The University of Chicago

THE INFLUENCE OF PARATHYROID TETANY ON THE LIVER AND THE PANCREAS

A DISSERTATION

SUBMITTED TO THE FACULTY OF THE OGDEN GRADUATE SCHOOL
OF SCIENCE IN CANDIDACY FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY
(DEPARTMENT OF PHYSIOLOGY)

BY

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CHICAGO
1913

Reprinted from the American Journal of Physiology
Vol. XXXIII — January 1, 1914 — No. I

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RESULTS recently obtained by various observers indicate a diminished activity of the liver during parathyroid tetany. Hirsch[1] found a decreased sugar tolerance in dogs when dextrose was given by the mouth. Underhill and Saiki[2] report that when dextrose was injected subcutaneously, a much larger amount of sugar appeared in the urine after parathyroidectomy than before. The investigations of Eppinger, Falta, and Rudinger[3] seem to show a weakened assimilation power for glucose injected subcutaneously, when three parathyroids were removed. Such a loss in sugar tolerance on the part of dogs in parathyroid tetany must be due to one or both of two factors, viz., a diminished activity of the liver for forming glycogen or a depression in oxidation. An experiment by Underhill and Saiki[2] appears to show that it is not due to a deficiency of the liver function. They found the amount of glycogen present in the liver, following two subcutaneous injections of dextrose, to be about the same in a parathyroidectomized dog as in a normal dog.

The experimental results on nitrogenous metabolism, although somewhat conflicting, point also to an impairment in the functions of the liver. Especially convincing are the results obtained relative to the excretion of urea. Ver Ecke[4] was the first to note the reduction in the quantity of urea excreted after complete thyroidectomy. This point was further investigated by Greenwald,[5] Cooke,[6] and Juschtschenko[7] in parathyroidectomized dogs. Their results all verify that of Ver Ecke in that the amount of urea in the urine diminished during tetany. Granted that the liver is the principal seat of the production of urea, these investigations must be interpreted as at least indicating a possibility of weakened activity on the part of this organ. Coronedi and Luzzatto[8] on

the contrary failed to obtain a decrease of urea and concluded that the parathyroid insufficiency has no effect on the liver activity.

In regard to the excretion of ammonia the results are even more contradictory than in the case of urea. This is particularly true in regard to the concentration of ammonia in the blood during tetany. An increase in relative and absolute ammonia has been reported by Coronedi and Luzzatto,[8] MacCallum and Voegtlin,[9] Berkeley and Beebe,[10] Cooke,[6] and Underhill and Saiki.[2] Greenwald[6] states that the proportion of ammonia nitrogen to total nitrogen is about the same after parathyroidectomy as before. Juschtschenko[7] reports that, following parathyroidectomy, there was first a decrease in the urinary ammonia, which was followed by an increase in the later stages of tetany.

The concentration of ammonia in the blood of parathyroidectomized animals as compared with that of normal blood is certainly an open question. MacCallum and Voegtlin[9] reported that the concentration of ammonia increased in the blood of dogs during parathyroid tetany. A similar increase was observed by Carlson and Jacobson[11] in cats and foxes, as well as a depression in the ammonia destroying power of the liver. Miss Jacobson[12] even found that the concentration of ammonia in the blood of dogs and cats in parathyroid tetany was as high as when sufficient ammonia was injected into the circulation to produce ammonia tetany, and concluded that the parathyroid tetany might be due directly to the excess of ammonia in the blood. More recently, however, Carlson and Jacobson,[13] using Nessler's method for the determination of ammonia instead of the titration method, discovered no gain in the ammonia content of the blood. The results obtained by Greenwald[5] verify these later results of Carlson and Jacobson.[13] The fact that Greenwald[5] fed his dogs a fixed diet makes his results all the more convincing on this point. The results of Medwedew[14] on the ammonia content of the blood of normal, starved, and parathyroidectomized dogs seem to show that there is more ammonia in the blood of parathyroid tetany dogs. This observer noted that the amount of ammonia set free from the blood for a period of twenty-four hours after the drawing was much higher for parathyroid tetany dogs than for normal animals

and lowest for starved dogs. He found that the blood drawn from an animal under aseptic conditions and allowed to stand at body temperature will show an increase or decrease of ammonia content during the course of twenty-four to thirty hours standing, depending on whether the "desamidase" or antiferment predominates. The ferment "desamidase" causes a setting free of ammonia and the antiferment a synthesis or binding of ammonia. The "desamidase" is higher during parathyroid tetany than during the normal condition. Following starvation the antiferment predominates. These results obtained by Medwedew show that it is important that the ammonia content of the blood be determined immediately after drawing. The conflicting results obtained relative to ammonia content of the blood of parathyroidectomized animals may be explained by Medwedew's observations.

Greenwald [5] obtained an increase in nitrogenous compounds of unknown nature in the urine of parathyroidectomized dogs. This author suggests that this indicates a depression of the liver. The increase in the amino acid nitrogen in the urine after parathyroidectomy would also indicate such a depression. Juschtschenko [7] found that the amino acids increased in the urine after parathyroidectomy. He used Sörenson's method for determining the amino acids and made observations on only two dogs. Cooke used Van Slyke's method for determining the amino acids and found no increase during parathyroid tetany.

The pathological changes of the liver in parathyroid tetany also point towards a depression of this organ. It must be remembered in this connection, however, that there can be a considerable degeneration of the liver without a marked depression in its physiological activity. Delitala [15] noticed various lesions of the liver following parathyroid tetany, but concluded that there was no constancy between the lesions observed and the thyro-parathyropriva syndrome. Morel and Rathery [16] made microscopic examinations of the livers of dogs before and after parathyroidectomy and found that hemorrhages occurred, but these were inconstant and not intense. The fatty changes were likewise not a constant feature and depended upon the diet. These investigators found, however, that the homogeneous condition of the

hepatic cells and islets was a constant characteristic. This feature was often coexistent with hemorrhages and an alteration in the number and form of the granules, fragmentation of the protoplasm, and the presence of large, greenish masses stuffing the cells. Koch [17] ascertained pathological changes in the liver cells as well as marked changes in the vessels of the liver.

The presence of lactic acid in the urine of parathyroidectomized dogs as observed by Cooke [6] led to the conclusion that there might be an impairment in the hepatic function of breaking up the lactic acid formed by the muscles.

Morel,[18] besides finding a decrease in the amount of urea and an increase in total and ammonia nitrogen, also reported the presence of diacetic and lactic acids in the urine of parathyroidectomized dogs. He showed that there is a decrease in the antitoxic functions of the liver during experimental suppression of the parathyroids.

In view of the fact that there is considerable evidence for liver depression, and taking into account that the results are contradictory, the work reported in this paper was undertaken in the hope of throwing more light on some of the phases bearing on liver activity in parathyroid tetany. Professor A. J. Carlson suggested the work and outlined the general plan of attack. The points investigated were sugar tolerance, concentration of fibrinogen in the blood, excretion of amino acids in the urine, and the secretion and some properties of the bile. The work on the secretion of pancreatic juice was an outcome of the results obtained on the excretion of amino acids in the urine.

I. The Effect of Parathyroid Tetany on the Physiological Activity of the Liver

1. Sugar Tolerance in Normal and Thyro-parathyroidectomized Dogs. — In previous work on sugar tolerance the experiments have been conducted by feeding sugar by mouth or by subcutaneous injections of dextrose. Feeding sugar to dogs in tetany by mouth is undesirable on account of the vomiting and the depression of the digestive tract. Subcutaneous injections of sugar are at best a severe treatment. The best method for investigat-

ing this question seems to be by intravenous injections of sugar. In these experiments we injected into the saphenous vein of the dog sufficient twenty per cent solution of dextrose in physiological salt solution to make one or one and one half grams per kilo of body weight. Professor Carlson had previously found that normal dogs tolerate about one gram of glucose per kilo of body weight injected intravenously. In several of the beginning experiments only one gram of dextrose per kilo of body weight was injected, but in some of these cases no sugar or only traces appeared in the urine. One and one-half grams per kilo of body weight were therefore used in the injections in the rest of the experiments in order to make sure that there would be enough sugar in the urine to make successful determinations. Fehling's method was employed and the end point was determined by means of acidified potassium ferrocyanide or acidified starch iodide solution. The dogs were kept in metabolism cages and the diet was maintained nearly constant throughout the experiments. Dogs 16 and 17 were fed a standard diet. One or more injections of dextrose were made two or three days before parathyroidectomy and the amount of sugar in the urine voided during the following twenty-four hours was determined. Sugar was again injected while the dogs were in tetany. In some cases, when the tetany symptoms were mild, as many as five observations were made. In all cases the injections were at least twenty-four hours apart. The results of this series are given in Table I.

In order to be certain that the anorexia so frequent in dogs during parathyroid tetany was not a factor in the results obtained, sugar tolerance tests were made on four dogs before and after starvation periods of four to eight days. The following results were obtained:

Dog 8, sugar tolerance, normal	0.90	gm.,	after starvation	1.12	gm.				
Dog 9	"	"	"	1.42	"	"	"	1.40	"
Dog 10	"	"	"	1.42	"	"	"	1.34	"
Dog 11	"	"	"	1.43	"	"	"	1.34	"

The sugar tolerance is practically the same during starvation as during normal feeding except in dog 8, where it is somewhat increased after starvation.

TABLE I

THE EFFECT OF PARATHYROID TETANY ON THE SUGAR TOLERANCE

Nos. 1 to 6 received one gram of dextrose per kilo of body weight; the others one and one-half grams per kilo of body weight, intravenously. The figures represent averages of the number of tests indicated by the figures inclosed in parentheses.

Normal dogs				Parathyroidectomized dogs			
No.	Dextrose injected gm.	Dextrose in urine, total gm.	Sugar tolerance, gm. per kilo of body wgt.	Dextrose injected gm.	Dextrose in urine, total gm.	Sugar tolerance, gm. per kilo of body wgt.	Remarks
1	9.4 (1)	0.652	0.93	9.4 (1)	1.25	0.867	
2	10.4 (1)	0.761	0.927	9.18 (2)	0.199	0.919	Died 5 hr. after last injection.
3	7.6 (1)	1.117	0.853	6.76 (5)	1.32	0.801	
4	7.48 (1)	0.000	1.000	6.23 (2)	0.00	1.000	
5	6.85 (1)	0.712	0.896	6.24 (1)	trace	1.000	
6	7.68 (1)	0.614	0.92	7.13 (2)	0.61	0.91	
7	7.35 (1)	0.25	1.114	7.7 (1)	1.08	1.28	
9	14.76 (1)	0.765	1.421	11.85 (1)	2.23	1.217	Died 9 hr. after injection.
11	12.09 (1)	0.54	1.433	9.75 (1)	0.54	1.416	Died 2 hr. after injection.
12	8.16 (1)	1.09	1.299	8.01 (2)	0.97	1.316	Died 9 hr. after last injection.
13	10.23 (1)	1.09	1.341	9.84 (1)	1.61	1.254	
14	10.74 (1)	2.01	1.219	10.16 (5)	1.62	1.255	
15	11.28 (1)	1.01	1.365	11.19 (2)	1.72	1.269	
16	14 (2)	3.71	1.108	14 (1)	2.18	1.273	
17	15 (3)	2.88	1.212	15 (3)	3.18	1.181	

A study of Table I shows that in seven dogs there was a slight increase in sugar tolerance during parathyroid tetany, while in six dogs there was a slight decrease. These results show conclusively that parathyroid tetany has no effect on the tolerance of sugar injected intravenously. It might be expected that during the increased activity of the muscles in parathyroid tetany there

would be an increased oxidation of sugar. The results obtained by other observers following subcutaneous injections, however, seem to show that there is a decrease in the oxidation of sugar. The sugar injected intravenously is rapidly taken up from the blood, because the urine passed within a few hours following an injection contains all the sugar which is excreted. It is, therefore, reasonable to suppose that most of this sugar is taken up by the liver to form glycogen. If there is a decrease in the oxidation of sugar and the tolerance is not changed, there must be an increase in the glycogenic function of the liver proportional to the decrease in oxidation. These results, then, on sugar tolerance furnish evidence that there is no deficiency in the glycogenic function of the liver during parathyroid tetany. The results recorded above show that the loss of appetite is not a factor in the results obtained.

2. The Formation of Fibrin in the Blood of Normal and Parathyroid Tetany Dogs. — The researches of Nolf,[19] and Doyon, Morel, and Kareff [20] furnish conclusive evidence that the liver is the seat of the formation of fibrinogen. It was more recently found by Meek [21] that there is no regeneration of fibrinogen in the blood of dogs following the extirpation of the liver by Eck's fistula, and ligation of the portal vein and hepatic artery. Since the liver is the principal seat of the formation of fibrinogen, the fibrin formation in the blood drawn from a parathyroidectomized dog as compared with that drawn from the same dogs in the normal condition ought to throw some light on this function of the liver. Such experiments were conducted on six dogs. Fibrinogen determinations as fibrin were made on blood drawn from the saphenous vein before parathyroidectomy and during parathyroid tetany. The blood was collected in a dry, weighed beaker, defibrinated by beating, weighed, water containing some of the washings from a previous coagulation added, and the blood again beaten. The fibrin was collected on a filter of known weight, washed with normal salt solution until free from color, extracted with boiling alcohol, then with ether, dried at 115° C., cooled and weighed. The specific gravity determinations were made by Hammerschlag's method. The blood obtained after parathyroidectomy was always drawn while the animals were in tetany. The results obtained in these experiments were as follows:

		Fibrin percentage	*Sp. gr. of blood*
Dog 24	Normal	(2) 0.66	..
	Tetany	(1) 0.84	..
Dog 25	Normal	(3) 0.34	..
	Tetany	(2) 0.50	..
Dog 26	Normal	(3) 0.34	..
	Tetany	(7) 0.56	1.043
Dog 27	Normal	(3) 0.33	1.051
	Tetany	(4) 0.41	1.049
Dog 28	Normal	(2) 0.52	1.046
	Tetany	(1) 0.45	1.045
Dog 29	Normal	(2) 0.51	1.052
	Tetany	(2) 0.76	1.053

In the data just recorded the figures are averages of a number of determinations indicated by the figures in parentheses. The above figures show an increase in the percentage of fibrin in the blood during parathyroid tetany in all except one of the experiments, dog 28. The specific gravity of the blood remained unchanged during tetany. The results obtained, therefore, verify those of Albertoni [22] in regard to the formation of fibrin. This observer, however, found an increase in the specific gravity of the blood during tetany and attributed the increase in fibrin to that cause. My results on fibrin formation furnish conclusive evidence that there is no depression in the fibrinogen forming activity of the liver. They indicate, if anything, an increase in the formation of fibrinogen by the liver or a decrease in the rate of the destruction of fibrinogen in the blood.

3. The Excretion of Amino Acids during Parathyroid Tetany as compared with Normal and Starved dogs. — Glaessner [23] reported a marked rise in the output of amino acids in the urine during various pathological conditions of the liver. An increased discharge of amino acids in the urine would, therefore, indicate a deficiency in the function of the liver. In this part of the work the total amount of amino acids and ammonia excreted per day

in the urine was determined for definite periods before and after parathyroidectomy. The amount of amino acids was determined by the formal titration method as described by Frey and Gigon.[24] In this method ammonia is removed from the urine before the titration for amino acids. Two series of experiments were carried out. In the first series, the results of which are reported in Table II, the dogs were fed the same amount of food, consisting of meat and bread, each day.

TABLE II

THE EXCRETION OF AMINO ACIDS IN THE URINE OF DOGS BEFORE AND AFTER PARATHYROIDECTOMY. THE FIGURES ARE AVERAGES PER DAY FOR NUMBER OF DAYS STATED.

		Normal				After parathyroidectomy				
No.	Wgt. kilos	No. of days	Average urine per day c.c.	NH_2N total mg.	NH_3N total mg.	No. of days	Average urine per day c.c.	NH_2N total mg.	NH_3N total mg.	Remarks
35	5.18	13	79	59.6	....	18	45	24.5	....	Cachectic, no severe tetany.
36	7.14	6	112	64.5	....	10	53	15.39	....	Cachectic, no severe tetany.
37	7.42	4	134	66.	222.2	3	134	45.	226.4	Tetany third day.
38	7.26	6	124	72.6	214.5	6	132	61.6	219.4	Tetany every day.
39	8.08	3	149	80.6	272.7	8	76	42.9	196.1	Tetany every day.

The dogs would usually eat their normal diet until the second or third attack of tetany set in. It was found that it was useless to attempt to feed dogs by stomach tube on account of the vomiting, which always follows. In this series of experiments the total amount of amino acids excreted per day during the period following parathyroid tetany is less than that excreted during the normal period. The decrease in the amino acids in the series can probably be accounted for by the loss of appetite.

A second series of experiments was conducted, in which a standard diet was fed to the dogs. This diet consisted of beef

TABLE III

THE AMINO ACID CONTENT OF THE URINE OF DOGS, COMPARING NORMAL DOGS ON A STANDARD DIET AND PARATHYROID TETANY DOGS ON A SIMILAR DIET, STARVATION PERIODS OF NORMAL AND PARATHYROIDECTOMY DOGS, AND NORMAL AND PARATHYROID TETANY DOGS ON STANDARD MIXED DIET AND NON-PROTEIN DIET

	Normal					Starved				After parathyroidectomy			
No.	Wgt. kilos	Days	Urine c.c.	NH_2 N total mg.	NH_3 N total mg.	Days	Urine c.c.	NH_2 N total mg.	NH_3 N total mg.	Days	Urine c.c.	NH_2 N total mg.	NH_3 N total mg.
40	6.6	5	385	83.	162.	5	131	41.3	137.	7	305	50.7	154.
41	7.36	5	334	51.98	132.	7	57	38.08	85.	—	—	—	— —
42	7.14	5	512	91.5	268.	5	99	67.2	226.	—	—	—	—
43	7.18	10	187	52.34	142.4	5	56	35.49	74.5	5	49	30.56	73.2
44	10.74	10	316	95.3	247.	5	78	59.4	139.2	5	149	63.6	106.9
						Non-protein diet				Non-protein diet			
45	8.4	10	250	57.28	173.8	5	253	43.31	151.4	3	228	32.14	122.
46	10.8	10	441	87.	366.	5	401	51.	299.8	5	131	54.6	257.
47	6.7	10	292	57.53	169.	5	313	39.41	196.	5	215	31.61	83.

No. 40, fed during the tetany period. Nos. 41 and 42, no data during tetany. Nos. 43 and 44, starved during tetany period.
No. 45, in tetany the third day. No. 46, anorexia after the second day.

heart, lard, sugar, and starch, sufficient for the calorific requirements and to maintain the nitrogenous equilibrium. A little bone ash was added to prevent diarrhoea. These results are reported in Table III. Dog No. 40 lived seven days after the thyro-parathyroidectomy, showed tetany the second day, and ate the complete diet every day. There was no increase in amino acids or ammonia during this period. No data could be obtained on dogs Nos. 41 and 42 as they died in the first attack of tetany, which came in less than twenty-four hours following the operation. In dogs Nos. 43 and 44 a feeding period of five days was run, followed by a starvation period of five days, then another feeding period of five days followed by a starvation period, at the beginning of which the parathyroidectomy was performed. In No. 43 the amino acid content of the urine is a little lower during the tetany starvation period than during the normal starvation period, while in No. 44 it is a little higher during the tetany period. In Nos. 45, 46, and 47 the dogs were fed a mixed standard diet for five days, a non-protein diet for five days, then a mixed diet again for five days, followed by parathyroidectomy. They were fed the non-protein diet after the removal of the parathyroids. There is again no marked rise or fall in amino acids in the urine during the parathyroid tetany period as compared with the non-protein diet period. The results above recorded show that the total amino acids excreted in a day in parathyroidectomized dogs is no higher than that in normal dogs. These results, therefore, substantiate those obtained by Cooke[6] on this point. Again there is no evidence for depression of the liver in parathyroid tetany.

It was not the purpose in these experiments to investigate the ammonia excreted in the urine of parathyroid tetany dogs in this series, but since the ammonia had to be removed from the urine by Folin's method before the amino acids were determined, it was collected in standard acid and determined either by titration or Nesslerization or both. An examination of the tables will reveal the fact that there was no appreciable increase in the ammonia in the urine during parathyroid tetany. There was, in fact, a decrease in most cases. This furnishes additional evidence against liver depression during parathyroid tetany.

4. The Effect of Parathyroid Tetany on the Secretion of Bile and the Formation of Bile Acids by the Liver Cells. — Biliary fistulas were made by the method described by Pawlow. The flap of the intestine containing the papilla of the bile duct was transplanted into the abdominal wall. As soon as the wound was properly healed the bile was collected by means of a funnel made

TABLE IV

THE EFFECT OF PARATHYROID TETANY ON THE SECRETION OF BILE AND THE FORMATION OF BILE ACIDS BY THE LIVER. THE FIGURES ARE AVERAGES FOR NUMBER OF DAYS INDICATED BY FIGURES IN PARENTHESES.

Normal				Tetany		
No.	Hr. of bile collection	Bile c.c.	Bile acids total per hr. gm.	Hr. of bile collection	Bile c.c.	Bile acids total per hr. gm.
48	6.5	21 (4)	0.07	6.5	22 (5)	0.009
49 [1]	7	40 (3)	0.29	7	21 (6)	0.15
50	2	13 (5)	0.19	2	4.7 (4)	0.14
51	2	9 (2)	0.18	2	3.3 (6)	0.035
52	2	11 (3)	0.15	2	6 (4)	0.11
53	3	16 (4)	0.11	3	3 (1)	0.014
54	3	9 (4)	0.038	3	1.5 (8)	0.009
55	5	10 (8)	0.031	5	2 (1)	0.010

[1] Dog did not develop tetany.

to fit the abdomen. The bile was collected in each dog for a definite period (two to seven hours) after feeding. The diet was kept nearly constant and was always mixed with about 10 c.c. of bile from the previous day. In all but the last experiment the diet consisted of bread and milk nearly free from cream. In the last experiment the dog was fed on a meat diet exclusively. In a few cases the dogs in parathyroid tetany could not be induced to eat. The bile acids were determined by the colorimetric method using Pettenkofer's test. It was observed that the coloration in

this test varies directly with the concentration of bile acids present. The bile was decolorized by animal charcoal, and the bile acids extracted, after drying over a water bath, with hot alcohol.

Pettenkofer's test was applied to this mixture and the tube compared with tubes of a known amount of bile salts. This method may not be accurate for quantitative determination of bile acids, but seems sufficiently accurate for comparative study such as was made in this case. There seems to be no better method for determining bile acids except to make complete analysis of the bile, which, of course, could not be done in these experiments. The results of this series of experiments are given in Table IV. There is a decrease in the secretion of bile after the removal of the parathyroids in all but one experiment. There is also marked fall in the total bile acids. The percentage of bile acids was about the same before and after parathyroidectomy except in the dog which showed no decrease in secretion of bile. In this case the concentration of bile acids diminished very markedly. There seems to be no doubt, therefore, that the secretion of bile and the formation of bile acids by the liver cells are distinctly diminished during parathyroid tetany. Whether the apparent depression in this function of the liver is due specifically to the absence of the parathyroid secretion or indirectly to the condition of the digestive tract is another question. The fact that there was no depression in the other functions of the liver would be a point against a specific relation of the parathyroid secretion to the activity of the liver.

II. The Effect of Parathyroid Tetany on the Secretion and the Composition of the Pancreatic Juice

The evident decrease in amino acids in the urine of parathyroid tetany dogs in the above mentioned experiments suggested that there might be a depression in the action of the digestive juices. The anorexia, vomiting, and gastero-enteritis so frequent during parathyroid tetany in dogs also suggested that, in addition to the increased irritability of the stomach, there might be a depression in the digestive activity. In fact, Carlson found that food remains a longer time than normal in the stomach and

the intestines during parathyroid tetany. The results he obtained gave very strong evidence of a depression of the gastric and intestinal digestion.

Pancreatic fistulas were made according to Pawlow's method. A piece of the intestine containing the papilla of the ductus Santorini was transplanted into the abdominal wall and, as soon as the wound was healed (six to twelve days), the juice was collected by means of a wick extending from the papilla into a funnel fitted on the abdomen. The enterokinase secreted by the piece of intestine surrounding the papilla may be sufficient to activate the trypsin, but some enterokinase was prepared and added to make certain that the trypsinogen was all changed to trypsin. The dogs were fed an equal quantity of milk each day and the juice was collected for three hours after feeding. In a few cases juice was collected for an hour before feeding to determine the rate of flow without feeding. It was found that when the periods for collecting were made longer the abdomen became so corroded by the action of the juice that the juice would become stained with blood. This work, therefore, bears only on the juice collected for three hours following feeding and in a few cases that immediately before feeding, i.e., twenty-three hours after feeding. The results of this series are given in Table V. It will be seen that there is a very noticeable fall in the secretion of the pancreatic juice during parathyroid tetany. That this is not entirely due to the failure of the animal to eat, is evident from the fact that the juice flowed more rapidly in the normal dogs before feeding than in the dogs in parathyroid tetany. Besides, the dogs would usually take some milk during the first attacks of tetany, which, on account of the milk diet, were somewhat mild. In Nos. 56 and 57 the amount of trypsin was determined by the method of Gross.[25] In Nos. 58, 59 and 60 the tryptic action was determined by the Mett's tube method as described by Cobb.[26] There was no marked change in the proteolytic action of the juice except in Experiments 57 and 60. The diastatic action was determined by Wohlgemuth's method.[27] There was no constant variation in the diastatic action. The alkalinity of the juice was not effected. The same was true of the solids.

In Experiment 60 the secretion during the first day of tetany

was as high as normal but there was no action on the Mett's tube and the diastatic action was diminished. On the second day the secretion of juice had fallen to almost nothing, although the papilla seemed to be in good condition.

The results obtained, although not very extensive, furnish strong evidence that there is a marked depression in the secretion

TABLE V

THE EFFECT OF PARATHYROID TETANY ON THE SECRETION AND THE PROPERTIES OF THE PANCREATIC JUICE

The figures represent the averages for the number of days indicated by the figures in parentheses

No.	Juice collected for 3 hr. after feeding c.c.	Alkalinity	Solids	Tryptic action	Diastatic action	Remarks
56	26.5 (2)	0.38	....	5	8	Normal
	9 (1)	0.36	....	6.6	8	Tetany
57	18 (3)	0.40	3.21	10	12.5	Normal
	8 (3)	0.40	3.35	4.3	12.5	Tetany
58	17.5 (2)	0.26	3.94	2.1	7.5	Normal
	14 (5)	0.38	3.70	1.9	6.06	Tetany
59	25 (2)	0.28	3.65	2.4	7.8	Normal
	12.5 (2)	0.40	3.48	2.3	6.7	Tetany
60	18 (3)	0.23	3.40	2.7	4.3	Normal
	12 (3)	0.23	2.30	1.0	3.6	Tetany

of the pancreatic juice and depression of digestion. It was frequently observed that the stomach was filled with undigested food after death from parathyroid tetany. This was true even when the animals had refused food for two or three days before death. It was also noticed that the tetany symptoms were more violent when the dogs were fed exclusively on a meat diet than when they were starved or fed on a non-protein diet after the parathyroidec-

tomy. It is possible that the hyperexcitability during parathyroid tetany can be partly accounted for by the irritation of the nerve endings in the digestive tract caused by the undigested food. The similarity of gastric and infantile tetany to parathyroid tetany also favors such a conclusion. However, this point needs further investigation.

Summary and Conclusions

1. During parathyroid tetany there is no change in sugar tolerance in dogs, when the sugar is injected intravenously.

2. The percentage of fibrin in the blood drawn from parathyroid tetany dogs is greater than that drawn from normal dogs.

3. The excretion of amino acids and ammonia in the urine of parathyroidectomized dogs is not different from that observed in the animals in a normal condition.

4. There is a distinct decrease in the secretion of bile during parathyroid tetany. The concentration of bile acids remains the same but the total bile acids formed by the liver cells is diminished in direct proportion to the secretion of bile.

5. During parathyroid tetany the secretion of pancreatic juice is less than that in the normal dog before and after feeding.

6. There appears to be no deficiency in the functions of the liver in parathyroid tetany except in the secretion of bile. This depression is probably not due specifically to the absence of the parathyroid secretion but to the condition of the digestive tract.

7. The marked decrease in the secretion of pancreatic juice during parathyroid tetany gives further evidence that the condition of the digestive tract is an important factor in the parathyroid tetany complex.

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