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CHARACTERIZATION OF THE PRESSURE PARAMETERS OF THE BOA CONSTRICTOR (BOA CONSTRICTOR)

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Abstract: Currently, exotic animals represent a new category of companion animals, including boa constrictors in this group. Therefore, there is an urgent need for reference parameters to establish the most varied diagnoses. Although the morphology and cardiac physiology of reptiles have already been studied, there is a gap in adult and geriatric boa constrictors, especially those in captivity, due to incorrect handling and breeding conditions. Therefore, the objective was to evaluate the heart rate (HR) and systolic (SBP), diastolic (DBP) and mean (MAP) blood pressure of the boa constrictor. This research is approved by the Ethics Committee on the Use of Animals. We used 40 specimens of boa constrictors (Boa constrictor), healthy adults, from the ``*Criatório Jiboias Brasil*`` (Brazil), 20 males (average 1.80 m) and 20 females (average 2.10 m), weighing between 5. 2 to 12.6 kg, in the pre-prandial period (21 days of fasting). The evaluation of HR (bpm), SBP, DBP and MAP (mmHg) were carried out using a non-invasive, high-resolution oscillometric method with the In Monitor - Inpulse device with seven sequential measurements. The mean values and standard deviation for males were: HR (18 ± 8); SBP (42 ± 1.8); MAP (33 ± 2.1); DBP (24 ± 3.8) and, for females: HR bpm (20 ± 5); SBP (47 ± 2.6); MAP (34 ± 3.5); PAD (26 ± 4.2). Only SBP was statistically different ($p<0.05$) between males and females. To date, there is no descriptive work on the SBP, MAP and DBP of boa constrictors (Boa constrictor), most likely due to the difficulty of measuring with conventional Doppler, as well as the invasive method. This way, the results generated by the high-resolution oscillometric method with quantitative and qualitative graphs are reliable, helping many reptile clinicians to establish more accurate diagnoses during their clinical routine.

Keywords: reptiles, boa constrictor, cardiology.

INTRODUCTION

In recent years, exotic animals represent a new category of companion animals, called "new companion animals" and among them, we have the boa constrictors (Boa constrictor). This way, the clinic for new companion animals is growing exponentially, creating an urgent need for reference parameters in different areas of the veterinary medical clinic, for the establishment of the most varied diagnoses.

In the modern world, breeding reptiles for entertainment is a relatively recent practice compared to other breeding, but it has been growing rapidly. Today, it is already considered the third largest in the pet industry in the United States and Europe, second only to cats and dogs, having even surpassed birds (``*Jiboias Brasil*``, 2022).

In Brazil, despite being very recent, the "Herpe" market has been following this trend and growing very quickly. Reptiles, however, require care that is quite different from that required by other domestic animals and this is why it is essential that we know the biology of each species that we intend to breed (``*Jiboias Brasil*``, 2022).

Among the various areas of knowledge in clinical medicine for exotic animals, reptile cardiology is a very underdeveloped specialty in relation to the diagnosis, treatment and prevention of cardiovascular changes (Kik and Mitchell, 2005; Pees and Tully, 2011).

It is known that the morphology and cardiac physiology of reptiles are already well studied and documented, however, the applicability of this knowledge in the medical clinic of reptiles is scarce and poorly developed (Kik and Mitchell, 2005; Mitchell 2009).

Many authors justify this scarcity due to the fact that many reptiles do not reach adulthood and geriatrics, due to incorrect management and breeding conditions for the species. Therefore, diseases of the cardiovascular system in adult or elderly animals are little studied (Mitchell and Tully, 2016).

On the other hand, conventional companion animals reach and often even exceed their average life expectancy, and there are, therefore, many published manuscripts on cardiovascular diseases. However, as dedication and interest in reptiles increases, their life expectancy increases and, with it, the advances and relevance of cardiology in reptiles grows as well (Murray and Mader, 2006; Mitchell and Tully, 2016).

The circulatory system of reptiles is very similar to that of birds and mammals in terms of basic morphology. However, it is important to be familiar with and know the existing anatomical differences in order to evaluate and diagnose pathological changes. The main differences between reptiles include the shape of the heart, degree of separation of the ventricular compartments, degree of development of the intraventricular muscular crest. In many cases, the structural-functional characteristics of the reptilian heart provide adaptive plasticity, allowing for the observed ecological and behavioral diversity.

As a result, variations in clinical measures of cardiac performance may arise (Wyneken, 2009).

The heart of reptiles is subdivided into three anatomical variations, and although they all share a basic morphology, they have differences that reflect the physiological variations of each species (Schilliger, 2006; Wyneken, 2009). Therefore, understanding variation in reptilian cardiovascular systems and its functional implications for the assessment and treatment of reptilian patients is imperative.

Snakes are excellent models for studying blood pressure and circulatory physiology due to their elongated body shape. Furthermore, they vary in size and length, and can survive in a vast number of habitats, ranging from completely arboreal to completely aquatic (Seymour and Lillywhite, 1976, Seymour and Arndt, 2004).

Due to the elongated bodies, the fluid columns within the vessels are extremely susceptible to hydrostatic changes during upright postures (due to gravitational action). Due to the absence of venous valves, blood tends to accumulate in the lower parts when the snake is in an upright position. This leads to a decrease in cephalic blood flow, eventually causing the animal's death after a long period (Seymour and Lillywhite, 1976, Seymour and Arndt, 2004).

However, many snakes have developed behavioral, physiological and morphological mechanisms to compensate for the problems caused by reduced blood flow to the brain. Arboreal and terrestrial snakes generally regulate blood pressure similarly, with only a few differences. Snakes, which have a completely aquatic habit, in turn, show little ability to regulate blood pressure when placed in a terrestrial environment (Seymour and Lillywhite, 1976, Lillywhite, 1985, Seymour and Arndt, 2004).

Arboreal and terrestrial snakes, for example, when in an upright position perform movements that facilitate circulation (cardiovascular facilitative movements), which consist of lateral undulations that move quickly along the body independent of circulation and always towards the anterior end. Such movements increase the heart's venous return and end-systolic volume, increasing both arterial and venous pressure and thus increasing systemic arterial flow (Lillywhite, 1985).

The mean arterial pressure (MAP) generated by the animals' hearts provides the driving force that ensures adequate perfusion of the various vascular beds to meet metabolic needs. MAP is composed of two main components: the pressure required to overcome total systemic vascular flow resistance (TPR), as well as the pressure required to overcome the vertical distance between the heart and upper extremities of the body, i.e., gravitational pressure (hydrostatic) (Gauer and Thorn, 1965, White and Seymour, 2014).

Gravitational pressure directly correlates with the vertical distance above the heart (h) and can be quantified as ρgh, where ρ equals blood density and g is acceleration of gravity (Gauer and Thorn, 1965). Because the vertical distance between the heart and upper extremities typically increases as animals get larger, greater gravitational forces predict MAP to increase with body size (Seymour, 1987; White and Seymour, 2014).

Consistent with this view, MAP is exceptionally high in giraffes, about 250 mmHg, well above other mammals of similar size, and is typically viewed as an adaptation to overcome the large vertical distance between the heart and head and thus provide a normal perfusion pressure of the cerebral circulation (Patterson et al., 1965; Brondum et al., 2009).

In birds, MAP is higher than in mammals, this is because MAP is directly proportional to body mass, with no relation to the distance between the heart and the head. Thus, it has been suggested that factors other than gravity, such as metabolic rate, have major impacts on MAP (Seymour and Blaylock, 2000).

The cardiovascular system of long-bodied animals, such as snakes, is particularly affected by gravity, and terrestrial and arboreal species are endowed with effective physiological mechanisms and structural adaptations that prevent the accumulation of blood in the lower parts of the body and maintain the heart when body position is altered (Lillywhite, 1985; Seymour and Arndt, 2004; Lillywhite et al., 2012).

An interspecific comparison of 16 individuals belonging to nine different species of land snakes revealed a significant increase in MAP with body length, such that MAP increased proportionally to the distance between the heart and head when expressed as the increase in gravitational pressure (Seymour, 1987).

Interspecific allometric analyzes often provide fundamental relationships that transcend taxonomic differences (Savage et al., 2008), but the scaling of intraspecific and interspecific relationships can differ significantly (Thompson and Withers, 1997).

Therefore, this work aims to describe the blood pressure parameters and heart rate of boa constrictors (Boa constrictor).

MATERIALS AND METHODS

This research was approved by the Ethics Committee on the Use of Animals (114/2022-CEUA/UFMG). The experiment was carried out at the Toxicology Laboratory of the Veterinary School of ``*Universidade Federal de Minas Gerais*`` – EV-UFMG, at the Santo Agostinho Veterinary Hospital - Belo Horizonte and at the Jiboias Brasil Breeding Facility - Betim (MG).

Forty boa constrictors (Boa constrictor) were used, 20 males (average of 1.80 m) and 20 females (average of 2.10 m), all adults, ranging from 5.2 kg to 12.6 kg, in a pre--prandial, 21 days of fasting, from ``*Criatório Jiboias Brasil*``.

The inclusion criteria established for this study were: boa constrictors of both sexes and ages, subject to correct management, without signs of clinical disease and preferably coming from the same source. The animals evaluated in this study are clinically healthy animals, with adequate management conditions and balanced nutrition.

The animals were handled in compliance with all biosafety and exotic animal handling protocols. All animals underwent the same experimental protocol in order to avoid different stress changes.

The assessment of heart rate, systolic, diastolic and mean blood pressure was carried out using the high-resolution oscillometric method with the In Monitor, Inpulse Brasil device. Carrying out seven sequential measurements, excluding the highest and lowest pressure to calculate the mean and standard deviation.

Data processing and analysis was carried out using SPSS © IBM version 20 and STATA version MP™ software. For the purposes of descriptive statistics, measures of central tendency were calculated as the mean, and measures of dispersion as the standard deviation. Mixed model regression analysis was performed at a significance level of $p<0.05$.

RESULTS AND DISCUSSION

There are several methods for measuring the blood pressure of reptiles, and the most reliable is the invasive method (gold standard) of measuring systemic blood pressure. However, this method is used during surgical procedures by anesthetists and is not viable for reptile clinicians. For this reason, it was decided to use the high-resolution oscillometry method with the presence of a sample graph.

The mean values and standard deviation of SBP, MAP, DBP and HR of male and female boa constrictors (Boa constrictor) are shown in Table 1.

Parameters	Groups/standard deviation	
	Male (1,80m)	Female (2,10)
PAS (mmHg)	42 ± 1,8 **a**	47 ± 2,6 **b**
PAM (mmHg)	33 ± 2,1	34 ± 3,5
PAD (mmHg)	24 ± 3,8	26 ± 4,2
FC (bpm)	18 ± 8	20 ± 5

Table 1: Average values and standard deviation of SBP, MAP, DBP and HR of male and female boa constrictors (Boa constrictor)

Averages followed by equal lowercase letters in the row or equal capital letters in the column do not differ from each other according to mixed model regression analysis at a significance level of $p<0.05$.

Analyzing the values obtained from the SBP, MAP, and DBP measurements of the different groups, we verified that there was a significant difference between the SBP values of males compared to those of females. In other words, the SBP of females (47 ± 2.6 mmHg) is higher than that of males (42 ± 1.8 mmHg), due to their larger size and weight, requiring a higher blood pressure in females than in males, as was observed in the study by Smour (1987).

An interspecific comparison of 16 individuals belonging to nine different species of land snakes revealed a significant increase in MAP with body length, such that MAP increased proportionally to the distance between the heart and head when expressed as the increase in gravitational pressure (Seymour, 1987).

The values obtained for SBP, MAP, MAP and HR are similar to those found by Seymour, 1976, in which he characterized the difference in systolic blood pressure of snakes in different habitats. As the boa constrictors studied are characterized as semi-terrestrial, the values found in the present study corroborate the work described by Seymour (1976).

There is little literature on systemic arterial pressure in reptiles, especially in Boa constrictors (Boa constrictor), and, to date, this is the first descriptive work on SBP, MAP and DBP, most likely due to the difficulty of measuring with conventional Doppler, as well as the invasive method. This way, the high-resolution oscillometric method with quantitative and qualitative graphs will help many reptile clinicians to be able to measure pressure during their clinical routine.

CONCLUSIONS

It was found that the normal values for SBP, PAM and DBP for boa constrictors are very similar to those of other snakes already described, such as *Corn Snakes* and *Pythons* and other reptiles in general. However, a difference in SBP was observed between males and females, which is explained by the size of the adult animal, as females are larger and heavier and consequently require a higher SBP for complete blood supply to the body, which corroborates the findings studies to date described in other species of snakes.

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