SOME FACTORS INVOLVED IN THE CONCENTRATION OF BLOOD BY THE SPLEEN.

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It has been shown by Barcroft and Poole(1) that it is possible to abstract from the spleen pulp blood which is more concentrated in hæmoglobin and corpuscles than that taken at the same time from the peripheral circulation; that is to say the spleen is capable of concentrating blood contained within it.

There are three possible explanations for this: (1) that corpuscles are manufactured in the spleen and added to the blood circulating through it, but all evidence is against the idea that the spleen in adult life manufactures corpuscles at all; (2) that the blood for some reason is held up in the spleen and during its sojourn the fluid is filtered off from it into spleen lymphatics, the corpuscles remaining in the pulp spaces. The samples then obtained by puncture of the pulp spaces will obviously be more concentrated than peripheral blood; (3) that the peculiar anatomical arrangement of the vascular bed in the spleen may favour a form of plasma skimming whereby corpuscles are concentrated through removal of plasma by the blood stream.

If the last explanation be correct, then shutting off the main venous return should bring any process of concentration to a standstill. If however the spleen be furnished with an apparatus for removing fluid, *i.e.* lymphatics, then shutting off the main veins, owing to increased intravascular pressure, should lead to a greater removal of fluid and concentration of blood.

These ideas have been put to the test in the following way. Cats anæsthetised with chloralose were used throughout. The spleen was exposed through an abdominal incision and blood samples taken in the way previously described. Peripheral samples were drawn from the saphenous vein into a dry syringe, hæmoglobin estimations being made on the specimens thus obtained.

After comparable specimens of spleen and peripheral blood were taken the spleen was made to contract by direct faradic stimulation in order to expel its blood content. The organ was then divided into two

portions by means of a thick ligature and the main vein from one portion tied. After a lapse of time further pulp specimens were abstracted from congested and normal portions respectively.

In five such experiments a considerable concentration invariably appeared in the blood of the congested half.

Protocols.

a.m.	*Cat.* Chloralose. November 5, 1927.	Hb. p.c.
10.40	Saphenous vein sample	66
10.50	Spleen sample before vessels tied. Spleen appeared purplish blue colour ...	83
10.59	Spleen sample after spleen tied into two portions but before main vein tied. Spleen changed from purple to red and became smaller	69
11.4	Vein tied off. Spleen immediately swelled	
11.19	From tied off portion of spleen	58
11.23	From tied off portion of spleen	73
11.27	Saphenous vein sample	61
11.34	From tied off portion of spleen. Artery held during taking of sample ...	90
11.47	Saphenous vein	64
11.52	From tied off portion of spleen. Artery held	85
11.57	From tied off portion of spleen. Artery held	98
p.m.		
12.5	Blood from portion of spleen with open vein. Spleen was rather contracted and blood difficult to obtain	67
a.m.	*Cat.* Chloralose. October 21.	
10.47	Spleen specimen	69
10.53	Saphenous vein sample	67
11.3	Saphenous vein sample	66
11.10	Spleen sample	83
11.38	Spleen tied into two portions with thick ligatures. Ligature placed round main vein but not tied. Spleen made to contract by direct stimulation with electrode. Puncture immediately after but no blood obtained	
p.m.		
12.0	Spleen sample obtained. Vein then tied	72
12.14	Spleen sample from tied off portion	86
12.17	Spleen sample from portion with vein not tied off	67
12.46	Spleen sample from tied off portion	94
12.48	Spleen sample from untied off portion	74
1.0	Saphenous vein sample	67 65

These experiments show that the spleen in a state of venous congestion can concentrate blood. The obvious channels therefore for the removal of fluid are the lymphatics.

Lymphatics from the spleen have been described (3, 4). There are superficial collecting trunks which are well developed in the ox and horse. In these animals they form a rich network which is situated between the

peritoneum and the fibrous capsule of the spleen. They then run towards the hilum of the spleen and terminate in the same way as the deep collecting trunks. The deep collecting trunks are connected to the preceding by numerous anastomoses. They are satellites of the blood vessels. In the hilum they are reduced to from 6–10 trunks which end in the external glands of the spleen chain.

A perfectly well-defined lymphatic system draining the spleen is therefore accepted by anatomists. It appeared to us desirable nevertheless to demonstrate, if possible, the elimination of fluid from the spleen by its lymphatics.

In line with the conception of this method of drainage the following observation was made in some of the experiments on venous ligature. After the spleen had been congested for some time it was possible to see, when pressure was exerted on the base of the splenic mesentery, blood-stained lymph eddying into the clearer fluid of the cisterna chyli. This observation has also been made by Kölliker. In this connection it may be mentioned that in some cats one meets with a small lymphatic gland in apposition to the splenic vessels near the hilum.

The following method also has been resorted to. With the object in view of perfusing the organ with all venous return blocked, the arterial and venous anastamoses with vessels of neighbouring structures were carefully ligated and cut, leaving the main artery and vein alone patent. A canula was inserted into this artery as close to the spleen as practicable, and the vessel was ligated near its exit from the aorta. The vein was tied. An artery and vein running in the splenic mesentery and supplying the upper pole of the spleen were ligated. One p.c. trypan blue solution at 130 cm. H_2O pressure was then run through the arterial canula. The spleen swelled up with this solution since the main vein was tied. In some experiments, after a short interval of time it was possible to see a blue coloured lymph entering into the cisterna chyli and mixing with the clear or white fluid there. This blue fluid emerged from the splenic mesentery. It had passed into the lymphatic system from the spleen, fatty tissue near it or from both. In some experiments however this phenomenon was not observed, a possible explanation being the ligation or rupture of lymphatics during the manipulations necessary for the insertion of the arterial canula and tying of veins. In one experiment of this type a perfectly conclusive result was obtained, for it was possible to trace a vessel filled with blue solution from the splenic hilum to the gland at the base of the mesentery. The general direction of the vessel was that of the main artery and vein, though it was not in close apposition to them.

From this gland several more blue filled trunks were followed to a second and then to the cisterna chyli.

It appears therefore that fluid can be eliminated from the spleen by lymphatics under the conditions of our experiments.

It may be objected that during life the splenic vein is not occluded and in consequence this drainage may not be of much significance. Certain observations nevertheless are in favour of the conception that the splenic veins are partially shut down under normal conditions. Tait and Cashin(2) have called attention to the very great contractility of these vessels when electrically stimulated. We have observed a considerable contraction from mechanical stimulation while clearing the vein as a preliminary to ligation.

That the blood does stagnate in the spleen is evidenced by the following observations. If the spleen of a chloralosed cat be exposed through a small incision it will usually be large and of a dark bluish-black colour, the blood in the veins being dark blue. When the spleen is made to contract by handling, electrical stimulation or sometimes merely by the insertion of a needle into its pulp, the colour immediately changes to a bright arterial red and the blood in the veins is now a bright red colour.

Whether the idea that the venous side of the splenic circulation has the importance here suggested awaits further investigation.

SUMMARY.

(1) Possible factors enabling the spleen to concentrate its contained blood are discussed.

(2) It is shown that ligation of the venous channels causes considerable concentration of the splenic blood.

(3) Evidence is produced that fluid is drained away by lymphatics under such conditions.

(4) A suggestion is made that the very marked contractility of the splenic vein is a factor of importance in connection with the phenomena discussed.

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4. Poirier. Traité d'Anat. Hum. Masson & Cie, vol. LV, p. 856.