Roentgenologic Studies on the Small Intestine, Especially on Effects of Foodstuffs on the Gastric Evacuation and the Function of the Small Intestine
Effects of a Hypoprotein-Diet on Human Subjects

By

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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
低蛋白食の人体に及ぼす影響

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習慣食の相違に従つて胃腸疾患の頻度は著しい差を示す．我々は食餌に対する胃小腸の反応性を検討することによつて，この興味ある事実を解明する一助としたいと考える．

前回は犬を対象とし，バリウム食にブドウ糖，プラスマおよびオリーブ油を別個にそれぞれ10%の割合で混ぜておくと，普通バリウム食の場合にくらべてみられる胃小腸の反応性の差異は，オリーブ油，ブドウ糖，プラスマの順に小さくなる事を述べた．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も検討し，一般にこれらの前処置によつてバリウム食に混ぜた食餌の影響が強調されたことについても報告した．

今回は同じ目的をもつて，成人男子を対象として，バリウム食に各種栄養素をそれぞれ10%の割合で混ぜた場合の胃小腸の反応性の差異を検討した．結果は犬においてみられたと同じ傾向を示した．すなわち，前処置として普通食を与える場合胃小腸の反応性に及ぼす食餌の影響は，オリーブ油，ブドウ糖，プラスマの順に小となる．前処置が低蛋白食の場合には，普通バリウム食によれば胃小腸は低緊張性でありバリウムが盲腸に到達するまでに長時間を要する．バリウム食に加えるブドウ糖の胃小腸に対する影響は減弱されるようであるが，プラスマおよびオリーブ油の影響は増強される．

Introduction

It is interesting how different diets may differently influence the function of the gastrointestinal tract. For instance, the Japanese live mostly on rice, while the Japanese-

American live mostly on Americanized diets (usually flesh, milk, bread, etc.) resulting in a higher incidence of gastric cancer in the former than the latter[4].

In our previous report[9], this subject was studied with dogs subjected to a three day fasting or ingested with different kinds of food for ten days. The fat-barium meal group showed the most marked difference in experimental results from the control group (water-barium meal) followed by the carbohydrate-barium meal group and the protein-barium meal group in order. Differences of experimental results were usualy more markedly revealed in this order when various kinds of pretreatment were performed to all the groups.

In the present experimentation, we demonstrated how different sorts of diet added to the routine barium meal may influence the gastrointestinal tract differently when human subjects were pretreated with a routine diet and with a hypoprotein-diet.

Methode and Results

The subjects stadied were healthy men aged between 40-50 years. In order to put them on experimental meals and to observe these influences on their gastrointestinal tract, we admitted them to our hospital. They were fed with a routine diet for about two weeks. Then clinical and roentgenological examinations were required for them before they were confirmed to be normal so that they might be employed as controls. Thus four healthy co-operative subjects who were little affected by psychological influences were selected for the study.

Experimental diets, employed were as follows:

a. Routine diet (daily)	
Calorie	2,200 Cal.
Protein	80 g.
b. Hypoprotein-diet (daily)	
Calorie	1.700 Cal.
Protein	40 g.

A study was made of the changes in the function of the small intestine due to different sorts of foodstuff added to a routine barium meal, after they were given a routine diet. Then, they were given a hypoprotein-diet before they were examined in the same way. They were checked up every weekend. They had been kept in fasting for twelve hours prior to ingestion of a contrast meal. 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.

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 gastrointestinal tract was manifested by the gastric evacuation of the barium meal, the width and continuity of the intestinal barium filling, the speed and mode of the intestinal movement and transit time, i.e. a period required for the barium meal to reach the caecum after ingestion (Table I and II).

Table 1. 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. 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	almost nothing	almost nothing	motley
Transit Time	1-2 hrs.	1-2 hrs.	1-2 hrs.	1 1/2-4 hrs.

Table II. Hypoprotein-Diet.

	Water-Barium Meal	Carbohydrate-Barium Meal	Protein-Barium Meal	Fat-Barium Meal
Gastric Euacuation Time	1 1/2-3 hrs. smooth & regular	2 1/2-3 1/2 hrs. relatively smooth & regular	1-3 1/2 hrs. relatively smooth & regular	2-4 hrs. (1/3-1/4) irregular
Width and Continuity of the Intestinal Barium Stream	wide & continuous	wide & continuous	relatively narrow & uneven	narrow & uneven
Speed and Mode of the Intestinal Movement	slow & gentle	slow & gentle	relatively rapid & active	rapid & active
Barium Meal Residue in the Intestine	nothing	almost nothing	motley	abundant, motley
Transit Time	3 1/2-4 hrs.	2 1/2-3 hrs.	2 1/2-3 hrs.	3 1/2-4 hrs.

Discussion

The present investigations of the human small intestine with a carbohydrate-barium

meal, with a protein-barium meal and with a fat-barium meal showed almost the same tendency as those of dogs. The fat-barium meal group showed the most marked deviation in the experimental results from the control group (water-barium meal) followed by the carbohydrate-barium group and the protein-barium group in order.

Mattsson, etc[5]. described a method for studying both gastric emptying time and transit time through the small intestine roentgenologically by means of a physiologic contrast medium. Their barium meal mixed with a foodstuff contained protain, carbohydrate, fat, etc. (Table III). In their 30 normal cases the barium meal required about four hours after ingestion for a whole evacuation from the stomach, spending about two hours for the first portion of the barium meal to reach the caecum. These results are similar to those obtained in the present study with the fat-barium meal.

Table III. Physiologic Contrast Medium by Mattsson, etc.

	g	Fat	Carbohydrate	Protein
Corn oil	74	74	—	—
Skim milk powder	126	0.5	50	63
Dextrose	138	—	138	—
PEG	5	—	—	—
Serum albumine	1	—	—	1
Water	1,000	74.5	188	64
mg per ml.:		60	150	50

The caloric content of the meal: 1.25 cal./ml.
PEG (polyethylenglycol) is used as a non-absorbable reference substance.

Next, a study was made of the changes in the function of the small intestine following pretreatment with a hypoprotein diet. This pretreatment resulted in a change in the deviation order, i.e., the fat-barium meal group, the proteinbarium meal group and the carbohydrate-barium meal group. These results are also correspondent to those with dogs. It was interpreted that the pretreatment might have given these subjects a habituation to carbohydrate, i.e., glucose.

There have been several roentgenologic studies made of the gastrointestinal tract of human subjects suffering from malnutrition during the wartime. For instance, Berridge and Prior[1] examined radiologically the alimentary tracts of 85 undernourished boys and 69 undernourished girls at an orphanage at Duisburg. They observed the evidence of slight gastric ptosis but could not observe the abnormality in the small intestines of 63 of the boys and 42 of the girls. In the small guts of the remainder the changes of "segmentation" and "flocculation"[2] were observed. The gastric emptying times and the small intestinal transit times were within normal limits. The alimentary tracts of 21 of the boys and 20 the girls were examined again after one year on a diet containing the German rations and unlimited amounts of bread. The results were

about the same as those previously observed. According to Hino[3], in the small intestines of patients suffering from malnutrition during the wartime, the tone was found reduced and the diameter wider in some places.

We observed similar results to the above authors except for the transit time. That is, when the water-barium meal was used, no significant difference was observed between influences of the routine diet and those of the hypoprotein diet (Table I and II). The transit time influenced by the hypoprotein diet proved longer than control. In Japan, however, the transit time of healthy human subjects is 3 to 5 hours on an average[8], so that the present data obtained seem to be within normal limits.

Pendergrass, etc[6),7)]. demonstrated that the motility of the gastrointestinal tract was reduced in patients suffering from nephrosis. According to our opinion, such decreased motility may be due to not only the disease itself but also to a prescribed diet.

Summary

A series of experiments is made on effects of a barium meal containing glucose, plasma, or olive-oil on the gastrointestinal motility of healthy human subjects, following pretreatment with a routine diet or a hypoprotein diet. The results are almost the same as those of dogs described in our previous report. The fat-barium meal group shows the most marked deviation in the experimental results from the control group (water-barium meal) followed by the carbohydrate-barium group and the protein-barium group in order, following pretreatment with a routine diet. Pretreatment with a hypoprotein-diet results in reduced influences of the subjects ingested with a carbohydrate-barium meal.

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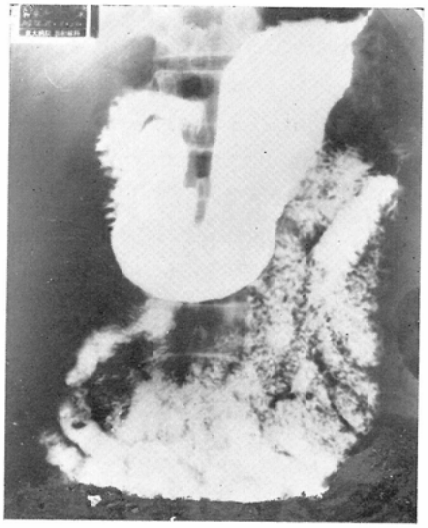

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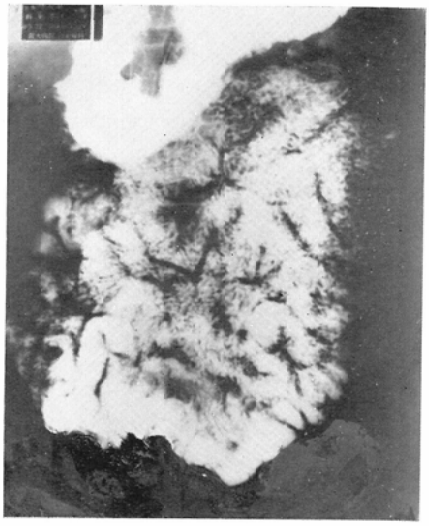

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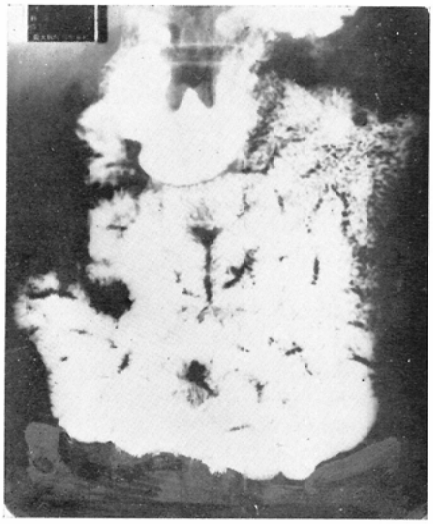

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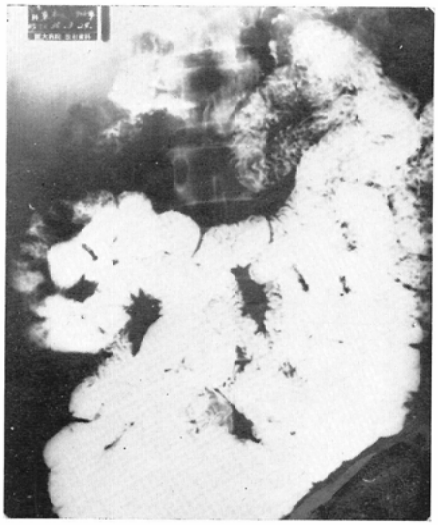

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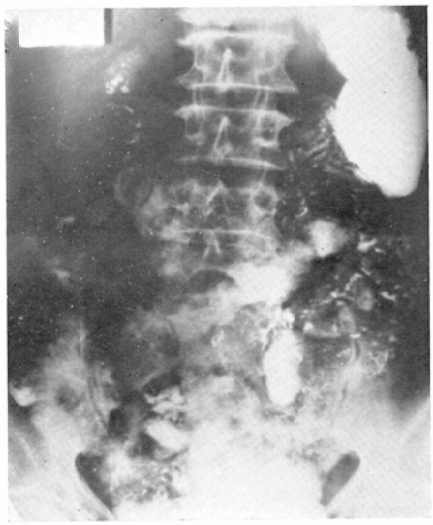
Fig. I a. A human subject was given a routine diet as the pretreatment. A contrast medium employed was water-barium meal. Intestinal barium stream ran slowly and continuously without residue. The diameter of barium stream was wide. Intestine moved gently.



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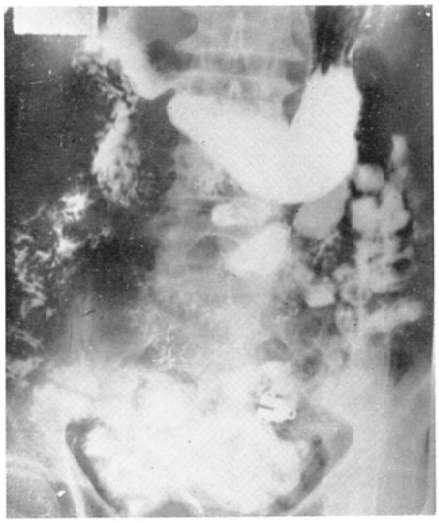

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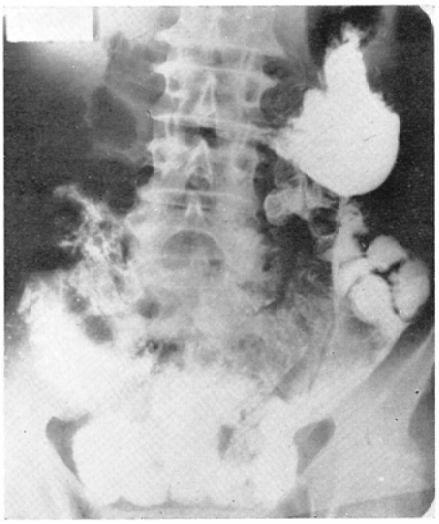
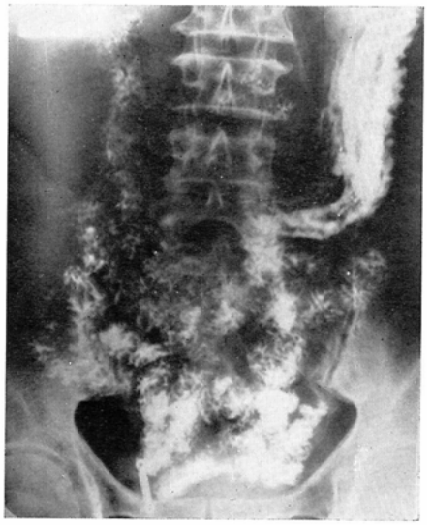


$1^1/_2$ hrs. p.c.

Fig. I b. A human subject was given a routine diet as the pretreatment. A contrast medium employed was carbohydrate-barium meal. Intestinal barium stream ran relatively rapidly and unevenly with almost no residue. The diameter of barium stream was relatively narrow. Intestine moved relatively actively.



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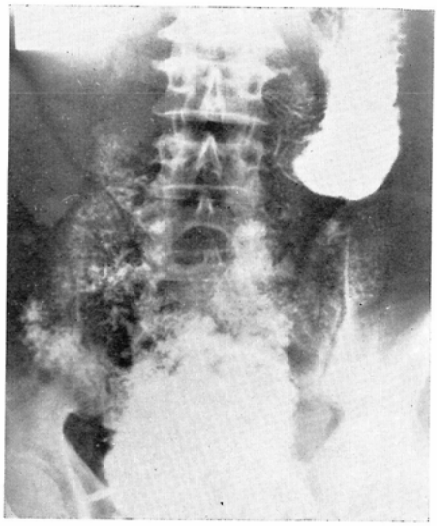

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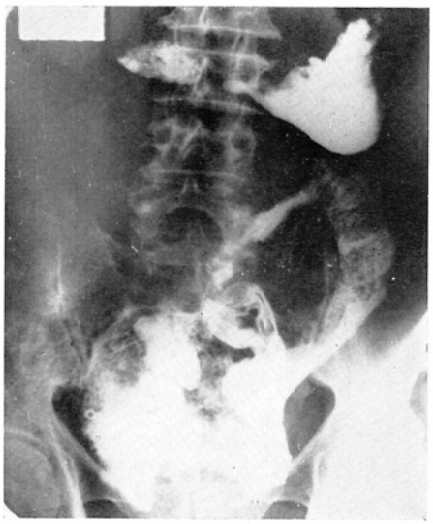
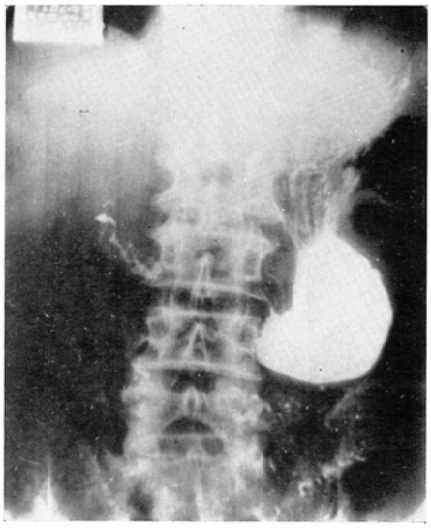


1 1/2 hrs. p.c.

Fig. I c. A human subject was given a routine diet as the pretreatment. A contrast medium employed was protein-barium meal. Intestinal barium stream ran relatively slowly and continuously with almost no residue. The diameter of barium stream was relatively wide. Intestine moved relatively gently.



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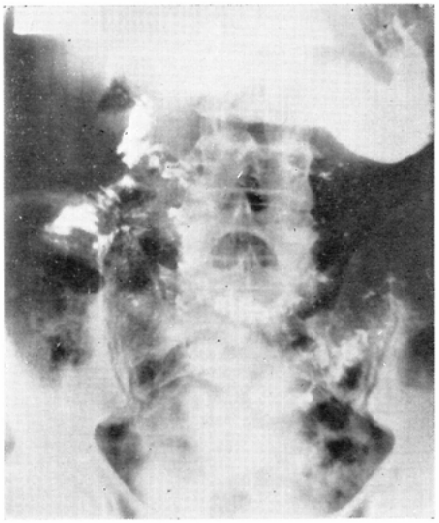

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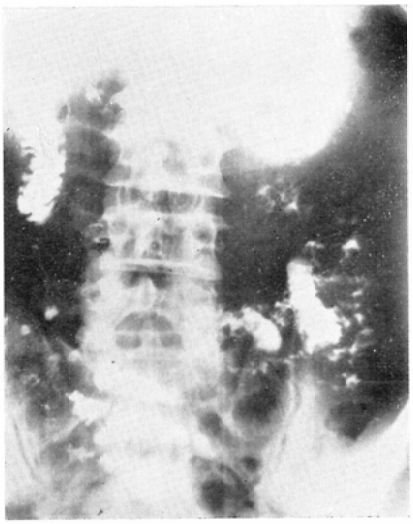

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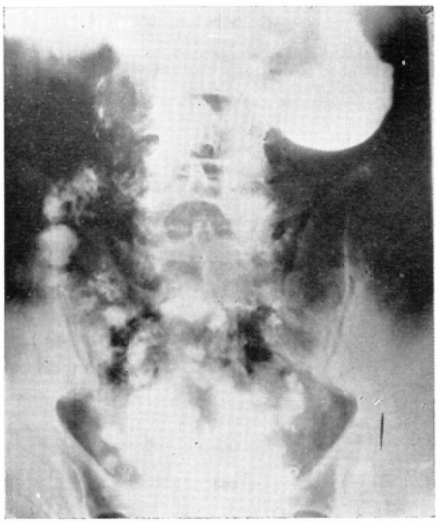

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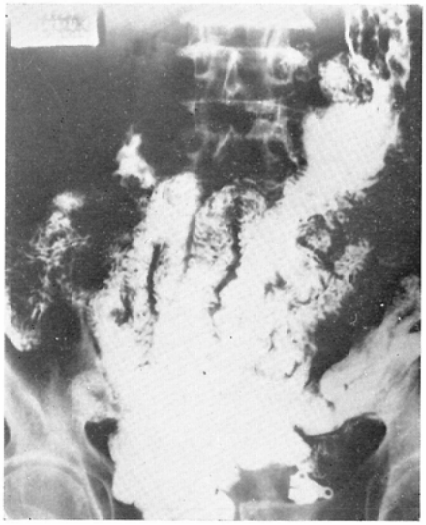
Fig. I d. A human subject was given a routine diet as the pretreatment. A contrast medium employed was fat-barium meal. Intestinal barium stream ran rapidly and unevenly with mottle residue. The diameter of barium stream was narrow. Intestine moved actively.



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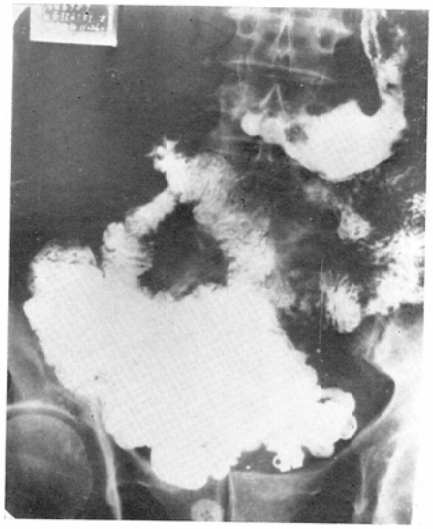

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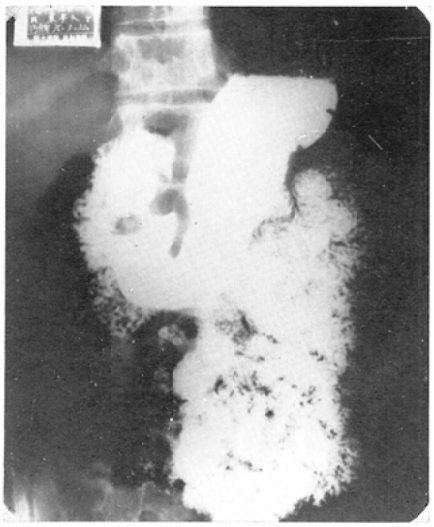
Fig. II a. A human subject was given a hypoprotein-diet as the pretreatment. A contrast medium employed was water-barium meal. Intestinal barium stream ran most slowly and continuously without residue. The diameter of barium stream was most wide. Intestine moved most gently.



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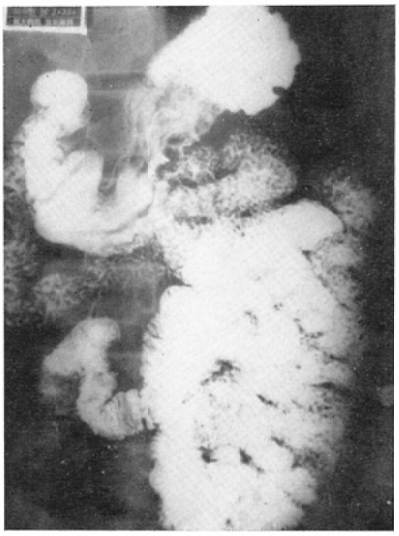

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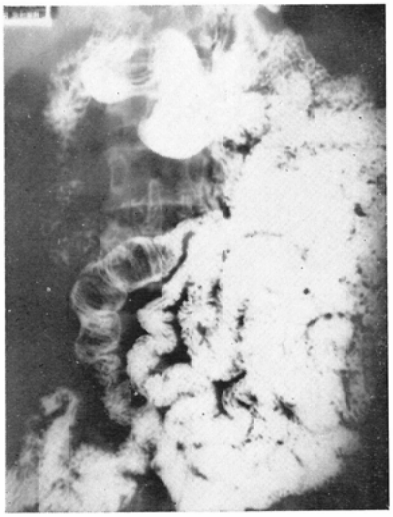

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Fig. II b. A human subject was given a hypoprotein-diet as the pretreatment. A contrast medium employed was carbohydrate-barium meal. Intestinal barium stream ran slowly and continuously with almost no residue. The diameter of barium stream was wide. Intestine moved gently.

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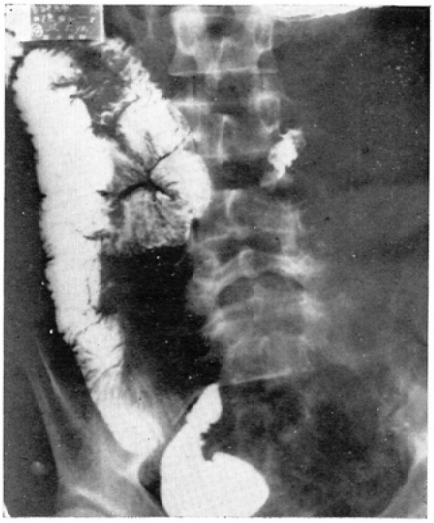

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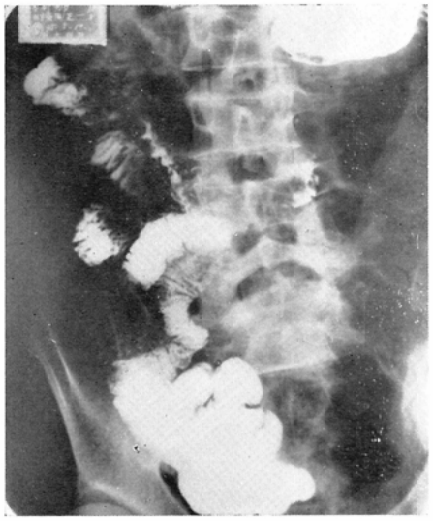

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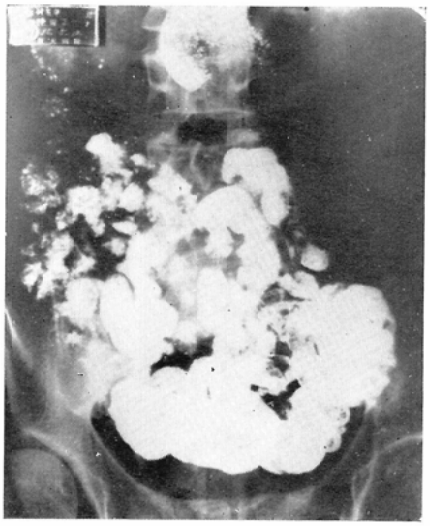

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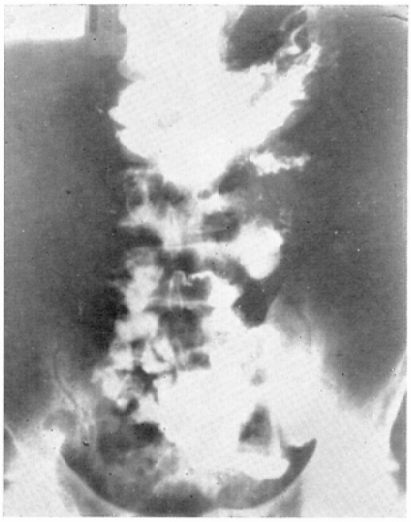
Fig. II c. A human subject was given a hypoprotein-diet as the pretreatment. A contrast medium employed was protein barium-meal. Intestinal barium stream ran relatively rapidly and unevenly with mottle residue. The diameter of barium stream was relatively narrow. Intestine moved relatively actively. (Mesontorium communic).



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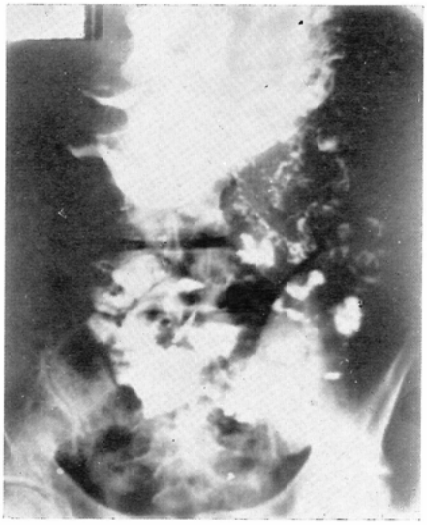

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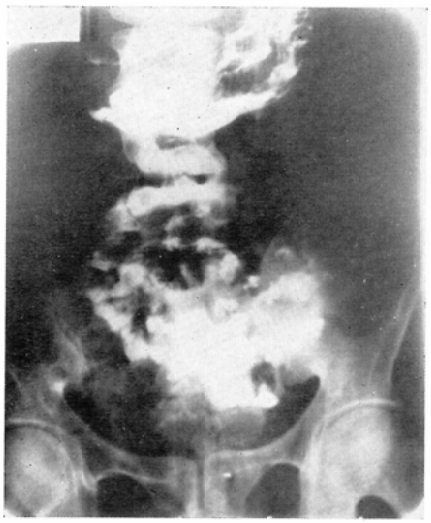

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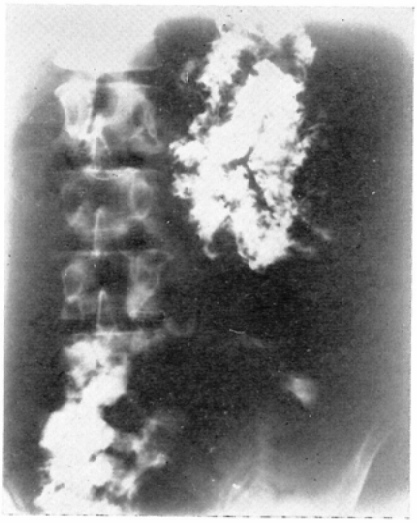

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Fig. II d. A human subject was given a hypoprotein-diet as the pretreatment. A contrast medium employed was fat-barium meal. Intestinal barium stream ran most rapidly and unevenly with mottle residue. The diameter of barium stream was most narrow. Intestine moved most actively.