Conventional and Doppler Abdominal Ultrasonography in Pacas (*Cuniculus paca*)

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ABSTRACT

***Background*:** The first report of ultrasound evaluation in pacas was for gestational diagnosis and monitoring. However, there are no reports of the use of this technique for the evaluation of abdominal structure in pacas. Elucidating the biology of wild species is important for preservation and potential use as experimental models for human and animal research. As such, this study aimed to describe an ultrasonographic view of major abdominal organs and determine the vascular indices of abdominal aorta and renal arteries in pacas (*Cuniculus paca*) by Doppler mode.

***Materials, Methods & Results*:** Fifteen adult females with a mean weight of nine kilograms were positioned into dorsal or lateral recumbency. A specific gel was applied, and transabdominal ultrasound examination was performed by a single experienced evaluator using MyLab 30 VET ultrasound equipment (ESAOTE, Italy) with 7.5 and 10.0 MHz linear transducers. Anatomy, biometry and ultrasonographic findings, such as ecogenicity, echotexture and wall thickness of main abdominal organs (bladder, kidneys, adrenals, spleen, liver, digestive system and ovaries), were assessed during the ultrasound scan. Doppler ultrasound was used to determine the peak systolic velocity (PSV), end-diastolic velocity (EDV), resistance index (RI = [PSV - EDV]/PSV) and pulsatility index (PI = [PSV - EDV]/mean velocity) of the abdominal aorta and renal arteries. The animals were healthy based on physical examination, hemogram and biochemical profile. Furthermore, we determined that the ultrasound technique for abdominal evaluation of these animals was feasible. Major abdominal organs were accessed using conventional ultrasonography biometric values and sonographic characteristics. Doppler examination was used to determine mean vascular indices of the abdominal aorta and the left and right renal arteries.

***Discussion*:** Several studies using the ultrasound technique in wild animals have demonstrated the clinical importance and applicability of this imaging method for veterinary medicine. As mentioned, ultrasound examination is feasible, effective and important for the assessment of topographical relations and ultrasound characteristics of abdominal organs in pacas. During urinary bladder ultrasound examination of the caudal abdomen, little repletion with anechoic content without sediment was observed, renal structures presented a topography, echogenicity and cortico-medullary relationship (1:1) and sonographic findings of the spleen and liver of pacas were similar to those described in dogs and cats. Upon digestive system ultrasound, the stomach showed sonographic characteristics similar to dogs such as peristaltic movements (3 to 5 per minute) and intestinal silhouettes (2 to 3 per min). The adrenal glands were easily detected by ultrasound, located cranial to the ipsilateral kidney, the same as in dogs, ferrets and coatis. Ovaries, as well as the internal follicular structures, were observed near the caudal renal pole. These findings corroborate the findings of normal ovaries in dogs and cats. Doppler mode of the abdominal aorta and renal arteries was feasible and useful for the study of the physiology and detection of hemodynamic abnormalities in pacas. Conventional and Doppler ultrasonography allowed the study of the abdominal structures of pacas (*Cuniculus paca*), providing original and valuable information on the topographic anatomy and morphophysiology of abdominal tissues and their sonographic descriptions. The results of this study may aid in abdominal injury evaluation in these animals and other wild species.

Keywords: paca, ultrasound, Doppler.

INTRODUCTION

Paca (*Cuniculus paca*) is a typical rodent of Brazilian wildlife in tropical regions. These animals have zootechnical potential due to their great meat quality. Studies involving pacas are important for the multidisciplinary use of these animals and for supporting collaborative initiatives for their preservation [9].

The first report of ultrasound evaluation in pacas was for gestational diagnosis and monitoring [14]. However, there are no reports of the use of this technique for the evaluation of abdominal structure in pacas.

Studies using conventional and Doppler ultrasonography of wildlife animals are essential for anatomical and physiological descriptions of organic structures. Such analyses are characterized by their accurate and noninvasive evaluation [1], making it possible to provide relevant information to wildlife clinics for zootechnical use of these species.

Elucidating the biology of wild species is important for preservation and potential use as experimental models for human and animal research [16]. As such, this study aimed to describe an ultrasonographic view of major abdominal organs and determine the vascular indices of abdominal aorta and renal arteries in pacas (*Cuniculus paca*) by Doppler mode.

MATERIALS AND METHODS

Fifteen adult females with a mean weight of nine kilograms were previously submitted for physical examination, hemogram and biochemical profile (serum urea, creatinine, alanine aminotransferase - ALT and alkaline phosphatase - FA) to determine health and suitability for the study.

Animals were sedated using midazolam (0.5 mg/kg) and ketamine (30 mg/kg) [15]. For ultrasound examinations, the abdomen was widely trichotomized between the epigastric and hypogastric regions to the xiphoid process and inguinal region, extending laterally to the ventral region of the lumbar muscles, next to the last pair of ribs on the left side and the last two pairs of ribs on the right side [6]. After tricotomy, the animals were transferred to the ultrasound room.

All animals were positioned into dorsal or lateral recumbency. A specific gel was applied, and transabdominal ultrasound examination was performed by a single experienced evaluator using MyLab 30 VET ultrasound equipment (ESAOTE, Italy) with 7.5 and 10.0 MHz linear transducers.

Anatomy, biometry and ultrasonographic findings, such as ecogenicity, echotexture and wall thickness of main abdominal organs (bladder, kidneys, adrenals, spleen, liver, digestive system and ovaries), were assessed during the ultrasound scan.

Doppler ultrasound was used to determine the peak systolic velocity (PSV), end-diastolic velocity (EDV), resistance index (RI = [PSV - EDV]/ PSV) and pulsatility index (PI = [PSV - EDV]/mean velocity) of the abdominal aorta and renal arteries [8].

For vascular indices, Doppler ultrasonography was performed to determine vessel volume using the uniform insonation method. Power Doppler ultrasonography was performed to increase the sensitivity in detecting the blood flow of the vessels and to transform the examination from angle-independent to insonation or incident angle [7].

RESULTS

The animals were healthy based on physical examination, hemogram and biochemical profile. Furthermore, we determined that the ultrasound technique for abdominal evaluation of these animals was feasible.

Major abdominal organs were accessed using conventional ultrasonography biometric values (Table 1) and sonographic characteristics (Table 2 and Figure 1). Doppler examination was used to determine mean vascular indices of the abdominal aorta and the left and right renal arteries shown in Table 3 (Figure 2).

Table 1. Biometric values (mean and standard deviation) of major abdominal organs of pacas (*Cuniculus paca*).

Organs	Length (cm)	Width (cm)
Left kidney	4.95 ± 0.45	2.16 ± 0.19
Right kidney	4.46 ± 0.57	2.05 ± 0.23
Left adrenal	2.66 ± 0.45	0.75 ± 0.15
Right adrenal	2.61 ± 0.41	0.81 ± 0.08
Left ovary	1.48 ± 0.34	0.85 ± 0.16
Right ovary	1.29 ± 0.27	0.80 ± 0.12
Stomach wall thickness	0.31 ± 0.04	-------------
Bladder wall thickness	0.12 ± 0.02	-------------

Table 2. Sonographic characteristics of major abdominal organs of pacas (*Cuniculus pacas*).

Organ	Topography	Sonographic findings
Bladder	Caudal abdomen and ventral to distal colon	- Outer layer: hyperechoic - Muscle: hypoechoic - Lamina propria: hyperechoic - Mucosa: hypoechoic
Left kidney	Medial to the splenic silhouette - left hypochondrium	- Homogeneous parenchyma and hypoechoic compared to the spleen - Cortical medullary ratio 1:1
Right kidney	Renal fossa of the caudate lobe of the liver - right hypochondrium	
Adrenal	Cranial and medial to the ipsilateral kidney	- Homogeneous parenchyma and hypoechoic compared to the spleen
Spleen	Left hypochondrium	- Homogeneous parenchyma, coarse echotexture compared to liver, and isoechoic to kidney
Liver	Cranial abdomen	- Homogeneous parenchyma with fine echotexture and hypoechoic in relation to spleen - Right and left lobes
Stomach	Cranial abdomen lateralized to the left hypochondrium	- Lumen: hyperechoic - Mucosa: hypoechoic - Submucosa: hyperechoic - Muscular: hypoechoic - Serous: hyperechoic - peristaltic movements: 3 at 5 per min.
Ovaries	Nearby to the caudal pole of the ipsilateral kidney	- Homogeneous or heterogeneous parenchyma (presence of follicles) and hypoechoic compared to the spleen - Visualization of follicles (hypoechoic structures with thin walls)

Table 3. Sonographic characteristics of major abdominal organs of pacas (*Cuniculus pacas*).

Index	Abdominal aorta	Right renal artery	Left renal artery
PSV (cm / s)	20.15 ± 3.98	15.22 ± 2.30	15.31 ± 4.03
EDV (cm / s)	4.13 ± 1.96	4.16 ± 1.26	5.51 ± 1.96
PI	2.67 ± 1.84	1.82 ± 0.42	1.46 ± 0.23
RI	0.89 ± 0.22	0.79 ± 0.08	0.73 ± 0.06

PSV: Peak systolic velocity; EDV: end diastolic velocity; RI: vascular resistance; PI: pulsatility index.
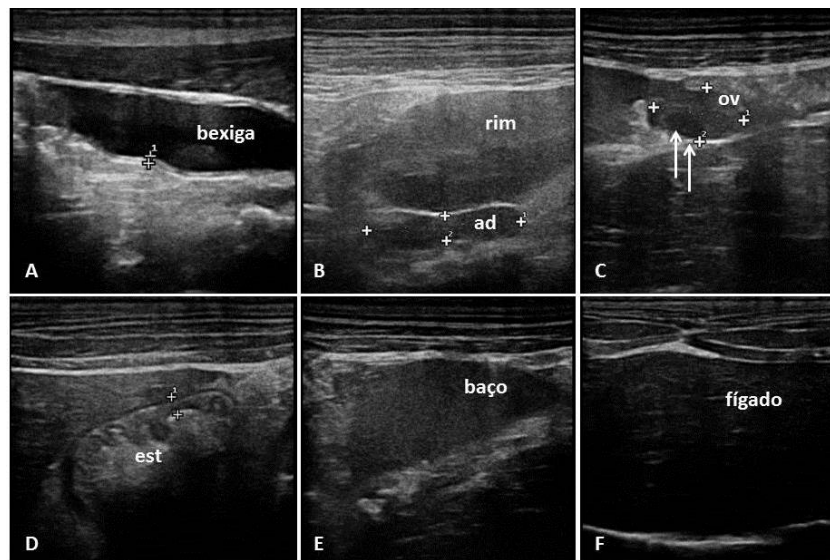
Figure 1. Images of abdominal ultrasound in pacas (*Cuniculus paca - Linnaeus*, 1766). Note the sonographic evaluation of abdominal structures: (A) bladder (bexiga); (B) kidney (rim) and adrenal (ad) left; (C) ovary (ov) and follicles (arrows); (D) stomach (est); (E) spleen (baço); (F) liver (fígado).

Figure 2. Doppler image of vascular indices determination of the abdominal aorta in pacas (*Cuniculus paca* - Linnaeus, 1766).

DISCUSSION

Several studies using the ultrasound technique in wild animals, such as ferrets (*Mustela furo*) [13], marmosets (*Callithrix jacchus*) [21], leopards (*Acinonyx jubatus*) [3] capuchin monkeys (*Sapajus apella*) [1] and coatis [17], have demonstrated the clinical importance and applicability of this imaging method for veterinary medicine. As mentioned, ultrasound examination is feasible, effective and important for the assessment of topographical relations and ultrasound characteristics of abdominal organs in pacas.

During urinary bladder ultrasound examination of the caudal abdomen, little repletion with anechoic content without sediment was observed, similar to that described in small animals [18] with a mean bladder wall thickness of 12 mm and pets with a bladder wall thickness of 1 to 5 mm [20].

In the present study, the renal structures presented a topography, echogenicity and cortico-medullary relationship (1:1) similar to that observed in marmosets [21], small animals [18,19], coatis [17] and leopards [3]. Regarding kidney size, the width and length were close to those found in adult dogs,

which have an average length of 5 cm [2] and a width of 2.97 cm [18].

Sonographic findings of the spleen and liver of pacas were similar to those described in dogs, cats [18,19] and coatis [17], except for the close relationship of splenic structure with the ipsilateral kidney.

Upon digestive system ultrasound, the stomach showed sonographic characteristics similar to dogs [10], such as peristaltic movements (3 to 5 per min) and intestinal silhouettes (2 to 3 per min). However, due to limitations in performing appropriate fasting, sonographic evaluation of intestinal structures was limited.

The adrenal glands were easily detected by ultrasound, located cranial to the ipsilateral kidney, the same as in dogs [5], ferrets [13] and coatis [17]. Regarding biometry values, the adrenals were larger than adrenal parameters observed in companion animals (cats: 10.7 mm length and 40 mm width; dogs: 10.7 to 50.0 mm length and 1.9 to 12.4 mm width for the left adrenal and 10 to 39.3 mm length and 3.1 to 12 mm width for the right adrenal [5].

Ovaries, as well as the internal follicular structures, were observed near the caudal renal pole. These findings corroborate the findings of normal ovaries in dogs and cats [11].

Doppler mode of the abdominal aorta and renal arteries was feasible and useful for the study of the physiology and detection of hemodynamic abnormalities in pacas. The vascular resistance and pulsatility indices are similar to healthy dogs. However, values for diastolic and systolic velocities are smaller than those reported in the literature for domestic dogs [4,12].

CONCLUSION

Conventional and Doppler ultrasonography allowed the study of the abdominal structures of pacas (*Cuniculus paca*), providing original and valuable information on the topographic anatomy and morphophysiology of abdominal tissues and their sonographic descriptions. The results of this study may aid in abdominal injury evaluation in these animals and other wild species.

Ethical Approval. The trial was conducted following approval by the Animal Welfare and Ethics Committee of the School of Agrarian and Veterinary Sciences of the São Paulo State University (FCAV/UNESP - Jaboticabal) (process no027420/11).

Declaration of interest. The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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