ROENTGENOLOGIC STUDIES ON THE SMALL INTESTINE, ESPECIALLY ON EFFECTS OF FOODSTUFFS ON THE GASTRIC EVACUATION AND THE FUNCTION OF THE SMALL INTESTINE

By

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Introduction

Several roentgenologic investigations of the small intestine have been carried out [1)-9),11)-16)] leaving, it seems, some basic problems on them only partially explained. For instance, Frazer et al.[3)] described the so-called "deficiency pattern" being seen in normal human subjects following administration of a hypertonic solution of sodium bicarbonate, glucose and hydrolysed fat.

Regarding such experimentation the present authors are of the opinion of using preferably animals in stead of humans. Because humans are more subject to psychosomatic influences during experimentation[8)], and their exposure to radiation should be limited.[5)] Thus the authors employed dogs which have been domesticated for over 2 years.

Peoples live on different diets according to their own living habits, e.g., the Japanease live mostly on rice and the Eskimo on flesh. It is interesting to find how different diets may influence the function of the small intestine differently.

In order to obtain such findings dogs were observed being subject to fasting or to different kinds of breeding. The animals were pretreated in various ways and then given contrast media containing glucose, plasma or olive-oil.

Methods and Results

The contrast media employed were as follows:

a. Water-barium meal	
Routine barium meal	100 ml.
Water	200 ml.
b. Carbohydrate-barium meal	
Routine barium meal	100 ml.
Water	200 ml.
Glucose	30 g.
c. Protein-barium meal	
Routine barium meal	100 ml.

Water	200 ml.
Plasma	30 g.

d. Fat-barium meal

Routine barium meal	100 ml.
Water	170 ml.
Olive-oil	30 ml.

As the pretreatment, the dogs were ingested or kept in fasting as follows:

I. With a routine diet for ten days (control),
II. Kept in fasting for three days,
III. With a carbohydrate-diet for ten days,
IV. With a protein-diet for ten days,
V. With a fat-diet for ten days.

The dogs had been kept in fasting for twelve hours prior to administration of contrast meal.

I. Routine Diet.

	Water-Barium Meal	Carbohydrate-Barium Meal	Protein-Barium Meal	Fat-Barium Meal
Gastric Evacuation Time	1/2–1 1/2 hrs. smooth& regular	1–2 hrs. relatively smooth & regular	1/2–1 1/2 hrs. relatively smooth & regular	4 hrs. spastic & irregular
Width and Continuity of the Intestinal Barium Stream	wide & continuous	relatively narrow & uneven	relatively wide & continuous	narrow & uneven
Speed and Mode of the Intestinal Movement	slow & gentle	relatively rapid & active	relatively slow & gentle	rapid & active
Barium Meal Residues in the Intestine	nothing	stringy or sometimes motley	stringy or motley	abundant, stringy or motley
Transit Time	1–2 hrs.	1–2 hrs.	1–2 hrs.	1 1/2–4 hrs.

II. Kept in Fasting for 3 Days.

	Water-Barium Meal	Carbohydrate-Barium Meal	Protein-Barium Meal	Fat-Barium Meal
Gastric Evacuation Time	1–2 hrs. relatively smooth & regular	2 hrs. (1/2) relatively smooth & regular	not followed, similar case to carbohydrate-barium-meal being assumed	2 1/2 hrs.(1/3) spastic & irregular
Width and Continuity of the Intestinal Barium Stream	wide & continuous	relatively wide & not so continuous		narrow & uneven
Speed and Mode of the Intestinal Movement	relatively slow & gentle	relatively active & somewhere rapid		active & rapid
Barium Meal Residues in the Intestine	nothing	stringy or motley		stringy or motley
Transit Time	1–1/2 hrs.	3 hrs.		2 hrs.

III. Carbohydrate-Diet for 10 Days.

	Water-BariumMeal	Carbohydrate-Barium Meal	Protein-Barium Meal	Fat-Barium Meal
Gastric Evacuation Time	5 hrs. (1/5) not sosmooth & regular	1 1/2 hrs. relatively smooth & regular	3 hrs. (1/5) relatively spastica & irregular	5 hrs. (1/3) spastic & irregular
Width and Continuity of the Intestinal Barium Stream	wide & continuous	relatively wide & continuous	relatively narrow & uneven	narrow & uneven
Speed and Mode of the Intestinal Movement	not so slow & gentle	relatively slow & gentle	relatively rapid & active	rapid & active
Barium Meal Residues in the Intestine	nothing or little	stringy	stringy	motley
Transit Time	6 hrs.	3–4 hrs.	3 hrs.	5 hrs.

IV. Protein-Diet for 10 Days.

	Water-Barium Meal	Carbohydrate-Barium Meal	Protein-Barium Meal	Fat-Barium Meal
Gastric Evacuation Time	1/2–1 hr. (1/3) relatively smooth & regular	4 hrs. (1/3) relatively smooth & regular	not followed, similar case to carbohydrate-barium meal being assumed	2 1/2 hrs. (1/3) spastic & irregular
Width and Continuity of the Intestinal Barium Stream	relatively wide & continuous	relatively wide not so continuous		narrow & uneven
Speed and Mode of the Intestinal Movement	relatively slow & gentle	relatively rapid & active		rapid & active
Barium Meal Residues in the Intestine	stringy	stringy or motley		stringy or motley
Transit Time	1 1/2 hrs.	2 hrs.		3 hrs.

V. Fat-Diet for 10 Days.

	Water-Barium Meal	Carbohydrate-Barium Meal	Protein-Barium Meal	Fat-Barium Meal
Gastric Evacuation Time	1 hr. (1/2) relatively smooth & regular	1 hr. (1/2) not so smooth & regular	1 hr. not so smooth & regular	3 hrs. (1/2) spastic & irregular
Width and Continuity of the Intestinal Barium Stream	relatively wide & continuous	relatively wide & continuous	relatively wide & continuous	narrow & uneven
Speed and Mode of the Intestinal Movement	relatively slow & gentle	relatively rapid & active	relatively rapid & active	rapid & active
Barium Meal Residues in the Intestine	stringy	almost nothing	almost nothing	abundant, stringy
Transit Time	3 hrs.	2 1/2 hrs.	1 1/2 hrs.	4 hrs.

Roentgenologic examinations were carried out at half hour intervals till the contrast meal reached the caecum, with a series of films taken under fluoroscopic observations

and/or cineradiographic recordings.

The function of the small intestine was manifested by the gastric evacuation of the barium meal, the width and the continuity of the intestinal barium filling, the speed and mode of the intestinal movements and transit time, i.e., required for the barium meal to reach the caecum after administration.

The results were summarized in table I, II, III, IV and V.

Discussion

Barium sulphate has been used as a contrast medium for years in roentgenologic investigations of the alimentary tract.[1)-9),11)-16)].

The common vehicle is water or normal saline with or without suspending agent such as arabic gum, tragacanth gum, CMC..

According to Frazer et al.,[3)] the addition of cane sugar (5 per cent) or a flavourer results in no modification in a normal pattern of roentgenologic visualization.

For the routine examination, we use a barium meal containing 3,000 g. of barium sulphate, 7,000 ml. of water, 30 g. of CMC., 20 ml. of lemon-essence and 8 g. of sugarine for thirty persons.

In the present experimentation, 300 ml. of a contrast meal was administered, because it corresponded to the volume of a canine stomach estimated on autopsy.

In the first place, we demonstrated the alterations of the function of the small intestine due to the different sorts of foodstuffs added to the routine barium meal. Effects on the small intestinal function were the greatest with a fat-barium meal, followed by a carbohydrate-barium meal and a protein-barium meal in order.

But there was a very slight difference between the second and the third.

The effects observed consisted of an irregular evacuation and a prolonged emptying time in the stomach, an uneven and irregular intestinal stream, more activated intestinal movements, more intestinal residues and prolonged time in passage.

Pendergrass et al.[12)-14)] used, as control, a water-barium meal containing 5 oz of barium sulphate and 3-5 oz. of water, in studying the effects of foods on gastric emptying and on the small intestinal pattern. In spite of some differences of the methods, however, their results were similar to ours.

Next, we demonstrated the alterations of the function of the small intestine due to the different sorts of pretreatment. When the dogs were pretreated with different sorts of breeding or fasting. They showed more marked effects of foodstuffs added to the routine barium meal than those dogs pretreated with a routine food. We regarded the alterations obtained as those due to alimentary deficiency.

When the dogs were pretreated with a carbohydrate-diet, the influences of the glucose added to the routine barium meal seemed to be reduced. A pretreatment with a fat-diet showed a slight effect. A longer pretreatment than employed in the present experimerimentation would have resulted in more marked findings.

In the Mackenzie Davidson Lecture of 1950, Golden, R.[5)] hoped in the not too distant

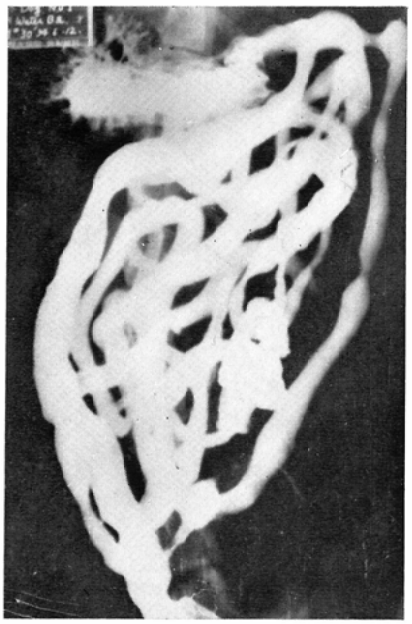

Fig. 1. A dog ingested with a routine diet. The picture was taken 1 $^{1}/_{2}$ hrs. after administration of water-barium meal.

Fig. 2. A dog kept in fasting for 3 days. The picture was taken $^{1}/_{2}$ hr. after administration of water-barium meal.

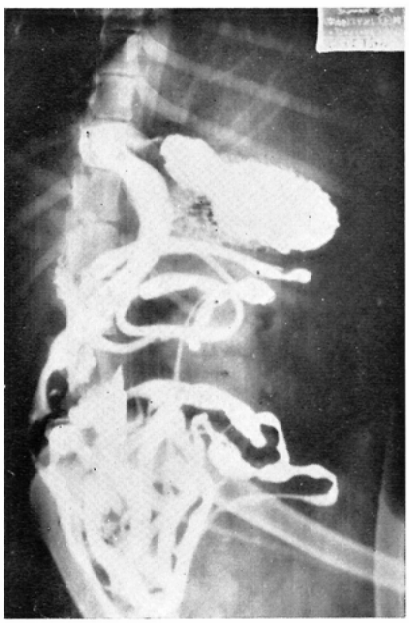

Fig. 3. A dog ingested with a high carbohydrate-diet for ten days. The picture was taken 1 $^{1}/_{2}$ hrs. after administration of water-barium meal.

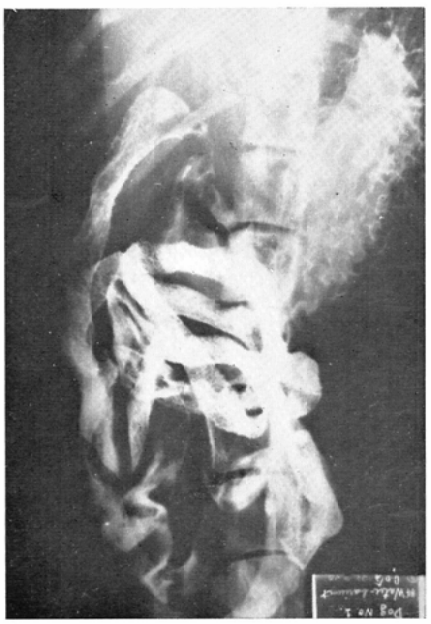

Fig. 4. A dog ingested with a high protein-diet for ten days. The picture was taken 1 hr. after administration of water-barium meal.

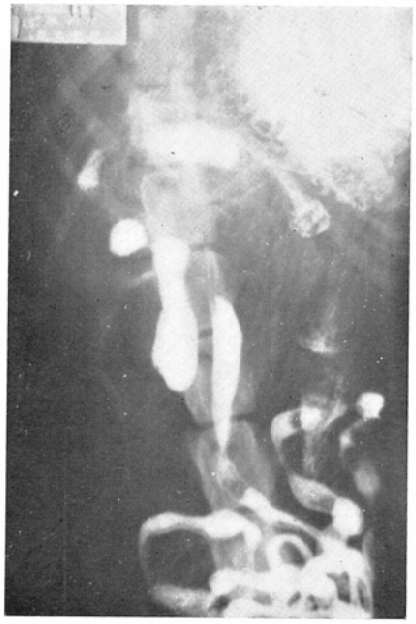

Fig. 5. A dog ingested with a high fat-diet for ten days. The picture was taken 1 $^{1}/_{2}$ hrs. after administration of water barium meal.

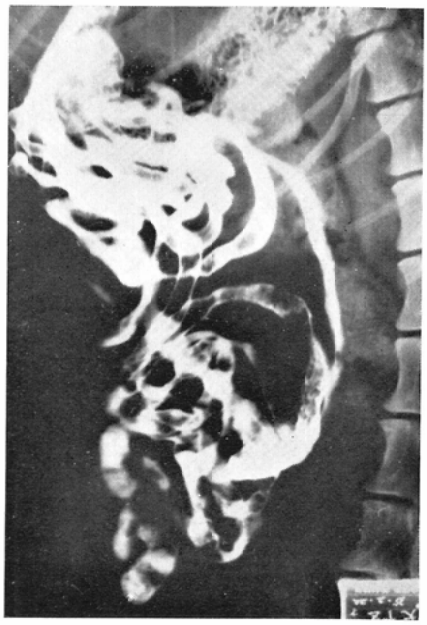

Fig. 6. A dog ingested with a routine diet. The picture was taken 1 hr. after administration of carbohydrate-barium meal.

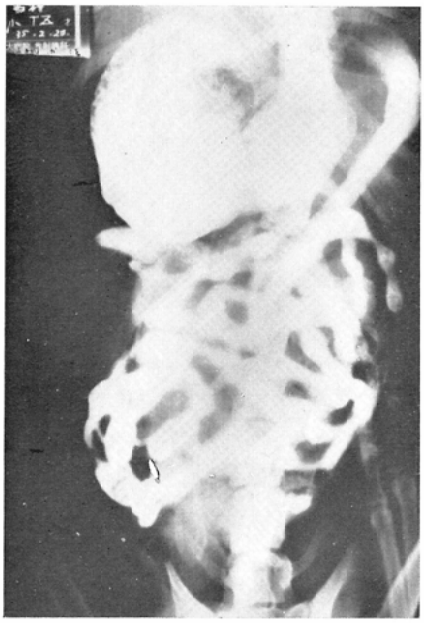

Fig. 7. A dog ingested with a high fat-diet for ten days. The picture was taken $^{1}/_{2}$ hr. after administration of carbohydrate-barium meal.

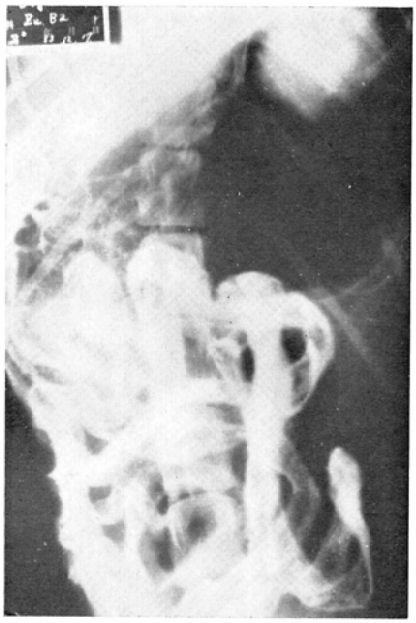

Fig. 8. A dog ingested with a high fat-diet for ten days. The picture was taken 2 hrs. after administration of carbohyerate-barium meal.

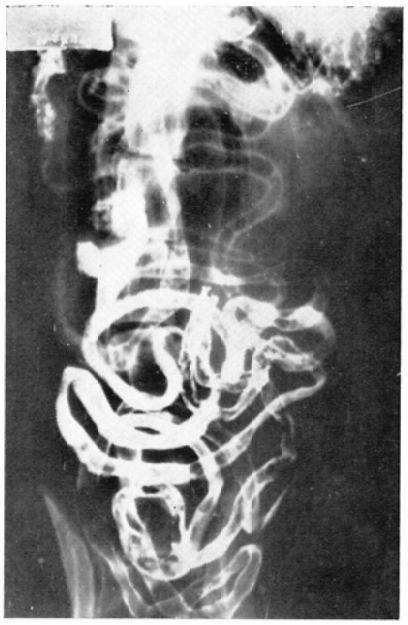

Fig. 9. A dog ingested with a routine diet. The picture was taken 1 hr. after administration of protein-barium meal.

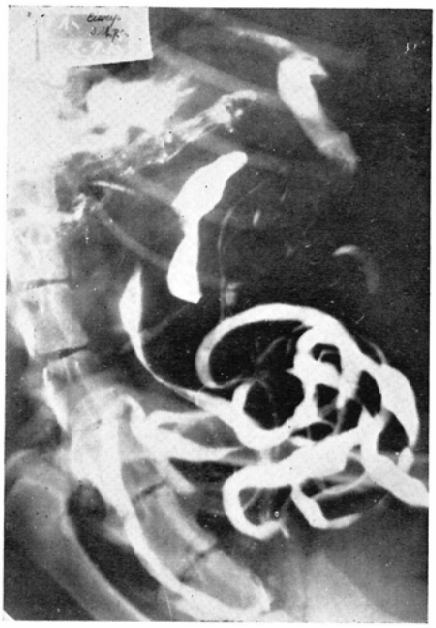

Fig. 10. A dog ingested with a high carbohydrate-diet for ten days. The picture was taken 3 hrs. after administration of protein-barium meal.

Fig. 11. A dog ingested with a routine diet. The picture was taken $^1/_2$ hr. after administration of fat-barium meal.

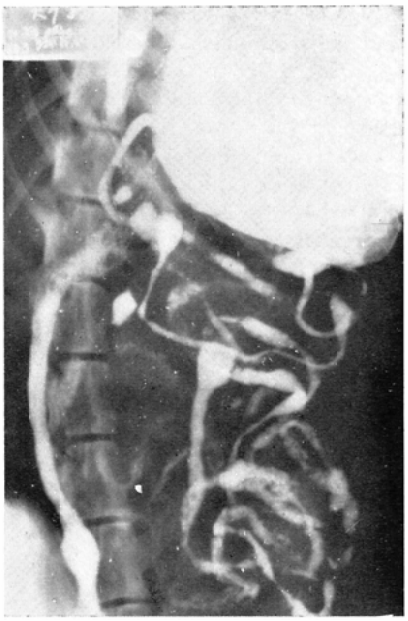

Fig. 12. A dog ingested with a high carbohydrate-diet for ten days. The picture was taken 3 hrs. after administraton of fat-barium meal.

future it will be possible to make motion picture films of the intestine which can be studied repeatedly and at leisure.

At the present time our roentgenologic study consists also of a cineroentgenographic technique through image amplifier. These films give, indeed, undoubtedly more detailed informations of the small intestinal function. Present paper will be of use only foundation for the further studies of the small intestine.

Summary

A stuby is made of the effects of various kinds of pretreatment and contrast media which contain glucose, plasma or olive-oil on the intestinal motility of dogs.

The fat-barium meal group shows the most marked difference in the experimental results from the control group (water-barium meal) followed by the carbohydrate-barium group and the protein-barium group in order.

The differences of experimental results are more markedly revealed in this order when the various kinds of pretretment are performed to all the groups.

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小腸のレ線学的研究殊に胃排出および小腸機能に及ぼす食餌の影響

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犬を対象として，胃排出および小腸機能に及ぼす食餌の影響をレントゲン学的に観察し，つぎのような結果を得た．

バリウム食にブドウ糖，ポリタミンおよびオリーブ油を別個にそれぞれ10%の割合で混じておくと，普通バリウム食の場合に比較して一般につぎのような差異を生じる．

バリウム食の胃排出は遅延する．

小腸内バリウム充盈状態は狭くて不連続なものとなる．

小腸の運動は活発となり，バリウムの流れは速くなる．

バリウムが通過した後小腸壁にみられるバリウム残渣が多くなる．

バリウムが盲腸に到達するに要する時間は長くなる．

以上のような傾向はオリーブ油によつて最も著しく，ブドウ糖とポリタミンではあまり著明でない．

つぎに，前処置として3日間絶食とする場合と，10日間高含水炭素食，高蛋白食あるいは高脂肪食を与える場合について検討した．

一般にこれらの前処置によつてバリウム食に食餌を混ぜる場合の食餌の影響が強調されるようである．前処置をより長時間とすれば，いわゆる習慣食による胃小腸の食餌に対する反応性についても言及することが出来ると考える．

人を対象とする場合については別に報告する．