Effects of Hypocapnia on the Vascular Resistance of the Dog's Hind Limb*

By

J. LITWIN**, A. H. DIL*** and D. M. AVIADO

With 7 Figures in the Text

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Disagreement exists concerning the effects of acute hypocapnia on the flow and vascular resistance of the cutaneo-muscular area. According to some authors (BERNHAL 1930; GELLHORN and STECK 1938) hypocapnia produces in anesthetized dogs a reduction of blood flow to the hind limbs, and there is no secondary increase of blood flow following readmission of normal air, which is characteristic of acute anoxia. According to others (FLEISCH, SIBUL and PONOMAREV 1932), however, both hypocapnia and anoxia elicit in cats a biphasic vasomotor response in the hind limb, the first phase being vasoconstrictor, and the second, appearing on readmission of normal air, strongly vasodilator. Unfortunately, the changes in vascular resistance were not quantitatively measured in the above experiments.

Moreover, the mechanism underlying hypocapnic vasoconstriction in the cutaneo-muscular area is not definitely elucidated. Although there is general agreement that the reduction of blood flow to the extremities is the result of neurogenic vasoconstriction (BERNHAL 1930; GELLHORN and STECK 1938), the role of chemoreceptors in the carotid and aortic bodies lacks direct proof.

The experiments reported in this paper were undertaken as an attempt to fill these gaps in information.

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** Fellow of the Rockefeller Foundation. Present address: Department of Human Physiology, School of Medicine, Warsaw, Poland.
*** Participant of the International Cooperation Administration of the U.S. Public Health Service. Present address: Department of Pharmacology, Kabul University Medical College, Kabul, Afghanistan.
The experiments were performed on 32 mongrel dogs, weighing 10 to 24.5 kg, which were anesthetized with morphine sulfate (2 mg/kg s.c.) and chloralose (70 mg/kg i.v.). In all experiments, the chest was opened in the right fifth intercostal space and the lungs were ventilated by means of a Starling Ideal Pump. A mixture of 10 per cent CO$_2$ in air was administered through this pump. Mannuronate (10 mg/kg) or heparin (200 to 400 L.U./kg) was injected intravenously as an anticoagulant. A Sanborn PolyViso was used to record the following: a) aortic blood pressure by a Statham transducer from a catheter inserted via the right femoral artery; b) inferior vena cava pressure by a second Statham transducer from a catheter inserted in the corresponding femoral vein; and c) special measurements on the left leg which will be described under each of the 2 types of experiments.

Measurement of blood flow (15 dogs). The left iliac artery was ligated and cannulated peripherally. One common carotid artery was cannulated and this was connected by rubber tubing to the iliac arterial cannula. Blood flowing into the iliac artery was recorded by a Shipley-Wilson rotameter.

Perfusion of hind leg (17 dogs). In a second group of dogs, a Sigmamotor pump was inserted between the common carotid and the left iliac artery to supply blood at a constant rate of flow. Perfusion pressure into the iliac artery (left leg) was recorded by means of a Statham transducer. In some of these dogs, pressure in the right femoral artery distal to the ligature was measured by means of another Statham transducer. This offered an opportunity to compare changes in vascular resistance of the perfused leg with corresponding changes in pressure in the ligated vessels of the right leg. The latter has been interpreted to represent changes in vascular resistance (NOLF and PLUMIER 1994).

Denervation of the left hind limb was accomplished by sectioning the sciatic, femoral and obturator nerves, as well as nerve fibers running along the iliac artery. Transection of the spinal cord was performed at the level of C$_5$ to C$_3$ after its exposure by laminectomy. Chemoreceptors in the carotid and aortic bodies were denervated by sectioning both sinus nerves and bilateral cervical vagotomy. Bilateral adrenalectomy was accomplished by a transabdominal approach. The following autonomic blocking agents were injected intravenously; bretylium bromide 5 to 10 mg/kg; and hexamethonium bromide 1 to 5 mg/kg. In order to maintain the vasomotor tone intravenous infusions of levarterenol (0.05 to 0.2 μg/kg/min) were used.

Results

Hypercapnia on limb blood flow

The first group of experiments on 15 dogs consisted of measurements of aortic blood pressure, inferior vena cava pressure and blood flow in the iliac artery. The vascular resistance was calculated by dividing pressure gradient by blood flow. The inhalation of 10 per cent carbon dioxide for 1 to 3 minutes induced responses which are described below (Table 1, Fig.1).

During hypercapnia. The aortic blood pressure usually rose progressively during the inhalation of 10 per cent carbon dioxide (mean $+ 9.5$ per cent). In spite of this consistent rise, blood flow to the extremities was reduced in the majority of experiments, being either slightly increased or unchanged in others (mean $-19$; range $-57$ to $+9$ per cent).