SUGAR, LACTATE, AND PYRUVATE CONCENTRATIONS IN BLOOD ENTERING AND LEAVING THE LUNG IN EXPERIMENTAL PATHOLOGICAL STATES

R. M. Izabolinskaya and K. N. Grigor'eva

UDC 616.24-089.87-031.4/-06:
616.36-07:616-008.934.54-074

Participation by the lungs in carbohydrate metabolism has been demonstrated both clinically and experimentally [1, 4, 5, 7, 8, 9], but the effect of unilateral pneumonectomy on this role of the lungs has received little study [2].

When extensive areas of the lungs are involved in a pathological process (pneumonia, lung abscess), the fasting blood sugar level rises and the glycemic reaction after carbohydrate loading is disturbed [3]. This is regarded as the result of functional disturbances affecting the liver and brought about by interoceptive reflex influences from the respiratory system. No reference could be found in the literature to the effect of liver pathology on the character of the metabolic reactions in the lung.

The object of the present investigation was to examine the effect of pneumonectomy on the concentrations of sugar, lactate, and pyruvate in the blood entering and leaving the residual lung and to determine the changes in these indices in pneumonectomized rabbits with experimental liver disease.

EXPERIMENTAL

Experiments were carried out on 15 healthy rabbits, 11 rabbits subjected to left-sided pneumonectomy, 15 rabbits with liver lesions caused by carbon tetrachloride (experimental cirrhosis of the liver), and 15 rabbits subjected to both unilateral pneumonectomy and experimental cirrhosis of the liver.

The blood entering and leaving the lung was taken simultaneously from the right ventricle (venous) and the central artery of the ear (arterial).

The lung was removed under Nembutal anesthesia combined with local anesthesia with procaine.

Experimental cirrhosis of the liver was produced by subcutaneous injections of 0.2 ml of carbon tetrachloride twice a week for 6 weeks. This resulted in the development of cirrhosis of the liver with only slight fatty infiltration [12].

The investigations were carried out not earlier than 5-6 weeks after the operation, when the principle physiological functions (circulation, respiration) were restored [11].

The venous and arterial blood was obtained from fasting animals 10-15 min after fixation to a frame.

EXPERIMENTAL RESULTS

The sugar concentration in the blood from the right ventricle of the rabbits averaged 110±4.5 mg%, compared with 126±4.2 mg% in the arterial blood ($P < 0.05$). In 13 of the 15 rabbits sugar was added to the arterial blood and only in two was sugar retained by the lungs. In this respect the results were in agreement with those obtained by N. P. Kochneva [5].

Five or six weeks after pneumonectomy the fasting sugar level in the venous blood was 149 mg%, i.e., it was considerably higher than in the control animals ($P < 0.005$); its level in the arterial blood was slightly raised to 138 mg%. In contrast to what was found in the intact animals, in all the rabbits subjected to unilateral pneumonectomy the sugar concentration in the blood entering the lung was raised and sugar

Biochemical Department, F. G. Yanovskii Kiev Institute of Tuberculosis and Thoracic Surgery (Presented by Active Member of the Academy of Medical Sciences of the USSR S. R. Mardashev). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 63, No. 6, pp. 24-26, June, 1967. Original article submitted August 10, 1965.

was retained by the remaining lung ($P < 0.05$). The metabolic functions of the remaining lung were adequaltely developed, it seems, at this time, and were capable of actively controlling the blood sugar level.

In 10 of the 15 rabbits with experimental cirrhosis of the liver the sugar concentration in the venous and arterial blood was raised, and in the other five it was within normal limits (mean level in the venous blood 142 mg% and in the arterial blood 144 mg%). An increase in the sugar concentration in the peripheral blood in carbon tetrachloride poisoning was reported by É. Ya. Sterkin [10]. The mechanism of this hyperglycemia may be attributed to a decrease in the synthesis and fixation of glycogen in the damaged liver parenchyma. The normal sugar level in some of the poisoned rabbits is perfectly feasible, because the ability of the liver to synthesize glycogen is not always lost in experimental cirrhosis.

Six weeks after pneumonectomy, 15 rabbits started to receive injections of carbon tetrachloride. These animals developed a well marked hyperglycemia, presumably brought about both by the pneumonectomy and by the carbon tetrachloride poisoning. Retention of sugar in the residual lung was considerable in all the animals (sugar concentration in the venous blood 196 mg% and in the arterial 176 mg%; $P < 0.05$), confirming the role of the remaining lung in the regulation of metabolism.

A. K. Aleksandri [1] has shown that the lungs of healthy dogs secrete pyruvate into the arterial blood. So far as lactate is concerned, the role of the lungs in its metabolism is not clear.

The results of the present investigations show that in the control rabbits the pyruvate concentration in the blood entering the lungs averaged 1.3 mg% (with variations from 0.7 to 1.9 mg%), while its concentration in the arterial blood was 1.9 mg%. In 11 of the 14 rabbits pyruvate was added to the blood, while in three slight retention of pyruvate took place in the lungs. The arterio-venous difference was significant ($P < 0.05$). The results thus indicate that pyruvate may be formed in the lung and subsequently secreted into the blood stream.

After pneumonectomy, the concentration of pyruvate concentration in the blood entering the lungs averaged 1.3 mg% (with variations from 0.7 to 1.9 mg%), while its concentration in the arterial blood was 1.9 mg%. In 11 of the 14 rabbits pyruvate was added to the blood, while in three slight retention of pyruvate took place in the lungs. The arterio-venous difference was significant ($P < 0.05$). The results thus indicate that pyruvate may be formed in the lung and subsequently secreted into the blood stream.

After pneumonectomy, the concentration of pyruvate in the blood entering the remaining lung averaged 2.7 mg%, compared with 2.1 mg% in the arterial blood ($P < 0.05$). Hence, with an increase in the initial level of pyruvate in the blood entering the lung, the lung exerted a regulatory role and retained pyruvate. However, in the animals with only one lung and poisoned with carbon tetrachloride, when the pyruvate concentration in the venous (2.7 mg%) and arterial (2.1 mg%) blood was high, there was no significant arterio-venous difference. The lactate concentration in the venous blood of the intact rabbits averaged 15.7 mg%, compared with 15.3 mg% in the arterial blood ($P > 0.05$). In the rabbits with only one lung, the lactate concentration in the blood of the right ventricle was 22.5 mg%, compared with 28.2 mg% in the arterial blood ($P < 0.001$). The secretion of lactate from the lungs into the blood may probably be explained by stimulation of the glycolytic processes in the residual lung, to which rather more sugar is brought after pneumonectomy and from which rather less sugar leaves. In the unilaterally pneumonectomized rabbits poisoned with carbon tetrachloride, in which the blood lactate concentration was more than twice its level (33.8 mg% in the venous blood, 35.2 mg% in the arterial) in the healthy animals, practically no arterio-venous difference was present.

The results of these experiments thus confirm that the lungs participate in intermediate carbohydrate metabolism, and thus to some extent supplement and duplicate the function of the liver in this metabolism.

LITERATURE CITED

1. A. K. Aleksandri, In: Problems in Pathology and Metabolism [in Russian], Leningrad (1950), p. 37.
2. E. S. Aleksentseva, In: Problems in Physiology [in Russian], Kiev, No. 8 (1954), p. 137.
3. B. D. Borevskaya, Probl. Tuberk., No. 6, 60 (1957).
4. A. L. Vilkovyskii, Klin. Med., No. 4, 29 (1941).
5. N. P. Kochneva, In: Problems in Pathology and Metabolism [in Russian], Leningrad (1950), p. 23.
6. S. M. Leites, Vrach. Delo, No. 5, 291 (1939).

7. E. S. London, In: Problems in Pathology and Metabolism [in Russian], Leningrad (1950), pp. 6, 10.
8. R. M. Perchik and É. Simonson, Byull. éksp. Biol., 4, No. 5, 428 (1937).
9. Sokolov, Cited by A. L. Vilkovyskii.
10. É. Ya. Sterkin et al., Byull. éksp. Biol., 9, 1, 89 (1940).
11. L. P. Cherkasskii, Fiziol. Zh. (Ukr.), No. 1, 79 (1960).
12. H. Petzold and K. Stöhr, Z. ges. inn. Med., 14, 853 (1959).