

ABSTRACT

DIAGNOSIS OF CHIARI-LIKE MALFORMATION AND SYRINGOMYELIA IN DOGS

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The aim of this paper is to present and evaluate the imaging features in Chiari-like malformation and syringomyelia in dogs, corroborated with clinical signs and paraclinical investigations, highlighting the diagnostic value and complexity of the information provided by the magnetic resonance imaging.

The PhD thesis „**Diagnosis of Chiari-like malformation and syringomyelia in dogs**” is structured in accordance with the legal provisions in two main parts, the first one, of bibliographic study, and the second part, of personal researches.

The first part contains 4 chapters, exposed in 40 pages, and represents approximately 28% out of the total PhD thesis. In the first chapter is presented the general neuroanatomy and physiology data of nervous system, followed by the second chapter, which presents the etiology and pathogenesis of Chiari-like malformation and syringomyelia.

In the third chapter the specific clinical signs of Chiari-like malformation and syringomyelia are described, and the disorders with which the differential diagnosis is performed are mentioned.

Chapter four describes the current diagnostic imaging methods of Chiari-like malformation (CM) and syringomyelia (SM), as well as specific imaging aspects obtained by magnetic resonance.

First part contains 24 figures and 8 tables.

The second part is structured in 3 chapters, exposed in 105 pages, and represent approximately 72% out of the total PhD thesis. This section of personal researches contains the materials and methods, results and partial conclusions. At the end of this part the general conclusions are presented, and also the references. Of the total 181 bibliographic sources, 96 have been published in the last 10 years, and of these 8 were published in 2018.

In the second part are included 41 original figures, 42 charts and 23 tables.

Chapter V, which includes materials and methods, is divided into two subchapters. In the first subchapter are presented the materials included in the study. The cases were investigated during the period 2013-2017, both in Turkey - in collaboration with PetCode Veterinary Hospital, Ankara (51 cases) and in Romania - Clinic of Faculty of Veterinary Medicine of the University of Agronomic Sciences and Veterinary Medicine Bucharest (2 cases).

The studies presented in the personal research section were performed on 53 dogs of different ages and breeds, 30 females and 23 males, the mostly representative breed was Cavalier King Charles Spaniel (47) followed by Bichon (4) and Chihuahua (2). The average age of the cases included in the study is 4 years old, with a range of 1 to 10 and a half years old.

In addition to these dogs, a group of 10 dogs was introduced for comparative purposes only, medium size dogs without Chiari-like malformations and syringomyelia signs, and without space occupying lesions evaluated through magnetic resonance imaging.

The second subchapter presents the methods used in the study, aims to describe the diagnostic steps and also the methods and techniques used in this paper.

The diagnosis of Chiari-like malformation and syringomyelia followed for each case, the next steps: *clinical examination*, together with a detailed *medical history*, *neurological examination*, *additional investigations* and *magnetic resonance imaging*.

All 53 cases were subjected to MRI examination, carried out in collaboration with the PetCode Veterinary Hospital, Ankara, Turkey, using the *Siemens TrioTim*® magnetic resonance device, with a circular magnet of 1.5 Tesla, as also in the Clinic of Faculty of Veterinary Medicine Bucharest, using the *ESAOTE VetMR-Grande*® IRM scanner, with a 0.3 Tesla open magnet.

All the cases have been subjected to magnetic resonance imaging investigations, T1 and T2-weighted sequences, scans of the brain and cervical spinal cord were performed both in sagittal and transverse plane. In 48 cases the thoracic segment of the spinal cord was also partially examined. The scans obtained were imported as DICOM files in *Horos*TM, a medical image viewer software that allows the processing of images. All the imaging and morphometric studies from this paper are performed using this software.

All the computational and statistical correlations from this research were performed using the statistical software *R*© - The R Project for Statistical Computing©.

In chapter VI are exposed the results obtained in this thesis. It contains clinical, imaging and statistical studies and is structured into 4 subchapters.

In the first subchapter are described the imaging aspects obtained through magnetic resonance for Chiari-like malformation and syringomyelia cases, the fourth ventricle and cisterna magna (cerebellomedullaris cistern) were subjectively evaluated, the linear size of the cerebellar hernia and the cerebellar compression index were evaluated also.

All of the cases presented abnormal cerebellar shapes and different degrees of cerebellar compression. Cerebellar hernia was found in the majority of the cases (94.34%), the linear measurements performed in the midsagittal plane ranged from 1.16 mm to 6.02 mm. Cisterna magna presented modifications (attenuation or obliteration of the subarachnoid space) in all the cases included in the study, and for 83.02 % from the total number of cases, the fourth ventricle showed different degrees of expansion.

In order to evaluate syringomyelia, due to the complexity of medullary lesions, we followed multiple criteria, namely: the localization and length of the intramedullary cavities, determination of the internal maximum diameter of the syrinx measured in transverse plane, the aspect of the cavities, the ratio between the height of the syrinx and the height of the spinal cord, the ratio between the area of the syrinx and the area of the spinal cord. Out of the 53 cases included in the study, 14 presented a dilated central canal, and 39 cases presented well delimited intramedullary cavities, showing a maximum internal diameter comprised between 1.48 mm and 8.52 mm; the length of intramedullary cavities measured in sagittal plan varied from 7.25 mm to 18 cm. The most frequent localization of the syrinxes was in the cervical spine, C2 – C4 segment, followed by C3 – C4 segment and C1- C2. In 8 cases (20,51%) has been detected the presence of multiple intramedullary syrinxes.

Among the objectives of the study one was to establish if there is any correlation between the cerebellar compression index and the degree of cerebellar hernia and between the degree of Chiari-like malformation and syringomyelia. Following the statistical analysis it has been found that there is no direct association between these variables. The syrinxes dimensions are not influenced by the degree of cerebellar hernia.

The second subchapter of the chapter VI aimed to assess the position of the medulla oblongata in the Chiari-like malformation and syringomyelia cases. The medulla was evaluated by performing 2 measurements - medullary kinking index and the medullary elevation angle.

Out of the total cases included in the study, in 77.63% of them medullary kinking was observed at the craniocervical junction.

One of the objectives of this subchapter was to estimate the relation between the medullary kinking index and Chiari-like malformation and syringomyelia, and also the relation between the

medullary elevation angle and Chiari-like malformation and syringomyelia. Following the statistical analysis no direct correlation was established between these variables.

In the third subchapter are presented morphometric studies that aim to determine the values of cerebellar and caudal cranial fossa areas for the dogs diagnosed with CM and SM, and also to compare the values obtained between the CKCS dogs and the other affected breeds, but also between the dogs diagnosed with Chiari-like malformation and syringomyelia and the dogs that do not have these conditions.

In the first part of this subchapter are presented the area values of the cerebellum and the nervous system parenchyma from the caudal cranial fossa. These values were used to determine the occupancy index of the caudal cranial fossa with cerebellum and the occupancy index of the caudal cranial fossa area with parenchyma of the nervous system, in order to eliminate individual and size variations due to the anatomical differences. The values of the indexes were compared between the Cavalier King Charles Spaniel dogs and the other breeds included in the study - Chihuahua and Bichon, dogs that were diagnosed with Chiari-like malformation and syringomyelia. The average values of these indexes are significantly higher ($p < 0.05$) for the CKCS dogs than for the non-CKCS dogs diagnosed with CM and SM. This observation suggests that the cerebellum and the nervous system parenchyma from the caudal cranial fossa presents higher volume values for the CKCS dogs than other dog breeds diagnosed with CM and SM.

Among the objectives of this study one is to determine if the Cavalier King Charles Spaniels dogs present a smaller caudal cranial fossa in comparison with other dogs that are diagnosed with Chiari-like malformation and syringomyelia. The dimensions of the caudal cranial fossa were quantified and evaluated by calculating the occupancy index of the cranial cavity with caudal cranial fossa. The obtained values were compared between the Cavalier King Charles Spaniel dogs and the other breeds included in the study- Chihuahua and Bichon, with no significant differences ($p > 0.05$) between the two groups of dogs.

In this subchapter the group consisting of dogs that do not show signs of CM and SM is introduced, in order to perform comparative studies between dogs diagnosed with Chiari-like malformation and syringomyelia and dogs without these conditions.

Another objective of this subchapter is to determine if the patients diagnosed with Chiari-like malformation and syringomyelia presents the dimensions of cerebellum and the nervous system parenchyma from the caudal cranial fossa proportionately bigger, and a smaller caudal cranial fossa in comparison with other dog breeds that do not present Chiari-like malformation and syringomyelia signs. For this, it was calculated the occupancy index of the caudal cranial fossa with cerebellum, the

the occupancy index of the caudal cranial fossa area with parenchyma of the nervous system and the occupancy index of the cranial cavity with caudal cranial fossa and the results obtained were compared between the group of dogs diagnosed with CM and SM and the group of dogs without signs of CM and SM. Following the statistical analysis it was concluded that the cerebellum dimensions are proportionately higher in the group diagnosed with CM/SM in comparison with the dogs that do not present any sign of CM/SM. Also, the parenchyma of the nervous system from the caudal cranial fossa presents a higher volume in the group diagnosed with CM/SM than the group without CM/SM. We also demonstrated the fact that the patients diagnosed with CM/SM presents a smaller caudal cranial fossa than the dogs without CM/SM.

In the last subchapter of the results and discussion chapter are presented and evaluated the clinical signs encountered in dogs diagnosed with CM and SM and the neuropathic pain scale was used to classify the patients. All the cases included in the study have presented different intensities of neuropathic pain, 8 cases were included in grade 1, 15 in grade 2, 18 in grade 3 and 11 had corresponded to grade 4 of neuropathic pain.

Another objective of this study was to define the relation between the clinical symptomatology and imaging aspects of CM and SM. The statistical analysis established a strong, direct, dependent relation between the degree of neuropathic pain and the dimensions of intramedullary cavities.

The correlations between the degree of neuropathic pain and the occupancy index of the caudal cranial fossa area with parenchyma of the nervous system, between the degree of neuropathic pain and the occupancy index of the cranial cavity with caudal cranial fossa, between the degree of neuropathic pain and the size of the cerebellar hernia are weak, without statistical value.

The same results were obtained regarding the correlation between the degree of neuropathic pain and the occupancy index of the caudal cranial fossa with cerebellum and between the degree of neuropathic pain and the position of the medulla oblongata.

The presence of asymmetric intramedullary cavities (to the left or to the right) was correlated with predominantly unilateral scratching, on the same side of the syrinx asymmetry.

Chapter VII presents the general conclusions based on the results obtained in this paper.

The study brings new information into the Romanian veterinary medicine by presenting the complex neurological disorders Chiari-like malformation and syringomyelia, describing the imaging features obtained through magnetic resonance and creating a imaging and morphometric database of Chiari-like malformation and syringomyelia in dogs.