ON THE INFLUENCE OF FASTING UPON THE BACTERICIDAL ACTION OF THE BLOOD.

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In the following we shall report the results of some experiments which we have made to ascertain the influence of fasting upon the bactericidal action of the blood. We were led to this line of experimentation by the casual observation made in our investigation of the bactericidal action of the lymph from the thoracic duct of the dog,* that our parallel experiments with the blood did not show such an intense germicidal effect as most other writers on this subject had observed. It occurred to us that the weaker bactericidal action observed by us may have been due to the fasting of our animals. In order to compare satisfactorily the number of colonies in the different plates, we had to obtain lymph free from the misleading fine droplets of chyle, and, therefore, our dogs were allowed to fast for 30 to 40 hours previously to their being operated upon. The investigations of other writers have not had this motive, and we may presume that in their experiments the blood was obtained within a few hours after feeding the animals.

The assumption that inanition might reduce the bactericidal action of the blood seemed to us plausible for the following reasons: It is now generally conceded that the bactericidal powers of the blood are generated in some way by the leucocytes. The hyperleucocytosis of digestion is a well established fact, and on the other hand, Luciani† found in a fasting human being (Succi) and Rieder‡ in fasting dogs a marked hypoleucocytosis. It is therefore reasonable to assume that the bactericidal elements are increased also during digestion, and

* Meltzer and Norris, *Journal of Experimental Medicine*, 1897, ii, 701.

† Luciani, Das Hungern, Hamburg and Leipzig, 1890.

‡ Rieder, Beiträge zur Kenntniss der Leukocytose u. s. w. Leipzig, 1892.

decreased in a state of inanition. Furthermore, if we consider the bactericidal elements as the natural protectors of the body against infection our hypothesis would coincide with the generally acknowledged fact, that a poorly nourished body is more apt to be attacked by an infectious disease than a well-fed one, a fact which finds support in the experiments of Canalis and Morpurgo,* showing that starving pigeons lose their natural immunity from the infection with anthrax bacilli.

To test the validity of this hypothesis was the object of our experiments. We restricted our experiments to dogs and the typhoid bacillus. The blood was obtained under the usual precautions either from the femoral or the carotid arteries under cocaine anæsthesia. The comparisons were made between specimens of blood from the same dog and similar arteries under different conditions of feeding. Serum and blood defibrinated by shaking with glass beads were examined in each experiment. The bactericidal power was studied by the Buchner method, *i. e.* a quantity of blood or serum was inoculated with the typhoid bacillus; from this plates were made immediately after inoculation, and then one hour, two hours, etc., after inoculation other plates were made, and the number of colonies on the different plates counted. In some of the experiments two series of observations were made; one with serum kept at 37° C., the other with serum kept at room temperature. We were often compelled by outside reasons to keep the blood two days or longer in the ice-box before the bactericidal power could be tested, but then with few exceptions the blood of the well-fed and of the fasting animal were kept under exactly the same conditions.

Exp. B[1]. Medium-sized male dog. Fed twice daily for two days. Nov. 4, a few hours after feeding, blood was taken from the right femoral artery. The defibrinated blood and the serum were kept in the ice-chest for 3 days, then inoculated and plated with the following result:

37° C.	Immediate.	1 hr.	6½ hrs.	25 hrs.	4 days.
Blood	5899	42	4	34916	....
Serum	1499	90	0	29	40000

* Canalis and Morpurgo, *Fortschr. d. Med.*, 1890, viii, 693 and 729.

Exp. B[2]. The same dog, after fasting for five days, on Nov. 9 (previous wound having healed per priam) was operated upon and blood was taken from the left femoral artery. Blood and serum kept in ice-box for 20 hours, then inoculated and plated.

37° C.	Immediate.	1 hr.	3½ hrs.	25 hrs.
Blood	3445	1197	60	6169
Serum	2210	496	60	13992

In this experiment there seems to be a slight difference in favor of the blood from the well-fed animal, although it was kept longer in the ice-box than the blood from the fasting animal.

Exp. C[1]. Small female dog fed a few hours before operation, Nov. 17; blood taken from the right femoral artery; blood and serum kept 40 hours in ice-chest, then inoculated and plated.

37° C.	Immediate.	1 hr.	3½ hrs.	6½ hrs.	24 hrs.
Blood	2316	169	9	4	27
Serum	689	79	19	15	194
21° C.					
Blood	1012	567	265	69	9
Serum	625	418	116	90	12

Exp. C[2]. Nov. 22 from the same dog, the previous wound having healed, fasting (without water) since the first operation, blood was taken from left femoral artery; the blood and serum were kept 48 hours in ice-box, then inoculated and plated.

37° C.	Immediate.	1 hr.	3½ hrs.	6 hrs.	24 hrs.
Blood	4086	583	43	8	81
Serum	5633	1155	123	4	390
21° C.					
Blood	3079	1706	678	413	185
Serum	5194	2234	1303	483	68

In this experiment there is apparently no difference between both kinds of blood and serum. Six hours after inoculation at 37° C., there is about the same reduction in all the specimens of the blood and the serum, though there was a higher initial number of colonies in the blood and the serum taken from the starved animal. The fasting apparently did not reduce the bactericidal power of the blood.

Exp. D[1]. Large dog fasted five days, no water; Dec. 1 blood was obtained from right femoral artery, blood and serum kept on ice for 4 days, then inoculated and plated.

37° C.	Immediate.	1 hr.	3 hrs.	6 hrs.	28 hrs.	3 days.
Blood	3831	572	84	14	∞	∞
Serum	2046	471	104	21	∞	∞
21° C.						
Blood	2814	1653	922	336	?	
Serum	1552	1701	662	381	651	

Exp. D[2]. The same dog well fed since last operation, Dec. 17, blood from left femoral artery, blood and serum 4 days in ice-chest, then inoculated and plated.

37° C.	Immediate.	1 hr.	3 hrs.	6 hrs.	28 hrs.
Blood	1807	286	81	23	∞
Serum	954	265	54	3	∞
21° C.					
Blood	1219	948	579	286	328
Serum	3768	588	445	312	1817

In this experiment the dog fasted first and was then fed well for over two weeks before blood was again taken; the result obtained was the same as in the foregoing experiments, and, to say briefly, as in all the previous experiments. Our hypothesis did not stand the test of the experiments; these have shown conclusively that five days' fasting did not affect the bactericidal power of the blood as tested with the typhoid bacillus, in the slightest degree. There seemed to be no difference in the bactericidal action of the blood, no matter whether it was taken from a well-fed or even over-fed dog or from an animal in a state of complete inanition.

We might perhaps explain this surprising fact in the following manner: According to Buchner the degree of the bactericidal action of the body-fluids depends upon two opposing factors; the alexines, which are generated by the leucocytes, and the nutritive character of the fluid. There can be no question that fasting impoverishes the blood. If we now assume that feeding or fasting increases or diminishes the nutritive capacity of the blood to the same degree as hyper- or hypoleucocytosis is obtained, it would then be quite natural that the bactericidal action should always remain the same, for when numerator and denominator are multiplied or divided by the same number, the value remains unchanged.

As to any apparent incompatibility of our results with the common assumption that inanition favors infection, we must in the first place

bear in mind that our present results apply only to the bactericidal action of the blood of the dog upon the typhoid bacillus; with other animals and with other microörganisms the conditions may be different. Canalis and Morpurgo could not by starvation influence the immunity of the rat from anthrax, although the immunity of the pigeon was abolished. On the other hand the bactericidal properties of the blood are not the only defensive elements of the body against infection. Other factors, notably the body cells, are concerned, and it may well be that the powers of resistance of the latter may suffer to a considerable measure through the starvation of the animal.