Abdominal Baro- and Chemosensitivity in Dogs

By C. Heymans, M.D., A. F. De Schepdryver, M.D., and G. R. De Vleeschhouwer, M.D.

The activity of baroreceptors located in the mesenteric arteries was first studied in cats by Gammon and Bronk,1 in 1935. These authors observed a reflex local vasoconstriction in response to distention of the superior mesenteric artery, but no effect on the general blood pressure.

Experiments performed by Heymans and co-workers,2,3 in 1936, showed that increase and decrease of arterial pressure in the mesenteric circulation in dogs induce a reflex vasodilatation and vasoconstriction, respectively, in the spleen, kidney and limbs, but do not affect the systemic arterial blood pressure.

Recently, Sarnoff and Yamada4 claimed to have found a reflex control of the systemic arterial pressure from abdominal baroreceptors in cats. On the other hand, Latschenberger and Deahna5 had observed, as early as 1876, that chemical stimulation of nerve endings located in the vascular periphery may induce respiratory reflexes.

According to Spalitta and Consiglio,6 Heger,7 Pagano8 and Siciliano,9 circulatory reflexes may also be elicited by the same procedure.

More recently, Chernigovsky et al.10,11 and Matthies et al.12 claimed that in cats various pharmacologic substances, e.g., acetylcholine, nicotine, sodium cyanide, potassium chloride, etc., introduced into the isolated circulation of intestine, limb, spleen and other organs with intact innervation, are capable of producing respiratory and circulatory reflexes. These authors consider these reactions as a result of chemical stimulation of receptors (interoreceptors) situated in the peripheral vascular system. It is obvious that high doses of irritating substances, if injected into the arterial circulation, will induce reflex respiratory and cardiovascular reactions. These reflexes should be attributed, however, to an unspecific stimulation of pain or other receptors, but not to a stimulation of specific chemoreceptors.13 Riker14 also concludes that apnea and inhibition of rhythmic contractions of the intestine elicited by injection of veratridine, acetylcholine and nicotine into the superior mesenteric artery of the anesthetized dog, are of reflex origin and should be attributed to stimulation of intramesenteric endings of pain fibers and that these reflex responses have their sole afferent pathway in the splanchnic nerves.

The assumption of Sarnoff and Yamada4 that in cats the carotid sinus and aortic baroreceptive areas are dominated with regard to their reflex influence on arterial blood pressure by baroreceptors located in the abdominal vessels incited us to reinvestigate this problem in dogs.

Methods

All experiments have been performed on 11 adult mongrel dogs, anesthetized with morphine (1 mg./Kg. s.c.) and chloralosane (80 to 100 mg./Kg. i.v.). Arterial blood pressure and respiration were recorded, respectively, by means of a mercury manometer connected with a femoral artery, and a pneumograph. A tracheal cannula was inserted routinely. Through a midline abdominal incision, the eoeliac, superior and inferior mesenteric arteries were dissected free, very carefully, and provided with copper clamps, a model of which is shown in figure 1. After closing
Figure 2

Dog, 19 Kg.; morphine-chloralosane anesthesia, vagi intact. R, respiration, BP, general arterial blood pressure. 3', time in 3 seconds. I: t1 - t2, occlusion and desocclusion of inferior mesenteric artery. II: t3 - t4, occlusion and desocclusion of coeliac artery. III: t5 - t6, occlusion and desocclusion of superior mesenteric artery. IV: t7 - t8, combined occlusion and desocclusion of coeliac, inferior and superior mesenteric arteries. V: t9 - t10, occlusion and desocclusion of both common carotid arteries.

In the abdomen, these clamps allow occlusion and desocclusion of the abdominal arteries from outside.

In some experiments, a cannula was inserted into the peripheral end of the superior mesenteric artery and connected with the cardiac end of a common carotid artery in order to maintain a normal blood pressure level and to inject pharmacologic substances in the mesenteric vascular area. Cervical bilateral vagotomy was performed in most experiments.

**Results**

**Barosensitivity**

In all dogs with intact vagi, or after vagotomy, occlusion and desocclusion of the inferior mesenteric artery, or of the coeliac artery, or of both arteries, have no significant effect upon general arterial blood pressure and heart rate. The hypertensive responses to 28 clampings of the superior mesenteric artery vary between 20 and 44 mm. Hg, with a mean value of 28, while heart frequency remains unaltered. The increase of general blood pressure to 36 combined occlusions of the coeliac, superior and inferior mesenteric arteries attains a mean of 50 mm. Hg, with extreme values of 30 and 58. In all experiments, the pressor response to 42 clampings of both common carotid arteries has a mean value of 112 mm. Hg, with extreme variations of 80 and 140. It is obvious that in all cases, the vasomotor reflexes elicited by occlusion and desocclusion of both common carotid arteries are much more pronounced than the circulatory responses to clamping and declamping of the abdominal arteries (fig. 2).

On the other hand, the local decrease of blood pressure provoked by occlusion and desocclusion of the coeliac or of the superior mesenteric arteries results in a stimulation of respiration (fig. 2).

In 3 vagotomized dogs, prolonged occlusion of the superior mesenteric artery is followed...
Dog, 15 Kg; morphine-chloralosane anesthesia, vagi cut. BP, general arterial blood pressure. 3", time in 3 seconds. I: t1 - t2, prolonged occlusion of superior mesenteric artery. II: t3 - t4, prolonged occlusion of both common carotid arteries.

by an average increase of 30 mm. Hg of the general blood pressure, which progressively decreases, while prolonged occlusion of both common carotid arteries results in a marked (average value of 120 mm. Hg) and more sustained hypertensive effect (fig. 3).

Clamping of the renal artery or mechanical stimulation of the posterior peritoneal wall does not affect general blood pressure, but

provides a marked hyperpnea (fig. 4).

Reversely, increase of intravascular pressure in the superior mesenteric arterial circulation, by injecting repeatedly 10 to 20 ml. of blood or dextran under high pressure, is not followed by reflex hypotension, but produces, in most cases, a delayed rise of general blood pressure (fig. 5).

The hypertensive response to combined occlusion of the coeliac, superior and inferior
mesenteric arteries is unaffected by intravenous injection of hexamethonium in doses producing maximal depression of the carotid sinus vasomotor reflexes (fig. 6).

In the spinal dog, without or with ganglionic blockade, the hypertensive response to abdominal arterial occlusion still persists (fig. 6).

**Chemosensitivity**

In 7 dogs with intact vagi, or after vagotomy, the injection of 50 to 200 μg, acetylcholine into the superior mesenteric artery has no cardiovascular or respiratory effects. In doses larger than 500 μg, acetylcholine may produce a slight apnea.

In the same experimental conditions, epinephrine, in doses of 25 to 100 μg., does not induce any variation of general blood pressure or respiration.

Potassium cyanide, administered in doses of 0.5 to 1 mg., has no effect upon blood pressure or respiration, while doses of 5 mg., in dogs with intact vagi, produce a transient apnea.
followed by respiratory stimulation. These respiratory effects do not occur after vagotomy (fig. 7). It should be remembered that very small doses of acetylcholine, or KCN, injected into the common carotid artery, provoke an intense reflex respiratory excitation due to stimulation of the carotid body chemoreceptors (fig. 7, III).

Injection of 1 mg. of lobeline into the superior mesenteric artery induces a transient respiratory arrest in dogs with intact vagi as well as in vagotomized dogs, while intracarotid injection of 0.1 mg. of lobeline provokes a marked reflex hyperpnea and bradycardia.

In dogs with intact vagi, injection of 1 to 3 mg. of nicotine into the superior mesenteric artery has no effect upon blood pressure or respiration. In doses of 5 to 10 mg., however, nicotine produces a slight cardiac and respiratory inhibition. After cutting both vagi, the injection of 5 to 10 mg. of nicotine in the superior mesenteric artery only provokes a transient apnea.

In dogs with intact vagi or after vagotomy, injection of 100 to 200 mg. of potassium chloride into the superior mesenteric artery always results in a slight bradycardia and primary apnea, followed by a secondary hyperpnea (fig. 8). In higher doses, KCl may also induce a marked hypertensive effect.

Discussion

The actual experiments performed to reinvestigate the existence of baro- and chemoreceptors in abdominal arteries have shown that the occlusion of the coeliac and superior mesenteric arteries induces a moderate increase of general arterial blood pressure. Clamping of both common carotid arteries, however, always provokes a much stronger hypertensive effect.

The hypertensive response to occlusion of the abdominal vessels is not to be considered of reflex origin, since this response is not affected by doses of hexamethonium which abolish the carotid sinus vasomotor reflex. The same hypertensive responses were also observed in the spinal dog, treated or not with hexamethonium.

Moreover, increase of intravascular pres-
artery but who found this response blocked by tetraethylammonium chloride.

Our experimental results in dogs do not agree with the observations of Sarnoff and Yamada in cats. Differences in animal species should be considered.

Respiratory stimulation was observed after occlusion of the coeliac, mesenteric and renal arteries, but similar respiratory effects occurred after mechanical stimulation of the peritoneum. These respiratory effects seem not to be due to a specific stimulation of baro-sensitive nerve endings, but rather to an unspecific stimulation of pain receptors.

Small doses of pharmacologic substances, e.g., KCN, lobeline and nicotine, producing a marked stimulation of carotid body chemoreceptors, are without effect upon respiratory and cardiovascular systems when injected into the abdominal arteries.

High amounts of the same substances, injected into the abdominal arteries, generally produce a transient apnea followed by a respiratory stimulation. These respiratory responses should be attributed to the irritating properties of these drugs, rather than to a stimulation of specific abdominal chemoreceptors, as also suggested by Riker.

**Summary**

Experiments performed in anesthetized dogs have shown that occlusion of the coeliac and mesenteric arteries may determine minor increases of systemic blood pressure, obviously of hemodynamic nature and not induced by baroreceptive vasomotor reflexes. Increase of pressure into the mesenteric arterial circulation does not decrease the systemic blood pressure. The aortic and carotid sinus baroreceptors are the major means of the reflex blood pressure homeostasis. Evidence for the existence of specific chemoreceptors in the abdominal vascular area could not be obtained.

**References**

11. —, and Yaboshvsky, A. Y.: Problems of nervous regulation of the blood system (Voprosy Nervny Regulatsii Krovi), Medgiz (Moscow) 222, 1963.
Abdominal Baro- and Chemosensitivity in Dogs
C. HEYMANS, A. F. DE SCHAEPDRYVER and G. R. DE VLEESCHHOUWER

Circ Res. 1960;8:347-352
doi: 10.1161/01.RES.8.2.347
Circulation Research is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1960 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7330. Online ISSN: 1524-4571

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circres.ahajournals.org/content/8/2/347