# Role of Baroreceptors in the Zone of Vertebral Arteries in the Reflex Regulation of Venous Tone in the Splanchnic Basin

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Pressure elevation in the reflexogenic zone of vertebral arteries was accompanied by a decrease in the tone of splanchnic veins, reduction of blood pressure, and suppression of external respiration. An opposite response of the cardiorespiratory functional system was observed under conditions of low baseline pressure in the vascular zone. Our findings and results of previous physiological and morphological studies indicate that the capacitance vessels play an important role in cardiorespiratory reactions.

**Key Words:** *vascular reflexogenic zone; vertebral artery; cardiorespiratory system*

Functional regulation of veins and their passiveness or activity is an urgent problem of modern physiology. There is no agreement on the response of the capacitance and resistance vessels under conditions of similar activation. Some authors reported the absence of proper coupled mechanoreflex influences on the tone of capacitance vessels. Previous studies showed that various humoral or nervous factors induce the same functional changes in hemodynamic characteristics of the capacitance and resistance vessels [7-9]. The realization of baroreflexes from the vascular reflexogenic zone (VRZ) of the carotid sinus is accompanied by synergistic changes in tonic activity of arteries and veins. Acetylcholine (major transmitter of autonomic nervous regulation) dilates the main arteries, but constricts the venous vessels [5,11]. Hence, there is large discrepancy between the results of various studies. The realization of reflex influences from baroreceptors in the vertebral artery zone (VAZ) on splanchnic vessels is little studied.

Here we studied the reflex influence from baroreceptors of vertebral arteries on the colic vein, external respiration, and systemic blood pressure (SBP). The observed response was compared with baroreflex influences of VAZ on peripheral veins [1].

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## MATERIALS AND METHODS

Acute experiments were performed on cats under urethane anesthesia (1 g/kg). The hemodynamically isolated left colic vein and its arcade with the middle colic vein (colic vein in the following text) were perfused with Ringer—Lock solution (37-38°C) under constant pressure (10-15 mm Hg). The vertebral artery (right artery in the majority of experiments) was isolated hemodynamically by the method developed in our laboratory [3]. The tone of the colic vein was estimated from the number of perfusate drops at the venous outlet. The volume was recorded with a special device, which provided the linear data input, graphic recording, audio monitoring, and video monitoring of perfusion. External respiration was analyzed by spirography after tracheostomy. SBP in the femoral artery was measured by the occlusion method. The linear data input of external respiration and SBP was performed using two electromanometers (MEP-I-01) and electronic attachments. VAZ baroreceptors were stimulated using a syringe—manometer system (pumping/

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aspiration of 0.5 ml physiological saline) or upward/downward shift of a Mariotte vessel. Pressure variations in hemodynamically isolated VAZ were 30-75 mm Hg. This value exceeds the baroreceptor irritability threshold in vascular reflexogenic zones, but corresponds to adequate physiological stimulation [3,12]. In some experiments, all manipulations were performed under conditions of pharmacological blockade of the sinocarotid zone and/or aortic arch.

Under control conditions, VAZ receptors were affected after pharmacological blockade with 2% Novocain or pharmacological denervation of the corresponding mesentery. Constant-pressure perfusion of VAZ with Ringer—Lock solution was performed in another control series.

Statistical analysis was performed with hemodynamic and respiratory parameters, which exhibited the maximum reaction in each series of the present study. The data are expressed in absolute units or percentage of the baseline level (before treatment). The results were analyzed by means of Excel software. The significance of differences was evaluated by Student's *t* test and rank test. All experiments were performed in accordance with the rules of studies on laboratory animals.

## RESULTS

A total of 60 measurements were performed. Pressure elevation in the hemodynamically isolated VAZ was followed by a significant decrease in colic vein tone (12 of 15 samples). It was manifested in an increase in perfusate volume per unit time. These changes were accompanied by reflex inhibition of external respiration and decrease in SBP (Fig. 1).

Pressure drop in the hemodynamically isolated vertebral artery was followed by an increase in arterial tone (by 50 mm Hg; 32 of 45 samples, 7.11%), rise of blood pressure, and stimulation of external respiration. This effect was observed repeatedly in the same experiment. In 13 samples (28.89%), the tone of capacitance vessels, external respiration, and total blood pressure were characterized by opposite or complex changes.

In control samples, the hemodynamic and respiratory response was abolished after pharmacological blockade of vascular regions or constant-pressure perfusion of VAZ. Our results illustrate the reflex type of these changes.

In both series, the response of the colic vein was qualitatively similar to the reaction of peripheral (femoral) veins [1]. We conclude that afferentation from baroreceptors of VRZ in the vertebral arteries is accompanied by functionally synergistic response of peripheral veins and veins of the internal organs (Tables 1 and 2).

Our previous studies revealed the baroreflex influences from VAZ on the hemodynamic and respiratory system under normal and pathological conditions. We showed that baroreceptors of this zone are involved in the regulation of external respiration, SBP, spleen volume, cardiac function, and arterial tone in the heart, inner ear, brain, bulbar conjunctiva, and retina. Moreover, these receptors play a role in the development of vertebral artery syndrome and therapeutic treatment of Meniere's disease and Arnold—Chiari syndrome [2,4]. Resistographic study and simultaneous perfusion of the vascular network (arteries, capillaries, and vein) in cat pelvic limbs under conditions of constant flow rate show that peripheral vessels of the limbs play a role in the depressor and pressor reflex from VAZ.

Our findings indicate that the increase or decrease in blood pressure is accompanied by the opposite re-

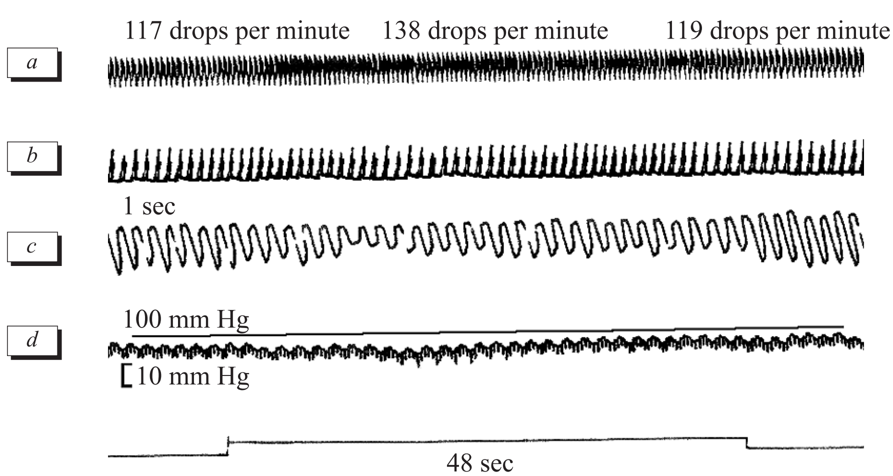


**Fig. 1.** Pressor activation of receptors in the vertebral artery with a syringe-manometer system. (*a*) Perfusion velocity in the colic vein (number of drops before treatment, at the maximum response, and during the aftereffect period; (*b*) time mark (division value=1 sec); (*c*) pneumogram; (*d*) SBP (isoline and calibration). Duration of treatment, 48 sec.

**TABLE 1.** Reflex Influences on the Tone of the Femoral and Colic Veins, SBP, and External Respiration after Pressure Elevation in the Vertebral Artery (*M*±*m*)

| Parameter | Directionality of response | Degree of response | | Latency, sec | Duration of response, sec | Aftereffect, sec |
|---|---|---|---|---|---|---|
| | | I | II | | | |
| Venous tone | Dilation | 177.83±6.01%* | 123.05±3.95%* | 4.29±1.30* | 56.40±6.02⁺ | 19.85±3.75* |
| SBP, mm Hg | Decrease | 18.300±2.725 | | 1.78±0.60* | 51.0±2.3⁺ | 13.74±2.21* |
| External respiration | Inhibition | — | | 1.97±0.90 | 51.6±3.0 | 13.98±2.43 |

**Note.** Here and in Table 2: *I*, response of the femoral vein; *II*, dilation of the capacitance vessel in the splanchnic basin; relative standard deviation $v$=0.52. *$p$<0.05 and ⁺$p$<0.01 compared to the baseline (pretreatment) level.

**TABLE 2.** Reflex Responses of the Capacitance Vessels in Peripheral and Internal Organs, Blood Pressure, and External Respiration after Pressure Drop in the Vertebral Artery (*M*±*m*)

| Parameter | Directionality of reflex | Degree of response | | Latency, sec | Duration of response, sec | Aftereffect, sec |
|---|---|---|---|---|---|---|
| | | I | II | | | |
| Venous tone | Constriction | 56.155±4.895%* | 37.84±2.47%* | 3.875±1.400* | 55.45±4.67⁺ | 20.14±4.30* |
| SBP, mm Hg | Elevation | 10.63±3.50* | | 1.38±0.30* | 51.0±2.8 | 13.39±2.53* |
| External respiration | Stimulation | — | | 1.85±0.40* | 51.3±2.4⁺ | 12.03±1.64* |

**Note.** $v$=0.198.

flex response in VAZ. Similar changes were observed in the tone of the colic vein and SBP. The simultaneous changes in these parameters probably provide rapid recovery of normal blood pressure. For example, excessive increase in the basal blood pressure in the whole organism is accompanied by a reflex increase in venous capacitance in internal organs. This response is mediated by baroreceptors of VRZ in the vertebral arteries and results in normalization of SBP due to a decrease in blood return to the heart. The observed changes are also associated with an increase in capacitance of the spleen and venous vessels in peripheral organs, decrease in resistance of the main arteries, and suppression of electrical and mechanical function of the heart. The decrease in the amplitude of external respiration is directed toward the reduction of blood oxygenation. The initial decrease in the pressure in VRZ is followed by opposite changes in the hemodynamic and respiratory systems. Our results are consistent with published data on baroreceptor activity of the vertebral arteries. However, little is known about this problem [6]. The majority of previous studies were performed on the hemodynamically non-isolated vertebral arteries [10]. Moreover, the reflex response of the resistance and capacitance vessels and respiratory system is realized from baroreceptors of VRZ in the carotid sinus [13].

Our results indicate that pressure variations in VAZ have a reflex influence on venous tone in the internal organs. We conclude that the vertebral arteries include a specific baroreceptor VRZ, which serves as a functional analogue of the carotid sinus.

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