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DEGENERATIVE-DYSTROPHIC CHANGES OF THE CERVICAL SPINE IN HUMANS AND ANIMALS

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Abstract: -

Introduction. Destructive changes in the spine occur through a number of reasons, one of the most important being spondyloarthrosis, osteochondrosis, herniated discs, etc.

Purpose. A morphological analysis of the body of the spine, as well as the neurological structure of patients, dogs and cats was carried out.

Materials and methods. In people and animals, the intensity of pain was assessed using additional adaptations, computed tomographic indicators with varying the thickness of the body ridges, morphometric indicators with an emphasis on localization regions C5–C7.

Results. Pathology of the spine configuration has been recorded in most people and dogs of large breeds. At the same time, deformation of the cervical spine has not been registered in other dogs and cats. The thickness of the body of the ridges along the length of the ridge in all groups was not uniform and there were few underlying patterns.

Conclusions. Creatures, especially dogs of great breeds, can be a model for the treatment of etiopathogenetic factors, clinical progression, and the prognosis of degeneration of the cartilaginous apparatus. Conducting a routine analysis of the possible development of prevention of the development of the osteochondral apparatus and the body.

Keywords: Vertebra pathology; cervical region; people; animal; pain; neurological disorders; computer tomography; densitometry.

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Introduction:

The cervical spine is the most mobile region of the spinal column.

The upper (cervical) spine is the most active of all its parts. It is also easily injured in both humans and animals. Furthermore, it is susceptible to degenerative-dystrophic changes, leading to severe pain syndromes and neurological complications associated with this type of vertebrogenic pathology [1,2]. These factors are related to the presence of major arteries, autonomic structures, and sensory and vestibular interactions in the neck, which together contribute to a wide range of pathological conditions [3-5].

It is known that diseases of the musculoskeletal system and surrounding tissues are the leading causes of morbidity among adults [6,7]. In Ukraine, primary osteoarthritis or osteochondrosis predominates in young people [6].

Musculoskeletal diseases account for over 5% of all registered diseases and traditionally rank fourth in disabling the population (third among adults of working age), and their number increases with age [8-10]. With such pathological changes in the IVC, patients complain of pain during examination, which is confirmed by neurological examination [11].

Pathological changes affect the so-called physiological lordosis of the cervical spine, which prevents damage to the osteochondral apparatus of the neck during walking and running and other important processes [12]. It is known that structural changes mainly at the level of C_5-C_7 segments give rise to various pain syndromes in the head, neck, and upper body. In addition, motor and sensory disorders in the extremities occur, and a number of diseases associated with impaired blood supply to the brain, symptoms of autonomic dysfunctions of the cervical and higher levels [12, 18].

Not enough attention is paid to the study of pathological deformation and density of spinal cord vertebrae using clinical and morphometric analysis in animals.

This is due to the difficulties in identifying algic conditions, animal owners not seeking help from specialists in a timely manner, the behavioral characteristics of dogs and cats not being taken into account, and other factors.

The aim of the study. To develop adequate early diagnostics using clinical and morphological studies of vertebral bodies, their configuration and their relationship in humans and animals with suspected pathological changes in the cervical spine.

Materials and methods

Object of the study. In the conducted studies, all manipulations with animals were checked by the bioethical commission for compliance with the recommendations of the European Convention for the Protection of Vertebrate Animals (1986) and the Law of Ukraine "On the Protection of Animals from Cruelty".

The work retrospectively analyzes clinical and morphometric data and results of CT examination of the spinal cord of 65 patients who applied to the outpatient department of the Odessa Regional Clinical Hospital with complaints of pain of varying intensity and frequency, the presence of neurological deficit, etc. Among the examined, there were 25 (38.5%) men and 40 (61.5%) women. The average age of the examined patients was 41.5±5.4 years (including men - 42.7±6.2 and women - 39.3±7.6 years). The average age of the examined men and women was comparable ($p > 0.05$), that is, we had every reason to conduct further comparative studies. We also formed a control group ($n = 14$) from among practically healthy individuals with an average age of 38.8±5.7 years , who also underwent a medical professional examination.

CT images in men and women, the influence of densitometric changes in the vertebral bodies, and the curvature of physiological lordosis were studied.

The study included patients with pain syndrome in the cervical and upper thoracic spine with an intensity of more than 3 points on the visual analog scale (VAS), sensitive disorders in dermatomes C_1-C_7, and pathological changes in the osteochondral apparatus in the cervical spine according to radiological methods.

Exclusion criteria were comorbid pathology: congenital dysplasias and dysraphies of the spinal elements, significant, mainly congenital, changes in bone density determined by radiological methods, oncopathology, osteoporosis, and systemic connective tissue diseases.

The work also used clinical and morphometric data and results of CT studies of the scrotum of 75 animals, including 14 cats, 42 small breed dogs, and 19 overweight dogs 20 кгwith acquired behavior, antalgic postures, and nociceptive reactions to painful stimuli or palpation.

The age of dogs was converted to human age using the formula [19, 20], and in this case it was on average 43.5±6.9 years, which was identical to the age of the examined people (41.6±5.3 years). Similarly, the age of cats was converted to human age, which was also comparable to the corresponding figure in the examined patients [21].

The criteria for excluding animals from the study were similar to human pathology, as well as chondrodystrophic dogs.

Research methods

The Visual Analogue Scale was used to determine the intensity of pain in patients [22]. To diagnose pain syndrome in animals, a five-point VAS adapted for animals (from 0 to 4 points) was used, taking into account the antalgic posture, gait, behavior, reaction to manual touch, and body tension [23, 24].

For imaging of patients, a SOMATOM Definition AS computed tomography scanner (“Siemens”, Germany) was used. For examination of animals, an MX 8000 CT scanner (“Philips”, Netherlands) was used in DICOM mode to construct multiplanar 3D reconstructions using the Horos Viewer for animals software and WorkStream 4D™. Morphometric-densitometric measurement of vertebral body density was performed in the localization of the maximum at the apex of physiological lordosis, i.e. at the level of C5-C7. Separate parameters of the vertebral bodies related to the spinal canal, the Pavlov-Torg index, etc. were also used. [25,. 26].

The obtained data are presented taking into account the standard error of the mean (M ±m) and were statistically calculated using the parametric multiple Bonferroni t-test. In the case of statistical calculation of absolute indicators, non-parametric criteria were used.

Results

Pain syndrome was the leading clinical sign in all 65 examined patients with localization in the neck, upper torso with characteristic irradiation to the upper extremities with an intensity of 4.4±1.2 points (in the range from 3 to 6 points) according to VAS.

Manifestations of pyramidal insufficiency in the form of a feeling of weakness, tendon hyperreflexia, positive Barre test in the hands were registered in 73.8% (including in one hand – 21.5%, in both hands – 52.3%); in the legs – in 20.0% of cases. Change in gait was determined in 18.5% of patients; fascicular twitching - in 3.1%; feeling of numbness of the upper extremities – in 46.1%, myalgia – in 23.1%. Stenotic changes in the SHVH were expressed in mild dysfunctions of the pelvic organs in 10.7% of patients.

Organic destructive changes in the cervical spine in the examined contingent of patients were detected, using CT, in the form of deforming spondyloarthrosis (78.5%), narrowing of the intervertebral foramina (72.3%), deforming spondylolisthesis (46.1%), thickening of the longitudinal ligament (64.6%). These pathological processes in the cervical spine determined the curvature of the spine and caused the formation of stenosis and compression myelopathy.

Analyzing the data of CT studies according to the gender principle of people, it was found that the sagittal diameter of the vertebral body depends on the gender of all examined individuals (average indicator: in men – 17.8± 0.8 мм; in women this indicator was 2.9 mm smaller).

Spinal stenosis was registered in 84.1% of male and 70.2% of female patients. According to the Pavlov-Torg index, spinal stenosis was observed in 75.4% of patients. Morphometric indicators in individuals with clinical symptoms of degenerative-dystrophic process of the cervical spine are given in Table 1

Table 1. Morphometric measurements in the examined patients (M±m)

People	Average (Sag) body size C_6 vertebrae	Diameter (Sag) of the spinal canal at the level of C_6	Distribution of stenoses according to the Pavlov-Torg index (%)
1. Clinical group , n= 65	16.1 ± 0.6 *	10.0 ± 0.7 *	75.4 #
2. Control group, n=14	17.4 ± 0.5	14.2 ± 0.8	7.1

Notes: * – p <0.05 – indicators compared with practically healthy people (Bonferroni multiple t -test) ;

 # – p < 0.05 – indicators compared to practically healthy patients (nonparametric Kruskall-Wallis test)

Physiological lordosis of the SVC was recorded in a small number of patients, with a maximum in men (p<0.05). Pathological configuration of the SVC was recorded in 84.6% of cases (p<0.05) (Table 2).

Table 2. Changes in the configuration of the spine in humans

Patients examined	Number of people surveyed	Forms of lordosis of the cervical spine		
		Angular kyphosis	Lordosis straightened	Norm
Men	25	11 (44.0%)	9 (36.0%)	5 (20.0%)*
Women	40	16 (40.0%)	19 (47.5%) *	5 (12.5%)
Total	65	27 (41.5%)	28 (43.1%)	10 (15.4%)

Notes: * – p <0.05 – comparison between men and women (non-parametric Kruskall-Wallis test)

In animals, during objective examination, behavior, habits, gait changes, the presence of lameness, depressive behavior, painful reactions to palpation, and body tension were studied. Nervous system lesions were detected in 42 adult dogs (6-14 years old): with stenosis in 35.7%. Motor deficit of one paw (28.6%) or both forelegs (7.2%), one and both hind limbs (9.5%). Atypical paw positioning, decreased/increased muscle tone of the limbs (or dystonia) were regarded as manifestations of pyramidal insufficiency. Such changes were recorded in large breeds of dogs, in small breeds (up to 20 kg) - less often, and in cats - were rare.

Analysis of dynamic-static features in dogs shows that there were difficulties in moving from a "sitting" or "lying" position in 21.9% of dogs weighing up to 20 kg and 52.6% above 20 kg (P<0.05); changes in statolocomotorics in 7 (17.1%) small dogs and 8 (42.1%) large dogs (P<0.05); disorders of the pelvic reservoirs in 2 (4.9%) small and 3 (15.8%) large dogs.

Local pain syndrome upon palpation of the spinal cord, which was characteristic of spinal canal narrowing, radicular syndromes and compression of the neurovascular bundle, involvement of the peripheral nervous system with characteristic reflexogenic foci, and spasm of nearby muscles

During neurological examination, the above symptoms were two to three times more pronounced in large breed dogs (p<0.05) with changes in SHVH compared to all other animals (Table 3).

Table 3. Absolute changes in SHVH in patients and domestic animals

Study groups	Forms of lordosis		
	Normal	Kyphosis	Straightened lordosis
Men, n= 25	5*	11	9*
Women , n= 40	5	16	19
Cats , n=14	11 ##	1 #	2 #
Dogs by the mass < 20 кг, n=42	33 ##	4 #	6 #
Dogs by weight > 20 кг, n=19	5 ** #	5 ** #	9 *

Notes: Likely differences:

**** - p<0.05 - compared to patients;***

*****– p<0.05 – compared to small breed dogs;***

 # – p<0.05 and ## – p<0.01 – compared with patients (in all cases, the nonparametric Kruskall-Wallis test was used).

In multi-plane post-processing of 3D reconstructions in groups of animals, physiological distortion of lordosis prevailed in large breed dogs, against the background of corresponding clinical symptoms in degenerative-dystrophic changes of the cervical spine (Table 3). Pathological lordosis was recorded in 3 cats over 12 years of age with minor symptoms, as well as in small breed dogs of the older age group.

Thus, physiological forms of lordosis prevailed in cats and dogs with a smaller mass 20 кг(78.6% and 78.5%, respectively; p<0.05), which was significantly higher compared to large dogs - 26.3% (p<0.05), the latter indicators being identical to similar indicators in humans.

CT scan of the cervical spine revealed that the greatest cervical lordosis deformation was at the level of the C6 vertebra in all examined groups.

Morphometric-densometric density was preserved at the C3 level, which was accepted as a relative norm for patients, since only at the C3 level were no changes in the body and intervertebral disc observed. When comparing the density of the last vertebrae at the level of the lesion (in most cases in humans this is the level of the C6 body and the C5-C7 bodies), a pattern was observed (Table 3), in which the density increases in the distal direction, which, in our opinion, is associated with mechanical influences (Table 4).

Table 4. Average vertebral body density in humans

Patients examined	Density of the C3 vertebral body	Cranial vertebral body density	Caudal vertebral body density
Men , n= 25	416.6±32.8	450.8±62.7	347.8±47.5
Women, n= 40	433.3±29.2	510.3±51.8	439.6±45.2
Total	424.5±30.2	480.1±57.9	393.6±44.8

It was found that the densitometric density of the C3 vertebrae, as well as those located above and below, is higher in women compared to similar indicators in men.

Using prospectively performed CT scans in the sagittal direction, multi-planar 3D reconstructions and post-processing, it was shown that in all small animals the peak of physiological lordosis falls on the level of C6. It was established that the degenerative-dystrophic process was directly related to the formation of pathological lordosis and was most morphologically and clinically expressed only in dogs weighing more than 20 kg (Table 5).

Table 5. Average densitometric data of the density of the vertebral bodies of domestic animals

Animals	Density of the C3 vertebral body	Cranial vertebral body density	Caudal vertebral body density
Cats , n=14	524.3±79.5	525±71.3	511.2±76
Dogs by the mass < 20 кг, n=42	543±46.5	491.3±49.7	454±41
Dogs by weight > 20 кг, n=19	569.5±53	471.3±46.7	404±50.8

Clinical examination suggests that neurological symptoms in dogs weighing more than 20 kg were more pronounced compared to the examined small breed dogs.

Considering that osteodystrophic changes in the spine can prevent premature aging processes, the study of new etiopathogenetic mechanisms of its development in a model of large breed dogs may become most relevant.

Discussion

Typical destructive pathological processes in the vertebral bodies, in the intervertebral discs, and joint surfaces as a result of osteoarthritis and osteochondrosis with the formation of various forms of spondylosis, straightening of the cervical lordosis and other spinal deformities, and the progression of osteoporosis are the leading factors of secondary damage to the nervous system, which lead to irreversible changes and determine the corresponding neurological clinical picture and its course [27]. Therefore, we paid attention to such types of damage as osteochondral and nervous system [28].

Starting the discussion of the obtained results, we would like to focus on the differences in definitions. We use the distinction *"degenerative-dystrophic"* changes in the vertebral bodies of a certain part of the spine [3, 29], which directly follows from the fundamental ideas about pathomorphological, pathobiochemical and pathophysiological mechanisms that are initiated under conditions of any damaging influence by etiology and "launch" a number of pathological processes defined above, the final result of which is a decrease in the mineral density of the bone tissue of the vertebral bodies, their demineralization and, accordingly, functional inability to physical and dynamic loads. The formation of functional incapacity of the cervical, as well as other, parts of the spine, according to fundamental ideas, indicates the development of the so-called dysregulatory pathology [30], since it is necessary to understand that in such a case, the dysfunction of a separate part of the spine occurs despite the functioning in the biological organism of numerous powerful duplicating mechanisms, a regulatory feedback mechanism, and others that should be aimed at eliminating the influence of the initiating damaging factor and preventing the corresponding cascade pathological processes. In similar foreign scientific works, the spinal pathology we studied is treated exclusively as *"degenerative"* [10, 17, 19, 31], which, in our opinion, negates the most important understanding and significance of the pathophysiological mechanisms of destructive processes in the bone tissue of the vertebrae and contributes, unfortunately, to an incomplete understanding of the outcome of the disease, the prospects for the development of concomitant pathology, as well as possible schemes for pathogenetically determined pharmacological corrections of this pathological condition and comorbid pathology using the example of pain syndrome [32].

Organic changes in the configuration of the splenic vein in the examined population due to dystrophic lesions reached 84.6% ($p<0.05$)

Deformities of the scrotum in the examined dogs and cats of different breeds were observed in 34.6% of cases. However, in large breed dogs, these indicators were probably changed and reached 73.7% ($p<0.05$). Preservation of the normal shape of the scrotum was more often registered: in cats and dogs with a body weight of less than 20 kg (78.6% and 78.6%, respectively, $p<0.05$), while in dogs weighing more than 20 kg, such deformations occurred 2.7 times more often ($p<0.05$).

A significant association has been found between cervical spine pain and lordosis <20° and the "clinically normal" range of cervical lordosis greater than 30°–40° [12, 33, 34].

Comparative analysis of the deformity of the spinal column in all examined groups indicates that, despite the similar anatomical structure of the spine, the decisive features of its axial load, posture, statolokomotorics and gait with the greatest similarity to humans were found only in large breeds of dogs, in which all the studied indicators of spinal deformity resembled those in humans. These dogs, in our opinion, can be a model for studying the etiopathogenetic factors of the pathology of the osteochondral apparatus of the spinal column, the study of neurological complications and pain syndrome.

The obtained data on the normal state of the C3 vertebra and the intervertebral disc in degenerative-dystrophic processes in the lumbar spine allowed for comparative measurements between the indicated level and the most affected and deformed vertebrae C5-C7 (C6), which is the apex of pathological lordosis.

It was found that morphometric data in all groups of animals coincided with similar degenerative-dystrophic changes in indicators in human observations. At the same time, in animals, dogs weighing more than 20 kg prevailed over dogs weighing less than 20 kg and cats (rarely and mainly in older age).

It was found that the density of the vertebral bodies in all examined groups decreased in the cranial direction. In humans, this indicator was most pronounced, and in women it was higher compared to similar indicators obtained in men.

The animals had a similar distribution of vertebral body density. With minimal indicators in cats, its increase in dogs up to 20 kg and a significant increase (5 times compared to cats and 2 times compared to dogs up to 20 kg, $p<0.05$)

The density of the vertebral bodies between the examined groups shows that the maximum values were recorded in humans and dogs with a body weight of more than 20 kg.

It is known that degenerative-dystrophic changes in the spinal cord are characteristic of older age groups of people. In our studies, a similar phenomenon was observed in younger patients (however, the actual data of these observations are not included in this work). It should be noted that such a trend was registered only in large breed dogs, that is, a clear "rejuvenation" of the disease could be observed both in humans and in some animals, which requires further study. Despite the fact that the groups of animals had an age range similar to humans, in small breed dogs and cats degenerative changes in the spinal cord were characteristic of older age (11-14 years). They can be considered as a predictor of aging of the structures of the spine and the whole organism.

Signs of spondylogenic spinal cord compression with neurological deficit at the cervical level against the background of lordosis curvature and provocation of spinal canal stenosis were found in 73.7% of large adult dogs.

Thus, the revealed patterns of clinical and morphometric research of degeneration of the osteochondral apparatus of the SCI allow using animals for modeling secondary vertebrogenic

myelopathy of the SCI and other diseases, the dynamics of the clinical picture, prognosis and other risks in humans. This is also due to the fact that metabolic processes occur faster, and pathological destructive processes in bones and cartilage tissue correlate with age, body weight, breed characteristics, etc.

It is advisable to continue studying the processes of spinal aging by studying data on dystrophic changes in the spine in animals, since they can be extrapolated to humans and, as a result, can be a model for studying predictors of aging of the organism as a whole.

Conclusions

Pathological deformations of the cervical spine with degenerative-dystrophic changes in humans had gender differences and were recorded more often in men than in women. Similar deformations of the cervical spine were recorded in 34.7% of animals, mainly as a straightened lordosis. The configuration of the cervical spine in cats and small breed dogs was more often physiological. Only in large breed dogs were pathological changes in the cervical spine significant and had the most similar spinal deformity to humans.

The density of the C3 vertebra in all groups of the examined practically preserved physiological parameters. The change in the density of the deformed C5-C7 (C6) vertebrae, which determine the "peak" of pathological lordosis, apparently indicates significant dynamic loads in humans and mainly large-breed dogs. Similarly, this indicator decreased in the caudal direction of the cervical vertebrae. This was maximally registered in humans and dogs weighing more than 20 kg, the indicators of which approached those of humans.

The conducted research and analysis of degenerative-dystrophic changes in the cervical spine indicate that large breed dogs can be a model for studying etiopathogenetic factors, course, prognosis and other risks of degeneration of the osteochondral apparatus at the cervical level in humans. Such comparative characteristics between groups can form the basis for modeling degenerative processes in the spine, prevention of premature aging in humans.

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