

MICROCIRCULATION AND RESPONSES OF PIAL VESSELS IN ANAPHYLAXIS

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Intravenous injection of a reacting dose of horse serum (2 ml/kg) into sensitized rabbits and dogs was followed by lowering of the blood pressure in the main arteries and by slowing of the blood flow, disturbance of the laminar pattern of flow, aggregation of the blood cells, and blood stasis in the terminal segments of the pial vessels. The arterioles and venules were dilated. After injection of a smaller reacting dose of serum (1 ml/kg) into rabbits, elevation of the blood pressure in the main arteries, acceleration of the blood flow in the pial vessels, and spasm of the arterioles and venules were recorded initially, followed by a fall of blood pressure, dilatation of the arterioles and venules, and the development of the microcirculatory disturbances described above.

KEY WORDS: anaphylaxis; microcirculation; pial vessels.

In anaphylactic shock considerable disturbances are found in the terminal circulation in the mesentery, liver, heart, and lungs [1-9]. However, the features distinguishing the microcirculation and responses of the pial blood vessels of the brain to anaphylaxis have not yet been investigated.

EXPERIMENTAL METHOD

Dogs and rabbits were sensitized with normal horse serum. On the 19th-21st day of sensitization, under local procaine anesthesia, a burr-hole 1.5-2 cm in diameter was drilled in the right parietal bone. The dura was carefully removed, and the pial blood vessels were then clearly revealed. The exposed area was irrigated with Ringer - Locke solution containing 1% gelatin. Anaphylactic shock was induced in 10 dogs and seven rabbits by injection of horse serum (2 ml/kg) into the jugular vein over a period of 30 sec. Since rabbits died 7-10 min after the injection of this dose, in 10 rabbits shock was induced by the injection of 1 ml/kg of the same serum.

The responses of the pial vessels were studied under the MBS-2 microscope (ocular 8, objective 7). The diameter of the pial vessels was determined on photomicrographs under the MBS-1 microscope. The scale of an ocular micrometer (1 division = 10 μ), photographed with the MBS-2 microscope (ocular 8, objective 7), was used for reference. Photomicrographs were made before and 1-2, 5-6, 10, and 15-20 min after injection of the reacting dose of serum and after restoration of the normal blood pressure (in the femoral artery). Visual observations were made on changes in the microcirculation in the pial vessels of 15 dogs and 12 rabbits.

EXPERIMENTAL RESULTS AND DISCUSSION

Aggregation of the red cells was observed in the pial venules 1-2 min after injection of the reacting dose of serum into the dogs. In the larger veins the disturbances of the laminar flow developed later and were less severe. Aggregation was found last of all in the arterioles and arteries. The smaller the decrease in the arterial blood pressure, the less severe the disturbance of the laminar flow pattern.

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TABLE 1. Changes in Arterial Pressure and Diameter of Pial Blood Vessels in Dogs during Anaphylactic Shock ($M \pm m$)

Parameter studied	Initial level	Shock				Recovery arterial pressure
		1-2 min	5-6 min	10-12 min (stable hypotension)	15-20 min	
Arterial pres. p (mm Hg)	$104,6 \pm 6,74$	$32,4 \pm 5,65$	$33,4 \pm 8,06$	$35,3 \pm 8,44$	$52 \pm 11,02$	$104,8 \pm 12,28$
Diam. of arteries (mm)	$0,33 \pm 0,067$	$<0,001$ $0,29 \pm 0,068$	$<0,001$ $0,34 \pm 0,090$	$<0,001$ $0,35 \pm 0,085$	$<0,001$ $0,33 \pm 0,076$	$>0,1$ $0,33 \pm 0,11$
Diam. of arterioles (mm)	$0,068 \pm 0,007$	$>0,1$ $0,092 \pm 0,014$	$>0,1$ $0,1 \pm 0,011$	$>0,1$ $0,1 \pm 0,014$	$>0,1$ $0,1 \pm 0,015$	$>0,1$ $0,11 \pm 0,056$
Diam. of veins p (mm)	$0,26 \pm 0,027$	$>0,1$ $0,273 \pm 0,019$	$<0,05$ $0,285 \pm 0,025$	$<0,05$ $0,280 \pm 0,028$	$<0,05$ $0,278 \pm 0,03$	$>P>0,05$ $0,237 \pm 0,0009$
Diam. of venules (mm)	$0,107 \pm 0,012$	$>0,1$ $0,123 \pm 0,012$	$>0,1$ $0,138 \pm 0,014$	$>0,1$ $0,140 \pm 0,018$	$>0,1$ $0,155 \pm 0,019$	$>0,1$ $0,131 \pm 0,029$
	—	$>0,1$	$>0,1$	$>0,1$	$<0,05$	$>0,1$

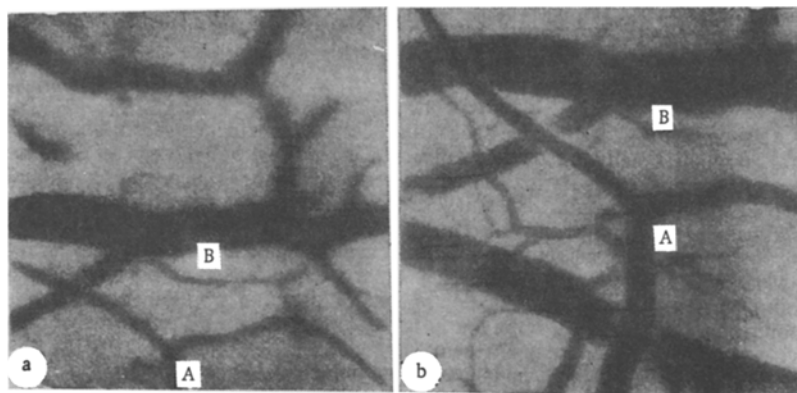


Fig. 1. Experiment No. 6. Pial vessels of a dog: a) original background. Blood pressure 130 mm Hg; b) 12 min of shock. Blood pressure 74 mm Hg. A) Arteriole; B) venule. Ocular 8, objective 7.

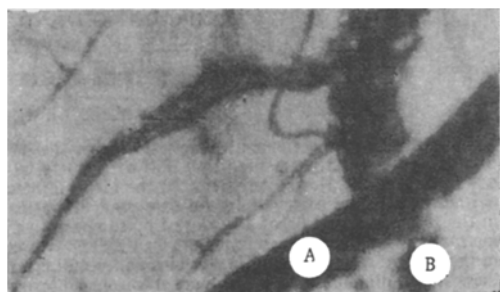


Fig. 2. Experiment No. 8. Dog in a terminal state. Marked aggregation of blood cells in arterioles (A) and venules (B).

As the blood pressure in the main arteries returned to normal the aggregation of the blood cells disappeared; the laminar pattern of flow recovered in the opposite order (in the arteries and arterioles first, later in the veins and venules).

In the course of shock in the dogs changes were found in the diameter of the arterioles and venules, but the diameter of the arteries and veins was unchanged (Table 1; Figs. 1 and 2). In some experiments by the time of recovery of the pressure constriction of the arterioles was found, and this was the reason why the mean increase in their diameter, which occurred in most dogs, was not significant.

By the 15th-20th minute of shock the diameter of the venules was increased, but when the blood pressure in the main arteries was restored to normal, it also returned to normal. Disturbances affecting the pial vessels in shock largely coincide with changes in the microcirculation in other organs [7-9, 12]. This parallel is evidence that the disturbances of the circulation in the various organs take place in the same direction.

Intravenous injection of the serum into rabbits in the reacting dose of 2 ml/kg led to a catastrophic fall of blood pressure and as a rule the animals died after 7-10 min. Disturbances of the microcirculation

TABLE 2. Changes in Arterial Pressure and Diameter of Pial Blood Vessels in Rabbits

Parameter studied	Treatment	Initial level	Shock			Tendency for arterial pressure to recover after 1-2 h
			1-2 min	5-10 min	15-20 min	
Arterial pressure (in mm Hg) P	Injection of 1 ml/kg horse serum	93,8 ± 2,29	107,7 ± 4,93	36,0 ± 7,80	57,5 ± 10,9	67,5 ± 2,88
Diameter of arterioles (in μ) P		90,6 ± 7,58	<0,01	<0,0001	<0,01	<0,01
Diameter of venules (in μ) P		93,8 ± 8,50	<0,05	>0,1	>0,1	>0,4
			>0,1	>0,1	=0,07	>0,1
Arterial pressure (in mm Hg) P	Injection of 2 ml/kg horse serum	93,3 ± 3,98	61,6 ± 6,58	43,6 ± 11,56		
Diameter of arterioles (in μ) P		77,5 ± 13,64	<0,01	<0,01		
Diameter of venules (in μ) P		101,2 ± 11,63	>0,1	=0,09		
			>0,1	>0,1		

in the pial vessels were observed just as quickly - slowing of the blood flow, aggregation of the cells, and stasis. The diameter of the pial arterioles and venules was very slightly increased.

Very interesting changes were observed after injection of a smaller reacting dose of horse serum (1 ml/kg) into rabbits (Table 2). A sharp acceleration of the blood flow was observed after 1-2 min, followed after 5-10 min by slowing of the blood flow and the formation of the microcirculatory disturbances described above.

After 1-2 min the arterial blood pressure of these animals increased. During this period marked spasm of the arterioles and, to a lesser degree, of the venules was observed. The pressure fell most suddenly after 5-10 min of shock and the arterioles and venules were slightly dilated. After 15-20 min a tendency was observed for the pressure in the main arteries to be restored, although it had not returned to its initial level after 1-2 h. The arterioles and venules on the average remained dilated. Just as in dogs, after 1-2 h repeated spasm of the arterioles was recorded in some experiments, possibly reflecting a mechanism responsible for restoring the blood pressure in the main arteries.

These results correspond in general to those obtained by other workers studying changes in the microcirculation in shock in rabbits [11], mice [10], and rats [6].

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