Agreement between direct and indirect blood pressure measurements obtained from anesthetized Hispaniolan Amazon parrots

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Objective—To determine the level of agreement between direct and indirect blood pressure measurements obtained from healthy Hispaniolan Amazon parrots (*Amazona ventralis*) anesthetized with isoflurane.

Design—Validation study.

Animals—16 healthy adult Hispaniolan Amazon parrots.

Procedures—Parrots were anesthetized, and a 26-gauge, 19-mm catheter was placed percutaneously in the superficial ulnar artery for direct measurement of systolic, mean, and diastolic arterial pressures. Indirect blood pressure measurements were obtained with a Doppler ultrasonic flow detector and an oscillometric unit. The Bland-Altman method was used to compare direct and indirect blood pressure values.

Results—There was substantial disagreement between direct systolic arterial blood pressure and indirect blood pressure measurements obtained with the Doppler detector from the wing (bias, 24 mm Hg; limits of agreement, –37 to 85 mm Hg) and from the leg (bias, 14 mm Hg; limits of agreement, –14 to 42 mm Hg). Attempts to obtain indirect blood pressure measurements with the oscillometric unit were unsuccessful.

Conclusions and Clinical Relevance—Results suggested that there was substantial disagreement between indirect blood pressure measurements obtained with a Doppler ultrasonic flow detector in anesthetized Hispaniolan Amazon parrots and directly measured systolic arterial blood pressure. (*J Am Vet Med Assoc* 2008;233:1587–1590)

Direct measurement of blood pressure requires catheterization of a suitable artery. Although this is considered the gold standard method for measuring blood pressure, it is technically challenging and impractical in many clinical situations. Therefore, indirect methods of measuring blood pressure are commonly used in veterinary practice. This has facilitated monitoring of anesthetized patients and aided in the identification and treatment of hypertensive patients.

The use of indirect methods for measuring blood pressure in dogs and cats has been made possible as a result of studies[1–4] demonstrating good agreement between values obtained with direct and indirect methods. To our knowledge, the level of agreement between direct and indirect blood pressure measurements obtained from birds has not been reported, even though indirect monitoring of blood pressure in birds weighing as little as 70 g (0.15 lb) has been advocated and proposed reference ranges have been published.[5,6] The purpose of the study reported here therefore was to determine the level of agreement between direct and indirect blood pressure measurements obtained from healthy Hispaniolan Amazon parrots (*Amazona ventralis*) anesthetized with isoflurane. Our hypothesis was that blood pressure measurements obtained by use of an indirect method involving a Doppler ultrasonic flow detector would provide a reasonable approximation of direct blood pressure measurements obtained by means of arterial catheterization.

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Materials and Methods

Birds—Sixteen healthy adult Hispaniolan Amazon parrots (*A ventralis*) obtained from the Louisiana State University School of Veterinary Medicine research flock were used in the study. Hispaniolan Amazon parrots were used in the study because they were of sufficient size to allow for arterial catheterization and were comparable in size to many other psittacines commonly kept as pets. The study was performed in accordance with regulations established by the Institutional Animal Care and Use Committee at Louisiana State University.

Experimental procedure—Birds were anesthetized with 5% isoflurane in oxygen (flow rate, 1 L/min) delivered via a face mask. Once birds were anesthetized, an uncuffed endotracheal tube (2 mm outer diameter) was placed and connected to a Bain system, and isoflurane concentration was decreased to 2%. End-tidal partial pressure of carbon dioxide was monitored, and birds were manually ventilated as needed to maintain an end-tidal partial pressure of carbon dioxide between 35 and 45 mm Hg.[a] A hot-water blanket and convective air warmer[b] were used to maintain body temperature while birds were anesthetized.

After sterile preparation, a 26-gauge, 19-mm catheter[c] was placed percutaneously in the superficial ulnar artery. A suture was used to secure the catheter, and the wing was manually stabilized. The catheter was connected to a continuous multifunction monitor[a] via a disposable pressure transducer system.[d] The system was calibrated in accordance with the manufacturer's recommendations. The system was flushed with saline (0.9% NaCl) solution, and the pressure transducer was zeroed at the level of the right atrium. Direct blood pressure measurements were checked for stability and consistent waveform before proceeding.

Indirect blood pressure measurements were obtained with a Doppler ultrasonic flow detector.[e] All measurements were obtained by a single individual (DG) who was blinded to direct blood pressure measurements. Indirect blood pressure measurements were obtained from the wing and the leg contralateral to the arterial catheter. For obtaining measurements from the wing, a size 1 neonatal cuff[f] was placed around the humerus, and the Doppler ultrasonic flow detector was placed over the distal aspect of the superficial ulnar artery. Feathers in the area underlying the cuff were groomed so that they were not between the cuff and the humerus. In a few instances, feathers that could not be satisfactorily moved were plucked. In all instances, width of the cuff was 30% to 40% of the circumference of the wing, as recommended.[5] The cuff was inflated until sounds of pulsating blood generated by the Doppler unit were no longer heard. The cuff was then gradually deflated until the first Doppler-generated pulsatile sounds were audible, and pressure in the cuff was recorded as systolic pressure. At the same instant, a second individual (MA) recorded systolic, mean, and diastolic arterial blood pressures. The process was repeated 3 times at 1-minute intervals and then again 3 more times after a 5-minute pause.

Attempts were also made to indirectly measure blood pressure with an oscillometric unit[g] designed for animal use and a cuff that was 30% to 40% of the circumference of the proximal portion of the wing. However, all such attempts were unsuccessful.

For obtaining indirect blood pressure measurements from the leg, a size 1 neonatal cuff[f] was placed around the proximal portion of the tibiotarsus, and the Doppler ultrasonic flow detector was placed over the distal aspect of the ischiatic artery. In all cases, width of the cuff was 30% to 40% of the circumference of the leg where the cuff was placed. Blood pressure measurements were obtained as described for the wing, except that only 3 measurements were obtained at 1-minute intervals.

Attempts were also made to indirectly measure blood pressure with an oscillometric unit[g] and a cuff that was 30% to 40% of the circumference of the proximal portion of the leg. However, all such attempts were unsuccessful.

After all blood pressure measurements were obtained, arterial catheters were removed and the birds were allowed to recover from anesthesia. All birds were closely monitored until they were able to perch without assistance.

Statistical analysis—The Kolmogorov-Smirnoff test was used to determine whether blood pressure data were normally distributed. Because data were found to be normally distributed, values were summarized as mean, SD, and range. Repeated-measures ANOVA was used to determine whether initial blood pressure measurements (systolic, mean, and diastolic arterial pressures and indirect blood pressure) and measurements obtained 5 minutes later from the wing and initial blood pressure measurements obtained from the leg varied significantly within bird. A paired *t* test was then performed to determine whether initial and subsequent blood pressure measurements obtained from the wing were significantly different.

The Pearson correlation method was used to determine whether body weight was significantly correlated with blood pressure measurements. Agreement between the direct and indirect blood pressure measurements was determined by use of the Bland-Altman method. Because the sampling strategy used a repeated-measures approach, the mean for each of the pressure measurements was calculated and used for comparison.[7] Bias was defined as the mean difference between the 2 methods, and limits of agreement were calculated as the bias ± 1.96 SD. Because of the potential for underestimating the SD of the differences with a repeated-measures approach, SDs were corrected by use of a previously described technique.[7] The α was set at $P \leq 0.05$. All statistical analyses were performed with commercially available statistical programs.[h,i]

Results

Arterial catheters were successfully placed in all 16 birds included in the study. An additional 5 birds were eliminated from the study because an arterial catheter could not be placed. Mean ± SD body weight of the 16 birds included in the study was 294.3 ± 22.3 g (0.65 ± 0.05 lb; range, 254 to 333 g [0.56 to 0.73 lb]). Indirect blood pressure measurements were obtained from the wing in all 16 birds but were obtained from the leg in only 12 birds.

Initial blood pressure measurements and blood pressure measurements obtained 5 minutes later from the wing did not vary significantly within bird (for the initial blood pressure measurements, $P = 0.2$, 0.6, 0.4, and 0.4, respectively, for systolic, mean, and diastolic arterial blood pressures and indirect blood pressure; for the subsequent blood pressure measurements, $P = 0.1$, 0.1, 0.3, and 0.3, respectively, for systolic, mean, and diastolic arterial blood pressures and indirect blood pressure). Similarly, blood pressure measurements obtained from the leg did not vary significantly within bird ($P = 0.2$, 0.4, 0.3, and 0.3, respectively, for systolic, mean, and diastolic arterial blood pressures and indirect blood pressure). Initial blood pressure measurements obtained from the wing were not significantly different from subsequent measurements ($P = 0.1$, 0.2, 0.2, and 0.4, respectively, for systolic, mean, and diastolic arterial blood pressures and indirect blood pressure). Because significant differences were not identified within birds, mean values were calculated for the blood pressure measurements (**Table 1**). Body weight was not significantly ($P > 0.1$) correlated with any of the blood pressure measurements.

Table 1—Direct and indirect blood pressure measurements obtained in 16 Hispaniolan Amazon parrots anesthetized with isoflurane.

	Pressure (mm Hg)		
Measurement	**Mean**	**SD**	**Range**
Indirect (wing)	140	25	104–197
Direct			
Systolic	163	18	119–200
Mean	155	18	112–185
Diastolic	148	18	106–171
Indirect (leg)	145	28	96–196
Direct			
Systolic	159	28	113–206
Mean	152	28	97–190
Diastolic	144	30	83–181

Indirect blood pressures were obtained from the wing and a leg by means of a Doppler ultrasonic flow detector. Direct blood pressures were obtained by means of an arterial catheter at the same times indirect blood pressures were obtained.

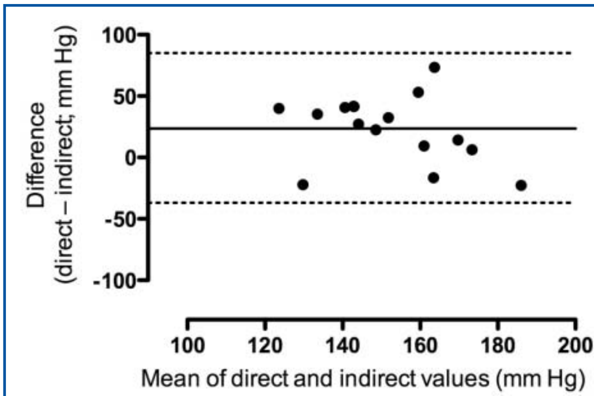

Figure 1—Bland-Altman plot of agreement between direct systolic arterial blood pressure measurements and indirect blood pressure measurements obtained from the wing in 16 Hispaniolan Amazon parrots anesthetized with isoflurane.

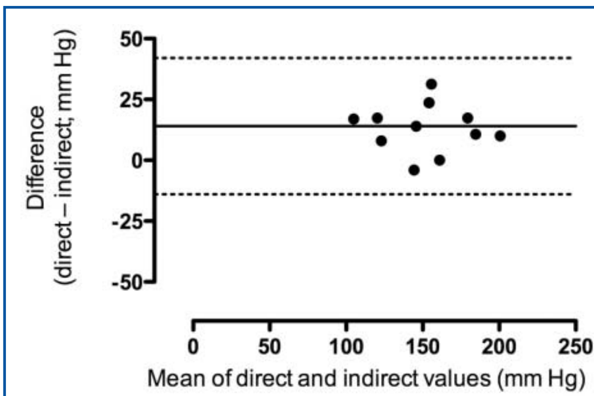

Figure 2—Bland-Altman plot of agreement between direct systolic arterial blood pressure measurements and indirect blood pressure measurements obtained from the leg in 12 Hispaniolan Amazon parrots anesthetized with isoflurane.

Derived and corrected SDs for comparisons between indirect blood pressure measurements obtained with the Doppler detector and direct systolic pressures were 27 and 31 mm Hg, respectively. The SD for indirect blood pressure measurements obtained from the leg was 10 mm Hg; the corrected value was 14 mm Hg.

Analysis of agreement between systolic arterial blood pressure and indirect blood pressure measurements obtained from the wing revealed substantial disagreement (bias, 24 mm Hg; limits of agreement, –37 to 85 mm Hg; **Figure 1**). Similarly, analysis of agreement between systolic arterial blood pressure and indirect blood pressure measurements obtained from the leg revealed substantial disagreement (bias, 14 mm Hg; limits of agreement, –14 to 42 mm Hg; **Figure 2**).

Discussion

Results of the present study suggested that there was substantial disagreement between indirect blood pressure measurements obtained with a Doppler ultrasonic flow detector in anesthetized Hispaniolan Amazon parrots and systolic arterial blood pressures measured directly. Attempts to obtain indirect blood pressure measurements from these birds with an oscillometric unit were consistently unsuccessful.

One possible explanation for the lack of agreement in blood pressure measurements in the present study was that the cuff that was used was an inappropriate size for these birds. Improper cuff size has been shown to adversely impact blood pressure measurement in other species.[1,8] However, errors associated with improper cuff selection in other species have been shown to be consistent.[1,7] That is, use of cuffs that are too wide results in pressure measurements that are consistently too low, whereas use of cuffs that are too narrow results in pressure measurements that are consistently too high. In the present study, however, indirect blood pressure measurements that were obtained were not consistently higher or lower than direct systolic blood pressure values. Thus, improper cuff size was not a likely cause of the disagreement in the present study.

Having a single individual performing all indirect blood pressure measurements could be considered a weakness of the present study. However, the individual performing indirect blood pressure measurements was familiar with this technique, and we believe that use of a single experienced individual reduced variability.

The most likely explanation for the poor agreement between indirect and direct blood pressure measurements is that the Doppler ultrasonic flow detector was not sensitive enough for use in these birds. Therefore, until further studies can be performed, use of indirect blood pressure measurements in Hispaniolan Amazon parrots and other similar-sized birds cannot be recommended.

a. Datascope Passport II with gas module, Datascope Corp, Montvale, NJ.
b. Arizant Healthcare Inc, Eden Prairie, Minn.
c. Abbocath-T, Venisystems, Sligo, Republic of Ireland.
d. DTX Plus, Becton Dickinson, Sandy, Utah.
e. Model 811-B, Parks Medical, Spokane, Wash.
f. ADCUFF, American Diagnostic Corp, Hauppauge, NY.
g. Cardell Max-1, Sharn Veterinary, Tampa, Fla.
h. SPSS, version 15.0, SPSS Inc, Chicago, Ill.
i. GraphPad Prism, version 5.0 for Macintosh, GraphPad Software Inc, San Diego, Calif.

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1. Binns SH, Sisson DD, Buoscio DA, et al. Doppler ultrasonographic, oscillometric sphygmomanometric, and photoplethysmographic techniques for noninvasive blood pressure measurement in anesthetized cats. *J Vet Intern Med* 1995;9:405–414.
2. Branson KR, Wagner-Mann CC, Mann FA. Evaluation of an oscillometric blood pressure monitor on anesthetized cats and the effect of cuff placement and fur on accuracy. *Vet Surg* 1997;26:347–353.
3. Stepien RL, Rapoport GS, Henik RA, et al. Comparative diagnostic test characteristics of oscillometric and Doppler ultrasonographic methods in the detection of systolic hypertension in dogs. *J Vet Intern Med* 2003;17:65–72.
4. Coulter DB, Keith JC Jr. Blood pressures obtained by indirect measurement in conscious dogs. *J Am Vet Med Assoc* 1984;184:1375–1378.
5. Lichtenberger M. Determination of indirect blood pressure in the companion bird. *Semin Avian Exotic Pet Med* 2005;14:149–152.
6. Lichtenberger M, Ko J. Critical care monitoring. *Vet Clin North Am Exot Anim Pract* 2007;10:317–344.
7. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986;1:307–310.
8. Brown SA, Henik RA. Diagnosis and treatment of systemic hypertension. *Vet Clin North Am Small Anim Pract* 1998;28:1481–1494.

Selected abstract for *JAVMA* readers from the *American Journal of Veterinary Research*

Comparison of the anesthetic efficacy
and cardiopulmonary effects of continuous rate infusions
of alfaxalone-2-hydroxypropyl-β-cyclodextrin and propofol in dogs

Barbara Ambros et al

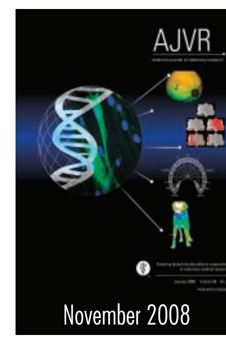
Objective—To compare the cardiopulmonary effects of continuous rate infusions (CRIs) of alfaxalone-2-hydroxypropyl-β-cyclodextrin (HPCD) and propofol in healthy dogs.

Animals—6 young adult medium-sized healthy crossbred dogs.

Procedures—A crossover design was used with a washout period of 6 days between anesthetic treatments. Each dog was sedated with acepromazine (0.02 mg/kg, IV) and hydromorphone (0.05 mg/kg, IV). Anesthesia was induced with propofol (4 mg/kg) or alfaxalone-HPCD (2 mg/kg). After endotracheal intubation, anesthesia was maintained with the same agent (propofol, 0.25 mg/kg/min; alfaxalone-HPCD, 0.07 mg/kg/min) for 120 minutes. Dogs spontaneously breathed 100% oxygen. Measurements included end-tidal partial pressure of carbon dioxide, heart and respiratory rates, mean arterial blood pressure, thermodilution-derived cardiac output, and body temperature. Paired arterial and mixed venous blood samples were collected for determination of blood pH, Pa_{CO_2}, and Pa_{O_2}. Data were recorded prior to induction; 5, 15, 30, 60, 90, and 120 minutes after induction of anesthesia; and 20 minutes after stopping the CRI, when feasible. Stroke volume and systemic vascular resistance were calculated. Quality of anesthetic induction and recovery and interval to recovery were recorded.

Results—Both propofol and alfaxalone-HPCD produced excellent induction of anesthesia, maintenance, and recovery. Respiratory depression was evident with both anesthetics. Clinically acceptable, mild hemodynamic changes were similar for both anesthetics.

Conclusions and Clinical Relevance—Alfaxalone-HPCD produced clinically acceptable anesthetic quality and hemodynamic values ideal for use as a CRI. Ventilation may need to be supported if hydromorphone is used at these propofol and alfaxalone-HPCD infusion rates. (*Am J Vet Res* 2008;69:1391–1398)



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