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# Information Condition of Dog's Liver at Pathologies

[1]D.A Areshidze, [2]L.D. Timchenko and [1]M.A. Kozlova

[1]Moscow State Regional University, Center of Cell Biology and Applied Biotechnology, Moscow, Russian Federation
[2]Institute of Applied Biotechnology Department of the Living Systems of the North Caucasus Federal University, Stavropol, Russian Federation

**Abstract:** In the The study revealed the nature of the state change information system of the liver tissue with hepatadenoma, liver cancer and non-cancer pathologies. Was shown that information parameters of non-cancer diseases indicate that liver tissue system uses existing structural adaptation resources. Information system of tumors of the liver is simplified and streamlined. Changes of information parameters characterizing a liver indicate various kinds of adaptive processes in the tissue at various pathologies study the method of assessing adaptive and regenerative opportunities of the liver by assessing of its information state was applied. The research revealed a change in the nature of the information state of the tissue of the liver at hepatoadenoma, liver cancer and non-cancer pathologies. Discovered changes of the information parameters characterizing the liver, indicate various kinds of adaptive processes in the organ. It is shown that at the non-neoplastic diseases of the liver, tissue system uses the existing structural adaptation resources, but it tends to collapse. Changes of the information parameters were more pronounced at malignant disease than at hepatoadenoma, it is revealed reduction of system reliability to negative value. When tumors of the liver, tissue system is simplified, ordered and directed the growth and increase the reliability, such system complicates the possibility of successful treatment of the organ in such pathologies.

**Key words:** Entropy · Biosystem · Liver Pathology · Adaptation

## INTRODUCTION

Changes in pre-and postnatal development of mammals in normal and pathological conditions are increasingly considered as a phenomenon caused by the dynamics of adaptation and regeneration capabilities of living systems at different hierarchical levels [1-4]. To assess the parameters of ability of adaptation and regeneration proposed to use Shannon entropy and its derivatives of tissue parameters. Information state of the tissue is an indicator of adaptive capacity of biosystem [5-8].

Several authors do not exclude the existence of an interrelation between change of information state of system and the development of pathological processes in the period of appreciable senile changes [9-11]. It is shown that in case of damage and adaptation responses in biological systems occurs a redistribution of energy-flow accompanying the process of restructuring the tissue. Small number of publications examine the information condition of organs and tissues [12, 14-17].

From the above, it seems actual to study the information status of the liver as an organ providing homeostasis in dogs at normal and at a hepatoadenoma, hepatocellular liver cancer and non-cancer diseases.

## MATERIALS AND METHODS

Were examined histologic specimens of a dog liver, with various pathological processes:

- normal liver (n = 150);
- at cirrhosis (n=88);

**Corresponding Author:** D.A. Areshidze, Center of cell biology and applied biotechnology, Moscow, Russian federation.

- at hepatitis (n=80);
- at granuloma (n=66);
- at lipophanerosis (n=70);
- at necrosis (n=88);
- at hepatadenoma (n=79);
- at hepatocellular carcinoma (n=87).

The diagnosis is based on data of postmortem and histologic examination. To determine the information status at focal lesions of the liver, pieces of tissue were taken from the least altered areas on the border of macroscopically distinct lesions. In case of visual homogeneity of organ material was taken from any part of it.

Based on the concept of information in a tissue system like 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) [18-20].

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 hepatocytes.

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

Carried out a breakdown of the aggregate of the measured volumes of hepatocyte nuclei into classes.

Information morphological capacity $H_{max}$, which means the maximum structural diversity, was calculated by formula [18-20]:

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

where n-number of classes of volumes of hepatocyte nuclei. This parameter is defined by a particular characteristic (hepatocyte nuclei volume) remains constant for a tissue or organ described in the norm and pathologies.

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 [18-20]. The calculation was made using the formula:

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

where $\Sigma P_i$ is the sum of probabilities of stay of the measured parameter of cells in 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 [5].

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 was used the formula [18-20]:

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

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 Avtandilov and Avtandilov and Areshidze *et al.* [18-20]:

$$h=H/H_{max}.$$

High levels of relative morphological entropy provide an evidence of the disorder of the system and significantly reducing of its structural integrity [18-20].

The coefficient on the relative organization of the system (redundancy factor) R is given by Avtandilov and Areshidze *et al*. [19,20]:

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

With these data, the researcher have the opportunity to calculate the equivocation of the system (the value of reliability) *e* [18-20]:

$$e=(H_p-H_n)/H_{max},$$

where $H_n$-real structural diversity in normal, $H_p$-real structural diversity in pathology.

Values are expressed as mean (± SD). The statistical analysis was performed using one-way analysis of variance (ANOVA). The statistical difference determined using repeated measures analysis of variance or paired Student t-tests. A p value of < 0.05 was considered statistically significant.

## RESULTS

Liver of healthy dogs was characterized by such parameters: $H_{max}$ was 3.32±0.0003 bit, rate of H was equal to 2.642±0.014 bits, respectively, S was 0.6785±0.0014 bit, h - 0.7958±0.0044 bit (Fig. 1), R equaled 20.42±0.45% (Fig. 2).

Liver at granuloma was characterized by increase of H in comparison with the norm to 2.786±0.016 bits, the value of S was much lower than normal, making 0.534±0.016 bits, h on the contrary, increased to 0.8391±0.005 but, R reduced to 16.08±0.5%. *e* ratio was 0.144±0.0044.

At hepatitis the value of H also increased to 2.807±0.077 bits, S reduces the 0.4231±0.077 bits, h is increased to 0.8690±0.0057 bit and R reduced to 13.1±0.57%. The value of *e* was 0.07677 ± 0.204.

In lipophanerosis informational parameters of normal organ were similarly differ from the norm. So, H value was 2.87±0.019 bits, S was equal to 0.3602±0.019 bits, h reached 0.8885±0.006 bits, R is reduced to 11,15 ± 0.6% and *e* 0.1987 ± 0.006.

For dog liver at necrosis we found the H equal 2.89±0.017 bits, S was 0.3399±0.017 bits, h-0.8948±0.005 bits, R equaled 10.52±0.53% and *e* is equal to 0.2144 ± 0.0053.

A character of difference from the norm of the information of the dog liver with cirrhosis was similar. H is 2.807±0.018 bits, S was equal to 0.4230±0.018 bits, h reached 0.8690±0.0056 bit, R reduced to 13.10±0.56%, *e* was 0.1894 ± 0.0056.

At hepatadenoma of dog liver we observed decrease of H concerning to the norm to 2.39±0.013 bits. Accordingly, the value of S was higher than normal-0.8404±0.013 bits, h reduced to 0.7398±0.004 and R increased to 26.02±0.4%. Index *e* was-0.3841 ± 0.039.

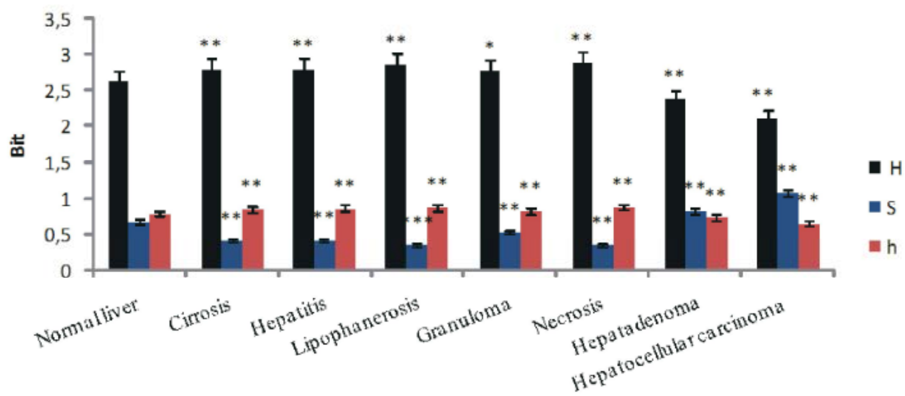


Fig. 1: Magnitude of the H, S and h in normal liver of dogs, liver with hepatadenoma, liver cancer and non-cancer diseases. Statistical significance was assessed using student t-test. *** indicates P<0.001, ** indicates P<0.01, * indicates p<0.05.

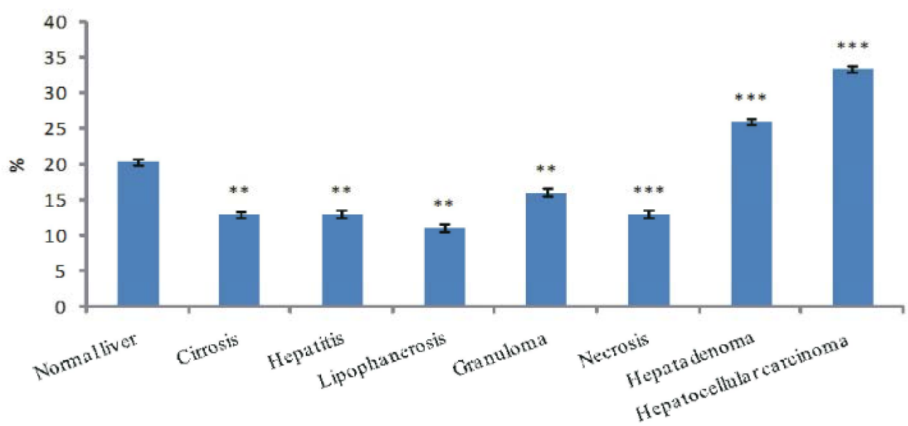


Fig. 2: Value of the R index at the liver of normal dogs, dogs with hepatadenoma, liver cancer and non-cancer diseases. Statistical significance was assessed using student t-test. *** indicates P<0.001, ** indicates P<0.01, * indicates p<0.05.

At hepatocellular liver cancer $H_{max}$ did not differ from the norm, the value of H concerning to the norm dropped substantially, making 2.121±0.013 bits, the value of S increases significantly to 1.079±0.013 bits, h reduced to 0.6658±0.004 bits, R increases up to 33.42±0.40% and *e* was- 0.6709±0.031.

## DISCUSSIONS AND CONCLUSIONS

At the non-neoplastic diseases of the liver it was the rise of the H, which means an increase of the entropy of system, in parallel with this process it has observed an increase of information compression, as evidenced by increase of coefficient of the relative entropy of the system (h). In addition, it was observed the decrease of the structural diversity of the system (S) and the coefficient of excess (R), which means the number of redundant structural elements of the system. At the cancer of the liver changes of information systems were different. In particular, there was a decrease of both total and relative entropy of the system against the increase of its structural diversity and the coefficient of redundancy. At the same time, changes of the information parameters were more pronounced at malignant disease than at hepatadenoma.

Thus, at non-neoplastic diseases of the liver tissue system uses existing structural adaptation resources, the level of structural diversity of the system reduces, the number of redundant structural elements is also reducing, with a tendency to destroy the integrity of the system. At tumors there is a simplification of the information system of the liver and as a consequence, increase of its reliability, ordering and the system is designed to rise, which may testify to the compensatory-adaptive reactions in the organ and in the case of metastatic cancer. Thus, changes of the information parameters characterizing the liver, indicate various kinds of adaptive processes in the organ.

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**Conflict of Interest:** The authors declare no conflict of interest.

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