liquid part of the blood into the surrounding tissue. A vicious circle is thus formed. Other no less important factors increasing the outflow of fluid into the lung tissue must also be taken into account. Besides the severe hypoxemia and the increase in the liberation of catecholamines, which are edema-inducing factors, the outflow of sodium ions and their accumulation in the lung tissues, increasing their hydrophobicity, may also play an important role. With an increase in the intensity of pulmonary edema, the ventilation—perfusion ratio is disturbed even more (0.05 compared with 0.71 in the initial state), and in conjunction with the other factors listed above this probably also led to the development of hypoxic edema of the lungs.

LITERATURE CITED

1. S. A. Gulyar, in: Special and Clinical Physiology of Hypoxic States [in Russian], Kiev (1979), Part 3, pp. 24-37.
2. É. M. Ismailov and R. R. Tukhvatshin, in: Special and Clinical Physiology of Hypoxic States [in Russian], Kiev (1979), Part 1, pp. 248-252.
3. Ya. A. Lazaris and I. A. Serebrovskaya, Edema of the Lungs [in Russian], Moscow (1962).
4. M. M. Mirrakhimov, Heart Diseases and Mountains [in Russian], Frunze (1971).
5. M. M. Mirrakhimov and P. N. Gol'dberg, Mountain Medicine [in Russian], Frunze (1978).
6. D. M. Aviado, I. S. Lund, and C. F. Schmidt, Am. J. Physiol., 189, 253 (1957).
7. C. R. A. Clarke, Practitioner, 217, 235 (1976).
8. A. P. Fishman, J. Am. Med. Assoc., 239, 1299 (1978).
9. C. S. Houston, Chest, 74, 359 (1978).
10. H. N. Hultgren, R. F. Grover, and L. H. Hartley, Circulation, 44, 759 (1971).
11. H. N. Hultgren and F. A. Marticorena, Chest, 74, 372 (1978).
12. M. S. Malhotra, H. D. Brahmachari, R. Sridharan, et al., Aviat. Space Environm. Med., 46, 409 (1975).
13. D. Penaloza and F. Sime, Bull. Physiol-Pathol. Resp., 4, 17 (1968).
14. C. H. Scoggin et al., New Engl. J. Med., 297, 1269 (1977).
15. J. W. Severinghaus, in: High-Altitude Physiology: Cardiac and Respiratory Aspects (R. Porter and J. Knight, eds.), Edinburgh (1971), pp. 61-68.
16. R. Sujoy et al., Br. Heart J., 31, 52 (1969).
17. R. Visneanathan, S. K. Jain, and S. Subramanian, Am. Rev. Resp. Dis., 100, 342 (1969).

DYNAMICS OF BILE SECRETION IN RATS AFTER SIALADENECTOMY

V. D. Sukhodolo and N. S. Meleva

UDC 616.316-089.87-07:616.36-008.811-092.9

KEY WORDS: salivary glands; bile secretion; sialadenectomy.

The role of the external and internal secretory activity of the salivary glands extends far beyond digestion [1-3, 5, 11]. It has been shown that sialadenectomy, loss of the saliva, and obstruction to the salivary ducts are all followed by functional and tissue-structural disturbances in the organs of the gastrointestinal tract, including the hepatobiliary system, and in the biochemical composition of the bile in dogs [6-8].

For these reasons it is interesting to study the relations between function of the salivary glands and liver in animals of other species, notably rats, the bile-secreting apparatus of which has certain morphological and functional peculiarities, and the investigation described below was carried out with that aim.

EXPERIMENTAL METHODS

Experiments were carried out on 150 albino rats weighing 200-250 g, kept on a standard diet with water *ad lib.* There were three series of experiments: I) removal of the sub-

Department of Normal Physiology, Tomsk Medical Institute. (Presented by Academician of the Academy of Medical Sciences of the USSR I. V. Toroptsev.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 92, No. 12, pp. 669-670, December, 1981. Original article submitted October 9, 1980.

0007-4888/81/9212-1635$07.50

Table 1. Concentrations of Bilirubin and Protein (in mg %) in Bile after Sialadenectomy (M ± m)

Experimental conditions	n	Bilirubin	Protein
Control	28	12,0±0,4	5,2±0,4
Removal of submandibular glands:			
1 week	8	6,9±0,6*	2,9±0,4*
2 weeks	10	3,7±0,4*	4,2±0,2*
3 weeks	7	9,0±1,0*	7,0±0,1*
4 weeks	8	18,0±1,4*	3,2±0,3*
6 weeks	11	13,5±2,0	3,0±0,5*
Removal of parotid glands:			
1 week	6	7,1±1,0*	5,6±0,4
2 weeks	6	8,0±1,0*	5,2±0,6
3 weeks	4	8,3±1,0*	6,8±0,3*
4 weeks	8	12,3±1,0	2,6±0,3*
6 weeks	9	14,0±0,6	3,8±0,5*
Total sialadenectomy			
1 week	8	9,6±1,0*	4,1±0,6
2 weeks	7	12,0±1,5	5,1±1,0
3 weeks	6	9,0±1,0*	6,0±0,6
4 weeks	6	9,0±1,0*	2,2±0,2*
6 weeks	10	14,5±1,0	4,1±0,3*

*P < 0.05 compared with control.

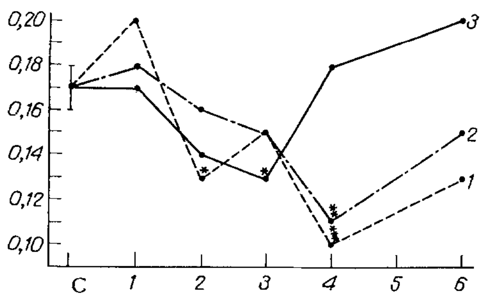

Fig. 1. Rate of bile secretion after extirpation of submandibular (1), parotid (2), and all the main salivary glands (3). Abscissa, time (weeks); ordinate, rate of secretion (in ml/h/100 g body weight). C) Control. *P < 0.05; **P < 0.01; ***P < 0.001.

mandibular glands, II) removal of the parotid glands, III) total sialadenectomy. In parallel control experiments intact rats and rats undergoing mock operations were used. The salivary glands were removed under ether anesthesia by the usual method [10]. At different times (1, 2, 3, 4, and 6 weeks later) the animals were anesthetized with pentobarbital (40 mg/kg) and a cannula was introduced into the common bile duct to remove the bile. The rate of bile secretion was measured in ml/h/100 g body weight. Bilirubin in the collected secretion was determined by Jendrasik's method, cholesterol by Ilek's method, bile acids according to Reinhold and Wilson, and protein by the biuret reaction.

EXPERIMENTAL RESULTS

Observations showed that bilateral removal of homonymous salivary glands and total sialadenectomy caused changes of different severity in bile secretion during the 6-week period of observation. The parameters of bile secretion tested in the intact rats and after mock operations (1 week after the operation) showed no significant changes.

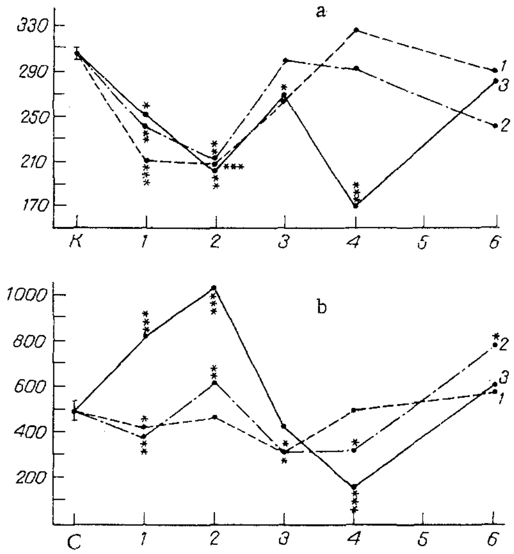

Fig. 2. Concentration of cholesterol (a) and bile acids (b) in bile after sialadenectomy. Ordinate, concentration of components (in mg %). Remainder of legend as to Fig. 1.

Hepatocyes were found to react most sensitively to the extirpation of the submandibular glands. Under these experimental conditions, after a small increase in the rate of secretion in the first week, a significant decrease in bile secretion was observed in the 2nd-4th weeks of the experiment, followed by an increase in secretion toward the 6th week (Fig. 1). Removal of the parotid glands caused similar but less marked changes. Disturbances of bile secretion after total sialadenectomy were unexpected and difficult to explain. The changes in the external secretory function of the liver after this operation were less marked and shorter in duration. In the 4th week after the operation the rate of bile secretion was restored to its initial level although disturbances in the biochemical composition of the secretion still persisted.

Tests on the bile acids and cholesterol showed a distinct reciprocal relationship between these components and individual periods of the investigation (Fig. 2). For instance, a fall in the cholesterol level in the bile after extirpation of the various salivary glands was accompanied by an increase in secretion of bile acids. These changes were most severe after total sialadenectomy: One week after the operation the cholate content was increased by 1.7 times, and 2 weeks after the operation by 2.2 times; the cholesterol content was reduced by 1.2 and 1.6 times respectively. The cholate level in the bile 1.5 months after extirpation of the parotid salivary glands and after total sialadenectomy was significantly higher, whereas the cholesterol concentration in the bile was somewhat lower.

As regards the bilirubin concentration in the bile in these series of experiments (Table 1), a significant fall in its excretion was observed during the 1st-3rd weeks of the experiment after all types of operation. The pigment-excretory function of the liver recovered much more slowly after total sialadenectomy. The sharpest changes in this function (a reduction by 50% in the 2nd week, followed by an increase of 50% in the 4th week) were found after removal of the submandibular glands.

Changes in the protein concentration in the bile after sialadenectomy were more stable. They showed a parallel in the level of this component of the secretion in all three variants of the experiments, with a maximal decrease in the 4th week, but without recovery of the protein concentration to normal in the 6th week.

Bilateral removal of homonymous salivary glands and total sialadenectomy in rats thus give rise to dissimilar phasic changes in the qualitative and quantitative composition of bile produced by the liver. This evidently indicates that the deficiency of physiologically active substances produced by individual salivary glands is reflected in the intimate pattern of neurohumoral regulation of bile secretion [4, 9] in animals of this species.

LITERATURE CITED

1. B. P. Babkin, The Secretory Mechanism of the Digestive Glands [in Russian], Leningrad (1960).
2. B. E. Esipenko, "Role of the secretory functions of the digestive glands in the regulation of water metabolism," Author's Abstract of Doctoral Dissertation, Kiev (1965).
3. A. P. Levitskii, R. D. Barabash, S. V. Vovchuk, et al., in: Mechanisms of Adaptation and Compensation of Physiological Functions under Extremal Conditions [in Russian], Tomsk (1977), p. 128.
4. A. S. Saratikov and N. P. Skakun, Bile Formation and Cholagogues [in Russian], Tomsk (1977).
5. O. I. Sukmanskii, Usp. Fiziol. Nauk, 3, No. 2, 46 (1972).
6. V. D. Sukhodolo, "Periodic secretion of saliva and mechanisms of its regulation," Author's Abstract of Doctoral Dissertation, Tomsk (1972).
7. I. V. Sukhodolo, "Effects of the external and internal secretory activity of the salivary glands on the morphological and functional state of organs of the pancreatico-gastroduodenal system," Author's Abstract of Candidate's Dissertation, Novosibirsk (1978).
8. V. D. Sukhodolo, N. S. Meleva, and S. V. Nizkodubova, in: Internal Secretion of Enzymes by Digestive Glands [in Russian], Andizhan (1978), p. 122.
9. P. T. Tikhonov, External Secretion of the Liver in Farm Animals [in Russian], Ufa (1973).
10. V. D. Cheyne, J. Dent. Res., 18, 457 (1939).
11. A. R. Moreira and M. Celso, J. Exp. Med., 121, 105 (1977).

USE OF THE PROTON MAGNETIC RELAXATION METHOD TO STUDY EXPERIMENTAL BURNS

V. S. Veksler, V. I. Naidich, and R. I. Kaem

UDC 617-001.17-092.9-073.916:539.171.12

KEY WORDS: proton magnetic relaxation; spin-lattice relaxation time; burns.

Various physical methods of investigation are nowadays widely used to study many problems in experimental and clinical medicine. One such method is proton magnetic relaxation (PMR), by means of which information can be obtained on proton mobility in biological and chemical objects by measuring the proton spin–lattice relaxation (T_1) and spin–spin relaxation (T_2) times [7]. In the study of biological cells and tissues the relaxation time characterizes mainly the mobility of protons of water molecules [12, 14]: the higher the water content, the longer the relaxation time. Since the beginning of the 1970s the PMR method has been used to investigate some pathological processes which are accompanied by changes in the water content in tissues and organs [6, 8, 10, 13].

In burns regulation of water metabolism in the body is disturbed, edema of the affected tissues arises, and the content of water in organs not directly affected by the burn is changed [1, 2, 11]. Hence the interest in the study of experimental burn pathology by the PMR method. Preliminary investigations showed an increase in T_1 in certain animal organs after burns [5]. In the present investigation the kinetics of changes in the proton spin–lattice relaxation time of the tissues of animals with experimental thermal trauma was studied parallel with the morphological changes in the affected tissues and internal organs.

EXPERIMENTAL METHODS

A burn of the IIIB degree, affecting 2 and 6% of the body surface, was inflicted under ether anesthesia on 160 SHK mice (weighing 16-20 g) by means of a metal rod heated to a tem-

Sector of Kinetics and Biological Processes, Institute of Chemical Physics, Academy of Sciences of the USSR. Department of Pathomorphology, A. V. Vishnevskii Institute of Surgery, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR M. I. Kuzin.)

Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 92, No. 12, pp. 670-672, December, 1981. Original article submitted July 15, 1981.

0007-4888/81/9212-1638$07.50