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Determination of the Morphofunctional Opportunities of Organs of Dogs in Norm with Use of Information Parameters

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Abstract: Conducted research shows that the resistance of organ to various influences depends on level of its organization. The tissue systems consisting of actively dividing cells on various stages of differentiation are more subject for various influences, than the organs consisting of highly specialized cells with low degree of proliferative activity. The conducted research shows that the studied organs can conditionally be divided into two groups depending on the value of an existing structural variety. The liver, kidneys, pancreas, stomach, mammary gland, skin, ovaries and endometriya entered the first group. These organs are characterized by H value bigger than 2 bits. All types of muscles and the lungs, which have made the second group, are characterized by the H value less than 2 bits. Level of the greatest possible information capacity and the information morphological organization in tissues of dogs is defined by extent of differentiation of tissue and level of its mitotic activity. Thus, quite essential level of information morphological organization and rather high levels of relative morphological entropy, information morphological redundancy are noted in the tissues consisting of highly specialized, low-active or inactive in proliferative aspect cells. Such biosystems are rather steady against influences as in them sufficient level of reserves which can be involved in adaptation process remains.

Key words: Adaptation · Regeneration · Entropy · Dog

INTRODUCTION

The phenomenon of the morphofunctional changes in pre- and post-natal ontogenesis in modern science is even more often explained with fluctuations in dynamics of adaptation and regenerator opportunities of live systems. These fluctuations are observed at all hierarchical levels of the organization [1, 2]. Information now becomes one of key concepts of the solution of the main questions of modern science. The theory of information finds application not only in technical science, but also in actively developing branches of modern medicine and biology. The concept "information condition of system" can be applied to an explanation of regularities of above-mentioned processes [3, 4].

Information parameters objectively display the level of morphofunctional opportunities of organs of dogs which cause adaptation and regenerator potential [5, 6]. Use of information parameters in various branches of medicine, including in prenatal diagnostics, diagnostics of inflammatory and tumoral processes, violations of hormonal secretion and work of cardiovascular system, etc can become especially actual. Techniques of research of information state are applicable equally for cellular, tissue and organ systems.

In the course of a morphogenesis in each biological object there are a certain number of structural elements which are urged to provide reliability of function in normal and possibility of its adaptation and functioning in the conditions of pathology is formed. The information

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analysis allows revealing both an optimum condition of morphological system and its shifts in various conditions. It permits revealing the hidden and/or excess reserves of system, which are aimed on increase of the reliability. By means of information parameters it is possible to estimate a morphofunctional condition of tissue and organ systems, both in normal and at various pathologies. Besides, it is reasonable that the condition of the same systems will differ at different stages of ontogenesis [7-20].

The major question of an initial condition of various organs and systems of dogs, including the human, i.e. about their condition in normal, is low-studied. Research of information condition of cellular, tissue and organ systems of dogs out of any stressor and pathogenic factors was seemed very actual to us. Carrying out of such research allows defining an initial, normal information state of various systems that, in turn, will allow drawing conclusions about aberrations in case of any pathology. Knowledge of normal condition systems is extremely important for any branch of human biology, medicine and veterinary.

For an assessment of information parameters in normal, we chosen dog as one of the used experiments animals..

MATERIALS AND METHODS

Animals: Specimens from twenty dogs at the age of 5-7 years were collected for histological examinations.

Histological Analysis: A small portion of organs was taken and fixed in to 10% formaldehyde. After several treatments for dehydration in alcohol, sections having 5ìm thickness were cut and stained with hematoxylin and eosin and histopathological analysis was carried.

Morphometric Studies: Information condition of the following organs was investigated: liver, kidneys, skin, pancreas, mammary gland, endometrium, ovaries, stomach, lung, myocardium, skeletal and smooth muscles.

Karyometry with the subsequent definition of information condition of organ was made for cells which are actually carrying out the main function of organ, i.e. hepatocytes in a liver, splenocytes in a spleen, epithelial cells in kidneys, etc.

Volume of the nuclei of cells was measured by image analyzer "Videotest" at hematoxylin and eosin stained sections.

Studies of the Information Condition of the System of the Organs: We carried out a breakdown of the aggregate of the measured volumes of cells nuclei into classes.

Based on the concept of information in a tissue system as the displaying of the diversity of morphology and function of the process for assessing the information status of organs and tissues have been proposed and tested the such indicators - information morphological capacity (H_{max}), information morphological entropy (H), information morphological organization (S), the relative morphological entropy (H) and redundancy (R) [21-23]. In this case, the baseline characteristics, which were used to calculate these parameters, can vary widely (the linear dimensions of the structures, their number, etc.). In our study was defined the volume of the nuclei of cells.

Information morphological capacity H_{max}, which means the maximum structural diversity, calculated by formula [21-23]:

$$H_{max}=\log_2 n,$$

where n - number of classes.

Next, we made the calculation of the real structural diversity H. Real structural diversity is the parameter that clearly illustrates the degree of determinism of morphofunctional system in time and space [21-23]. The calculation was made using the formula:

$$H=-\Sigma P_i \log_2 P_i,$$

where ΣP_i is the sum of probabilities of stay of the measured parameter of cells in a one of existing classes; $\log_2 P_i$ - logarithm of the probability of staying in one of the possible classes. In this case, the value of P_i is defined as the classical probability.

Knowing the maximum and actual structural diversity, we can calculate the organization of the system (S), the difference between the maximum possible and the real structural diversity (implemented structural diversity). This parameter, in our opinion, displays the state of the system adaptability to date. To determine the value of this parameter is used the formula [21-23]:

$$S=H_{max}-H.$$

It is necessary to consider that when $H = H_{max}$, the system is deterministic, but such relation to the vast majority of permissible is possible only in theory.

Then we determined the coefficient of relative entropy of the system, or (the coefficient of compression of information) h by formula [21-23]:

$h=H/H_{max}$.

High levels of relative morphological entropy provide evidence of the disorder of the system and significantly reducing of its structural integrity [21-23].

The coefficient of the relative organization of the system (redundancy factor) R is given by [21-23]:

$R=(S/H_{max})\times 100\%$.

Statistical Analysis: Values are expressed as mean (± SD).

RESULTS

For a liver of dogs the following indicators are characteristic – H_{max} makes up 3.32±0.0003 bit, H is equal to 2.550±0.014 bit, respectively, S makes up 0.764±0.0014 bit, h – 0.7682±0.0044 bit, R is equal to 23.23±0.47% (Fig. 1).

Lungs of dogs are characterized by value of H_{max} equal to 2.584±0.0001 bits, H makes up 1.145±0.021 bits, S is equal to 1.43±0.021 bits, h – 0.4457±0.008 bits and R – 55.43±0.79%. For an epithelium of kidney tubules of dogs value of H_{max} was equal to 2.807±0.0001 bits, H during this period of ontogenesis makes up 2.10±0.021 bits, S – 0.7260±0.021 bits. Value of h was equal 0.7410±0.008 bits and R – 22.75±0.79%.

The analysis of a myocardium of dogs showed that H_{max} for this organ makes up 2.58±0.0001 of bit, the H is equal to 1.289±0.015 bits, S makes up 1.294±0.016 bits, h is equal to 0.4990±0.006 bits and R makes up 50.25±0.074% (Fig. 2,3).

For skeletal muscles H_{max} was equal to 2.58±0.0001 bits, H – 1.10±0.015 bits, S – 1.48±0.015 bits, h makes up 0.579±0.008 bits and R equaled to 57.37±0.60%.

By consideration of smooth muscles of dogs it is revealed that H_{max} also makes up 2.58±0.0001 bits, H – 1.0±0.016 bits, S – 1.546±0.016 bits, h makes up 0.400±0.008 bits and R is equal to 59.91±0.61%.

For a pancreas of dogs we found H_{max} making up 3.32±0.0003 bits, the H during this period of ontogenesis makes up 2.00±0.65 bits, S – 1.320±0.065 bits, h is equal to 0.6036±0.020 bit and R – 40.50±2.21%.

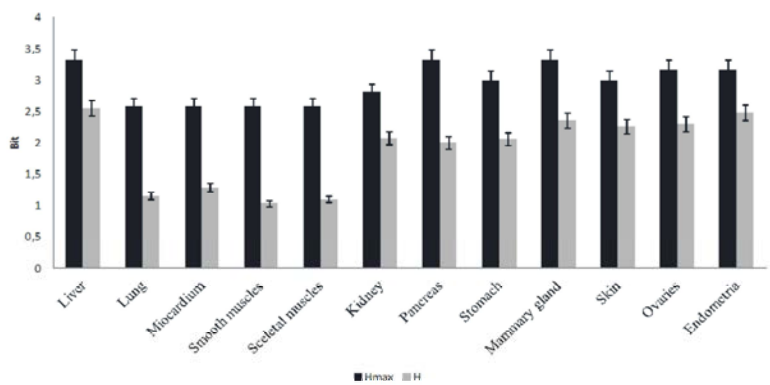

Fig. 1: Value of H_{max} and H in organs of dogs.

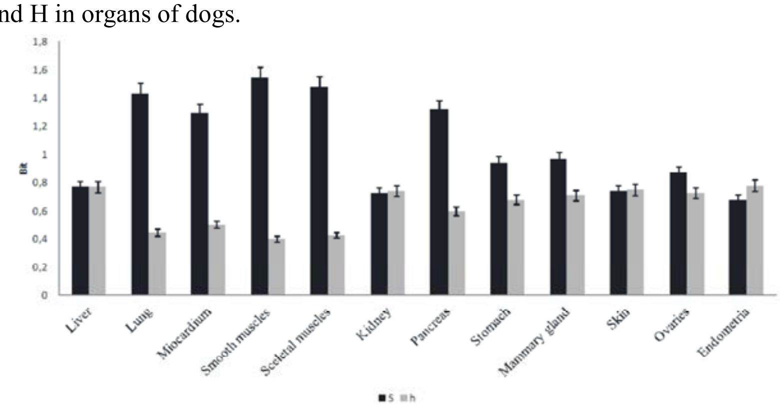

Fig. 2: Value of S and h in organs of dogs.

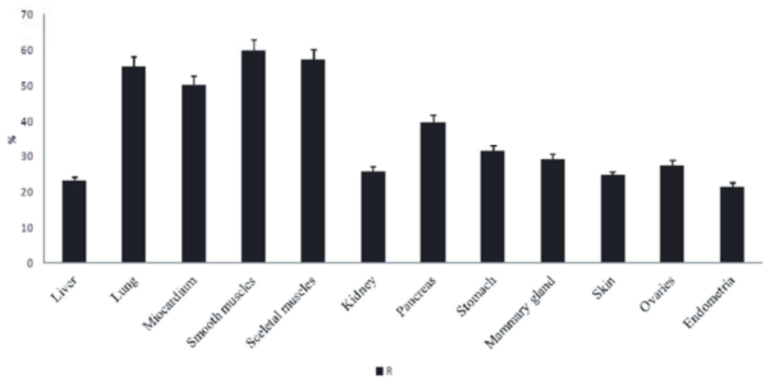

Fig. 3: Value of R in organs of dogs.

For skin of dogs H_{max} equal to 3.0±0.0001 bits is found, the H is equal to 2.25±0.016 bits, S – 0.743±0.015 bits, h – 0.7536±0.0050 bits and R equal to 25.60±0.49%.

For a mammary gland of dogs H_{max} makes up 3.32±0.0003 bits, the H is equal to 2.350±0.13 bits, S – 0.965±0.13 bits, h – 0.7084±0.039 bits, R – 29.15±3.96%.

For the stomach of dogs allowed to establish that H_{max} at this time makes up 3.0±0.0001 bits, the H is equal to 2.059±0.021 bits, S makes up 0.9433±0.02 bits, h – 0.6856±0.0066 bits and R is equal to 31.44±1.55%.

By consideration an endometrium of dogs it is revealed that H_{max} makes up 3.16±0.0001 bits, H – 2.475±0.020 bits, S – 0.681±0.020 bits, h makes up 0.7849±0.010 bits and R is equal to 21.55±0.63%.

For ovaries of dogs we found H_{max} making up 3.16±0.0001 bits, the H during this period of ontogenesis makes up 2.240±0.30 bits, S – 0.8670±0.30 bits, h is equal to 0.7258±0.009 bits and R – 27.42±0.88%.

DISCUSSION

It is established that the highest information morphological capacity is peculiar to the organs consisting of updating populations of cells (kidneys, a liver, a pancreas). These facts speak both about level of functional activity of body and about level of proliferative activity in it.

It is natural that the indicator of the greatest possible structural variety displays only potential morphofunctional possibilities of tissue which can be realized to some extent. The analysis of other studied indicators allows giving a better understanding about a condition of organ [24, 25].

The highest rates of the greatest possible structural variety are peculiar to a liver, a pancreas and a mammary gland. Smaller this value is for ovaries and an endometria. On this sign the stomach, kidneys and skin are intermediate. Minimum it appeared for lungs and all types of muscles.

The conducted research shows that the studied organs can conditionally be divided into two groups depending on the value of an existing structural variety. The liver, kidneys, pancreas, stomach, mammary gland, skin, ovaries and endometriya entered the first group. These organs are characterized by H value bigger than 2 bits. All types of muscles and the lungs, which have made the second group, are characterized by the H value less than 2 bits.

Thus, we can claim that level of the greatest possible information capacity and the information morphological organization in tissues of dogs is defined by extent of differentiation of tissue and level of its mitotic activity. Thus, quite essential level of information morphological organization and rather high levels of relative morphological entropy, information morphological redundancy are noted in the tissues consisting of highly specialized, low-active or inactive in proliferative aspect cells. Such biosystems are rather steady against influences as in them sufficient level of reserves which can be involved in adaptation process remains [26-30].

The tissues of dogs consisting of actively sharing cells on different degree of a differentiation, are characterized by the indicator of an existing structural variety which is coming nearer to the greatest possible variety. Such tissue systems are unstable, as evidenced by the low level of information morphological organization, information morphological redundancy and very high level of relative morphological entropy.

The tissues consisting of updating populations of cells are characterized by level of the information parameters which values hold a certain average position concerning values of the above described systems. The systems formed by these tissues, respectively, also hold some average position on resistance to influence of various factors.

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