ABSORPTION AND METABOLISM IN OBSTRUCTION OF THE PANCREATIC DUCT.

By VAUGHAN HARLEY, M.D., M.R.C.P., *Assistant Professor of Pathology and Teacher of Chemical Pathology, University College, London; Grocer Research Scholar.*

CLINICAL observers and experimental pathologists have, during the last few years, thrown much light on the true pathology of diseases of the pancreas; so that we are now in a position to diagnose cases which formerly would only be recognised by post-mortem examination.

We know that in all cases where, either from disease or the artificial removal of the pancreas, it is entirely excluded from the organism, sugar invariably appears in the urine (*vide* von Mering and Minkowski,[1] Lépuin,[2] Hedon,[3] Vaughan Harley,[4] etc). In cases of total extirpation of the pancreas, sugar only disappears from the urine when the animal suffers from some inflammatory disease (pneumonia, peritonitis, etc.), or coma is about to make its appearance, as indicated by an increased excretion of ammonia in the urine, as well as acetone, aceto-acetic acid, or even by oxybutyric acid.

On the other hand, in experimental cases, where even only a small portion of the pancreas is left, we invariably get no sugar in the urine, or, at the most, a transient glycosuria caused by the operation. In those cases only when the animals are rapidly losing flesh does acetone or aceto-acetic acid appear in the urine.

In the human subject, when the pancreatic duct from any cause (inflammatory obstruction or concretion, or pressure from malignant disease, etc.) is obstructed, and only the pancreatic juice prevented from reaching the intestines without destruction of the gland itself, no sugar appears in the urine. These cases correspond to the animals in which the gland is only partly removed, and are extremely difficult to diagnose.

Consequently, it is of particular interest to investigate what changes occur in the absorption of food, as well as in metabolism in that dis-

[1] Von Mering and Minkowski, *Arch. f. exper. Path. u. Pharmakol.*, Leipzig, 1889, bd. xxvi.
[2] Lépuin, *Compt. rend. Soc. de biol.*, Paris, Avril 1890.
[3] Hédon, *ibid.*, Oct. 1890.
[4] Vaughan Harley, *Journ. Anat. and Physiol.*, London, 1891, vol. xxvi. p. 1.

eased condition in which so important a juice as that of the pancreas is prevented from entering the alimentary canal.

Since as early as 1832, Bright[1] stated that, in diseases of the pancreas, large quantities of fat were found in the stools. In 1862, George Harley[2] pointed out that the solidification of oil taken by the mouth in the stools was a reliable sign of occlusion to the pancreatic duct. Experimentally, von Mering and Minkowski[3] showed that in dogs in which the pancreas had been entirely extirpated, and the animals thus rendered diabetic, large quantities of fat occurred in the stools.

Subsequently, Abelmann[4] investigated the metabolism of dogs from which the pancreas was either partially or totally extirpated. In this research he showed that von Mering's and Minkowski's observations were perfectly correct, and that animals thus operated on were unable to absorb as much fat as normal animals. In fact, olive oil was entirely unabsorbed, and milk fat was only absorbed in small quantities. He further found that not only was the absorption of proteids very much diminished, but carbohydrates were not absorbed in the normal quantity.

In this paper it is my intention to describe the results of an investigation into the absorption of food in a human subject in which the pancreatic duct was probably obstructed. I shall first give a résumé of the results I have obtained in the case of dogs, in which the pancreas has been either partially or completely extirpated, in order to show that the results obtained in the human subject correspond to those known to occur in experimental cases.

In all the cases in which the pancreas had been completely removed, as has been already stated, sugar occurred in greater or less quantity in the urine; even if a dog was kept fasting 5 days, the urine contained from 1 to 7 per cent. of sugar. Polyuria, although never very marked, now and again showed itself. The quantity of nitrogen in the urine was always in excess of the quantity really absorbed, and was accounted for by the rapid emaciation. Dogs in which the pancreas had been removed lost from $1\frac{1}{2}$ to $3\frac{1}{2}$ kilos. during 4 days' fasting; while only in one case did a dog in which no operation was performed lose 1 kilo. during the same time. In most cases both acetone and aceto-acetic acid appeared in the urine before death.

If the pancreas was only partly removed, there was no glycosuria; or, at the most, only a transient one, immediately after the operation. The quantity of nitrogen in the urine was not so markedly increased, and the emaciation more gradual, large quantities of food sometimes being able to maintain the body weight for some time. Acetone and aceto-acetic acid appeared only in the urine when the animals had

[1] Bright, *Trans. Med.-Chir. Soc. Edin.*, 1832.

[2] George Harley, "Complete Obstruction to the Bile and Pancreatic Ducts," *Trans. Path. Soc. London*, 1862, vol. xiii. p. 118.

[3] Von Mering and Minkowski, *Arch. f. exper. Path. u. Pharmakol.*, Leipzig, 1889, bd. xxvi. s. 371.

[4] Abelmann, "Inaug. Diss.," Dorpat, 1890.

considerably lost flesh. The fæces of all the animals that I have experimented upon have had a most peculiar smell; this fact, trifling as it may appear, is nevertheless of interest, as I have found it invariably to occur in animals, and it has also been present in the case about to be described.

When the dogs were fed on raw meat, this very often reappeared in the stools apparently unaltered; when fat was given, this also appeared in large quantities in the stools.

Before describing the results it will be as well to give in a few words the methods employed in analysis in the case of the dogs and boy.

With the first meal a quantity of charcoal was given, so that the fæces of that meal might, by their dark colour, be distinguished from those belonging to the previous diet. With the last meal charcoal was also given for the same purpose. In the case of the dogs, they were kept fasting before commencing diet, in addition to their getting charcoal. The quantity of nitrogen was always estimated by the method of Kjeldahl. In the case of the food and the fæces, at least four samples were analysed, and the quantity of nitrogen calculated from the average. In the urine two analyses were found sufficient.

In analysing the fats, some of the fæces were first extracted with alcohol and then with ether in a Soxhlet's extractor; and the two extracts, after being dried, were again treated with absolute ether, and then the extract was weighed. The residue, after complete extraction with ether, was heated with dilute hydrochloric acid, dried, and again extracted with ether, so as to obtain the fat acids liberated from the soaps. The quantity found in the first ether extract, together with the soap, is termed total fat in the following table.

In order to separate the neutral fat, fat acids, and cholesterin, the first ether extract was warmed with a solution of sodium carbonate to saponify the free fat acids; and, after drying, the neutral fat and cholesterin were extracted with absolute ether. The free fat acids were calculated by the loss of weight.

The new ether extract was then treated with a freshly-prepared alcoholic solution of metallic sodium (NaOH), and, after drying, extracted with ether to separate the cholesterin. It was found in practice often necessary to repeat the process several times before pure cholesterin could be obtained, and in all cases it was repeated until there was no longer any loss of weight. By subtracting the quantity of cholesterin from the neutral fat and cholesterin, the quantity of neutral fat was obtained.

In order to study the absorption of milk fat and proteids in the case of the boy, a quantity of milk was sterilised, and a litre analysed to form a standard of comparison. The method of analysis was exactly similar to that employed in the case of the dogs.

The results of the analysis on one dog, which lived for 2 months after an almost total extirpation of the pancreas, will now be given as

an example. The dog had lost flesh considerably, although the urine at no time contained any sugar, for which it was repeatedly examined by fermentation, phenylhydrazine, and Fehling's tests. The urine, on the other hand, contained not only acetone but aceto-acetic acid in small quantities. The fæces always contained undigested food, and had the remarkably foul odour above described.

TABLE I.—*Absorption of Nitrogen in a dog after Extirpation of the Pancreas, the Animal having considerably lost flesh, but the Urine never containing Sugar, due to the fact of very small portions of the tail of the Pancreas having been left.*

Day.	Weight.	Food.	Urine.	Fæces.	Absorbed.		
		Nitrogen.	Nitrogen.	Quantity.	Nitrogen.	Total Nitrogen.	Nitrogen per cent.
	Kilos.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
1	5·700	No food	1·945	...	...	...	...
2	5·700	...	2·198	80·2	5·900	14·469	17·88
3	5·500	17·618	2·260	60·3	3·100		
4	5·450	...	3·013	66·4	2·221		
5	5·300	No food	1·147	67·0	3·248		
6	5·150	Do.	1·520	18·7	0·644	...	...

On the first day (Table I.) no food was given, while during the next 3 days the animal was given meat containing 17·618 grms. of nitrogen. With the first and last meal charcoal was given to indicate how long the fæces passed belonged to this diet, the black colour disappeared on to the sixth day. The stools passed on the sixth day, as they did not contain any charcoal, are not reckoned in calculating the total quantity of nitrogen unabsorbed.

That fasting animals pass fæces, we know from the experiments of Voit, and that the same holds good in human beings is still further shown by observations made on various fasting individuals. The fæces passed on the sixth day correspond in all probability to the fasting stool, which is supposed to be derived from an excretion into the alimentary tract, as described by Hermann, Ehrenthal, Bernstein, and F. Voit. It is interesting to note that when the food was given on the second morning, the animal passed some of the black-coloured stools in the evening. The stools were each day collected in the morning before the food was given, but for the purpose of convenience they are entered in the above table as if passed during the same day.

It is seen in Table I. that the quantity of nitrogen given in the meat was 17·618 grms., while the quantity eliminated from the alimentary canal was 14·469, consequently only 17·80 per cent. of the nitrogen

given was absorbed. In reality, in all probability, somewhat more was absorbed, as some of this nitrogen found in the fæces would correspond to that which is normally eliminated in a fasting animal.

In the analysis of the urine, we find that during the 3 days on which the animal was fed the quantity of nitrogen eliminated was almost uniform; at the same time the animal could not be said to be on nitrogen equilibrium, as it continuously lost weight.

The quantity of nitrogen eliminated in the urine and fæces was more than was really given to the animal in the diet, so that some of the nitrogen contained in the urine was derived from a breaking down of the tissues themselves, hence the loss of weight.

The loss of weight in this experiment may be partly explained by the diminished absorption of food from the alimentary canal, but this alone does not seem a sufficient explanation.

Abelmann found that when he removed the entire pancreas, 22 to 58 per cent. of the proteids given to his dogs were absorbed, while, when the gland was only partially removed, the absorption ratio rose from 40 to 83 per cent.

It is therefore brought out by these experiments that the absorption

TABLE II.—*The Absorption of Mutton Fat after almost complete Extirpation of the Pancreas, one-twentieth of the Tail of the Pancreas being left.*

Day.	Weight.	Fat in Food.		Fæces.		Absorbed.	
				Quantity.	Fat.	Fat.	Fat.
	Kilos.	Grms.	Total Grms.	Grms.	Grms.	Total.	Per Cent.
1	7·670	12·08		19·3	2·25		
			36·40			26·71	26·62
2	7·600	24·32		106·0	24·461		
9	6·850			116			
10	6·830		75·81	174		47·05	37·94
11	6·720			53			
15	6·500			None.			
16	6·350			9·620			
17	6·250			8·037			
			46·95				
18	6·100			9·914		44·885	4·44
19	5·900			10·936			
20	5·900	No food.		6·378			

of proteids from the alimentary canal are markedly affected in pancreatic disease, and that, as will be seen later, they are in reality not much less affected than the absorption of fat which has hitherto been generally believed to be, if not the only, at least the principal one affected.

If we now turn to the effects on the absorption of mutton fat, produced by extirpation of the pancreas in dogs, we find that the proportion varies with the period which has elapsed since the operation.

Charcoal was given as indicator in this case, in the same manner as previously described. In the above table it is seen that in the first two periods of 2 and 3 days respectively, 26·62 to 37·94 per cent. of the fat given was absorbed; the largest absorption taking place when the largest quantity of fat was given. While during the third period, when the animal was in a weaker condition, and would not take so much food, the quantity of fat absorbed was much less, being only 4·44 per cent.

Abelmann found that after the total extirpation of the pancreas in his dogs, no fat was absorbed; whereas, in partial extirpation, from 25 to 59 per cent. of the quantity given was absorbed. Milk fat, however, proved an exception to this rule, for he found that in total extirpation 28 to 53 per cent. of milk fat was absorbed.

In other experiments, in which I have endeavoured to ascertain the amount of fat absorbed from the intestinal canal of dogs, after either partial or total extirpation of the pancreas, I have in all cases found a very marked decrease from the normal amount of fat absorbed, but the above samples are the best of them.

In a paper on the absorption of milk fat, recently published in the *Journal of Physiology*,[1] I showed that while a normal dog fed on milk absorbs 21 to 46 per cent. of the fat given in seven hours, in a dog from which the pancreas had been entirely removed no absorption of milk fat whatsoever could be found to have occurred in this space of time.

With these preliminary remarks, I will proceed to narrate an exceptionally characteristic case of pancreatic duct obstruction in which, through the kindness of Dr. Auld of Wimborne, I had the opportunity of making a series of analyses while on a fixed diet.

The patient was a boy aged 13, who was attacked by severe gastritis, after recovering from scarlet fever, in February 1894. He had previously suffered from an attack of acute nephritis. Two months after the scarlet fever, an offensive smell was noticed by persons coming near him, and this was found to be due to an oily excretion which collected on the seat of his trousers.

On examining the fæces, Dr. Auld found them of a light brown colour, soft, and containing undigested food. A large quantity of oil floated about them; on cooling, the oil solidified into a hard beeswax, like cake. A motion followed immediately upon each meal, associated

[1] Vaughan Harley, *Journ. Physiol.*, London, 1895, vol. xviii. p. 1.

with pain in the rectum, which was found to be due to inflammatory congestion of the mucous membrane and an appearance of villous growths.

When Dr. Auld brought the boy to Dr. George Harley on the 4th October 1894, he was passing, every tenth day or so, a large quantity of more or less bright orange-coloured oily fluid, which immediately gave rise to the supposition that he was labouring under some form or another of pancreatic disease. His abdomen was consequently carefully examined, without any pain, tenderness, or swelling of any kind being found in the pancreatic region. The oily stools were, however, so characteristic of the absence of pancreatic juice that he was put under the appropriate treatment for that affection.

When I examined the urine in June it contained 1·51 per cent. of urea, no acetone or aceto-acetic acid, nor any sugar. At this time he weighed 78 lbs. Some of the oily matter he passed was sent to me for analysis in July, and I found that it consisted of small quantities of neutral fat and soap, and large quantities of fat acids.

During December 1894 all medicines were stopped, and the patient was placed for 4 days on an entirely milk diet.

On this diet the fæces were of a yellowish-white colour, and of the consistence of a soft cream cheese. They contained a few yellowish lumps like beeswax, and smelt like extremely bad cheese. They contained a small quantity of bile acids and urobilin. From this, and the absence of any jaundice or bile in the urine, the bile duct was evidently pervious. The results of a quantitative analysis are given below in a tabular form.

TABLE III.—*Boy, æt.* 13, *suffering from probable Obstruction to the Pancreatic Duct.*

Date.	Weight.		Milk Diet.				Urine.				Fæces.			
			Quantity.	Nitrogen.	Proteids.	Fat.	Quantity.	Reaction.	Sp. gr.	Nitrogen.	Quantity.	Nitrogen.	Proteids.	Fat.
	Kilos	Lbs.	C.c.	Grms.	Grms.	Grms.	C.c.			Grms.	Grms.	Grms.	Grms.	Grms.
Dec. 13,	37·8	84	Ordi	nary	diet.	..	..	..	..	..	..	..	..	..
„ 14,	37·8	84	3976	13·12	82·5	196·85	1680	Acid.	1007	10·047	..	..	..	..
„ 15,	37·6	83·5	3976	13·12	82·5	196·85	1960	Do.	1007	10·272	257·84	1·149	8·931	19·98
„ 16,	37·4	83	3976	13·12	82·5	196·85	2240	Do.	1008	12·096	688·02	5·631	35·194	149·72
„ 17,	37·4	83	3976	13·12	82·5	196·85	1960	Do.	1009	10·027	576·40	4·859	30·368	137·87
„ 18,	37·6	83·5	Ordi	nary	diet.	..	..	..	..	..	..	..	..	..
„ 19,	37·3	84·0	Ordi	nary	diet.	..	..	..	..	..	..	..	..	..

The analysis of the 4 days given in Table III., shows that as far as the urine is concerned, the quantity of nitrogen excreted is fairly equal. During the first 2 days, on a milk diet, he lost a pound in weight (14th to 16th), the next 2 days (from the 16th to 17th) his weight remained the same, and the nitrogen eliminated in the fæces and urine was prac-

tically equal. In calculating the absorption and metabolism in his case, we can only employ the results of the 16th and 17th of December.

As regards the absorption of nitrogen and fat from the alimentary canal, it will be as well to compare the average of these 2 days with that found by Rübner [1] in a healthy man on a milk diet.

TABLE IV.—*Comparing the quantity of Nitrogen and Fat absorbed from the Alimentary Canal on Milk Diet in a healthy Man (Rübner), and one suffering from probable Obstruction to the Pancreatic Duct.*

Condition.	Milk contained.			Fæces contained.				Absorbed.			
	Quantity.	Nitrogen.	Fat.	Nitrogen.		Fat.		Nitrogen.		Fat.	
	C.c.	Grms.	Grms.	Grms. Total.	P.Ct.	Grms. Total.	P.Ct.	Grms. Total.	P.Ct.	Grms. Total.	P. Ct.
Health, . .	3075	19·4	119·9	1·5	7·7	6·7	5·6	17·9	92·3	112·9	94·4
Pancreatic obstruction, . .	3976	13·12	196·85	5·25	40·0	143·80	73·05	7·87	60·0	52·05	26·95

In Table IV. it is seen that in a healthy man the fæces contain 1·5 grms. of nitrogen, *i.e.*, 7·7 per cent. of the total nitrogen given, consequently 92·3 per cent. of the total nitrogen given has been absorbed. When we compare this with the case under investigation it is seen that in an average of 2 days, during which the patient was on nitrogen equilibrium, the fæces contained 5·25 grms. of nitrogen, so that 40 per cent. of the total nitrogen given was eliminated in the fæces, and only 60 per cent. had been taken into the system to be made use of in metabolism.

As regards the fat, in Rübner's healthy man only 6·7 grms. were excreted in the fæces, *i.e.*, 5·6 per cent.; whereas in our case (of probable obstruction to the pancreatic duct) the fæces contained 143·80 grms. of fat, *i.e.*, 73·05 per cent. So that 26·95 per cent. of the fat given was absorbed from the intestines, and rendered capable of being made use of in metabolism.

The 2 cases seem fair ones to compare, as, in both, the quantity of food given was about equal; the only difference being that, while the boy received a larger quantity of fat in his diet, Rübner's received a larger quantity of nitrogen.

Turning now from what the results given in these tables show as regards the absorption to the actual nourishment, it may be as well to express it in the form of calories; that is to say, the quantity of heat necessary to raise 1 kilo., 1° C.

From Rübner's [2] calculations we obtain the following results:—

[1] Rübner, *Ztschr. f. Biol.*, München, 1889, bd. xv. s. 115.
[2] Rübner, *ibid.*, 1893–5, bds. xix. and xxi.

1 grm. proteid converted into urea, uric acid, ammonia, etc. = 4·1 calories.
1 „ fat converted into carbonic acid and water = 9·3 „
1 „ carbohydrate converted „ „ „ = 4·1 „

In metabolism experiments it is customary to reckon that 100 grms. of proteid contain on an average 16 per cent. of nitrogen, so that if we multiply the quantity of nitrogen by 6·25 we get the quantity of proteid it represents.

In our own case we did not estimate the quantity of carbohydrates, so that an average of other analyses has been taken.

If we convert the quantity of food given to our patient into calories we find—

Proteid, . .	82·51 × 4·1 =	338·25 calories.
Fat, . .	195·85 × 9·3 =	1830·71 „
Carbohydrate, .	198·75 × 4·1 =	814·87 „
		2983·83 „

Consequently, the patient had received in his diet 2983·83 calories, and as he weighs 37·4 kilogs. (78 lbs.) during the days of observation, he received 78·9 calories per kilog. in his food.

Numerous observers have found that a normal man on an average requires from 30 to 40 calories per kilog. to maintain his weight, according to the amount of muscular work, and that 32 calories per kilog. is sufficient for most people doing an ordinary amount of muscular exercise. Thus, then, our boy received in his diet, twice the quantity of nourishment necessary to maintain his body weight, yet notwithstanding this he lost flesh.

The loss of weight is partly explained by the greatly diminished absorption of food which we have found by analysis of the fæces to have occurred, and we therefore see the importance of both analysing the urine and fæces before formulating a diagnosis in cases like his.

If we now subtract from the quantity of food given the quantity which we have found by analysis to have remained unabsorbed from the alimentary canal, we get the following results. The carbohydrates in our case not having been calculated, I have taken the results found by Abelmann as my standard. He found in partial extirpation of the pancreas that only 77 to 78 per cent. of carbohydrate given in the food was absorbed from the intestines.

In the case of the boy we find—

	Given.	Unabsorbed.	Absorbed.	
Proteid, . .	82·5	− 32·75 =	49·72 × 4·71 = 203·85	calories.
Fat, . .	196·85	− 143·80 =	53·05 × 9·3 = 493·37	„
Carbohydrates,	198·75	− 43·00 =	155·75 × 4·1 = 638.58	„
			1336·80	„

From these calculations it is seen that, instead of the boy absorbing into his system 2983·83 calories, he really absorbed 1338·80 calories; that is to say, only 36 calories per kilog.

On returning to Table III. we see that he weighed 37·8 kilogs. while on ordinary diet. On the first day of milk diet (14th December) his weight remained the same, while on the third day (15th December) it fell to 37·6 kilogs., and on the fourth day (16th December), to 37·4 kilogs., and remained so on the 17th. Whereas on resuming ordinary diet (on the 18th) it rose to 37·6, and, on the 19th, to 37·8 kilogs.

The results of our analysis have shown that during his milk diet, while taking a large quantity of food, he only absorbed a small part of it, but at the same time he absorbed as much as 36 calories per kilog., and in spite of this he lost weight. From which it appears since 32 to 34 calories per kilog. per diem would have been ample for him to keep up his body weight in health, it was insufficient under the circumstances.

We must therefore conclude that not only was there in his case a disordered absorption of food from the alimentary canal, but there was also a defective metabolism of what was absorbed. Having shown that in the case of the boy there is not only a diminished absorption of both fat and proteids from the intestines, but that there is also a defective assimilation of the food materials actually absorbed, I will now turn to the chemical changes which the fat has undergone in its passage along the alimentary tract.

The following table shows the changes milk fat undergoes during its passage through the alimentary canal in the case of the boy under observation :—

TABLE V.—*Showing the Composition of the Fat in the Fæces of a Boy suffering from probable Obstruction of the Pancreatic Duct, and the Composition of Fat in the Milk given.*

	Total Fat.	Neutral Fat.		Free Fat Acids.		Fat Acids as Soap.		Cholesterin.	
		Total.	Per Cent.	Total.	Per Cent.	Total.	Per Cent.	Total.	Per Cent.
Milk, . .	196·85	191·000	97·02	5·690	2·89	0·121	0·06	0·160	0.08
Fæces, 16th,	149·72	59.051	39·44	54·348	36·30	26·270	17·55	10·051	6·71
,, 17th,	137·87	49·149	35·65	61·355	44·50	18·135	13·15	9·231	6·70

In Table V. we find the quantity of neutral fat taken has diminished from 191 grms. to 59·051 and 49·149 grms. respectively, so that a large quantity of it has either been absorbed during its transit along the alimentary canal, or, in spite of the absence of the pancreatic secretion, it has been broken up into fat acids, etc.

In the milk given there was only 5·690 grms. of free fat acids, while 54·348 and 61·355 grms. were found in the fæces. From this it is seen that we can at least account for the disappearance of part of the neutral fat from the alimentary canal, by its having been split up

into free fat acids in its passage along the intestines, seeing that they were increased tenfold.

As regards soaps, their quantity in the milk was only 0·121, while in the fæces it was no less than 26·270 and 18·135 grms.

Thus, in spite of the pancreatic secretion being absent, the neutral fats have not only been split up into free fatty acids and glycerine, but the fat acids have been able to find an alkali wherewith to form soap.

The amount of cholesterin in the milk was only 0·16 grms., while the quantity found in the fæces was 10·051 and 9·231 grms. respectively. This increase cannot be regarded as being due to any chemical change in the milk, but is, in all probability, due to a quantity of cholesterin being eliminated by the bile, or due to intestinal secretion.

That the above chemical changes should have taken place in the milk fats during their sojourn in the alimentary canal, in the boy, might be argued against the absence of the pancreatic juice really occurring; but experiments have shown me that the same thing occurs when we have undoubtedly not only hindered the flow of pancreatic juice into the intestines, but have removed the entire gland.

I here give a table showing the results found in the above boy, and those I found in the fæces of dogs which had had their pancreas extirpated:—

TABLE VI.—*Showing average Composition of Fat in the Fæces of a normal Dog on Milk diet, compared with one from which the Pancreas had been removed, placed side by side with the average result obtained in the two days' analysis in the case of the Boy supposed to be suffering from obstruction of the Pancreatic Duct.*

	Total Fat.	Neutral Fat.	Free Fat Acids.	Soap as Free Fat Acids.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Normal dogs, ...	100	34·17	58·65	7·19
Pancreas extirpated, . .	100	33·90	55·25	10·84
Boy with obstructed pancreatic duct, ...	100	37·55	40·40	15·35

It is seen in Table VI. that if we take the total ether extract of the fæces as representing 100, the quantity of neutral fat contained in it is, in normal dogs, 34·17, while in those from whom the pancreas was artificially removed, as well as in the boy, we get respectively 33·90 and 37·55 per cent.

In the normal dogs, while the free fat acids are 58·65 per cent., in dogs without the pancreas, and in the boy, they are respectively 55·25 and 40·40 per cent. On the other hand, the soaps as represented as free fat acids are, in normal dogs, only 7·19 per cent., while, after pancreatic extirpation, they are increased to 10·84 per cent., and in the

case of the boy they are 15·35 per cent. Consequently, these cases very closely resemble each other in so far as neutral fat and fat acids are concerned. In fact, merely from the analysis of neutral fat and fat acids, one would be unable to say whether the pancreatic juice was present or absent. In the case of the soaps, we see that there is a slight tendency to excessive formation, or, I should rather say, an excessive excretion of soap in the stools when the pancreatic juice is hindered from reaching the intestines. This may be regarded as most remarkable, since when the pancreas is either entirely removed or its secretion is merely prevented reaching the alimentary canal, there is either a non-absorption, or a greatly diminished absorption of fat from the intestines.

According to former ideas, this non-absorption would have been attributed to the fat splitting-up action of the pancreatic juice no longer coming into play, and from the fats not being broken down, no emulsification taking place, and therefore no absorption.

In the case of the dogs, as well as the boy, it is seen from the above analysis that, in spite of the absence of this fat-splitting ferment of the pancreas, the fats during their passage through the alimentary canal are, by some means or another, broken up, and not only form free fat acids, but also soaps. Yet, in spite of this fact, they are not absorbed.

Abelmann[1] showed that when the pancreatic juice was prevented reaching the intestines, the ether extract of his dog's fæces contained even as much as 80 per cent. as free fat acids, and only a small portion as soap. Hédon and Ville[2] showed that when bile was prevented from entering the intestines by ligature of the common bile duct, the fæces of a dog contained 41 per cent. of soap, 57 per cent. of free fat acids, and only 2 per cent. of neutral fat. He then removed the greater part of the pancreas, only the tail being left to prevent glycosuria; the fæces now contained 45 per cent. of the ether extract as fat acid, 55 per cent. as neutral fat, but no soap, milk having been used as the diet.

I am still investigating the subject of the splitting up of neutral fat in the alimentary canal, and will therefore at present not go further into the question. One important fact is, that in spite of the absence of pancreatic juice, fat is able to be split up in the alimentary tract.

It may be well to try and explain what is the probable state of affairs in the case of the boy we have been investigating.

The results of the analyses show us that large quantities of fat appear in the stools, no less than 73·05 per cent. of the total quantity given. And, still further, the proteids excreted in the fæces are far above the amounts normally found, so that 40 per cent. of the nitrogen given has been excreted in the stools.

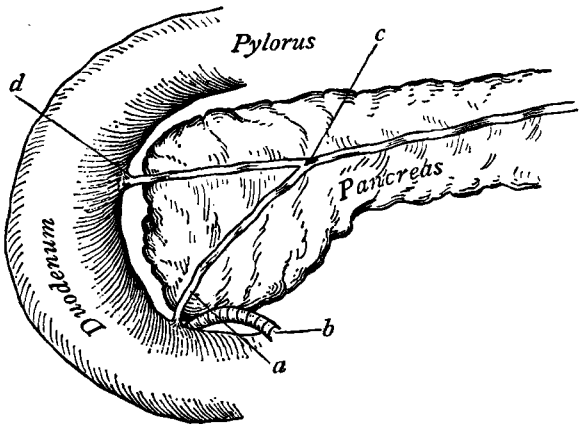
The foul odour of the stools was a constant feature in the case of

[1] Abelmann, *loc. cit.*

[2] Hédon and Ville, *Compt. rend. Soc. de biol.*, Paris, 1892, p. 308.

my dogs, and was, at the same time, specially marked in the case of this boy, so that it is worthy of note. These facts led me to believe that for some reason or other the pancreatic secretion was not reaching the alimentary canal. That this is not due to an absence of the pancreas, or destruction by disease, is shown by the fact that sugar at no time has been present in the urine, and, therefore, the evidence is in favour of an occlusion of the duct of the pancreas.

The morbid anatomical condition which has led to this obstruction would appear to be some chronic inflammatory stricture of the duct. At the same time, since analysis has shown us that bile is reaching the intestine, the common bile duct must have remained free. We cannot suppose that the common orifice of the bile and pancreatic duct can even be partially obstructed, for since bile and pancreatic juice are secreted at about the same pressure, namely, 200 mm. of water, it is hardly possible that only one should be hindered reaching the intestines. The pancreas is, however, known to have, very frequently, accessory ducts, or in some rare cases to enter the duodenum separately from the common bile duct.



a. Main pancreatic duct.
b. Common bile duct.
c. Point of junction of main and accessory pancreatic duct.
d. Accessory pancreatic duct.

The commonest form of accessory duct is one entering the duodenum nearer the stomach *d*, and we know from the history of the case that the boy suffered from gastritis previous to the appearance of the foul-smelling motions. It is conceivable that either the main duct of the pancreas *a* may be absent, and only the accessory duct is present, so that the inflammation spreading from the stomach down the duodenum may have involved it, without having extended far enough to have likewise involved the orifice of the common bile duct *c*. In this way there might have been a complete obstruction to the pancreatic duct, or we can imagine that both the main duct *a* and the accessory duct *d*

were present, but the inflammation had extended up the accessory duct so as to involve also the main duct.

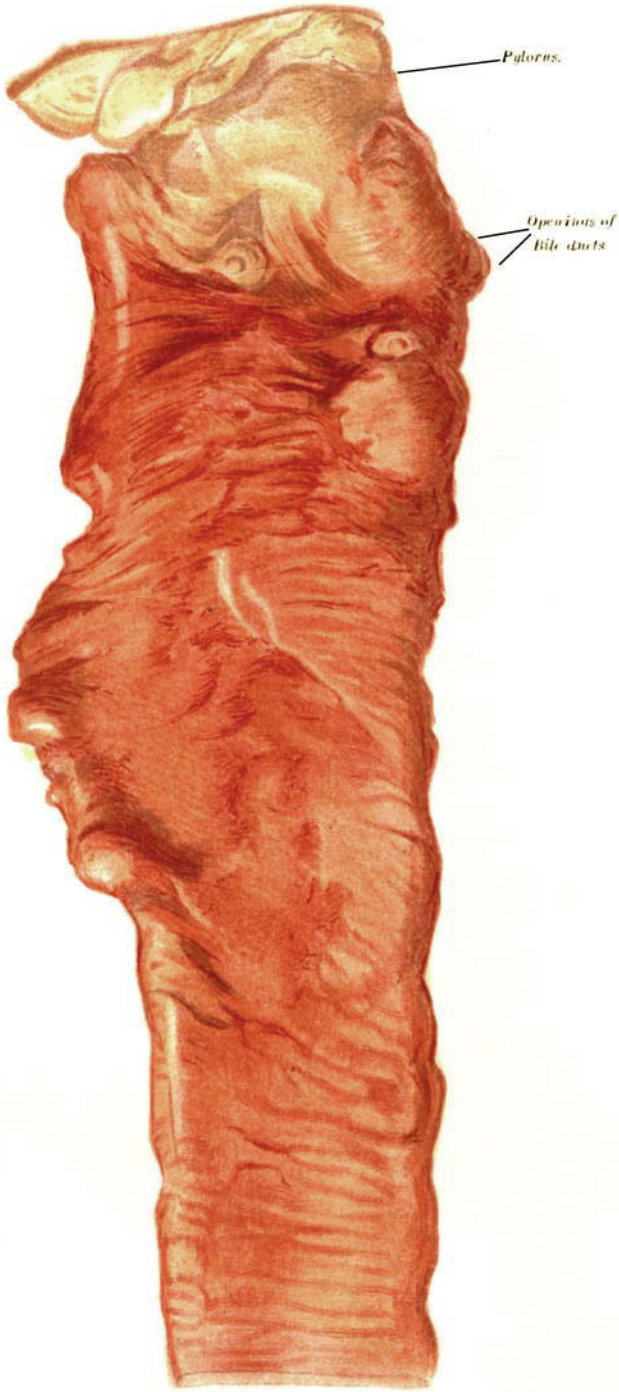
This being the diagnosis, and it being impossible to give a drug which could with any certainty cure the morbid condition, it was necessary to consider what could be done in the case.

Abelmann found that feeding dogs after removal of the pancreas with raw pancreas caused an increased absorption of fat. I therefore recommended Dr. Auld to give the boy raw pancreas. From 28th February until 10th March 1895 this was done; and during this time the quantity of oil passed with the stools was very markedly decreased, although it did not entirely disappear. The foul smell was absent, but, since the boy was at the same time taking calomel and potassium benzoate, both powerful intestinal antiseptics, we can hardly put this fact down to the raw pancreas. The parents, later, refused to continue the pancreas treatment, in consequence of his having been ill after eating a supposed bad one. Since this date oil has been present, off and on, intermittently, and Dr. Auld has endeavoured to get the parents to allow the boy to resume taking the pancreas. During the last 4 months, with careful dieting and treating symptoms, he has increased 2 lbs. in weight.

In conclusion, it may be said, from the results of the analyses in this boy's case, and of the dogs' cases from which the pancreas was either partially or completely removed, that the pathology of the absence of pancreatic juice from the intestines is more complicated than one is at first led to believe, seeing that not alone is there a diminished absorption of fat, so that only 26·95 per cent. of the total given was absorbed in the case of the boy, and from 4 to 37 per cent. in dogs; but, at the same time, the proteid absorption is greatly diminished, so that in dogs only 18 per cent., and in the boy 60 per cent., was absorbed.

The results of the analysis of the fæces in the boy has shown that the non-absorption of fat after removal of the pancreas is not due, as is generally supposed, to any want of the splitting up of the neutral fat into fat acids, glycerine, and the formation of soaps, but, on the contrary, is due to some cause as yet unexplainable.

When the quantity of food given is increased above the quantity necessary for a healthy individual, so that the quantity absorbed may be equal to the number of calories necessary to maintain the body weight in health, owing to improper metabolism, they are insufficient to keep the weight up to the normal standard when the pancreatic duct is obstructed. On still further increasing the quantity of food, however, the body weight can be maintained, and we see that in the case of this boy careful dieting, together with treatment, has not only been able to keep up his weight, but even to cause a gain of 2 lbs. in the space of 4 months.


Pylorus.
Openings of
Bile ducts