ABSTRACT

Keywords: diagnostic imaging, thoracolumbar, lumbosacral, dog

The discovery of X-rays in 1895 by the German physicist W.C. Röntgen, for which he has been awarded with the Nobel Prize (1901), it was regarded as the greatest medical discovery of the 19th century, on the diagnostic line. Indeed, the radiology fundamentally revolutionized the art of diagnosis. This specialty has become, due to its continuous infusion with innovations by science and modern technology, a subject of great importance.

Radiology evolution culminates with the discovery in 1972 of the most complex device in this field, the Computed Tomography, considered the greatest medical achievement of the last century, stated by the representative of Nobel Federation, in 1979, with the occasion of awarding the discoverers with the famous prize (G.N. Hounsfield and A.M. Cormack).

The procedures of diagnosis using X-rays are the most commonly used in veterinary medical practice, often being the first employed in a diagnostic protocol. In the case of bone diseases, the radiography is the method of choice, emphasizing both the lesion itself and the anatomical segment topography.

The emergence and the introduction in the practice use of some medical equipments led to a wide application of the imaging investigations by the veterinarian clinicians, while the importance of diagnostic imaging results become a necessity.

Although the medical imaging has recorded a significant development by the emergence of new techniques, the radiological examination remains an important step in the diagnosis of spinal disorders. In cases where the injuries of spinal column and spinal cord are not detectable by conventional radiological methods, there are appealed more detailed investigation methods (myelography, CT, MRI), providing a more detailed picture of the causes and the changes that occur.

Many researches at national and international level (da Costa and Samii, 2010; Purdoiu et al., 2009), which are based on diagnostic imaging of the spinal column diseases in dogs, emphasize both the importance attributed to such methods and the desire for a deepen and continuous development.

The doctoral thesis entitled "**Study of correlations between diagnostic imaging results and thoracolumbar and lumbosacral spine lesions in dog**" comprises 218 pages, written in 11 chapters and is structured in accordance with current legal scientific standards in two main parts: the first part (28 pages) and the second part (135 pages), plus table of contents, introduction, summary and references list.

The first part "**Current state of knowledge**" is structured into 3 chapters, synthesizing the main data in the literature regarding the diagnostic imaging of thoracolumbar and lumbosacral spine in dog.

The second part „**Personal contributions**" consists of 8 chapters, presenting purpose, objectives and research framework, the results of the investigations regarding the diagnostic imaging of thoracolumbar and lumbosacral spinal affections in dog, the materials and methods used, the interpretation and discussion of the results, conclusions and recommendations drawn from the experiments undertaken.

The paper is illustrated in 114 figures and 23 tables.

For the scientific documentation, 219 reference titles from national and international literature were used.

The first part of the work briefly describe a synthesis of the literature regarding the morphophysiology, the pathology and the diagnosis of thoracolumbar and lumbosacral spinal affections in dogs, with the main aspects of the current state of knowledge at national and international level.

Chapter I, entitled: "**Bibliographic data regarding the morphophysiology of spine in dogs"** describes the anatomical data regarding the spinal column in dogs. This chapter refers to the ontogeny, the structure of vertebrae and the morhophysiology of spinal column in dogs.

Chapter II, entitled „**Bibliographic data regarding the thoracolumbar and lumbosacral spinal disorders in dog**" describes the main characteristics of the thoracolumbar and lumbosacral spinal affections in dogs, and the clinical signs caused by these affections. In the first part of this chapter is presented a classification of spinal injuries in dogs, while in the

second part are given the particularities of the clinical features of the thoracolumbar and lumbosacral spinal affections in dogs.

Chapter III, entitled „**Diagnostic imaging of thoracolumbar and lumbosacral spinal lesions in dog**" briefly describes the main imaging methods used in the diagnosis of dog's spondilopathies (radiography, myelography, computed tomography), treating the radiological techniques and the imaging characteristics for the thoracolumbar and lumbosacral spinal affections in dogs.

The second part comprises in 8 chapters the personal contributions.

Chapter IV mentions the "**Purpose and objectives**".

A main goal of the thesis was to establish correlations between thoracolumbar and lumbarsacral spinal lesions and the diagnostic value of imaging exams in dogs. For ongoing researches, the main propose was represented by an epidemiological study in order to establish the thoracolumbar and lumbosacral spinal lesions prevalence in dogs, the achievement of a clinical examination and establishment of the characteristics of thoracolumbar and lumbosacral syndromes in dogs. The description and interpretation of the results obtained after performing imaging exams (radiography, myelography, computed tomography) of thoracolumbar and lumbosacral spine represented another important objective of the doctoral thesis. Moreover, the investigations have allowed to establish correlations between imaging exam results and the changes of thoracolumbar and lumbosacral spinal column in dogs, starting from the following hypotheses: (1) the body weight influence computed tomography lesional pattern in dogs affected by cauda equine syndrome; and (2) the existence of the possibility of developing a vertebral canal map based on GIS technology, useful in interpreting and the characterization of dislocation pattern of the disc material extruded inside the vertebral canal in dogs.

Chapter V, entitled „**Epidemiological investigations regarding the thoracolumbar and lumbosacral spinal lesions in dog**" gives data related to the epidemiological investigations conducted during 2010-2014. The investigations regarding the epidemiological aspects of the thoracolumbar and lumbosacral spinal column lesions in dogs included a total number of 3225 dogs, presented for a clinical and imaging evaluation at the Faculty of Veterinary Medicine, Iași, and to the Department of Veterinary Medicine and Animal Production, Napoli, Italy, of which 365 patients were diagnosed with various thoracolumbar and lumbosacral spinal conditions.

The prevalence of thoracolumbar spinal diseases in dogs was 7.75%, while for the lumbosacral spinal conditions was 3.57%. The males have been predisposed 1.8 times higher than females in developing spondilopathies, and as predisposition breed, out of 35 breeds included in this study, mixed breed dogs had a higher frequency of thoracolumbar and lumbosacral spinal column affections. The thoracolumbar vertebral segment was the mostly affected in German Shepherd, Dachshund and Bulldog breeds, while the lumbosacral spinal column was more affected in Rottweiler, German Shepherd and Boxer breeds. Dogs aged from 6 to 10 years are more likely to develop thoracolumbar and lumbosacral spinal column lesions, while in those aged between 2 and 5 years have been seen a smaller number of affections. These epidemiological data should be interpreted with caution because (1) the analyzed group contains a small number of subjects and (2) the patients came from two geographically different locations, with a various canine population.

Chapter VI, entitled "**Researches regarding the clinical diagnostic of thoracolumbar and lumbosacral spine disorders in dog"** underlines the importance of neurological examination in confirming neurological disorders in dogs with thoracolumbar or lumbarsacral syndromes and the location of medullary injuries. At the same time, for the dogs diagnosed with thoracolumbar or lumbarsacral spinal cord injuries, the aim was to determine the severity of lesions, to determinate the prognosis and the differential diagnosis. This chapter refers only to the technical and neurological examination results achieved in the case of 365 dogs with myelopathies localized at the level of thoracolumbar and lumbosacral spine. The cifosis was encountered in 46 patients (18.4%), the scoliosis in 6 patients (2.4%), the kangaroo posture in 16 patients (6.4%), seal posture in 10 patients (4%), while the Schiff-Sherrington posture was seen in 11 (4.4%) dogs affected by thoracolumbar syndrome. The main clinical signs in patients with thoracolumbar syndrome were represented by: ataxia (189/250), paraparesis (115/250), pain (64/250), lameness (38/250) and paraplegia (26/250). From the neurogical point of view, both the thoracolumbar and lumbosacral lesions did not reveal any changes in the forelimb reflexes, but only the hind limbs were translated by signs of upper motor neuron in the case of thoracolumbar lesions and signs of lower motor neuron in the case of lumbosacral lesions.

Chapter VII, with the title "**Results of radiological examination of thoracolumbar and lumbosacral spine in dog"** describes the epidemiological and radiological characteristics of various thoracolumbar and lumbosacral spinal lesions in dogs diagnosed by radiographic examination. The importance of the radiological examination of the spine consists in the

information conferred about the structure, the morphology of the vertebrae, information which gives the possibility of a correct diagnosis. Thus, the radiographic examinations of thoracolumbar spine performed in the dogs included in this study resulted in diagnosis and characterization of the following types of disorders: discospondylitis (2/197), trauma (fractures, luxations, subluxations) (11/197), vertebral anomalies (20/197), mucopolysaccharidosis (1/197), diffuse idiopathic skeletal hyperostosis (8/197), vertebral tumours (2/197), spondylosis deformans (116/197) and intervertebral disc degeneration (68/197). The lesions radiologically diagnosticated at the level of lumbosacral spine were: discospondylitis (2/169), trauma (fractures, luxations, subluxations) (9/169), vertebral anomalies (22/169), diffuse idiopathic skeletal hyperostosis (5/169), vertebral tumours (2/169), spondylosis deformans (84/169) and degenerative lumbosacral stenosis (73/169). The real advantages of the radiographic exam consisted of reduced costs of materials, short time image processing and, more importantly, providing a useful medical diagnostic for the therapeutic care.

Chapter *VIII*, entitled "**Results of radiological examination with contrast medium of thoracolumbar and lumbosacral spine in dog"** followed to describe the atlanto-occipital and lumbar myelography technique and to determinate the diagnostic value of myelography in the case of spinal cord injury in dogs presented with neurological deficits and clinically diagnosed with thoracolumbar or lumbosacral myelopathies. The objectives of this study were the confirmation and to precisely determine the localization of thoracolumbar and lumbosacral spinal cord lesions, to specify the severity and extension degree of thoracolumbar and lumbosacral spinal cord lesions, to determine the importance of various incidences used to indicate the localization of thoracolumbar and lumbosacral spinal cord lesions and the evaluation of diagnostic value of myelography in identifying spinal cord lesions. In the case of extradural lesions, the myelography signs consisted in deviation of the contrast column in the opposite direction of the compressive lesion (25/27; 92.59%), thinning of the contrast line (18/27; 66.67%) or a reduced line (5/27; 18.52%), depending of the views that were used. In 2 patients diagnosticated with acute disc extrusion it could be observed a duplication of ventral contrast line, a characteristic pattern for intradural extramedullary lesions and less commonly seen in extradural lesions. In the case of intradural extramedullary lesions, the myelographic patterns were represented by the thinning of the contrast line (1/2) and duplication of ventral contrast line (1/2), while for the intramedullary lesions, the main characteristic patterns were consisting in thinning of the contrast line (3/6) and a diffuse concentration of the contrast agent at the level of

medullary parenchyma (3/6). Myelographic signs were the main criterion used for the diagnostic of compressive medullar injuries, while the contrast column deviation represented the myelographic pattern the best highlighted.

Chapter IX, entitled „**Results of Computed Tomography examination of thoracolumbar and lumbosacral spine disorders in dog"** shows the results obtained from carrying out the Computed Tomography (CT) examination; the aim of this study was represented by the confirmation of the Computed Tomography diagnosis value and CT evaluation of thoracolumbar and lumbosacral spine disorders in dog. Among the main objectives are included the CT characterization of various thoracolumbar and lumbosacral spinal affections in dogs and the assessment of the role of multiplanar reformating imaging, 3D reconstruction and virtual endoscopy in the case of thoracolumbar and lumbosacral spinal affections in dogs. CT exam has proven to be a valuable diagnostic method, allowing the visualization and characterization of thoracolumbar and lumbosacral spinal cord lesions in dog; the multiplanar reformating imaging helped to better understand the connections between the spinal cord, vertebral column and surrounding tissues, being also very intuitive. It has been useful in helping to characterize the herniated disc and understand the displacement direction of herniated disc material into the vertebral canal. Furthermore, the study of lumbosacral junction in different positions (neutral, flexion, extension) provided important data on the dynamic quantitative changes at the level of this vertebral segment.

Chapter X, entitled „**Correlations between the results of diagnostic imaging and thoracolumbar and lumbosacral spine disorders in dog"** presents 2 studies named "Considerations regarding the influence of body weight on Computed Tomographic pattern in dogs affected by cauda equina syndrome" and "Using Geographical Information System for spatial evaluation of extruded disc herniation in dogs".

Comparing the obtained results with literature data, it was noted that there are no studies regarding the influence of body weight on the CT lesional pattern in cauda equina syndrome in dogs. Therefore, in this context it has been followed: (1) the description and comparison with previous studies regarding the epidemiological characteristics of the dog group diagnosed with the cauda equina syndrome at the Interdepartmental Center of Veterinary Radiology from Department of Veterinary Medicine and Animal Production, Napoli-Italy, (2) describing the CT lesional pattern in cauda equina syndrome in dogs, and (3) achieving a statistical study, correlating the body weight and computed tomography lesional pattern in dogs diagnosed with

cauda equina syndrome. Thus, after the analysis of the computed tomography results from 60 dogs that have fulfilled the conditions to be included in the study, the following conclusions were drawn: the correlations between the body weight and the degree of disc protrusion or extrusion and foraminal stenosis suggest a body weight influence in cauda equine syndrome occurrence; the main causes of this syndrome occurrence are represented by degenerative changes at the level of lumbosacral junction. In medium and large dogs, the body weight influence the degree of lumbosacral disc bulging and hence the severity of foraminal stenosis; the CT scan lesional pattern in dogs affected by cauda equine syndrome is not influenced by the breed, while the statistical studies are refuting the influence of body weight in the CT scan lesional pattern in dogs affected by cauda equine syndrome

Given the lack of information about the using of Geographic Information System (GIS) in spatial analysis of vertebral canal surface in dog, the objective of the second study was represented by the development of a map of the vertebral canal based on GIS technology, which subsequently would be useful in characterization and interpretation of dislocation pattern of the extruded disc material within the vertebral canal in dogs. Therefore, based on the anatomy of the vertebral canal, the data regarding those 177 disc herniations coming from 142 dogs were introduced in the system and the maps were designed based on GIS technology, that have proven to be useful in characterizing a specific lesional pattern. Creating maps by combining these two GIS and CT instruments, it was possible to visualize and analyze the dislocation patterns of intervertebral disc herniations at the vertebral canal. Mapping the vertebral canal in dogs is a new concept, being the first time when a GIS-based map was developed. This new approach shows real advantages for veterinary clinicians and represents a new interdisciplinary direction which can be more developed in the near future. The clinical relevance of the new GIS-CT approach is highlighted by understanding the dynamics of the extruded disc material starting from localisation of the disc herniation.

Chapter XI briefly presents a number of 25 final conclusions, and based on the obtained results during the experimental work, a series of recommendations regarding the imaging study protocol of thoracolumbar and lumbosacral spinal column in dog were proposed.