

THE INFLUENCE UPON THE SPLEEN AND THE
THYROID OF THE COMPLETE REMOVAL OF
THE EXTERNAL FUNCTION OF THE
PANCREAS.

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PLATE 77.

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In the course of studies upon the pancreas in which the external function of the gland was completely removed, either by double ligation of both ducts, cutting and interposing omentum, or by the complete removal of the duodenal portion of the gland, two findings were encountered which seem worthy of a brief communication. The first is that a striking simple atrophy of the spleen rapidly follows such an operation. The second is that the thyroid apparatus of these animals shows a constant change, evidenced macroscopically by a translucency which may amount to an actual transparency, microscopically by an evident increase in the amount of colloid, chemically by a marked increase of the iodine content of the gland, and physiologically by a greatly delayed appearance of tetany, after the complete operative removal of the thyroids and parathyroids.

The details of the operation are shown in Fig. 1. The pancreas of the dog, in our experience, always possesses two ducts, a smaller one draining a definite island of tissue and opening at or near the ampulla of the bile duct, a, and a larger one draining the far greater portion of the pancreas, b. Several authors have described instances in which more than two ducts have been found, so that we have usually tied off the pancreas at A and B, and completely removed the duodenal, duct-bearing portion of the pancreas between the lines A and B.

The results as regards the effects on the spleen and the thyroid

are the same with either method, provided the blocking of the ducts by the interposed omentum has been successful.

Such animals lose weight at first rather rapidly; after several months they reach a level at which they continue or even gain slightly. None of our animals developed sugar in the urine; all showed the voluminous fatty stools typical of loss of pancreatic juice.

Both of the observations here recorded were purely accidental. The operations were undertaken for a definite purpose, and the changes in the spleen and thyroids would doubtless not have attracted our attention had it not been for the extreme changes noted in the first animal of the series. The outline of this animal's spleen (one-half actual size) is shown in Text-fig. 1 (Dog 1). We did not have the measurements of this spleen at the time of the operation upon the pancreas, but if we may judge from the routine measurements of spleens made since, it is fair to assume that this spleen measured at operation at least 18 cm. in length, while at autopsy it measured 6.75 cm.

Following this first observation we repeated the experiment, carefully measuring the spleen at the time of the operation upon the pancreas. The results are seen in Table I and in Text-fig. 1, which shows the simple outline drawings of the spleens of two animals, the outer outline being the spleen at operation, the inner outline the same spleen at autopsy. Under the microscope this atrophy appears as a simple atrophy.

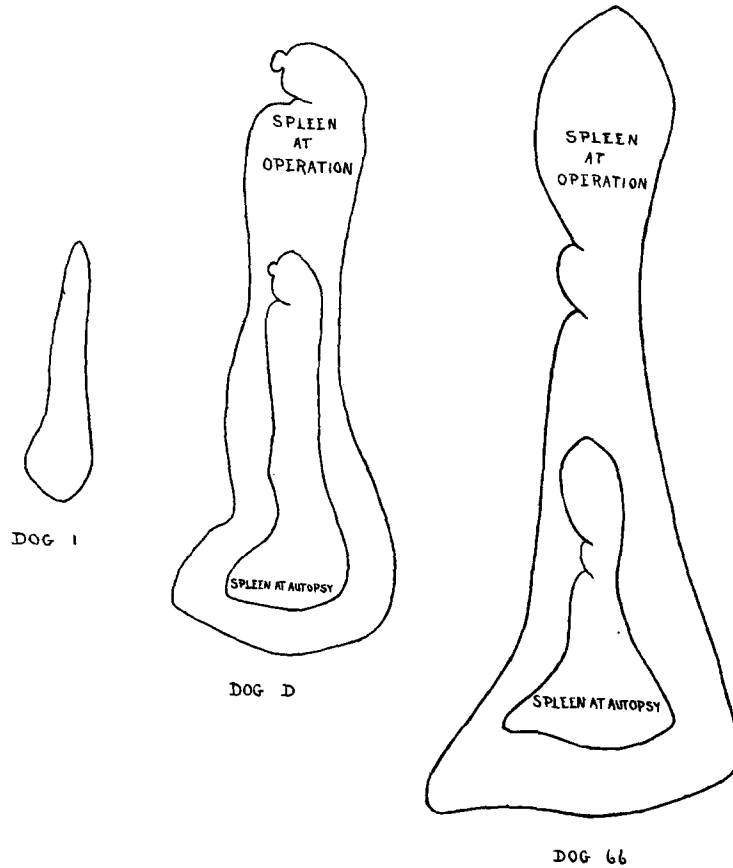
That the splenic atrophy is something more than the expression of the share taken by the spleen in the general loss of body weight is shown, we believe, in the comparative study of some of these animals.

Dog 1 lost 45.6 per cent of its original body weight. While we have not the actual figures, it seems fair to assume that the spleen was at autopsy at least 66 per cent smaller than at the time of the operation. The actual figures for Dog 66 show a loss of weight of 37.9 per cent, with a loss of spleen, as measured by the length of the organ, of 61.9 per cent. Dog 1 reached a constant weight after 150 days, having lost 45.6 per cent of its original weight. Dog 48 was killed at the end of 131 days, having lost 40 per cent of its original weight, but the spleen of Dog 1, the spleen which first

TABLE I.

No. of dog.	Weight at operation.	Weight at autopsy.	Measurements of spleen at operation.	Measurements of spleen at autopsy.	Length of life after operation.	Thyroparathyroidectomy.	Tetany.
I.....	gm. 11,400	gm. 6,200	cm. Length..... 6.75 Width of head. 1.75 " tail. 0.75	cm. Length..... 6.75 Width of head. 1.75 " tail. 0.75	Killed after 10 mos.		
A.....	10,080	.....	Length..... 18 Width of head. 5 " tail. 5	Length..... 12 Width of head. 3.5 " tail. 2.25	" " 21 days		
B.....	8,190	.....	Length..... 16 Width of head. 6 " tail. 4	Length..... 10 Width of head. 3.5 " tail. 2.25	" " 12 "		
D.....	10,220	.....	Length..... 16 Width of head. 5.5 " tail. 2.75	Length..... 9.3 Width of head. 3 " tail. 1.5	Died after 3 days of acute pancreatitis		
48.....	9,680	5,805	Length..... 18.5 Width of head. 6 " tail. 4.5	Length..... 9 Width of head. 3 " tail. 2	Killed after 131 days		
24.....	26,122	12,300	Length..... 24 Width of head. 13 " tail. 7	Length..... 12.25 Width of head. 6 " tail. 3	" " 76 "		
49.....	7,410	4,850	Length..... 19 Width of head. 8 " tail. 3.5	Length..... 11.5 Width of head. 4.5 " tail. 2.5	" " 62 "		
66.....	12,580	7,800	Length..... 21 Width of head. 8.5 " tail. 3.5	Length..... 8 Width of head. 4.5 " tail. 1.15	" " 123 "	96 days after pancreatectomy	19 days after removal of thyroids and parathyroids. Recovered.
C.....	9,220	6,600	Length..... 18 Width of head. 5 " tail. 4	Length..... 11.5 Width of head. 3 " tail. 2	Died " 49 "	35 days after pancreatectomy	None.
E 25..	13,000	11,630	Length..... 20 Width of head. 7.25 " tail. 3	Length..... 13.5 Width of head. 3.2 " tail. 2	Killed " 19 "	7 days after pancreatectomy	Slight tetany. Recovered.

attracted our attention, was only about one-half the size of the spleen of Dog 48, and showed clearly from its slate-colored, shrunken appearance a greater degree of atrophy than did the spleen of Dog 48. This we are inclined to interpret as meaning that the observed atro-



TEXT-FIG. 1. Outline drawings of the spleen before and after the complete removal of the external function of the pancreas.

phy of the spleen had continued in Dog 1 after the body weight had become stationary. That this atrophy is due to something other than the general loss of weight we think is further shown in the dog designated D, which died of an acute pancreatitis three days after operation. The atrophy of the spleen is here clearly marked (Text-

fig. 1), although the subcutaneous and intra-abdominal fat had not appreciably decreased in amount in the short space of three days. The actual weight of the dog at autopsy was not determined.

The observations regarding the thyroid apparatus can be supported in such a variety of ways that their accuracy is hardly to be doubted. The macroscopical appearance of the gland at autopsy is marked by a peculiar translucency which often amounts to an actual transparency. If such a lobe is held towards the light both parathyroids can be plainly seen; in the dog the lower parathyroid body is imbedded completely within the thyroid tissue, and can usually be found only by cutting serial sections; the outline of an opaque object held between the thyroid and the light can be clearly seen through the translucent lobe.

Microscopically the thyroid is seen to contain somewhat more than the normal amount of colloid, with a consequent flattening of the alveolar cells. The parathyroids, as far as we have discovered, are normal; in some instances they have given us the impression of hypertrophy.

In view of the well known variations in the macroscopic and microscopic appearance of the thyroid, one is inclined to speak with reserve concerning conditions based upon such variations. We are therefore fortunate in the case of the thyroid apparatus in having two definite proofs of change, the physiological test and the chemical determination of the specific content of the thyroid.

The physiological results are shown in the three dogs, 66, C, and E 25. Dog 66 developed mild tetanic attacks 19 days after the complete thyroparathyroidectomy. Dog C developed no tetany during the 14 days after the thyroid operation. Dog E 25 developed tetany 7 days after thyroparathyroidectomy.

We have already stated that the parathyroids appear entirely normal, unless, indeed, they are somewhat enlarged. We offer these findings concerning tetany without attempting an explanation. It has been our experience, in several fairly large series of parathyroid tetany experiments, that a normal dog will develop a severe and fatal tetany on the third or fourth day following the complete extirpation of the thyroid apparatus; in a very few instances, not over 5 per cent of our cases, the animal has failed to show any symptoms whatever of tetany.

The iodine determinations in eighteen normal thyroids and in seven thyroids from operated animals are shown in Table II, in which the result is expressed in milligrams of iodine per gram of dry thyroid tissue.

TABLE II.

Source of thyroid.	Weight of dry gland. mg.	Iodine per gm. of dry gland. mg.
Normal dog	0.2460	0.723
" "	0.1530	0.953
" "	0.4530	1.036
" "	0.5710	1.205
" "	1.0000	1.402
" "	0.3550	1.068
" "	0.1620	0.960
" "	0.7128	2.676
" "	0.4248	1.220
" "	0.1621	1.200
" "	0.42	0.400
" "	0.4	1.050
" "	0.3	0.495
" "	0.7	0.228
" "	0.25	0.800
" "	0.30	0.993
" "	0.2	0.500
" "	0.13	Negative.
Pancreatectomy		
Dog 124	0.5	3.151
" 228	0.25	6.960
" 279	0.4456	1.434
" 257	0.1430	9.925
" 67 P	0.6934	1.134
" 267	0.3502	1.316
" 19 P	0.3448	1.827
Average of 18 normal determinations = 0.9393 mg.		
Average of 7 pancreatectomies = 3.678 mg.		

We take pleasure in expressing our thanks to Mr. Robert B. Krauss of the Laboratory of the Henry Phipps Institute, for the iodine determinations which were made by the method elaborated by him.¹

We have found nothing in the literature concerning the thyroid, the pancreas, or the spleen which aids in the explanation of the

¹ Krauss, R. B., The Determination of Iodine in the Presence of Organic Matter, *Jour. Biol. Chem.*, 1915, xxii, 151.

above findings. Any discussion of their meaning at present would therefore be mere speculation, and should, at best, await the confirmation of our results.

SUMMARY.

The complete removal of the function of the pancreas concerned in digestion is followed by marked changes in the spleen and in the thyroid apparatus. Second, the spleen shows an extreme simple atrophy. Third, the thyroid apparatus exhibits a constant change shown by the macroscopic transparency of the gland, by the microscopic increase in the amount of colloid, by the chemical increase of the iodine content of the gland, and by the functional test of the delayed appearance of tetany after the complete removal of the thyroid apparatus.

EXPLANATION OF PLATE 77.

FIG. 1. Diagrammatic outline of the pancreas of the dog (posterior aspect) showing the points at which the operation is carried out. P = pylorus; d = bile duct. For further description, see page 732.

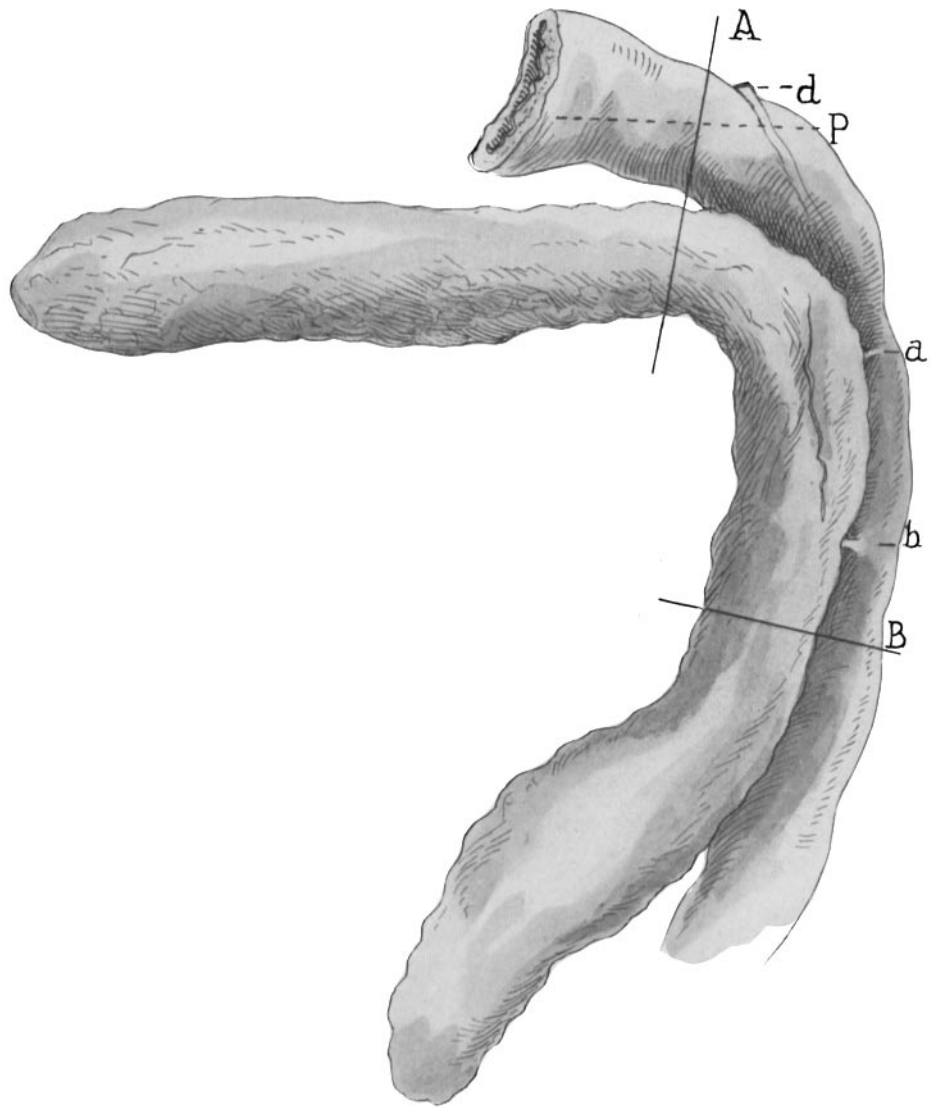


FIG. 1.

(Sweet and Ellis: External Function of Pancreas.)