RED CELL DEPOSITION (SLUDGING) AND RETURN TO THE CIRCULATION

(UDC 616-001-07:616.12-008-072.7)

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 59, No. 1, pp. 44-47, January, 1965
Original article submitted December 22, 1963

A curious fact has been observed in the course of the treatment of shock from trauma, burns or toxemia, and acute loss of blood. The dilution of the blood, which might logically be expected to follow the infusion of large quantities of blood-replacing solutions such as polyglucine, polyvinylpyrrolidone and others, does not develop.

The only explanation possible for these phenomena is disproportionate deposition and subsequent removal of the fluid part and the formed elements of the blood. Intravital observation of capillary blood-flow, a method described by several authors [1, 2, 3], was used in an attempt to obtain experimental confirmation of the occurrence of changes such as those indicated.

METHOD

Capillary blood-flow in the bulbar and conjunctival vessels of albino rabbits was observed in reflected light with a stereoscopic microscope and magnification of 25. The passage of each individual red cell along the vessels could be observed. In healthy animals the rate at which the red cells moved was such that the erythrocytes flowed past in a continuous shining chain.

When the normal state of the blood-flow had been adequately recorded, the rabbit's small intestine was ligatured 110-140 cm below the duodenojejunal fold.

RESULTS

Considerable slowing of blood-flow, first in the capillaries and then in the arterioles and venules of the eye, was observed 18-20 h after ligation of the intestine.

The rabbits developed states of severe toxemia after 38-40 h, with extreme adynamia (animals were unable to stand), constant twitching of different muscle groups, periodically replaced by clonic convulsive movements, and complete indifference to their surroundings. Blood-flow in the vessels of the eye now presented a curious picture. In the larger arterioles and venules there were very slowly moving solid continuous masses of red cells and the blood going to the eye contained practically no plasma. Forward movement was sometimes replaced by a pendulum-type movement of the blood, even in larger vessels.

The smaller arterioles and venules and all capillaries were packed with stationary agglomerations of red cells firmly adherent to one another. The capillaries were completely collapsed between agglomerations and presented "string of beads" appearances. Arteriovenous anastomoses were opened up and blood-flow in these was as in the larger vessels.

On this background, the rabbits were given intravenous infusions of 6% solution of small-molecule polyvinylpyrrolidone (20 ml/kg).

After 10 min movement of red cells in the larger vessels was accelerated and they no longer moved in the same tightly packed masses but were again separated by fluid.

The red cell agglomerations in the capillaries were "dissolved" away; individual red cells became separated off and began to move along the capillaries; in the course of a further 10 min all the vessels were again filled with evenly moving blood. The rate of cell movement was, of course, still slower than normal flow and the picture was generally very much the same as that observed 20 h after the production of intestinal obstruction. There was at the same time a marked change in the animals' behavior; they became active again and convulsions disappeared.

Progressive Change in Radioactivity of Venous Blood of Rabbits After Production of Intestinal Toxemia and Injection of Polyvinylpyrrolidone

No. of Expt.	Radioactivity								Difference between anticipated and observed levels	
	Initial values		After 20 h		After 40 h		After infusion of polyvinylpyrrolidone			
							Anticipated from dilution	Observed in experiment		
	Imp/min	%	Imp/min	%	Imp/min	%	(Imp/min)		Imp/min	%
1	2,260	100	3;090	181.0	2,140	82.3	1,500	2,850	+1,350	+ 90
2	1,450	—	1,650	113.8	970	66.8	680	1,050	+ 370	+ 54
3	1,440	—	1,610	110.4	1,440	100.0	1,005	1,490	+ 485	+ 46
4	310	—	312	100.0	240	78.0	168	250	+ 82	+ 49
5	540	—	720	133.8	530	98.1	370	460	+ 90	+ 24
6	400	—	766	191.5	316	79.0	221	323	+ 102	+ 46
7	310	—	368	118.7	250	80.9	175	228	+ 53	+ 30
8	360	—	520	139.0	140	38.9	94	280	+ 186	+200

Similar experiments were carried out on 22 rabbits and the progressive changes in the peripheral blood just described were regularly observed in all.

With the increasing toxemia, large numbers of red cells apparently became massed in peripheral capillaries and there was at the same time reduction of the fluid part of the blood was the result of extreme cell stasis and the same process could be observed in the capillaries of the retina which, phylogenetically, is part of the brain. Redistribution of the blood meant abolition of stasis and restoration of peripheral blood-flow. Although the process under observation was, in fact, the exclusion of some proportion of the red cells from the general circulation, it could not be ruled out that the changes were purely local disturbances of the peripheral blood-flow.

Supplementary experiments were carried out on 9 rabbits in an effort to exclude this latter possibility. ^{51}Cr-tagged rabbit's own red cells were injected into the animal 24 h before an experiment; blood from the ear vein contralateral to that into which the isotope had been injected was examined for radioactivity at the several stages of the experiment already indicated.

The radioactivity of the blood remained unchanged during the 24 h preceding ligature of the intestine. When, 18-20 h after ligation, the movement of red cells in the eye vessels was slowing down, there was a considerable increase of radioactivity in the venous blood, this being indicative of inspissation of the blood caused by plasma leaving the vascular bed. Later, while the toxemia was still increasing, blood radioactivity began to diminish, a change which pointed to loss of red cells from the circulation. The reduction in the number of circulating red cells coincided with the development of capillary stasis and reduction continued progressively as stasis increased.

A single intravenous injection of polyvinylpyrrolidone solution (20 ml/kg) was given rapidly 38-40 h after ligation of the intestine. This rapid infusion should have produced a 30% dilution of the blood. Yet radioactivity and hematocrit estimations revealed increase in the number of red cells, coinciding with disappearance of capillary stasis, instead of the logically anticipated reduction. The results of these observations are given in Table 1. The intimate mechanisms responsible for this phenomenon are still obscure and their elucidation will require special research.

SUMMARY

In experiments carried out on albino rabbits it was established that the so-called blood deposition resulting from intoxication is manifested by 2 phases. During the first phase (at the early stage of intoxication) plasma leaves the blood channel; during the 2nd phase there is an erythrocyte stasis and an arrest of circulation in the capillary network. Blood redeposition is a restoration of circulation and elimination of erythrocyte stasis in the capillary network.

LITERATURE CITED

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