

**THE EFFECTS OF EXERCISE ON THE VASCULAR
CONDITIONS IN THE SPLEEN AND THE COLON.**

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DRURY, FLOREY and FLOREY(1) described a preparation in which a patch of colon was exteriorized, the mucous surface replacing a portion of skin in the side of a dog. The patch is about $2\frac{1}{2}$ cm. in diameter. It appears to maintain its normal character for a long time; one such dog we have kept in good condition for 11 months.

This preparation, as shown by Drury, Florey and Florey, readily shows any alteration in the vascular condition. Barcroft and Stevens (2) described a similar preparation of the spleen in which the more gross changes in volume in that organ may be observed.

There is no difficulty in making these two preparations on the same dog, and then comparing the effects of various procedures on the spleen and the mucous surface of the colon respectively. Our object in the present case was to compare the effects of exercise on the turgidity of the two organs.

The effect of the intestinal operation on the size of the spleen.

Two dogs were used during the present research. The first, "Topsy," had its spleen exteriorized on June 4th and the colon operation performed on August 1st, 1928. In the case of the second dog, "Betsy," the procedure was reversed, the colon operation being performed on August 8th, 1928, and the spleen exteriorized on October 18th. The case of Topsy yielded an opportunity of observing the effects on the size of the spleen of an operation on some other abdominal viscus.

Table I gives the area of the projection of the spleen on a surface of celluloid overlying the organ.

TABLE I.

Days before operation on colon	27	25	16	9	7	During operation								
Area in sq. cm.	36.5	39	43	37.5	40	22								
Days after operation on colon	5	6	7	8	16	24	33	38	44	52	58	66	67	88
Area in sq. cm.	24	21.5	22	21	20	20	23	30	28	29	29	31	27	12 (dead)

In Fig. 1 the approximate alterations in volume are shown. The volume of the spleen shortly before the operation is taken as 100. On

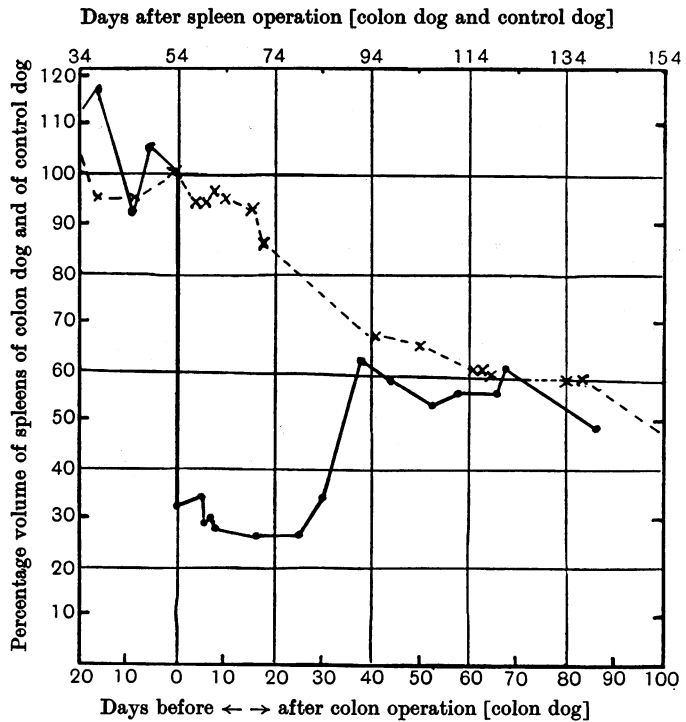


Fig. 1.

the figure are also shown by a broken line the corresponding alterations in volume for a control dog. The "100" volume for it is taken on the same number of days after the exteriorization of the spleen as that for the dog on which the colon experiment was performed. That the spleen should have shrunk temporarily during the operation is normal. The administration of chloroform or ether is known to produce that effect, and this has frequently been verified by one of us. The remarkable thing is that the spleen should have remained shrunken and practically bloodless for a month subsequently. It then distended and settled down to a volume about twice what it had been immediately after exteriorization of the colon patch and about 60 p.c. of what it was before the operation.

It seems premature to discuss the cause of these alterations until more is known about the mechanism. The first step, and one which is being already taken, is to repeat the experiment on denervated spleens,

a procedure which should go some way to show whether the contraction of the spleen is or is not caused by the absorption of some material from the seat of the operation.

Presumably, as the spleen has not been tampered with directly, the contraction must be due either to chemical or nervous impulses of an abnormal character reaching it from without as the result of the operation on the intestine.

It is not only this particular operation under discussion which produced semi-chronic contraction of the spleen. Figs. 2 and 3 show the

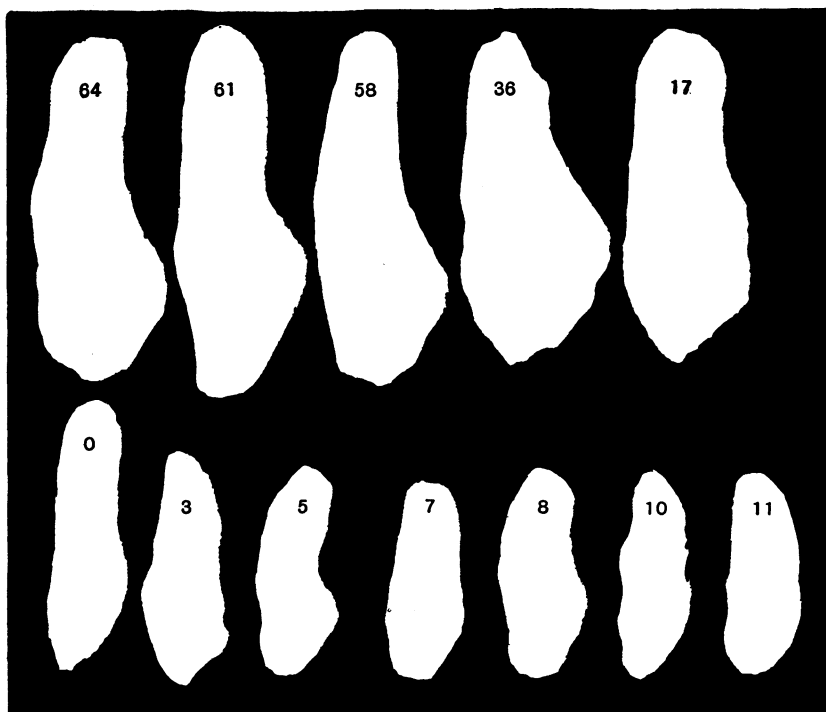


Fig. 2. Variations in the size of the exteriorized spleen due to exteriorization of the portion of jejunum. The figures indicate the number of days before or after the operation on the intestine.

same phenomenon in two animals which had portions of the jejunum exteriorized. Neither of these animals lived till the spleen returned to its relaxed condition. The first remained in excellent health until 25 days after the exteriorization of the portion of small intestine. It then lost

appetite and on the 27th day it developed an intestinal fistula and was killed. The fistula was due to the perforation by a long piece of bone which it had swallowed unknown to us.

Fig. 3 is the record of an animal (1) in which a portion of small

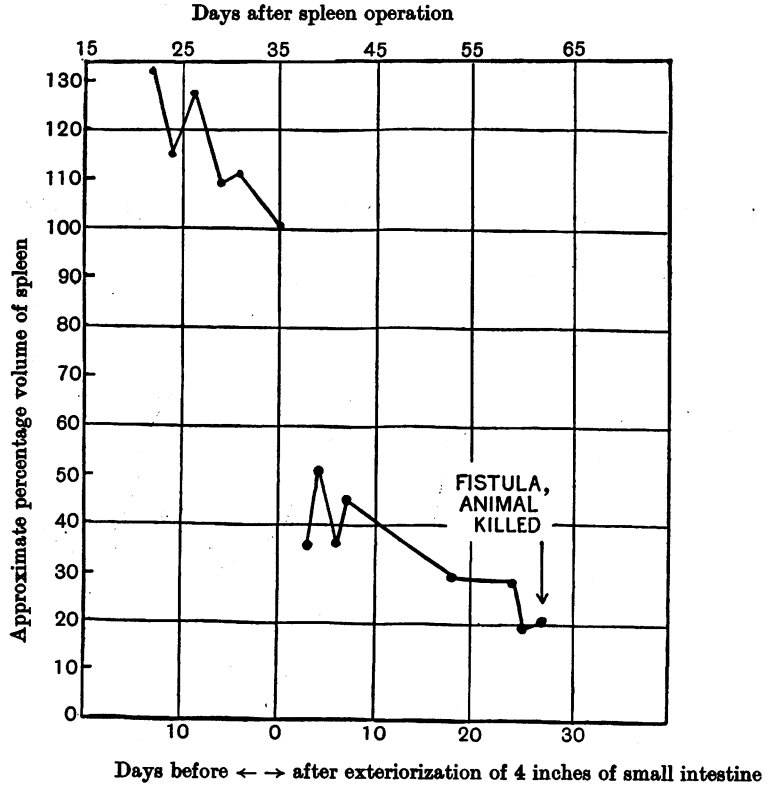


Fig. 3.

intestine was exteriorized on the 35th day after exteriorization of the spleen, and which (2) was killed 27 days subsequently and found *post-mortem* to have developed peritonitis as the result of an abscess.

To return, however, to the effects of exercise on the exteriorized spleen and colon patches of Topsy and Betsy. The size of the spleen was observed by the method already described, the more difficult observation was that of the patch of colon. For this purpose an artist (Mr Gillings) made us a series of colour standards somewhat after the manner of the Talquist Blood Standards. Indeed the Talquist Standards might have sufficed had they been, apart from intensity, the same tint as the spleen.

The standards which we used ranged from just redder than the colon was observed to be, to a pallor little removed from cream colour. This range was divided into ten standards. These of course mean nothing in units, but they proved more satisfactory than hæmoglobin mixtures of various concentrations and other devices which we tried.

In the case of Topsy, the spleen having been exteriorized on June 4th and the colon patch on August 1st, the first observations were made on October 6th and though correct they proved to be quite misleading—the exercise taken was once up and down the laboratory stairs. The spleen as usual shrank but no change could be seen with certainty in the exteriorized gut.

An experiment of much shorter duration however was more illuminating. In it the exercise consisted simply in running in the laboratory passage, which took about 17 seconds. Fig. 4 shows a typical record

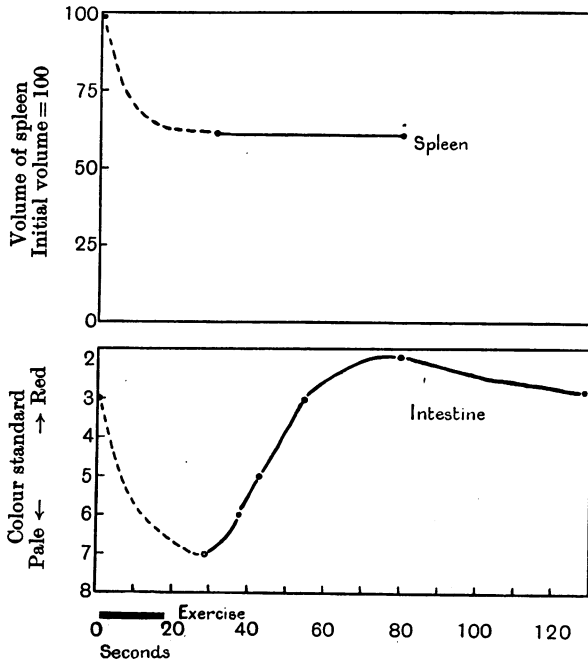


Fig. 4. Topsy. Effect of short "sprint" on the volume of the spleen and the colour of the mucous membrane of the colon.

of such an experiment. The mucous membrane of the colon at first becomes intensely pale (7 on standard) and the spleen contracts, but 60 seconds after the onset of the exercise the intestine has become as

red as, if not more red than, it was when the animal was at rest. The spleen on the other hand remained shrunken. This experiment was repeated a number of times and always with the same result. Taking it together with the result obtained on October 6th and others of the same sort, it became necessary to study the effects of exercise extending over various lengths of time. For this purpose Betsy was used—her colon patch had been exteriorized on August 8th and her spleen on October 18th, 1928; the experiments detailed were made in the spring of 1929.

The first series of experiments to be cited were made on the roof of the Pathological Laboratory; here it was possible to get an open stretch about 33 yards in length. A person whose call the dog was trained to obey was posted at each end of the roof and the animal was made to run to and fro, as soon as it reached one end being called from the other. Roughly speaking it took it 4 seconds to go from one end of the roof to the

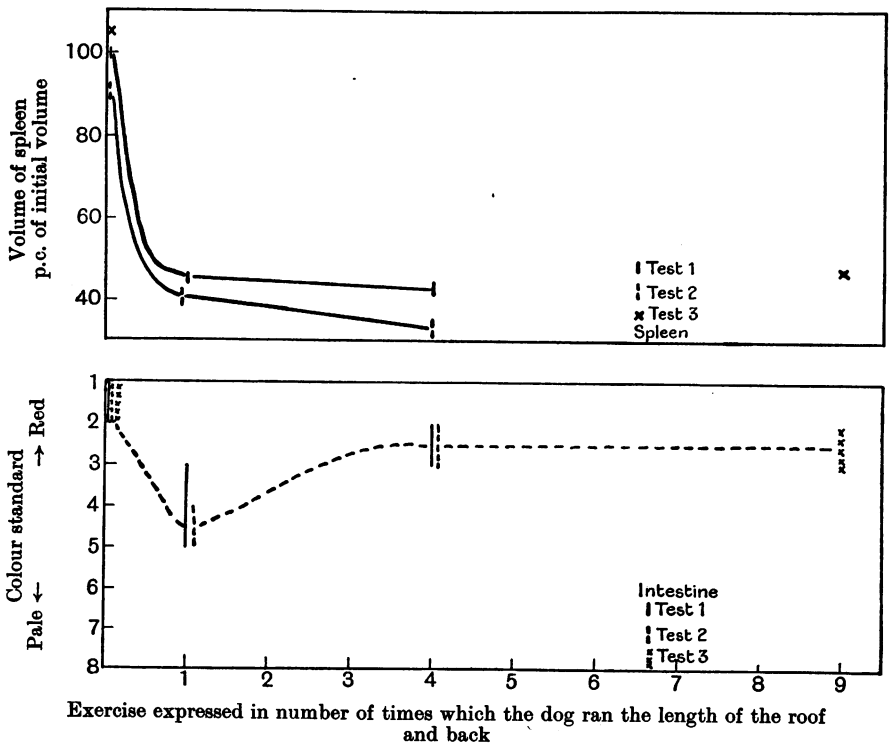


Fig. 5. Effect of more protracted exercise than shown in Fig. 5 on the volume of the spleen and the colour of the mucous membrane of the colon.

other, but the time was not recorded and the duration of the exercise is recorded in Fig. 5 in terms of the number of times which it went from end to end of the roof. This figure shows the result of tests on three separate occasions. On two, the dog was made to run (*a*) once and (*b*) four times the length of the roof, and on the third, nine times that distance. The result was a contraction of the spleen which persisted over the duration of the experiment, and a pallor of the intestine which was striking after the end of the first "lap" but was scarcely perceptible either at the end of the fourth or at the end of the ninth. These experiments bore out the earlier ones on Topsy in showing that over a range of exercise covering not more than a few minutes the principal pallor of the patch of colon mucous membrane is only in the first stages and commences to wear off after the first 20 seconds or so and at the end of a minute is gone. The spleen however maintains its contracted condition as long as the exercise lasts.

In view, however, of the experiments of Pembrey and his co-workers (3), who brought forward evidence to show that on severe exercise there was considerable constriction in the renal vessels, it seemed desirable to carry out our own experiments over much longer periods of time. Betsy was therefore trained to follow a bicycle, after which the following experiments were carried out at the Cambridge Field Laboratories. Here we would like to thank Prof. Buxton for his kindness in allowing us to use them. These experiments must be regarded as preliminary, but they gave some useful results to which reference will be made later, therefore they are mentioned; their weak point was that as the animal became more tired its exercise became more uneven, therefore it was further trained to run beside a bicycle on a lead. In this way it was given an amount of exercise which was sufficient but not excessive, the average speed being about 12 miles an hour, covered in 20 minutes at a more or less even speed, but which was graded somewhat according as the dog did or did not appear fatigued.

So far as the colon is concerned, the patch showed a little, but only a little, vaso-constriction, for it must be remembered that although the colon on each of the above occasions started at standard 1 it was not at all uncommon for it at rest to be 2 or even 2-3.

As regards the spleen it contracted quite unequivocally and remained contracted not merely during the exercise but for at least as long (about 20 minutes) as the dog was subsequently under observation. The long duration of the contraction of the spleen after the exercise is complete, in cases of extended and strenuous exercise, is a new point.

The following are the results of two experiments:

TABLE II.

March 12		Colour of colon, standard	Remarks	Area of spleen sq. cm.	Approximate volume of spleen as a percentage of volume at rest
Period	Time				
1.	3.0 p.m. 11 min.	1 3-4	Exercise commences	13.5	100
2.	18 min.	2-3	Exercise less vigorous than in period 1	—	—
3.	20 min.	3	Exercise same as period 2	—	—
4.	30 min.	4	Exercise less vigorous than periods 2 and 3 but made a sudden spurt when let off lead	10.2	59
5.	50 min.	1	Period 5 resting in car	11.7	75
March 11					
1.	3.0 p.m. 10 min.	1 3-4	Exercise commences	—	—
2.	20 min.	3-4	Exercise ends	—	—
3.	37 min.	1	Period 3 resting in car	Obviously still much shrunk	

It has been noted elsewhere that the vessels of the colonic patch constrict when the dog is frightened or excited in any way. One dog, which was particularly attached to the laboratory attendant, exhibited the paling reaction when the latter left it to go out of the room.

To what extent then is the pallor associated with sudden exercise the result of "anxiety" or excitement?

That excitement plays at least a part is shown by the following experiment. The dog, held in such a position that the patch could be observed, was called from a distance. The patch became pale—about 4 on the standard. If now the dog were allowed to run the patch became still paler—7 on the standard. This however does not prove that part of the pallor was due to excitement and part to the actual exercise, as the dog when held did not display the very great degree of eagerness to run that it did when freed. During a demonstration to the Physiological Society the dog was made to run along a passage 25 yards long. After each of the first few runs the patch exhibited its usual reaction, but towards the end of the demonstration the patch reacted less and less until very little pallor was observed after the 25-yard run. The dog was then apathetic and took less interest in the proceedings than at the

beginning of the demonstration though it ran at much the same rate. It would be reasonable to attribute at least part of this lessening of reaction to loss of interest on the part of the dog. We feel justified in thinking, therefore, that the pallor exhibited after a short burst of exercise is in part the result of "excitement" of the dog.

It has also been found that the colon patches are very sensitive to mechanical stimuli which produce local areas of pallor. It was possible that during the running the patch was stretched or knocked by the hind leg. However, if the patch were stretched by pulling on the surrounding skin no pallor could be produced. To obviate the effect of accidental knocks a ring of cork, of sufficient depth to prevent contact of the patch with other parts of the body, was fixed round the mucosa by means of sticking-plaster. During running it was then impossible for mechanical stimulation to affect the colour of the mucosa but a paling reaction after a short run still developed in its full intensity.

SUMMARY.

1. The vascular reactions simultaneously exhibited by the spleen and the colon in dogs are described.
2. Short bursts of running result in pallor of the colon and contraction of the spleen.
3. During exercise of longer duration the spleen remains contracted while the colon exhibits only slight evidence of vaso-constriction.
4. The spleen remains contracted for a considerable length of time after moderately heavy exercise.

REFERENCES.

1. Drury, Florey and Florey. *This Journ.* 68. p. 173. 1929.
2. Barcroft and Stevens. *This Journ.* 64. p. 1. 1927.
3. Mackeith, Pembrey, Spurrell, Warner and Westlake. *Proc. Roy. Soc. B*, 95. p. 413. 1923.