Observations on Microcirculation in the Mesentery of DCA Hypertensive Rats

TOSHIMI SUZUKI, KEIKO OYAMA and TAKASHI NAKAMURA

Division of Internal Medicine, Research Institute of Brain and Blood Vessels, Akita

Suzuki, T., Oyama, K. and Nakamura, T. Observations on Microcirculation in the Mesentery of DCA Hypertensive Rats. Tohoku J. Exp. Med., 1972, 107 (2), 193-195 — Microcirculation in the mesentery of rats with DCA induced hypertension was observed in vivo by high-speed cinematography. Tortuositities and lumina narrowings of the arterioles, venules and capillaries were observed. Red blood cells flowing in the capillaries smaller than 4.3 μ in internal diameter took a crushed, elongated cylindrical shape and the ratio of length/diameter was 2.6-4.6. Deformation of red blood cells when passed through narrow capillaries was thought to be an important causative element of hemolytic anemia. — microcirculation; hypertension; hemolytic anemia; high-speed cinematography

Hemodynamic features of established hypertension are thought to be due to increase of peripheral resistance by arteriolar constriction. However, very little has been known about the features of peripheral vessels smaller than arterioles. The present paper reports the findings obtained from in vivo observations on DCA hypertensive rats obtained by high-speed cinematograph analyses.

MATERIALS AND METHODS

Hypertension was produced in male rats of the Donryu strain by supplying 1% salt solution as drinking water and injecting 1 mg desoxycorticosterone acetate (DCA) subcutaneously every day after unilateral nephrectomy had been performed under ether anesthesia. The procedures were continued until the experimental rats had been observed in vivo on microcirculation of the mesentery. As a control group ten normotensive rats were given ordinary drinking water. Systolic blood pressure was measured once a week in unanesthetized rats using the tail plethysmographic method (Williams et al. 1939). Between 22 and 90 days after the first injection of DCA the mesenteries of fourteen hypertensive rats were observed in vivo under anesthesia with pentobarbital sodium 35 mg/kg given intramuscularly. The movement of red blood cells was observed at 900 times' magnification and photographed by a 16 mm high-speed camera (Milliken DBM-5D) at 500 frames per second, in 1/10,000 second of exposure time, using 150 watt Xenon lamp as the light source (Suzuki et al. 1971), the films of Eastman 4× Type 7224 and Anscochrome D/500 Type 2R 3000 being used. The histo-pathological examinations were made on the kidneys, brains and mesenteries of all the experimental rats. In two of the DCA hypertensive rats hematological examinations were also carried out.

RESULTS AND DISCUSSION

Systolic blood pressure of the DCA injected rats, when observed in vivo, was 175-240
mm Hg, giving an average value of 209±19 (S.D.) mm Hg. This value is evidently higher than the average value of 109±10 mm Hg for the control group, thus showing the successful production of hypertension. Tortuosities and constrictions of the arterioles and venules were seen in the hypertensive rats; and narrowings of lumina and tortuosities were also recognized in the capillaries, the narrowest internal diameter being 3.3 μ. The above-mentioned changes were recognized in the DCA hypertensive rats more than four weeks after the first injection of DCA. When the values of length/diameter ratio of red blood cells flowing in the capillaries (E, signifying the ratio of elongation of red blood cell) were counted out, they were almost always less than 2.0 and a rarely maximum value of 2.3 in normal capillaries. On the other hand, as shown in Fig. 1, in 8 of the eleven DCA hypertensive rats between 31 and 90 days after the first injection of DCA numerous red blood cells flowing in the capillaries smaller than 4.3 μ in internal diameter showed a crushed, elongated cylindrical shape convexing at the leading edge, even at a red cell velocity as slow as 0.3 mm/sec, and the E value ranged from 2.6 to 4.6. The E values for the red blood cells were found to be in inverse proportion to the internal diameter of capillaries, but no relationship could be recognized between the E value of red blood cell and the red cell velocity. The two DCA hypertensive rats showed high-degree hemolytic anemia and broken red blood cells such as burr cell, helmet cell and cell fragmentation, which were recognized not only in their blood films, but also numerously in vivo in the capillaries of the DCA hypertensive rats which showed the above-mentioned crushed deformation of red blood cells. The histo-pathological examinations revealed slight fibrinoid changes in the arterioles and capillaries of kidneys and very few intravascular fibrinoid substance.

It is thought that the flowing in capillaries of red blood cells with the value of E greater than 2.6 results in hemolysis of red blood cells when we refer to the previous publications on the related subjects such as the viscoelastic limit of the membrane of red blood cell (Rand 1964), the deformation of human red blood cells in an extremely minute glass tube (Seshadri et al. 1970), filtration of human erythrocytes through polycarbonate sieves of small pores (Chien et al. 1971), hemoglobinuria due to marching (Davidson 1969), that the minimum cylindrical diameter of normal human erythrocyte was assumed to be 3.66±0.04 μ (Canham and Burton 1968), and that hemolytic anemia in coarctation of aorta can be named as "macroangiopathic hemolytic anemia" (Westphal and Azen 1971). We may conclude that the deformation of red blood cells during the passage through narrow capillaries is one of the most important factors for causing hemolytic anemia.
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References


