DIAGNOSTIC IMAGING IN VETERINARY MEDICINE: ADVANCES AND FUTURE PERSPECTIVES

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ABSTRACT
Since their introduction in Veterinary Medicine, imaging exams have promoted a true revolution in the sector, allowing the production of moving images of animal structures and organs in real time. Diagnostic imaging technology has advanced significantly, driven by technological evolution, and reflected in several fields of activity in Veterinary Medicine. The objective of this article is to discuss these advances and the future perspectives for veterinary imaging, in addition to evaluating the impacts of these innovations on the clinical routine of small animals. Among the diagnostic methods that have been highlighted, ultrasonography with contrast by microbubbles and elastography represent remarkable advances. These technologies not only expand the possibilities for early diagnosis and treatment, but also emphasize the importance of continuous evolution in veterinary practice. Although the literature on these methods is still scarce, the number of reports and studies is growing rapidly, which indicates a promising future for these techniques.

Keywords: Diagnostic imaging. Contrast media. Elastography.

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INTRODUCTION

In recent years, technological advances have provided significant progress in medicine, covering several areas, helping in the evaluation and treatment of various conditions. In the field of veterinary imaging, these innovations have allowed for new tests and techniques, which have become essential for a more accurate diagnosis and clinical decision-making (Santo; Rafaine, 2024).

According to McEvoy (2015), veterinary imaging has the privilege and challenges that come with the continuous development of current and new imaging technologies and modalities. Imaging techniques play a key role in creating a standardization of normal anatomical, physiological, and functional parameters, essential for clinical application. In this context, new areas of specialization have emerged, such as ultrasound, radiodiagnosis, magnetic resonance imaging, endoscopy, and teleradiography, which have enabled accurate and rapid diagnoses for complex cases (Assefa, 2018).

Currently, in veterinary clinical practice, ultrasonography and radiography are the most commonly used imaging modalities. On the other hand, techniques such as computed tomography and magnetic resonance imaging are not yet frequently used, mainly due to the high cost and lower availability of the necessary equipment. This reality limits access to more advanced diagnostics, which could benefit many animals (Oliveira et al., 2024).

Radiology is the most widely used and accessible diagnostic imaging method in veterinary medicine. It has high specificity for the evaluation of bone and, in many cases, joint structures. With X-rays, it is possible to visualize internal structures, allowing the identification of changes such as inflammatory processes, fractures and dislocations. In addition to its relatively low cost and easy accessibility, radiology stands out for being a painless exam for animals (Nobre et al., 2024; Oliveira et al., 2024).

Another practical, fast and non-invasive method is ultrasonography, which enables real-time visualization of soft tissues (Valente, 2007). In the veterinary routine, knowledge of the anatomy and sonographic characteristics of the tissues is essential to assist in the diagnosis of various diseases. Ultrasonography is also used to confirm pregnancies, evaluate abdominal organs, and be a guide for precise fine-needle aspiration or tissue biopsy (Kealy; Mcallister; Graham, 2012).

Radiographic and ultrasonographic examinations are complementary methods. While chest x-rays may reveal only an enlargement of the heart, echocardiography offers a detailed view of several cardiac components, allowing a more accurate assessment and quantification of cardiac problems (Kealy; Mcallister; Graham, 2012).

Despite the significant evolution of veterinary imaging in recent decades, it is worth highlighting the importance of innovations in ultrasound. Microbubble contrast-enhanced ultrasonography and veterinary elastography are methods that enable veterinarians to diagnose pathologies more efficiently, early and safely, which contributes to a good prognosis and treatment (Teixeira; File; Santana, 2022; Servente et al., 2021).

This article aims to discuss the main advances in the field of veterinary imaging and future prospects, as well as to analyze how these developments have impacted the small animal clinic.

CURRENT TECHNIQUES IN VETERINARY IMAGING

ULTRASOUND

Several evaluation methods for the diagnosis of pathologies in domestic animals have been used. Among these methods, ultrasonography stands out as a widely used technique (Sales; Braga; Braga Filho, 2019). Its use has grown considerably, and today it is an essential tool to assist in clinical diagnosis, serve as a guide during interventional procedures, as well as an essential tool for the treatment and monitoring of diseases (Santos; Rafaine, 2024).

Ultrasound, also known as ultrasound, is an imaging test that uses sound waves to obtain images from inside the body. These waves are transmitted inside the body and reflect as an echo, allowing images to be obtained, with a two-dimensional representation, in real time (Lucatti et al., 2023; Kealy; Mcallister; Graham, 2012).

The adoption of this non-invasive, flexible, and relatively safe technique has become frequent in clinical practice, since, as it does not cause harmful biological effects, it can be applied in any environment without restriction or with specific safety. As a result, other contrast exams, such as radiographic exams, which are invasive, began to be replaced to a certain extent (Sales; Braga; Braga Filho, 2019; Kealy; Mcallister; Graham, 2012).

The main applications of ultrasound in the clinic of dogs and cats include abdominal and thoracic ultrasound, echocardiography, and musculoskeletal ultrasound (Meomartino et al., 2021). Its versatility makes it useful in the early diagnosis of pregnancy, in the identification of cranial cruciate ligament ruptures, in addition to the evaluation of abdominal and thoracic organs (Sales; Braga; Braga Filho, 2019). In recent years, contrast-enhanced ultrasonography (CEUS) has been applied and has undergone significant advances.

CEUS is a diagnostic method that uses intravenous contrast agents, microbubbles, to increase echogenicity and facilitate detailed visualization of vascular structures (Zavariz et al., 2017). Microbubbles are composed of a high molecular weight gas, which makes it easy for them to circulate exclusively within the intravascular space, without diffusing into the interstitium or being excreted through the urine. Its use is considered safe and does not cause unwanted hemodynamic effects. The evolution of CEUS makes the technique a reliable option to improve diagnoses, providing better results for patients (Silva, 2021).

CEUS has proven to be a particularly valuable tool for analysis, as it provides reliable quantitative and qualitative measures. The imaging test allows you to clearly visualize organs that are usually more difficult, thus reducing the need for other more complex tests, such as CT scans and MRIs.

The clinical applications of CEUS in veterinary medicine are broad and focus mainly on organs such as the liver, spleen, lymph nodes, pancreas, kidneys (Santos; Rafaine, 2024) and the evaluation of placental perfusion (Silva, 2021). This technique is also suitable for the evaluation of different types of neoplasms and the identification of portosystemic shunts (Teixeira; File; Santana, 2022). Thus, CEUS stands out for its ability to facilitate rapid clinical decision-making and more accurate diagnoses.

In a study carried out by Silva (2021) in brachiocephalic pregnant, placental vascularization and perfusion were evaluated in with fetal abnormalities close to delivery, through the use of microbubbles. Through the evaluation of hemodynamic patterns during pregnancy, tissue perfusion failure and placental dysfunction were observed, an essential mechanism in the early detection of fetal anomalies. The results also showed that the evaluation in CEUS proved to be easy to apply routinely and the use of contrast did not cause any complications or detectable side effects to the clinical evaluation of females and neonates. With more reliable results, veterinarians can opt for more appropriate treatments, contributing to the health and well-being of patients.

In summary, CEUS is a technology that has proven to be indispensable in veterinary practice, as it not only improves the quality of diagnoses but also optimizes workflow, allowing animal health professionals to offer more efficient and targeted care. The technique is simple, which makes it more attractive for use in veterinary clinical settings. Overall, CEUS is not only safe and non-invasive, but it also provides reliable quantitative and qualitative measurements, as well as detecting changes that are less easily detected by traditional methods (Teixeira; File; Santana, 2022).

ELASTOGRAPHY

Acoustic radiation force impulse elastography (ARFI) is an ultrasound technique that makes it possible to evaluate the elasticity of tissues by analyzing the speed at which sound waves propagate through them. This approach is safe and non-invasive, providing both quantitative and qualitative information on the stiffness of different organs (Cintra et al., 2020).

Although elastography emerged in the early twenty-first century, for veterinary medicine, the use of elastography is relatively recent. The diagnostic method is based on physical principles such as strength, elasticity, compression, traction and tension in the tissues. This results in a promising diagnosis when combined with ultrasound, offering accurate data on the mechanical and acoustic properties of tissues (Cintra et al., 2020; Santos and Rafaine, 2024).

Unlike conventional ultrasound, which does not measure tissue stiffness, elastography recognizes that elasticity is a fundamental characteristic that can be altered with several diseases (Servente et al., 2021). Each type of tissue has a specific pattern of elasticity, and changes in this pattern can be indicative of pathologies, allowing the differentiation between benign and malignant lesions based on elasticity and hardness (Santos and Rafaine, 2024; Lima, 2023).

The clinical application of ARFI elastography extends to the detection of malignant processes in focal lesions located in various organs, including the spleen, breast, prostate, thyroid, pancreas, and lung. This makes it a valuable and innovative tool in medical practice, contributing to more accurate and faster diagnoses (Santos and Rafaine, 2024).

Soares (2025) studied the applicability of strain elastography in with pyometra for evaluation of acute kidney injury. In veterinary, research with this elastographic modality focuses not only on the evaluation of kidney function in dogs and cats, but also on the detection of neoplasms (Massimini et al., 2022). The research was carried out on 20 animals in the experiment. In the first study, B-mode ultrasonography and Doppler ultrasonography showed that no statistically significant differences were observed between the groups of echogenicity, corticomedullary ratio, renal length/aortic diameter ratio (R/AO), resistivity index (RI), systolic velocities (SV), diastolic velocities (RV), and numerical resistivity index (RI) (Table 1). After verification of nonspecific sonographic alterations, 17 of the 20 animals were submitted by means of manual compression applied by the sonographer veterinarian, with the transducer on the body surface, to the use of the elastogram, close to the left renal area.

Table 1 - Distribution of qualitative ultrasound variables and their respective scores in with pyometra, grouped according to discrete (D) and severe (S) histopathological renal lesions.

Variável qualitativa			Grupos fa (%) [IC]95%		P valor[1]
	Escore		D	S	
Ecotextura	1 (n=20)	Homogêneo	8(40,0) [19,1-63,9]	12(60,0) [36,0-80,9]	-
Ecogenicidade	1(n=10)	Isoecoico	5(50,0) [18,7-81,3]	5(50,0) [18,7-81,3]	0,65
	3(n=10)	Hipoecoico	3 (30,0) [6,7-65,2]	7 (70,0) [34,7-93,3]	
Relação Corticomedular	1(n=17)	Preservada	6(35,3) [14,2-61,7]	11 (64,7) [38,3-85,8]	0,54
	2(n=3)	Alterada	2 (66,7) [9,4Z-99,2]	1 (33,3) [0,8-90,6]	
R/AO	1(n=19)	Preservada	7(36,8) [16,3-61,6]	12 (63,2) [38,4-83,7]	0,40
	2(n=1)	Aumentada	1 (100,0)	0 (0,0)	
Escore IR	1(n=11)	Regular	4(36,4) [10,9-69,2]	7 (63,6) [30,8-89,1]	1,0
	2(n=9)	Aumentado	4(44,4) [13,7-78,8]	5 (55,6) [21,2-86,3]	

Legend: [1] p value of the Chi-square test. CI: Confidence interval for proportion. FA: Absolute frequency. R/AO: ratio of renal size/diameter to aorta. IR: resistivity index.
Source: Soares, 2025.

The elastogram generated by ultrasound made it possible to delimit the area of interest, which covers the corticomedullary region of the left kidney. The image obtained was analyzed with the Image J software (National Institutes of Health, Bethesda, Maryland, USA), which allowed the generation of a histogram of the color map, facilitating a quantitative analysis of the pixels in the image. The program evaluated the amount of red, green, and blue colors, providing data on the mean and standard deviation.

The predominance of the color red indicates that the fabric is soft and undergoes greater deformation. The green color represents intermediate stiffness, while the blue predominance signals that the fabric is more rigid and, therefore, less deformable. The analysis of the elastogram revealed statistically significant differences in the observed colors, which highlights the variation in the stiffness of the analyzed tissue.

The analysis of the elastogram colors revealed statistically significant differences between the groups, evidencing a predominance of intermediate elasticity in the elastograms of the animals studied. The results showed that the median of the green pixels, which represent the intermediate elasticity, was higher than the median of the red pixels, which indicate greater tissue elasticity, in both groups analyzed (Table 2).

Table 2 - Medians of the mean pixels estimated via ImageJ of 17/20 animals with pyometra.

PARÂMETRO	D		S
Pixels			
Verde*	95,3		105,0
Azul	90,7		95,0
Vermelho	71,8		81,1
CV (%)		19,7	
P-valor [1]		0,018	

[1] p-value of the Kruskal-Wallis test, * differs from the post-hoc test of the Kruskal-Wallis.

This type of analysis has been shown to be effective for the early detection of alterations related to acute kidney injury (AKI), as it highlights the variations in tissue elasticity linked to acute inflammatory processes. Therefore, the study suggests that elastography may be an essential and effective tool to differentiate animals with acute chronic kidney disease from those with AKI.

FINAL CONSIDERATIONS

Among the most promising diagnostic methods in veterinary imaging, microbubble contrast ultrasonography and elastography stand out as significant advances.

Elastography, by quantifying the elasticity of tissues, offers an essential complementary approach for the identification of pathologies, neoplasms and fibrosis in a non-invasive manner. In addition, the results of recent studies establish that imaging will be an important basis for clinical investigations, since elastography provides additional data to Doppler and B-mode ultrasonography, helping in the preliminary diagnosis.

On the other hand, ultrasonography with microbubble contrast allows a thorough analysis of the perfusion and vascularization of the organs, increasing the diagnostic accuracy in lesions in various organs and gestational evaluation of. As a result, its proven safety and versatility in multi-organ application reinforce its clinical value.

The combination of these technologies not only expands the possibilities for early diagnosis and treatment, but also underscores the importance of continuous evolution in veterinary medicine. Although there is a paucity of studies on both diagnostic methods, the number of reports has grown rapidly, confirming that techniques can be used more broadly, either as a first-line tool or as a resource to solve problems in the clinical approaches of the future.

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