

PERMEABILITY CHANGES IN VESSELS FOLLOWING BLOOD LOSS

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Most workers have studied permeability change in vessels either very soon after their occurrence, or else after severe hypoxemia; in clinical practice, hypoxic conditions, though not severe, are frequently prolonged, so that naturally, it is not possible to apply results obtained from acute cases to these conditions. Thus, for instance, it is generally accepted that a severe hypoxia increases vessel permeability, but that moderate hypoxia has no such effect. Little is known either about permeability changes occurring at different times after hemorrhage, or after other kinds of hypoxia.

E. Landis [10, 11] has shown that washing out the mesenteric vessels with Ringer's solution containing no oxygen causes a marked increase in their permeability; a similar change is induced by a three minute period of ischemia, caused by ligaturing the arteries. G. Saslow [14] perfused frog vessels, and observed an edema which could be eliminated by adding erythrocytes to the perfusate. F. Maurer [13], S. Drinker and M. Field [7], M. Field, A. Koranyi and G. Szabo [8] found an increase in capillary permeability and in lymph formation on adding hemoglobin and oxygen to the blood, and found the pulmonary vessels particularly sensitive to hypoxemia [17].

A relation between hypoxemia and a tendency to edema has also been observed clinically [6, 16]; on the other hand, when oxygen is administered, a reduction in the flow of fluid from the capillaries into the tissues has been observed [1].

Many authors doubt whether moderate oxygen lack causes any increase in blood vessel permeability [9, 12, 15]. G. Sh. Tairov [4, 5], has shown in animals and in blood donors that after bleeding, for several hours there was a reduction in peripheral circulation and an absorption of substances of low molecular weight from the skin in spite of the fact that the volume of the circulating blood and the blood pressure had regained their initial values some time previously.

The object of the present work has been to find the effect of moderate blood loss on general blood vessel permeability at later periods.

METHOD

The experiments were carried out on 22 rabbits and 14 dogs, who were divided into 4 groups according to the amount of blood lost (Table 1). Before the experiment, the animals were kept for 3 days under constant living and feeding conditions. The hemoglobin was then determined and a red cell count made. The animals were bled by withdrawing blood from the heart through a syringe; the total amount of blood taken was equal to 1/13 of the body weight. On the following day the same determinations were repeated, after which the total permeability of the blood vessels was determined. According to L. A. Oivin and his coworkers [2] a good index of this quantity is the rate at which substances of low molecular weight pass through the vessel walls. We therefore used a radioactive isotope of phosphorus in the form of $\text{Na}_2\text{HP}^{32}\text{O}_4$; 4 μ Ci per kg was injected into the jugular vein. After 5, 30, and 60 minutes, blood samples were withdrawn to determine its activity; for this purpose,

TABLE 1

Distribution of Animals According to Amount of Blood Lost

Group	Number of animals			Amount of blood lost (in %)
	rabbits	dogs	total	
1-	10	5	15	Control
2-	4	3	7	5
3-	4	3	7	10
4-	4	3	7	15

TABLE 2

Change in the Erythrocyte Count and Hemoglobin Content in Rabbits and Dogs After Bleeding

Group	Conditions of test	Average indices			
		rabbits		dogs	
		hemoglobin	erythrocytes (in thousands per mm ³)	hemoglobin (in Sahli units)	erythrocytes (in thousands per mm ³)
2-	Before bleeding	80	4 480	92	4 996
	After "	70	3 760	91	4 230
3-	Before bleeding	79	4 450	93	4 983
	After "	68	3 612	78	3 570
4-	Before bleeding	80	4 527	95	5 153
	After "	68	3 492	77	3 526

TABLE 3

Reduction in Radioactivity of Blood (in impulses per minute)

Group	Rabbits			Dogs		
	5 minutes	30 minutes	60 minutes	5 minutes	30 minutes	60 minutes
1	112	82	54	106	93	88
2-	97	80	57	65	56	53
3-	78	66	41	64	53	50
4-	69	56	53	66	52	45

0.03 ml of blood was transferred onto a standard sized filter paper, and after drying, the activity of the blood sample was determined on a type B instrument using an MS-4 electronic counter. The number of impulses in excess of the background level per minute was counted; the average of three counts was taken.

RESULTS

The results of all investigations are given in Tables 2 and 3.

In general, the reduction in the radioactivity of the phosphorus in the blood, both in rabbits and in dogs, corresponded to the amount of blood lost, the relationship being quantitative. It is especially in the first few minutes, when the concentration of the isotopes in the blood is highest, that there is the greatest loss of isotopes from the blood stream, and therefore that the permeability of the vessels to substances of low molecular weight is greatest. It seems to us that this phenomenon must be an adaptation to hypoxia. It is known that in oxygen lack, many compensatory processes develop which improve the absorption of oxygen by the tissues. Although the peripheral vessels are temporarily constricted, those of organs such as the heart, brain, and probably the lungs and other organs dilate, so that the increased permeability of the membrane of the vessel, occurring reflexly, eliminates the tissue hypoxia following a moderate blood loss [3].

The immediate reason for the increased general permeability one day after the bleeding, which is the time at which our investigations were made, is evidently the temporary posthemorrhagic hydremia and anemia which bring about a certain degree of hypoxia; the early and complete restoration of the circulating blood volume and blood pressure, which is complete by this time, prevents any ischemia of the peripheral tissue.

SUMMARY

A study was made of the effect of various amounts of blood loss on general blood vessel permeability to substances of low molecular weight.

An increase in permeability was observed after 24 hours, the extent of the increase being proportional to the amount of blood lost.

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