EFFECT OF ANESTHESIA, POSITIONING, TIME, AND FEEDING ON THE PROVENTRICULUS: KEEL RATIO OF CLINICALLY HEALTHY PARROTS

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Healthy, adult Hispaniolan Amazon parrots (*Amazona ventralis*) were imaged on three occasions to determine the effects of anesthesia, patient rotation, feeding, and short/long-term temporal factors on the proventriculus:keel ratio. Increasing rotation up to 15° from right lateral resulted in increased inability to measure the proventriculus in up to 44% of birds, meaning that the proventriculus:keel ratio could not be calculated from those radiographs. There was a significant difference between the proventriculus:keel ratio for individual parrots when quantified 3 weeks apart. Despite this difference, all ratios remained within normal limits. No significant effect was identified due to anesthesia, feeding, fasting, or repeated imaging through an 8-h period. Interobserver agreement for measurability and correlation for the proventriculus:keel ratio values was high. It is recommended that the proventriculus:keel ratio be calculated from anesthetized parrots to attain images in true lateral recumbency. Ratio fluctuations within the normal range between radiographs obtained on different dates may be observed in normal parrots. © 2010 *Veterinary Radiology & Ultrasound, Vol. 51, No. 2, 2010, pp 141–144.*

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Introduction

Proventricular disease in psittacines has many etiologies and results in gastrointestinal signs and, typically, proventricular enlargement either through luminal dilatation or mural hypertrophy.[1–3] The proventriculus: keel ratio[4] is one method for differentiation of a normal vs. enlarged proventriculus. Normal reference values for the proventriculus:keel ratio were determined from retrospective data and variations due to anesthesia, patient rotation, and short or long-term temporal effects were not addressed.[4]

The goal of this study was to investigate the following hypotheses in healthy Hispaniolan Amazon parrots (*Amazonia ventralis*): (1) anesthesia will have no effect on the proventriculus:keel ratio in healthy parrots, (2) proventriculus size does not vary over the short-term or the long-term in healthy parrots, and (3) obliquity will not affect the ability to accurately measure the proventriculus diameter.

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Material and Methods

All procedures were approved by the Institutional Animal Care and Use Committee of the University of Wisconsin School of Veterinary Medicine. All parrots were part of a teaching and research flock and were clinically healthy.

Data were collected in two parts. Part one included right lateral radiographs from 15 healthy adult Hispaniolan Amazon parrots (*Amazona ventralis*) (mean ± SD body weight 271 ± 11 g) without signs of gastrointestinal disease and in good body condition. Radiographs had been acquired as part of another prospective study. Right lateral radiographs were acquired without the use of anesthesia using conventional film-screen radiography following *ad libitum* feeding. Food was removed at the time of the first radiograph, time 0, and radiographs were repeated at hourly intervals over 8 h. These radiographs were used in this study to evaluate proventricular size variation over the short-term and the effects of the fed and fasted state. Part two was divided into two sessions 3 week apart. Eighteen healthy adult Hispaniolan Amazon parrots (*Amazona ventralis*) (mean ± SD body weight of 273 ± 12 g with a body condition score ranging from 2.5 to 3.5 on a scale of 1–5; median score was 3) from a different cohort were radiographed. Weight and body condition score did not change between sessions. Direct digital radiography* was performed to evaluate the effect of time over a 3-week period, anesthesia, and rotation on the proventriculus size. Food was withheld for 1 h before radiography. A single right

*Eklin Medical Systems Inc., Santa Clara, CA.

lateral view was acquired. Each parrot was restrained on a purpose-designed avian restraint board. Following a rest period of at least 30 min but no >2 h, each parrot was anesthetized using isoflurane administered initially by mask before endotracheal intubation. Once anesthetized, each parrot was again secured to the restraint board. Ventrodorsal (keel superimposed on the spine) and lateral (coxofemoral joints superimposed by at least 75%) radiographs were acquired followed by three obliqued lateral projections; 5/10/15° left ventral—right dorsal oblique.[5] Oblique projections were achieved by elevation of the edge of the avian board that the sternum was closest to, using a protractor for consistency. All radiographs were collimated as much as possible but the entire keel, spine, and coelomic cavity were included in the primary beam. The same protocol was repeated for each parrot ($n=18$) 3 weeks later.

Conventional radiographs acquired and used for part one were anonymized at the time of acquisition. These radiographs were interpreted by one author and the proventriculus:keel ratio calculated as previously described.[4] For part two, digital radiographs were anonymized, randomized and reviewed independently by two authors. The proventriculus:keel ratio was calculated as in part one.[4]

Analysis of variance (ANOVA) was used to compare proventriculus:keel data from part one. Wilcoxon's matched-pairs signed rank test was performed to compare proventriculus:keel ratio data from part two. Analysis of covariance (ANCOVA) was used to evaluate interobserver measurement correlation after adjustment for other model factors including session and state of consciousness, where a small *P*-value indicates a high likelihood of correlation.

Results

Part 1: The proventriculus:keel ratio ranged from 0.27 to 0.4 with a median of 0.3. These were all lower than the previously reported maximum normal value of 0.48.[4,6] There was no significant difference in the proventriculus:keel ratio over the 8 h time period ($P>0.12$).

Part 2: One of the 18 parrots did not undergo radiography while under anesthesia on the second occasion due to marked bradycardia on induction of anesthesia. Data contributed by this parrot included a full set of ratios from the first session but only the awake lateral ratio from the second session. For these 18 parrots, the proventriculus:keel ratio ranged from 0.29 to 0.44 with a median of 0.35 for one observer and 0.28–0.42 with a median of 0.34 for the second observer. All ratios were within the normal reference range.[4,6] Interobserver agreement was excellent for the keel and proventriculus measurability and actual measurements ($P<0.01$) and observers agreed that as the degrees of rotation from lateral increased, the conspicuity of the proventriculus margins was lost in up to 44% of parrots. All proventriculus margins were identified from true lateral projections. The degrees of rotation required to result in loss of proventriculus conspicuity varied between parrots (Fig. 1). One parrot was affected at 5°, 10°, and 15° of rotation, one parrot was affected at 10° and 15° of rotation, six parrots were affected at 15° of rotation and 10 parrots were never affected. Without exception, the same parrots were affected on both occasions. No correlation was identified between body weight or body condition score and loss of conspicuity of the proventriculus margins. There was no statistically significant effect of anesthesia ($P=0.18$) or degree of body rotation ($P>0.30$) on the proventriculus:keel ratio. There was no significant difference between awake true lateral views and views
acquired under anesthesia at varying degrees of rotation for the same session ($P>0.20$). A statistically significant difference in the proventriculus:keel ratio was identified as a function of time between radiographic sessions 3 weeks apart ($P<0.01$).

Discussion

Hispaniolan Amazon parrots were used for this study due to their availability within our institute's research animal colony. While this species of Amazon parrot is not kept commonly as household pets, their size is representative of other medium sized parrots. Factors compromising proventriculus conspicuity are likely to be more

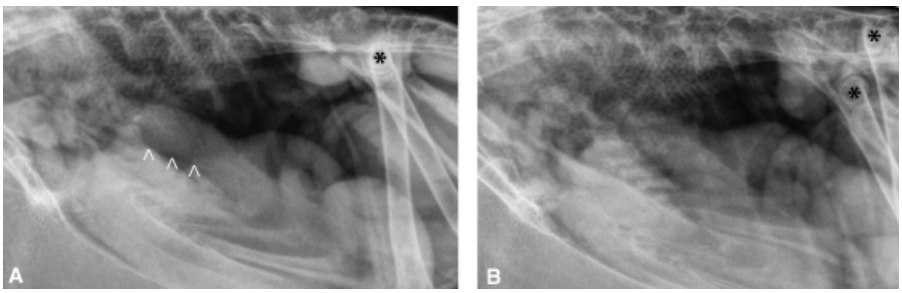

FIG. 1. Effect of rotation on conspicuity of proventriculus margins (part two of the study). Images are from the same parrot on the same occasion acquired while anesthetized and have been cropped for publication. The ventral proventricular margin (white arrowheads) is more conspicuous in the lateral view (A), than in the left 15° ventral—right dorsal oblique view (B). Note the coxofemoral joints (black asterisk) are not superimposed on the oblique view. The proventriculus:keel ratio could not be confidently determined from (B).

profound in parrots of this size, thus the measurements made in this species may be easier in larger psittacines.

All proventriculus:keel ratio data included in the analysis from parts one and two of the study were categorized as normal.

There are advantages and disadvantages regarding the use of anesthesia in birds to acquire radiographs. Not using anesthesia increases stress for the parrot. On the other hand, anesthesia results in loss of muscular tone and reduced gastrointestinal motility. This could result in an increased proventriculus:keel ratio, however we did not find any effect of anesthesia on the ratio. Anesthesia permitted positioning of the parrots without resistance and reduced motion during the exposure that blurs margins and encourages rotation.

Rotation causes foreshortening of the keel of the sternum while measurements of the cylindrical proventriculus remain similar. Rotation then could result in an increased proventriculus:keel ratio as obliquity increases. Our measured ratios did increase slightly with degree of rotation for individual parrots however this difference was not statistically significant and did not result in categorizing a normal bird as abnormal. More importantly, and of more clinical significance, was the decrease in the number of ratios that could be calculated as rotation increased due to border effacement between the proventriculus and the liver. This effect of rotation did not affect all parrots but was repeatable on different occasions for those susceptible to the effect. No correlation between the affect of rotation and weight or body condition score was identified in this study. The number of degrees for border effacement to manifest varied among susceptible parrots and validates the importance of careful positioning.

There was no significant difference identified among parrots in part one that were radiographed immediately following feeding, then compared with 1–8 h periods of fasting, indicating that voluntary feeding and fasting will not affect the proventriculus:keel ratio. In general, we recommend a short period of fasting before radiography in parrots with clinical signs of gastrointestinal disease to reduce the chances of aspiration. Anorexic parrots are frequently hand-fed liquid formulation diets. The effect of hand-feeding such liquid diets on proventriculus size was not investigated.

In part one, short-term fluctuations in proventricular size were not observed thus the significant proventriculus size fluctuation identified over 3 weeks in part two was unexpected. As different parrots were used for evaluation of short-term vs. long-term fluctuations, the effect of individual birds cannot be ruled out. However, this is still an interesting observation as there was no significant variation in the proventriculus:keel ratio for individual parrots used for part two within a session, between awake and anesthetized views, in agreement with the short-term findings in part one. A significant difference was only identified for the part two parrots between sessions 3 weeks apart. There are a number of possible reasons for this variation, which likely is due to an absolute change in proventriculus size as the size of the keel would not change. Observer error when calculating the ratios was considered unlikely due to strong interobserver correlation and there was no statistically significant difference between the two observers' data. Different radiography suites were used on each occasion for the part two parrots and technical factors were considered. No parrots had any evidence of proventricular disease, suggesting that the alterations in the ratio were most likely due to natural, nonpathologic causes. Despite being statistically significant, ratio fluctuation did not result in any parrot being categorized as abnormal. Variation in the proventriculus:keel ratio has been observed previously.[6] In that study no relationship between prognosis for short-term survival and ratio magnitude was found. Instead, the final conclusion was that a ratio >0.52 inferred proventricular disease.

Subclinical proventricular disease, such as early neuropathic gastric dilatation, cannot be completely ruled-out as the crop was not biopsied[7] nor was postmortem examination possible. Isolation of the bornavirus that has been recently associated with this disease was also not performed.[8] However, neuropathic gastric dilatation is considered unlikely as the colony used for part two of the study has been assembled for 3 years and there are no signs of neurologic or proventricular disease 18 months following the study.

The effect of immaturity was not evaluated. Neonatal parrots have a comparatively larger proventriculus compared with body size than adults of the same species.[1] The validity of the proventriculus:keel ratio in neonatal birds remains undetermined.

In conclusion the proventriculus:keel ratio should be calculated from well-positioned lateral radiographs performed under anesthesia to aid positioning. Fluctuations in the proventriculus:keel ratio within the normal range appear to be normal and are not indicative of proventricular disease.

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