FULL ARTICLE

ISSN Online 1678-4456

Ultrasonographic characterization of abdominal organs of baby opossums

Caracterização ultrassonográfica de órgãos abdominais de filhotes de gambá

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ABSTRACT

Abdominal ultrasound is an important resource for diagnosing numerous conditions in veterinary medicine. Describing the ultrasound findings of abdominal organs that are considered normal is important for guiding diagnosis and therapeutic follow-up. There are few studies around abdominal ultrasound in wildlife medicine, such as opossums, which are widely distributed throughout the Americas and are frequently sent to wildlife care centers and yet very little is known about them in terms of ultrasound. The aim of this study was to evaluate the abdominal organs of healthy baby opossums. Thirty-eight opossums (19 males and 19 females) weighing between 110 and 180 grams were evaluated. There was no significant difference between the genders; however, there was a difference between the weight classes when measuring the kidneys and the urinary vesicle wall. The average thickness in centimeters of the gastric wall was 0.13 (±0.01), of the gallbladder was 0.05 (±0.01) and of the colon was 0.15 (±0.17). In the subjective assessment, the organ characteristics such as echotexture and echogenicity were similar to those described in the literature and the measurements obtained were specific to the species.

Keywords: Wild animals. Didelphids. Ultrasound. Abdominal organs.

RESUMO

A ultrassonografia abdominal é um importante recurso para o diagnóstico de inúmeras afecções na medicina veterinária. A descrição dos achados ultrassonográficos dos órgãos abdominais considerados normais é importante para o direcionamento do diagnóstico e acompanhamento da terapêutica. Especialmente na medicina de animais silvestres, poucos estudos são realizados nesta área, por exemplo os gambás, embora amplamente distribuídos pelas Américas e frequentemente encaminhados para os centros de atendimento de animais silvestres, pouco se sabe na área da ultrassonografia. Desta forma, o objetivo deste trabalho foi avaliar os órgãos abdominais de gambás filhotes saudáveis. Foram avaliados 38 gambás (19 machos e 19 fêmeas) com peso entre 110 e 180 gramas. Não houve diferença significativa entre os sexos, entretanto, foi observado diferença entre as classes de pesos na mensuração dos rins e a parede da vesícula urinária. A espessura média, em centímetros, da parede gástrica foi de 0,13 (±0,01), da vesícula biliar foi de 0,05 (±0,01) e do cólon foi de 0,15 (±0,17). Na avaliação subjetiva, as características dos órgãos como ecotextura e ecogenicidade foram similares as descritas na literatura estudada e as medidas obtidas são específicas para a espécie.

Palavras-chave: Animais silvestres. Didelfídeos. Ultrassom. Órgãos abdominais.

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Received: September 21, 2023
Approved: July 19, 2024

How to cite: Cavalcanti EANLD, Cavalcanti GAO, França RT. Ultrasonographic characterization of abdominal organs of baby opossums. Braz J Vet Res Anim Sci. 2024;61:e216172. https://doi.org/10.11606/issn.1678-4456.bjvras.2024.216172.

Introduction

Abdominal ultrasound is a noninvasive imaging modality used to evaluate abdominal organs. It is highly accessible and can be used in any condition. It is essential in evaluating and identifying alterations in different animal species' urinary, digestive, and reproductive tracts (Hildebrandt et al., 2000; Penninck & D'Anjou, 2015).

The description of the ultrasound findings considered normal for abdominal organs serves as a subsidy for the imaging specialist to correctly identify changes, reducing the possibility of error in the diagnostic interpretation (Mattoon et al., 2014; Massari et al., 2019). Although the ultrasound examination is widely used in the diagnostic routine in veterinary medicine, there are few references in the literature addressing the ultrasound anatomy of healthy wild animals (Hildebrandt & Göritz, 1998; Hildebrandt et al., 2000; Massari et al., 2019; Pinto, 2020).

A study in southern Brazil (Cavalcanti et al., 2021) pointed to opossums as the mammals most often referred to for imaging studies. The white-eared opossum (*Didelphis albiventris*) is a marsupial widely distributed in South America and frequent in southern Brazil (Tyndale-Biscoe, 2005). However, few studies have been described in the literature on this species, mainly in diagnostic imaging (Bortolini et al., 2013; Massari et al., 2019).

Thus, this study aimed to describe the ultrasound findings of baby opossums to serve as reference values.

Methodology

A total of 38 animals (19 males and 19 females), considered healthy in the clinical examination and weighing between 100 and 180 grams, were selected. The animals underwent screening abdominal ultrasound evaluation.

The animals were positioned in a supine position and manually restrained. No food or water fasting was performed, but the abdominal region of each opossum was carefully massaged to stimulate defecation before each evaluation, and 70% liquid alcohol and acoustic gel were used to obtain the images.

The same evaluator performed two-dimensional ultrasound evaluations, evaluating the size, shape, contour, echogenicity, and echotexture of the abdominal organs: urinary bladder, kidneys, stomach, intestine, liver, gallbladder, and spleen. The evaluations were performed using a Sonosite MicroMax® ultrasound and a linear multifrequency probe (6-13 MHz).

The data were recorded individually in a spreadsheet with identification, weight, sex, and ultrasound measurements and subjected to descriptive analyses. The data were grouped into classes, namely, class I (CI): 101 to 120 g; class II (CII): 121 to 140 g; class III (CIII): 141 to 160 g; and class IV (CIV): 161 to 180 g.

The mean and standard deviation were calculated, and the BioEstat® software presented each organ's minimum and maximum values. Pearson's correlation test was performed, and subsequently, the data were analyzed for normality using the Shapiro-Wilk test, homoscedasticity using the Hartley test, and independence of residuals using graphic analysis. The data were submitted to analysis of variance using the F-test ($p \leq 0.05$) and compared by the Tukey's test ($p \leq 0.05$) using the SAS System® and RStudio® software, and the graphs were plotted in the Sigmaplot® software.

The experiment was submitted and approved by the Chico Mendes Institute (ICMBio) No.76962-1 and by the Ethics Committee for Animal Experimentation of the Federal University of Pelotas (CEEA/UFPel) No. 012630/2021-18.

Results

The weight of the 38 baby opossums (*D. albiventris*) ranged from 101 to 180 grams, and the data were grouped into four classes with an interval of 20 grams. CI (100-120 g) presented the highest number of animals, n=18 (48.6%), followed by CII (121-140 g), n=8 (21.6%), and CIII (141-160 g) and CIV (161-180 g), with n=6 opossums (14.9%) in each. The analysis between the sexes showed no significant difference.

However, the weight classes of the evaluated baby opossums showed a statistical difference, except for the thickness of the gastric wall and gallbladder, in which the measurements did not change significantly compared to the weights (Table 1).

The correlation between the ultrasound measurement of abdominal organs and weights reflects the intensity of

Table 1 – Comparison of abdominal organs (cm) measurements of baby opossums between weight classes

Weight class	Abdominal organs								
	UB	ST	GB	LKL	LKH	LKW	RKL	RKH	RKW
I	0.06a	0.11a	0.05a	1.81a	0.87a	0.92a	1.79a	0.87a	0.92a
II	0.07ab	0.12a	0.05a	1.81a	0.84a	0.93a	1.79a	0.88a	0.94ab
III	0.09b	0.12a	0.06a	1.87ab	0.89a	0.93a	1.82ab	0.91a	1.04b
IV	0.09b	0.12a	0.06a	1.99b	0.91a	1.00b	1.93b	0.93a	1.00b

Means followed by the same letter in the column do not differ from each other by Tukey's test (p≤0.05), comparing the ultrasound measurements of abdominal organs between the weight classes of baby opossums. UB = urinary bladder; ST = stomach; GB = gallbladder; LKL = left kidney length; LKH = left kidney height; LKW = left kidney width; RKL = right kidney length; RKH = right kidney height; RKW = right kidney width.

a linear relationship between two sets of data (Figure 1). The relationship between the increase in organs and weight classes was positive, with R^2 values close to 1. That is, the values were equal to 0.99 for almost all organs, except for the kidneys, whose values were higher than 0.82 for renal height and higher than 0.90.

The ultrasound evaluation of the abdominal cavity was complex due to the animal's size and the pair of epipubic bones present caudally in the abdomen. However, this did not prevent a careful abdominal evaluation. There was no sign of free abdominal fluid.

The urinary bladder wall (Figure 2) was thin and regular, with a mean thickness of 0.08 cm (±0.01). Moreover, the bladder presented anechogenic contents in a moderately filled organ.

The kidneys (Figure 3) presented oval morphology, were symmetrical, and showed no sign of pyelectasis. The renal cortical region was isoechoic about hepatic echogenicity and hypoechoic about the spleen. In addition, the renal medullary region was markedly hypoechoic in the evaluated animals. The renal length and width varied according to the classes, showing a significant difference (p>0.05). The width of the renal cortical region was also evaluated, and the corticomedullary ratio was equal to 1.01 (Table 2).

The evaluated organs of the gastrointestinal tract were the stomach, intestine, liver, and gallbladder. However, the liver was the only organ evaluated subjectively. The stomach (Figure 4) was centrally disposed at the xiphoid level, with a slight predominance to the left side. The organ was filled with gaseous content, which allowed the identification of its ventral wall (proximal to the transducer), regular wall, and absence of gastric wrinkles. The mean thickness of the gastric wall was 0.13 (±0.01).

The intestinal layers were not correctly observed in all segments (jejunum, ileum, and colon), and the jejunum and ileum could not be adequately evaluated. Therefore, only the descending colon (Figure 5) was evaluated among the intestinal loops. The mean thickness of this organ was 0.15 (±0.02), a segment with a moderate amount of gaseous content.

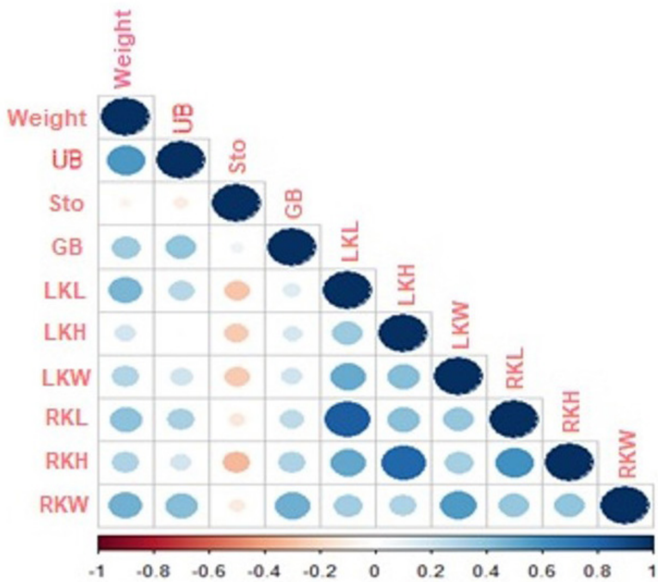

Figure 1 – Graphic representation of Pearson's correlation for the variables weight and ultrasound measurements of abdominal organs of baby opossums. Size and color represent correlation; the larger and darker, the more correlated. UB = urinary bladder; STO = stomach; GB = gallbladder; LKL = left kidney length; LKH = left kidney height; LKW = left kidney width; RKL = right kidney length; RKH = right kidney height; RKW= right kidney width.

The echogenicity evaluation showed that the liver was similar to or slightly higher than the renal cortical and lower than the spleen. Its echotexture was homogeneous. Moreover, the hepatic hilum could be observed. The gallbladder (Figure 6) was observed with a rounded shape, filled with anechogenic and homogeneous content, and its wall had a mean value of 0.05 cm.

The spleen (Figure 7) was elongated in the longitudinal section and triangular in the transverse section. The subjective evaluation showed that the spleen's echogenicity was higher than that of the hepatic parenchyma and the cortical region of the kidney. The splenic parenchyma showed a homogeneous echotexture.

Other abdominal cavity organs, such as the pancreas and adrenals, were not evaluated due to the difficulty of

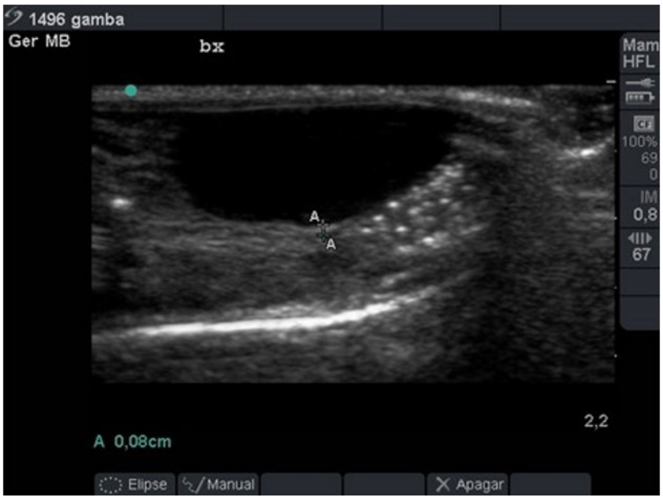

Figure 2 – Ultrasonographic image of the urinary bladder of a *D. albiventris* pup. Note the area between “A’s” (+) measuring the organ wall. Note that the organ is filled mainly with anechoic content.

optimally characterizing them using the device and the conditions in which this experiment was carried out.

Discussion

The organs were arranged as observed anatomically in dogs, cats, anteaters, and kangaroos (Lopes et al., 2015; Penninck & D’Anjou, 2015; Carvalho, 2020; Menzies et al., 2020), with no sign of free abdominal fluid. However, wild animals may have fluid in the abdominal cavity, as described by Lopes et al. (2015), who found a discrete amount of free fluid near the left kidney in healthy giant anteaters (*Myrmecophaga tridactyla*).

The wall thickness of the urinary bladder was similar to that presented by Santos (2009) for cats, and the anechogenic content was as described for dogs and cats (Santos, 2009; Penninck & D’Anjou, 2015) and wild animals (Lopes et al., 2015).

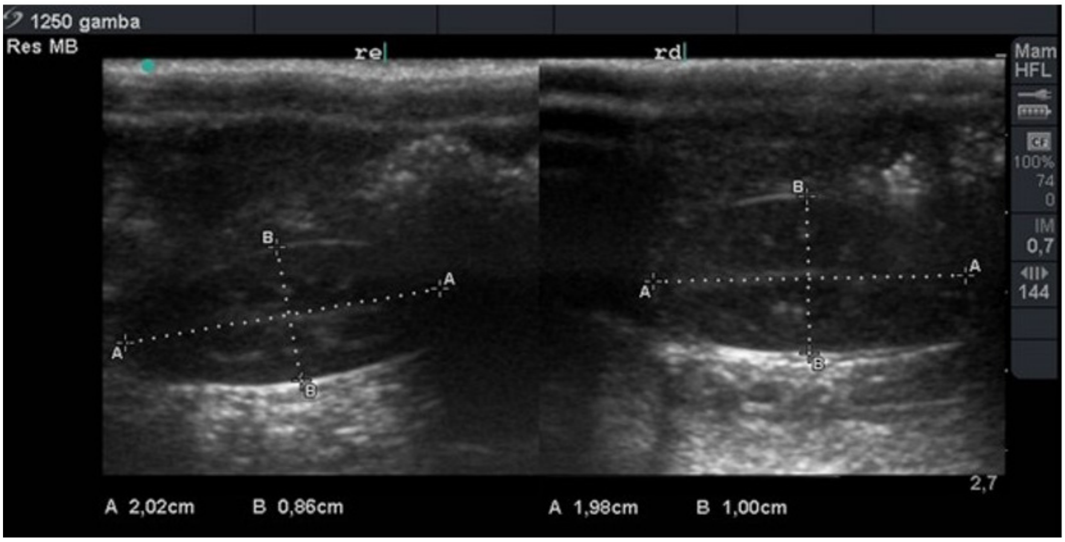

Figure 3 – Ultrasonographic image of the left (left) and right (right) kidneys of a baby *D. albiventris*. Organs presenting oval and symmetrical shapes. A greater echogenicity of the cortical region can be observed. The measurement area between “A’s” indicates the organs’ length and “B’s” width.

Table 2 – Summary of descriptive analysis of ultrasound measurements (in centimeters) of abdominal organs of baby opossums

Organ		Mean	Standard deviation	Minimum	Maximum
UB		0.08	0.01	0.05	0.10
ST		0.13	0.01	0.09	0.16
GB		0.05	0.01	0.04	0.07
Kidney	**LKL**	1.84	0.14	1.60	2.18
	LKH	0.88	0.08	0.76	1.09
	LKW	0.94	0.09	0.76	1.10
	RKL	1.81	0.12	1.57	2.05
	RKH	0.89	0.08	0.74	1.08
	RKW	0.95	0.07	0.78	1.10
	Cortical	0.19	0.01	0.16	0.23
	Medullary	0.18	0.02	0.15	0.23
	C/M	1.01	0.05	0.90	1.13
Colon		0.15	0.17	0.13	0.17

UB = urinary bladder; ST = stomach; GB = gallbladder; LKL = left kidney length; LKH = left kidney height; LKW = left kidney width; RKL = right kidney length; RKH = right kidney height; RKW = right kidney width; C/M = renal corticomedullary ratio.

Figure 4 – Ultrasonographic image of the stomach of a baby *D. albiventris*. Note that the measurement between "A's" (+) of the organ wall is regular and lacks gastric wrinkles. The organ is moderately replete with echogenic content.

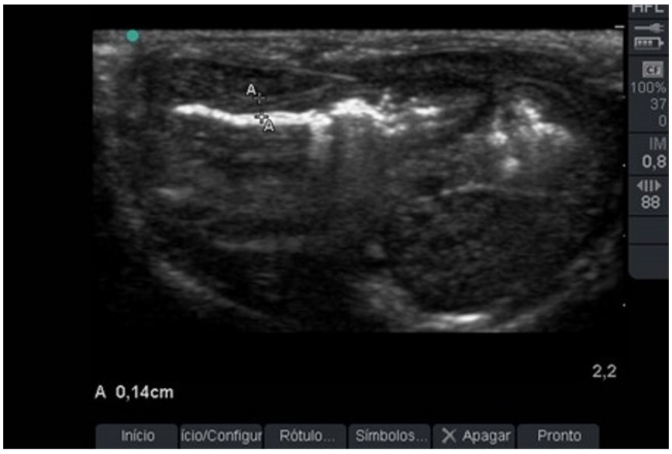

Figure 5 – Ultrasonographic image of the colon of a baby *D. albiventris*. Note the measurement between "A's" (+) of the organ wall and the presence of intraluminal gas.

Figure 6 – Ultrasonographic image of the liver and gallbladder of a baby *D. albiventris*. Note the measurement between the "A's" (+) of the gallbladder wall, which is piriform in shape and tends to be rounded, thin, and filled with anechoic content—liver presenting homogeneous echotexture.

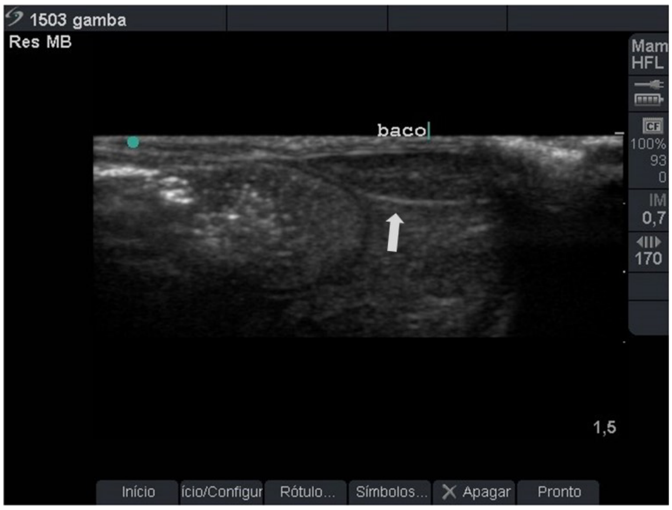

Figure 7 – Sonographic image of the spleen of a pup *D. albiventris* (arrow). It was not possible to observe the splenic hilum in the evaluation.

The renal architecture and corticomedullary ratio were evaluated similarly to those reported for cats and dogs (Vac, 2020). Moreover, no medullary signal was observed, as found for puppies, unlike what was found in half of the kittens studied by Santos (2009).

The stomach location and slight predominance to the left side were similar to those reported for cats (Froes, 2020). The thickness of the stomach wall was relatively thinner than that of 4-week-old puppies (Banzato et al., 2017). Regarding the intestinal loops, specifically the colon, Banzato et al. (2017) found similar values for puppies aged between 4 and 16 weeks.

The echotexture and hepatic and splenic echogenicity were similar to those described for dogs and cats (Penninck & D'Anjou, 2015; Griffin, 2019). The spleen morphology was triangular, as described for dogs, cats, and giant anteaters (Nyland & Mattoon, 2014; Lopes et al., 2015). In addition, the splenic hilum was challenging to observe, as reported for cats (Santos, 2009).

The adrenals and pancreas were not evaluated because they were not visualized. Santos et al. (2013) reported similar difficulties in cats. Also, they did not visualize the adrenals in puppies and kittens. However, the animals in this experiment were much lighter than the dogs and cats evaluated in those studies, thus justifying the difficulty found here.

Conclusion

This is the first study on the measurements and ultrasonographic characteristics of abdominal organs of baby opossums. The subjective evaluation showed that the organ characteristics, such as echotexture and echogenicity, were similar to those described in the studied literature. However, values obtained for the thickness of the wall of the stomach, gallbladder, and colon, in addition to the length and width of the kidneys, differ from those found for other species. No statistical difference was observed regarding the sexes, but animal weight directly influenced the size of the largest evaluated measures.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethics Statement

The experiment was submitted and approved by the Chico Mendes Institute (ICMBio) No.76962-1 and by the Ethics Committee for Animal Experimentation of the Federal University of Pelotas (CEEA/UFPel) No. 012630/2021-18.

Acknowledgements

This study was partly financed by the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - Finance Code 001 and the Graduate Program in Veterinary Medicine - UFPEL. The authors thank the Wildlife Rehabilitation Center (NURFS).

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Financial Support: None.