Malpighian corpuscles to the termination of abundant arterial capillaries in the intercullular spaces of the splenic pulp in this region. These spaces evidently constitute a connecting link between the arterial and venous channels, significant for spleen function.

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The effect of "complete circulatory block" on the concentration of venous blood.

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It is now well established that the production of venous stasis in a limb causes certain consistent alterations in the venous blood of the part, the most conspicuous of which is a loss of water, with a resulting hemo-concentration. Such a condition may also be produced by nearly completely cutting off the circulation in a limb for a period of 25 to 75 minutes. The latter fact was demonstrated by Dautrebande, Davies and Meakins[1] in 1923. However, since most of the reports on venous stasis were the results of short periods of compression, it was desirable to learn what change in the blood, if any, could be produced by nearly completely cutting off the circulation of a part for a short period. In other words, does nearly complete occlusion of the circulation of a limb for two or more minutes cause the blood of that part to concentrate? The results of our experiments answer that question and the data are given below.

Procedure and Methods. No breakfast was given to any subject. In all experiments the systolic pressure was first determined by means of a sphygmomanometer and the pneumatic cuff was inflated to keep the pressure 15 to 20 mm. above the systolic level. The duration of such stasis varied from 2 to 5 minutes. In two subjects the compression was relieved at the end of two minutes; in one at the end of three; and in two others at the end of

[1] Dautrebande, W., Davies, H. W., and Meakins, J., *Heart*, 1923, x, 133.

five minutes. No subject complained of actual pain. All, however, described a tingling sensation or that of "pins and needles" in the limb about which the cuff of the sphygmomanometer was wrapped. After maintaining the pressure at a level sufficient to produce nearly complete circulatory occlusion for the desired period of time, blood was drawn from a vein at the bend of the elbow. A 20 cc. luer syringe was used into which some sterile mineral oil was placed to prevent the blood from coming into contact with air. At times it was difficult to obtain the 20 cc. of blood desirable for analytical purposes. After the first 10 cc. were withdrawn, the blood flowed more slowly and on two occasions it was necessary to withdraw the needle from the vein and proceed with the material available, as no more could be obtained from that particular vein. The cuff was released immediately before the withdrawal of the neledle. The blood thus obtained was then placed over mercury in a blood sampling tube. About 3 cc. of mercury were left in a 20 or 25 cc. bulb, and this was used to defibrinate the blood, by repeatedly inverting and keeping the sampling tube in motion for about 10 to 15 minutes. For the controls, blood was drawn from the opposite arm, and treated in a similar manner. Both bloods were then studied for their respective oxygen capacity, cell volume, and serum proteins, employing the same technical methods described in a former paper.[2]

The results of our experiments are presented in the accompanying table. Their striking feature is the lack of any detect-

TABLE 1.

Experiment No.	Cell volume	Oxygen capacity	Serum proteins	Remarks.
	vols. per cent	*vols. per cent*	*per cent*	
1	42.5	17.95	6.94	Constriction for 2 minutes
	42.8	17.95	6.93	Control
2	50.0	21.0	7.57	Constriction for 2 minutes
	50.1	21.2	7.56	Control
3	42.0	17.2	7.53	Constriction for 3 minutes
	42.2	17.3	7.52	Control
4	47.0	20.5	7.42	Constriction for 5 minutes
	47.0	20.4	7.42	Control
5	48.0	21.80	7.67	Constriction for 5 minutes
	47.5	21.85	7.70	Control

[2] Peters, J. P., Eisenman, A. J., and Bulger, H. A., *J. Clin. Invest.*, 1925, v, 435.

able change in the constituents studied. No change whatever was observed in bloods taken from parts in which the circulation was cut off as compared with bloods taken from the opposite limb without any stasis.

A satisfactory explanation of this observation is difficult, since longer periods of similar type of occlusion cause demonstrable alterations in the water content of the blood. Venous stasis for short periods also causes like changes, due to a transfer of water from the blood to the tissues. If the underlying process causing the fluid shift is a mechanical one, namely filtration, then the explanation of our results on that basis may prove possible. The establishment of venous stasis causes after a short period, an increase of tension in the obstructed vein, such an increase being due to the constant inflow of blood from the artery. As the duration of the stasis is increased the pressure within the vein rises and probably causes a filtration of water, and a resulting hemo-concentration. When, however, both the artery and vein are obstructed for *short* periods as we have done, then no changes are detectable, because no great alterations of the intravenous tension are possible in so short a period, since little blood can flow from the constricted artery. Should the above explanation be tenable how then can we explain the results of Dautrebande, Davies and Meakins, that is, cutting off the circulation for long periods of time and obtaining a concentration of the venous blood?

In a recent publication Lewis and Grant[3] claim that it is not always possible to completely occlude the circulation with a 12 cm. armlet such as is ordinarily used for blood pressure determinations. No matter how snuggly such a pressure cuff is applied and how greatly inflated, such a procedure will not "always exclude a very slow trickle of blood through bone anastamoses into the lower part of the arm." Since the return of blood is through the veins and since the largest veins of the arm are easily compressible so that venous return is blocked, it is not difficult to appreciate the fact that during a long period of so called "complete occlusion" blood slowly flows into the veins, increases the tension therein with the resulting filtration of water and a concentration of the venous blood. Such a hypothesis may explain why a long period of so called "complete occlusion" will

[3] Lewis, T., and Grant, R., *Heart*, 1925, xii, 1, 73.

produce changes in the venous blood similar to those caused by short periods of venous stasis, while short periods of "complete" block (2 to 5 minutes) show no change in blood concentration.

This explanation assumes that hydrostatic pressure is the only factor that produces exudation of fluid from the blood. This is obviously not the case. As Dr. J. P. Peters[2] pointed out to us, osmotic and acid-base changes must be important factors. The production of tissue acidosis as a result of asphyxia should lead to a transfer of water from the blood to the tissues. It may be that this asphyxia does not become serious enough in short periods to exhibit its effect in the blood. In this connection it must be appreciated that the circulation in these experiments was at a standstill and changes in the tissues could affect the blood of the anti-cubital veins only by a process of diffusion through a considerable distance.

The practical application of our observation should be appreciated. The concentration changes which occur when blood is drawn by the usual method from a compressed vessel have been pointed out. We merely wish to emphasize the desirability of drawing blood either *without* stasis or with "complete occlusion where concentration changes are to be carried out; especially where determinations of such constituents as serum proteins, chlorides, and blood gases are to be determined.

SUMMARY AND CONCLUSIONS.

Studies were carried out on venous bloods obtained from limbs in which the circulation was cut off for periods of 2 to 5 minutes by means of a sphygomomanometer cuff. Such bloods were studied for their cell volume, oxygen capacity, and plasma proteins. Control bloods were obtained from the opposite limb where no compression was made.

No changes in the constituents studied were observed in cases where "complete compression" was used and we are forced to conclude that short periods of so called "complete block" do not produce a shift of water either from or to the tissues.

The practical application of the above is emphasized.