Thus GMI of mature skin scars in the dorsal region of rats lead to their reconstruction into regenerating tissues of dermal and cutaneous types, similar in their structure to normal skin. With an increase in the number of GMI procedures the number of reconstructed scars increased; for example, repetition of GMI twice induces reconstruction of scars in only 13.0% of cases, but repetition four times does so in 59.1% of cases.

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INFORMATION ANALYSIS APPLIED TO MORPHOMETRIC INVESTIGATION OF POSTMORTEM CHAHACTERISTICS OF THE LIVER

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Hepatic failure is a frequent complication of many surgical diseases and often terminates in death [3, 4, 12]. However, morphological methods used in the postmortem diagnosis do not ensure precise evaluation of the degree of liver damage, due to a definite subjective element arising when its structure is described as a system, and to the rapid development of autolysis when ordinary autopsies are done [15]. Morphometry of the liver tissue followed by quantitative information analysis of the complexity of its structure may be a promising method in such cases [2, 11].

Accordingly, in the investigation described below, the possibility of using morphometric and information analysis of the liver tissue to assess the degree of its damage quantitatively was studied on early autopsy material from patients who died.

EXPERIMENTAL METHOD

Altogether 17 early autopsies were studied. The control group consisted of five medicolegal autopsies: cardiac death was diagnosed in three cases, and trauma incompatible with life in two cases. In five cases the cause of death was

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acute posthemorrhagic anemia following rupture of an aneurism of the abdominal aorta, in seven there was combined failure of more than one organ as a result of toxemia in patients with peritonitis and with gangrene of the lower limbs. The ages of the patients ranged from 52 to 78 years. Autopsy was carried out 45-90 min after confirmation of death. Paraffin sections of liver tissue were prepared and stained with hematoxylin and eosin. By means of a "Microvideomat" television image analyzer (Opton, West Germany) the optical density and area of the nuclei and cytoplasm of the hepatocytes, and the area and perimeter of the sinusoids were determined in zones I and III of the hepatic acini, and on that basis the nucleo-cytoplasmic ratio of the hepatocytes and the shape factor of the sinusoids were calculated To obtain numerical values of information entropy (H), relative entropy (h), excess (R), and organization (O) of the system, the usual equations [6] were used:

$$H=-\sum_{i=1}^{m} p_i \cdot \log_2 p_i;\ h=H/H_{max};$$
$$R=(1-H/H_{max}) \cdot 100\ \%=(1-h) \cdot 100\ \%;\ O=H_{max}-H, \quad (1)$$

where H_{max} denotes the maximal entropy of the system, equal to $\log_2 3 = 1.585$. The index of equivocation (D) also was calculated, for use as a quantitative criterion of structural disorganization of the system:

$$D=R_H-R_{nam}=\frac{H_{nam}-H_H}{H_{max}}. \quad (2)$$

EXPERIMENTAL RESULTS

The morphometric study of the liver tissue in the control group revealed structural heterogeneity of the acini (Table 1), in agreement with data in the literature [8, 10, 13]. In the zones I of the acini the area of the hepatic trabeculae was 7.3% greater than in zones III ($p < 0.05$), which was connected with the fact that the periportal hepatocytes have nuclei 16.5% larger ($p < 0.05$) and an area of cytoplasm 5.9% greater ($p > 0.05$). The perivenular zones have an area 59.8% greater ($p < 0.05$) and a perimeter of their sinsuoids 30.2% greater ($p < 0.05$), evidence of intensive exchange processes between the hepatocytes and blood in zone III of the acini.

Mathematical analysis of the results (Table 2) shows that the coefficient of excess in the control, guaranteeing reserve reliability and increasing the adaptive and compensatory capacity of the morphological system, enables that particular system (the acinus) to be classed as determined [5], so that the resistance of the liver to pathogenic influences can be maintained at a high enough level. In this case the values of organization and excess of the hepatocytes in zone I of the acini are higher than the corresponding values for zone III, and parameters of current and relative entropy are greater in the case of perivenular (centrilobular) hepatocytes. This state of affairs is evidence of the greater degree of chaos and unreliability of the hepatocyte system in zone III of the acini, largely due to the worsened conditions for the circulation.

Dilatation and congestion of the vessels of the portal tract and sinusoids, frequently with the presence of aggregates of erythrocytes and leukocytic stasis and microthrombi in them, are observed in the liver of patients dying from combined failure of more than one organ as a result of toxemia. Evidence of damage to hepatocytes is given by cloudy-swelling, vacuolar, and fatty degeneration and also by centrilobular and triangular necrosis. In the cases studied the liver of patients dying from hemorrhagic shock showed anemia of the vessels of the portal tract and sinusoids, with monocellular and solitary centrilobular foci of necrosis.

Morphological changes observed in the liver also are noted by morphometric investigation. In the case of failure of more than one organ there is a considerable increase, especially in the perivenular zones, of the area (by 54.1 and 90.1% in zones I and III respectively, $p < 0.05$) and perimeter of the sinusoids (by 174.6 and 314.2% respectively, $p < 0.05$), in agreement with data in the literature [7], and this may be regarded as an objective quantitative parameter of the degree of pathological deposition of blood in the liver. The more marked changes in zone III of the acini are reflected in values of the shape factor (Table 1). In acute anemia the area of the sinusoids is increased on average per acinus by only 9.5% ($p < 0.05$), whereas their perimeter is 3.5 times greater than the control values ($p < 0.01$). As a result of this, the shape factor also increases, Changes of this kind must evidently be regarded as compensatory/adaptive, aimed at increasing the area of exchange between the incoming blood and the parenchyma of the liver under conditions of anemia and circulatory hypoxia [14]. The parenchyma of the liver in combined failure is characterized by a decrease in area of the hepatocytes by 6.1% ($p < 0.05$) in zone I and by 17.6% ($p < 0.05$) in zone III of the acini compared with that in the control group. In this case

TABLE 1. Morphometric Characteristics of Liver Acini during Toxemia and Acute Blood Loss (M ± m)

Parameter	Control		Toxima		Blood loss	
	I	III	I	III	I	III
Area of nuclei of hepatocytes (S_n), conventional units	19,19±1,40	16,47±0,43	13,78±1,91	14,42±2,27*	16,27±2,18*	17,11±2,24*
Area of cytoplasm of hepatocytes (S_c), conventional units	115,56±4,37	109,16±4,04	112,72±6,03*	89,08±7,11	117,93±4,34*	105,29±3,66*
Nucleo-cytoplasmic ratio (S_n/S_c)	0,17±0,02	0,15±0,01	0,12±0,01	0,16±0,02*	0,14±0,01	0,17±0,02*
Area of hepatocytes (S_h), conventional units	134,75±1,71	125,63±3,90	126,50±3,09	103,50±6,83	134,20±2,59*	122,40±1,82*
Area of sinusoids (S_s), convention conventional units	15,25±1,31	24,37±1,20	23,50±2,07	46,50±4,81	15,80±0,95*	27,60±0,81
Perimeter of sinusoids (P_s)	1,89±0,14	2,46±0,21	5,19±0,41	10,19±0,87	6,42±0,90	8,57±1,10
Shape factor of sinusoids (P_s^2/S_s)	0,23±0,02	0,25±0,02	1,15±0,12	2,23±0,21	2,61±0,21	2,66±0,22
Optical density of hepatocyte nuclei, conventional units	0,305±0,027	0,301±0,024	0,222±0,016	0,260±0,017*	0,278±0,017*	0,282±0,018*
Optical density of cytoplasm of hepatocytes	0,150±0,013	0,168±0,014	0,106±0,009	0,144±0,012*	0,156±0,013*	0,175±0,014*

Legend. I) Periportal, III) perivenular zone of acinus; all values except those marked by an asterisk differ significantly from the control.

TABLE 2. Information Characteristics of the Liver in Toxemia and Acute Blood Loss

Group	Zone of acin	H, bits	h	R, %	O, bits	D, %
Control	I	0,9710	0,613	38,7	0,6140	0
	III	1,0743	0,678	32,2	0,5107	0
Toxemia	I	0,9986	0,630	37,0	0,5864	1,7
	III	1,2703	0,801	19,9	0,3147	12,3
Blood loss	I	0,9248	0,583	41,7	0,6602	—3,0
	III	1,1325	0,715	28,5	0,4525	3,7

both the area of the nuclei and the area of the cytoplasm are reduced. The more marked changes in the perivenular zones of the acini reflect the predominant localization of foci of necrosis in these regions.

By calculating the information characteristics the changes observed in the acini of the liver can be compared with the aid of generalized criteria. In combined failure there is an increase in the current and relative entropy, and equivocation, and a decrease in the organization of the system (Table 2). The observed decrease in the excess parameter points to the development of pathological processes in the system [2]. It will be clear that the more marked deviations from the control values, especially in the equivocation values, are found in zone III of the acini, where mainly degenerative and necrotic changes in the hepatocytes are observed. This localization of the lesions is connected with the fact that the perivenular cells are under worse conditions of blood supply. Acute blood loss is characterized by opposite changes in the information parameters in zones I and III of the acini, which confirms yet again the importance of the study of the morphological and functional state of the liver, allowing for differences within the acini [9]. The perivenular zones are characterized by an increase in the chaos of their structural organization. In the I zones, on the other hand, adaptive and compensatory powers are increased. It will be evident that during the development of degenerative and necrotic changes in the III zones the periportal hepatocytes will take over their function. On the average, however, for the acinus an increase in the absolute and relative entropy, and equivocation, and a decrease in the levels of organization and excess will be observed. In other words, under conditions of acute blood loss there is a disturbance of the morphological and functional state of the liver, and this plays an essential role in the pathogenesis of hemorrhagic shock and death from it.

Thus the study of liver tissue in cases of toxemia and acute blood loss, conducted on early postmortem material, enabled objective quantitative characteristic: of the structural changes to be obtained, and the morphological features of damage to the zones of the hepatic acini to be detected. By the use of information analysis an integral estimate can be given of the morphometric parameters, and in that way the character of the response of different zones of the acinus to various pathogenic influences can be compared.

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