CHANGES IN THE VELOCITY OF THE BLOOD FLOW IN THE CORTEX AND MEDULLA OF THE KIDNEY FOLLOWING INJECTION OF ADRENALIN AND COMPRESSION OF THE TRACHEA

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Numerous facts have been reported indicating the considerable differences between the structure and function of the cortex and medulla of the kidney. It has been found, in particular, that the structure of the vascular system of the medulla and cortex differs [9, 12]. Blood enters the capillaries of the cortex through the cortical glomeruli, and the capillaries of the medulla through the juxtamedullary glomeruli, situated at the border between cortex and medulla. According to some reports, extraglomerular channels are also of definite importance in supplying blood to the medulla [2, 3]. It might be supposed that functional differences are present between the circulation in these two parts of the kidney. Some workers [1, 4, 6, 7, 12] have obtained evidence indicating the possibility of producing various changes in the velocity of the blood flow in the vessels of the renal cortex and medulla by various procedures. The vessels of the medulla have been shown to differ functionally in certain respects from the cortical vessels [11]. However, the changes in the volume velocity of the blood flow were measured indirectly by these authors.

It is essential to study the circulation in the cortex and medulla of the kidney by a method enabling direct recording of the dynamics of the changes in the volume velocity of the blood flow in the individual areas of the organ. We have carried out an investigation of this type, using a thermoelectric method for recording the velocity of the blood flow.

EXPERIMENTAL METHOD

Experiments were carried out on 24 dogs anesthetized with urethane (0.8 g /kg). The velocity of the blood flow was recorded by means of modified Gibbs' thermoelectric needles simultaneously in the cortex and medulla. An important advantage of the thermoelectric method is the opportunity it gives of obtaining a continuous recording of the velocity of the blood flow, so that the dynamics of the observed changes in the circulation can be studied. At the end of the experiment the difference between the galvanometer readings obtained before and after sacrifice of the animal was recorded. This gave an idea of the sensitivity of the electrodes and enabled the relative magnitudes of the reactions (even if they were in the same direction) in each layer to be compared. The arterial pressure was recorded by mercury and membrane manometers. Adrenalin was injected intravenously in a dose of 0.5-30 μg/kg body weight and the compression of the trachea lasted for between 1 and 5 min.

EXPERIMENTAL RESULTS

Injection of adrenalin invariable caused a lowering of the velocity of the blood flow in the cortex, which was more marked with an increase in the dose (Fig. 1). Investigation of the change in the velocity of the blood flow in the cortex at various depths (3 and 7 mm) showed no significant difference in the reactions (Fig. 1, b, c, d). The velocity of the blood flow depends on the relationship between the arterial pressure and vascular tone. Since, after

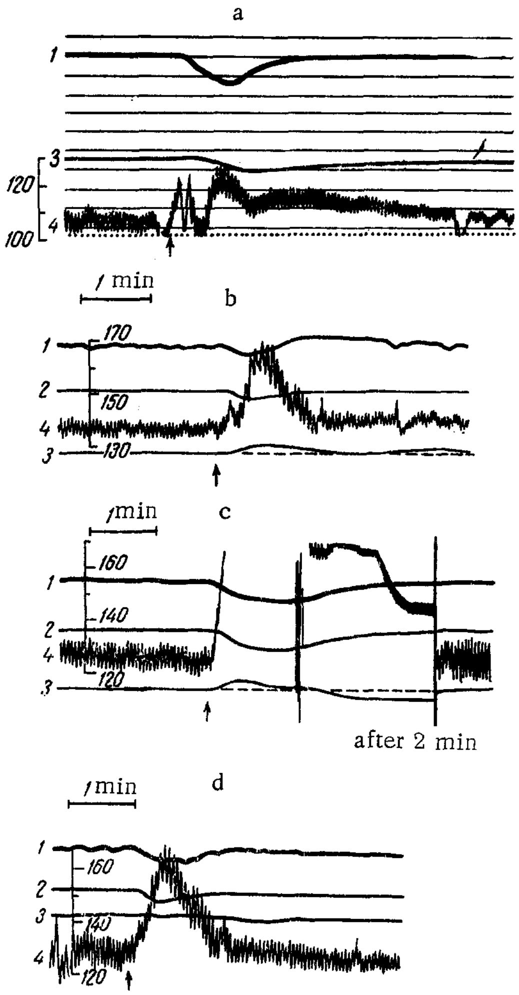

Fig. 1. Changes in velocity of blood flow in the cortex and medulla of the kidney after intravenous injection of adrenalin. a, b) 4 μg/kg; c) 20 μg/kg; d) 6 μg/kg; 1) blood flow in cortex at a depth of 3 mm; 2) blood flow in cortex at a depth of 7 mm; 3) blood flow in medulla at a depth of 18 mm; 4) arterial pressure. Time marked 5 sec.

injection of adrenalin, the velocity of the blood flow fell at the same time as the arterial pressure rose, it may be concluded that a considerable increase in the tone of the blood vessels of the cortex must have taken place under these circumstances. The changes in the velocity of the blood flow in the medulla were of a different character. In some cases, just as in the cortex, the velocity was lowered (Fig. 1, a). Usually, however, the decrease was less marked than in the cortex. In other cases an increase in the velocity of the blood flow in the medulla was observed (Fig. 1, b). Sometimes the changes in the velocity of the blood flow were biphasic (Fig. 1, c) or the velocity itself remained unchanged (Fig. 1, d).

Analysis of these results showed that during the action of adrenalin an increase took place in the tone of the vessels of both cortex and medulla, but the tone of the medullary vessels rose much less than the cortical. As a result of this, the effect of the increase in arterial pressure may become predominant, thus determining the increase in the velocity of the blood flow in the medulla. Other conditions being equal, an increase in the velocity of the blood flow in the medulla was observed more often in cases when the increase in the arterial pressure was greater. It was further discovered that an increase in the velocity of the blood flow in the medulla took place more frequently following injection of small doses of adrenalin (0.5-4 μg/kg). It will be clear from Fig. 1, a and c, that the fall in the velocity of the blood flow in the medulla was of far longer duration than in the cortex, and this is also a characteristic of the functional properties of the medullary vessels.

During compression of the trachea the arterial pressure rose and the velocity of the blood flow fell in the cortex (Fig. 2, a). In the medulla, as during the action of adrenalin, an increase in the velocity of the blood flow was often observed (see Fig. 2, a). This may be accounted for by the preponderant action of the raised arterial pressure. It follows from Fig. 2, a that at the end of stimulation the arterial pressure reached its initial level, while the velocity of the blood flow in the medulla fell below its initial level. This indicated an increase in the tone of the vessels. In another experiment (Fig. 2, b) there was practically no increase in the arterial pressure in response to compression of the trachea. Just as in the cortex (although to a lesser degree), in the medulla the velocity of the blood flow was slowed. The slowing of the blood flow in the medulla began later and lasted longer than in the cortex (see Fig. 2, b).

In order to discover the cause of this difference in the reactivity of the cortical and medullary vessels, surgical denervation of the kidney was performed, after which, in response to compression of the trachea, an approximately equal increase in the velocity of the blood flow was observed in both layers (Fig. 2, c). It may be concluded that the difference between the reactivity of the cortical and medullary vessels is largely due to differences in their nerve supply. The vasoconstrictor innervation is evidently less powerfully developed in the medulla than in the cortex. Another important factor is evidently the morphological difference between the arterioles in the two types of glomeruli. Whereas the diameter of the efferent arterioles of the cortical glomeruli is only half the diameter of the afferent arterioles, in the juxtamedullary glomeruli the diameter of the efferent vessel is equal to or even slightly larger than that of the afferent arteriole [9, 12].

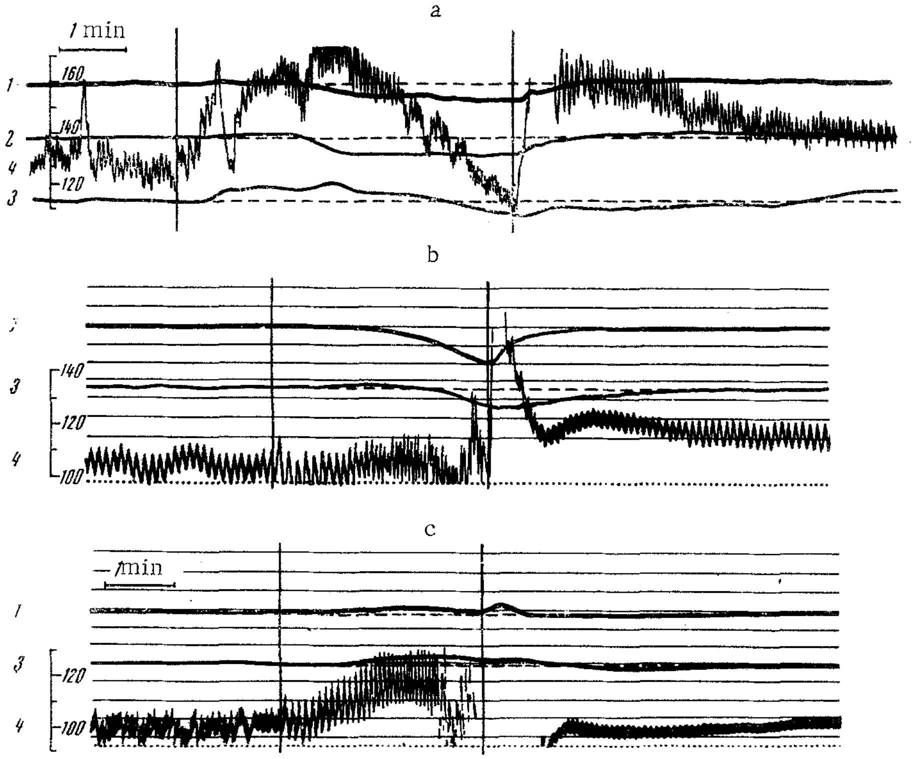

Fig. 2. Changes in velocity of blood flow in the cortex and medulla of the kidney during compression of the trachea. a, b) With innervation intact; c) after surgical denervation of the kidney. Remainder of legend as in Fig. 1. The vertical lines denote the beginning and end of compression.

According to modern ideas of the function of the renal medulla [5, 8, 11], an increase in the velocity of the blood flow in the medulla must lead to an increase in the diuresis as a result of a decrease in the reabsorption of water. For this reason the increase which we observed in the blood flow in the medulla may be one of the causes of the increase in diuresis during the action of small doses of adrenalin [10]. It may be assumed that these distinctive features of the vessels of the renal medulla are related to the fact that these vessels are concerned in the regulation of the diuresis.

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