriX) and further processed for a diagnostic report. The image analysis was performed on a personal computer equipped with a hardware-accelerated graphics card (NVIDIA Quadro 4000).

A full body MRI examination was planned before the CT examination, but was canceled due to unexpected technical problems with the MRI system (Siemens Magnetom Prefix, Forchheim, Germany) after the CT examination. The magnetic resonance imaging was performed using a 1.5 Tesla MRI system (Siemens Magnetom Avanto) with a 22 cm diameter head and body coils. Parameters for the computed tomography and magnetic resonance imaging avoided the use of surgical contrast agents and were based on previous experiences in other veterinary species (Dirnhofer et al., 2006). The scans were acquired with various sequences and thickness settings to achieve the best image contrast for the various body tissues and organs.
After a thorough investigation of the CT and MRI, are valuable imaging modalities for noninvasive adjunction or alternative examination methods for necropsy (Thali et al., 2007; Munro & Munro, 2011; Lee et al., 2011; Franckenberg et al., 2015; Watson & Heng, 2017; Gascho, Bolliger, et al., 2018). Despite the high-resolution CT and MRI, further pathologies or injuries of the adult snake or its fetus were not detected.

The necropsy confirmed that the fetus was dead and slightly decomposed. Further pathologies or injuries were not revealed during necropsy.

Postmortem examination of the adult female demonstrated mild emaciation and hepatic lipidosis. Histological and IHC investigations showed characteristic intracytoplasmic eosinophilic and IHC-positive reactions, respectively. These reactions were predominantly detected in the brain, liver, pancreas, uterus and kidneys. In addition, pyogranulomatous splenitis due to mycobacterial infection was detected. Due to the progressive stage of decomposition, no further investigations of the fetal tissues were performed.

**4. Discussion**

This article illustrates the use of CT and MRI for the examination of a gravid *Boa constrictor* before necropsy and demonstrates the detection of “normal” postmortem findings leading to the confirmation of fetal death in situ.

The constant further developments in the field of radiologic imaging along with an increase in image quality has led to gaining importance of diagnostic imaging of captive snakes for the diagnosis of diseases and injuries (Banzato et al., 2013). The use of radiography and ultrasound is mainly described in the literature, while the use of CT and MRI is much less frequently mentioned (Banzato et al., 2013). The use of CT scanning was presented for the diagnosis of fractures (Rahal et al., 2011) or the investigation of the lung (Pees et al., 2007). MRI, in turn, was applied for neurologic examinations (Mariani, 2007) or investigations of the gastrointestinal tract and other visceral organs (Hansen et al., 2013). In addition to the diagnosis of diseases and injuries in (clinical) veterinary radiology (Dennis, 2003; Labruyere & Schwarz, 2013) or the noninvasive visualization of the anatomy for biological purposes (Lauridsen et al., 2011), CT and MRI are valuable imaging modalities for noninvasive adjunction or alternative examination methods for necropsy (Thali et al., 2007; Munro & Munro, 2011; Lee et al., 2011; Franckenberg et al., 2015; Watson & Heng, 2017; Gascho, Bolliger, et al., 2018).
Fig. 2. T2-weighted images of the fetus in situ in the coronal (A) and transversal (B1-3) views. The MRI examination displays the soft tissue in high resolution. The arrowhead points to the head of the fetus. The MRI examination did not detect pathologies or injuries.
The virtopsy approach describes a new and rapidly evolving noninvasive examination procedure involving the use of modern imaging modalities (Dirnhofer et al., 2006). This approach is based on the idea that radiologic examinations before a body orifice provide additional information on the case. In the present case, CT presented decomposition-related gas formations in accordance with the mumified state of the fetus. Further radiologic or macroscopic findings were not detected. BIBD is thought to be immunosuppressive, and pathological alterations, e.g., pneumonia or enteritis, often occur only in late stages of the disease. Thus, the absence of radiologic and macroscopic lesions is not unusual. Hence, vertical, i.e., transplacental transmission of reptarenaviruses is known in Boa constrictors (Keller et al., 2017); thus, fetal death could be related to maternal BIBD and viral infection.

In summary, this article presents high-resolution imaging of a Boa constrictor fetus in situ by CT and MRI. These radiologic modalities allow for not only imaging the anatomy, pathologies and injuries but also detecting “normal” postmortem findings, such as decomposition-related gas, which allowed for determining the death of the fetus in the present case. Fig. 3.

Conflict of Interest Statement

None of the authors has a real or perceived conflict of interest in any of the material that is presented in the manuscript. The authors have no conflicts of interest to report. This scientific paper received no external funding.

Ethical Statement

Ethical approval is not required for this case report. No animals were killed for the scientific purpose of this study.

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