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Studies on Vasomotor Reflexes. Vasoconstriction from a Deep Inspiration of Air.

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The superficial and total blood flows of the forearm and hand were studied by the use of 4 different methods. Over 100 experiments were performed on 15 healthy adults, including 2 women. Each experiment was preceded by a rest of 15 to 30 minutes, and equally lengthy periods of control observation. The experiments lasted from 1 to 3 hours.

The plethysmograph indicates that a deep breath causes a fall in forearm volume of from 5 to 10 cc. The shrinkage begins near the end of inspiration, and reaches a maximum in from 15 to 30 seconds. Recovery is slower but complete.

The fall in volume may be analyzed further by the discontinuous blood flow method of Hewlett and Zwaluwenberg.[1] While the hand and part of the forearm are in the plethysmograph, the venous outflow is obstructed suddenly by abruptly raising to 70 or 80 mm. Hg. the pressure within a small cuff placed just centrad to the plethysmograph. The resultant changes in forearm volume indicate the rate of inflow of blood through the still open arteries. Although this method of measuring is discontinuous, it has the advantage of indicating the total blood flow through the forearm.

This method shows that on deep inspiration the blood flow begins to slow in mid-inspiration; reaches its maximum at the end of inspiration, and disappears rapidly. A record obtained in mid-expiration shows the flow already partly recovered. On deep inspiration, the blood flow through the forearm is stopped completely, for from 1 to 15 seconds, depending upon the rate and depth of the inspiration and the subject of the experiment. Experiments performed at every phase of the respiratory cycle indicate that the diminished flow is due to the inspiratory movement, for recovery becomes complete even when the breath is held at inspiration. Forced expiration after a normal inspiration has no vasoconstrictor effects. These results on total blood flow are supported by direct observation of the nailfold capillaries.

The flow of blood through the nailfold capillaries may be ob-

[1] Hewlett and Zwaluwenberg, *Heart*, 1909, **1**, 87.

served through the microscope. A deep breath results in slowing and complete stoppage of capillary flow, which returns to normal in a space of time analogous to that of the other methods. During a deep inspiration there is no discernible change in size and number of capillaries under observation. The blood flow impedance from a deep inspiration of air resembles that described by Wright[2] as occurring with the inhalation of cigarette smoke.

Since there is no accumulation of blood in the capillaries during the arrest of blood flow from a deep inspiration, it is assumed that the obstruction to the flow occurs in the arterial side of the capillary tufts. That this is so is shown by the following experiment: A large blood-pressure cuff is wrapped on the arm, the finger of which is being observed. Next the pressure in the cuff is raised suddenly to 250 mm. Hg., in order to obstruct the inflow with as little venous filling as possible. In from 15 to 45 seconds the blood in the capillary tufts stops flowing forward, and in most individuals soon moves backwards. A deep inspiration of air while the capillary stream is stagnant results in a forward movement; while a deep breath taken during the retrograde movement causes a slowing, stoppage, or reversal of the retrograde movement of blood.

These experiments suggest that the vasoconstriction from a deep breath occurs on the arterial side of the capillary tuft, a fact borne out also by the marked changes in temperature of the skin. They suggest also that the phenomenon is of neural or reflex origin, and is not due to mechanical shifts of blood into the pulmonary circulation, for such shifts are prevented by the circulatory occlusion induced.

Skin temperatures taken during a deep breath show a drop of from 1°C. to 3°C. Several deep breaths taken at one-minute intervals show a summation of effect, and a drop in from 1°C. to 6°C. That this can occur is denied specifically by Wright and Moffat,[3] and impliedly by Maddock and Coller.[4]

The reflex mechanism has not yet been analyzed further, but may be due to one or more of such factors as alveolar stretching; to vascular reflex from pulmonary blood pressure changes; or to the cooling effect of the inspired air.

Our thanks are due to Mr. Raymond L. Osborne for his assistance in this research.

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[2] Wright, *J. Am. Med. Assn.*, 1933, **101**, 439.

[3] Wright and Moffat, *J. Am. Med. Assn.*, 1934, **103**, 320.

[4] Maddock and Coller, PROC. SOC. EXP. BIOL. AND MED., 1932, **29**, 487.