EFFECT OF VAGOTOMY ON THE MICROCIRCULATION IN THE STOMACH WALL

V. P. Lakhtina and V. I. Kozlov UDC 616.833.191.9-089.85-07:616.33-005-07

It was shown by intravital microscopy in transmitted light that vagotomy in rats leads to complex reorganization of all parts of the microcirculatory system of the stomach and, in particular, to slowing of the blood flow and a decrease in the number of capillaries in the mucous membrane and to the opening of arteriolo-venular anastomoses in the submucosa.

Key words: vagotomy; gastric microcirculation; intravital microscopy; intravital morphometry.

Vagotomy is used for the treatment of gastro-duodenal hemorrhage, including in hemorrhagic gastritis. The arrest of bleeding from the gastric mucous membrane after division of the vagus nerves has been shown to be connected with changes in microcirculation [12]. However, whereas the effect of vagotomy on the function of the stomach and other organs of the gastro-intestinal tract has been studied quite extensively [1, 5], the microcirculatory changes thereby produced have received little attention.

This investigation was carried out to study the effect of vagotomy on the gastric microcirculation.

EXPERIMENTAL METHOD

Wistar rats weighing 150-200 g were anesthetized with pentobarbital (5 mg/100 g body weight). The microcirculation in the stomach wall was investigated in 15 rats without preliminary vagotomy. After laparotomy through an incision below the left costal margin the stomach was brought up into the wound and a gastrotomy 1.5 cm in length performed. The animal was placed on a special transparent plastic frame fixed to the microscope table. The vessels in the stomach wall were examined under the microscope in transmitted light by the method described earlier. The state of the microcirculation was recorded by photomicrography and the frames were analyzed on a decoder. Subdiaphragmatic vagotomy, with division of the trunk of the nerve, was performed on the other 15 rats after the gastrotomy. The subsequent observations and recording the state of the microcirculation were carried out as on the control animals.

EXPERIMENTAL RESULTS

The vessels of the gastric microcirculation of the control rats were well filled with blood. The capillaries formed a diffuse, close-mesh network. From 14 to 50 capillaries could be counted in one field of vision of the microscope (on the average 500 capillaries per mm^2 surface of the mucous membrane). The capillaries showed little variation in length and diameter. The mean internal lumen of the capillaries was $9.6 \pm 0.01\ \mu$. The gastric mucous membrane had a transcapillary blood flow of comparatively high intensity. The submucosa contained arterioles, giving rise to the capillaries of the mucous membrane and muscular layer of the stomach wall, as well as a well-developed venous plexus, into which blood drained from the capillary networks via the postcapillary venules and veins (Fig. 1A). The diameter of the arterioles varied from 14 to $42\ \mu$, with an average of $26.9 \pm 1.0\ \mu$. The internal diameter of the venules varied from 22 to $63\ \mu$ (mean $35.3 \pm 1.2\ \mu$). The venules of the submucosa, like the arterioles, anatomosed widely with each other. Arteriolo-venular anastomoses (AVAs) were found extremely rarely. They lay in the submucosa and, according to Kupriyanov's classification [3], they must be classed as shunts with controllable blood flow.

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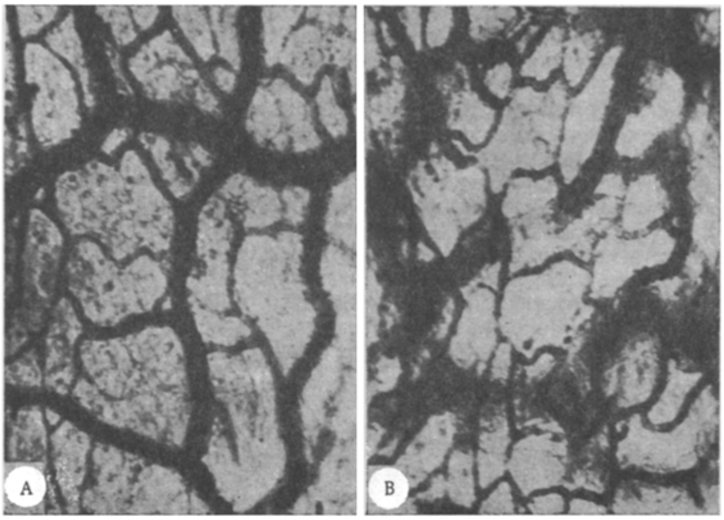

Fig. 1. State of gastric microcirculation in rats before (A) and 15 min after vagotomy (B). Intravital photomicrographs, 180 ×.

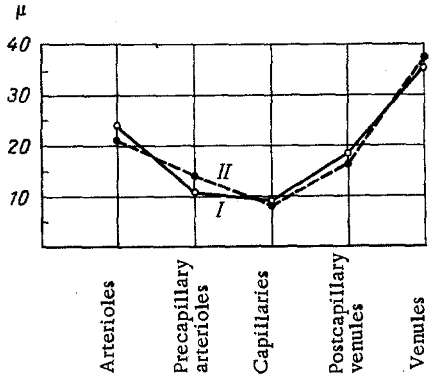

Fig. 2. Mean diameters (in μ) of vessels of gastric microcirculation of rats before (I) and after vagotomy (II).

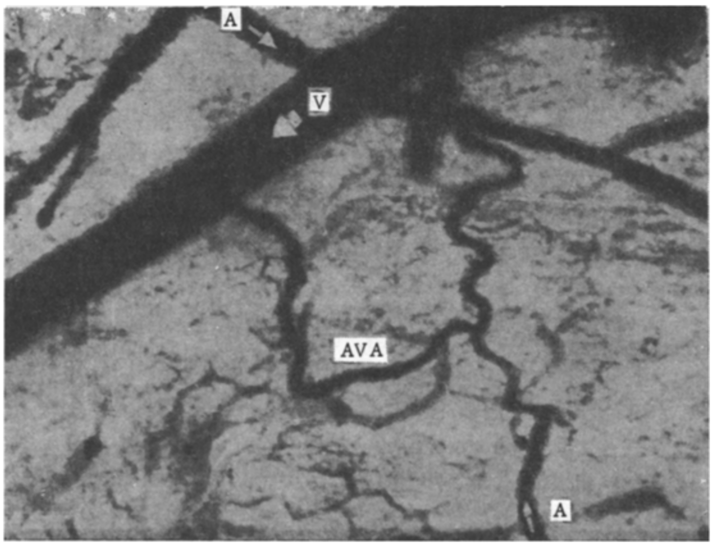

Fig. 3. Arteriolo-venular anastomosis (AVA). Reconstruction of fragment of microcirculation from intravital photomicrographs: A) arteriole; V) venule. Arrows show direction of blood flow. 180×.

A decrease in the number of functioning capillaries in the gastric mucosa on the average to $338/mm^2$, i.e., by 30-35% ($P < 0.05$), was observed 30-40 min after vagotomy. The velocity of the blood flow in the arterioles and venules of the microcirculation was appreciably slowed, and in some parts stasis appeared (Fig. 1B). In some venules a paradoxical blood flow was seen: blood from the main trunk of the venule returned into the smaller branches and the postcapillary venules.

The mean diameter of the arterioles after vagotomy decreased to $21.4 \pm 0.01\ \mu$ whereas the diameter of the precapillary arterioles increased from 11.2 ± 0.4 to $14.3 \pm 0.4\ \mu$. The blood cells moved slowly in the capillaries and here and there they aggregated into rouleaux. The mean diameter of the capillaries showed little change (Fig. 2).

In the submucosa many functioning AVAs could be seen (Fig. 3). In shape they appeared as simple or branched channels of different lengths, ranging in diameter from 20 to 40 μ. Smooth-muscle cells were clearly visible in the arteriolar portion.

The results of microangiographic [8] and fluorometric [9-11] investigations and determination of the clearance of krypton and rubidium isotopes [4] have demonstrated the inhibitory effect of vagotomy on the gastric blood flow. The effect of vagotomy is attributed to the opening of AVAs. The present experiments, using intravital microscopy, confirmed the fact that after vagotomy the decrease in the inflow of blood to the stomach is accompanied by a redistribution of the incoming blood between the mucous membrane and the submucosa. The decrease in the active microcirculation in the mucous membrane and its reduced density of functioning capillaries are accompanied by opening of by-pass channels for the blood flow in the gastric submucosa.

It may thus be considered that the regulation of AVAs in the stomach (and, in particular, their closure [3]) is under the control of the vagus nerves, although in their thoracic and abdominal divisions these nerves contain many sympathetic fibers [2].

Most workers [4, 7, 9, 10] explain the changes arising after vagotomy by predominance of the influence of the sympathetic nerves. Evidence in support of this conclusion is given by the marked decrease in diameter of the arterioles. By contrast with the arterioles, the precapillary arterioles dilate after vagotomy. This somewhat paradoxical response of the precapillaries is in good agreement with data for the self-regulation of blood vessels in the gastro-intestinal tract in response to changes in the intravascular pressure [6].

The results obtained by intravital microscopy thus indicate that after vagotomy changes take place in all components of the microcirculation. It would therefore be wrong to explain the effect of vagotomy entirely by the opening of AVAs. Subdiaphragmatic vagotomy leads to a complex reorganization of the gastric microcirculation, affecting all its parts. Predominance of the influence of the sympathetic nerves, together with a decrease in the total blood flow in the stomach, gives rise to a redistribution of blood between the various layers of the stomach wall, so that the principal role in the transorganic circulation begins to be played by the AVAs, opening up by-pass channels for the blood flow.

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