UNIVERSITY OF AGRICULTURAL SCIENCES AND VETERINARY MEDICINE CLUJ NAPOCA
DOCTORAL SCHOOL
FACULTY OF VETERINARY MEDICINE

Dr. PURDOIU ROBERT CRISTIAN

SUMMARY OF THE PhD THESIS

CONTRIBUTIONS REGARDING THE CLINICAL, IMAGISTIC AND LABORATORY DIAGNOSIS IN SYSTEMIC DISEASES OF THE DOG

SCIENTIFIC ADVISOR
Prof. Univ. Dr. PAPUC IONEL

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INTRODUCTION: AIM AND OBJECTIVES

Medical literature, both in human medicine and in veterinary medicine strongly emphasizes the rigor and importance of the clinical examination in the diagnosis, but equally believes that in the current era, modern laboratory methods of great precision and smoothness, have considerably widened the field of investigation, providing a scientific model for the interpretation of symptoms and diagnosis.

Medical Imaging includes physical laboratory methods including X-ray and fluoroscopic, endoscopic examination, CT, ultrasound, scintigraphy, MRI and so on, means that modern technology provides to medicine as an element of certainty in the diagnosis. Medical imaging is nothing but a complement to data from the clinician, obtained by the sense organs, during clinical examination, when the diagnosis becomes a visual health revelation.

One of the most common, accessible and sufficiently powerful, imaging methods in addition to radiological examination is the ultrasound. Accessibility of the ultrasound is given firstly by the fact that it is a non-invasive technique, but also by time allotted and cost. Ultrasound exploration can be performed in several ways. It is an investigation "on demand" for which normally a longer time is allocated. Under these conditions, the method must respond to requests made under the suspicion of a clinical syndrome or suspected disease. There are also ultrasound investigations performed on "target", directed strictly towards the ailing organ. In both cases, the ultrasound must be rigorous. Ultrasound exploration is probably the imaging method that is most "operator dependent". There are therefore, very high performance ultrasound results or, on the contrary, some very poor results (Badea et al., 2002).

The main purpose of this paper was to establish the necessary steps in diagnostic imaging, the recommendations and limits of this exam, very necessary in veterinary medicine in general and in various systemic diseases in dogs in particular.
The purpose of this thesis is to identify and use the most relevant imaging techniques necessary to establish a diagnosis of certainty in different diseases in dogs correlated to the affected system or apparatus and correlated with the laboratory results, with the essential criterion the specific clinical signs. Another aim of the thesis is to establish the necessary stages in implementing and maintaining a quality management system in medical imaging laboratory and clinical laboratory so as to optimize the medical act and improve the processes developed in these laboratories.

The main objectives of the thesis were:
1. identifying and using the most relevant imaging methods in the diagnosis of certain diseases in dogs;
2. establishing working parameters in radiology and ultrasound so as to ensure best results;
3. comparing the results of radiographic examination with results obtained by other imaging methods of investigation;
4. correlating the results of radiographic and ultrasound examination with results of the hematological and biochemical examinations;
5. composing an algorithm to use for various diagnostic imaging methods for various diseases in dogs;
6. assessment of contrast ultrasound and elastography as diagnostic methods in various systemic diseases in dogs;
7. identifying and determining the steps needed to implement and maintain a quality management system within the medical imaging laboratory and in the clinical laboratory.

Structure of the thesis: the thesis consists of two main parts, called bibliographic study and personal research, including materials and methods used, results and discussion for each chapter separately.

The first part includes three chapters (1-3):

Chapter 1 briefly describes the origin of the dog and its biological systematic classification and reviews theories on the origin and evolution of existing breeds of dogs. Also mentioned
in Chapter 1 are anatomical aspects of various body regions of the dog and particular aspects of the anatomy of thoraco-abdominal organs in dogs.

Chapter 2 summarizes the principles necessary to implement a quality management system.

Chapter 3 reviews the main techniques used in medical imaging, detailing the technical and practical aspects of radiographic and ultrasound examination.

The second part comprises 5 chapters (4 - 8):

Chapter 4. The aim of the thesis reviews the purpose and objectives that the other proposes.

Chapter 5. Research venue mentions the period of the study, and where the trials were conducted.

Chapter 6. Material and method indicates the number of cases studied and their systematization in 6 categories, depending on the compromised system from the main clinical symptoms manifested. The equipment and imaging techniques used in the examination of cases are described.

Chapter 7. Results and discussion describes the results obtained for the 6 categories of patients examined. Separate chapters are assigned to study a double dose of nonionic contrast substance administered to dogs and the study of contrast ultrasound, elastography examination and the necessary steps for implementing a quality management system in medical imaging laboratories.

Chapter 8: General conclusions systematize the findings obtained from the survey.

The thesis has 356 pages, Part I - Bibliographic study comprises a total of 60 pages representing 16.85% of the total thesis; Part II - Personal research comprises 260 pages representing 73.04% of the total thesis and 36 pages representing 10.11% of the total work are the table of contents and index figures, graphs and tables.
The originality of the PhD thesis

The major originality of the thesis consists of specialized information supplementing the importance of imaging examination in the certainty diagnosis of some systemic diseases, highlighting the relevance and limitations of each exploration technique correlated with the system or apparatus affected, with the functioning principles of equipment and manifested pathology.

Also, original elements are the usage of elastography in the diagnosis of liver and spleen diseases, with a software optimized procedure that led to obtaining histograms which allowed a correlation between the histogram and liver parenchyma contrast loading type in different types of diffuse conditions.

Another element of originality adds the ultrasound with SonoVue contrast agent focused on liver and spleen pathology that allows mathematical calculation based on a graphical representation of how parenchyma fills with contrast, thus differentiating normal from pathological tissue.

Liver structure analysis using a calculation of lacunarity of the ultrasound image based on mathematical methods, provides valuable data in determining the degree of homogeneity of the parenchyma, is another original aspect of the thesis.

Kilovoltage, miliamperage, exposure, contrast agent dose, type of transducer, frequency and type of ultrasound complement the originality of the data and gives pragmatism to the thesis by the proposed interventional protocol.

Personal research

The study was conducted over a period of four years between 2007-2011, on a number of 1500 dogs. Clinical and laboratory investigations were performed in the Clinic of Radiology and Medical Imaging, Faculty of Veterinary Medicine Cluj-Napoca.
Of the many existing medical imaging methods, X-ray and ultrasound were predominantly used, taking into account the available technical facilities, supplemented by laboratory tests, complying with the known working protocols.

To establish an algorithm to use the methods for diagnostic imaging of systemic disease in dogs, patients were divided into six categories denoted by Roman numerals according to the affected system or apparatus, according to the main clinical signs.

**Category I**: nervous system, spinal cord and analyzers conditions having as main clinical signs nervous disorders, motor disorders, impaired vision and balance.

**Category II**: respiratory and cardiovascular conditions that have as main clinical signs shortness of breath, dyspnea and cough effort.

**Category III**: disorders of the digestive system that had as main clinical signs of vomiting, regurgitation, abdominal distension and constipation.

**Category IV**: disorders of the genitourinary system having as main clinical signs urinary disorders and inflammation.

**Category V**: musculoskeletal and dental disorders having as main clinical signs lameness and difficulty chewing.

**Category VI**: diseases of the lymphatic system which had as main clinical signs adenitis and the presence of nodular formations.

**Radiography and ultrasonography in conditions of the nervous system, spinal cord and analyzers which have major clinical signs of nervous, motoric and vision and balance disorders**

Of the 1,500 dogs examined, a number of 876 dogs showed nervous system, spine and analyzers disorders in the following percentages: 12.79% were diagnosed with diseases of the inner ear, 1.71% of the disorders were tumors, 36.53% were traumatic disorders, 13.01% were diagnosed with Wobbler syndrome, 35.62% were diagnosed with degenerative diseases and 0.34% were other problems.

In nervous system diseases in dogs, the most relevant diagnostic methods are X-ray imaging because most diseases that cause nervous
symptoms have a spinal location. Radiological examination allows the identifying of lesions in the spine, injuries that are affecting the integrity of the marrow.

The examination of spinal integrity may be performed by using contrast radiography. Ultrasound does not provide sufficient data to diagnose a disease localized to the skull or spine.

Radiological examination of the inner ear allows investigation of the opacity degree of the tympanic bulla, something which is seen in inflammatory diseases, trauma, and is manifested clinically by impaired balance. Radiological examination aims to follow the degree of opacification of the two tympanic bullae and the examination results were correlated with the clinical examination.

Ultrasound of the eye and orbital cavity allows early diagnosis of degenerative diseases of its various components, as well as identification of different configurations of tumoral nature difficult to observe through radiological examination. Doppler examination of the eye allows ophthalmic vascular package and lateral ciliary arteries and veins examination, this helps to identify any abnormalities or obstructions at this level.

**Radiography and ultrasound in respiratory and cardiovascular diseases that have as main symptoms shortness of breath, effort dyspnea and cough**

Symptoms of dyspnea and cough are related exclusively to lung and heart disease. Of all cases studied, a total of 278 patients experienced these symptoms (18.53% of all cases, n = 1500).

Diagnosis of heart disease needs a major radiographic examination whereby local changes and those that occur in the lung are highlighted. Ultrasound allows examination of morphology and function of the heart, as a complementary examination. ECG also provides data on cardiac muscle function, these combined data will help to establish a diagnosis of certainty.
Ultrasound examination of the lungs is only relevant if pleural or interstitial collections or a formation examined is in contact with the chest wall.

In the radiological examination of the lungs, lung model interpretation is the key to establishing a correct diagnosis in lung diseases. Depending on the affected lung area, several lung models may be encountered: interstitial lung model, alveolar lung model, bronchial lung model, mixed pattern lung model, hyper or hypo-vascular lung model. To reduce radiological artifacts in lung images that appear due to breathing movements, one will increase kilovoltage and reduce exposure time and milliamperage.

Radiological examination with contrast substance allows examining vasculature on a specific area once. Double doses of contrast substance does not lead to a risks in patients, but dose escalation should be performed with caution in patients presenting liver disorders, double doses of contrast notional may worsen these conditions.

**Radiography and ultrasonography in digestive diseases that have as main symptoms vomiting, regurgitation, abdominal distension, constipation**

The most common disorders diagnosed radiographically and through ultrasound were inflammatory diseases of the stomach (gastritis), followed by intestinal obstruction, inflammatory bowel disease (enteritis), fatty degeneration of liver and tumors.

Ultrasound examination of abdominal cavity organs must take into account the size, conformation of the individual and the fullness of the digestive tract. To view the entire gastrointestinal tract, radiography is recommended. Ultrasound provides more data than radiographs for examination of the liver and spleen.

In liver disorders, calculating the lacunarity of the ultrasound image provides information about the homogeneity of liver parenchyma, bringing extra information in the diagnosis.

Elastography allows determination of the elasticity of the liver parenchyma, histograms obtained reveal examination of increased
stiffness in hepatic parenchymal areas compared with normal tissue. Elastography needs to be correlated with the results of laboratory examination and biopsy of the liver parenchyma.

Ultrasound with contrast substance allows identification of the hepatic or splenic changes that are not apparent at ultrasound examination in B mode, these changes can be identified by calculating the starting point of contrast absorption and the moment of maximum capture peak.

Radiological examination with contrast substance (barium sulphate) in the esophagus provides certain elements in the diagnosis of megaesophagus.

For the diagnosis of gastritis, the best examination is radiological, with barium sulfate which allows visualization of transit and gastric mucosal appearance.

Ultrasound of the dog intestinal mass provides information necessary to establish the diagnosis in cases of ascites, tumors of diverse etiology and diseases of the intestinal wall.

**Radiography and ultrasonography in diseases of the genitourinary system having as main symptoms urinary disorders, inflammation**

Urogenital ultrasound examination allows detailed examination of the kidneys, bladder, prostate, testes and uterus, providing necessary data for disease diagnosis at this level. Radiological examination is limited in terms of urogenital examination, but with relevance to the diagnosis of urinary lithiasis. Radiological examination with contrast substance evidentiates the renal pelvis and provides information on the degree of integrity of the ureters.

In the case of mammary tumors in the bitch, the ultrasound allows investigation of the mammary parenchyma and adjacent vasculature and provides data necessary to the establishment of the degree of invasion of the tumor tissue, tumor size and structure.
Using ultrasound with contrast substance and elastography in the diagnosis of tumors in dogs

Contrast enhanced ultrasound (CEUS) in the study of vascular behavior patterns of tumors in dogs is an optimal imaging technique for investigation, offering good quality images in real time, compared to other imaging methods. The use of contrast ultrasound allows visualization of certain lesions that are not visible to conventional ultrasound.

Elastography allows visualization of tissue rigidity, and is a valuable adjunct in the diagnosis and differentiation of tumor types. Assessment of the degree of stiffness of the tissue or tumors examined helps determining the degree of malignancy of the tumor. Identifying areas of tissue stiffness helps to better assess the site location for a biopsy in sampling of tissue for pathological examination.

Radiography and ultrasonography in skeletal and dental diseases with main clinical signs of lameness and difficulty chewing

For skeletal disease and dental diseases diagnosis, the best data are obtained by X-ray. Ultrasound is limited in terms of skeletal and dental disease diagnosis.

Radiography and ultrasound examination of the lymphatic system with the main symptoms adenitis and nodular formations

Examination of the lymphatic system is of particular importance, lymph nodes are the main migration gate of tumor cells. Radiological examination is limited because it cannot reveal changes in consistency or structure of lymph nodes, their radio opacity being similar to the one of the adjacent tissues. We consider B mode ultrasound, Doppler ultrasound, contrast ultrasound and elastography reference tests in the diagnosis of lymphatic system disorders in dogs.
Quality management in the medical imaging laboratory

Implementing a quality management system in medical imaging laboratories in veterinary medicine allows maintenance of accurate patience records, developing a database on working protocol used to establish the diagnosis based on clinical signs, in conjunction with imaging data and laboratory results, as well as a follow-up on the development of the patient's condition over time. An important benefit in management systems is the ability to develop new applications in the veterinary medical field for continuous improvement of care by creating new software dedicated to this purpose.

General conclusions

Based on the results we obtained from the studied casuistry, we identified and used the most relevant imaging techniques necessary to establish a diagnosis of certainty in various systemic diseases in dogs. Diagnostic imaging has been customized for the damaged system or apparatus and correlated with the laboratory results and specific clinical signs. Also, the importance and steps required implementing and maintaining a quality management system within the laboratory and medical imaging clinical laboratory in order to optimize the medical act and improve activity in these laboratories has been established.

In diseases of the nervous system, spinal cord and analyzers of the dog, diagnostic imaging relevance have classic radiologic examination and radiographs with contrast substances, ultrasound B-mode and Doppler ultrasound.

In cardiovascular disease in dogs, diagnostic X-ray, ultrasound in B and M mode as well as Doppler ultrasound for the heart and radiographic examination with contrast substance and Doppler ultrasound in the diagnosis of diseases of the vascular system are the ones that have relevance.

In respiratory diseases in dogs, the radiographic diagnostic relevance lies on radiographs with which the lung pattern can be
established, related to disease type whereas ultrasound has little relevance.

In *digestive disorders* in dogs, B-mode ultrasound, Doppler, elastography and ultrasound examination with contrast substance have diagnostic relevance, especially for examining parenchymal organs, followed by X-ray and barium transit used to examine the stomach and intestines. Elastography and contrast ultrasound are relevant in the diagnosis of localized disease in the liver or spleen.

In *urogenital diseases* in dogs, B-mode ultrasound, Doppler ultrasound and contrast ultrasound have diagnostic relevance. Classical radiological examination does not provide a lot of data on changes in the kidney, but provides enough data on the bladder and administration of nonionic contrast substance allows the examination of the pelvis, ureters and bladder.

In *skeletal and dental localized disease* of dogs, of increased diagnostic relevance is the classic radiological examination.

To examine *lymph nodes* in dogs, B mode ultrasound, Doppler, elastography and ultrasound contrast examination have diagnostic relevance.

**References**


