Significance of Mesenteric Arterial Receptors in the Reflex Regulation of Systemic Blood Pressure

By GARRY O. BOYER, B.S., and ALLEN M. SCHER, PH.D.

SINCE the demonstration of pressoreceptors in the carotid sinus and the aortic arch,1 many other areas have been considered as possible sites of similar receptors. One such region is the mesenteric arterial bed and the splanchnic vasculature in general.1-4 In earlier studies, the existence of such receptors was never substantially established, and they were not actively investigated for many years. Recently, the controversy concerning these receptors has been revived by Sarnoff and Yamada's study.4 In their experiments, changes in systemic arterial pressure followed various manipulations of the cat's splanchnic vasculature. They hypothesize that the Pacinian corpuscles which are widely distributed in the mesentery, particularly in the cat, mediate these effects. The present study was undertaken to investigate the significance of the postulated mesenteric arterial receptors.

Methods

In this study, 14 of 17 cats weighing 2.5 to 5 Kg. and 2 dogs weighing 15 Kg. were given chloralose (35 to 60 mg./Kg.). Three cats were given light barbiturate anesthesia. The vessels to be occluded or perfused were dissected free from the surrounding structures very carefully to avoid nerve damage. The arteries were occluded by reversible periarterial ligation or by clamping, both methods producing identical systemic pressure responses. The systemic pressor response to unilateral and bilateral carotid occlusion was used repeatedly throughout each experiment as an index of the reflex cardiovascular excitability of the animal.

Perfusion of the abdominal aorta, mesenteric arterial system, and carotid sinuses was performed using the animal's own arterial blood, the pressure of which was modified with a Sigmasmotor pump. In the 8 aortic perfusion experiments, arterial blood was obtained from the thoracic aorta, just above the point of occlusion, via an intra-aortic catheter which was inserted in the right femoral artery. In the remaining perfusion experiments the arterial blood was obtained directly from the femoral artery via a polyethylene cannula. In 4 experiments (2 on cats and 2 on dogs) the blood was fed directly to the pump, whereas in the remaining 10 experiments the blood was fed into a small polyethylene reservoir. Small bore rubber tubing, connected either to the arterial catheter or to the reservoir, was led through the Sigmasmotor pump to a glass T-tube. One arm of this T-tube was connected with the polyethylene cannula in the vessel (s) to be perfused. A Statham pressure transducer was connected with the remaining arm to continuously record the pressure in the perfused vessel. The tubing was initially filled with heparinized 6 per cent Dextran in isotonic saline. In addition, each animal received 30 to 40 mg. of heparin during an experiment.

An electronic feedback loop connecting the Statham pressure transducer and the pump motor allowed a given pressure level independent of flow to be delivered to the perfused arterial bed. A sine-wave voltage generator was also placed in this feedback circuit so that sine waves of pressure could be employed if desired.

The systemic arterial pressure and perfusion pressures were measured with conventional strain-gage or variable inductance transducers. The pressures and the pump speed were continuously recorded with a Brush multichannel oscillograph.

The study was divided into 3 phases. In the first phase, the abdominal aorta was perfused (in 6 cats and 2 dogs) with sudden or subtle variations in pressure during supra diaphragmatic aortic occlusion. In the second phase, involving 6 cats, the celiac, superior mesenteric and inferior mesenteric arteries were carefully occluded individually or together at the abdominal aorta. The superior mesenteric arterial system was then perfused with various pressure waveforms via a distal arterial branch. In the last 2 experiments of this second phase, the systemic pressure response to perfusion of the mesenteric arterial system was compared with the response to bilateral perfusion of the carotid sinuses. In the third phase, the systemic
Systemic pressure response to perfusion of the isolated abdominal aorta in the cat (A) and the dog (B), and to perfusion of the carotid sinus in the dog (C). Time in seconds. Cat #5, dog #2.

Pressure responses to occlusion of the carotid arteries and of the mesenteric artery were compared (a) before and after spinal transection at C1 in 2 cats and (b) before and after infusion of sodium thiopental (in amounts sufficient to eliminate spontaneous respiration) in 3 cats.

Results

Perfusion of the Isolated Abdominal Aorta

Neither sudden variations in pressure during perfusion in cats nor sine-wave variations in dogs produced a reflex response in the systemic arterial pressure above the diaphragm (fig. 1A, B). Indeed, the supradiaphragmatic pressure usually paralleled the perfusion pressure. In contrast, unilateral perfusion of the carotid sinus with a sine wave or a square wave of pressure produced a significant reflex response in supradiaphragmatic arterial pressure in both dogs (fig. 1C).

Perfusion of Splanchnic Vessels

No reflexly induced systemic blood pressure response to perfusion of the superior mesenteric arterial system was detectable during occlusion of the superior mesenteric artery or during occlusion of that vessel and the celiac and inferior mesenteric arteries. Even sudden variations in perfusion pressure of 350 mm. Hg produced no reflex response (fig. 2).

A comparison of the systemic pressure response to sine-wave perfusion of the isolated superior mesenteric arterial system and of both carotid sinuses shows most clearly the striking difference between these 2 procedures (fig. 3). Variations in pressure of 45 mm. Hg in the carotid sinus produced reflex systemic pressure alterations of approximately the same magnitude, about 90 degrees out of phase with the input. Pressure variations of 60 mm. Hg in the superior mesenteric artery, on the other hand, produced no significant changes in the systemic pressure.

It may be noted, in passing, that the 3 cats anesthetized with barbiturates were among the subjects of phases 1 and 2. In neither study did the results with these animals differ qualitatively from those with animals under chloralose anesthesia.

Effects of Spinal Lesions or Massive Doses of Anesthetic

As can be seen in figures 2 and 4A, occlusion of the various splanchnic arteries uniformly produced a systemic pressor response similar to and at times greater in magnitude than the pressor response occurring during bilateral carotid occlusion. In order to ascertain whether this response represented a reflex or merely a mechanical alteration in systemic blood flow, 5 experiments were performed in which cardiovascular reflex activity was abolished or markedly diminished. After transection of the spinal cord at C1 or after intravenous infusion of sodium thiopental in amounts sufficient to eliminate spontaneous respiration, the response to bilateral carotid occlusion was obliterated (fig. 4B). In contrast, the response to occlusion of the splanchnic arteries was the same as or greater than...
MESENTERIC ARTERIAL RECEPTORS

Systemic Pressure
Superior Mesenteric Artery Pressure
Pump Speed

Figure 3
Comparison of the systemic pressure response to sine-wave perfusion of the isolated superior mesenteric arterial system (A) and both carotid sinuses (B). Time in seconds. Cat #12.

Figure 4
Systemic pressure response in a cat to bilateral carotid artery occlusion (a to b) and combined superior mesenteric, celiac, and inferior mesenteric artery occlusion (c to d) prior to (A) and following (B) the massive infusion of sodium thiopental. Time in minutes. Cat #15.

the response observed prior to the transection or thiopental infusion. Although the systemic pressure fell after either procedure, the resulting pressure appeared to be well within the range in which carotid occlusion reflexly influences the systemic circulation.

Discussion
In 1935, Gammou and Bronk demonstrated afferent impulses in the cat's splanchnic nerve which apparently originated from the mesenteric Pacinian corpuscles. These receptors discharged rhythmically during the cardiac cycle, predominantly during systole, and showed vigorous transient bursts of activity when the perfusion pressure within the superior mesenteric arterial system was suddenly raised. Wide variations in pressure during this perfusion did not, however, produce any significant alterations in the systemic blood pressure. Heymans et al. reported that increasing or decreasing the perfusion pressure within the celiac and superior mesenteric arteries in the dog produced "vaso-motor reflexes" (splenic dilatation and constriction). These effects "persisted after bilateral vagotomy and high cervical transection of the cord, but were abolished by total sympathectomy or by destruction of the spinal cord"; however, occlusion of these vessels did not produce any significant changes in the systemic blood pressure. These authors concluded that the receptors in this region play a role in the distribution of blood in the deep abdominal circulation, but contribute little to the reflex regulation of the systemic blood pressure.

Sarnoff and Yamada's results and conclusions differ, for the most part, from these earlier observations. In their experiments, occlusion of the mesenteric and pancreatic arteries in cats produced a rise in systemic pressures similar to the rise seen during bilateral carotid occlusion. Also, multiple injections into the isolated superior mesenteric arterial system of small increments of blood drawn from the femoral artery produced a definite fall in the systemic pressure. They conclude that there are pressure receptors capable of influencing systemic pressure in the region of the superior mesenteric artery and pancreas; they presume that these receptors are Pacinian corpuscles, which are widely distributed in this region in the cat. These authors further suggest that these receptors are significant in the regulation of the systemic pressure in the cat, perhaps even exceeding the sino-aortic receptors in importance.

The present observations furnish little support to this suggestion or to an earlier suggestion that these receptors respond primarily to changes in volume. The consistent absence of changes in systemic pressure when the pressure within the abdominal aorta (and the many branches arising from it) was widely varied and, more specifically, the lack of a systemic response to pressure variations within the superior mesenteric arterial system agree with earlier observations and indicate that the role of these receptors in reflex regulation of the systemic blood pressure is negligible.

The pressure alterations seen during occlusion of the various splanchnic arteries appear
to be manifestations of the mechanical shunting of blood away from the mesenteric vessels into the remainder of the cardiovascular system. This was shown most conclusively when the cardiovascular reflex excitability was depressed by high cervical section of the spinal cord or by massive amounts of sodium thiopental. In these instances, the effects of mesenteric arterial occlusion were greatly enhanced.

Summary
The isolated abdominal aorta was perfused in 6 cats and 2 dogs, and perfusion of the isolated superior mesenteric arterial system was performed in another 6 cats. In every experiment, wide variations in perfusion pressure produced no alterations in the systemic pressure, although it was responsive to manipulation of the carotid pressure. A comparison of the systemic pressure responses to mesenteric artery occlusion and to carotid artery occlusion prior to and following (1) high spinal transection in 2 cats or (2) venous perfusion of sodium thiopental in 3 cats showed an obliteration of the responses to carotid occlusion while the systemic response to occlusion of the mesenteric artery persisted. The results indicate that the systemic responses seen during mesenteric artery occlusion are probably caused by mechanical diversion of blood from one vascular bed to another and do not represent true reflex responses. The observations indicate that mesenteric pressure receptors do not contribute significantly to the reflex regulation of the systemic blood pressure.

Addendum
While this paper was in the process of publication, a similar study was reported by Heymans and his co-workers. Using somewhat similar techniques, they reached the conclusion that there are neither baroceptors nor chemoceptors in the abdominal circulation. Our results are thus in complete accord with those of Heymans and his coauthors.

Summario in Interlingua
Le isolate aorta abdominal esseva perfusiouate in 6 cattos e 2 canes. Perfusione del isolate systema arterial supero-mesenteric esseva effectuate in 6 altere cattos. In omne isto experimentos, extense variationes in lo tension perfusional produceva nullo alteration in le tension del circulation major, ben que iste tension respondeva al manipulation del tension carotidic. Le comparation del responsa del tension del circulation major a occlusion de arteria mesenteric e a occlusion de arteria carotidic ante e post (1) transaction supero-spinal in 2 cattos o (2) perfusion venose con thiopental de natrium in 3 cattos revelava un obliteracion del responsas a occlusion carotidic durante que le responsas del circulation major a occlusion del arteria mesenteric persisteva. Le resultatos indica que le responsas del circulation major vidite durante le occlusion del arteria mesenteric es probabilemente causate per un diversion mechanic de sanguine ab un vasculatura al altere e non representava ver responsas reflexe. Le observationes indica que receptores de pression mesenteric non contribue significativamente al regulation reflexe del tension de sanguine in le circulation major.

References
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