DYNAMICS OF THE TISSUE RESPIRATION OF THE PANCREAS, SPLEEN, LIVER, AND KIDNEYS AFTER LIGATION OF THE CRANIAL AND CAUDAL PANCREATICO-DUODENAL AND THE SPLENIC ARTERIES

L. I. Khananaev and G. F. Grishilo

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Investigations [5, 6, 11, 13] have shown that in the presence of an acute circulatory disturbance oxidative processes are depressed and a state of oxygen deficiency develops in the tissues, especially in the central nervous system. The suggestion has been made [2-4, 10] that the oxygen deficiency, along with other factors, causes an increase in the flow of afferent impulses with subsequent stimulatory effect of the compensatory systems on the process of opening up of collaterals.

Because of the almost total absence of studies of the mechanism of opening up of collaterals and the fact that no analysis has been made of the problem of oxygen deficiency in the conditions of a collateral circulation, the authors studied the dynamics of the tissue respiration of the pancreas, spleen, liver, and kidneys before and after a one-stage ligation of the cranial and caudal pancreatico-duodenal arteries and the splenic artery.

EXPERIMENTAL METHOD

Experiments were carried out on 76 adult male albino rats. To produce a collateral circulation, laparotomy was performed in sterile conditions under ether anesthesia, and a one-stage ligation of the cranial and caudal pancreatico-duodenal and splenic arteries was performed. The intensity of the oxygen consumption in the organs (in the pancreas, spleen, liver, and kidneys) was determined by Warburg method. The development of the collateral circulation after ligation of the arteries was studied by the method of contrast angioroentgenography and dissection. The experiments lasted from 3 h to 35 days after the operation.

EXPERIMENTAL RESULTS

After ligation of the cranial and caudal pancreatico-duodenal arteries and the splenic artery, the vascular system of the pancreas and the adjacent organs was modified. The intramural vessels of the duodenum and the pyloric part of the stomach became tortuous and enlarged in diameter, and short collaterals developed, connecting the stumps of the divided arteries. Filling of the spleen with blood in these conditions took place both along the short collaterals between the stumps of the divided splenic artery, and along the more extensive collaterals from the hepatic, left gastro-epiploic, and intestinal arteries. The character of the modification of the vascular system of the pancreas and of the adjacent organs in the rats was identical in its general features with reports in the literature [12] and also with the results obtained after ligation of the homonymous arteries in dogs [1, 4, 9].

The study of the tissue respiration of the pancreas, spleen, liver, and kidneys of the experimental rats in normal conditions showed that the absorption of oxygen was highest in the case of the kidneys and lowest in the case of the pancreas (see table). The intensity of absorption of oxygen by the tissues of the liver and spleen was only half that of the kidney tissue but was 25-30% greater than the intensity of absorption of oxygen by the pancreatic tissue.

During the first hours after control laparotomy without ligation of the vessels, an increase in the respiration of all the tested organs except the kidneys was observed, but later this gave way to a decrease. On the 7th day the intensity of absorption of oxygen by the tissue of the pancreas, spleen, and kidneys was within the normal preoperative limits. The respiration of the liver on the 7th day after laparotomy did not reach the preoperative level.

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Volume of Oxygen (in mm^3) Absorbed by 100 mg of Fresh Tissue of the Pancreas, Spleen, Liver, and Kidneys in Normal Conditions and After Ligation of the Cranial and Caudal Pancreatico-Duodenal and Splenic Arteries in Albino Rats

Organ	Statistical index	Normal	Duration of life of animals after ligation of arteries: 3 h	6 h	48 h	4 days	7 days	14 days	21 days	35 days
Pancreas	$M \pm m$	70,8±3,4	52,9±3,6	64,4±3,6	62,5±2,4	62,4±4,0	73,5±3,2	64,4±3,1	64,7±2,4	71,1±2,9
	P		<0,01	>0,05	<0,05	>0,05	>0,05	>0,05	>0,05	>0,05
Spleen	$M \pm m$	93,4±3,7	52,9±3,2	52,2±3,0	67,5±2,1	68,1±2,4	85,6±2,8	97,7±3,4	81,1±3,9	97,0±2,0
	P		<0,01	<0,01	<0,01	>0,01	>0,05	>0,05	>0,05	>0,05
Liver	$M \pm m$	104,7±3,7	127,9±3,0	131,9±3,7	86,2±4,5	76,2±5,6	84,8±2,9	73,6±5,6	96,4±2,8	104,7±3,4
	P		<0,01	<0,01	<0,01	<0,01	>0,01	<0,01	>0,05	>0,05
Kidney	$M \pm m$	212,0±4,9	222,3±3,3	240,6±5,7	209,2±4,0	239,7±6,2	181,1±5,2	171,1±2,1	190,2±6,5	250,6±4,2
	P		>0,05	<0,01	>0,05	<0,01	>0,01	<0,01	<0,02	<0,01

The one-stage occlusion of the arteries mentioned caused depression of the tissue respiration of the pancreas. During the first 3 h after the operation the intensity of absorption of oxygen fell. After 6 h the tissue respiration increased slightly, but even 48 h later it was still below the initial level. Subsequently the tissue respiration was essentially indistinguishable from its preoperative level.

The tissue respiration of the spleen was sharply depressed during the first 3-6 h after the operation. On the following days of the experiments the tissue respiration gradually increased in intensity and after the 7th day it had practically returned to the initial level. The intensity of absorption of oxygen by the tissue of the necrotic areas of the spleen was between one-third and one-quarter its level in the apparently healthy parts of the organ.

The dynamics of the tissue respiration of the liver after ligation of the three arteries showed an increase in the intensity of absorption of oxygen in the first 3-6 h after the operation on the vessels; this increase gave way to a depression of respiration in the following two weeks. On the 35th day of the experiment the tissue respiration of the liver was restored to normal. The dynamics of the intensity of oxygen absorption by the kidney tissue closely resembled the dynamics of the tissue respiration of the liver tissue.

It follows from the results described that after ligation of the nutrient arteries the tissue respiration in the pancreas and spleen was disturbed and an oxygen deficiency developed, probably associated with a disturbance of the enzyme systems fixing oxygen. However, the fall in the oxygen consumption was not accompanied by irreversible changes in the enzyme systems. The tissue respiration gradually improved and returned to normal.

The intensity of the oxygen consumption of isolated tissues in a Warburg's apparatus does not correspond exactly to what takes place in the tissues of the intact organism. However, some conclusions may be deduced from the results obtained. The mechanism of opening up of collaterals is a complex process, in which many of the adaptive systems of the organism play a part. It has been claimed [8, 11] that their activation is due to the developing hypoxia, as a result of which the incompletely oxidized products act on the receptor fields, increasing the flow of afferent impulses. The present experiments confirmed the presence of hypoxia of this type, most marked in the first hours and days after ligation of the vessels, and a direct relationship was observed between the changes in tissue respiration and the opening up of the collaterals: as the collateral channels developed, an increase took place in the intensity of oxygen absorption.

SUMMARY

Experiments on 76 adult male rats were used to study the dynamics of tissue respiration of the pancreas, spleen, liver and kidneys by Warburg's method, before and after a simultaneous ligation of the cranial and caudal pancreatico-duodenal and splenic arteries. The development of collaterals was studied by methods of angioroentgenography and dissection.

It was established that in the early hours and days after ligation of the above-mentioned arteries there was a considerable depression of the tissue respiration of the pancreas and spleen followed by its gradual in-

tensification and restoration to normalcy by the 35th day of experiment. The tissue respiration of the liver and kidneys under these conditions was characterized by undulatory changes with intensification in the early hours and days, with subsequent depression during a fortnight, and returning to the normal condition by the 35th day of experiment. Angioroentgenographic investigations helped to reveal the characteristic features of the collateral blood circulation in the pancrease in rats.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of the first issue of this year.
