EFFECTS OF HALOTHANE AND ETHER ANESTHESIA ON OXYGEN INDICES IN THE HEPATO-PORTAL REGION

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In experiments on cats, ether and halothane anesthesia lowered the blood oxygen saturation in the portal vein and caused the development of circulatory hypoxia in the aorta–portal vein sector. Utilization of oxygen by the tissues of the hepato-portal region was reduced in connection with the decrease in volume blood flow. A tendency was observed for the liver to change to an arterial circulation because of an increase in the resistance to the portal blood flow.

A study of changes in the oxygen indices of the hepato-portal region under the influence of inhalation of anesthetics has an important bearing on the correct assessment of liver function and activity of the circulatory system during general anesthesia. Data on this problem in the literature are few in number and highly contradictory in nature [8-11].

EXPERIMENTAL METHOD

Altogether 26 chronic experiments were carried out on cats. A polyvinyl chloride catheter was inserted into the portal vein 4-7 days before the main experiment by the method of Seleznev and Khrabrova [4] slightly modified by the writer. During the main experiment, when the animals were fixed to a frame, catheters were introduced under local anesthesia through the femoral artery into the aorta and through the femoral vein into the posterior vena cava as far as the mouth of the hepatic veins.

To measure the volume of blood flowing from the liver, a catheter was introduced into one of the hepatic lobular veins before its occlusion by passing it through the right external jugular vein and the anterior and posterior venae cavae. Blood flowing from this particular part of the liver was passed through a bubble rheometer [6, 12] into a catheter introduced into the left external jugular vein. From these results the volume of blood flowing from the whole liver was calculated [5].

Tracheotomy was then performed, and after an interval of 30 min, anesthesia was given by Ayre's method [7] for 1 h with a mixture of ether and oxygen (12 animals) or of halothane with oxygen (nine animals). Spontaneous breathing was preserved. In the control series (five animals), inhalation of oxygen was given.

During the experiments, besides the volume of blood flowing from the liver, the pressure in the aorta, portal vein, and posterior vena cava (at the mouth of the hepatic veins) was recorded, and the oxygen saturation of the blood in the aorta and portal and hepatic veins was determined periodically by means of the OKO-01 "Biofizpribor" cuvette oxyhemometer. From the results of these measurements, values characterizing the circulation and oxygen indices of the hepato-portal region were calculated. The numerical results were subjected to statistical analysis [2, 3].

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TABLE 1. Changes in Oxygen Indices of the Liver During Ether and Halothane Anesthesia (M ± m)

Index	Region studied	Initial state	Ether anesthesia	Initial state	Halothane anesthesia
Blood oxygen saturation, % oxyhemoglobin	Aorta	94 ±1.2	93 ±7.9	94 ±1.1	96 ±2.0
	Portal vein	59 ±3.1	50 ±3.3	60 ±1.1	53 ±1.1
	Hepatic vein	54 ±2.4	51 ±2.4	52 ±1.9	50 ±1.7
Arterio-venous oxygen difference, % oxyhemoglobin	Between aorta and portal vein	35 ±3.7	42 ±3.5	33 ±1.9	42 ±1.9
	Between aorta and hepatic vein	40 ±2.2	42 ±1.9	41 ±3.1	46 ±1.2
Coefficient of oxygen utilization	In sector aorta–portal vein	0.38 ±0.03	0.45 ±0.05	0.35 ±0.02	0.44 ±0.02
	In sector aorta–hepatic vein	0.43 ±0.03	0.46 ±0.01	0.43 ±0.03	0.48 ±0.01
Oxygen absorption, ml/100 g/min	Whole hepato-portal region	2.2 ±0.5	1.7 ±0.3	2.2 ±0.2	1.2 ±0.1

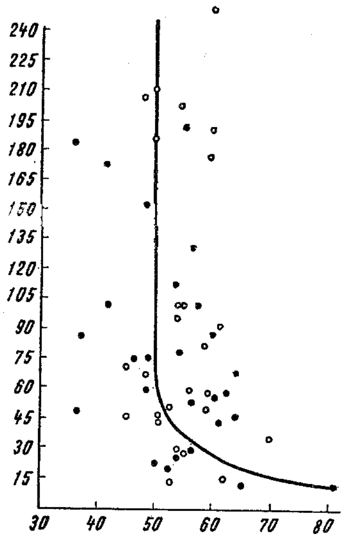

Fig. 1. Portocaval gradient as a function of blood oxygen saturation in portal vein during ether and halothane anesthesia. Black circles show observations during ether anesthesia; white circles observations during halothane anesthesia. Abscissa, blood oxygen saturation in portal vein (in% oxyhemoglobin); ordinate, portocaval gradient (in mm water).

RESULTS

Changes in the circulation in the hepato-portal region during ether and halothane anesthesia have been partly described previously [1], and they consisted mainly of a decrease in the volume blood flow in the liver. Under ether anesthesia this decrease (from 52.1 ±7.1 to 28.1 ±3.8 ml/min/100 g weight of organ) was due to an increase in vascular resistance (from $9.5 \pm 3 \cdot 10^5$ to $24.8 \pm 10.7 \cdot 10^5$ dynes · sec · cm^5). The coefficient of correlation between these two indices was −0.46 ±0.1; $P < 0.01$. During halothane anesthesia, the quantitatively similar decrease in blood flow was due to arterial hypotension (the coefficient of correlation between these two indices was +0.60 ±0.1; $P < 0.01$).

The changes in oxygen indices of the liver occurred in the same direction in both series of experiments (Table 1).

The oxygen saturation of the arterial blood was unchanged by anesthesia, and in both series of experiments a significant ($P < 0.05$) decrease in the blood oxygen saturation in the portal vein and a corresponding increase in the arterio-venous oxygen difference and coefficient of utilization were observed in the sector aorta–portal vein. The observed decrease in absorption of oxygen in the whole hepato-portal region (from 2.2 to 1.2 and 1.7 ml/100 g/min) was certainly due to a decrease in the volume blood flow through this region. The coefficient of correlation between these two indices was +0.8 ±0.04 ($P < 0.01$) in halothane and +0.90 ±0.03 ($P < 0.01$) in ether anesthesia.

The blood oxygen saturation in the hepatic vein, the arterio-venous oxygen difference, and the coefficient of oxygen utilization in the sector aorta–heptic vein was not significantly altered.

It can be concluded from these results that the principal changes in the oxygen indices of the hepato-portal region during ether and halothane anesthesia reflect the development of circulatory hypoxia in the sector aorta–portal vein. The decrease in blood oxygen saturation in the portal vein, in the absence of any such decrease in the hepatic veins, is evidence of a tendency for the liver to change over to an arterial blood supply.

This analysis showed conclusively that the lower the blood oxygen saturation in the portal vein, the higher the portocaval gradient (i.e., the lower the portal blood flow). Correlation relationships and coefficients of curvolinear correlation between the degree of blood oxygen saturation in the portal vein and the portocaval gradient during ether and halothane anesthesia ranged from 0.55 to 0.70. This dependence is expressed graphically by a hyperbola (Fig. 1). The curve was obtained by equalization of an empirical series by the method of the weighted sliding mean and by a graphic method.

The tendency for the liver to change to an arterial blood supply is evidently one of the principal mechanisms compensating for circulatory disorders in the whole hepato-portal region during general anesthesia.

No significant changes in the blood supply or oxygenation of the hepato-portal region were observed in the control series of experiments.

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