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Original Study

Determination of Gastrointestinal Transit Times in Barred Owls (*Strix varia*) by Contrast Fluoroscopy

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Abstract: Contrast imaging studies are routinely performed in avian patients when an underlying abnormality of the gastrointestinal (GI) tract is suspected. Fluoroscopy offers several advantages over traditional radiography and can be performed in conscious animals with minimal stress and restraint. Although birds of prey are commonly encountered as patients, little is known about GI transit times and contrast imaging studies in these species, especially owls. Owls are commonly encountered in zoological, educational, and wildlife settings. In this study, 12 adult barred owls (*Strix varia*) were gavage fed a 30% weight-by-volume barium suspension (25 mL/kg body weight). Fluoroscopic exposures were recorded at 5, 15, 30, 60, 120, 180, 240, and 300 minutes after administration. Overall GI transit time and transit times of various GI organs were recorded. Median (interquartile range [IQR]) overall GI transit time was 60 minutes (IQR: 19–60 minutes) and ranged from 5–120 minutes. Ventricular and small intestinal contrast filling was rapid. Ventricular emptying was complete by a median of 60 minutes (IQR: 30–120 minutes; range: 30–240 minutes), whereas small intestinal emptying was not complete in 9/12 birds by 300 minutes. Median small intestinal contraction rate was 15 per minute (IQR: 13–16 minutes; range: 10–19 minutes). Median overall GI transit time in barred owls is more rapid than mean transit times reported for psittacine birds and red-tailed hawks (*Buteo jamaicensis*). Fluoroscopy is a safe, suitable method for investigating GI motility and transit in this species.

Key words: barium, fluoroscopy, gastrointestinal transet time, bird of prey, raptor, avian, barred owl, *Strix varia*

Introduction

Contrast studies are often used to evaluate suspected pathologic changes of the avian gastrointestinal (GI) system. Traditionally, contrast material is administered orally, and serial radiographic images are taken, providing information about transit times of various organs, as well as assisting with identification of other disorders, including luminal or filling defects, masses within the coelom, foreign bodies, or perforations.[1] Fluoroscopy offers several advantages over traditional radiography in positioning and the ability to perform studies in awake animals.[2] The repeated anesthetic or restraint events required for the multiple time points needed for a radiographic contrast study may increase the risk for adverse effects, and anesthetics used may also affect GI motility.[1,2] Fluoroscopy is also considered the ideal method for evaluating GI motility in birds.[1–4] Pathologic changes in motility can occur secondary to a variety of GI or extragastrointestinal processes, with major causes including ileus, inflammation, parasitism, and heavy metal toxicosis.[1]

Owls (order Strigiformes) are a unique group of nocturnal raptors that are found throughout the world. They are often encountered as educational animals, displayed in captive zoological collections, treated in rehabilitation settings, and occasionally, used in falconry. Despite their prevalence, little information exists regarding contrast imaging in these birds of prey. Most research evaluating avian GI transit times has involved psittacine species, with little focus on raptorial birds.[2,4–6] To our knowledge, there are no prospective studies

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evaluating fluoroscopic GI transit times in any owl species.

Barred owls (*Strix varia*) are a common species found throughout large portions of North America, and they are often presented to wildlife hospitals and rehabilitators. Because of their large geographic range and frequency as patients, barred owls were chosen as a suitable species for this study.

The goal of this study was to use contrast fluoroscopy for evaluating transit times of various GI organs in barred owls to provide baseline data for this species and to supplement the limited existing knowledge about this unique order of raptors.

Materials and Methods

Animals

Twelve adult (>1 year of age) barred owls of undetermined sex were used for this study. The birds were healthy, free-ranging animals undergoing rehabilitation at wildlife centers for orthopedic injuries. All birds underwent physical examinations, with negative results on fecal floatation and direct smear tests and were considered to be in good health for the duration of the experimental trials. Only owls nearing the end of the rehabilitation period were used for this experiment. Animals were housed at their respective institutions and were maintained on diets consisting of frozen-thawed mice. Birds fasted for 12–18 hours before the trials and were transported to the University of Wisconsin School of Veterinary Medicine on the day of each experiment. All procedures were approved by the Institutional Animal Care and Use Committee of the School of Veterinary Medicine, University of Wisconsin, Madison.

Study design

For the experiment, birds were housed in plastic cages that had been used previously for transport. All birds were allowed a minimum of 60 minutes to acclimate within the transport enclosures before the experiments. Owls were placed in cardboard boxes measuring 42 cm × 32 cm × 32 cm, which were lined with a cloth towel. Openings in two sides of the box allowed for ventilation and some light transmission. Ambient room temperature was maintained between 22–23°C (71–73°F).

Both right lateral and ventrodorsal survey fluoroscopic images were obtained with a commercial C-arm unit (OEC 8900 C-arm, General Electric, Fairfield, CT, USA) while the birds were kept in the boxes before administration of contrast medium. Each bird was then manually restrained and administered 30% weight by volume barium suspension (25 mL/kg) via gavage with a 14-Fr red, rubber feeding tube. The contrast media was delivered into the GI tract at the level of the cranial point of the keel. The owls were then returned to the cardboard boxes. Paired right lateral and ventrodorsal fluoroscopic still images were obtained at 5, 15, 30, 60, 120, 180, 240, and 300-minute time points after barium administration. Sixty-second clips of fluoroscopic video were captured at 60 minutes after barium administration with both views to assess GI peristalsis.

Overall GI transit time was defined as the time to presence of contrast material within the cloaca (Fig 1). Gastric emptying time was defined as the absence of contrast material within the proventriculus and ventriculus on both fluoroscopic views or the presence of sufficient barium to highlight the rugal folds only. A single, board-certified radiologist (J.M.W.) examined all radiographic views.

Statistical analysis

The data were analyzed with a commercial statistical software package (SigmaPlot, version 12.5, Access Softek, Berkeley, CA, USA). The data were tested for normality with a Shapiro-Wilk test. All data are reported as median, range, and interquartile range (IQR) unless otherwise specified.

Results

The median body weight of the barred owls in this study was 0.79 kg, with a range of 0.68–1.05 kg. All owls remained clinically healthy both during and after the study, and no adverse effects of contrast administration were observed. The contrast fluoroscopic findings are summarized in Table 1. The median overall GI transit time was 60 minutes (IQR: 19–60 minutes) and ranged from 5–120 minutes. Ventricular and small intestinal contrast filling was rapid, with luminal contrast present by 5 minutes in all birds. Ventricular emptying was complete by a median of 60 minutes (IQR: 30–120 minutes; range: 30–240 minutes), whereas small intestinal emptying was not complete in 9/12 birds by 300 minutes. Small intestinal contractions were observed in all studies. Median small intestinal contraction rate was 15 per minute (IQR: 13–16; range: 10–19). Ventricular contractions were occasionally observed in some owls. Differentiation between the sections of small

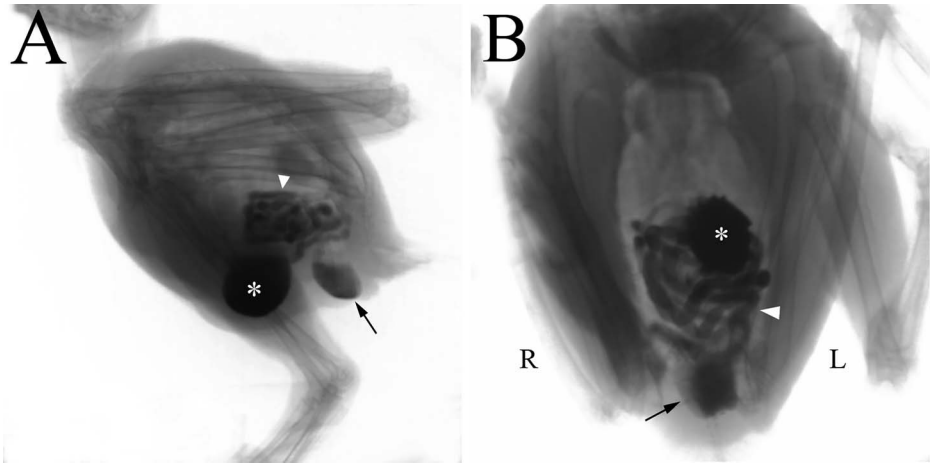

Figure 1. Still images from a fluoroscopic contrast study in a barred owl 5 minutes after contrast administration, illustrating the relative position of various gastrointestinal organs. The ventriculus (white asterisk), intestines (white arrowhead), and cloaca (black arrow) are filled with contrast media. (A) Right lateral view; (B) ventrodorsal view (R and L labels indicate animal positioning).

intestine and determination of filling and emptying times of the large intestines was not possible because of superimposition of bowel loops in the fluoroscopic images.

Discussion

The findings of this study reveal that overall GI transit time in barred owls is highly variable among individuals. This is similar to reports in other studies evaluating GI transit times in various avian species.[2,6,7] The median overall GI transit time in this group of barred owls (60 minutes) was faster than mean rates (100 minutes) reported for another bird of prey, the red-tailed hawk (*Buteo jamaicensis*).[6] However, our study differed from that study in reported measures as well as in study methodology. In our study, contrast material was administered directly into the GI tract at the level of the proventriculus because owls lack a crop. In contrast, in the red-tailed hawks,[6] barium suspension was instilled into the crop, possibly resulting in longer overall transit times. In general, this overall transit time was also faster than those described in several psittacine bird species and

Table 1. Temporal parameters obtained by contrast fluoroscopy in 12 barred owls after barium administration.

	Time to initial luminal filling, min				Time to emptying, min	
Barred owl No.	Ventriculus	Small intestines	Cloaca[a]	Contraction rate, small intestines[b]	Ventriculus	Small intestines
1	5	5	120	15	60	>300
2	5	5	60	16	30	240
3	5	5	60	16	60	240
4	5	5	60	13	30	240
5	5	5	60	14	60	>300
6	5	5	60	13	30	>300
7	5	5	15	15	30	>300
8	5	5	60	16	120	>300
9	5	5	30	17	120	>300
10	5	5	5	19	60	>300
11	5	5	120	11	240	>300
12	5	5	5	10	240	>300
Median	5	5	60	15	60	
IQR	5	5	19–60	13–16	30–120	
Range	5	5	5–120	10–19	30–240	

Abbreviation: IQR indicates interquartile range.
[a] Overall transit time.
[b] Number of contractions per minute measured 60 minutes after administration of contrast material.

pigeons (*Columba livia*).[2,4,5,8] Conversely, times to filling of the distal GI tract in toco toucans (*Ramphastos toco*), cedar waxwings (*Bombycilla cedrorum*), and kestrels (*Falco sparverius*) were faster than in this subpopulation of barred owls.[9–11] These differences are not surprising, given distinctions in metabolism and feeding strategies among the various avian species.

Both ventricular and small intestinal fillings were rapid in all owls, which is similar to findings in red-tailed hawks.[6] Use of a liquid contrast medium rather than a material more closely mimicking the natural diet of birds of prey may explain the rapid ventricular and small intestinal filling times in these studies.

Ventricular emptying was noted by 240 minutes in all birds. The median time for this group of owls was faster than reported individual values for red-tailed hawks and caracaras (*Caracara plancus*) and for median values of several *Falco* species.[6,7,12] These dissimilarities may be secondary to differences in ventricular processing of prey items. In one report, the average meal-to-pellet interval was significantly shorter in several owl species when compared with hawks.[13] Another explanation for the faster ventricular emptying times in this population of owls may be differing study methodologies. In studies evaluating GI transit times in red-tailed hawks, caracaras, and falcons, contrast media was instilled into the crop.[6,7,12] This site of administration may have resulted in continuous ventricular filling with contrast material, resulting in longer ventricular emptying times when compared with the owls in this study. Further research is necessary to understand differences between ventricular emptying in different birds of prey species.

Emptying of the small intestines was not complete by 300 minutes in 9/12 owls. Comparably, intestinal emptying was not complete in Congo African grey parrots (*Psittacus erithacus*) and red-tailed hawks by 360 and 300 minutes after contrast administration, respectively.[2,6]

Small intestinal contractions were observed in all owls in this study. Although retrograde peristalsis is a common finding in birds,[2–4,14] the fluoroscopic images in this study did not allow for clear differentiation of the direction of peristalsis. Little information exists regarding the reference interval for peristaltic frequency of the small intestines in birds of prey. Peristaltic movement of the intestines is considered a healthy finding in many birds[14] and has been reported in several psittacine species,[2–5] but contraction frequency is poorly described in birds of prey. Near-constant peristalsis was observed in red-tailed hawks undergoing contrast fluroroscopy.[6] In kestrels,[10] duodenal contractions occurred at approximately an average of 3–4 times per minute, which is less frequent than the peristaltic contractions noted in this study.

There are limitations with this study. Owls and other birds of prey often feed on whole prey items, and the use of a liquid contrast media could affect the GI transit time. However, the goal of this study was to replicate a diagnostic examination that would be performed in a clinical setting in which liquid contrast material is readily available. Further studies investigating consistency of contrast media on GI times in birds of prey are warranted. Additionally, withholding food from the owls before the examination may have resulted in changes to GI motility and thereby affected the results. In turkeys, fasting resulted in longer pauses between ventricular contractions and fewer overall contractions when compared with nonfasted animals.[15] Although unavoidable, the stress associated with manual restraint and gavage administration of contrast material may also have influenced the results of this study. However, after this brief period of handling, the owls were placed into the darkened boxes and not disturbed for the remainder of the study in an effort to minimize the effect of stress on GI transit. Finally, light cycle has been shown to influence digestion in red-tailed hawks.[16] Placing owls in a darkened enclosure may have disturbed the natural light cycle, possibly influencing the results. Further research regarding the effect of photoperiod on GI transit times in birds of prey is needed.

In conclusion, fluoroscopy is a safe, convenient method for performing GI contrast studies in barred owls. The results of this study provide basic data to assist veterinarians when performing and interpreting contrast studies in barred owls. Additional research is warranted to better understand fluoroscopic GI transit times in Strigiformes and other raptorial orders.

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