

JOHN HARVEY KELLOGG (1852-1943)

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COLON AND GASTRO-INTESTINAL TRACT

CHANGING

THE

INTESTINAL

FLORA



The Sanitation of the Colon

CEREAL LACTIC

A new bacterial formula of potent, viable lactic acid-producing organisms, cultured in a powdered cereal media, yielding 1600 million bacteria to the c.c. The potency and viability are not affected by the element of time nor by changes in atmospheric temperatures.

Indications

Cereal-Lactic is indicated in all gastro-intestinal conditions where a change in intestinal flora is known to be beneficial; also in reflex symptoms due to toxins of gastro-enteric origin.

COMPLIMENTS OF
THE CEREAL LACTIC CO., Inc.
WOODWARD, IOWA

Authoritative Laboratory Analyses of Cereal Lactic Prove

173 million aciduric organisms per gram of dry material.

1600 million aciduric organisms per c. c. after culturing 24 hours.

Withstands all atmospheric temperatures and conditions ranging from 20 degrees below zero to 108 degrees above zero (F.) without loss of potency or viability.

Viability exceeds 3 years.

Clinical Results Prove

Cereal-Lactic is the most potent, viable lactic acid-producing bacilli known and substantiates the theories relative to the role of lactic acid as a healing agent and natural body antiseptic.

Due to its unusual ruggedness and its power to combat the physiological body elements and conditions ordinarily destructive to lactic acid producing bacilli, namely, gastric hydrochloric acid and intestinal putrefaction, it is a revolutionary advance over any lactic acid therapy heretofore developed.

According to the experience of 10,000 physicians who have administered over 5 million doses of Cereal Lactic, *it is the answer to the problem of the sanitation of the colon and the normalizing of the alimentary tract.*

It is palatable and easily administered. The dosage is small.

It is economical for the patient, cost less than 10c a day.

Cereal-Lactic is prepared exclusively for the profession.

You are invited to try Cereal Lactic on your most stubborn cases of chronic constipation, gastric disturbances, and colitis in any of its various forms.

(Laboratory Reports on Following Pages)

WHY CHANGE THE INTESTINAL FLORA?

One Hundred Eighty-Nine various strains of organisms have been isolated from the contents of the gastro-intestinal tract, classified as follows:

Intestinal Pathological	70 strains.	Saprophytic	49 strains.
Zymogenic	55 strains.	Non-Pathogenic	10 strains.

In so far as any of the 16 strains of STREPTOCOCCI in the intestinal tract are concerned, it may be said that all are inimical to man. To know these strains is to know half of what there is to be known about the treatment of gastro-intestinal diseases.

The unfriendly organisms in the intestinal tract, when gram-stained, show largely gram-negative; the friendly, gram-positive. To maintain an even balance between the positive and negative is the desired objective.

SANITATION OF THE COLON

It is a biological truism that practically all organisms which can cause an acute condition can also cause a chronic condition.

Hypertension, in many cases, owes its direct etiology to bowel toxins. The atonic colon is the result of chronic toxemias causing degeneration in the cells of Meissner and Auerbach plexuses, the nuclei and neurons showing distinct changes from the normal.

The most common of all causes of chronic constipation are the atrophic changes accompanied by atonic conditions in the gut wall secondary to intestinal toxemia. In ulcerative colitis, approximately 79 various bacterial strains are known as etiological factors. Intestinal toxemias are the commonest cause of the production of gastric hyperacidity, anacidity and gastric hyperperistalsis.

In some cases the toxic products in the blood act directly upon the stomach structures, and in others they act reflexly.

METHODS THAT HAVE BEEN TRIED

COLONIC IRRIGATIONS are without doubt a wholesale fallacy as a method to correct intestinal toxemias.

PURGATIONS mechanically remove quantities of toxic substances and benefit some, while in others it is harmful.

MINERAL OIL does not correct constipation, does not absorb toxic products, limits the efficiency of the digestive functions and lies in residual pools throughout the intestinal tract, which, according to the best clinicians, constitute the cause of serious lesions.

YEAST has never controlled a primary toxemia. The intestines of many people laden with yeast fungi, not only continue to harbor the infections, but are made definitely worse. Yeast has nothing scientific or biologic to sustain its advertised reputation.

DRUGS tested by the Strassburg technic have been weighed in the balance and found wanting.

When studied culturally with reference to the change in intestinal flora, some

of the accepted intestinal antiseptics are known to be positively efficient, when given only in the following prohibitive doses :

Betanaphthol	Dose required	9 grains
Copper Sulphate	"	80 grains
Creosote	"	30 minims
Phenol	"	3 drams
Resorcinol	"	45 grams
Formaldehyde	"	30 minims
Thymol	"	60 grams

THE CONCLUSION ARRIVED AT BY MANY CLINICIANS IS THAT THERE NEVER WAS, IS NOT NOW, AND NEVER WILL BE, ANY CHEMICAL SUBSTANCE WORTHY OF THE TERM "INTESTINAL ANTISEPTIC."

The Bulgarian Bacillus milk ended in disappointment.

THE L. BACILLUS ACIDOPHILUS WHEN INGESTED WILL REACH THE INTESTINAL CONTENTS IN VIABLE FORM AND KEEP THEM ACID, THEREBY CONTROLLING THE ALKALINE PRODUCTS OF PUTREFACTION. HOWEVER, DUE TO ITS LOW RESISTANCE, ITS THERAPEUTIC EFFECT IS LIMITED.

WHY CEREAL LACTIC?

The pioneer work of Moro, Tissner, Mereschkowsky, Rettger and Cheplin was not basically erroneous. The fact is still outstanding that the L. Bacillus Acidophilus of Moro and the Bacillus Bifidus of Tissner, still persist in the intestinal flora of the healthy infant in conspicuous numbers.

While it is true that people on a milk diet harbor fewer organisms in the intestinal canal than when on mixed diet, yet it is also true that the *evils of intestinal toxemia persist and recur in these same people so long as the aciduric organisms of the stool remain at 0 to 10% of the total flora.*

A long time is required to learn medical truths and it is an easy mental process to disregard and discredit a truth. Might we not serve mankind better to accept truth and resort to biological forces in accord with its significance?

NATURE'S ORIGINAL PROTECTIVE FORCES HAVE PROVEN INADEQUATE AND ARE UNABLE TO COPE SUCCESSFULLY WITH THIS PARTICULAR "CIVILIZED" PROBLEM OF GASTRO-INTESTINAL SANITATION.

Our hairy ancestors could survive the rigors of the climates, but you and I have to resort to variation in the type of our wearing apparel.

In the toxic condition of the gastro-intestinal tract, nature gave us the Bacillus Bulgaricus, Acidophilus, and Bifidus, with their stabilizing influences for normalcy. *But, either due to attenuation or added responsibility they are unable to control the existing situation.*

Our body has been sending out S. O. S. signals for a century calling for help.

CEREAL LACTIC is our endeavor to answer this call with a formula of RUGGED BIOLOGICAL ORGANISMS OF ZYMOGENIC AND ACIDURIC PROPERTIES THAT WILL MEET THE EMERGENCY.

What is Cereal Lactic?

CEREAL LACTIC Mother Culture is the resultant bacterial formula of lactic acid bacilli in which is associated organisms which have the property of changing the molecular forms of a mixed media, without harmful effects to the lactic acid forming organisms. As a result of a series of transplants, a culture is grown in a moist media of wheat and corn, finely ground and properly dehydrated, yielding 1600 million bacteria to the c. c. This Culture has an acidity of 120 degrees. These live bacterial strains exhibit the characteristics on laboratory test, culturally, in staining properties, and microscopically, of lactic acid organisms. *Cereal Lactic is the pure Culture of these Viable Lactic Acid-Forming Organisms.*

WHAT DOES CEREAL LACTIC DO?

CEREAL LACTIC is two-fold in its results. It not only has its therapeutic possibilities in the intestinal tract, but also exercises the full power of its acid content and acid-forming organisms to the task of *normalizing the stomach functions.*

CEREAL LACTIC IS SELF-PROTECTIVE

By reason of the characteristics of its bacterial content, CEREAL LACTIC provides measures for its self-defense. A protective coating for CEREAL LACTIC is contra-indicated and is undesirable in the exercise of its full therapeutic force as a remedy applicable to both gastric and intestinal medication.

CEREAL LACTIC IS POTENT

By laboratory tests it has been demonstrated that CEREAL LACTIC concentrate remains viable for *3 years at atmospheric conditions without refrigeration.* No loss of potency is noted as compared with fresh strains.

CEREAL LACTIC IS PURE

By laboratory tests it is free from contamination of any kind .

CEREAL LACTIC IS NON-TOXIC

It may be prescribed in any medicinal quantity without fear of deleterious effects upon the patient, except the possible allergy due to the cereals, wheat and corn.

CEREAL LACTIC DOES NOT CONTAIN ANY DRUGS--CHEMICALS--GLAND PRODUCTS--HABIT FORMING OR HARMFUL ELEMENTS.

RECENT LABORATORY REPORT FROM STATE BOARD OF HEALTH LABORATORY

Results of Bacteriological Examination of Cereal Lactic

1. Direct microscopic count—
Gram—positive coccoid 151,000,000 per gram dry material.
Gram—positive bacilli 5,000,000 per gram dry material.
Gram—negative bacilli 17,000,000 per gram dry material.

Total Organisms 173,000,000 per gram dry material.
2. PLATE COUNT—
Culture medium used—1% Dextrose beef infusion agar.
Temperature of incubation—37.5 degrees C.
Plate count (organisms developing colonies) 200,000 per gram of dry material.
3. Presence of Mold and Yeasts—
No molds or yeast were observed on a direct microscopic examination. A few colonies of mold developed on agar plates. The number present, however, appeared negligible.
4. Cultivation and isolation of colonies growing on dextrose beef infusion agar at 37.5 degrees C.

The colonies listed were observed microscopically and their growth in beef infusion broth and in litmus milk was noted.

1. Large gram-negative rod growing well in broth and changing litmus milk acid in 24 hours.
2. Large gram-positive rod growing well in broth and producing acid in litmus milk at the end of 24 hours.
3. Gram-negative rod, shorter than Nos. 1 and 2, growing well in broth and producing acid in milk at the end of 12 hours.
4. Large gram-negative rod probably identical with 1.
5. Test for the detection of members of the colon-aerogenes group—

Cereal-Lactic was examined by the Standard Lactose Broth method for the detection of colon-aerogenes group in various food products. The product was also examined by means of the Eijkman Method for the detection of members of this group. All tests were negative indicating the absence of contamination.

Table Showing Bacteriological Condition of Intestinal Flora Before Treatment

Age of Patient	Com-plaint	Duration of Illness	Original No. Lacto Acidophilus in Stool	C—Constipation		CH—Constipation accompanied by hepatic symptoms.	
56	C	24 yrs.	0%				
41	C. H.	6 yrs.	0%				
42	C	11 yrs.	0%				
64	C. H.	12 yrs.	0%				
39	C	10 yrs.	0%				
26	C	11 yrs.	0%				
22	C	13 yrs.	0%				
56	C	34 yrs.	0%				
24	C	11 yrs.	0%				
41	C	12 yrs.	0%				
42	C	21 yrs.	0%				
64	C	41 yrs.	0%				
35	C	6 yrs.	0%				
27	C	2 yrs.	0%				
25	C	4 yrs.	0%				
46	C	22 yrs.	0%				
23	C. H.	6 yrs.	0%				
26	C	7 yrs.	0%				
34	C	18 yrs.	0%				
84	C	61 yrs.	0%				
45	C	9 yrs.	0%				
37	C	12 yrs.	0%				
33	C	10 yrs.	0%				

Typical Reports Showing Rapid Change in Intestinal Flora to Gram-Positive GRAM STAIN ON STOOLS

(24 hours after beginning Cereal Lactic Therapy)	Date	Negative Positive	
		%	%
	Aug. 27, 1935	90%	10%
	Aug. 28, 1935	90%	10%
	Aug. 29, 1935	80%	20%
	Aug. 30, 1935	75%	25%
	Sept. 4, 1935	80%	20%
	Sept. 9, 1935	80%	20%
	Sept. 14, 1935	80%	20%
	Sept. 20, 1935	60%	40%
	Sept. 25, 1935	60%	40%
	Sept. 27, 1935	65%	35%
	Oct. 2, 1935	60%	40%
	Oct. 4, 1935	50%	50%

Conclusion: After the third day, bowels began to act better and appearance of stools improved. After a week, appetite returned and insomnia was less pronounced. Worry and anxiety were forgotten. After two weeks was able to return to work, and is now active, working, eating, and sleeping normally.

(24 hours after beginning Cereal-Lactic Therapy)	Date	Negative Positive	
		%	%
	Sept. 24, 1935	98%	2%
	Sept. 25, 1935	98%	2%
	Sept. 26, 1935	90%	10%
	Sept. 28, 1935	60%	40%
	Sept. 29, 1935	60%	40%
	Sept. 30, 1935	60%	40%
	Oct. 2, 1935	60%	40%
	Oct. 4, 1935	50%	50%
	Oct. 9, 1935	40%	60%

Conclusion: Today, 18 days from beginning of treatment I noted the following results:

1. She has less exhaustion.
2. Abdomen less tender.
3. Stools more normal in appearance and consistency.
4. Marked improvement in eczematous condition all over body.

ADMINISTRATION

Cereal Lactic can be taken with water, milk, fruit juices or any liquid or food.

For Constipation: 1 or 2 teaspoonfuls in milk after meals, for 5 days, then $\frac{1}{2}$ teaspoonful.

Intestinal medication: $\frac{1}{2}$ to 1 teaspoonful in milk after meals, 3 times daily. If administering capsules, give 2 to 4, as above.

For Gastric symptoms: $\frac{1}{2}$ to 1 teaspoonful of powdered concentrate in glass of milk or lactose water, 3 times daily after meals. If administering capsules, give 2 to 4, as above.

Nervous symptoms, headaches, body fatigue: Follow same dosage as in *gastric symptoms*.

Hypertension, arthritis, colitis, neuritis: Follow same dosage as in *constipation*

Infants: Beginning at birth, give the measure of $\frac{1}{2}$ of a "00" capsule; before each nursing. Moisten in a spoon with milk and place in baby's mouth just prior to nursing.

Children: 7 to 12 yrs. of age: $\frac{1}{4}$ to $\frac{1}{2}$ teaspoonful of powdered concentrate, 3 times daily, can be given in cold milk, lactose water, prune juice or cold cereal.

Eczema: Prepare CEREAL LACTIC acid water by adding $\frac{1}{2}$ oz. of powdered CEREAL LACTIC to 1 pint of luke warm water. Allow to stand 1 hr. and sponge eczematous areas twice daily. In addition, administer CEREAL LACTIC in generous doses internally.

Chafing and Galding: Sponge affected parts with CEREAL LACTIC acid water 2 or 3 times daily. N. B.—when applying CEREAL LACTIC acid water, do not dry the areas treated by wiping with towel or cloth.

NOTE:- Directions for making lactose water: 1 heaping tablespoonful powdered lactose to one pint luke-warm (not hot) water, to which add the dose of CEREAL LACTIC at time of administration.

COMPLIMENTS OF
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WOODWARD, IOWA

DOCTOR TISSIER
and
His Work at the Pasteur Institute

Comprising a Summary of Dr. Tissier's Researches on the Bacteria
of Putrefaction and of the Intestinal Flora in Infants,
Children and Adults

BY
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TRANSLATOR'S NOTE

The translator had the honor of knowing Dr. Tissier personally for many years, and mourns his loss as a friend. The doctor was for some years consulting bacteriologist to the Battle Creek Sanitarium and rendered important service in the development of the dietetic methods of changing the intestinal flora in use at that institution. For more than twenty years prior to his death, Dr. Tissier followed closely the biologic regimen, abstaining from meats of all sorts because of the observations made in his laboratory referred to in Prof. Besredka's account of his work. He also required his patients to follow closely the same diet which he termed the "vegetalien regimen."

The reader will find in this brochure the first authentic account which has appeared in English of the true genesis of researches in relation to the normal and abnormal intestinal flora. Dr. Tissier, unfortunately, contributed few papers concerning his researches although he was an incessant worker and as Dr. Besredka says in concluding his résumé of his activities "was justly considered one of the best specialists in disorders of the digestive tract in France."

JOHN HARVEY KELLOGG

DR. TISSIER AND HIS WORK AT THE PASTEUR INSTITUTE

BY PROF. A. BESREDKA

Pasteur Institute, Paris

Henry Tissier was born at Roanne, Loire, October 17, 1866, and died at Paris, December 31, 1926. His life was one of incessant activity. He was the son of a carriage maker and began his education in the school of



his native village. Later he entered college at Compiègne. Having received his diploma as bachelor, he went to Paris, as he had long desired to do, and matriculated at the Faculty of Medicine.

From the beginning of his medical studies Tissier was greatly impressed by the ravages of gastro-enteritis among young infants. Having made himself familiar with the current literature of the question, he noted that works upon the etiology of this disease were full of contradictions. While still a young interne he conceived the idea of devoting himself to the study of the intestinal flora. He made known his ambition to his friend, Veillon, who presented him to Professor Grancher, of the Pediatric Clinic, by whom he was given an opportunity to work in the laboratory of the Pediatric Clinic. There were at work at that time in the laboratory under the direction of Veillon a sextet of highly talented investigators who were devoting themselves to the study of anaërobic microbes; namely, Zuber, Hallé, Rist, Auclair, Cottet, and Guillemot. Tissier could not have found a more favorable field for undertaking a study of the intestinal flora. So he entered upon the work with great energy and during four years devoted his entire time to work in the laboratory of the Hospital for Sick Children. At the end of his internship he published a remarkable monograph entitled, "Researches Upon the Normal and Pathological Intestinal Flora of the Nursing Infant," which he presented as his inaugural thesis in receiving his degree as Doctor of Medicine in 1900.

At this time Metchnikoff and his numerous students were studying old age and the rôle played in senility by the intestinal flora. Evidently the place for Tissier was at his side. Tissier left his own laboratory at the Hospital for Sick Children and entered the Pasteur Institute where he remained until his death.

For a long time bacteriologists had been endeavoring to determine the composition of the intestinal flora. The hope was that by an understanding of the nature of the intestinal flora it would be possible to make clear on the one hand the rôle of bacteria in the numerous fermentations which developed in the intestine in the normal state, and on the other hand to determine their rôle in digestive disorders, especially in the disorders of young infants who, as is well known, suffer a high mortality rate from intestinal disorders. But prior to the researches of Tissier it had been nearly impossible to establish a distinction between a pathologic and a normal flora, and still less between the different varieties of pathogenic flora. When the microscope revealed two or three species the bacteriologist found a great number derived for the most part from atmospheric dust. On the contrary, when the direct examination showed a varied flora it was possible to isolate only one or two species.

These paradoxical observations were evidently due to the imperfection of the technic employed. It was necessary then, before beginning the study of the pathogenic flora of the intestine, to perfect a dependable method which would give constant results, and then by the aid of a perfected technic to study the normal intestinal flora.

Such was the plan that Tissier marked out for himself and which developed, as we shall see, in the most brilliant manner.

After having described in detail the technic of culturing the stools and the method of culture, he studied both normal and pathological stools in breast-fed infants, in bottle-fed infants, and in young children taking a mixed diet. It was only after a minute study of the microorganisms observed in these different classes that Tissier approached the problem of the physiologic rôle of the intestinal flora in gastro-enteritis of nurslings.

Let us note in passing that in the course of these researches Tissier found some species which had not previously been described: *Bacillus bifidus communis*, *Bacillus exilis*, *Bacillus minutus*, *Coccobacillus perfoetens*, *Diplococcus griseus liquefaciens* and a streptococcus which was negative to the Gram stain.

THE NORMAL FLORA OF THE NURSING INFANT

According to Tissier, the digestive tube of a breast-fed infant is at first sterile. The first bacteria make their appearance between the tenth and the twentieth hours after birth. Bacteria appear even before food has been administered. One sees at first small cocci (*Staphylococcus albus*) and with them coccobacilli which lose their color with the Gram stain. At the end of twenty-four hours, when feeding usually begins, the *Bacillus perfringens* (Welch's bacillus) and the *Bacillus III* of Rodella appear and then progressively the following organisms appear and become very numerous toward the third day; namely, *Coccobacillus perfoetens*, *Bacillus lactis aërogenes*, enterococcus, Sarcinae. After this time this highly varied flora tends to become simpler. A diplobacillus with slender extremities (*B. bifidus*) develops rapidly. The other bacteria disappear gradually until the intestinal flora seems to consist almost exclusively of the one species, *B. bifidus*. This flora remains constant so long as the breast feeding continues, but the least error in diet or the least fault in hygiene will react upon the flora injuriously and this effect will become apparent even when neither the weight nor the external appearance of the child give indication of anything wrong.

In bottle-fed babies the phase of increasing infection is more prolonged than in breast-fed infants. Yeasts and certain varieties of Sarcinae are found in the stools. Many species of bacteria are present. Besides *B. bifidus*, *B. coli* and the enterococcus there exist in equal numbers the *B. acidophilus*, *B. exilis*, *Staphylococcus albus* and *B. lactis aërogenes*. Of all these different species no one is predominant.

In infants taking a mixed diet, if cow's milk is given from birth the flora resembles that of a bottle-fed infant. If the infant begins the use of cow's milk later, as toward the sixth or eighth month, the appearance of the stool differs little from that of a breast-fed infant.

Let us see now what is the physiologic rôle of the normal intestinal flora, according to Tissier.

As shown by his researches, the digestive tube is from the first hours of life invaded by the ordinary bacteria of putrefaction which set up in the intestine a process of putrid decomposition. The presence in the intestine of the nursling of certain species of bacteria is certainly harmful for an organism which is not yet able to defend itself. These species give rise to an abnormal condition and through infection such as is encountered, as we shall see, only in well-defined pathological conditions. But, as has been said above, in breast-fed infants, the *B. bifidus*, a strict anaërobie, rapidly develops and so completely dominates the *B. coli* and the enterococcus that the action of these organisms becomes negligible.

The *B. bifidus* in acting upon sugars produces none of the volatile acids of strong odor such as butyric and valerianic acids. In its action upon peptones the *B. bifidus* gives rise to no harmful products such as indol and phenol. It even destroys the organic waste products such as urea. The *B. bifidus* opposes the invasion of the digestive tube by abnormal species and prevents them from becoming acclimated by producing such quantities of acid that their development is arrested and by removing from the residues such substances as the proteoses which are necessary for their existence.

In the bottle-fed infant the situation is different. On account of the large amount of protein contained in cow's milk the food residues are greater in volume. The *B. bifidus* is not able to develop so readily in this medium as in the residues of breast-fed infants. Because of this, other proteolytic ferments [putrefactive organisms] develop equally as abundant as the *B. bifidus* and become acclimated to the intestine. It is this which explains the proteolytic properties of stools of this sort and the presence of such substances as indol, phenol, volatile acids—butyric, valerianic, etc.—which are not found or found only in small traces in the stools of breast-fed infants.

By these comparative researches Tissier has shown that in breast-fed infants the intestinal flora is inoffensive and protective and that it exercises no harmful influence upon the development of the organism.

After having studied the microbes composing the intestinal flora of the nursling, Tissier began the study of organisms which invade and become acclimated in the digestive tube of children who have ceased to adhere to a milk regimen and have adopted a more varied diet similar to that of adults. This period, known as weaning, usually begins between the twelfth and the eighteenth month and is generally completed by the third or fourth year.

Beginning with the weaning period, the flora of the infant is little by little invaded by a series of species of bacteria which tend to become ac-

climated in the intestine. At the age of five years, when the infant's diet becomes essentially the same as that of an adult, the flora is constituted as follows: On the one hand a fundamental flora consisting of vestiges of the flora of the nursling and of similar composition, consisting of the *B. bifidus*, the enterococcus and the *B. coli*, with the addition of *B. acidophilus*, *B. exilis* and *B. III* of Rodella which are constant, and on the other hand a super-added flora of variable composition (*B. perfringens*) [Welch's bacillus], *Coccobacillus proecutus*, *Staphylococcus parvulus* and some others. [The first is much the more important. It is to the second in a vegetarian child in relation of 90 to 10; 80 per cent of the colonies are still formed by the *B. bifidus*.] In a child taking a mixed diet the relation changes to 80-20; 70 per cent of the colonies are formed by the *B. bifidus*. In an infant fed with animal protein this relation is 70-30, with 50 per cent only of *B. bifidus* colonies.

The intestinal flora is no longer like that of the breast-fed infant. The chemical products of the intestinal bacteria are not offensive. While little harmful in a vegetarian child, this mixed flora becomes more injurious in a child receiving a mixed diet and still more harmful in a child taking considerable quantities of protein substances of animal origin. This harmful action is chiefly due to the superadded flora of which certain organisms possess pathogenic products and are even capable of giving rise to gangrenous processes. In general the richer the intestinal flora is in super-added organisms the more intense will be its injurious action.

The microbes of the fundamental flora, on the contrary, possess, as in the flora of the nursling, protective properties. A diet which will enable these organisms to live in the digestive tube and there maintain a preponderate activity will be the best diet.

These views of Tissier find full confirmation in daily medical practice.

Desiring to penetrate still more deeply the processes of fermentation and putrefaction which occur in vivo, Tissier had the idea to attempt to reproduce them in vitro by reproducing natural conditions as closely as possible. He proposed especially to study the mechanism of putrefaction in two principal aliments, butcher's meat and milk.

For a long time the bacteria putrefaction or decomposition of the protein molecule had attracted the attention of investigators. Let us recall that it was Pasteur who first in 1877, in studying the septic vibron, demonstrated the existence of a bacterium endowed with proteolytic power. He proved the existence of anaërobic life and established the primordial rôle in putrefaction of organisms capable of living without air. Twenty years later Veillon and then Zuber, then Hallé, Rist, Guillemot and Cottet in a series of studies of great interest demonstrated that in all pus with putrid odor there always exist anaërobes and often anaërobes only. It is then probable that in the destruction of dead albuminoid matters anaërobes

would also be found. This Bienstock demonstrated in 1900 in his studies of *B. putrificus*.

This last proteolytic anaërobe, by reason of its resemblance to the *B. bifidus*, especially attracted the attention of Tissier, and so much more because the protective action exercised by the *B. coli* and *B. lactis* and *B. putrificus* recalled the protective action of the normal flora of the nursling against certain abnormal organisms. "These two protective processes," said Tissier, "must be due to the same cause." It was thus that he was brought to isolate the *B. putrificus* from decomposing flesh and then to study the other species found developing in decomposing flesh in symbiosis and to determine their respective actions.

These researches had necessarily been very tedious and prolonged. Our knowledge concerning the chemical constitution of albuminoid matters is as yet rudimentary. It is consequently not possible to determine the exact chemical action of the various species of proteolytic organisms.

But incomplete as were the researches undertaken by Tissier and his collaborators, Martelly and Gasching, they must be regarded as among the most important that have been made in relation to the putrefaction of alimentary substances.

Meat taken from the slaughterhouse as fresh as possible already contained all the bacteria necessary for its complete putrefaction, germs which will multiply only when the medium is favorable to their development.

At first the fermentation of sugars is active, there being at the same time a slight attack upon the albuminoids. Cultures show aërobes, mixed ferments such as *Micrococcus flavus liq.*, *Staphylococcus albus*, *B. coli*, *Streptococcus pyogenes*, *Diplococcus griseus non liq.*, *B. filiformis*.

At the end of three or four days the acid reaction is less pronounced. Changes in the albumins are much more active. The odor begins to be slightly putrid. The medium being deoxidized, anaërobes make their appearance. As yet only the mixed ferments are present such as *B. perfringens* and *B. bifermentans sporogenes*.

At the end of 8 or 10 days the sugar has disappeared. The saponified fatty matters have become ammonia soaps. Glycerin is burned (oxidized). The odor is very fetid. The presence of indol, phenol, hydrogen sulphide and ammonia indicates the rapid destruction of protein. The pure proteolytic ferments, *Diplococcus magnus anaërobius* and *proteus*, are present.

At the end of three weeks only the most resistant species survive along with the products of bacterial action. At the end of four months the flesh has become a black, viscous, odorless mass. It no longer contains peptones. The only microorganisms remaining are *B. putrificus* and *B. gracilis putidus*. Such in brief is the process of putrefaction in contact with the air.

When the culture medium is deprived of air the appearance of anaërobes is more rapid but occurs in the same order.

In brief, in the putrefaction of the flesh of beef, Tissier distinguished two phases:

1. A phase in which mixed proteolytic and peptolytic ferments destroy sugar and attack albumin.

2. A phase in which pure proteolytic ferments complete the destruction of albumin and its ultimate derivatives.

As we have seen in the putrefaction of the solid substance of flesh, composed for the most part of albuminoid matters and a relatively small quantity of carbohydrate, the destructive process is eliminated by proteolytic anaërobes. It remains to be seen if the destructive process obeys the same laws in milk where the proteolytic matters are in solution or in suspension and where hydrocarbons are present in large amount.

This study, so far as it relates to meat, has been undertaken for the purpose of facilitating researches in relation to the intestinal flora and to throw light upon the pathology and physiology of the intestinal flora.

In the case of milk, as in that of flesh, the breaking up of the albuminoid matters is accompanied by decomposition of its hydrocarbons. Tissier desired to identify the organisms by which meat is the most readily invaded and to determine the order in which the destruction of its various elements—albuminoids, fat and sugars—takes place.

Tissier observed that milk as it comes from the dairy contains all the bacteria necessary for its complete putrefaction, bacteria which will multiply only when conditions become favorable.

Very soon after the milk is drawn its reaction becomes modified. There are found traces of peptone and of ammonia; the lactose diminishes slightly. Next slight changes in albumin and lactose are noted. Bacteriological examination shows the dominant species to be the enterococcus. Next comes *B. coli*. Thus in comestible milk there are already modifications due to the simultaneous action of mixed ferments and pure ferments.

At the end of two to four days the milk coagulates. By the method of Duclaux there may be shown to be present a mixture of acetic acid and another volatile acid, either valerianic or butyric acid. The dominant organism is the enterococcus. To this is due the coagulation of milk.

Three or four days after the spontaneous coagulation of the milk changes in the curd may be observed. It becomes dense and retracted. The lactose is diminished. The total acidity is increased. A bacteriological examination shows that another organism has become dominant in place of the enterococcus. This is the *Bacillus acidi paralactici*. Toward the eighth or tenth day after coagulation volatile acids appear together with the *Bacillus lactopropylbutyricus* and molds, *Oidium* and *Rhizopus*.

At the end of a month the acidity lowers. The lactic and butyric ferments are no longer the dominant species. Along with them are developed the *Bacillus faecalis alcaligenes* or other bacilli such as the *B. proteus* and *B. Zenkeri*. Molds, playing the rôle of proteolytic organisms, destroy the casein and gradually neutralize the medium.

At the end of three months the casein is transformed into a viscous mass. The layer of molds detaches itself. Simple ferments develop in their turn, among them proteolytic bacteria.

At the end of ten months there remains only a fetid, yellowish deposit. Chemical analysis shows leucin, tyrocin, a quantity of fatty acids and ammonia. Peptolytic bacteria have completed the destruction of the ultimate derivatives of the albuminoid substances.

This, then, is the usual program in the fermentation of milk. At first a phase in which mixed ferments cause a complex acid fermentation, then a lactic fermentation and finally a lactic, propionic, butyric fermentation. Molds destroy the acid products and attack the casein. Finally, simple ferments complete the destruction of albumins and its derivatives.

It appears, then, that while in a general way the putrefaction of milk resembles that of meat, it is evident that in the details there are differences, particularly in the longer duration, the lessened putridity and the constant presence of molds.

After having thus shown that the process of fermentation is essentially the same for the albumins of the muscles and those of milk, Tissier wished to determine if other proteins are attacked in like manner by bacterial diastases. This was a question of great importance for both the biologist and the physician. To establish an appropriate dietary should always be, in the mind of Tissier, regarded as the most important duty of hygienists and physicians.

For these new researches Tissier has chosen the principal proteolytics concerned in the spontaneous putrefaction of butcher's meat; namely, *B. perfringens*, *B. putrificus* of Bienstock, and *B. proteus*. To these he added two other powerful proteolytic organisms found in the human digestive tract, *B. sporogenes*, isolated and studied by Metchnikoff, and *B. colicogenes*, isolated by himself from the stools of an infant suffering from diarrhea with violent colic pains.

Tissier cultured these five organisms in great flasks of peptonized water containing a certain quantity of albuminoid matter—blood albumins, the yolk of egg, the white of egg, vegetable albumin and fibrin, fat-free flesh, milk, cheese, lentils, beans and cereals. To determine the amount of albumin destroyed he determined the nitrogen present both before and after the culture.

It was shown by these experiments that albumins differ very greatly in their resistance to bacterial diastases. The albumins most readily at-

tacked were those of the white of egg. Next in decreasing order come the albumins of the yolk of egg, then those of milk, cheese, flesh and fibrin, and last of all vegetable albumins of which the most resistant were the albumins of legumes. These showed double the resistance of animal albumins. For a given weight of albumin destroyed, the albumins of legumes gave twice as large a quantity of acid amines, while the proteins of cereals gave no more than the proteins of animal origin.

The physician or the hygienist who wishes to establish a rational dietary should not lose sight of the fact that if vegetable proteins are less digestible they are at the same time only half as putrescible, a matter of very great importance.

These studies have thrown light upon the etiology of certain gastrointestinal infections. Thus, to cite a single example, Tissier has observed that in the presence of a pure albuminoid, *B. perfringens* (Welch's bacillus) shows little activity, less than that of facultative aerobic bacteria. But when in addition to albumin a hydrocarbon, sugar or starch, is present, the vitality and activity of *B. perfringens* is greatly increased. Cultured in milk, it destroyed three-quarters of the casein present before the acidity of the culture medium became sufficient to arrest its growth.

This explains the cause of the gastro-intestinal troubles observed in certain patients subjected to a diet of cereals mixed with milk or eggs. Such a diet produces gaseous distention of the bowels, colic and liquid, frothy stools which cease at once when the diet is confined to meat or meat and eggs. In these cases the gastro-intestinal flora contains numerous strains of *B. perfringens*, the activity of which is doubled in a medium consisting of a mixture of albumin and starch.

When the digestive residues contain only albumin, fermentation diminishes and changes in type. Gas is no longer produced. The stools are no longer soft and frothy. They become compact and fetid. However, the cause of the disease has not disappeared and whenever food rich in starch is taken the old symptoms return.

Tissier has thus demonstrated by his researches how important is the study of intestinal putrefaction both from the point of view of the growth and development of the human organism and that of the genesis of infections of the digestive tube.

As regards infants, he has demonstrated that by reducing to a minimum the putrid fermentation of the alimentary residues the liability to intestinal infections is greatly diminished, while on the other hand the danger of infection is doubled by a diet containing an excess of protein.

The World War compelled Tissier to interrupt his researches upon the intestinal flora and instead to undertake the study of war wounds. Being called to examine from a bacteriological point of view wounds of all sorts, Tissier made an observation which had for the treatment of

wounds a practical importance of the first order. He especially noted that when wounds contain streptococci it is necessary to avoid closing them, otherwise failure is certain to occur. Some thousands of human beings have been saved during the war, thanks to this observation of Tissier, which still retains all its value in times of peace.

This brief note, which has for its purpose to present a summary of the scientific work of one whose labors have been an honor to the Institute Pasteur, will be incomplete if we do not add that while Tissier devoted his life to laborious and continuous laboratory research, he was in addition a devotee of art and especially of sculpture. He was also a highly trained practitioner and was justly considered as one of the best specialists in disorders of the digestive tract in France.

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Colitis—The Spastic Type

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COLITIS—THE SPASTIC TYPE *

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A discussion of any type of colon dysfunction is apt to elicit differences of opinion, especially since the lower part of the gastro-intestinal tract has not been as carefully studied as the stomach and duodenum, with the result that our information has not been so accurately summarized. In the literature, the older classifications have been clung to, but in practice they are being found unsatisfactory and not in keeping with more recent observations. The work of the roentgenologist completely changed the ideas of colon function, and it is now recognized that the majority of cases of intestinal stasis result not from atrophy but rather from undue muscular tonus secondary to abnormal nervous stimuli, this being particularly noticeable in the distal portion. Atonic changes may be observed at times in the proximal colon, as indicated by dilatation of the cecum and ascending colon.

Employment of the term colitis in describing this condition invites criticism, as in many cases definite inflammatory changes are not observed by sigmoid examination or found on examination of the stool; nevertheless, the clinical manifestations are such as to warrant the use of the term if only for convenience. Hurst¹ would apply the term enterospasm to this group of cases and reserve the term colitis for the ulcerative types. In my use of the term I am in accord with many of the recent observers. Dawson² is of the opinion that, if the condition is primarily due to disordered function and inflammation is only an added and not a constant feature, and if the disturbance is not limited to the colon, it might be objected that colitis is

* Read before the Section on Practice of Medicine at the Seventy-Ninth Annual Session of the American Medical Association, Minneapolis, June 13, 1928.

1. Hurst: *Essays and Addresses on Digestive and Nervous Diseases*, 1926.

2. Dawson, B.: *The Colon and Colitis*, *Brit. M. J.* **2**: 31 (July 9) 1921.

a misleading name. No name, however, has been suggested to take its place, and for complex clinical conditions comprehensive titles are difficult to devise, and convenient labels have often had to serve; meanwhile, colitis has the advantages of usage, brevity, and therefore of convenience.

ETIOLOGY

The etiology of spastic colitis has not received the attention by the profession that it deserves, though the persistence of symptoms and the resulting incapacity are so serious as to demand careful consideration. My observations lead me to conclude that an unstable nervous condition is the most prominent etiologic factor. I have reviewed a large number of cases showing symptoms of spastic colitis and find that the majority exhibit a definite neurosis, while a careful history warrants the conclusion that exacerbations in the severity of symptoms practically always follow some nervous disturbance. There appears to be a fear complex which must be taken into consideration before the trouble can be thoroughly understood and treatment properly outlined. To anticipate relief by attempting to correct only the intestinal stasis is usually doomed to failure, as with the neurosis still persisting it is but a little time until the symptoms recur.

The patient may be inclined to attribute his nervousness to constipation, and in all probability obstinate constipation may frequently be the cause of a psychoneurosis; but I am of the opinion that a nervous instability is always a precursor of this trouble. However, there are many observers who still believe that the symptoms of spastic constipation result from the irritation caused by retained fecal matter in the distal colon. There are others who believe that the trouble has its origin in the use of drugs, particularly purgatives. It is true that in this trouble drugs have been employed and in many cases for a long time, and there is no doubt that they do have a disturbing effect locally; but I would consider them as a factor in causing exacerbations of the trouble rather than as being a true etiologic factor.

The close relationship existing between spastic colitis and the so-called mucomembranous colitis, a condition generally recognized as having a definite neurologic basis, would further warrant this conclusion as

to its etiology. The presence of mucus is observed at times in a large percentage of these cases, as at least 18 per cent of the patients mentioned this in their histories and mucus was found in abnormal amounts in the fecal analyses in a much larger number; yet in none were the symptoms such as would warrant a diagnosis of a typical mucous colitis. I sometimes find it difficult to differentiate between mucous colitis and spastic colitis except by the amount of mucus observed in the examination of the stool. It is true that the patient suffering from mucous colitis frequently passes nothing but mucus, often in the form of molds or casts, usually following an attack of rather severe abdominal pain, but I would conclude that these are the more severe cases of spastic colitis and that the only differentiation between them is in the severity of symptoms. The subject of mucous colitis has been so thoroughly studied by those believing it to be a disease entity that to repeat that discussion here is unnecessary. The reader may be referred to the works of Herschell and Abrahams,³ Hemmeter,⁴ Woodward,⁵ DaCosta,⁶ and Nothnagel.⁷ These authors arrived at their conclusions on what would now be considered insufficient evidence to make a proper diagnosis. It may be concluded today that spastic colitis simulates very definitely a mucous colitis, and probably the etiology in both cases is a disturbance in the equilibrium of the sympathetic and parasympathetic nervous effect on the distal portion of the colon.

There is a noteworthy difference in the sex incidence in this trouble. In my experience females preponderate, the ratio being about 75 to 25, although other authors do not find so marked a variance. It is to be noted that this ratio is practically reversed in relation to peptic ulcer. Both of these conditions are probably diseases of modern life and it is not entirely apparent why women should be so susceptible to colitis and men to peptic ulcer. It has been suggested that the preponderance among women may be due to visceroptosis. In some cases I do observe visceroptosis, but I am of

3. Herschell and Abrahams: *Chronic Colitis*, New York, Longmans Greene & Co., 1914.

4. Hemmeter: *Diseases of the Intestines*, Philadelphia, P. Blakiston's Son & Co. **1**: 483, 1909.

5. Woodward: *Medical and Surgical Report of the Civil War* **2**.

6. Da Costa: *Am. J. M. Sc.*, October, 1871, p. 37.

7. Nothnagel: *Diseases of Intestines and Peritoneum*, Philadelphia, W. B. Saunders Company, p. 224.

the opinion that it is a result rather than a cause. In a recent article Carslaw⁸ discusses right-sided visceroptosis exhaustively, and while recognizing the nervous element in the causation, he is still of the opinion that the intestinal dysfunction may be responsible for the nervous instability in a certain proportion of cases. The trouble may have had its inception in a fear complex acquired in infancy or early life, and if recognized early much can be done to correct it; but when the symptoms are so severe as to annoy the patient almost constantly and these patients begin to notice on inspection of the feces the presence of mucus, relief is much more difficult to obtain. This is the type of case in which the patient becomes so introspective, and so analytic of his abdominal symptoms, as gradually to abandon interest in everything else and live only for his lower bowel.

There has recently been a craze among women of all ages to acquire a silhouette figure. Reduction in weight has been sought in many ways and has resulted in a weakened physical and nervous resistance and an undermined abdominal support; frequently a spastic colitis has developed with a coincident visceroptosis. Moreover, the intemperate indulgence in intestinal irrigations has in some parts of the country been a decided factor in aggravating the colon irritation and may also be a factor in the causation of spastic colitis. It is possible that the irritation resulting from retained feces may be a factor in producing the enterospasm and, as a result of absorption in the proximal colon, toxins may have a local irritating effect and may also be disturbing to the nervous mechanism both centrally and peripherally. In many of my cases a polyneuritis has been observed, the intercostals being especially involved. The age when the condition is most frequently seen is early and middle life, though it may also be encountered late in life if there is sufficient disturbance of the vago-sympathetic nervous mechanism. The third and fourth decades, when the individual encounters the greatest stress and strain of life, apparently produce the larger number. It has also been observed in the very young, some cases being reported as early as at 4 or 5 years.

SYMPTOMATOLOGY

A complete review of the symptomatology of spastic colitis would extend the limits of this paper unduly;

8. Carslaw, R. B.: *Brit. J. Surg.* **15**: 545 (April) 1928.

therefore, only a few of the more prominent symptoms will be mentioned. A history of chronic constipation, averaging more than ten years in duration, was noted in a series of 100 cases recently reviewed. Cathartics and enemas had been used with unsatisfactory results. Abdominal pain was a more or less constant symptom, simulating organic conditions such as chronic appendicitis, cholecystitis, and gastric ulcer. Twenty-two per cent had been subjected to appendectomy with little or no improvement, and in many instances the nervous and abdominal symptoms were more severe following surgery. Five per cent had submitted to cholecystectomy with no improvement. It is true that these cases had not been satisfactorily studied; an x-ray examination of the gastro-intestinal tract had been neglected in many of them and cholecystography had not been resorted to in any of them. Many of the women had submitted to pelvic operations—dilation and curettage, shortening of the ligaments—for relief of a dysmenorrhea complicating the spastic colitis, with but little relief.

The majority of these patients complain of chronic fatigue and usually exhibit a low blood pressure. They are apt to be underweight and complain of chronic indigestion with abdominal flatulence. The abdominal pain, usually located in the lower abdomen along the course of the pelvic colon, is at times cramping in character and very severe, or it may be a persistent dull aching discomfort. Borborygmus is present in many cases and is very troublesome. The patient reports lead pencil stools, which may be unduly dry or putty-like in consistency, and complains of abdominal distress and irritation following the use of cathartics, especially in the later stages. Mucus is found in abnormal amounts in the majority of cases. It may be mixed with the feces and not readily observed, or it may be found as an envelop covering the stool, and frequently is passed in the form of a pure mucous cast. Introspection and insomnia are complained of in at least 50 per cent of the cases, and periods of depression are common and may lead to a diagnosis of manic-depressive psychosis. Because of the low blood pressure, lack of libido or menstrual disorders, endocrine disturbances probably exist. There is a low basal metabolic rate, indicating a hypothyroidism, and a certain number of these patients respond satisfactorily to thyroid medication.

PHYSICAL OBSERVATIONS

The physical observations are very important. The patient is apt to be below par in general nutrition, exhibiting cold, perspiring extremities, coated tongue, bad breath, low blood pressure, and frequently a disturbance in pulse rate. In practically all cases there is a spastic, ropelike pelvic colon observed on palpation, and the sensitiveness over this area is very definite, the pain under pressure being frequently referred to the region of the cecum. In a certain proportion of cases, in addition to the general tenderness along the pelvic colon, there is marked tenderness over the cecum and ascending colon, the contraction of the pelvic colon causing a dilatation with possibly a catarrhal irritation resulting. It is because of this tenderness involving the cecum and ascending colon that so frequently a diagnosis of chronic appendicitis is made and the patient referred to the surgeon for appendectomy. The operative results are not satisfactory; the constipation is not relieved; the tenderness is made worse; the patient's nervous instability is aggravated, and there is often a loss of confidence in the profession on the part of the patient. Brown⁹ thinks it a wise rule never to diagnose chronic appendicitis and never to operate on such a patient without a history, definite or perhaps even indefinite, localized or with referred symptoms, which may be regarded as a probable attack of acute or sub-acute appendicitis. Frequently the cecum is found to be very low—the so-called mobile cecum—and also markedly dilated.

The x-ray study of these cases is very essential, as it tends to rule out other organic disturbances that might prevent proper diagnosis. A contracted distal colon in which the haustral markings are frequently lost, and in chronic cases a dilated cecum and ascending colon, are the usual observations. There is disturbed motility in the majority of cases and an emptying time longer than fifty hours following the barium meal is the rule. An incompetent ileocecal valve is noted, probably due to the dilated cecum, and in some cases a barium-mixed mucus can be discerned, while in others a diverticulosis is obtained particularly involving the pelvic colon.

9. Brown, T. R.: *Internat. Clin.* 3: 24 (Sept.) 1927.

The observations by the proctologist are not striking; nevertheless, it is essential that each case have the benefit of his study. He may find some rectal changes, such as hemorrhoids, cryptitis or a spastic sphincter, but in many cases the rectum is practically free from disease. A sigmoidoscopic examination usually reveals a contracted rectopelvic junction, which, according to Soper¹⁰ and others, is a decided factor in producing the intestinal stasis.

In making a diagnosis of spastic colitis great care must be exercised, as in many organic conditions there may be a disturbed colon function simulating this condition. Moreover, there is frequently a neurosis or psychoneurosis complicating many of the more chronic diseases, so that a spastic type of constipation exists at least temporarily. With the subsidence of the organic trouble the spastic state of the colon may persist, because of a neurosis incident to the unstable nervous condition following the primary trouble. Many patients feel that if they could obtain relief from constipation they would regain a normal state of health, but in my experience, unless with the temporary relief of the constipation there is an improvement in the nervous condition, the trouble promptly recurs. I frequently encounter this condition following operations, especially those on the pelvic organs of the female, and it is most essential that the care of the patient under these conditions be assiduously followed up.

TREATMENT

The treatment of spastic colitis presents a problem which in many cases is difficult of solution. Because of the chronicity, the intestinal stasis, which frequently amounts almost to an obstipation, and the neurotic mental state of the patient, there is a tendency for the symptoms to persist in spite of the most careful therapeutic management. One of the difficulties is to relieve the intestinal stasis satisfactorily. I frequently find patients that obtain an evacuation only once in three or four days, and at times they may go a week or ten days without a bowel movement. They have discovered that laxative drugs cause a severe irritation and have usually discarded them of their own volition. Enemas have not proved to be of permanent value, as the patient is either unable to take a sufficient quantity of water

on account of the spasm of the pelvic colon or, if able to take it, finds he is unable to expel it. A great deal of discussion relative to the use of the water enema has failed to settle the question as to whether it is a valuable measure. Some authorities feel that it is as harmful as laxatives; but I have found it advantageous to have the patient resort to it at least temporarily. The so-called colon irrigation has frequently been tried, sometimes with temporary relief but rarely with permanent benefit.

In those patients suffering from almost complete obstipation, I find heat to be most valuable in relieving the spasm of the pelvic colon. The enema given slowly at a temperature of from 110 to 120 F. will usually prove efficient in relieving the spasm temporarily, but it may also be necessary to apply heat locally over the descending colon. At times it is necessary to place the patient in the knee-chest position and resort to the use of the colon tube. Soper¹⁰ advises dilation by means of the sigmoidoscope and then applies magnesium sulphate to the rectosigmoid junction for its relaxing effect. I have used the oil enema advantageously. From 6 to 8 ounces (178 to 236 cc.) of cottonseed oil at a temperature of 100 introduced into the rectum in the knee-chest position and retained over night, or for several hours, has a tendency to relax the pelvic colon and produce satisfactory movements. This may have to be supplemented by agar-agar or psyllium seed by mouth.

DIET

Diet is a very important therapeutic measure in all cases of colon dysfunction, and particularly in cases of spastic colitis. Since many of these patients are decidedly reduced in nutrition and practically all of them have such symptoms of indigestion that they have of their own volition reduced their diet much below that required for nutritive equilibrium, it is essential that a liberal diet be prescribed. There is a decided difference of opinion as to whether the diet should be bulky and contain much roughage or, on the contrary, very bland and devoid of all bran and uncooked vegetables. My experience indicates that, in the more acute stages of the trouble, bulk should be avoided. After the acute tenderness and irritation have subsided, bulkier articles

10. Soper, H. W.: *Am. J. of Roentgenol.* **11**: 503 (June) 1924.

may be gradually added until the patient is on what might be considered a normal diet. The patient may be annoyed by the excessive accumulation of gas, which is usually attributed to the use of some specific type of food, but my experience is that this is usually a result of the intestinal stasis, as it promptly disappears when constipation is relieved. In certain cases it may be necessary to change the intestinal flora, and in accomplishing this acidophilus buttermilk and lactose are very valuable.

DRUGS

Spastic colitis may be treated without resorting to drugs, but in the acute stages much help can be obtained from two types of drugs, the antispasmodics and the sedatives. Belladonna is of considerable value in relieving the spasm, as is benzyl benzoate, although to a less degree. Since the majority of these patients suffer from insomnia and undue anxiety, it is impossible to accomplish any great improvement until these have been relieved. In the past bromides have been used extensively, but of late the barbituric group (barbital, phenobarbital) has been considered of greater value. These should not be used over too long a time and should be changed from time to time.

Of the nonmedical measures, hydrotherapy is particularly useful. The abdominal tenderness and the spasticity of the colon may be relieved by the application of fomentations, the use of the sitz bath, the Scotch douche to the abdomen and the lower part of the spine, care being taken that the treatment is not too vigorous or exhausting to the patient. The tonic effects of the cold rub or short cool baths are beneficial in bringing about an improvement in the nervous condition, especially in institutional cases. Massage is also advantageous, as the patient is chronically fatigued and does not respond satisfactorily to active exercise. Electrical measures, such as diathermy to the pelvic colon, or high frequency applied by the rectal electrode, may be helpful in selected cases.

Because of the neurotic condition it is advantageous to have these patients removed from home surroundings to an institution where a satisfactory program can be followed and every effort made to relieve their anxiety. Psychotherapy is an essential part of the treatment. Dawson² is of the opinion that the profession needs to take up in a large-minded spirit the

question of psychic treatment; that the patient with colitis who is in danger of being crushed by his illness is not helped by being dubbed "neurotic;" that the patient's mind can be trained and helped to detach itself, to control what it contemplates, to temper rather than reinforce in consciousness the aches and ills of the body, and thus establish the benign rather than the vicious circle. It is not necessary that the patient be referred to a neurologist, provided the internist has the confidence of the patient and has at least a working knowledge of psychotherapy. It is sometimes difficult to determine the underlying fears of these patients, but in time they will confide in the physician, thus giving him an opportunity for doing the greatest amount of good.

In some cases it is necessary to prolong treatment over a considerable period. I have patients at present who have been under observation for over a year but who have not acquired such satisfactory nervous reserve as to permit of their getting along without medical supervision. They have gained materially in weight and are free from constipation under normal conditions, but, when they become introspective and alarmed relative to their condition, the constipation immediately recurs. Anything that tends to excite or unduly fatigue the patient always results in an aggravation of symptoms.

In the treatment of the misbehavior of the gastrointestinal tract, the same measures as used by a group of psychologists spoken of as the "behavior group" may have to be resorted to. They believe that emotional states are largely responsible for disordered function of the viscera. In the child they are able to remove fear states and, as the same emotional disturbances continue on into mature life, the same need exists to eliminate fear states from the emotions in order that certain functional gastro-intestinal disorders may be relieved. I find in the great majority of my cases an underlying neurosis which frequently escapes the attention of the physician entirely. We are too prone to observe pathologic change without attempting to explain it. In these cases of dysfunction I have reason to believe that until the emotional life of the patient and his ability to live above his fears are corrected, little hope of complete relief can be seen. In many

cases the trouble has its incipience in early childhood and may continue during the greater part of life.

Since the number of people suffering from this trouble is much larger than has been supposed and apparently is increasing, it is essential that the problem be given the most careful attention. My observation warrants the belief that many by persistent effort may be practically restored to health, or at least sufficiently so to permit their earning their own livelihood. I feel that more can be accomplished for their relief through a careful study of their nervous condition and a rational adjustment of their emotions than by the use of any other therapeutic effort. They are the type of individuals who have found the stress of life too hard and have broken under the strain. Sympathetic understanding of their trouble may lead to a restored confidence which will be of assistance in relieving their digestive complaints and their chronic intestinal stasis. Surgery is of little assistance and usually tends to lower further their resistance and to aggravate their nervous instability.

SUMMARY

1. The principal etiologic factor in spastic colitis, or enterospasm, is nervous instability. The spasm and secretion of mucus are due to disturbance of the sympathetic and parasympathetic effects on the distal portion of the colon. Unless this is taken into consideration, all attempts to relieve the intestinal stasis are doomed to failure. The mucomembranous type of colitis is an aggravated form or end-product of the spastic type.

2. The following therapeutic measures are suggested as of the greatest value: Heat is the most effective measure for relief of the spasm and may be applied in the form of the hot enema (from 114 to 120 F.), fomentations or sitz baths. The oil enema given in the knee-chest position and retained all night is advantageous.

3. Diet is important. A liberal diet is indicated and in the more acute stages of the disease should be bland and devoid of bulk or roughage, which may be added as the patient improves. The gas with which these patients are troubled is usually due to the stasis and will disappear as the constipation is relieved.

4. For general improvement the tonic effects of the cold rub massage and, in selected cases, diathermy are of value. If drugs are needed, belladonna is serviceable as an antispasmodic, and the barbituric acid group as sedatives.

5. Psychotherapy for the removal of those emotional or fear states that are responsible for the disordered function of the viscera is an important part of the treatment.

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X-RAY STUDIES OF THE ILEOCECAL REGION AND THE APPENDIX*

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THE investigation of the upper alimentary tract by means of the X-rays has engaged the attention of leading Roentgen workers ever since the advent of the bismuth meal, and the various details of the examination and the limitations of the Roentgen method in studying the pathology of the esophagus, stomach and duodenum have now received proper recognition among Roentgenologists. Much the same can be said of the X-ray examination of the colon, though the information obtainable by this method is so promisingly helpful in addition to the older methods that one is only stimulated to renewed endeavors to work out the details of technique and interpretation which are still unsatisfactory. Perhaps one of the least explored fields of gastrointestinal Roentgenology at the present time is that centering in the ileocecal region, including the terminal ileum, the ileocecal valve, the cecum and the appendix vermiformis.

Among the earliest studies of the ileocecal zone was that presented by Holzkecht in 1907 concerning the value of the Roentgen investigation of the bismuth-filled alimentary tract in the diagnosis of the ileocecal region. During the preceding year Albers-Schönberg called attention to appendical concretions as a possible source of error in the diagnosis of ureteral stone, and Fittig and Weisflog each reported a case of appendical calculus diagnosed radiographically. X-ray studies of the ap-

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pendix have also been reported by Bennett (1908), Béclère, Leven and Barret (1909), Aubourg, Liertz, and Jordan (1910). Stierlin's work on the ileocecal region has been particularly helpful as has also the work of Dietlen, Kienböck and Haenisch.

One of the most important lessons taught by the careful researches of the foregoing is that the X-ray investigation of any part of the alimentary tract must include a careful study of the entire digestive system. Just as in radiography of urinary calculi, one does not feel justified in reaching conclusions without having carefully searched the entire urinary tract, so also in gastro-intestinal Roentgenology one should not voice conclusions until the entire alimentary tract has been studied. The importance of the recognition of this necessity is ably demonstrated in Jordan's work on the ileum, showing the relation between intestinal stasis and various symptoms located in the stomach and duodenum. The technique which follows is only part of the routine pursued in the writer's method of examination of the gastro-intestinal tract, and no opinion is expressed on any single part of the digestive tract until after the entire examination has been carried out.

Technique.—As the opaque medium in intestinal work the writer has used various compounds of bismuth and lately barium sulphate. Bismuth subcarbonate was first used but later the oxychloride, as being perhaps less likely to alter the chemical reaction of the gastric contents and less likely to interfere with the influences controlling the pylorus. A number of European Roentgen workers have introduced the use of barium sulphate, not only for bowel injection but also as a substitute for bismuth in the ordinary Rieder test meal. Schwartz, of Vienna, has given the barium by mouth for over a year without any untoward effects. Koehler, of Wiesbaden, has used the barium sulphate without any untoward results; and was able to report only two cases in which the use of the barium has proved

harmful. In each of these cases, a soluble salt of barium was used in place of the insoluble barium sulphate by physicians not accustomed to routine X-ray examinations. The writer has not yet succeeded in obtaining from a wholesale supply house a preparation of barium sulphate which is guaranteed safe from contamination with minute quantities of the soluble barium salts. Accordingly, bismuth oxychloride has been continued as an opaque medium for test meals but the barium sulphate now obtainable is used for the bowel injections. Barium is many times cheaper than bismuth, which makes its use certainly desirable. (See note, page 25.)

In studying the ileocecal region, it is important to examine *both after the ingestion and after the injection of bismuth*. The most favorable time after the bismuth meal is from the fourth to the twenty-fourth hour. In many cases, the bismuth begins to pass through the terminal ileum into the cecum by the end of four hours, and in nearly all cases, before the end of six hours.

Two ounces of bismuth added to the Rieder meal is sufficient. Jordan, of Guy's Hospital, administers four to six ounces, thereby lengthening the time required for the stomach to empty itself. No untoward effects have been observed after such a dose. The administration of the bismuth oxychloride meal is carried out in the usual manner. One may employ any of the oriental clotted milks for sale throughout the country under various names, such as Yogurt, Fermolac, Biolactyl, Lactone, Kephir, etc. These serve as better vehicles than ordinary milk or buttermilk, since they keep the bismuth in suspension for a much longer time. The clyisma consists of ninety grammes of barium sulphate in a liter and a half of warm water.* Singer and Holzknecht recommend the use of a potato starch preparation as being a desirable

* To 2½ dr. of gum tragacanth add about 1 oz. of alcohol. Shake well. Add 20 oz. of warm water and shake. Add 3 oz. of barium sulphate, then 20 oz. of water, shaking well each time. This mixture should be made up fresh shortly before using.

vehicle. The clyisma is employed only for studying the mobility and relations of the colon and for determining the competency or incompetency of the ileocecal valve. For a study of the motility, a test meal is preferable.

No cleansing enemas are ordered before administering the Rieder meal, but before the injection it is important that the bowels shall have been cleaned out very thoroughly by means of proper laxatives or by thorough enemas or both. The preliminary cleansing enemas should not be large, but the patient should be asked to retain each one ten or twenty minutes before evacuating, thus better cleansing the upper colon.

The patient lying supine upon the trochoscope, the barium suspension is placed in a container about two feet above the patient and allowed to flow by gravity through an ordinary enema tube and rectal point into the bowel. The rectal point should be introduced only past the sphincter—not more than two or three inches. No attempts should be made to push the tube for a number of inches up into the bowel. It is well to attach a bulb such as accompanies a bulb syringe for added force in case the barium suspension should sediment and clog the tube. Under these conditions, the head of the barium column reaches the cecum as a rule within two or three minutes. Where hindrance is encountered, it may be necessary to force the clyisma, either by means of the bulb, or by turning the patient upon the right side, or by using manipulations combined with deep respiratory efforts on the part of the patient.

The use of the Haenisch trochoscope or some instrument equally good is a requirement for satisfactory bowel study. Most important of all, perhaps, is an easily adjustable diaphragm, permitting at will a large field of illumination or localizing the ray to a smaller area as in the study of some localized point of special moment. The infinitely clearer screen shadow afforded by limiting the il-

lumination to the exact area under scrutiny, makes possible the detection of important details which might otherwise be lost. The use of a protective apron and gloves, even with the Haenisch trochoscope, is a feature with which the writer has not yet felt willing to dispense in spite of the fact that many European workers continue, as they have for years, working over these different forms of apparatus without any more protection than afforded by the apparatus itself.

The writer uses a specially constructed fluorescent screen fourteen by seventeen inches square with a border about three inches wide on all sides, protected with lead. By means of proper handles, this screen can be placed over the patient in any desirable angle and with any desirable pressure. During the introduction of the barium clysmas, the screen should not be allowed to rest heavily upon the patient's abdomen but should be supported by an assistant or by some suspensory device.

Before beginning fluoroscopic work, preparation of the eyes by a few minutes' stay in an obscure light or in a totally dark room is an absolute essential. Professor Bécclère, of Paris, who has made precise experimental observations, states that after ten minutes in the dark, the sensibility of the retina to the light of the fluorescent screen becomes fifty to one hundred times greater than on emerging from broad daylight, and after a longer interval it still increases.

A very great convenience in radiosopic work is an overhead green light connected with the foot switch attached to the coil. Whenever the tube is not in use, the overhead light is automatically turned on, but the moment the pressure of the foot turns the current through the tube, the overhead light automatically goes out. It is also convenient to graduate the intensity of the overhead light by means of an ordinary rheostat on the wall.

The great majority of our trochoscope examinations after bowel injection have been made between

10:30 and 12:00 A. M. and between 4:30 and 6:00 P. M. An effort has thus been made, by carrying out the examination at an almost uniform time after meals, to make constant whatever influence may be exerted upon the opening or closing of the ileocecal valve by the relation of meals to the time of injection.

Everything having been made ready and the eyes thoroughly prepared, the clyisma is started and its progress watched, inch by inch, as it ascends the colon. The temperature of the clyisma should be one hundred degrees as being best tolerated by the patient. Should a pause be noted in the onward flow of the barium column, one first makes sure that there is not a kink in the rubber tube or a clogging of the tube. At intervals during the inflow, special points may be studied by manipulations under the screen with the protected hand or by means of a wooden spoon (Holzknecht) or by having the patient turn from one side to another. Radiograms or tracings may be made at important moments to record special phases of the situation.

In cases where the preliminary cleansing has not been complete, small collections of fecal matter may be accumulated by the stream in its progress upward and may cause the filling of the cecum to be imperfect or slowed. Careful observation will easily eliminate these sources of error.

Whenever special features are noted in a given case, it is important that the examination should be repeated at some later date—better after several days—in order to place a reliable check upon the conclusions drawn from the previous observation.

The actual exposure of the patient to the ray during fluoroscopic work is practically negligible, provided one has means at hand for immediately cutting off the current the instant it is not needed. A convenient foot switch makes this very easy. By interposing between the tube and the patient filters of aluminum or leather (Pfahler) and the canvas upon which he lies, the likelihood of a dermatitis

following the examination, even when considerably prolonged, is not serious. In the writer's experience, there has not occurred a single instance of Roentgen dermatitis following radiosopic examination.

Haenisch, who employs a mixture of bolus alba, bismuth and water, urges that after the examination, thorough enemas should be employed to eliminate the fuller's earth from the bowels. In the writer's formula, in which the fuller's earth is omitted, it is not found necessary to take special precautions to remove the barium except in cases of actual obstruction where the patient is unable to expel it spontaneously.

After studying the patient on the trochoscope, first supine, next lying on the right or on the left side, or with the hips elevated, he is then placed in a vertical fluoroscope and observation is made in the erect position. The observations upon the barium-filled colon being concluded, the patient is allowed to evacuate the clyisma, after which observations should be repeated to determine how successful the evacuation has been. Haenisch withdraws the enema instead of allowing the patient to expel it. While this is particularly helpful in the study of the lower colon, it is probably of minor value when investigating the ileo-cecal region.

It may be well to repeat that the barium clyisma gives valuable information regarding the size, relations and mobility of the bowel, and, when used according to the careful technique worked out by Haenisch, information concerning stenosis of the bowel or bowel motility; but in pursuing the studies of interest in this paper, the Rieder or some similar test meal is an essential. It was only after the writer began to study the bowel and especially the cecum, following the Rieder test meal, that he observed that the lumen of the appendix was very frequently filled with bismuth. In the last three hundred bismuth meal examinations, I have been able to demonstrate the bismuth-filled appendix radio-

graphically in thirty-eight cases, but I have rarely seen the appendix filled in connection with the bismuth clyisma. With the bismuth meal, the cecal shadow is more dense, more complete, and the bismuth by mouth is more convenient and less distasteful to many patients than the injection, and the determination of adhesions and points of localized tenderness about the cecum may be more easily made. On the other hand, during the barium injection, the process of filling the cecum may be watched under the screen, the competency of the ileocecal valve may be determined, the presence of filling defects is more easily made out, and the actual capacity of the colon is better determined.

Examination of the Terminal Ileum and the Ileocecal Valve.—In the majority of cases, bismuth does not begin to pass from the ileocecal valve until four hours from the time of ingestion. Under certain circumstances, viz: duodenal ulcer, achylia gastrica, carcinoma of the stomach producing pyloric insufficiency, and in cases of perigastric adhesions especially about the pyloric end of the stomach, the head of the bismuth column may reach as far as the middle of the descending colon within four or five hours. Usually, however, observation four or six, twelve and twenty-four hours after the test meal will give ample information concerning the state of the terminal ileum.

The presence of stasis is easily determined at a glance at these observations. The presence of adhesions about the terminal ileum is not nearly so easily determined. The following maneuvers are helpful in determining the presence of ileal adhesions which produce stasis:

First.—Inspection of the ileocecal region reveals the terminal ileum distended with bismuth but separated from the cecum by a more or less constricted area of ileum.

Second.—During the movements attending deep respiration a point in the ileum may be observed which does not change its position although the

adjacent bismuth-filled bowel moves up and down. It should be remembered, however, that where adhesions exist between the cecum and the terminal ileum, their presence cannot be determined in this manner.

Third.—By palpation under the screen with the protected hand or with a wooden spoon, the position of the various mobile shadows may be changed while the fixed point remains immovable. The fixed point is often the seat of pain on pressure. In determining the presence of adhesions, between the cecum and the terminal ileum in this manner, one may note whether the shadow of the tip of the cecum and of the terminal ileum may be moved independently of each other.

Fourth.—By performing the above maneuvers with the hips elevated as in Trendelenburg's position.

Fifth.—Examination with the patient lying on the left side.

Sixth.—Examination with the patient erect shows in many cases a descent of the cecum and movable ileum towards the true pelvis while the fixed point in the ileum remains only slightly or not at all changed in its position. In a certain number of cases, however, the cecum itself is also fixed so that this point of the examination often fails.

Seventh.—In a considerable number of cases the making of stereoradiographs gives additional information invaluable in confirming a diagnosis of adhesions.

The report from the attending physician or surgeon as to the presence or absence of tenderness, enlargements or adhesions of the right uterine appendages and an inquiry into the history of the patient give further necessary points of differentiation.

The ileum may be fixed at more than one point, and in a large number of cases, the fixation is attendant upon a perityphlitic inflammation which

limits the possibility of determining definitely the exact location of ileal kinks.

In the study of ileal kinks, the clyisma as well as the Rieder meal is of value when the ileocecal valve is incompetent. Kraus has found in 150 autopsies after deaths from all causes, twelve cases presenting incompetency of the ileocecal valve. Out of a series of the last two hundred gastro-intestinal cases referred to the writer for Roentgen examination, thirty-three have shown the ileocecal valve incompetent as determined by the barium clyisma.

Singer and Holzknecht remark upon the relative frequency of the insufficiency of the ileocecal valve—three out of fifteen cases examined by clyisma presenting this condition. Sometimes only a few inches of ileum are filled and at other times, the clyisma may ascend many feet of the small intestine. When this has occurred, it is best to allow the patient to expel the clyisma from the colon, after which he returns to the table and detailed study of the terminal ileum is thus more satisfactorily made without the confusion of overlying shadows of the barium-filled colon. Radiographs, especially when made stereoscopically, again afford valuable information.

Ileal stasis may be observed, not only associated with ileal kinks, but in colon obstruction from any cause and is more marked the nearer one finds the obstruction to the cecum.

Sometimes the distension of the terminal ileum causes it to drag heavily upon the mesentery and in this way indirectly produces duodenal stasis and dilatation, with corresponding dilatation and stasis in the stomach. Such cases have not been at all uncommon in Jordan's wide experience. Our experience confirms Jordan's opinion that there are at least a certain number of cases in which this combination of pathological findings may exist. Comment should also be made on Bloodgood's idea that not only may the drag upon the mesentery be due

to ileal stasis but it may also be due to prolapse of the right half of the colon.

In the differential Roentgen diagnosis between a true pyloric stenosis and gastrectasis dependent upon ileal stasis and drag upon the mesentery, it may be said that in the former, there will usually be some pressure pain point associated with the pyloric shadow, absence of ileal stasis and absence of distension of the duodenum. The writer has not observed anti-peristalsis in any case of gastrectasis due to ileal stasis and mesenteric drag.

The determination of incompetency of the ileocecal valve must be of great importance. Anatomists agree that the valve is normally competent, preventing the return of gas or fluid cecal contents into the ileum. The work of Cannon, particularly as regards anti-peristalsis, makes it very probable that this view of the matter is correct. Surgical experience shows numerous confirmations of the fact that the normal ileocecal valve is thoroughly competent.

Groedel before the Eighth Congress of the German Roentgen Society, 1912, read a paper on the Pathological Changes in the Region of the Ileocecal Valve in Cases of Ileal Stasis, in which he states that with rectal injection, the contents of the bowels are frequently seen to pass upward through the ileocecal valve into the ileum, and he believes that where this is well marked, the incompetency is due to chronic perityphlitis. Haenisch, Holz knecht and others have noted the comparative frequency of this incompetency.

As above noted, Kraus found the ileocecal valve incompetent in only twelve cases out of one hundred and fifty examinations. He states that the ileocecal valve in newborn infants is patent, but in a child of five, it was found, postmortem, to be competent. The writer observed that the ileocecal valve of a pig and of a dog was competent, withstanding enormous distension of the colon. Kraus found that the bowels with incompetent valves

showed the following particulars: First.—The colon and cecum broad (in all of them). Second.—Colon quite straightened (straight anterior taenia). Third.—The three haustra are in apposition. In other words, in bowels with insufficient ileocecal valves, he found the same changes as in incompetency artificially produced. The writer has found that, in the main, the above holds good, but one sees frequently the valve competent with a large, widely distended cecum, and, *vice versa*, incompetency of the valve in the presence of normal size and shape of the cecum.

During the injection of the colon it will sometimes be observed that after the barium clyisma has proceeded without interruption clear to the cecum, the stream passes on through the ileocecal valve before there has been time for an accumulation of pressure through distension of the cecum. In these cases, the barium stream passes through the ileocecal valve just as the first swallow of a bismuth-water mixture is often seen to pass through the pylorus. This observation certainly eliminates, in these cases at least, the factor of distension through overfilling as being the cause of incompetency of the ileocecal valve. In other cases, however, it is seen that the barium clyisma does not pass on into the ileum when it first is injected, nor even during the time required for close inspection of the ileocecal region, but after the patient has evacuated the clyisma and has returned to the trochoscope, it is seen that the barium has meanwhile penetrated into the ileum and that the valve has been patent, indicating some relaxing influence associated with the effort at bowel evacuation. Again in numerous cases it is observed that even though there is marked distension of the bowel the ileocecal valve remains competent. It seems, then, that there are at least three classes of cases of patency of the ileocecal valve:

First.—Incompetency of the valve associated with over distension of the walls of the cecum,

which, as Kraus has so clearly pointed out, interferes with the mechanical factors connected with the closing of the valve.

Second.—In many of the instances of valve incompetency, even where the cecum is not at all enlarged and where the element of over distension has been avoided, from the history and other findings in addition to the X-ray findings, it is evident that there is a peritoneal inflammatory process in the region of the ileocecal valve which exerts an influence upon the closure of the valve.

Third.—There are doubtless a number of physiological and pathological factors which operate to open the valve. Gruetzner has observed that when starch emulsion is injected into the bowel along with normal saline solution, starch granules can be washed out of the stomach four to six hours afterwards. Sutherland has failed to corroborate this finding in the majority of cases, although in a certain percentage, insoluble particles such as charcoal could be washed out of the stomach where charcoal was added to the nutritive enema. Examples, such as Church's, where in a case of duodenal fistula the soap and water of the enema invariably flowed through the fistula, are isolated instances and are probably pathological. Swiezinski confirms the observation of Gruetzner that substances introduced with salt solution by enema may afterwards be found in the stomach. Magnus in a paper before the twenty-ninth German Congress for Internal Medicine, makes the statement that with nutritive enemas, there is frequently seen an opening of the ileocecal sphincter and passage of the nutritive stream into the small intestine. In the case of the bladder, according to von Zessl, the sphincter vesicae opens not only in a passive way, but also by irritation of the *nervi erigentes* even after the detrusor had been cut through. It seems probable that there are various influences which operate normally to open an intact ileocecal valve through its innervation.

The Roentgen observer frequently sees the whole of the bismuth meal accumulate in the terminal ileum up to the fifth or sixth hour after the meal, not any having passed into the cecum. The patient then takes a second meal and within one or two hours, the head of the bismuth shadow has reached the pelvic colon and the ileum is emptied. This is a frequent observation and indicates that the taking of meals operates to influence the opening or closing of the ileocecal valve. It is probable, therefore, that there may be cases of spasmodic closure of the ileocecal valve, the etiologic factors being similar to those which operate to produce spasm of the pyloric sphincter.

Examination of the Appendix.—It was only when the writer began to devote special attention to the ileocecal region, making the examination of this part chiefly with the patient in the reclining position, that he began to expect to find the appendix shadow, and he is now able to report more than sixty cases in which the appendix has been seen and studied during the bismuth examination. Most of the Roentgen workers have, on more than one occasion, accidentally found the shadow of the appendix. The writer must say that he has seen many so-called appendix shadows which were really ileal shadows mistaken for the appendix.

Professor Rieder before the 1912 meeting of the German Congress for Internal Medicine, dismisses the Roentgen study of the appendix by the statement that it is attended by many difficulties. Des-ternes and Belot report a case of chronic appendicitis in which two radiographs, one with the patient standing and the other with the patient reclining, showed a displacement of the cecum by one centimeter in change of position, while the bismuth-filled appendix remained at the same point, from which they conclude that in chronic appendicitis, the X-ray examination of the cecum and appendix gives valuable information concerning the presence or absence of adhesions in the region of the cecum and

ascending colon. In the case reported by Belot, there are no operative confirmations of the findings. Jordan states that he has observed some bismuth in the appendix on several occasions and he cites one case in which the whole of the appendix was very clearly shown. There was a sharp bend of the terminal portion of the appendix which remained unaltered during the few hours that the appendix was visible. In this instance, the appendix emptied itself while there was still a considerable amount of bismuth in the cecum and it did not fill again, thus demonstrating, according to Jordan, the fact of active contraction of the appendix. Jordan concludes, therefore, that the appendix is in a state of tonic contraction alternating with atonic relaxation. At the operation, the appendix was found to be firmly constricted and the end kinked sharply as shown in the skiagram. The kink was due to adhesions and was permanent. In only two or three instances has the writer been able to confirm Jordan's observation that the appendix emptied itself while there was still a considerable amount of bismuth in the cecum.

McEwen, who has made observations upon the cecum and the appendix, states that in some patients, immediately upon taking food into the stomach, there was a cecal movement commencing from below upwards as if expulsive and therefore regarded as probably due to reflex action. McEwen claims that some of these cecal movements originate in the appendix, the undulating movement running upwards from the appendix and causing contraction of the cecum.

That there is often a valve formation at the cecal orifice of the appendix is a common observation. The prominence of mucous membrane caused by an increase of the lymphoid tissue forming a small valve was first described by Gerlach in 1847. In a certain proportion of cases, moreover, the appendix enters the cecum obliquely, forming a valve in the same way that the ureter enters the bladder.

The question arises as to whether or not there may be a competency or incompetency of the valve of the appendix just as there may be disturbance of the competency of the ileocecal valve.

Be that as it may, and whether or not the contents of the cecum are normally able to flow into and out of the appendix, authors agree that probably the most important factor in the etiology of the appendical inflammation is poor drainage. Hence, while there may be a doubt as to the actual pathological state of an appendix which permits the bismuth to fill its lumen, it seems to the writer that there can be no question of the potentiality for danger where the appendix retains the bismuth shadow for many hours and sometimes even for many days after the rest of the bismuth has entirely left the colon. Therefore, the question of surgical treatment should at least be considered in every case where the appendix is visible in the X-ray examination.

Where the appendix shadow is visible a number of points may be determined, (a) by palpation under the screen, (b) by turning the patient this way and that, (c) by radiographic studies, and (d) especially by stereoscopic radiography. Adhesions between the appendix and the cecum, the length of the meso-appendix, the length of the appendix, the caliber of the lumen of the appendix and the position of the organ as related to the cecum are among the points which may sometimes be determined. Occasionally one will find a fleck of bismuth which can be freely moved about within certain limits. A number of such instances have been observed by the writer (and in a few operated upon, the observation has been confirmed) in which it seems evident that the fleck of bismuth was in the freely movable tip of the appendix.

When the bismuth shadow in the cecum is very dense, a retrocecal appendix, even though it contains bismuth, may escape observation, hence it is well to have all patients return at six hour intervals

until the bismuth shadow has passed on, when it may be that the appendix will still remain visible. In several cases, the writer, by watching at frequent intervals until the cecal shadow has become gray, has been able to determine the position of a retrocecal appendix, closely adherent, and sharply bent upon itself in the form of a staple. The shadow of the appendix may persist for from twenty-four to forty-eight hours to a week. In one case the appendix shadow was still visible on the tenth day after bismuth was ingested. It is a common observation to find bismuth in the appendix two and three days after the rest of the colon has been emptied.

On numerous occasions, examination has been repeated and, in some cases, repeated the third time to see whether or not the appendix was again visible. On the other hand, in a number of cases, where the appendix was not visible, the examination has been repeated and most searching observation failed to find the appendix shadow.

Palpation with the wooden "palpatorium" or the gloved finger over the appendix shadow may reveal an area of severe localized pain on pressure. Sometimes the entire ileocecal region is tender but the point which coincides with the appendix is frequently by far the most tender. When the cecum and the appendix shadow is moved by manipulation, the point of localized tenderness moves correspondingly. In this palpation, one must be careful to exclude other sources of pain, such as kinking of the ileum, disease of the uterine appendages, ureteral lesions, etc.

In other cases, the appendical shadow seems to be associated with only moderate pain on pressure or perhaps no pain at all. Even in these cases, if the appendical shadow persists for a long time—for several days even after the rest of the colon shadow has disappeared—one must conclude that the appendix is a potent source of danger through its lack of proper drainage. One should not lose sight of

the fact that the appendix may be only one of several manifestations of intestinal stasis, as pointed out by Lane and frequently demonstrated radiographically by Jordan.

In the differentiation between urinary stones and appendical calculus the X-ray examination of the bismuth-filled ileocecal region may be valuable, especially should it happen that the appendix is patent. The writer has had one such case in which a suspected calculus was proved to be appendical by the fact that the bismuth entered the upper part of the appendix for a part of the way, and, though the bismuth shadow in the appendix did not quite reach nor coalesce with the shadow supposed to be calculus, yet by manipulation, it was satisfactorily determined that the two shadows were both in the appendix.

Occasionally small collections of bismuth are found in the lower end of the cecum which radioscopically resemble very closely the shadow of the appendix. Careful manipulation under the screen and a radiograph may be necessary to differentiate.

Study of the cecum after appendectomy frequently gives valuable information regarding the presence or absence of adhesions and the presence or absence of cecal stasis. In the majority of instances, in which pain in the right side has persisted after appendectomy, X-ray examination has revealed more or less fixation of the cecum with a varying degree of stasis in the cecum lasting from twenty-four hours to several days after the rest of the bowel has been emptied. Many of these cases are associated with adhesions about the terminal ileum. The cecal shadow is frequently deformed by these adhesions.

Summarizing, therefore, the writer has observed that in cases where the appendix shadow has been visible following the bismuth meal, he has always been able to show up the appendix following the second or even the third bismuth meal given after an interval of at least a few days, except where

acute inflammation has intervened. The appendix has not been found after the second bismuth meal when it was not found following the first. The bismuth shadow sometimes persists in the appendix for many days after the rest of the bismuth has been evacuated. The appendix shadow is frequently coincident with the point of severe localized pain on pressure. In a fair percentage of cases, the appendix has been visible and yet not the seat of severe localized pain on pressure. Nevertheless when the bismuth shadow persists for days and for sometimes more than a week, the conclusion seems inevitable that such an appendix though not distinctly pathological, possesses a potentiality for danger through its poor drainage. Even in instances where the appendical shadow is not visible through competency of its valve—should such exist—or through obliteration of its lumen by pathological processes, palpation in connection with the Roentgen examination renders great service when appendical disease is suspected by determining definitely the outline of the cecum and permitting much more intelligent and satisfactory study of the relation of the pain point to the cecal shadow and to the shadow of the terminal ileum. Certainly the diagnosis of left sided appendicitis can be more certainly made when examination is practiced in this way.

Tuberculosis of the Ileocecal Region.—Ileocecal tuberculosis is a condition which in a certain number of cases can be almost surely diagnosed by the X-ray examination. Stierlin of Basle has described the Roentgen findings in ileocecal tuberculosis in seven cases. Extensive fixation or constriction of the terminal ileum with more or less fixation and deformity of the cecum and ileum, especially in connection with radiosopic signs of tuberculosis in the lungs, is very suggestive of a tuberculous process. There may be simply the appearance of distended coils of small intestine forming ropy, blotchy shadows rather than the symmetrical

shadow of the terminal ileum frequently seen in the true pelvis, or there may be a palpable tumor associated with the cecal shadow in connection with the widely distended small intestine. In the latter case, the ileum may have such a caliber as to resemble very closely the colon. According to Jordan, the occurrence of tuberculosis in the ileal region is much more common than is generally supposed. In two of our cases, the ileocecal tuberculosis seemed to have its focus in an acute purulent appendical inflammation. In both the proven cases (by operation) there have been evidences of active tuberculosis in the lungs. In at least three of Stierlin's cases there was found pulmonary tuberculosis.

Adhesions of the Cecum and Ascending Colon.—“Agglutinations,” probably of embryonic origin, may cause close adherence of the posterior wall of the cecum. The appendix may be involved in such adhesions without having been the seat of inflammation. True adhesion bands, the result of chronic pericolicitis or other forms of inflammation, are most often found on the posterior external border of the cecum although they may involve any portion of this organ. The writer has seen one case where there existed a true veil behind which the cecum was tucked away as though in a pocket which had been made for it.

The perityphlitic adhesions which are set up by pericolicitis (Jackson) or appendicitis are frequently found to cause curious distortion of various parts of the colon. I have seen a case in which the distal loop of the sigmoid colon was adherent to the diseased appendix and the top of the sigmoid loop adherent to the gall bladder, in a case correctly diagnosed before operation. In this instance, the stereoradiographs were of the greatest importance and led to a recognition of the situation. The X-ray did not reveal the gall stones which were present. The sigmoid was retrocecal and retrocolic, measuring from ileopelvic junction to rectum, fifty-four inches by actual determination at postmortem, the

patient having died on the second day in uraemic coma associated with extensive cystic degeneration of the kidneys.

In another instance, the sigmoid loop was shown by stereoradiographs to be procolic, passing up in front of the cecum as far as the gall bladder region, adherent to both the cecum and gall bladder.

In certain other cases, the sigmoid colon occupies an anomalous position in the abdomen which, from the radiograph alone, might be suspected as being associated with adhesions.

Cecum Mobile et Atonicum—Typhlatomy.—This condition, which has been described by Wilms, Fischer and many others, is easily recognizable radiologically. Associated with abnormal mobility, varying degrees of dilatation and elongation, there is stasis in the cecum long after the remainder of the colon has been emptied. There is often great tenderness elicited by palpation over the cecal shadow. This dilated, elongated cecum is not always mobile, being often associated with adhesions.

Fistulous Tracts Associated with the Cecum.—The injection of Beck's paste through the external orifice of fecal fistulae is also likely to give very helpful information especially when the radiosopic examination is supplemented by stereoscopic plates. Beck's paste has proved more satisfactory for the purpose than the ordinary bismuth or barium suspension in that it causes a denser shadow by its larger percentage of bismuth and it holds its form better after it has cooled. The injection should always be carefully made after Beck's technique. Following the injection of the bismuth paste, the colon may be filled in the usual manner and the relations of the fistulous tracts studied.

Malignant Tumors of the Ileocecal Region.—When the new growth causes stenosis of the ileocecal valve, there is naturally an ileal stasis of varying degree which in its extreme form is typical of complete ileocecal valve obstruction, the distended coils of small intestine having a caliber equal to or

greater than that of the colon. In these cases, the chief characteristics are a persistent filling defect in the cecum, usually associated with a palpable tumor, the seat of pain.

Thanks are due Dr. J. H. Kellogg and Dr. R. H. Harris of the Surgical Department of the Battle Creek Sanitarium, for permission to utilize the reports of cases referred for X-ray study and later operated on by them.

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DESCRIPTION OF PLATES.

PLATE I. FIGURE 1. The appendix is long, tortuous and not adherent, but retains the bismuth longer than 96 hours, 32 hours longer than was required for emptying the rest of the colon. There was slight sensitiveness to pressure over the appendix. Typical Lane's kink was present in this case, with adhesions about the cecum.

FIGURE 2. A long, narrow appendix, freely movable in all its parts. No adhesions nor kinking demonstrable, but severe pain on pressure limited to the appendical shadow.

FIGURE 3. A long, narrow appendix, kinked and adherent within its first inch. Retained bismuth three days after the rest of the bowel was emptied. Seat of localized pain on pressure.

FIGURE 4. Appendix long, curled upon itself, retaining the same position at all examinations. Considerable tenderness on pressure exactly coinciding with the location of the appendical shadow. The patient gave a history of several attacks within the last two years, attended by nausea and vomiting, gas in the stomach and bowels, and frequent bowel movements, with constipation in the interim. The X-ray examination showed the stomach to be radiologically normal.

PLATE II. FIGURE 5. The appendix shadow does not represent the entire appendix, the distal portion having been obliterated. The proximal half which shows was adherent both to the cecum and to the ileum, and the cecum itself was bound down by adhesions. There was stasis of bismuth in the cecum and the appendix long after the rest of the colon was emptied. The patient gave a history of repeated attacks which had been diagnosed as recurrent appendicitis.

FIGURE 6. Appendix shown retrocecal, bent upon itself and adherent. The appendix shadow corresponds exactly with the spot at which the patient always complained of pain on pressure and described by the patient as "the" spot. Careful examination was made in this case during the appendix operation but no other abnormalities could be discovered. No ileal adhesions were found in this case.

FIGURE 7. Appendix kinked and adherent in its malposition. No localized pain on pressure. The appendix retained the bismuth only one day.

FIGURE 8. This appendix was retrocecal, adherent and its shadow corresponded exactly with the patient's pain point.

PLATE III. FIGURE 9. This appendix is characteristic of a type which the writer considers dangerous, having a lumen wide in its distal portion, but much narrowed near its cecal end. Although the rest of the bowel emptied completely in 53 hours, the appendix was still filled with bismuth. The appendical shadow coincided exactly with an exceedingly tender spot.

FIGURE 10. Another appendix of the class mentioned under Figure 9, dilated in its distal portion, and constricted in its proximal third. Certainly an appendix potent for danger, although up to the present time nothing in the history suggests appendical disease. In this case there was only moderate tenderness on pressure over the appendical shadow. The bismuth meal was repeated on two succeeding occasions and the shadow was seen at all examinations.

FIGURE 11. Appendix shadow seen behind the outer, lower border of the cecal shadow. The appendix was fixed in its bent position, retaining the same shape at all times, adherent to the cecum, but freely movable with the cecum. Although the rest of the colon was empty at the end of 46 hours, the appendix shadow persisted.

FIGURE 12. Appendix shown in Figure 11 after the rest of the bowel had been emptied. This patient had, for years, been subject to aching pains in the lower right abdomen, complicated with three attacks of pneumonia and lung abscess three years before. Prominent internists diagnosed his case as neurasthenia.

PLATE IV. Stereoradiogram of the pelvis showing the pelvic colon, the cecum and a fistulous tract between the lower angle of an old appendicectomy wound and the sigmoid. The fistula was filled with Beck's paste, considerable of which passed into the sigmoid (note the denser shadow). The colon was then injected in the usual manner. The patient had an appendicectomy some years before followed by long suppuration and the formation of a fistula. Note the ease with which the fistulous

tract can be followed from the skin to the bowel. Observe the subcutaneous blind pouch branching off toward the suprapubic region.

PLATE V. Stereoradiogram showing stomach, colon and terminal ileum in a case of ileal adhesions. Note the dilated ileum reaching up out of the pelvis with the constricted three or four inches of terminal ileum separating the dilated ileum from the cecum.

PLATE VI. FIGURE 15. Typical Lane's kink of the ileum associated with ileal stasis. The hiatus between the shadow of the dilated ileum and the cecum represents the portion of the ileum which was bound down by fibrous bands.

FIGURE 16. Typical kinking of the terminal ileum about an inch and a half from the ileocecal valve, associated with ileal stasis.

FIGURE 17. Distortion of the terminal ileum associated with adhesions, ileal stasis, and fixation of the cecum.

FIGURE 18. Another case of Lane's kink of the terminal ileum showing ileal stasis.

PLATE VII. FIGURE 19. Very much dilated, elongated cecum, freely movable and the seat of stasis. Colon filled by injection.

FIGURE 20. Cecum elongated, freely movable and atonic. Bismuth ingested.

FIGURE 21. Case of incompetency of the ileocecal valve which permits the bismuth enema to pass through the ileocecal valve, filling many feet of the small intestine. This condition was found on repeated examinations.

FIGURE 22. Elongated, dilated cecum, with fixation and kinking of the terminal ileum following pelvic peritonitis.

NOTE.—Since penning the foregoing, the writer has been using a special barium sulphate imported from Germany which has been carefully tested to determine its fitness for internal use. Barium sulphate is now used both for meals and for injections.

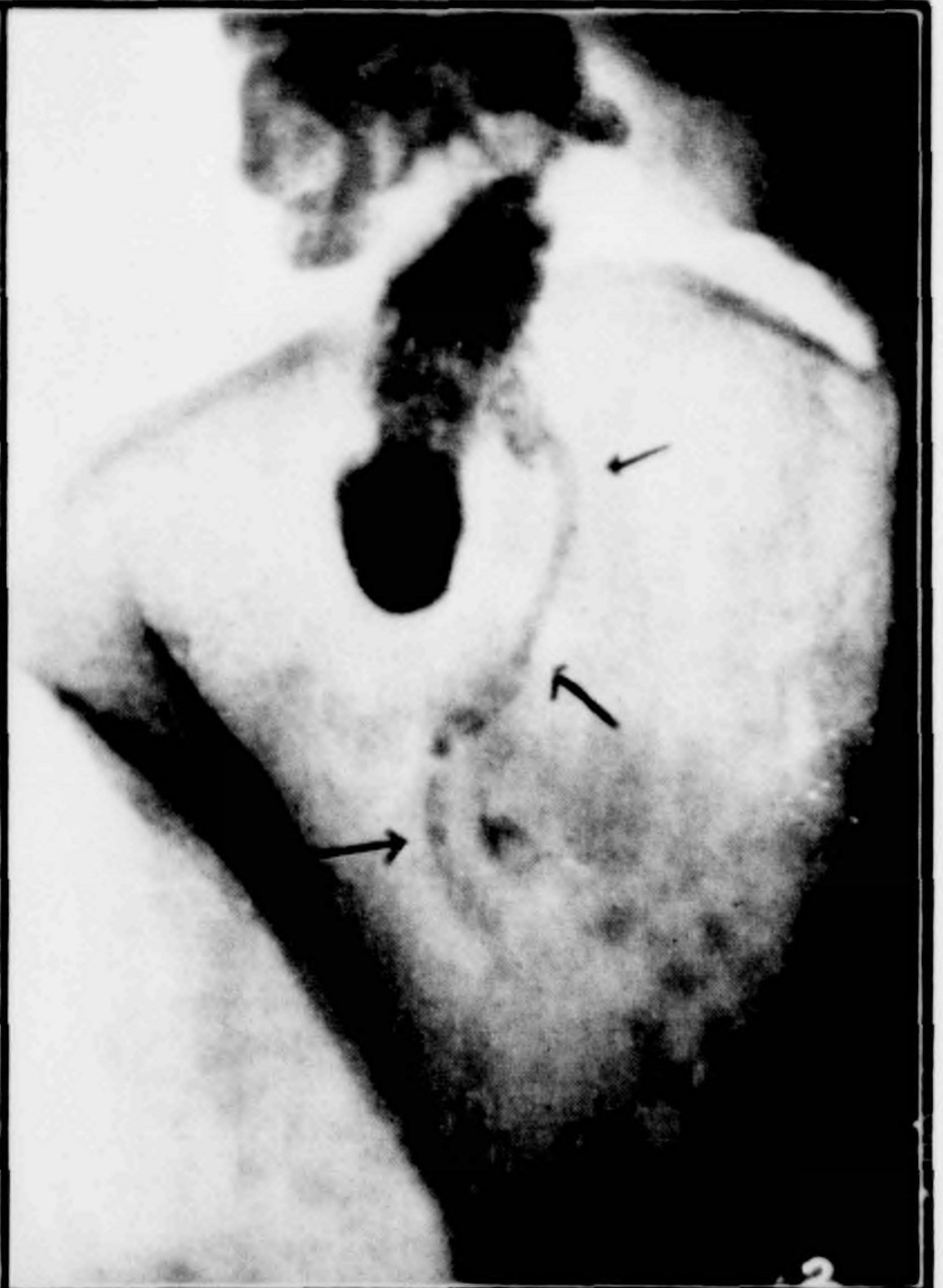
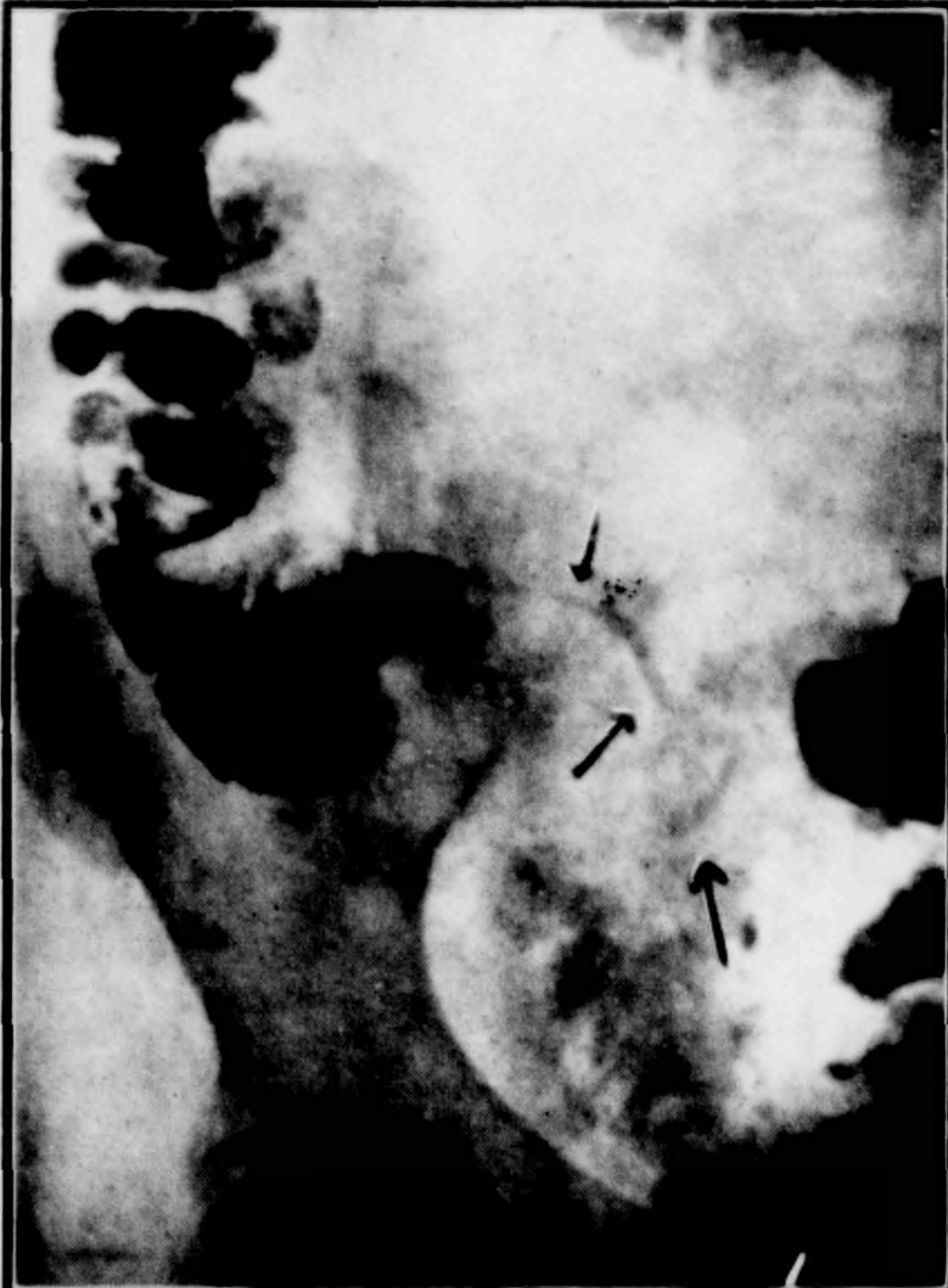


PLATE I (Dr. J. T. Case)
Types of Long, Narrow Appendix, the Seat of Stasis and
Localized Tenderness. (See "Description of Plates.")



PLATE II (Dr. J. T. Case)
Types of Adherent Appendix. (See "Description of Plates.")

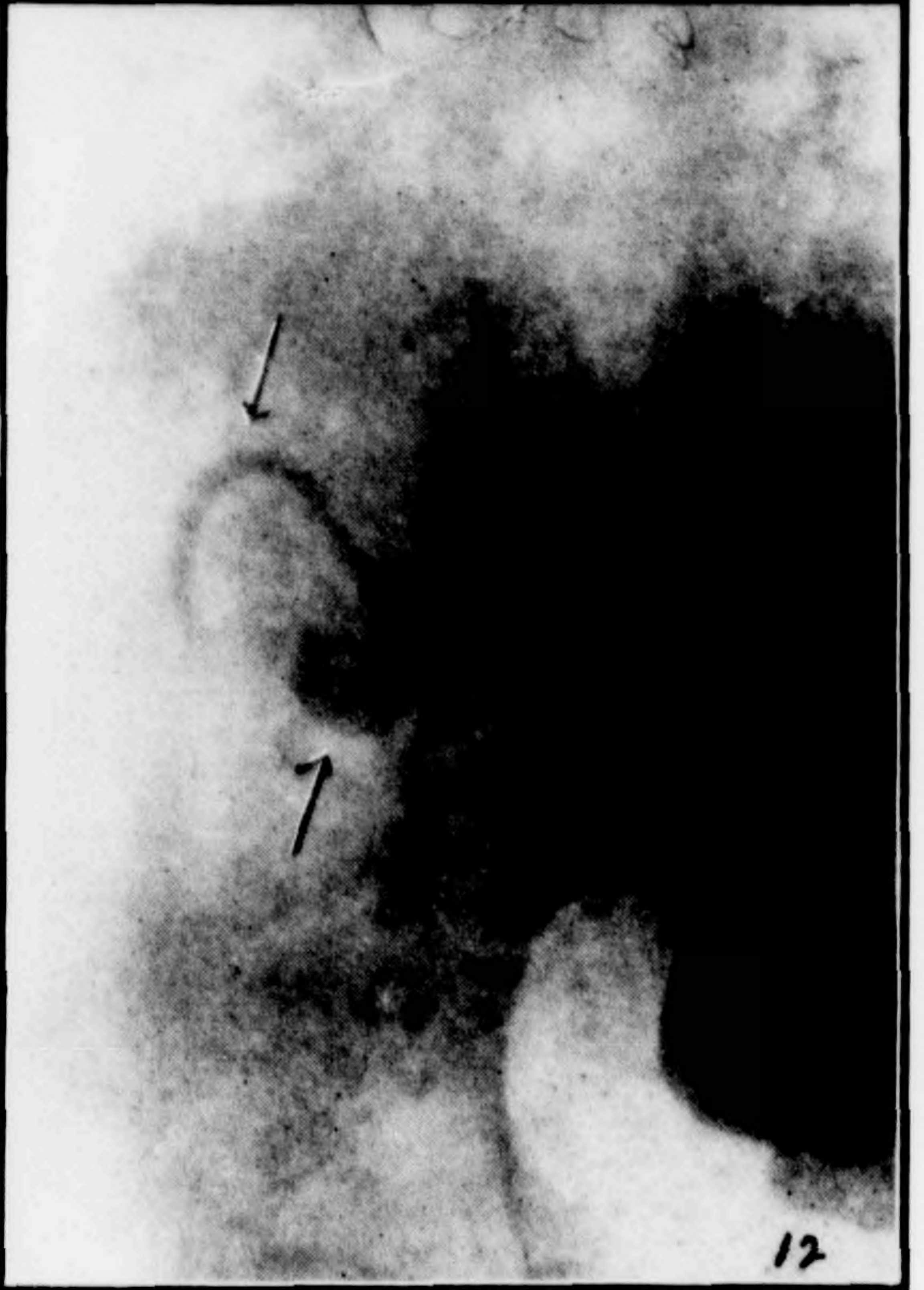


PLATE III

(Dr. J. T. Case)

Fig. 9, 10.—Constriction of Lumen of Appendix near Cecal End.
Fig. 11, 12.—Adherent, Retrocecal Appendix. (See "Description of Plates.")

PLATE IV

Stereoradiogram of Pelvic Colon and Cecum, and Fistulous Tract, Connecting Pelvic Colon with Skin.
(See "Description of Plates.")
(*Dr. J. T. Case*)

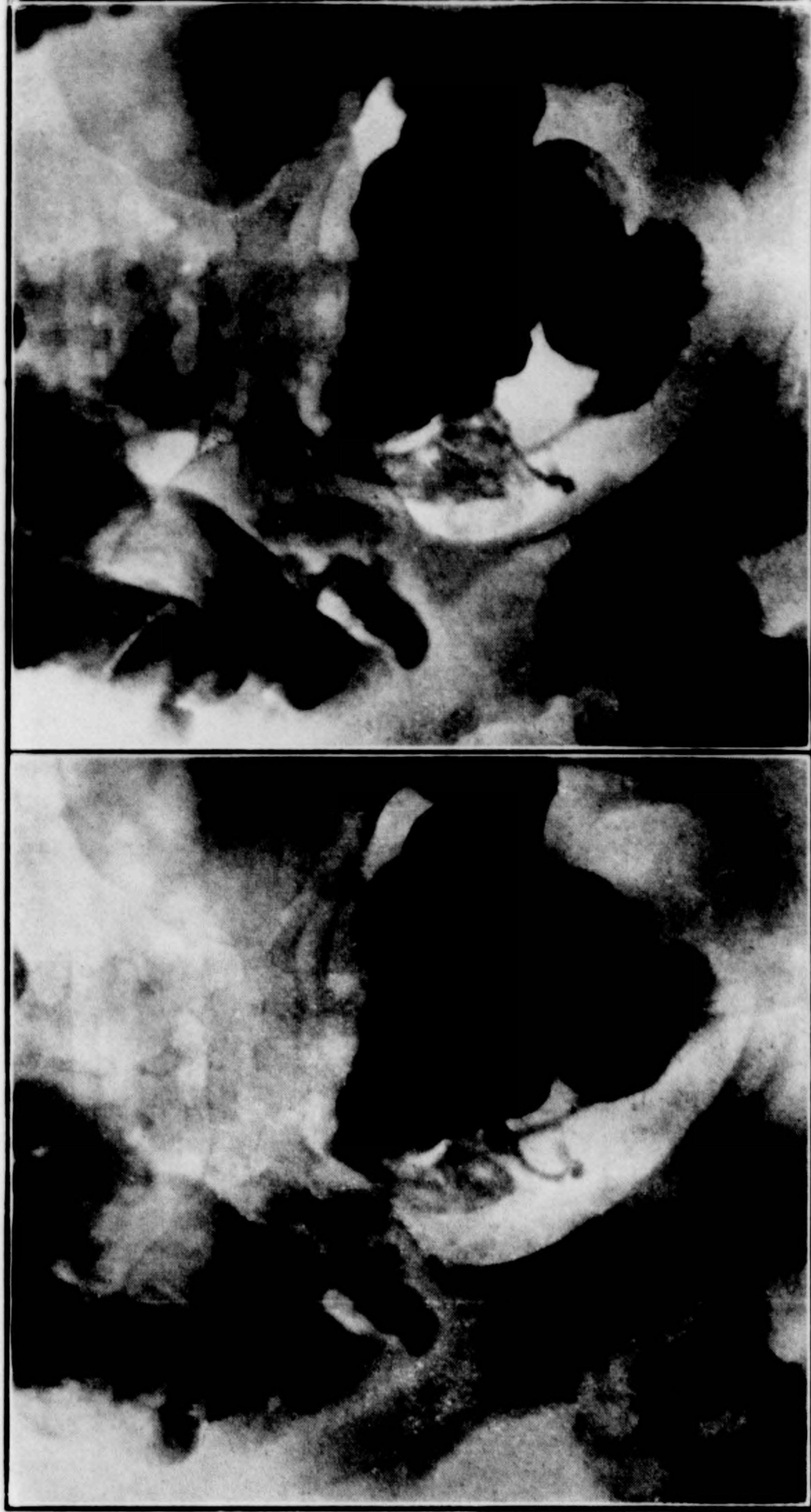


PLATE V

Stereoradiogram of Stomach, Colon and Terminal Ileum. Adhesions about Terminal Ileum.
(See "Description of Plates.")
(*Dr. J. T. Case*)

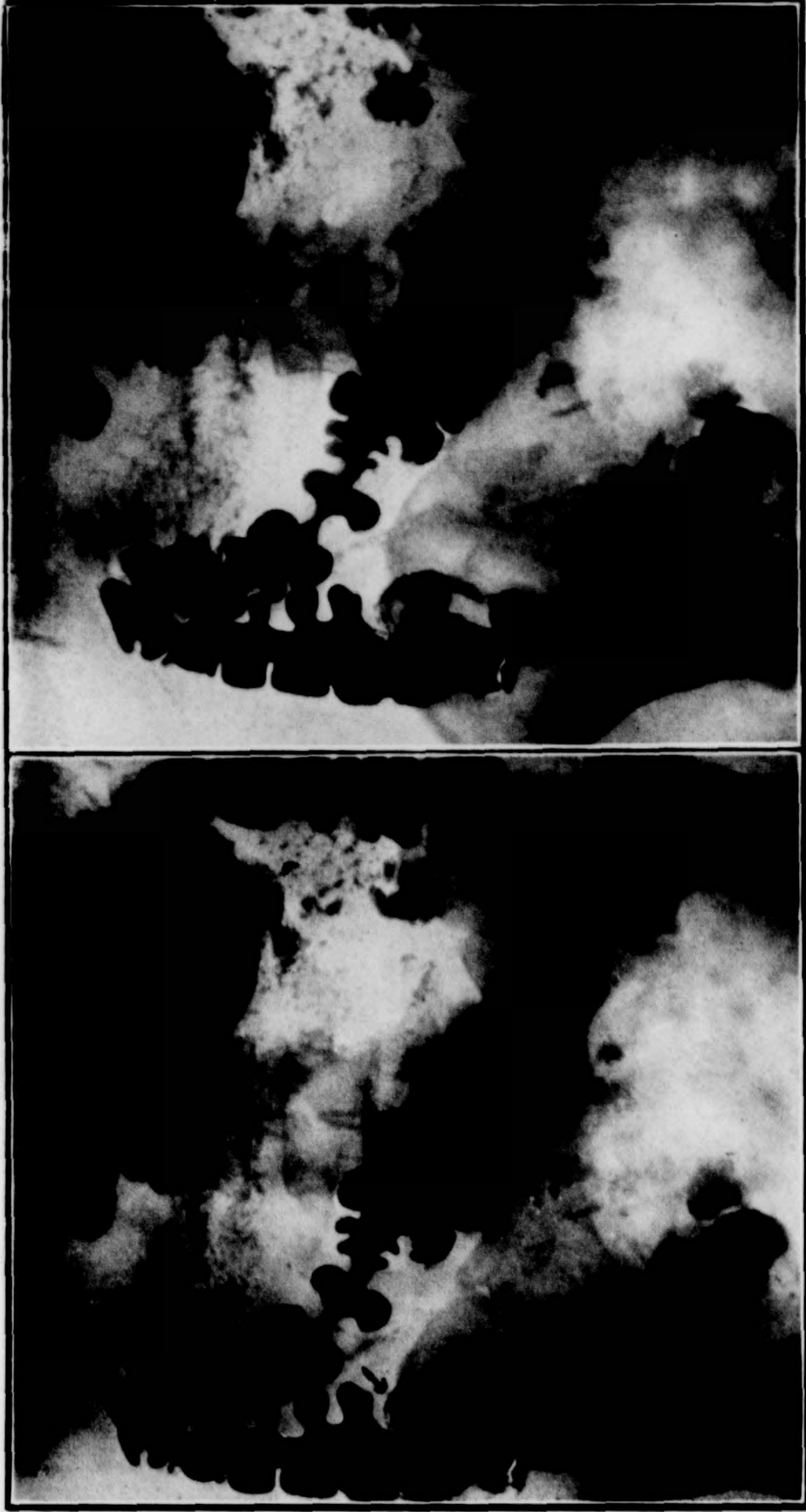




PLATE VI (Dr. J. T. Case)
Cases of Adhesions about the Terminal Ileum. (See "Description of Plates.")

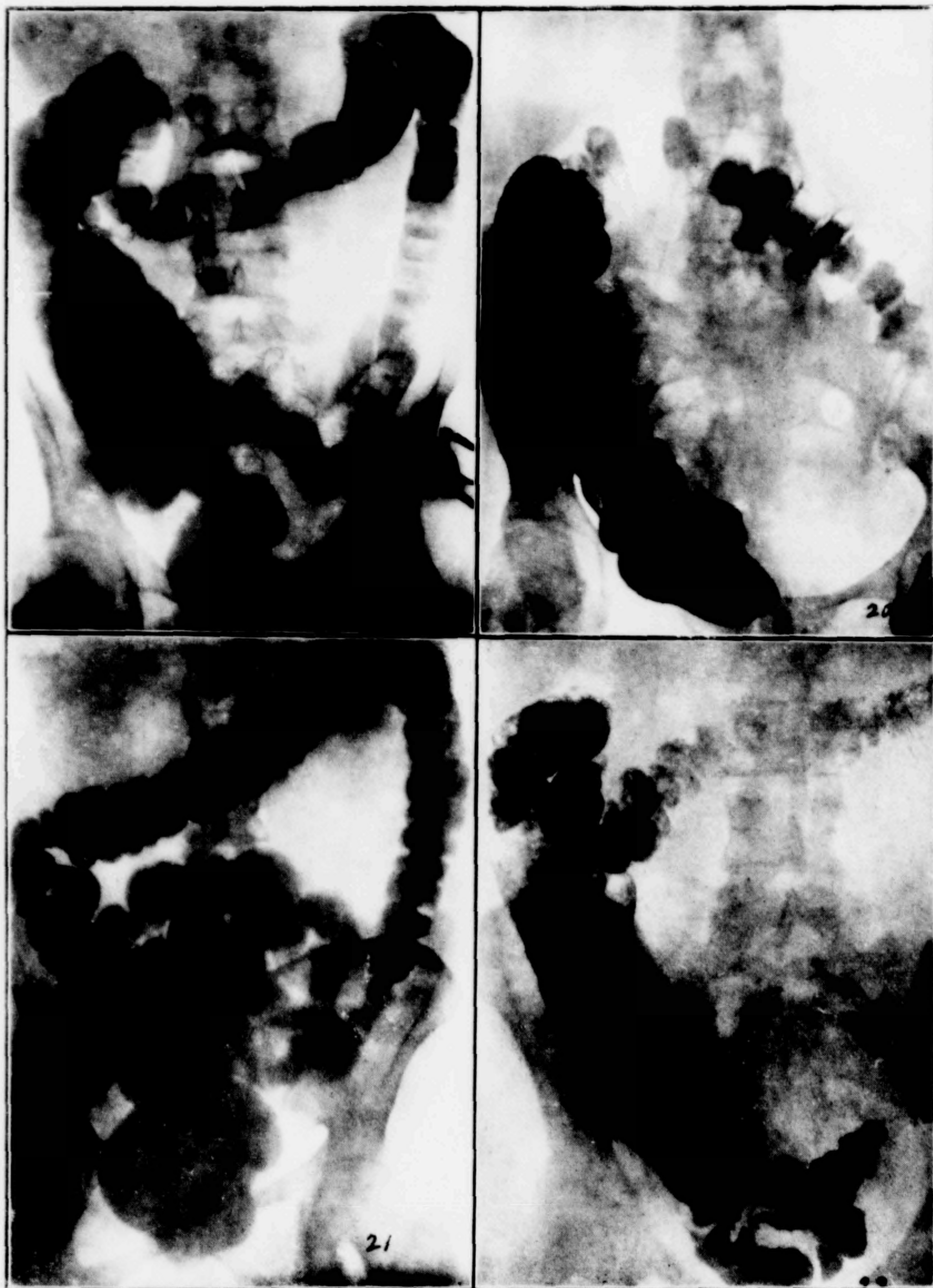


PLATE VII

(Dr. J. T. Case)

Fig. 19, 20.—Cecum Mobile et Atonicum.

Fig. 21.—Incompetency of the Ileocolic Valve.

Fig. 22.—Distortion of Ileum and Cecum due to Adhesions.
(See "Description of Plates.")

Roentgenologic Observations on the Function of the Ileocolic Valve

**With Special Reference to the Causation
of Ileac Stasis**

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ROENTGENOLOGIC OBSERVATIONS ON THE FUNCTION OF THE ILEO- COLIC VALVE

WITH SPECIAL REFERENCE TO THE CAUSATION OF
ILEAC STASIS *

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The subject of intestinal stasis, particularly ileac stasis, has recently aroused much interest and not a little controversy. Most of the discussants are agreed as to the significance of ileac stasis, but the mechanism of its causation, and, consequently, the choice of methods aimed at its relief, has been the subject of much theorizing and controversy. Enteroptosis, adhesion bands, various pericolonic membranes, intestinal kinks, cecum mobile, and typhlatony have been among the causes named; but the instances in which ileac stasis exists without any demonstrable bands or kinkings are so numerous it seems some other cause must be found to explain the stagnation.

It is, therefore, important to determine, if possible, the correct basis on which to build the argument relating to the causation of ileac stasis. If the cause be the kinking of the terminal ileum or some similar lesion and it is conceded that, in comparatively rare cases, obstructing kinks and adhesions do occur, careful consideration must be given the recommendations for serious surgery which seem to be indicated. On the other hand, if the ileac stasis be dependent on some other and simpler cause as, for instance, ileocecal

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sphincter spasm or incompetency of the ileocecal valve, there will be little indication for hazardous surgery.

For several years (since 1910) I¹ have been urging ileocolic valve incompetency as an explanation of a large share of these cases of ileac stasis. In September, 1912, I reported a series of 200 gastro-intestinal cases,² most of the patients being constipated, in which 33, or 1 in 6, showed ileocecal valve incompetency when tested by the bismuth enema. In August, 1913, I reported a much larger series of 1,500 persons,³ tested by means of the bismuth enema, in which nearly 250, or again 1 in 6, showed ileocolic valve incompetency. It should be emphasized that this large series of patients were all suffering from gastrointestinal symptoms and most of them were seeking relief from constipation. I have now found more than 500 cases of ileocolic valve incompetency, the frequency of occurrence remaining about 1 in 6 of the cases examined.

The anatomists describe the ileocolic valve as formed by partial inversion or telescoping of the ileum into the cecum. The end of the small intestine is invaginated through the wall of the large bowel, carrying with it certain layers of that wall which project into the cecum as two folds, lying, respectively, above and below its orifice and constituting the two segments of the ileocecal valve. The peritoneum and the longitudinal muscular fibers of the bowel do not take part in this infolding, but are stretched tightly across the crease produced on the exterior by the inversion, thus serving to preserve the fold and the formation of the valve. According to Cunningham, whose description has just been given, the efficiency of the ileocolic valve is largely due to the oblique manner in which the ileum enters or invaginates the cecum, and he states that, in the great majority of instances, when in position within the body, the ileum is perfectly protected from a return of the cecal contents. In fact, anatomists are almost unanimous in thus considering the normal ileocolic junction a barrier against a reflux of cecal contents.

1. Case, James T.: Proc. Am. Roentgen-Ray Soc., 191.

2. Case, James T.: Tr. Am. Roentgen-Ray Soc., September, 1912.

3. Case, James T.: Proc. XVII. Internat. Cong. of Med., Section on Radiology, London, August, 1913; also in Med. Rec., March 7, 1914.

According to Arthur Keith⁴ there are muscular fibers situated directly at the ileocolic orifice which are evidently designed to secure that orifice from reflux from the cecum. In addition to the sphincter action of the circular muscles included in the valve itself, the last few centimeters of the terminal ileum present a distinct thickening of the circular muscular coat which seems to be endowed with a special tonic function; it serves as a sphincter for the terminal part of the ileum. This sphincter relaxes in front of the peristaltic wave, allowing the passage of food into the colon, but, on the other hand, it contracts, as a rule, against any regurgitation which might be caused by contractions in the colon. In marked contrast to the rest of the bowel in its relation to the central nervous system, the ileocolic sphincter is not affected by vagus stimulation. According to Elliott, stimulation of the splanchnic nerves causes complete relaxation of the terminal ileum and produces a strong contraction of the ileocolic sphincter. These statements are based on the current teachings relating to the anatomy and physiology of the ileocolic junction.

It thus appears that the ileocolic junction is possessed of a double function, namely: (1) a sphincter action which controls the passage of ingested food from the ileum into the colon and tends to protect the ileum from a reflux of cecal contents; (2) a valve action which is probably purely mechanical, guarding against reflux back into the ileum. Much of the force of the arguments relating to ileocolic valve incompetency as a factor in the causation of ileac stasis hinges on the determination of whether or not the ileocolic valve is normally competent.

Most anatomists and physiologists have thus far agreed that the valve is normally competent. The work of Cannon and others on antiperistalsis adds importance to the conception of normal ileocolic valve competency. Our present-day conceptions of the functions of the ileum and of the colon point to the need of such a barrier. My Roentgen-ray studies on colonic peristalsis and antiperistalsis confirm, almost to the minutest detail, Cannon's deductions from Roentgen-ray observations on animals.

Bull,⁵ in 1878, after a careful series of experiments, stated his belief that, in the living body, fluid could

4. Keith, Arthur: *Proc. Roy. Soc. Med.*, April, 1913 (supplement).
5. Bull: *Virchow's Jahresbericht*, 1878, ii, 205.

not be forced beyond the ileocolic valve, but when the bowel was overdilated by air the valve was rendered incompetent and the air entered the small intestine. Dawson,⁶ in 1885, experimenting on the cadaver, concluded that the ileocecal valve, when normal, effectually guards the small intestine from gas and fluid from below. Ziemssen⁷ recommended inflation of the rectum as a means of diagnosis and treatment by "special procedure," the patient being placed under anesthesia. He states that ordinarily the small intestine is closed to the return of material from the cecum by the ileocolic valve, but under deep chloroform anesthesia this resistance is decreased and fluid can be forced into the small intestine. Heschl,⁸ after a number of experiments, agreed with Ziemssen as to the normal barrier function of the valve.

On the other hand, a few observers, such as Cantani,⁹ firmly believed that the ileocolic valve was permeable to fluid injections and suggested that the small intestine be utilized in cases of rectal alimentation. In one instance in which he treated acute bowel obstruction by injection of oil, half an hour later a part of the oil was vomited. Ziemssen records a similar case in which a fistulous connection between the colon and the stomach was suspected because the patient vomited oil shortly after an oil enema. Hemmeter, Church, and Gruetzner¹⁰ have all conducted experimental work which supports the idea that, in certain cases at least, the ileocolic valve permits the reflux of material from the colon. Yet Boyd¹⁰ makes the statement that the reflux of fluid through the ileocolic valve cannot, in every case, be expected, and that he has frequently failed to find insoluble substances, such as charcoal, in the gastric contents, in cases in which charcoal had been added to the nutrient enemas.

Illoyay¹¹ reports four cases of intestinal obstruction treated by forcing water past the ileocecal valve, with recovery in three cases. In this connection it is proper to refer to the experiments of Senn¹² who, discussing the use of rectal injections in overcoming

6. Dawson: *Lancet-Clinic*, Feb. 21, 1885.

7. Ziemssen, quoted by N. Senn: *Experimental Surgery*, 1889.

8. Heschl: *Zur Mechanik diastaltischen Darmperforationen*, *Wien. med. Wchnschr.*, 1881, No. 1.

9. Cantani: *Virchow's Jahresbericht*, 1879, ii, 180.

10. Quoted in Sutherland's *System of Diet and Dietetics*, 1908, p. 287.

11. Illoyay: *Am. Jour. Med. Sc.*, xli, 168.

12. Senn: *Experimental Surgery*, 1889.

bowel obstruction due to invagination, concluded that, when the obstruction is located beyond the ileocolic valve, no reliance can be placed on this method. Senn based this statement on carefully conducted experiments on animals in which fluid was forced beyond the ileocecal valve. In two cases post-mortem examination revealed longitudinal lacerations of the muscular coat of the rectum. A third animal died immediately after the experiment from the effects of the injection. Further, but less crucial, experiments were carried on in man. Senn concluded that "the forcible injection of water beyond the ileocolic valve must therefore be recognized as a dangerous expedient and should never be resorted to."

Senn further states, however, that, in the healthy adult, the competency of the ileocolic valve is overcome by rectal inflation under a pressure of from $1\frac{1}{2}$ to $2\frac{1}{4}$ pounds, and that this amount of pressure is not sufficient to injure the bowel. Behrens agrees with Senn in this statement. The incompetency of the valve is caused in cases of overdistention by a lateral and longitudinal distention of the cecum which mechanically separates the margins of the valve.

In 1897, Max Hertz¹³ of Vienna, while practicing abdominal massage on a patient for abdominal pains, observed peculiar symptoms, which after further study on other cases, led him to describe a symptom-complex of insufficiency of the ileocecal valve. In 1910, and on numerous occasions since, I have demonstrated, roentgenologically, the retrograde filling of the ileum after bismuth clysmas. Holz knecht and Singer,¹⁴ in 1911, mentioned the relatively frequent occurrence of ileocecal valve incompetency in connection with chronic obstipation. In 1912, Groedel¹⁵ reported insufficiency of the ileocecal valve and submitted roentgenologic evidence. In 1913, Groedel¹⁶ continued his discussion of ileocecal valve incompetency and there appeared papers by Dietlen,¹⁷ Kellogg,¹⁸ Reider, Schwarz,¹⁹ Katsch²⁰ and myself.²¹

13. Hertz, Max: Wien. med. Wchnschr., 1897, Nos. 36 and 37.

14. Holz knecht and Singer: München. med. Wchnschr., 1911, No. 48.

15. Groedel: Verhandl. d. deutsch. Roentgen Gesellsch., 1912, viii, 56.

16. Groedel: Fortsch. a. d. Geb. d. Roentgenstr., 1913, xx, No. 2.

17. Dietlen: Fortsch. a. d. Geb. d. Roentgenstr., 1913, xxi, 23.

18. Kellogg: Med. Rec., June 21, 1913.

19. Schwarz: Die klinische Roentgendiagnostik des Dickdarmes, Berlin, 1914.

20. Katsch: Fortsch. a. d. Geb. d. Roentgenstr., 1913, xxi, 177.

21. Case, James T.: Proc. Am. Roentgen-Ray Soc., 1914; New York Academy of Medicine, Jan. 15, 1914.

From certain quarters, however, have come expressions of doubt as to the serious significance of ileocecal valve incompetency, and skepticism has been expressed concerning the normal competency of the valve. I therefore wish to tabulate at some length a series of findings, most of them roentgenologic, which seem to indicate that the ileocecal valve is normally competent, protecting the ileum from a reflux of cecal contents.

1. The ileocecal valve is almost universally present in vertebrate animals (Kellogg¹⁸). I have found the ileocolic valve of the dog and of the pig competent, withstanding enormous distention of the colon by gas. The following surgical operation on a dog is submitted as further evidence of the competency of the ileocolic valve, at least, in the dog. The pelvic colon and the ileum were so divided and reinserted that the course of the food was from the ileum into the descending colon, then through the transverse, the ascending, and through the ileocolic valve and the last 10 inches of the ileum into the pelvic colon and rectum. Dr. D. B. Phemister, who performed the operation, reported that the dog died of intestinal obstruction thirty-six hours later, intestinal contents having accumulated on the distal side of the ileocolic valve, which remained thoroughly competent.

2. A young man was given a silk string 9 meters long, one end of which he swallowed. At the end of twelve hours, the string had transversed the entire gastro-intestinal tract. By means of the bismuth enema, I tested the valve competency on two separate occasions before introducing the thread, and again after the thread was in place, and found that the valve was thoroughly competent. Then, for the purpose of an experiment on electrical stimulation of the bowel, the thread being used as a guide, a metal electrode was introduced as far as the upper end of the descending colon, incidentally considerable traction being made on the thread in an unsuccessful effort to pass the sound around the splenic flexure. Roentgenograms made a few moments later showed the terminal ileum filled for a considerable distance. This was attributed to traction on the thread, rendering it taut in the region of the valve, producing temporary incompetency. After the experiment was concluded and the

thread withdrawn, another bismuth enema was injected, and the valve was again found to be competent.

3. In a certain number of cases, following the injection of a bismuth enema, the head of the bismuth column will pass the ileocecal valve and fill the terminal ileum for a varying distance. As already mentioned, I have found ileocolic valve incompetency in about one-sixth of my bismuth cases. This statement is based on the roentgenoscopic examination of more than 3,000 persons (June, 1914), most of them constipated, and all suffering from gastro-intestinal disturbances. Dietlen,¹⁷ in 100 cases, found 22 in which the bismuth clyisma showed ileocecal valve incompetency, 1 to 5. Holzknrecht and Singer¹⁴ found 3 cases of valve incompetency out of 15 cases examined, or 1 in 5. On the other hand, Dietlen observed insufficiency of the valve in only one of the normal cases which he examined during a period of several years. This agrees with my experience in examination of a number of presumably normal persons.

The method of testing the competency of the valve is the following: The patient should lie supine on the horizontal fluoroscopic table. It is not necessary to introduce the rectal point, or colon tube, more than 1 or 2 inches. The container should be placed not higher than two feet above the patient and the barium or bismuth enema allowed to flow by gravity, the course of the bismuth column being watched fluoroscopically. Ordinarily 1,200 c.c. of the barium enema at 100 F. will suffice to fill the colon. It is important that a uniform technic be followed. I insist on seeing, by means of the fluoroscope, that the cecum is well filled. Massage of the abdomen over the shadow of the cecum is practiced in the antiperistaltic direction. Still further to insure complete filling of the cecum, the patient is sometimes asked to lie on the right side for ten or fifteen minutes after the injection of bismuth, and a second examination is made when the patient returns to the table after evacuating the colon. The roentgenograms are made with the patient lying prone, plate anterior, rather than lying supine, plate anterior. In the latter position "saddling" of the ileum over the iliopectineal line may lead to confusion. In marked cases of ileocolic valve insuffici-

ency, however, there is never any difficulty in recognizing the terminal ileum.

4. When the valve is once found incompetent it has been possible to demonstrate incompetency during succeeding tests. I have tested the valve a second time in more than fifty cases and on numerous occasions, a third time. The incompetency is seen to be a constant phenomenon in all cases in which it is once seen.

5. In preparation for the enema test, thorough preliminary cleansing bowel-flushings are ordered two hours before the bismuth test. Every once in a while, a patient complains bitterly that the cleansing enemas make her ill. Patients find difficulty in describing their feelings accurately; it seems to be a peculiar, sickening sensation accompanied by abdominal distress and nausea. Almost invariably it is found in these cases that the bismuth enema ascends a considerable distance into the terminal ileum, which seems to be wider than usual.

6. A still more convincing evidence of ileocecal valve incompetency, at least to me, is the reflux of ingested bismuth from the colon into the ileum. I have observed this reflux of ingested bismuth in more than seventy cases. For example, the terminal ileum is seen to be empty at the tenth or twelfth hour following the bismuth meal but at the twenty-sixth hour the terminal ileum is again filled with bismuth though no bismuth has been taken in the interim. Roentgenoscopic examination for this purpose must be conducted with the patient horizontal, so that accurate visualized palpation may be practiced under the fluorescent screen. Often, by massage in the anti-peristaltic direction, bismuth ingesta may be forced back into the ileum from the cecum. Such cases invariably show extreme incompetency to the enema.

7. The literature concerning rectal alimentation contains the statement that if the nutriment be given in saline solution it will be more likely to pass the ileocecal valve. In order to test the possible influence of saline solution in testing the ileocecal valve by means of the bismuth enema in a series of fifty colon injections, I added enough salt to the clyisma to equal normal saline solution. Comparing this series of cases with the fifty preceding and the fifty succeeding cases

in which colon injections were made without salt, there was no difference in the frequency of ileocolic valve incompetencies. Several experiments were made in testing the influence of the composition of the enema. It was found that when barium sulphate, bismuth oxychlorid or bismuth subcarbonate was used in a gummy suspension in water, with or without saline solution, and in buttermilk suspension with or without the addition of salt, a constant proportion of cases, about 1 in 6, of ileocecal valve incompetency, was observed.

It seems to be a current opinion that rectal alimentation is, on the whole, unsatisfactory, although there are enough cases reported of successful rectal alimentation to warrant the continuance of the practice. In the light of our present knowledge concerning ileocecal valve incompetency, it seems to me reasonable to presume that those cases in which rectal alimentation has proved successful are instances of ileocecal valve incompetency.

8. To me one of the strongest evidences in favor of the normal competency of the ileocolic valve is the fact that when it is incompetent, the competency may be restored by a simple surgical procedure. Kellogg, agreeing with me that the ileocolic valve incompetency must be an important factor in the production of ileac stasis, devised a simple but successful operation for restoring the competency of the ileocolic valve. I have already reported postoperative studies on more than one hundred cases in which this operation for restoration of the ileocolic valve competency has been performed. With only three or four exceptions, the Roentgen-ray diagnosis of ileocolic valve incompetency was confirmed at operation, and the valve competency was restored by the simple operation above mentioned. That the competency was restored was proved, not only by testing the valve *in situ* before the abdomen was closed, but later by roentgenologic tests. Although, in several instances, more than a year and a half had elapsed since the operation was performed, in only three or four cases out of the hundred did subsequent roentgenoscopy find the valve incompetent.

The effect of the operation on the emptying-time of the ileum has also been tested by the bismuth meal,

but thus far no evidence has been secured which would lead me to believe that the operation has caused the slightest interference with the passage of ingested food from the ileum into the colon. On the contrary, the emptying-time of the ileum, which before the operation was in every single instance prolonged, has been definitely shortened, nearly always within eight hours. Emphasis should be laid on the fact that the operation for repair of the incompetent valve has been done, in by far the majority of cases referred to, in connection with some other operation which required opening of the abdominal cavity.

In a few instances in which the ileocolic valve had appeared to be competent to the enema, at subsequent operation the competency of the valve appeared to be open to question, at least in relation to gas, since slight pressure on the cecum was found sufficient to cause a reflux into the ileum after the latter had been thoroughly emptied. In accounting for these cases, I have borne in mind the experimental evidence submitted by Ziemssen, who found that, under deep chloroform anesthesia, the resistance of the valve to reflux from the colon was decreased and fluid could be forced into the small intestine. I have, therefore, assumed that, in these cases, the valve itself was really incompetent, even at the time of the enema; but with the patient awake and the bowel tone normal, the activity of the sphincteric mechanism was sufficient to prevent a reflux from the cecum into the small intestine, even though the valve lips did not closely approximate. Further, at operation, the test of the valve competency is usually made with gas and not fluid. The experiments of Senn and others would indicate that one can overcome the competency of the ileocolic valve more easily with air than with fluid, especially when the patient is anesthetized.

9. Another significant observation is made in connection with surgical operation in cases in which ileocolic valve incompetency has been demonstrated roentgenologically. At operation the surgeon often finds the small bowel filled with gas to a very disturbing degree in spite of the careful preoperative preparation, whereas in cases in which the valve is competent the small intestine is collapsed.

10. Still another evidence of normal valve competency is found in the fact that it is possible in the

operation of ileosigmoidostomy to construct an artificial ileocolic valve which will stand the test of postoperative roentgenologic studies. The operation does not differ from the ordinary end-to-side anastomosis except that there is a distance of 2 or 3 cm. measured along the surface of the ileum, between the inner and the outer suture-lines. The result is an inversion of the ileum into the colon for about half an inch, forming a circular valve-like fold, which acts as an efficient valve. I have made such postoperative studies in twelve patients thus operated on by Kellogg in which roentgenoscopic tests have proved the competency of the artificial ileocolic valve.

11. At operation, cases of ileocecal valve incompetency show definite deviations from the normal anatomic structure. The crease marking the normal invagination is obliterated; the ileum is pulled out of its cecal pocket; the last inch or two is dilated into a trumpet-shaped sac, which Kellogg has found at operation to have a diameter of from 5 to 7 cm. instead of the normal 3 cm. Kellogg has also called attention to a thinning of the walls of the terminal ileum often seen in marked cases of stasis.

12. Post-mortem studies show a great predominance of competent valves. Surely the only function persisting in the cadaver is a mechanical action, yet Kraus in one hundred and fifty necropsies after death from various causes, found the ileocolic valve competent in all but twelve. The reports of a few other pathologists who have published their observations, agree closely with this statement.

In the foregoing pages evidence is cited which, it seems to me, demonstrates the fact that the ileocecal valve is normally competent and that the competency is due to an action of the valve lips which is largely, if not entirely, mechanical. This evidence may be summarized as follows:

1. The ileocecal valve is almost universally present in vertebrate animals; and, at least, in the dog, pig, and cat, the valve is competent to the enema, withstanding enormous distention of the colon by fluid and gas.

2. By means of a string passed through the alimentary canal traction may be made on the valve lips, producing temporary incompetency.

3. In about one-sixth of three thousand persons, most of them constipated and all suffering from gastro-intestinal disturbances, the bismuth enema passed the ileocecal valve and filled the terminal ileum for varying distances.

4. The valve incompetency thus determined is a constant phenomenon in those cases.

5. Patients with incompetency of the ileocecal valve describe characteristic disagreeable symptoms apparently due to passage of the enema into the small intestine.

6. In the marked cases there is also observed a reflux of ingested bismuth from the colon back into the ileum.

7. The occurrence of the incompetency is, to a large degree at least, independent of the temperature or composition of the opaque enema.

8. The incompetent ileocolic valve may be restored to competency by a simple surgical procedure, the competency persisting in some cases at least a year and a half.

9. In operation on patients with incompetent ileocolic valve the small bowel is found filled with gas to a very disturbing degree.

10. It is possible in the operation of ileosigmoidostomy to construct an efficient artificial ileocolic valve which will successfully act as a barrier against reflux from the colon.

11. Definite deviations from the normal anatomic structure are found at operation on cases of ileocecal valve incompetency.

12. Post-mortem studies show the ileocolic valve to be competent in the great majority of cases.

Roentgen Studies After Gastric and Intestinal Operations

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CHICAGO**

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ROENTGEN STUDIES AFTER GASTRIC AND INTESTINAL OPERATIONS *

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Through my institutional connections I have for a number of years enjoyed special advantages for the roentgenologic study of patients after gastric and intestinal operations. My colleagues have extended many much appreciated courtesies in arranging for the postoperative studies on which this paper is based. Results both good and bad have been included, the patients studied representing the work of a number of different surgeons, some of the cases coming from the most famous clinics of this country. Many of the patients had no complaint, the postoperative condition being satisfactory, at least subjectively. Others were referred for postoperative convalescence, and the opportunity was improved to make the postoperative roentgenologic observations. In the majority of the cases reported in this paper, the examination was advised in the hope that it would assist in ferreting out the cause of untoward symptoms. I would not insinuate that, because the majority of the cases included in the series studied have been unsatisfactory, referring especially to colonic operations, the majority of such cases with operation show similar late results; I merely report my findings on account of their obvious importance. The untoward results have been particularly frequent after operations for the relief of intestinal stasis, real or supposed.

The limits of this paper will preclude a relation of the findings in more than three or four classes of cases. I have therefore decided to confine my discussion to the following: (1) acute intestinal obstruction; (2)

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gastro-enterostomy; (3) appendectomy; (4) ileocolostomy, without and with colectomy. Lack of space forbids a detailed description of the many interesting cases, the details of which I hope to publish at some future time.

ACUTE SMALL BOWEL OBSTRUCTION

Our experience during the last five years has convinced us of the value of the Roentgen examination in the diagnosis of postoperative acute small bowel obstruction, with special reference to the decision as to the advisability of surgical interference. Having accumulated the evidence in a sufficient number of cases of suspected obstruction following operation, it has seemed warranted to urge strongly the value of the Roentgen study in all such suspected cases with special reference to the existence of an obstruction, the degree of the hindrance, the location and perhaps the nature of the lesion, and whether or not the obstruction is progressive. If nonsurgical treatment seems preferable at first, the progress of the case under treatment may be observed roentgenologically.

Emphasis should be laid on the fact that it is not necessary to administer any barium or other opaque material in pursuing these studies, the observations being made possible by the gas distention of the intestine. There is, therefore, no delay incurred; and no objection can be raised to the Roentgen study of these patients on account of possible danger through delay or through the introduction of new food material into the digestive tube in the presence of possible obstruction. A Roentgen study should be required in every case of suspected postoperative obstruction.

Given a patient on the third day after operation, presenting symptoms suggestive of acute intestinal obstruction, he should be transferred to a carrier, conveyed to the Roentgen-ray department, a 14 by 17 inch plate with intensifying screen placed under him, and a flash exposure made. It must be short enough so that the patient can hold the breath during the exposure. The plate is then removed and the patient returned to his room and bed without further manipulation or inconvenience than is required to lift him onto the stretcher and back to bed again. No preparation of any kind is required; dressings are not removed. The plate is then developed and the find-

ings may be noted as soon as it is taken from the fixing bath. Not more than twenty minutes need be consumed in the entire process.

The developed roentgenograms will reveal at once whether there is any gas distention of the bowel, and if so, whether the distention occurs in the small or in the large intestine. Acute postoperative dilatation of the stomach may be at once ruled out. Small and large bowel may be distinguished by the characteristic outlines of the gas areas. In acute colonic obstruction, the haustral markings as well as the



Fig. 1.—Gastro-enterostomized stomach, five hours after eating. Note the delay in the jejunum opposite the stoma. After complete clearance of the stomach, this residue in the jejunum persisted for several hours. This case is typical of the findings in a large percentage of gastro-jejunosomies.

peripheral distribution of the gas along the course of the colon are sufficiently characteristic to identify the large bowel. Equally characteristic is the appearance of the gas-distended coils in acute obstruction of the small bowel; the coils are more or less parallel and the caliber of the small intestine is increased to $1\frac{1}{2}$ or 2, and sometimes 3 inches. It is seen that the distention

is not confined to a short segment of the intestine but involves one or more feet of the small bowel, usually many feet. A certain amount of postoperative distention of the small bowel is frequently noted where there are no symptoms suggestive of obstruction, but in the serious cases the degree of distention is at once apparent and suggestive. The serrated contour of the bowel is characteristically different from the contour of the colon due to the markings of the haustra coli;

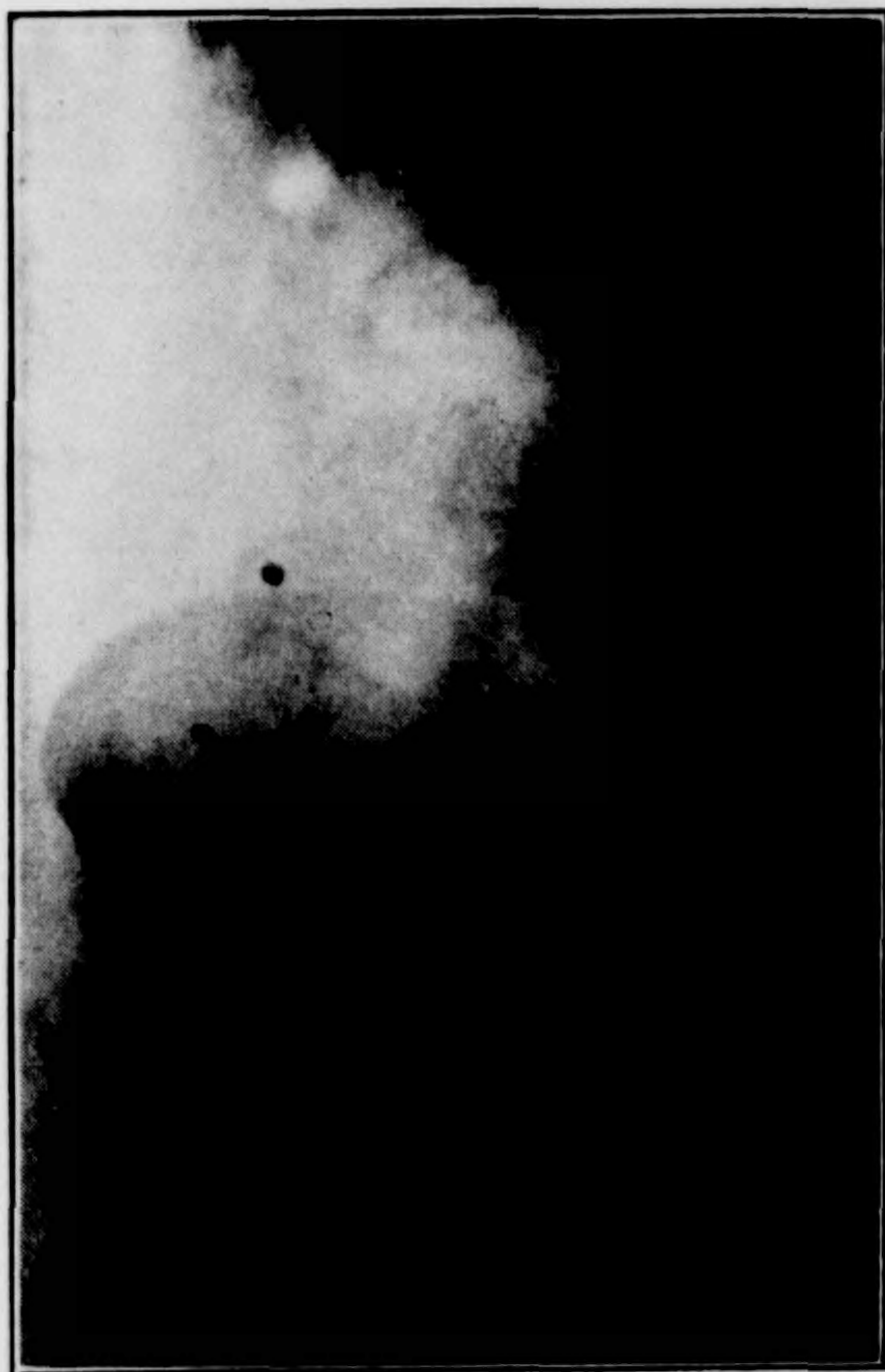


Fig. 2.—The small rounded residue often seen at the site of the appendix stump following appendectomy; also sometimes seen about the base of a diseased appendix before removal. In some of the cases showing such a residue after the barium meal, the operation had been performed years before.

so that we are at once able to recognize and differentiate acute postoperative gastric dilatation and obstruction in the large or small intestine.

Observation of the cecal region is especially helpful, for if the cecum contains gas, it is not likely that the obstruction is in the small bowel. If the gas collections, as above described, are seen to occupy the middle of the abdominal shadow while the flanks are gas free, it is probable that the obstruction is in the lower ileum,

though not so low as the ileocecal region. When the gas areas occupy the true pelvis and the middle of the abdominal shadow, one may suspect the ileocecal region. Intussusception may be discovered by colonic injection with an opaque material. Early physical findings in these cases are very difficult to demonstrate with surety, whereas the roentgenologic findings may be demonstrated much earlier, and gain in surety as the gas distention progresses.



Fig. 3.—Very marked distention of the colon with gas in a case thought to be acute small intestinal obstruction. The gas distention was relieved by washing out the colon, and the administration of pituitary extract. The distribution of the gas and the characteristic markings of the bowel outlines indicate colon rather than small bowel.

If the observation of the gas-filled bowel (without the ingestion of barium) does not make clear the location of the obstruction, time will be saved by proceeding at once to the administration of the barium enema to rule out colonic obstruction. If the entire colon fills, it is then recognized that the obstruction must exist in the small bowel. If the findings thus far are still indecisive, and the clinical symptoms are not yet clear, with the permission of the surgeon a small

amount of barium sulphate, say half an ounce, may be administered by mouth in any medium which the patient will take. These cases are usually also so doubtful from the clinical standpoint that final decision as to operation is postponed in any case, and there is ample time for some of the barium to pass on into the small intestine. After a little experience, however, it is quite unnecessary to administer any barium at all by mouth, the decision being rendered on the appearance of the abdominal shadow with reference



Fig. 4.—Acute obstruction high up in the small intestine, somewhere near the junction of the jejunum and the ileum. Note the absence of gas-distended coils in the lower half of the abdominal shadow.

to the character and distribution of the gas areas which it may present.

GASTRO-ENTEROSTOMY

To Cannon belongs the credit for some of the earliest Roentgen studies on gastro-enterostomized patients. Until a few years ago gastro-enterostomy was looked on as a drainage operation, and it was the effort of surgeons to make the anastomosis as near as possible to the lowest point of the stomach. This

idea was based on the conception of the stomach as a passive reservoir from which food was discharged more or less under the influence of gravity. Cannon's studies on the movement of food after gastro-enterostomy were very carefully carried out and constitute a classic to which no exceptions can be taken.

In our studies following gastro-enterostomy, it is seen that we deal with at least three classes of patients. The first class includes those in whom the gastro-enterostomy opening is very large and the food does



Fig. 5.—Marked gastric dilatation. Acute obstruction low in the small bowel, yet a little distance above the ileocolic junction. One determines this by the distribution of the gas-distended coils. The trace of barium in the cecum remained there from a preoperative barium meal study.

seem to drop in a passive way from the stomach or into the small bowel. These patients frequently complain of a sickening distress, especially after the ingestion of a meal consisting largely of warm liquid. I have attributed this distress to the sudden overdistention of the small bowel resulting from the quick clearance of the stomach through the large stoma.

In the second class fall those patients in whom the stomach does not empty well following the operation.

The opening is probably not too small, but it is apparently placed too high or too far from the pylorus. The stomach empties quickly until the level of the opening is reached, after which it empties very slowly, the residue at that time remaining for eight, ten or more hours.

The normally functioning cases form the third class—those patients in whom the passage of material from the stomach occurs very much as in the normal patient. A few moments elapse before food is seen

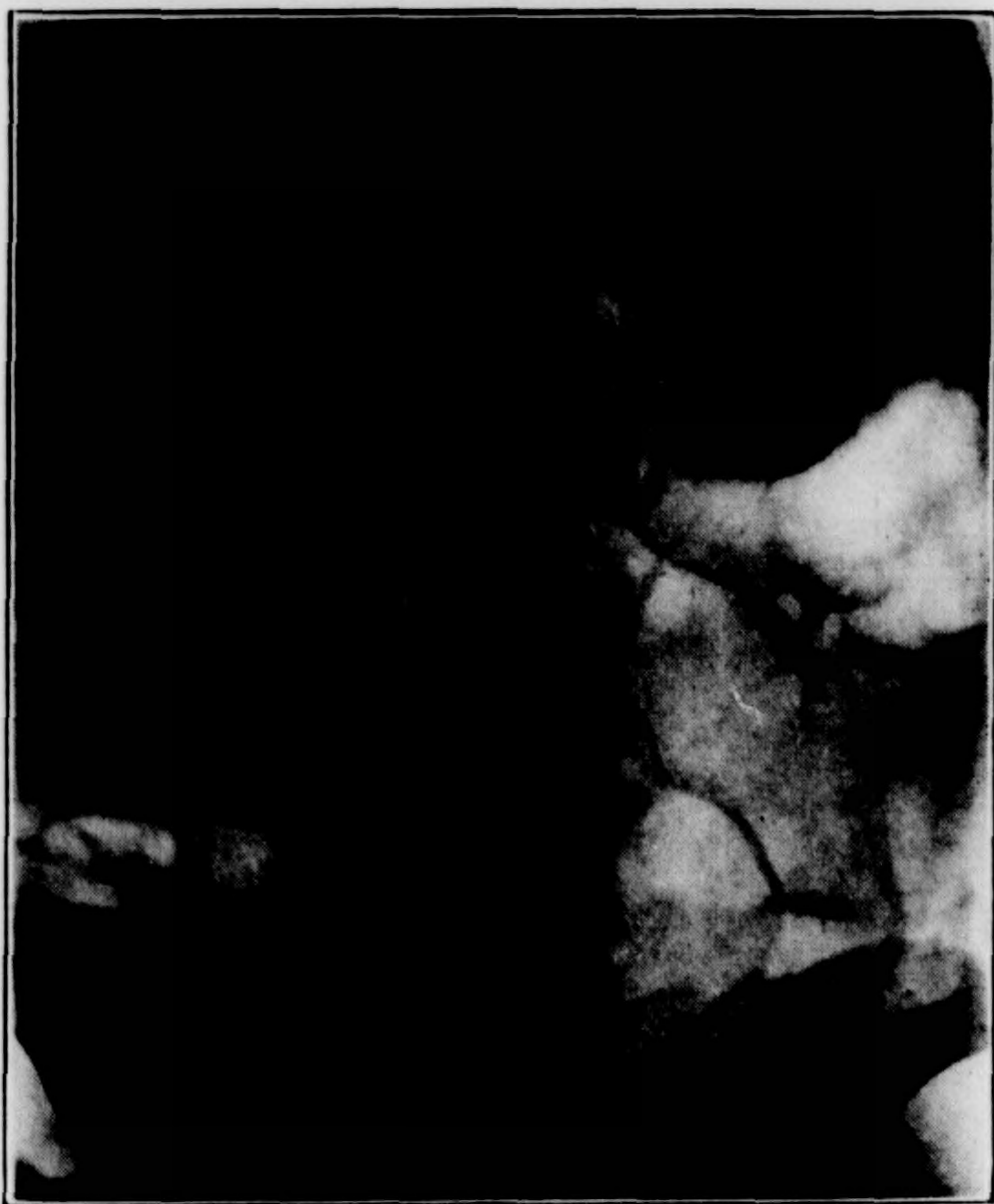


Fig. 6.—Very high grade of acute obstruction near the ileocolic junction. The dilatation of the entire small bowel in this case was extreme.

in the jejunum, the passage of food boluses is irregularly intermittent, and the total time required for clearance of the opaque meal averages from four and a half to six hours. Unless the operative procedure has been done for the relief of organic pyloric obstruction, it is the rule to find some of the barium passing through the pylorus. The nearer the new stoma to the pylorus and the greater curvature, the smaller is the proportion of material seen passing through the pylorus by the old route.

The only occlusion operations which were successful for more than a few weeks in preventing the passage of food through the pylorus involved considerably more than mere ligatures. In several cases in which pyloric occlusion was attempted by a tight chromic catgut ligature reinforced by linen and four to eight mattress sutures of linen to produce reduplication of the gastric wall over the ligature, examination with the barium meal showed patency of the pylorus as early as the fifth or sixth week.



Fig. 7.—Acute obstruction in the small intestine in which the decision to operate was not made until the second examination, six hours after the first. Meanwhile a small amount of barium had been given, and the characteristic appearance of the small bowel visualized.

Sometimes the gastric delay in the unsuccessful cases occurs in the duodenum and in the few inches of jejunum proximal to the anastomosis. Occasionally one sees a marked dilatation of the duodenum, with vigorous onward and retrograde peristalsis, the food surging backward and forward in the duodenum in a manner characteristic of duodenal obstruction. Vicious circles are sometimes encountered, and valve-like obstructions in the jejunum in the neighborhood

of the operation. These have been fully described by Cannon and many others, and verified in the experience of every roentgenologist.

There are, however, two new points to which I should like to direct attention. It will be recalled that Cannon and Blake from their experimental work concluded that the stoma should be fairly large and near the pylorus—that conditions which stretch the stomach should be avoided, and that several centimeters of distal intestine should be attached to the stomach to prevent kinking in the jejunum. But when pyloro-

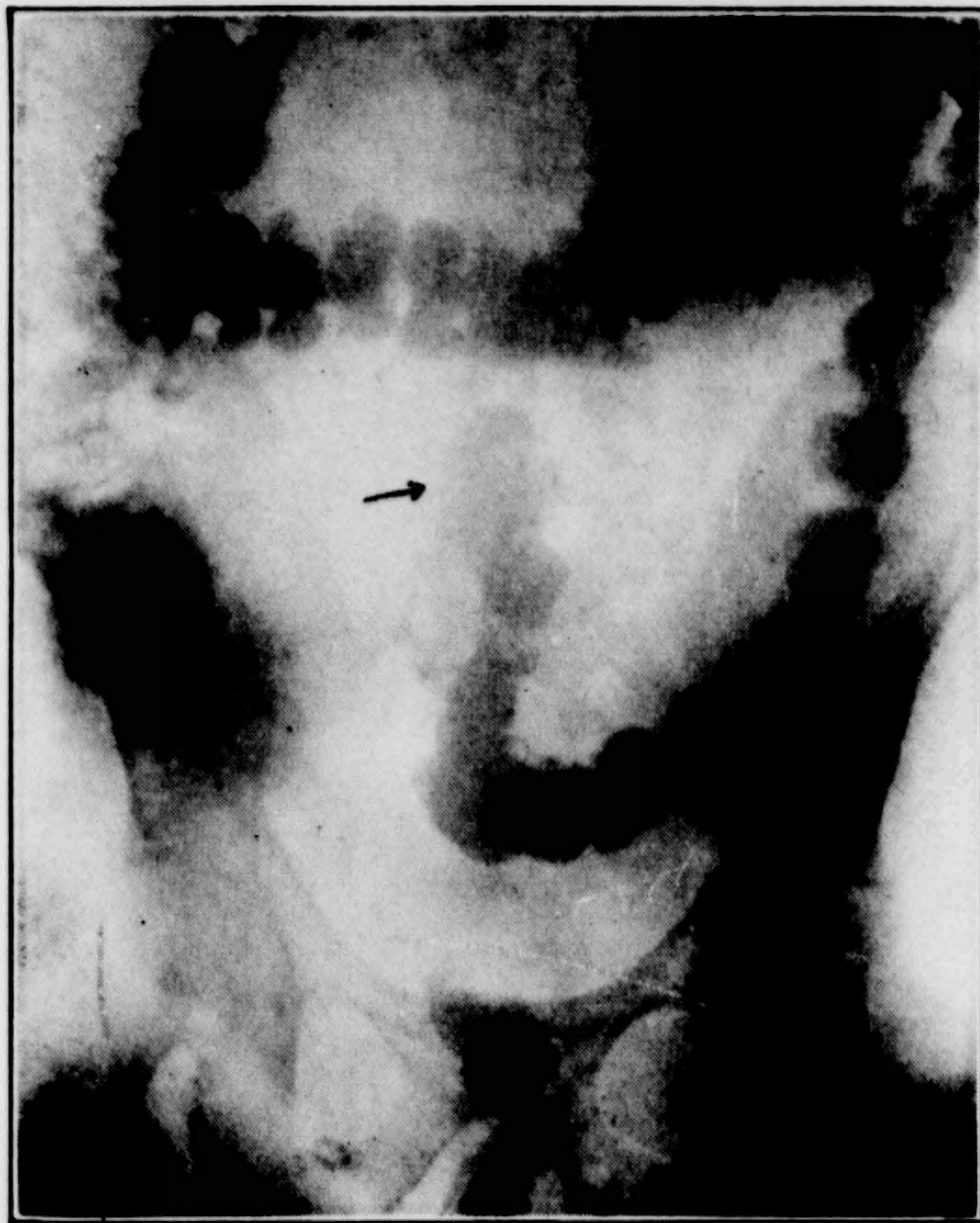


Fig. 8.—Three years after ileosigmoidostomy. The arrow indicates the site of the anastomosis. Appearance of the colon forty-eight hours after barium meal. The colon is filled by material carried backward from the rectum by retrograde peristalsis. This retrogression of food residues often forms large cecal tumors.

plasty was possible, these authors thought it was the operation of choice. They found that the rapid exit of food from the stomach was prevented by the formation of rhythmically contracting constriction rings in the duodenum. They believed that this activity replaced in part the function of the pylorus and also served to mix the food with the pancreatic juice and

the bile. I have observed this phenomenon in two out of four cases in which a Finney operation had been done. It is interesting that analogous phenomena were noted in a large number of cases in which the ordinary gastrojejunostomy had been performed, namely, a sort of sphincter action established in the jejunum at a point varying from 3 to 6 cm. below the gastrojejunal opening. This was at first interpreted as a spastic contraction of the circular muscle of the jejunum; but in the light of Cannon's observation on rhythmic contractions of the duodenum after



Fig. 9.—Even after removal of the right half of the colon, including the first third or half of the transverse colon, there is a tendency to the formation of a tumor in the proximal end of the remaining large intestine. In this case the barium-mixed residues in the stump are shown on the ninth day following the meal, forming an easily palpable tumor.

pyloroplasty, it seems reasonable to conclude that this contraction ring in the jejunum is purposive, serving somewhat as a sphincter.

Kocher years ago made the statement that the gastro-enterostomy opening developed a sphincter action and actually underwent rhythmic contractions.

It seems possible that the formation of a contraction ring in the jejunum below the site of operation may well simulate the normal action of the pyloric sphincter. Under the fluorescent screen, one sees a small fingerlike shadow gradually build down behind the gastric silhouette, simulating very much the formation of pseudopodia in the ameba. This fingerlike shadow projects farther and farther until it is suddenly constricted off an inch or two below the stomach, the pinched-off bolus passing onward into the distal

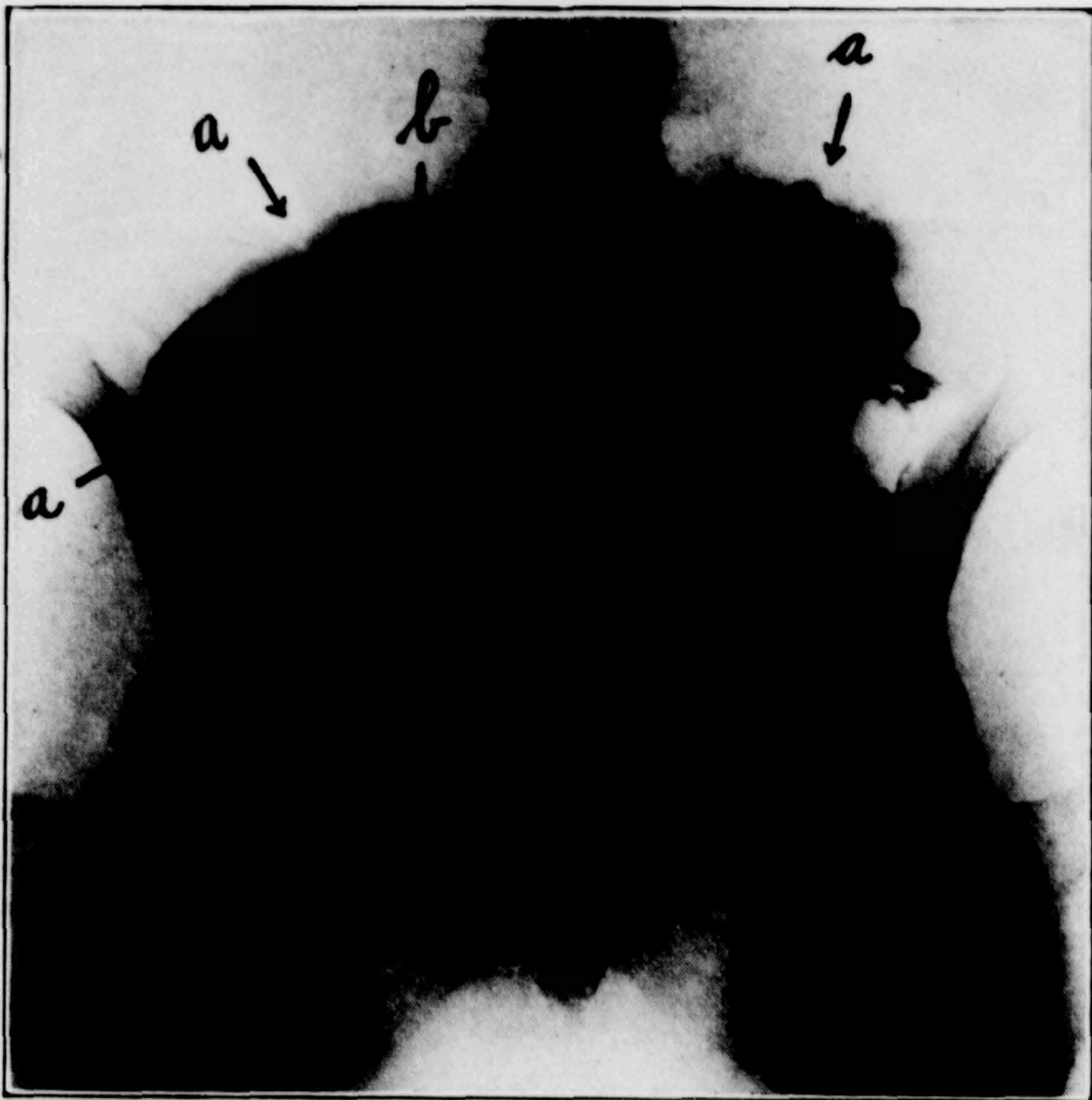


Fig. 10.—This backing up into the short-circuited colon takes place constantly, and begins immediately after food reaches the rectum. This roentgenogram, twenty-six hours after eating, shows at *a* the backed-up material in the transverse colon and cecum, and at *b* a large residue still remaining in the terminal ileum. The bowels had meanwhile moved satisfactorily (?) several times. (See Figure 11.)

small bowel, the proximal portion remaining and gradually assuming larger proportions until the distal portion of it is again pinched off by succeeding contractions. In other words, this action has in a certain degree seemed to take the place of the rhythmic contraction normally occurring at the pylorus.

A second new point relates to a stagnation of food in the jejunum at or near the site of the gastro-enterostomy. Cannon, with F. T. Murphy, made intestinal resections in animals, uniting the severed intestine either by end-to-end or by lateral anastomosis. After lateral anastomosis, there occurred a more or less complete blocking of the canal by undigested detritus at the opening between the opposite loops. Necropsies on animals proved that the stasis was not due to previous accumulation of undigestible



Fig. 11.—(See Figure 10.) The very marked distention of the coils of terminal ileum attending the marked ileal stasis in some of these cases is illustrated by the colon injection. Same case as in Figure 10. The arrows point to distended small bowel, the seat of stasis in Figure 10.

waste, but that the two apposed coils did not cooperate to propel the enclosed food, and that after an ordinary meal, food was stagnant in the region of the anastomosis. It has seemed to me that the same phenomenon is also observed after gastro-enterostomy. Especially toward the end of gastric clearance, there occurs a stagnation, apparently in the small bowel, at the site of the anastomosis, this stasis being accounted for by

the inhibition of onward peristaltic activities at this point (Fig. 1).

APPENDECTOMY

A common cause of cecal stasis is adhesions, usually associated with disease of the appendix. It is also a fact that immediately following recovery from the operation of appendectomy, there is in the majority of cases a considerable degree of cecal stasis. The cecum retains portions of the barium meal for from two to four days, and sometimes more, although the

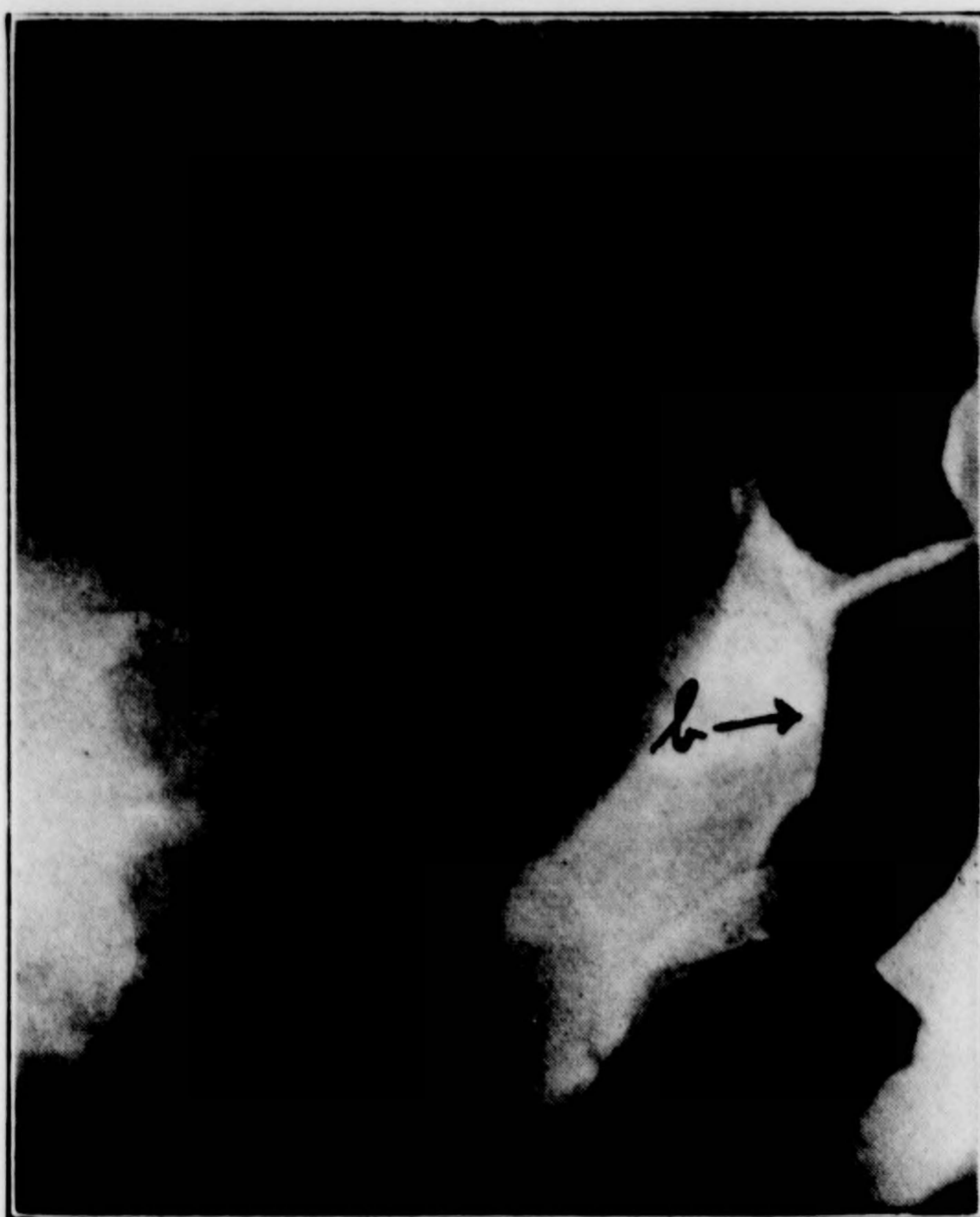


Fig. 12.—Another case two years after ileosigmoidostomy. Colon injection. Note the very marked dilatation of the small bowel shown at *a*, whose caliber equals that of the neighboring colon shown at *b*. There was marked ileal stasis in this case, shown after the barium meal. In cases of ileosigmoidostomy examined shortly after the operation, there is noted a similar insufficiency of the ileocolic orifice, but the coils of terminal ileum do not exhibit the same degree of dilatation until later.

remainder of the colon may clear itself normally. Following the attempt to expel the barium enema it is seen that the cecum has failed to contract, the propulsive ring peristaltic waves which evacuate the large bowel commencing at or above the ileocolic junction instead of at the tip of the cecum. Even at a remote

period after the operation, several years later, a certain degree of cecal stasis persists in a considerable number of cases, a rounded residue of barium the size of a 25-cent piece remaining in the cecum after the colon has otherwise been entirely cleared of the barium meal. This is especially likely to occur where the patient complains of a tenderness over the cecum. Sometimes this cecal stasis was present before the operation, as shown by the preoperative Roentgen records; but that it often exists after operation where



Fig. 13.—In performing the operation of ileosigmoidostomy, it is possible to make an artificial valve at the new opening, by Kellogg's method. In the case here figured, the right half of the colon had been removed, the ileum being inserted into the sigmoid with the formation of an artificial valve. The enema failed to enter the ileum. There was no ileal stasis following the meal. There was marked stasis in the blind portion of the remaining colon; *a*, stump of transverse colon; *b*, site of ileocolic junction.

it did not exist before is convincingly shown by our series. I believe that the rounded barium residue, above referred to, occurs at the site of the stump of the appendix, and that it has some relation to the invaginating suture by which in the technic commonly employed the stump is buried. The coincidence of a

point of localized tenderness on pressure with this rounded residue at the site of the appendix stump would suggest the desirability of including the least possible amount of cecal muscularis in the invaginating suture.

In a few cases in which it was thought that the appendix had been removed, a characteristic shadow was noted in the appendical region, resembling the appendix. In three of the four cases of this sort which went to operation a second time, there was found a definite, uninvaginated stump of appendix, the residue measuring more than 2 cm. in length in one instance. In the fourth case the operation revealed no abnormality in the cecum. In fact, it was difficult to decide just where the appendix had been removed.

ILEOCOLOSTOMY

I have been especially fortunate in having been able to study a large series of cases after ileocolostomy performed for adhesions, ileal stasis, Lane's kink of the ileum, and other nonmalignant lesions. Forty such cases have been examined very carefully, operation in most of them having been performed according to the technic advocated by Lane, one of them by Lane himself. Not all the patients in this series were clinically failures, though the majority of them were examined for the cause of an unsatisfactory result. In most of them, during the early months following operation, the result was apparently worth while, and in a few striking instances the operation had seemed to work like magic; but sooner or later, usually within a year after the surgical procedure, the symptoms have begun to recur and the patient's last state is worse than the first. It should be remembered that this series of cases represents the work of more than a dozen different surgeons, most of them of national reputation—work which I believe to be on the whole representative of the best in technic which this country affords. The unsatisfactory results can, therefore, hardly be attributed to poor technic.

Excepting only those cases in which an artificial ileocolic valve has been formed, all cases have shown incompetency of the ileocolic stoma permitting the enema to flow back into the small bowel as well as retrogradely around the colon to the cecum or as far

as the stump of the colon in those cases in which partial colectomy had been performed. The small bowel thus visualized has displayed a variable caliber, not much enlarged in the recent cases, but frequently so large as to be confused with the colon itself in patients examined two or three years after the operation. In some of the roentgenograms it is impossible to tell definitely from the roentgenogram alone which shadows are colonic and which are ileac. Of course, it is recognized that the test by enema reverses the usual order of progress of the food column, but there is also noted in many of these cases a regurgitation of *ingested* food. There is a very definite ileal stasis in most of the older patients (operation performed a year or more before the examination). It is not uncommon to find at the twenty-sixth hour a large mass in the terminal ileum simulating a colonic residue in size and caliber of the coils. The worst cases of ileal stasis, judged by the retention in the ileum of a mass of ingesta, are those cases which, when tested by the enema, show the greatest ileal dilatation and the most extensive ileal filling by the passage of the enema through the anastomotic opening. This incompetency of the stoma to enema and the ileal stasis should both be prevented by the formation of an artificial ileocolic valve by Kellogg's method. In one case reexamined three years after the operation just referred to, the artificial valve still prevented the reflux of the enema, and there was no ileal stasis.

Following the barium meal, there has been noted in every case, without exception, retrograde peristalsis carrying barium oralward as far as possible from the rectum. This regurgitation commences immediately after food reaches the rectum, and the head of the backed-up column has usually reached the splenic flexure by the tenth or twelfth hour. This retrograde movement of ingested material persists in spite of repeated enemas and in spite of repeated bowel movements, so that by the end of the twenty-sixth or even the fiftieth hour, the residues are banked up in the proximal colon, from which it is very difficult to dislodge them. I have seen a large barium-mixed mass in the cecum on the fourteenth day forming a tumor in the right inguinal region, easily palpable and visible on inspection of the abdomen. Hauchamps has

recently reported a case of a nervous woman of 26 years, who had suffered all her life from obstinate constipation. To give relief some surgeon made an appendicostomy, to facilitate colonic lavage. Later the patient was reoperated, the appendix being removed and the right kidney being anchored. Still later, the patient failing to improve, ileosigmoidostomy was performed. A month after the last operation the patient was given a barium meal. There occurred evident retrograde peristalsis with the formation of a large barium-mixed fecal mass in the right inguinal region, which was still visible both on inspection of the abdomen and roentgenologically on the thirtieth day, although no opaque salt had been administered meanwhile. This stasis in the excluded colon is usually attended by the formation of distressing amounts of gas, which sometimes distend the colon to enormous proportions, resisting all efforts to dislodge it. Gas distention of the colon after ileosigmoidostomy often distorts the stomach in such a way as to produce a pseudohour-glass appearance. Efforts to prevent the retrograde procession by making a kink in the sigmoid just proximal to the anastomosis result only in greater stasis and greater difficulty in dislodging the stagnant material, which is only slightly delayed in its regurgitation.

It thus appears that in a very considerable percentage of cases in which the operation of ileosigmoidostomy is performed for the relief of intestinal stasis, particularly ileal stasis, the end-result is infinitely worse than if the patient had not been operated on, at least so far as the ileal stasis and the patient's comfort are concerned. As before suggested, there is often a period of improvement, sometimes marked; but ultimately the majority of the patients under our observation exhibit a recurrence of the stasis.

To avoid a recurrence of the ileal stasis, Kellogg has endeavored to make an artificial ileocolic valve, hoping to prevent the regurgitation of food residues back into the ileum and to lessen the ileal delay. This operation, which results in the formation of a valve-like invagination of the terminal ileum into the colon in a manner resembling the formation of the normal ileocolic valve of the pig, is accomplished by a modification of the ordinary technic for end-to-side ileosigmoidostomy. In twelve cases the valve thus formed

has worked satisfactorily in seven, the five failures occurring early in the series. Even in those cases in which the effort to make an artificial valve failed, the patient was no worse off than if the ordinary anastomosis had been performed. When ileocolostomy must be performed, it seems distinctly worthwhile to attempt the production of an artificial one-way valve, simulating the normal ileocolic junction.

To obviate the retrogression of rectal contents back into the excluded colon in these cases of ileosigmoidostomy, a number of surgeons conceived the idea of resecting the right half of the colon, including the cecum, the ascending colon and a part of the transverse colon. This operation preserved the omentum and saved the patient much of the shock likely to attend removal of the colon down to the sigmoid. In all the cases thus operated in which the patients have come to me for postoperative study, there has been demonstrated the same retrogression of colonic contents with the formation of an obstinate residue in the blind end of the stump of colon, this residue in several cases forming a palpable and visible tumor, persisting many days. In one case this tumor persisted longer than nine days, in spite of repeated daily enemas and the use of laxatives. The severity of the stasis in the stump of the colon has a relation to the length of time which has elapsed since the performance of the operation, becoming progressively worse as the months go by.

The operation of cecosigmoidostomy was also proposed as a procedure which would obviate the distresses attending the retrogression of materials up the colon under the influence of antiperistalsis. This operation appears to me an illogical and unreasonable procedure in these cases. In one instance in which it has been impossible to secure a reexamination by means of the Roentgen ray, the reports from the patient are fairly satisfactory; but in the other cases examined at some interval after the operation (three cases), there has been seen a double procession of food residues, one column traveling up the ascending colon in the normal direction and the other up the descending colon, the two columns tending to meet near the middle of the transverse colon. My friend, Dr. L. T. LeWald, who has studied such a patient

two years after operation, has kindly communicated to me his Roentgen findings:

The intra-abdominal distress and the constipation were relieved for a time, but the symptoms recurred within two years and the constipation became extreme. The bowels never moved without enema, and the gas distention of the abdomen was very distressing. Roentgen studies after a barium meal showed most of the meal going in the direction of the hepatic flexure and transverse colon instead of through the cecosigmoidostomy opening. At the end of twenty-four hours the transverse colon was filled, only a little having passed from the cecum through the artificial opening. By the end of the second day only a trace of the meal had been eliminated, the greater part remaining in the cecum, ascending colon and the transverse colon. Seventy-two hours after the meal and after repeated enemas, it appeared that the elimination of the barium-mixed residue was almost impossible, the appearance suggesting a definite vicious circle. As some of the barium passed down the descending colon and began to enter the sigmoid, it appeared to enter the cecosigmoidostomy opening into the cecum, and thence through the ascending colon back into the transverse colon. Only a small portion remained in the rectum and was voided.

The next class of cases includes those in which it was not deemed advisable to subject the patient to an extensive colectomy, and yet radical treatment was demanded. It was finally decided to make an ileocolostomy with partial colectomy, that is, resection of the right half of the colon followed by insertion of the ileum into the transverse colon as near as possible to the stump. In our Roentgen studies as well as in our clinical observations in these cases, this type of operation has given the most satisfactory results. Thus far, it would appear, both clinically and from the Roentgen findings, that this type of operation is preferable where any operative procedure at all seems indicated for stasis in the right half of the colon. Of course, for a lesion in the pelvic colon such an operation would not be likely to afford any improvement of the condition.

It would thus seem that when for any reason it appears necessary to resect a portion of the colon, making a new ileocolic junction, the ileum should be implanted as near as possible to the proximal end of the remaining portion of the colon, and an effort should be made to produce an artificial ileocolic valve. Exclusion operations are invariably followed by stasis

in the excluded intestine, and blind ends, as after ileosigmoidostomy with or without partial colectomy, always sooner or later become the seat of stasis, usually with the formation of distressing amounts of gas which cannot be dislodged without great difficulty. The production of a serviceable artificial ileocolic valve by Kellogg's method is quite feasible, and in the majority of cases it is successful.

I have omitted reference to postoperative findings after repair of the ileocecal valve, or after operation for suspension of the pelvic colon after the relief of adhesions, or after various exclusion operations, feeling that the space at my command does not warrant a discussion of this important group of cases. I hope at some future time to detail my findings in these patients.

THE RÖNTGEN FINDINGS IN GASTRIC AND DUODENAL ULCER

By **JAMES T. CASE, M. D., Battle Creek, Michigan**

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I N attempting to summarize our present knowledge of the X-ray method in studying gastric and duodenal ulcers, I recognize that new facts are being developed daily in this newest of the accessory means of clinical study of the alimentary tract. The present-day scarcity of textbooks in röntgenology is easily explained when one considers the rapid advances being made from year to year and even from month to month. This is especially true in relation to the gastrointestinal tract. This field of röntgenologic study still remains, in a large measure, virgin soil. There must yet be large series of cases studied by the röntgen ray and checked up rigidly by the findings of the surgeon and the pathologist.

Gastro-intestinal röntgenology is in its infancy and needs all the help to be derived from other departments of clinical research. The child's mistakes do not negative his potential worth as a man. An attitude of helpful and friendly critical suggestions will surely serve best in considering the value of this means of clinical study.

The röntgen evidences of ulcer of the stomach and duodenum may be classified under the following heads:

1. Bismuth flecks representing ulcer craters filled with bismuth.
2. Filling defects in the stomach shadow.
3. Organic deformities of the stomach other than filling defects. These various phenomena constitute what may be called the *definite* X-ray evidences of ulcer.

Under the head of *inferential* evidence may be classified:

4. Spastic manifestations.
5. Abnormalities of peristaltic waves.
6. Abnormal emptying time of the stomach.
7. Unusual filling of the duodenum.
8. Pressure pain points.

These evidences will be considered in the order named.

Bismuth flecks representing ulcer craters filled with bismuth. The first suggestion with relation to gastric ulcer heard from one unfamiliar with X-ray examinations of the alimentary tract is that the crater of the ulcer should accumulate bismuth and thus cast a shadow visible on the screen or röntgenogram. In other words, it is the popular idea that the ulcer itself should show. As a matter of fact, however, experience has shown that it is rare indeed for an ulcer to show in this manner. Aside from the penetrating ulcers at about the middle of the lesser curvature, I have had only eight or ten proven cases (by operation) in which the crater filled with bismuth; and several of these were so near perforation that after exposing the stomach and before proceeding to the necessary surgical procedure, the surgeon felt obliged to reënforce the tissues at the site of the ulcer to prevent possible rupture during manipulation. Aside from these penetrating ulcers on the lesser curvature, and ulcers of the duodenum, I have encountered only four cases where the bismuth fleck in the stomach corresponded to a gastric ulcer.

Penetrating ulcers of the lesser curvature, the X-ray findings in which were first described by Haudek, will be considered under another head.

Flecks in the duodenum representing flecks in the crater of an ulcer may be confused with a number of shadows, as, for instance, bismuth flecks in the ampulla of Vater. This bismuth fleck is not easily demonstrated as being in the ampulla unless one manages to fill the duodenum at the same time the ampulla is made to show. I have a few such cases. Dr. L. G. Cole has also called attention to this source of error. Other confusing shadows which may be mistaken for the ulcer crater filled with bismuth are right renal calculi, small gall-stones and bismuth residues in the gall-bladder following cholecystenterostomy. I know of at least one case in which bismuth was found in the

¹ Read by invitation before the Chicago Surgical Society, December 5, 1913.

gall-bladder following spontaneous cholecystenterostomy. Normally, a small portion of bismuth persists in the first portion of the duodenum, the duodenal bulb, for some time after the stomach is completely emptied.

Filling defects in the stomach shadow. Defective filling of the stomach with the resulting defective shadow is most characteristic of carcinomatous invasion of the stomach, but it may also be seen in connection with inflammatory masses attending gastric ulcer. Defects in the duodenal bulb constitute one of the chief röntgenographic means of recognition of duodenal ulcer and its complications.

Filling defects on the lesser curvature are to be differentiated from carcinoma and rarely from syphilis and tuberculosis. I do not know of any way to differentiate from the X-ray findings alone between the defect caused by a small carcinoma and that caused by a callous ulcer (Fig. 11). The surgeon himself is sometimes unable to differentiate when he has the lesion between his fingers.

I am able to report and show the slides of a case of tuberculous ulceration of the stomach. This ulcer occurred on the greater curvature at the junction of the middle and lower thirds, measuring about two and a half inches by an inch and a half.

Instead of producing a filling defect, lesser curvature ulcers, as a matter of fact, may produce a projection from the stomach shadow. The size of the projection may vary from the scarcely discernible nodule upon the stomach shadow to a typical penetrating ulcer of the type described röntgenologically by Haudek.

Defects in the shadow of the duodenal bulb are rather common. Their discovery by means of the röntgen ray has been popularized by Cole in this country and later by George and Gerber. According to Moynihan, 95 per cent of duodenal ulcers occur in the first part of the duodenum, the so-called *bulbus duodeni*. The normal shadow of the duodenal bulb has been carefully studied by Cole and others and slight variations from the normal are easily recognized. Abnormal shadows of the duodenal bulb, the so-called "*pilleus ventriculi*" of Cole, may result from penetration or perforation of a chronic ulcer, cicatricial contraction, stenosis, pressure upon the duodenal

bulb of extra-duodenal tumors, adhesions resulting from gall-bladder or pancreatic disease. Occasionally sacculations of the duodenal bulb may be demonstrated. Filling defects in the duodenal shadow, to be interpreted as ulcer, should be differentiated from the normal defects due to the hepaticoduodenal ligament and the deformities of the bulb due to extraduodenal pressure, as, for instance, gall-bladder, blood-vessels, second portion of the duodenum, etc. The defects due to gall-bladder region adhesions are very characteristic; the defect occurs on the gall-bladder side of the duodenal bulb shadow, but the bulb is otherwise anatomically normal.

Complete or nearly complete absence of the duodenal bulb is frequently seen in duodenal ulcer with extensive periduodenal adhesions, in carcinoma of the pancreas with extensive adhesions of the duodenum, and more frequently in pyloric or juxtapyloric ulcer with stenosis. In these cases the stomach presents an appearance to which the term "*prognathian*" has been applied by Cole, the dilatation of the stomach occurring mostly in the pyloric portion and presenting a very characteristic appearance.

George quotes Moynihan as stating that "a duodenal ulcer which has been the cause of protracted and recurrent symptoms is always visible from the outside of the intestine, is always palpable and, therefore, is always demonstrable," and adds to this the statement that there can be no exceptions.

While I place considerable dependence upon the deformity of the bismuth shadow in the demonstration of duodenal lesions, I am not content to rest the case upon this evidence alone. Other evidences, such as hyperperistalsis, hypertonicity, hypermotility, or early pyloric insufficiency with later pyloric spasm and delayed emptying, are some of the other signs that ought to be demonstrated in duodenal ulcer.

Organic deformities of the stomach other than filling defects. Under this head I especially wish to discuss the organic hour-glass deformities and the sacculation of the stomach often attending penetrating ulcer on the lesser curvature. As above stated, aside from cases of penetrating ulcer, one rarely finds a bis-

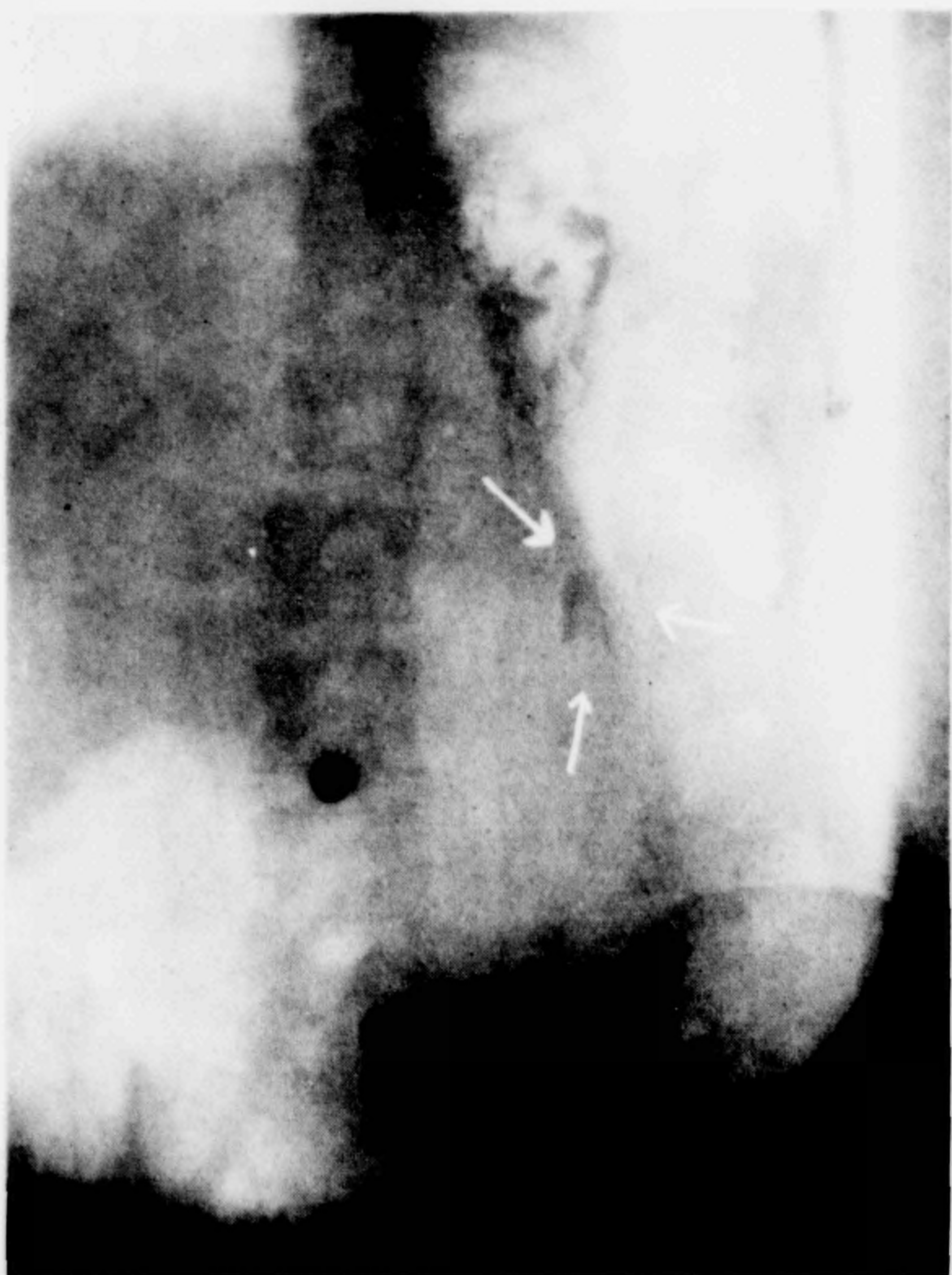


Fig. 1. Bismuth fleck (at arrows) seen six hours after a bismuth meal, marking the crater of an ulcer near penetration.

muth fleck which can be proven to be a bismuth accumulation in the crater of an ulcer. Penetrating ulcers on the lesser curvature frequently produce characteristic deformities which are röntgenographically demonstrable, according to the extent of penetration. The projecting bismuth shadow may vary from a small outcropping from the stomach shadow, scarcely discernible on the screen, to a large bismuth mass ten or fifteen centimeters in length and half as wide. Whether the projecting bismuth shadow or diverticulum has formed posteriorly in connection with adhesions and fixation to the pancreas, or anteriorly with adhesions to the liver, is easily observed by careful screen examination, turning the patient this way and that until by proper oblique illumination the location and extent of the perforation may be determined. The projecting shadow will be found to move up and down during respiration when the perforation is anterior in connection with the liver, but it will be immovable during

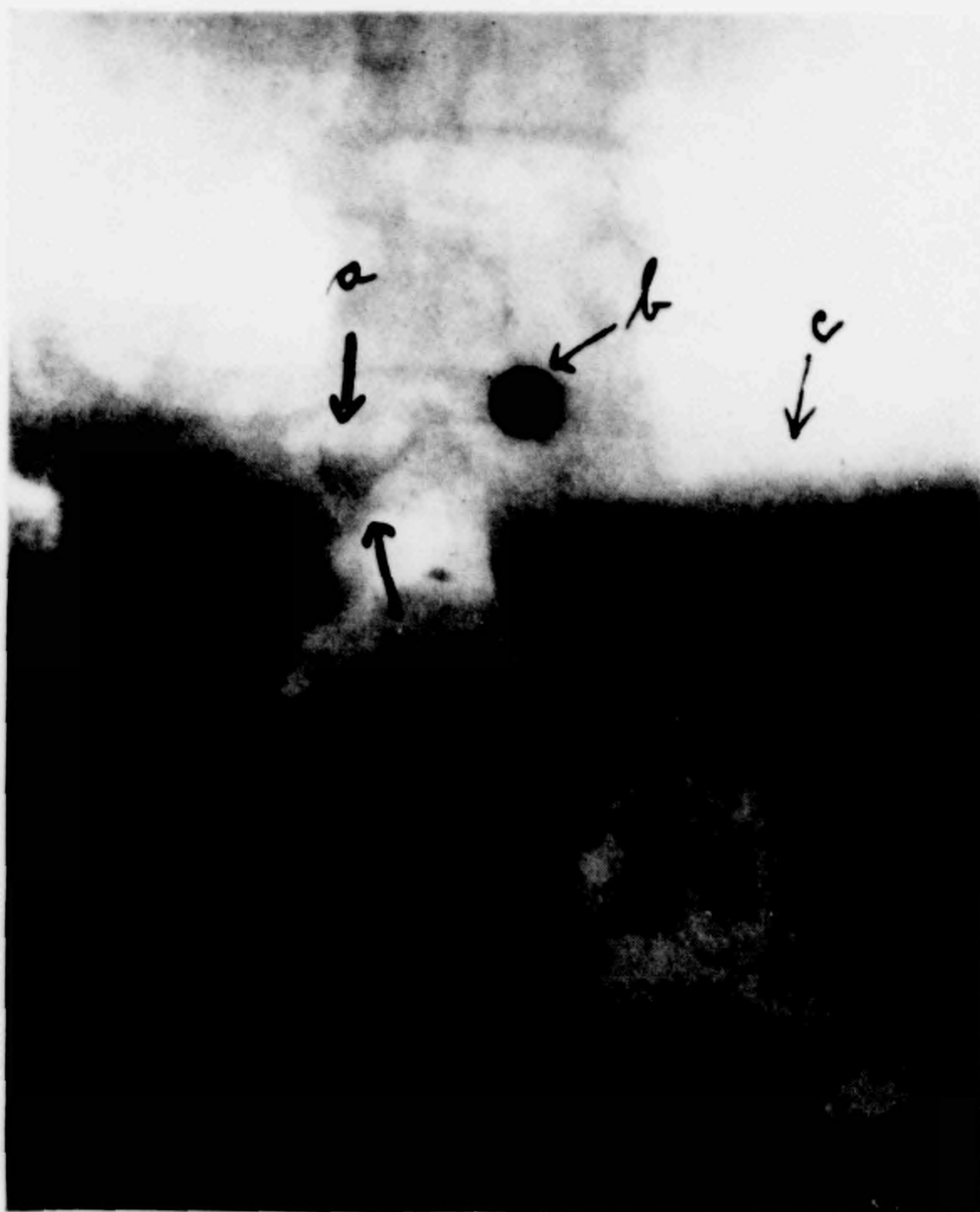


Fig. 2. Bismuth residue six hours after a meal in a case of penetrating ulcer of the duodenum; (a) bismuth fleck in crater of ulcer; (b) navel marker; (c) six-hour residue. Röntgenogram made with patient standing.

respiration when the perforation and fixation have occurred in relation to the pancreas.

Perigastric adhesions distorting the stomach and interfering with gastric peristalsis are likely to occur, and are responsible, in part, for the hour-glass appearance often seen in these cases. This hour-glass deformity is usually partly spastic and partly organic — the spasm being due to gastric ulcer, the organic changes being due to the perigastric adhesions. These adhesions frequently fix the stomach and often extensively involve the neighboring organs. Many times the inflammatory mass attending perforated ulcer may be definitely felt and when palpated under the fluorescent screen examination may be definitely identified as belonging to the stomach shadow. In the typical penetrating ulcer, Haudek, Faulhaber, and others have described above the projecting bismuth shadow a small collection of gas which has the same relation to the small diverticulum as the "magenblase" or stomach bubble has to the stomach itself. This small collection



Fig. 3. Röntgenogram made twenty-eight hours after a bismuth meal showing a bismuth residue in the gall-bladder region, proven to be bismuth in the gall-bladder, having passed through the cholecystenterostomy opening.

of gas lying above the localized bismuth shadow in connection with the ulcer has, in fact, been termed the "little magenblase."

The presence of this extra shadow with a tumor mass having an evident connection with the stomach speaks for ulcer rather than carcinoma, especially when there is no encroachment upon the shadow of the stomach with the resulting filling defect characteristic of carcinoma. When the patient is examined in the erect position, it is frequently possible to demonstrate above the localized addition to the gastric shadow, the superimposed air bubble above described, which definitely marks the case as one of penetrating ulcer of the stomach.

The hour-glass formation, partly organic and partly spastic, frequently associated with ulcer on the lesser curvature, differs from the appearance seen in carcinomatous hour-glass stomach. In differentiating the ulcer from the carcinomatous condition, it may be stated that in hour-glass stomach due to ulcer there

is frequently a residue of the bismuth meal after the sixth hour; the stoma between the upper and lower sacs lies along the lesser curvature, the outline of the greater curvature being drawn over toward the lesser; the narrowing occurs at one distinct point, and the canal is usually short. On the other hand, in carcinomatous hour-glass stomach, the narrow channel connecting the two sacs lies in the stomach axis and is much longer, and there is usually pyloric insufficiency.

Dilatation of the stomach of varying grades is a frequent finding in chronic gastric and duodenal ulcer. The so-called prognathian dilatation associated with stenosing pyloric ulcer has already been referred to. Marked gastric stasis without dilatation is suggestive of a malignant obstruction.

Spastic manifestations. A spastic indrawing on the greater curvature producing a sharply outlined localized indentation of the gastric wall, according to the early writers, was evidence of ulcer. It was at first stated that this spasm of the circular muscles of the stomach, which were in reality a deep tonic



Fig. 4. Bismuth-filled stomach and duodenum, the entire duodenum showing. The arrows point to a bismuth fleck seen within the curve of the duodenum. Repeated observation seemed to prove conclusively that this was bismuth in the ampulla of Vater. (Röntgenogram kindly loaned by Dr. L. G. Cole.)

constriction, was characteristic of lesions of the mucous membrane at the level of any given muscular ring. It was discovered, however, that these spastic disturbances were sometimes purely functional. At any rate, in many cases there was no discernible ulcer to be found. It was early admitted that these spastic indrawings might be seen in tabes and hysteria, as well as in gastric ulcer located on the lesser curvature at the level of the spastic indentation.

I reported before the Michigan State Medical Society, Surgical Section, 1913, sixteen operated cases in which such a spastic indrawing on the lesser curvature was proved by operation to be associated with well marked duodenal ulcer, no gastric ulcer being found at the level of the indrawing. In many of the cases, especially those in which gastro-enterostomy was done without clamps, the inside of the stomach was explored and no ulcer could be found. Among the other conditions in which this sign has been noted by the

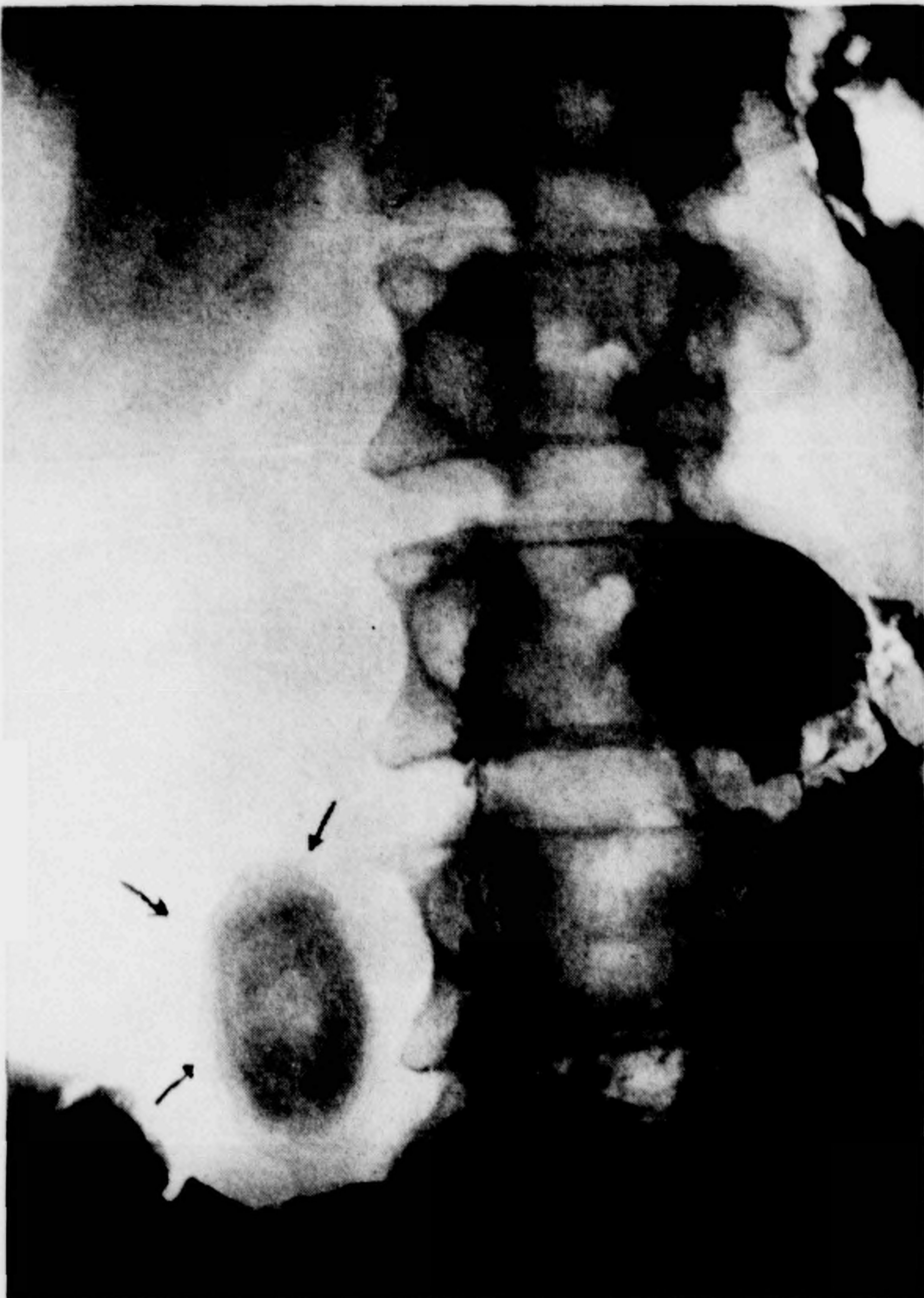


Fig. 5. A single laminated gall-stone found in a case of suspected duodenal ulcer.

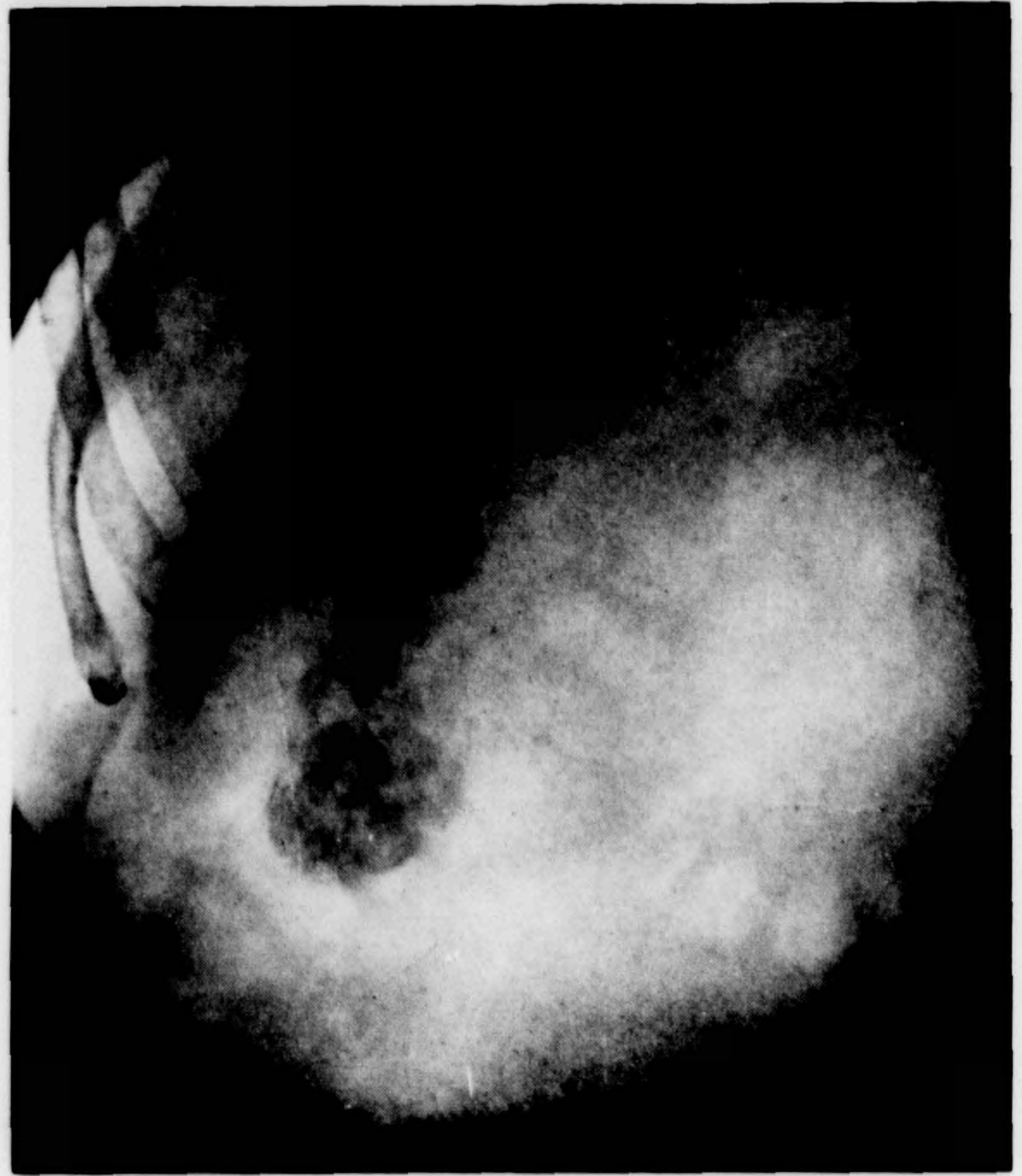


Fig. 6. A large collection of gall-stones found in a case diagnosed clinically as duodenal ulcer.

writer, and where anatomical proof has been afforded of the absence of ulcer on the lesser curvature at the level of the indrawing, have been a number of cases of gall-stones, carcinoma near the pylorus, appendicitis, and Grave's disease. Recently I have observed this sign in two cases of paralysis agitans. In fact, it seems that this spastic indrawing is a localized, especially deep tonic constriction of the stomach, the result of vagus irritation, and may be produced by any lesion which causes vagus irritation. The spasm is often overcome by the administration of atropine and it frequently fails to appear with the patient standing. With the patient lying, tension on the gastric walls being relaxed, the spasm occurs very characteristically. When it is due to ulcer on the lesser curvature there is usually a point of pain on pressure coinciding with the lesser curvature at the level of the spasm, and there is no special tenderness on pressure over the duodenal region. When the spasm is due to a duodenal lesion (gall-stones or duodenal ulcer) there is no pain on pressure over the lesser curvature at the level of the spastic indrawing, but there is usually pain on pressure under the



Fig. 7. Case of hepatofixation due to adhesions attending gall-bladder disease. Two gall-stones seen to be present.

right costal margin, and manipulation of the pyloric or duodenal shadow is often seen to increase the depth of the spastic indrawing high up on the greater curvature. On screen examination, peristaltic waves are often seen beginning above this spastic manifestation and pass it without causing it to disappear. The persisting spastic indrawing on the greater curvature has also been observed in cases of carcinoma on the lesser curvature in the antral portion of the stomach, but the carcinomatous deformity may be differentiated by watching the peristaltic waves. When this indrawing is present with the patient standing, it is found to be extremely marked with the patient lying. On the other hand, this deformity often occurs with the patient lying supine when it is not seen at all with the patient standing. Sometimes these spasms are transient, being seen one day and not another. If the patient is under the influence of any spasm-relaxing drug, such as atropine, this spastic manifestation may be absent.

Of course, at operation these spastic manifestations are rarely seen. An hour-glass constriction which almost bisects the stomach in connection with a penetrating ulcer on the



Fig. 8. Hepatofixation due to adhesions between the duodenum and gall-bladder. No gall-stones seen.

lesser curvature may be almost absent when the anæsthetized patient's abdomen is opened at operation.

Abnormalities of peristaltic waves. There is a certain variation in depth and frequency of the normal peristaltic waves, according to the tone of the stomach. When the depth of the peristaltic waves is increased and when they appear more frequently than the normal, the inference is that there is some obstruction at the gastric outlet. In pyloric obstruction, there is frequently observed a sort of systole and diastole similar to that which is claimed by Cole to occur in the normal stomach. Peristaltic waves may at one moment be practically absent and at other times so strong as to almost cut the stomach in two. It seems that this may represent fatigue and periods of revived activity after recuperation from fatigue. Hyperperistalsis and hypertonicity are both suggestive of duodenal ulcer.

Antiperistaltic waves, first described by Jonas, are pathognomonic of an organic lesion



Fig. 9. Case of duodenal obstruction due to adhesions attending an ulcer on the lesser curvature just proximal to the pylorus.



Fig. 11. Deformity on lesser curvature corresponding to a callous ulcer.



Fig. 10. Deformity of the stomach due to ulcer on the lesser curvature two inches from the pylorus. Ulcer shown at arrow.



Fig. 12. Lateral röntgenogram of the stomach showing deformity of the posterior wall due to ulcer with attending cicatrix.



Fig. 13. Filling defect on the greater curvature, due to a large tuberculous ulcer.

near the pylorus and frequently point to ulcer. This organic lesion does not necessarily obstruct the pylorus. Antiperistalsis occurs with comparative rarity. I have seen about fifteen cases. Hertz stated as recently as last year that he had never seen it. This phenomenon is best studied when the patient is lying supine. Naturally such study must be made fluoroscopically.

Abnormal emptying time of the stomach. Six hours is the period which experience has suggested as the limit of the emptying of the normal stomach following the Rieder test meal, which consists of ten or twelve ounces of farina mush into which two ounces of bismuth oxychloride or subcarbonate have been stirred. The oxychloride is preferable to the subnitrate or subcarbonate. Neither one is necessary, since barium sulphate, a much cheaper substitute, can be very satisfactorily employed. Groedel and others have called attention to the fact that the use of barium sulphate shortens the emptying time of the stomach. The stomach in normal cases usually empties within three or four hours.

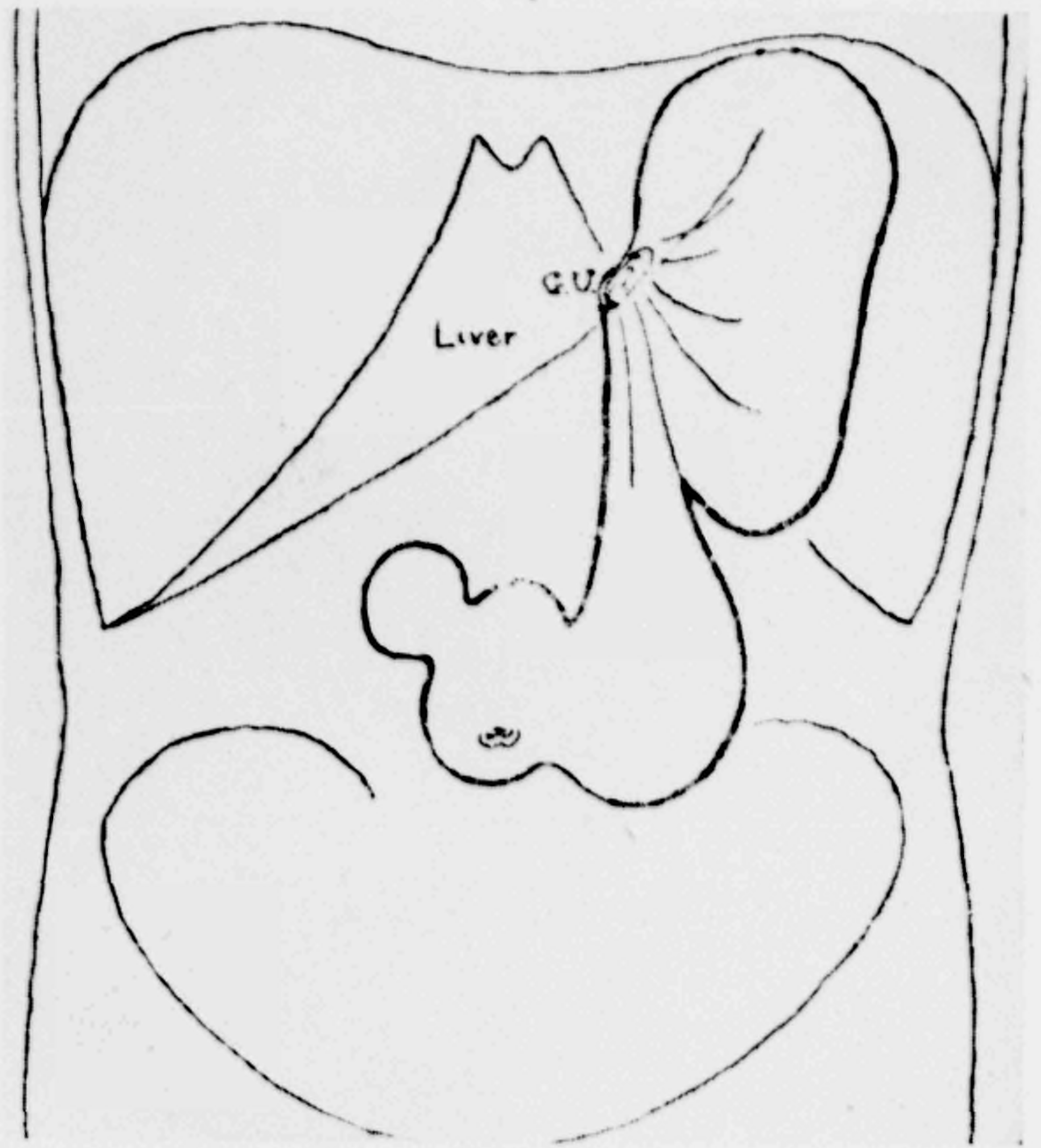


Fig. 14. Drawing (after Hertz) illustrating the deformity of the gastric shadow due to ulcer on the lesser curvature, which has become adherent to the liver.

The residue at the end of six hours may vary greatly from a small trace to practically all the stomach contents. In some cases, bismuth has been found in the stomach 125 or 150 hours following the bismuth meal. In these cases of prolonged stasis, the residue may become scarcely discernible because of the fact that the newly arriving food from each meal dilutes the bismuth contents of the stomach so that the proportion of bismuth is less from meal to meal.

Although Haudek claims that there can be no ulcer without spasm of the pylorus with a residue at the end of six hours, and that he has never seen a case where the emptying time was longer than six hours without serious alteration of the stomach wall, this claim is contrary to the experience of surgeons and many other röntgenologists. Recently Smithies has reported a hundred cases of gastric ulcer without delay in the emptying time. Many surgeons, basing their indication for operation upon the statement of Haudek, have been disappointed in finding no evidence of anatomical ulcer of the stomach where a six-hour residue has been demonstrated following a bismuth meal.



Fig. 15. Characteristic hour-glass deformity due to a penetrating ulcer on the lesser curvature, such as is illustrated in Fig. 14.



Fig. 17. Spastic indrawing (b) on greater curvature opposite ulcer on the lesser curvature. Normal pylorus shown at (c).



Fig. 16. Spastic indrawing (a) on the greater curvature, formerly considered pathognomonic of ulcer at the corresponding level on the lesser curvature; (b) represents a peristaltic wave which began above the spastic indrawing and fluoroscopically was seen to progress pyloruswards without disturbing the indrawing. It is now recognized that this spastic manifestation is not pathognomonic of gastric ulcer.



Fig. 18. Normal stomach and duodenal bulb. Pylorus at (a), bulbus duodeni or first portion of the duodenum at (b). This bulb, well filled out, should be demonstrable in every normal case.



Fig. 19. Characteristic deformity of the duodenal bulb in a case of well-marked duodenal ulcer.

Early clearance of the stomach, when not due to achylia, may be found in cases of gall-bladder disease (with or without stone) and in pancreatic disease when adhesions to the duodenum are present, and in cases of duodenal ulcer. Cases of early malignant induration of the walls of the pylorus, rendering the pyloric sphincter inelastic, are not rare. In pyloric ulcer, with or without actual obstruction, there is delay in the emptying. Gastric ulcer (not pyloric) is not necessarily associated with delayed emptying. It must be admitted, however, that in many gastric and duodenal ulcers, the emptying time of the stomach, after a bismuth meal, is perfectly normal.

In duodenal ulcer it is a frequent observation that the stomach begins to empty at once and at a very rapid rate, bismuth being seen throughout the small intestine within a very short time. If the meal has not been a large one, the stomach may be entirely empty within an hour. When the meal is larger, delayed pylorospasm may be set up, and a small residue remaining longer than six hours may result. Duodenal ulcer cases which do not exhibit this quick emptying, at least during the first hour of digestion, are those where actual mechanical obstruction exists,

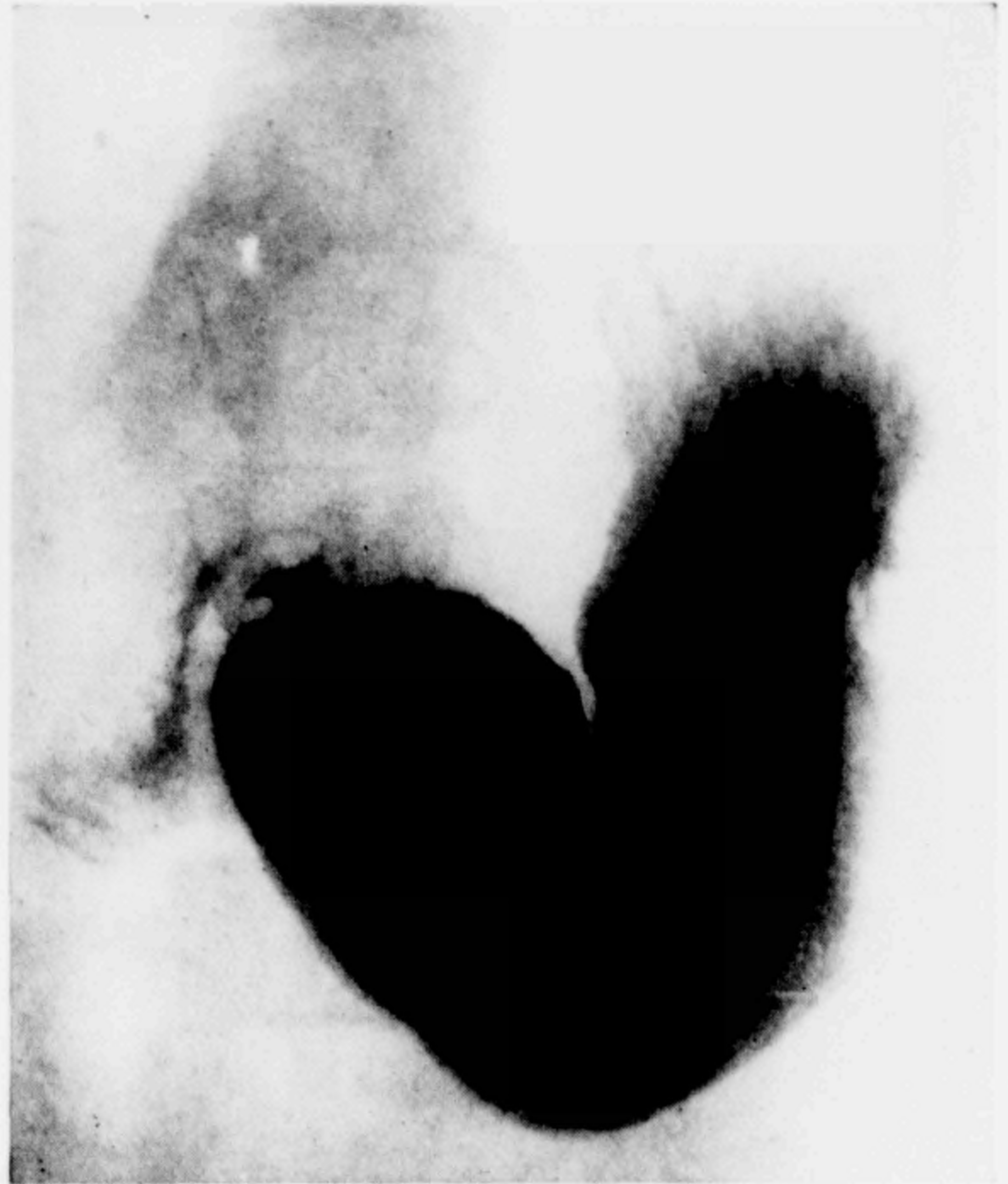


Fig. 20. Almost complete absence of the duodenal bulb in a case of perforating duodenal ulcer with considerable callous formation.

as by cicatricial contraction. The above behavior of the stomach may be explained, perhaps, as indicating that when the meal is a large one the delay is due to the development of a tardy pylorospasm associated with a delayed hypersecretion.

In pyloric ulcer, on the other hand, suggestive findings are delayed motility with hypersecretion and *early* pylorospasm. As above stated, ulcer in the body of the stomach is not necessarily associated with an abnormal motility.

Unusual filling of the duodenum. The normal duodenal bulb has already been considered. This first portion of the duodenum normally shows as a symmetrical, smooth shadow, which has been called the "cap" or "pilleus ventriculi." The shadow is smooth by reason of the fact that there are no valvulae conniventes in this portion of the duodenum. The bulb is not always well seen immediately after the ingestion of the bismuth meal, but it is usually well seen in the second hour of digestion.

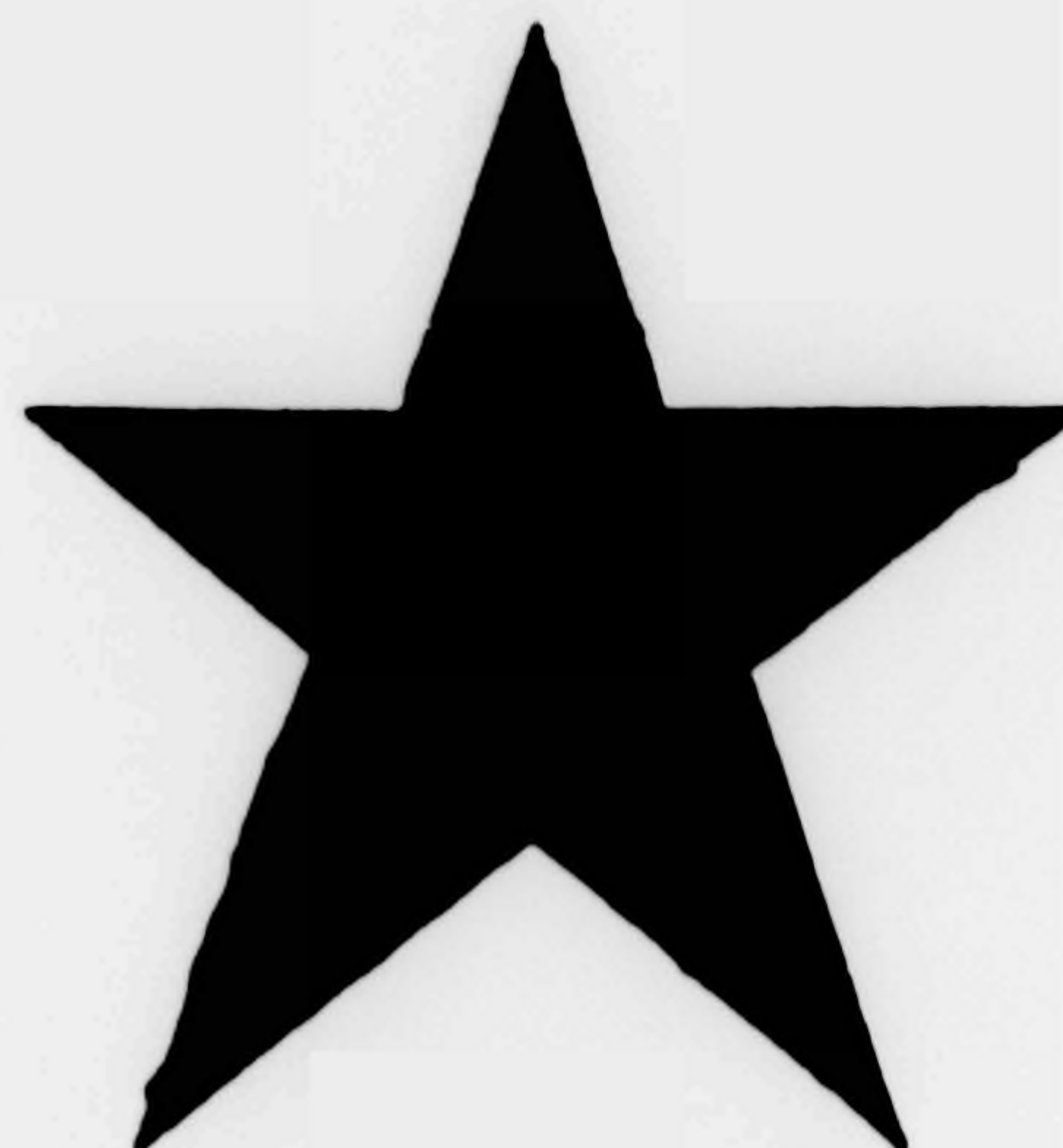
The second and third portions of the duodenum are rarely well seen under normal con-

ditions. But in duodenal obstruction, duodenal ulcer, achylia, and gall-bladder disease the duodenum is frequently seen in its entirety. Unusually marked filling of the entire duodenum is frequently seen in cases of duodenal ulcer, and it is due not so much to a lag in the emptying of the duodenum as to unusual promptness in emptying of the stomach.

Pressure pain points. A definite pressure pain point corresponding to the position of the duodenum is often noted during the fluoroscopic examination. The pain point is often seen to definitely coincide with the shadow of the duodenum. It is not, however, pathognomonic of duodenal ulcer. The writer has often seen it in connection with periduodenal adhesions without any evidence (even at operation) of duodenal ulcer. There have been a number of cases, however, in which, in spite of tenderness over the duodenal and gall-bladder shadow, nothing could be found wrong with either of these organs. The writer is satisfied that there is considerable value, however, in palpation over the gastric shadow to localize the points of pain on pressure, but this pressure pain point is not likely to correspond to the location of the ulcer, unless there has been periduodenal or perigastric involvement with adhesions.

In the foregoing paragraphs I have only attempted to summarize and correlate the X-ray evidences which contribute to the diagnosis of gastric or duodenal ulcer. I would like to go on record as stating that in the present stage of development we are not justified in believing that the röntgen method of gastric examination constitutes a reliable method of detecting early gastric or duodenal ulcer. Nevertheless, I believe that in general it is true that surgical lesions of the stomach or duodenum cannot exist without some of the foregoing signs being present. I wish to state that I have seen a few well-marked gastric and duodenal ulcers at operation or autopsy where, during the X-ray examination, there was nothing found either fluoroscopically or röntgenographically which could be considered as suggestive of anything but the normal. It is an astonishing thing how often the bismuth meal will reveal most astounding conditions when they are least expected, and, on the other hand, it may be repeated, very often the X-ray findings are quite the ordinary, even in cases of gastric or duodenal ulcer, when from the clinical study of the case it was expected that the X-ray evidence would be especially characteristic.

CORRECTION



***PRECEDING IMAGE HAS BEEN
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TO ASSURE LEGIBILITY OR TO
CORRECT A POSSIBLE ERROR***

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RÖNTGENTHERAPY IN NON-MALIGNANT DEEP-SEATED LESIONS

By JAMES T. CASE, M.D., Battle Creek, Michigan

Röntgenologist and Assistant Surgeon, Battle Creek (Michigan) Sanitarium; Professors of Röntgenology, Northwestern University Medical School, Chicago; Attending Röntgenologist, St. Luke's Hospital, Chicago; Consulting Röntgenologist, Cook County Hospital, Chicago

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THE application of röntgentherapy to skin lesions was the earliest therapeutic development of röntgenology.

Later, the attention of the early investigators was directed toward securing effects in deeper structures, but owing to the imperfections in tubes, generating apparatus, and methods of technique, only desultory results were attained during the first decade of röntgenologic history.

Several recent technical developments, combined with special experimental and clinical studies of the last five years have given a new significance to the term "deep röntgentherapy." The writer refers first to the invention of the Coolidge tube, which has placed in the hands of röntgenologists a very powerful, but precise instrument, with the use of which it is possible to control the dosage with very great practical accuracy; second, the perfection of newer and more powerful sources of high tension current; and, third, the development of a technique involving filtered irradiation at short focus-skin distance through multiple skin areas.

My colleagues² on this evening's program were among the first to apply the methods which have come to be known as deep röntgentherapy. Williams, Boggs, Johnston, Hulst, Pancoast, Hickey, Crane, Lange, and Dachtler are some other Americans who have contributed materially to our knowledge of this subject, in which American physicians have kept well abreast of our European confrères.

Necessity for accurate dosage. The empiricism of early röntgentherapy persisted for a number of years, not for lack of effort to determine the physiological effects of the röntgen rays, but because of the impossibility of comparing the work of one man with that of another. Imperfections in apparatus made accuracy in X-ray dosage extremely difficult. Statements as to technique and

dosage employed were so vague that much of the very exhaustive and painstaking experimental work of the older writers cannot be correlated with present-day researches concerning the effects of the rays. As a result, the present-day literature on röntgentherapy often shows a curious mixture of the old and the new—pouring new wine into old bottles, so to speak.

The record that in a certain experiment certain animals were treated fifteen minutes and other animals twenty minutes, or that one patient received two thousand minutes of treatment, or other similar incomplete statements with reference to the dosage, are very misleading. If one states that a certain number of X (Kienboeck) units or H (Holzknecht) units were administered to a given area, within a certain time, with or without a certain amount of filtration, such a record is perfectly comprehensible to all röntgen workers. In the absence of specific statements as to dosage in units, references to methods of treatment must include the following: Milliamperage, length of treatment, focus-skin distance, hardness of tube (either according to some standard penetrometer, or expressed as the equivalent spark gap), details as to the number of areas treated, amount and kind of filtration used, and the frequency of treatment. It is absolutely essential that published reports concerning röntgen irradiations include these technical details; otherwise, in the light of our present knowledge, such reports must be discredited.

The writer does not wish to leave the impression that all the questions relating to the accuracy of X-ray dosage are solved. The factors which govern the amount of irradiation reaching the deep-seated tissues are numerous and, in fact, not yet fully determined. But the introduction of certain new tubes which have come upon the market in the last year have made accurate measurements possible and it remains now for röntgen workers to

² Dr. Wm. Allen Pusey and Dr. G. E. Pfahler.

¹ Read before the joint meeting of the American Röntgen Ray Society (Western Section) and the Chicago Medical Society, March 3, 1915.

determine and formulate, out of clinical experience, the information still needed in this field. Now that it is possible to control the penetration of the tube with a satisfactory degree of accuracy, it is doubly important that estimates made by different observers under certain stated conditions be in very fair agreement.

Technical considerations. It is probably not expedient to devote here any space to the minutiae of the technique of röntgentherapy¹; and the technical and biological considerations may be abbreviated to a few necessary notes of explanation.

Owing to the differences of the radio-sensitiveness of the various tissues, doses which are sufficient to destroy or modify pathological cells are not always harmless for the normal tissues. The skin, in particular, which itself is very sensitive to the X-rays, allows the absorption of much larger doses than can possibly pass through it to the deeper organs. The skin is therefore the chief barrier to deep röntgentherapy.

Various means have been devised for protecting the skin while permitting the passage through it of large quantities of effective rays. Our colleague, Dr. Pfahler of Philadelphia, was one of the first to introduce the use of a leather filter for this purpose. Aluminum filters are also utilized, the thickness varying from one to four millimeters. The writer employs at least three or four millimeters of aluminum plus a thickness of sole leather as a filter in most of his deep röntgentherapeutic work; and sometimes the thickness of aluminum is increased to seven or eight millimeters.

The reasons for the employment of *filters* are easily understood. The emanations from the röntgen tube consist of a bundle of rays of varying penetration. The softer rays do not pass farther than the skin; the most penetrating rays are capable of traversing not only the skin, but heavy filters, and of passing on into the deeper tissues. Filters serve to sift out the softer rays so that the

skin is subjected only to the influence of the very hard rays, a maximum proportion of which are thus allowed to pass into, and be absorbed by, the deeper tissues. The present-day tendency in röntgentherapy, both in superficial and deep lesions, is to use harder rays. It is quite possible that the very hardest obtainable rays are not the most desirable nor the most effective, and that the optimum will fall somewhat short of the hardest obtainable rays; nevertheless, in the writer's opinion, harder rays are needed than are at present available even with the Coolidge tube in its present stage of development, and with the present forms of apparatus and tubes the hardest obtainable rays are utilized.

Besides filtration, special means have been sought for *desensitizing the skin*, among them being the production of superficial anæmia by the application of ice, by the injection or electrical introduction of adrenalin into the skin, and by the use of compression. Considerably more than the erythema doses may be safely passed through the skin thus rendered anæmic; but with the progress of our knowledge of filtration and the introduction of more powerful sources of röntgen rays, the need of thus desensitizing the skin seems to have diminished, and it does not find a place in our present technique.

The progress of deep röntgentherapy has gone hand in hand with the increase of our knowledge of filtration and cross-fire irradiation. *Cross-fire irradiation* is the term applied to the method by which one passes a bundle of rays of high penetration through the different surfaces of skin which surround the region under treatment; for instance, the anterior, posterior, and lateral aspects of the trunk if one is irradiating an abdominal tumor, or the anterior, posterior, and lateral aspects of the neck in the treatment of goiter. The principle of cross-fire irradiation may be considerably elaborated by dividing each of the surfaces in the neighborhood of the organ into a number of areas and directing the rays through each of these areas in succession, carefully protecting all except the one actually under treatment, thus introducing through each skin area the maximum dosage of filtered ray which the superficial tissues can

¹See two recent papers in press:

(a) James T. Case, M.D. Coolidge tube technic in deep röntgentherapy. Read before the American Electro-Therapeutic Association, Battle Creek, Michigan, September 15 to 17, 1914. (b) James T. Case, M.D., and Llewelyn L. Jones, M. D. Technic and recent results in deep röntgentherapy. Read before the American Röntgen Ray Society, September 9 to 12, 1914, Cleveland, Ohio.

tolerate. The amount of effective rays which reach the deeper tissues is increased as many times as there are ports of entry. In certain locations where the skin overlying the organ is very loose, it is possible, by sliding the skin about, to deliver several doses directly over the organ under treatment without overtreating any section of the skin.

It was formerly held that for the irradiation of deeper parts the tube should be relatively farther from the skin than when treating superficial lesions. Inasmuch as the intensity of the X-rays varies inversely with the square of the distance from the anode to the part under consideration, with a shorter *focus-skin distance*, it is evident that the tube being brought nearer to the skin, the length of time required to deliver a certain dosage to a deep-lying structure will be proportionally diminished. For instance, with a tube fourteen inches from the skin ($14^2=196$), nearly five and one-half times longer will be required to deliver a certain dosage to the skin than when the focus-skin distance is only six inches ($6^2=36$). The former objection to the short focus-skin distance was the much greater danger of injury to the skin. Since the introduction of filtration methods, however, this danger of skin injury is eliminated within certain limits, and it is now possible to bring the tube much closer to the skin, thus materially shortening the time required to administer an effective dose to the deep parts. If it were not for this possibility, the length of time needed for the application of deep röntgentherapy would almost preclude its employment.

Wider application of the improved method. These three developments, therefore—the use of filtered rays of high penetration, the method of cross-fire irradiation, and the close approximation of the tube to the skin—have rendered possible the practical employment of effective doses of röntgen rays, aggregating forty to one hundred times the maximum doses considered safe nine or ten years ago, in a number of deep-seated affections which hitherto had responded uncertainly to the efforts of röntgenologists; and this great advance has been accomplished without so greatly increasing the necessary labor as to

preclude its practical employment. It must be added, however, that the dangers of attempting the unskilled application of this potent means have been in the same degree increased. Röntgentherapy should be vigorously but carefully and skillfully given. As one expert has aptly put it, the possession of a röntgen apparatus is no more a guarantee of skill in röntgenology than is the possession of surgical instruments a guarantee of skill in surgery.

Biological effects of the röntgen rays. It is a generally accepted postulate that small röntgen doses exercise a stimulating effect upon cell development, while the larger doses give rise to depressant effects. A given dose will be more or less stimulating or more or less depressant to a certain tissue, depending upon its nature, for the rays seem to exercise a selective action. In general it may be stated that the cells most affected by the röntgen ray are those in which the reproductive activities are the greatest, those in which the karyokinetic process is most active and whose morphology and function are the least highly developed. Before beginning treatment it is therefore essential to decide first which therapeutic effect of the X-rays is desired.

In relatively few instances of deep therapy is the stimulating effect of the röntgen rays desirable; most often a depressant effect is needed, and one must exercise the greatest care to make sure that he is not giving a dose so small that it may be stimulant, lest he counteract the therapeutic effect it is desired to secure. This is perhaps most essential in the treatment of malignant conditions, as will be emphasized by another speaker of the evening, but it is also true in most benign lesions. It may be declared that for efficient deep röntgentherapy a constant source of rays of maximum penetration must be assured. It should further be considered absolutely essential to every procedure of röntgentherapy that the dosage be measured as accurately as the present developments of instruments will permit. The writer recognizes that absolute accuracy is not obtainable; nevertheless, it is possible to make such a close estimate of the number of x units delivered through a filter that any competent

röntgenologist will understand and be able to duplicate the technique and the results in a similar case. In fact, it would seem desirable if the practice of röntgentherapy could be limited to those who will equip themselves to administer dosage in definite measurements.

With these introductory remarks the writer will proceed to a brief consideration of some of the more important non-malignant diseases in which deep röntgen irradiation has been employed or in which its use seems indicated.

Leukæmia. American physicians were the first to use röntgentherapy in leukæmia, Pusey reporting the first case in 1902. Pancoast, Schultz, Senn, Williams, Kleineberger, Pfahler, Boggs, and Johnston are others who have reported excellent symptomatic cures. Pancoast particularly has contributed greatly to our knowledge of this subject.

It has been aptly stated that röntgentherapy in leukæmia is a symptomatic, transitory, therapeutic means. Practically all cases relapse sooner or later and ultimately die, although there are claimed a few exceptional permanent cures. Nevertheless, the prognosis with röntgentherapy is so much more favorable, as far as uniformity of symptomatic improvement and lengthening of life are concerned, that the therapeutic use of the X-rays finds in this disease one of its most valuable applications.

In the myeloid form the blood picture generally approaches the normal. In the lymphatic form the pathologically changed blood-cells remain practically the same, in spite of the fact that the white cell count may show considerable diminution. On the whole, the effect is more favorable in lymphatic than in myelogenous leukæmia. Bécclère, in 1913, reported 110 cases of leukæmia treated with the röntgen rays—twelve lymphatic, ninety-three myelogenous, and five acute forms. The lymphatic cases returned almost to normal. In the myelogenous form there was a transitory improvement with always a recurrence. In the acute cases the effects were unfavorable. Cases which have been manifest for less than a year, and in which the leukæmia is not very severe

in grade, offer more favorable prognosis than others. Some cases, both of the myelogenous and lymphatic forms, are refractory to röntgentherapy and give unfavorable results, even as far as symptomatic cure is concerned. In all acute forms the use of the X-rays is contra-indicated.

Favorable signs of successful röntgen treatment are an increase in the hæmoglobin or of the hæmoglobin and the red cells, as well as general improvement in the patient's condition. A diminution of the leukocyte count does not, as a rule, appear until a little later. In fact, there may be a temporary increase in the number of leukocytes preceding the fall.

At first treatments were directed over the enlarged spleen in splenomyelogenous leukæmia and over the spleen and other enlarged lymphatic structures in lymphatic leukæmia. While some of the long bones had been treated perfunctorily, no definite campaign had been introduced against the bone-marrow until the work of Pancoast.

In the light of modern research concerning the pathology of this disease, leukæmia may be regarded as a sort of cancer of the blood, the bone-marrow being considered the primary focus of the disease and the lymphatic enlargements as metastases. This is certainly borne out by the greater success of the plan of therapeusis whereby the most energetic treatment is directed against the primary foci in the bone-marrow, as recommended by Pancoast, rather than against the secondary manifestations of the disease in the spleen and other lymphatic organs. The writer has again and again observed that applications over the long bones alone have resulted in a diminution in the size of the spleen and a reduction in the white cell count without any direct exposure of the spleen itself. There are, however, exceptional cases which do not thus respond. The average prolongation of life may be estimated at about two years.

Pancoast and several others explain the frequent symptomatic cures, followed by a varying period of quiescence, with the older method of treatment, as follows: Röntgenization of the spleen and other lymphatic enlargements, through direct destruction of

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certain cells, thereby diminishes the size of these organs. Leukotoxic substances, having the power of destroying large numbers of leukocytes, are produced and liberated into the blood, thus diminishing the white cell count. These leukotoxic substances seem also to exercise an inhibitory effect upon the red-forming activities of the bone-marrow.

Linser and Helber found that this leukotoxic action could be demonstrated both *in vitro* and *in vivo*. They observed, for example, that the injection of blood serum of an irradiated rabbit into a second rabbit causes a decrease in leukocytes instead of the increase which should follow the injection of normal serum. A number of other workers, however, have achieved only negative results, and the evidence concerning the existence of a röntgen leukotoxin is on the whole still insufficient.

There are some dangers attending the röntgenization of leukæmic patients, the avoidance of which requires considerable skill and judgment. There is danger of toxæmia following over-exposures of the spleen and lymphatics and other tissues especially susceptible to the röntgen rays. This danger is especially great if the early efforts are directed against the spleen; later on, after a sort of tolerance has been established by treatment of the bone-marrow, applications may be directed toward the spleen with considerably less danger of toxæmia. It is probable that in certain instances death has been produced by overwhelming toxæmia resulting from an over-exposure of lymphatic structures at one sitting. The temporary increase in the white cell count which may occur during the period of reduction of the enlarged glands should not be considered as an indication of failure, as persistence in the treatment will finally reduce the count. If toxæmia seems imminent, the dosage should be diminished or the treatments should be temporarily discontinued. In very severe cases only one area should be treated daily, and one will thus wish to treat the patient every day. When there is less danger of toxæmia, several areas may be treated in one day, and the number of days of treatment in each month will be thus lessened.

The danger of "burns" should be considered, but if the first principles underlying the therapeutic action of the rays is understood, no "burns" should occur. The bone-marrow treatment, through furnishing more areas for the entry of the rays, involves less danger of skin injury than treatment confined to the lymphatic structures alone.

The duration of the course of treatment is variable and extremely difficult to decide upon. Unless the patient can be depended upon for at least three months' treatment, röntgentherapy should not be started, for if the treatment is stopped too soon a relapse is almost certain to occur, and it has been the universal experience of röntgenologists that each relapse shows greater obstinacy in its response to treatment. Pancoast has expressed the belief that a rapid symptomatic cure renders ultimate failure almost certain. It is not sufficient to correct the leukocyte count and to cause the various enlargements to disappear. No matter how healthy and vigorous the patient may seem to be, continuation of the treatment should be insisted upon until the differential blood count has returned to normal and the abnormal blood elements have disappeared. Even then differential blood counts must be insisted upon at frequent intervals, and, at the first sign of recurrence repetition of the systematic course of treatment should be begun at once.

Let it be repeated that after a course of röntgen treatment has once been mapped out it should not be discontinued until all the areas mapped out have been gone over three or four times and the abnormal cell elements have disappeared, for an earlier cessation of treatment practically precludes the probability of a cure, even a symptomatic cure. The prognosis in any case is unfavorable as to cure, even after X-ray treatment, although the symptomatic cure is better than with any other therapeutic method.

Hodgkin's disease. Hodgkin's disease is a condition in which very satisfactory results have followed röntgentherapy, though the question of final cure still remains. Indeed, except for the hope which is held out to us in recent developments in serum therapy, rönt-

genization is the only rational method available in this disease.

The prognosis is still undetermined. There is greater likelihood of cure in these cases than in true leukæmia. Pancoast believes the proportion of cures is between 10 and 20 per cent, and in all of the cases which respond to treatment one may expect many months or even years of comparative relief from symptoms. Some patients who, at the beginning of treatment, are helpless from weakness regain strength sufficiently to resume their usual occupations.

In contrast to leukæmia, Hodgkin's disease is a local rather than a general condition. The effects of röntgenization appear to be local, and if any leukotoxin is produced, it does not behave as in leukæmia. Remote lesions are not influenced; there is no effect upon lesions other than in the structures exposed.

Before outlining the treatment it is necessary to study the chest röntgenographically to determine the extent of the mediastinal involvement, and re-examination by means of röntgenograms at suitable intervals may serve to mark the progress of the disease.

As in leukæmia, there is a danger of toxæmia from exposure over too large a mass of lymphatic structures at one sitting. In fact, the toxæmia may appear within the first few hours after heavy treatment. The evidences of toxæmia (headache, lassitude, even nausea and vomiting) constitute the principal guide as to the frequency of treatment.

There is still another danger in these cases, especially when the enlarged glands embarrass the respiration. It is a common observation that the decrease in size which almost invariably follows röntgenization of these lymphatic structures is preceded by a temporary swelling, which appears within a few hours after treatment, and may be very marked. The treatment of too many areas in the neighborhood of the trachea at one sitting may result in serious respiratory embarrassment from the primary, though transient, swelling of the lymphatics which is almost certain to occur.

Various forms of anæmia. At the outset it should be admitted that as yet there is

little clinical evidence to warrant the use of röntgentherapy; yet in certain forms of anæmia, röntgenization should, theoretically, exercise a beneficial influence. Small doses of röntgen rays should stimulate the bone-marrow to increased activity. Large doses should exercise a destructive action. In the cases which have been reported it has appeared that as long as the bone-marrow is still capable of responding to stimulation benefit may be expected, but when the degeneration of the bone-marrow has so far progressed that it no longer reacts to stimuli, no good results can be hoped for.

As a general rule, however, generally recognized therapeutic means should be employed in conjunction with röntgentherapy, especially such remedial measures as tend to have a general or constitutional effect, for with the exception of a few blood disorders, the action of the röntgen rays is essentially a local action. The writer believes that a trial of röntgen treatment is worth while in every obstinate case, the blood being examined at short intervals in order to decide as to the value of the measure. When the anæmia is not severe, röntgenization should give way entirely to other methods.

In *pernicious anæmia* the röntgentherapy is not only still in the experimental stage, but is attended by such dangers from toxic effects that its use should be restricted to such cases as are distinctly not of toxic origin.

The technique is, in general, the same as for myeloid leukæmia, except that the dosage is smaller. Filtered small doses for stimulating effect should be applied especially to the knees, shoulders, and elbows, and occasionally to the sternum.

In *splenic anæmia*, at least according to present theories, röntgentherapy should be highly beneficial. Up to the present time the results of röntgen treatment in this condition have not been very encouraging, but the introduction of the Coolidge tube and the other improvements which have been mentioned earlier in this paper inspire hope that in the future the effects of filtered röntgentherapy directed over the spleen, utilizing the cross-fire method by numerous ports of entry, will simulate the effects of surgical

treatment by splenectomy. If splenectomy is a curative means, then also röntgentherapy should be beneficial. Very heavy doses will be indicated, utilizing the smallest possible areas of entry and as many fields of irradiation as possible, the only limitation, with proper technique, being the danger of producing toxic effects.

The thyroid gland. The hypertrophic goiter of adolescence responds fairly well and may be permanently and considerably reduced in size, although complete disappearance of the enlargement is hardly to be expected. In *cystic goiter* the effects of röntgenization are very unsatisfactory, practically the only result of prolonged treatment being a possible arrest of the growth of the gland.

In *Graves' disease*, however, röntgentherapy has given excellent results in the hands of the majority of experienced röntgenologists. The treatment is not merely symptomatic, but because of its effect in depressing the secretory function, has the character of an etiologic therapy, since it is aimed at the cause of a disease whose essential pathological feature is an exacerbation or aberration of its secretory functions, with resulting toxæmia.

The effect of the röntgen rays upon glandular secretions in general is especially marked, the secretion of certain accessible glands being almost completely inhibited after röntgen exposure. This is especially noticeable after intensive applications to the neck, jaw, and face in the treatment of lesions of the lip or tongue, as, for instance, carcinoma. After treating carcinoma of the lip and the related glandular areas, giving massive doses under strong filtration, the writer has often observed that within twelve hours the patient's salivary secretions have been dried up and have remained so for many days. When series after series of such treatments are given, the drying up of the salivary secretions comes to be a very great inconvenience to the patient. This by-effect of the röntgen rays on the salivary glands in treating carcinoma of the lip or tongue must strengthen our faith in the efficacy of röntgenization of the thyroid gland where the patient's symptoms are due to an abnormal secretory activity. This depressant effect constitutes the basis for our

plan of treatment, and indicates that a very heavy dosage must be given in order to secure certain results.

The permanent effects in Graves' disease depend upon the course of the disease before treatment. The shorter the duration of the disease or the shorter the time since there was any marked change for the worse the more permanent the results. A pathological condition that has been uniform for years demands long treatment. Cases that have rapidly increased in severity yield quickly after the beginning of treatment. Where acute exacerbations occur in chronic cases, röntgen treatment is indicated with fair prospect of good results, but in chronic cases without exacerbation, or with only slight exacerbation, especially when myocarditis threatens, röntgenization is not indicated.

In favorable cases the nervousness and tremors are the first symptoms to subside. There is next an improvement in the tachycardia and respiratory symptoms, and last of all the exophthalmos and glandular enlargement are seen to diminish. The enlargement of the gland, the protrusion of the eyes, and some tachycardia are likely to persist, but there is good prospect that the distressing symptoms will be permanently improved.

It is highly important that attention should be given to general therapeutic considerations in these cases, because of the toxic symptoms which may develop. Not every case will be cured by any means, but the method is worthy of trial in every case where it seems desirable to avoid operation, and it may even be required in connection with operation in certain cases where the expected good results do not appear or are not sufficiently marked.

It has recently become a practice with some physicians to require a röntgen examination of the chest in all cases of thyroid enlargement to determine whether or not the thymus is enlarged. Even where no thymic enlargement can be demonstrated, pre-operative treatments applied to the thymic, as well as the thyroid regions, improve the prospect of beneficial results.

The writer here would like to take issue with the opinion often heard that röntgen

treatment is not indicated in thyroid cases, for the reason that when it fails operation is rendered much more hazardous and difficult, owing to increased adhesions and greater danger of hæmorrhage. The majority of experienced röntgenologists will agree in this point at issue, disputing the opinion that röntgen treatment causes adhesions which make operation more difficult. As a matter of fact, pre-operative röntgen treatment should tend to thicken the capsule and the walls of the smaller blood-vessels, which theoretically would favor the outcome of the operation instead of hindering it. Adhesions and unusual hæmorrhage are encountered in just as many cases never treated by the X-rays as in those cases which have undergone pre-operative röntgenization.

Patience is required in the handling of these cases. No patient should be accepted for röntgen treatment unless the röntgenologist can be assured that the patient can be depended upon for at least four series of treatments, covering a period of twelve or thirteen weeks. With our modern technique the majority of these cases will show a favorable response in less time than this. Occasionally one finds such improvement that further treatment seems needless. In cases of apparent failure of X-ray treatment, where operation is finally decided upon, nothing has been done to jeopardize the patient's interest.

Thymus. Röntgenization in the treatment of thymic asthma is a well-established therapeutic measure. In infants a very short series of treatments is adequate to produce results which seem almost miraculous. In older children, and particularly in adults, the treatment must be considerably prolonged. Our utmost technical skill and judgment in the arrangement of areas for cross-fire are demanded. In such cases the writer irradiates the thymus through from twelve to sixteen areas—at least four anterior, four posterior, one obliquely through each supra-clavicular space, and one or two obliquely through each axillary region, the arm upraised.

The writer has seen nothing in the way of toxic effects following massive dosage in this condition, although such effects should be

watched for and the treatment arrested accordingly. Great credit is due to Lange of Cincinnati, Stoerck, and others who have carried on extensive experimental work on röntgen therapy in this condition.

As above noted, röntgenization of the thymus is probably indicated in most cases of Graves' disease in addition to the treatment over the thyroid gland itself.

Uterine myomata. Concerning the use of röntgentherapy in gynecology, there has arisen a great deal of discussion and considerable difference of opinion. Some gynecologists summarily dismiss the subject as not worthy of consideration. On the other hand, some have become so enthusiastic as to prophesy that in the future the majority of women suffering from myomata and metropathies who have recourse to a hospital will be treated by röntgentherapy.

There is a middle-of-the-road tendency in this country and England, however, to discount somewhat the estimate placed by our Continental colleagues upon the value of röntgentherapy in gynecology. Donald, of Manchester, for instance, reports a series of 201 operated cases in which there were complications in forty-four, or nearly one-fourth of the cases; thirteen ovarian cysts, twelve cases of red degeneration, six cases of suppuration in tube or ovary, four cases of appendicitis, five cases of calcareous degeneration, two cases of fibrocystic tumor of the uterus, two cases of carcinoma in the fibroid, two cases of adenomyoma, one case of necrosed polypus, and one case of hydroperitoneum.

It is manifestly important that a correct diagnosis be made before the case is submitted to the röntgenologist, and yet nearly all the complications in the forty-four cases referred to by Donald could have been, and doubtless were, diagnosed prior to operation, and hence would be declared to indicate operation rather than röntgentherapy. The difficulties in gynecological diagnosis are most common in the effort to differentiate inflammatory masses and adherent ovarian or tubal tumors from fibroid tumors of the uterus, and especially when they occur in association with uterine fibroids. Malignant degeneration of tumors,

which unfortunately occurs, though in a very small percentage of cases, is another contra-indication to X-ray treatment, except as a last resort in inoperable cases and as a post-operative measure. The writer is an advocate of routine post-operative röntgenization in all malignant cases.

In contrast to the foregoing array of difficulties and discouragements in the way of röntgentherapy of uterine disease is the report recently received from Dr. Gauss of Freiburg summarizing all the cases of myoma and metropathy treated by X-ray therapy of which reports had been published prior to January, 1914. The following tabulation of 1395 cases is furnished by Johannes of the Freiburg Frauenklinik. Only such reports were included as gave specific information as to the dosage and technique employed.

	Number of the treated cases	Percentage of		
		Cure	Death	Recurrence
Group I (50-175x).....	693	72	0.5	4
Group II (175-500x)....	544	82	0	3
Group III (500-1500x)..	158	95	0	0
Total.....	1,395			

It will be seen that corresponding to the increase of Kienboeck's X units there was an increase in the percentage of cures from 72 per cent to 95 per cent. It should be borne in mind that these cases were all of them studied by gynecologists previous to the beginning of röntgentherapy and the therapeutic effects judged by them, not by the röntgen therapeutists. The deaths which occurred in the first series could not be, in any way, attributed to the röntgentherapy.

Albers-Schoenberg, who is the father of deep röntgentherapy as applied to gynecology, summarizes his views on this subject. These views have been incorporated with the results of the writer's experience in the following paragraphs:

1. Röntgen deep therapy is based upon the fact that the röntgen ray has a decided deleterious effect upon the male and female glands. The effect on the myomata is primarily through the ovaries, but certainly in the majority of cases there is a direct effect upon the tumor-cells themselves, manifested

by decrease in the size of the tumor. The report of Kelly and Burnham on the direct effect of the gamma rays of radium upon myomatous tissue supports this view.

2. The symptoms caused by myomata improve and are sometimes entirely overcome. The hæmorrhage may be changed into the normal menstrual type or a complete cessation may be brought about.

3. The general conditions improve and the symptoms of the menopause are generally mild. In suitable cases the percentage of complete recoveries is high, yet it must be admitted that a certain number of myomata are refractory.

4. A certain percentage of myomata now, as before, must be operated upon. Not all are suited for röntgen treatment.

5. There is some danger of the appearance in the skin of injuries which are not manifest until some time after the cessation of the treatment. The future will show just how much they are to be feared. At the present time we are justified in believing that the late appearance of injury to the skin cannot occur unless the skin has suffered from a röntgen dermatitis of the first degree. It is essential that heavy dosage be applied, yet with careful observance of all the conditions necessary for the administration of deep röntgentherapy as much as twenty x units under the filter may be given as a routine without producing a röntgen dermatitis. As many as six or eight series of treatments, each area receiving 20 x, may be given each three or four weeks without producing any noticeable skin effects, not even atrophy of the skin. The writer would warn against larger doses except in cancer cases.

The indications and contra-indications for treatment have been fully stated by Pfahler in the *Journal of the American Medical Association*, August 22, 1914. We may summarize as the chief indications for deep röntgentherapy in gynecology the treatment of climacteric and other known benign hæmorrhages in older women, in whom the anatomical character of the endometrium should be ascertained by microscopic examination before röntgentherapy is decided upon.

It has also been urged as a contra-indication to deep röntgentherapy that, should the röntgen treatment fail and operation subsequently be decided upon, the intensive irradiation will have stimulated the formation of multiple adhesions which will interfere seriously with the operation. In fact, one prominent gynecologist, in confirmation of this argument, cited a case in which, following intensive irradiation in a case of uterine hæmorrhage, it was finally deemed necessary

to operate. At laparotomy the pelvic organs were found matted together by multiple adhesions which the operating surgeon attributed to röntgentherapy. The writer doubts very much the *post hoc propter hoc* nature of this argument, but he has not, until recently, had an opportunity to contradict it definitely. It seems, however, that the following case controverts any such argument that may be advanced:

The patient, E. C., age 62, was first referred for treatment on April 10, 1914, by Dr. W. F. Martin. Mr. C. had an extensive carcinomatous involvement of the prostate with 20 ounces of residual urine. By reason of carcinomatous extension to the bowel, it was not deemed feasible to operate. This opinion was concurred in by Dr. E. Wyllys Andrews, whom the patient later consulted, and palliative treatment was advised. Accordingly röntgen treatments were begun very much after the plan followed in treating uterine myoma, except that the doses were made heavier, twenty-five and sometimes thirty X units being given over the various skin areas chosen for cross-fire, the carcinomatous area being approached through twenty-six areas; twelve anterior, twelve posterior, and two perineal. Only palliative results were hoped for, but the results were awaited with great interest. The residual urine was reduced to 2 ounces within four weeks and the prostate was considerably diminished in size.

On February 18, 1915, ten months after treatment was begun, the patient meanwhile having received nine series of X-ray treatments, the constriction of the bowel by the malignant growth or its cicatrix seemed to demand colostomy. Therefore Dr. Kellogg decided to operate, the opportunity being utilized to explore the pelvis carefully. In view of the fact that the patient had been subjected to such an extensive course of X-ray therapeusis, nearly 6,000 X units measured under the filter having been administered during ten months, the appearance of the intestine was noted with great interest, to discover possible adhesions, the result of the röntgenization. The small bowel was entirely free from adhesions. The iliac colon was adherent near the iliopelvic junction but in a manner very commonly seen at operation in patients who have never taken any röntgen treatment. Just below the pelvirectal junction, the bowel was found tightly adherent, the adhesions being confined to an area not larger than a pigeon's egg, accurately coinciding with the site of the carcinoma. Proctoscopic examination of the adherent area showed an annular constriction with some ulceration of the mucosa which bled easily on being touched. A colostomy was performed in the usual manner.

The foregoing case, it seems to the writer, proves conclusively that there is no danger of

adhesions following intensive röntgentherapy directed toward the pelvis.

Prostatic hypertrophy. Gradually accumulating experience seems to show that the field of usefulness in deep röntgentherapy will include a certain number of cases of prostatic hypertrophy. The writer does not care to urge this form of treatment for any case where surgery can be carried out, but deep röntgenization may be recommended as a partial substitute for surgery in cases where surgical interference is inadvisable. In general, the technique is the same as that employed in the treatment of uterine myomata. Both anterior and posterior areas should be employed and several perineal areas. In the latter areas a somewhat smaller dosage should be administered because of the greater radiosensitiveness of the skin in these parts. The sensitive scrotum, if desired, may be protected from the effect of the ray, for there is probably no particular advantage from the irradiation of the testicles. The writer has seen the amount of residual urine diminished from 16 to 2 ounces within four weeks.

The treatment of these cases should be pursued energetically, but with the greatest care, and should be conducted for a sufficiently long time to insure a permanent reduction in the size of the gland. It is difficult to speak with certainty on account of the lack of reported cases, but certainly here is a field for the further development of deep röntgentherapy. As in the case of uterine fibroids, it is, of course, important that a correct diagnosis be made before beginning the röntgen treatment.

Tuberculous conditions. In practically all forms of tuberculosis, röntgentherapy has been tried out. Until within the last two years the verdict was almost unanimous that, in glandular and skin tuberculosis, röntgentherapy was reliable in the production of good results; in bone and joint tuberculosis the results were unsatisfactory and questionable; and that in peritoneal, pulmonary, and urinary tract tuberculosis there were no results to warrant the recommendation of this method of treatment.

Recent work by Kuepferle in de la Camp's

clinic in Freiburg has required us to revise our decision concerning the use of röntgen-therapy in *pulmonary tuberculosis*. Gibson of Denver was one of the first to report good results in pulmonary tuberculosis, but he claimed such a high percentage of favorable results without making any very definite statements as to the actual results secured or the technique employed that no great confidence was inspired in his statements. Nevertheless, the experimental work of Kuepferle¹ on animal tuberculosis and his recent report of forty-four cases in man causes us to reconsider the claims of Gibson.

Several investigators, including Leonard, Pancoast, and others, have called attention to the fact that in cases which are described as tuberculous cervical adenitis, röntgenization of the cervical glands has caused a disappearance of the apical signs of tuberculosis. Pancoast, however, issued a warning that, in cases of mixed infection, röntgenization might do harm rather than good.

Kuepferle's experiments are of extreme interest, especially his observation that recent and developing tuberculous foci, as well as old caseous processes of not too long standing, could be favorably influenced in the animal experiments. This is of special importance in considering the effect on human beings, where it is well known that fresh foci caused by reinfection occur alongside the older foci. The characteristic thing about all tuberculous lungs treated by röntgen rays is the lack of specific tubercular proliferation tissue and the great richness in young connective tissue as seen in the microscopic studies. The connective tissue not only replaces the granulation tissue, but penetrates the caseous and necrosing foci and surrounds them, so that there is a well-marked line of demarcation between the tuberculous foci and the normal lung-tissue.

In the lungs of control animals not subjected to röntgentherapy there were always more or less well-developed caseous foci surrounded by luxuriantly proliferating granulation tissue while no connective-tissue development could be seen. It seems reasonable to conclude from such experimental results that

in proper doses the röntgen rays destroy tuberculous granulation tissue and act as a stimulant to the development of young connective tissue. On the one hand the pathological granulation tissue caused by the infection is destroyed and on the other hand connective-tissue healing is powerfully stimulated. The tubercle bacillus itself is hardly influenced directly, as is shown by positive results of inoculation of the tissues of röntgenized animals into guinea pigs. It was noted, however, that less severe symptoms were caused by intraperitoneal injection of material from röntgenized tuberculous lungs than from tuberculous lungs which had not been treated.

Kuepferle reports on forty-four patients in different stages and with different forms of the disease. At first the patients were not selected, far-advanced and hopeless cases being included in order to best determine the effect on far-advanced processes. The forty-four cases were divided into three groups. In the first group there were nineteen cases in which there were active processes with febrile and subfebrile temperature. Seven of these, in addition to the pulmonary infection, had marked enlargement of the cervical and bronchopulmonary glands. In these patients not only the diseased part of the lung but also the lymph-glands were treated. In all there was a retrogression in clinical symptoms, decrease in cough and expectoration, and gradual decline in fever. The average duration of treatment was thirteen weeks. Some of the stubborn cases showed a recurrent rise of temperature. All such were given several series of treatments at long intervals until there was complete disappearance of the fever and retrogression of the symptoms. Four patients have been examined from nine to eleven months following treatment and have been found well and free from symptoms.

In the second group were included fourteen cases, some with disseminated and some with confluent foci. All of these were also favorably affected. Of the fourteen, ten are clinically cured and dismissed from treatment. The four remaining are yet under treatment. The longest series of treatments extended over

¹ Kuepferle, L. *Strahlentherapie*, 1915, v, No. 2.

thirty-two weeks, the patient having a recurrence of fever. This patient was able to work at the time of discharge.

Eleven patients were included in the third group. Five of the eleven were complicated by tubercular disease of the larynx or peritoneum. In all the process was extensive and in some cavitation had taken place to a marked degree. These patients showed only temporary improvement. In general, they were very much more sensitive to the effect of the rays than the patients with incipient disease.

Although final judgment is withheld, the results thus far secured are very encouraging and emphasize the fact that in this day of advanced technique, improved tubes, and better apparatus, too much reliance should not be placed upon the negative results of the older methods of röntgentherapy.

Cases best suited for treatment are those in the earlier stages of the disease with slight signs of disintegration, even though there may be slight rise of temperature. The advanced cases are ameliorated, but the improvements are not proportionately marked. Surely the good results thus far secured warrant further trial of this method.

In the treatment Kuepferle emphasizes that the laws of deep röntgenization must be followed. Homogenous rays must be secured, and fortunately the modern improvements in technique make this possible. Heavy filtration, relatively short focus-skin distance, and multiple field irradiation are other features of the technique. In severe cases from 15 to 20 X over one or two fields is the maximum daily dosage.

In *skin tuberculosis* the results of röntgentherapy are very satisfactory. Details as to results of superficial lesions are out of place in this paper.

In *glandular tuberculosis*, the results of different investigators vary, but Crane's investigations suggest that the investigators with poor results have failed to observe the principles which should govern the treatment of such cases.

In some experimental work comparing the opsonic index following vaccine injections with the opsonic index following X-ray treat-

ments, Dr. Crane was able to show that the opsonic curve was essentially the same under both conditions. This indicates that the interval between X-ray treatments should be the same as the interval between vaccine injections, and that if the X-ray treatments are too severe or over too large an area, the reaction would be the same as if too large an injection of vaccine had been given. In this way a negative phase could be produced from which the patient might not be able to recover.

Dr. Crane concluded that the duration of exposure and the extent of the diseased tissue exposed should be so regulated as to produce either a small negative phase or none at all. The repetition of exposure should, as far as possible, be governed by the duration of the negative and positive phases. It follows as a corollary that it is not necessary to expose the whole area in order to bring about complete recovery. Dr. Crane believes that, as a rule, exposures should not be repeated oftener than twice a week, and probably in most cases at less frequent intervals, to secure the maximum results and to avoid prolonged or incurable negative phases. The writer urges careful consideration of Dr. Crane's investigations concerning the treatment of this disease.

The results in *bone and joint tuberculosis* probably depend upon the same principles which govern the treatment in glandular tuberculosis, as just stated. American röntgenologists have not reported the good results which have been claimed by many French and German workers in the treatment of these conditions, but in view of the scientific standing of the men whose work is attended by success, further effort in bone and joint conditions seems indicated.

We still record negative results in the treatment of *tuberculosis of the urinary tract* and in *tuberculous peritonitis*, the number of favorably affected cases being still too small to warrant any definite conclusions.

In the foregoing pages the writer has sought, not only to emphasize the usefulness of deep röntgen irradiation in certain conditions where the value of this remedial agent has already been acknowledged, but also to

point out a number of fields in which, theoretically at least, this agent would be of value, but where up to the present time sufficient clinical evidence has not been accumulated under the conditions of accuracy which should attend the present-day employment of deep röntgentherapy. Emphasis has been laid upon the necessity of accuracy in dosage, skill in manipulation of instruments, filters, and lead protection, and judgment as to the dosage indicated. As already intimated, the ownership of a röntgen installation by no means signifies skill in its use. All röntgen treatments should be recorded in such terms that any röntgen worker will understand the exact dosage and be able to duplicate the treatment.

There is, at the present moment, no organized literature on the subject of deep röntgentherapy as a whole. Numerous papers have appeared on the various phases of treatment, particularly those phases relating to gynecology, but what the writer would like to urge very emphatically is that in view of the renewed possibilities from this method of treatment, no case in which röntgentherapy is theoretically indicated should be denied a trial of this measure merely because the literature reports unfavorable results. In other words, much of the literature of deep röntgentherapy must be rewritten and the writer ventures the opinion that many of the conclusions will be changed in the revision.

**THE PRESENT STATUS OF ROENTGENTHERAPY IN THE
MANAGEMENT OF DEEP-SEATED MALIGNANCY**

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IN reviewing the present status of roentgentherapy in the management of deep-seated malignancy, first let me say that the subject is hardly one which can be properly considered by itself, for in the battle against malignant disease one is not justified in the sole employment of single remedies. Operable malignancies certainly do not furnish the indication for roentgentherapy alone, but as a prophylactic against recurrence the application of radiant energy is of great value. In hopeless malignancies, we shall do well to avail ourselves of the combined effects of all the anti-cancer agencies at our command, whether roentgen rays, radium, surgical excision, or heat-destruction, as the needs of the individual case may require.

Further there is such strong similarity between roentgen rays and the γ -rays of radium, both as to physical properties and biological effects, that I shall include here certain considerations of the radium question.

Just at the present time the attitude of the surgical profession seems strongly influenced by a powerful wave of criticism of roentgen rays and radium as therapeutic agents in cancer. Some of this criticism is unkind and unjustifiable, the result of failure to distinguish between the claims made by over-enthusiasts and propagandists and the good results demonstrated by the relatively few men who are in a position to know whether the application of the roentgen rays or radium has been carried out with proper technique and adequate dosage.

Much confusion and skepticism have been generated by the extravagant claims of some whose opportunities outstripped their knowledge of the physical laws governing the therapeutic use of radiant energy; but on the other hand the records of conservative, competent men should command respectful consideration, and before pronouncing judgment as to the claims of the radiologists,

referring both to roentgen-ray and radium therapists, one should be sure he understands just what they have shown themselves able to accomplish.

The sincere radiologist aspires to be considered a scientist, not a propagandist. He seeks not the success of a particular method, for his greatest interest lies in contributing his share in the battle against disease, and though he may be disappointed over his failure to do the impossible by curing malignancy already beyond surgical relief, there is still the gratifying realization that his labors have relieved pain and lengthened the span of useful life in these unfortunate cases. In the words of an ancient English surgeon, "if a panegyric were necessary, it were best made by running through the particulars of the art and the history of the diseases relieved thereby." And though failing in absolute cure of malignancy, we shall still appreciate the good palliative effects of radiotherapy, which are far better than can be obtained for these cases in any other way.

Now, what are the claims which in the light of present clinical experience may be advanced for radiotherapy in cancer? Summed up briefly, they are as follows:

1. Radiotherapy, referring both to roentgen rays and to the γ -rays of radium, does experimentally destroy cancer-cells in laboratory animals.

2. Practically, also, there is no question about the successful destruction of cancer-cells in the human body.

3. This destructive effect is a deep one, both for roentgen rays and radium. There is no doubt about the possibility of local cure of malignancy, even when deep-seated, by exposure to radiant energy.

4. With reference to superficial malignancies, no one will contest the statement of Pusey that upward of 90 per cent of such lesions will yield to radiotherapy, resulting

¹Read before the Clinical Congress of Surgeons of North America, Philadelphia, October 26, 1916.

in absolute cure. Our entire time will therefore be spent in the discussion of deep-seated lesions.

Wickham has fully described the effects of radium and roentgen rays on various normal and pathological tissues, stating that there is practically no difference in the histological changes produced by these two agents. Of the pathological tissues, he studied epithelioma of the skin, glandular epithelioma, and connective-tissue tumors.

In an ulcerating epithelioma of the skin, after a latent period of fifteen days, more or less, depending on the dosage, the epithelioma cells show an extraordinary hypertrophy of their elements, and completely disappear after cornification, which is disseminated, total and atypical. The horny masses disappear through phagocytosis, and cicatrization is completed at the expense of the stroma of the tumor.

In glandular epitheliomata the changes are analogous. The neoplastic cells of breast carcinoma, for example, after going through a sometimes monstrous hypertrophy, disappear, ending in fusion by cytolysis or in absorption by phagocytosis. The hyperplastic stroma penetrates into the lobes of degenerated cells, displaces them, envelops them, and organizes a smooth, elastic scar tissue, rich in cells.

In sarcoma, at least of the spindle-cell type, after a latent period much shorter than that in the epithelioma, the neoplastic cells show an increased nutritive and proliferative activity which is evidenced by great hypertrophy. The cells then become stellate and are overtaken by death in the midst of their growth and development, being absorbed by phagocytes. In a specimen of fibrosarcoma, it seemed that at a certain depth the weakened rays did not destroy the neoplastic cells but produced a biological change, which gave them the morphological characteristics of a benign fibroma, with final transformation into cicatricial tissue.

These observations of Wickham, which agree absolutely with those of Haendly, Dominici, Clunet, Raulot Lapointe, and numerous others, demonstrate that the changes induced in epithelioma and sarcoma by

exposure to roentgen rays and radium show the same mechanism: The cells die in a condition of monstrosity, and their disappearance is accomplished by means of phagocytosis. The destructive effect is strictly local, being confined to the tissues upon which the rays are directed. There is no distant effect. Carcinomatous tissues are fairly sensitive to irradiation, this sensitiveness being greater than that of the surrounding tissues, except in certain locations. Histologically it has been demonstrated that, under roentgen or radium exposure, degeneration of malignant cells may take place before any effect upon healthy cells is demonstrable. The greater the capacity of a cell for proliferation and regeneration, the more sensitive it is to radioactive agents. The nearer the malignant cells approach the embryonal type of tissue, the greater their radio-susceptibility. The younger pathological cells are affected by rays which have passed through healthy tissues without producing destructive changes.

The latent period in sarcoma is shorter and the pre-degenerative hypertrophy of the sarcoma cells is much more active. Certain sarcomata are not destroyed by the rays but are simply converted into benign fibrous tumors, and from these into cicatricial tissue. Good effects are more often observed in round and spindle-cell sarcomata than in tumors with very much differentiated cells. Pfahler has apparently demonstrated that it is possible to heal certain osteosarcomata, the healing process being characterized by a progressive deposit of lime salts in the tumor areas, until the tumor area attains the solidity and density of normal bone.

All the cells and tissues irradiated are influenced by the rays, but to a very variable extent. This is well illustrated in a case of advanced pavement-epithelial carcinoma of the cervix reported by von Franque, in which operative removal occurred the day after the last irradiation. The epithelium of the uterine glands in the immediate neighborhood of destroyed malignant foci was unchanged, while the connective tissue seemed to be undergoing active proliferation. In some places the connective tissue looked like young granulation tissue, and contained abundant

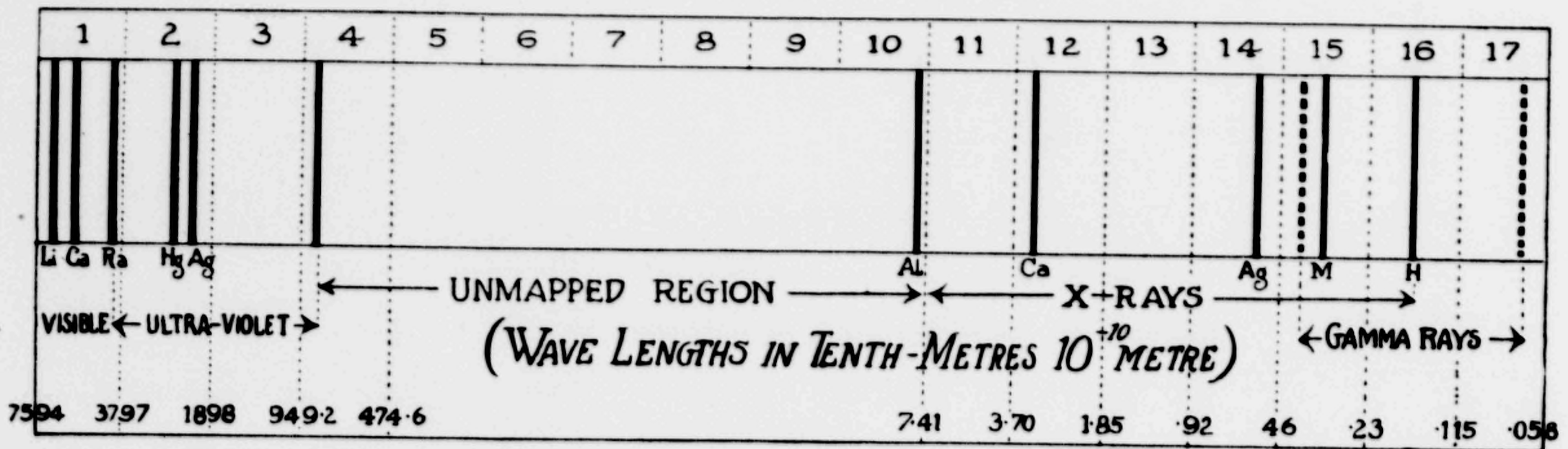


Fig. 1. From the visible to the γ -ray spectrum (Sidney Russ). The numbers across the top of the diagram represent the number of octaves through which the rays range. The numbers across the bottom give their respective wave lengths in ten thousand millionths parts of a meter.

multinuclear giant cells, probably engaged in the work of disposing of the dead carcinoma cells.

The destructive effect of radiotherapy is deep, both for radium and for the roentgen rays. This statement will hardly be questioned in the case of radium, the high penetrating power of the γ -rays having been deeply impressed upon all; but it is not generally appreciated that the hard roentgen rays, now easily obtainable, have almost as great a penetrating ability as the harder γ -rays. Your attention is invited to the accompanying diagram by Russ (Fig. 1), representing a chart of the wave lengths of rays ranging from the visible part of the spectrum to X-rays and the γ -rays of radium. The numbers across the top of the diagram represent the number of octaves through which the rays range; the numbers across the bottom give their respective wave lengths (in ten thousand millionth parts of a meter). The γ -rays are represented in wave lengths as extending between the two heavily dotted lines on the diagram.

It will be readily seen that while the most penetrating γ -rays are of appreciably shorter wave lengths than the hardest X-rays, some of the γ -rays are of longer wave length. The hardest γ -rays extend only about one octave higher than the hardest X-rays now available. Indeed, Rutherford's recent work indicates that the γ -rays of radium may be regarded as secondary X-rays produced in the radium. Russ further declares that the hard X-rays, such as we are using daily, have such a high penetration that the intensity of

a beam is only reduced to 10 per cent by going through 12 or 13 centimeters of tissue. Add to the foregoing a realization of the fact that roentgen tubes are capable of furnishing hundreds of times the amount of radiant energy for deep therapy obtainable from say 100 milligrams of radium element, and we begin to appreciate that there is probably not so very much practical difference between these two agents.¹

The γ -rays of radium are subject to the same physical laws which govern roentgen irradiation. The law of the inverse square of the distance applies just as truly in radium work. It is not enough to know the amount of filtration and the number of milligram-hours of application; the distance from radiant source to part must also be carefully noted, for only thus may the time of application be governed. The technique of radium application is as yet in many respects as prim-

¹ Through the courtesy of Mr. H. Clyde Snook I have been furnished with the following statement regarding the relative energy of radiation from radium and from an X-ray tube:

"The international standard value for the total heat generated per hour by a gram of radium is 134.7 gram calories. (Rutherford, Phil. Mag. 28, p. 320, Sept. 1914. Science Abstracts A, 1915, No. 180.) Of course only a small part of this energy is radiated as X (gamma) rays.

"For an X-ray tube.

$$\frac{\text{Energy radiated as X-rays}}{\text{Energy input to tube}} = \frac{1}{2000} \text{ to } \frac{1}{500}$$

(Kaye, X-Rays, p. 106, Beatty, Proc. Roy. Soc., 1913, Rutherford and Barnes, Phil. Mag., Sept. 1915).

"Assuming a tube operating at two milliamperes and 50,000 volts, the input is 100 watts, and the energy radiated as X-rays is:

$$100 \times \frac{1}{2000} \text{ to } \frac{1}{500} \text{ or } 0.05 \text{ to } 0.2 \text{ watts.}$$

"That is, an X-ray tube under moderate conditions of operation radiates as X-rays about as much energy as the total energy in all forms produced by a gram of radium."

Since available quantities of radium are measured in milligrams, there is justification for the statement I have just made that roentgen tubes are capable of furnishing hundreds, if not thousands, of times more rays suitable for deep roentgenotherapy than ordinary available amounts of radium.

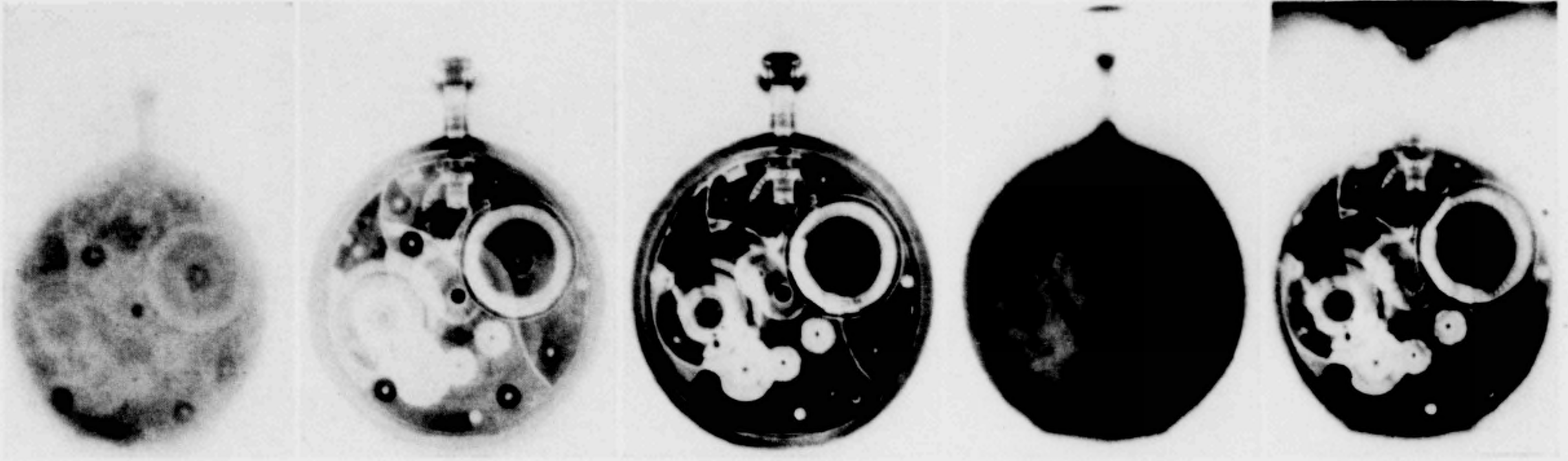


Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 2. Radiogram of a watch made by exposure for fifteen hours to fifty milligrams of unfiltered radium element at a distance of fifteen inches.

Fig. 3. Roentgenogram of the same watch exposed to six milliamperes (Coolidge tube backing up a ten-inch spark gap) for six seconds at a distance of fifteen inches, no filter.

Fig. 4. Roentgenogram of watch at fifteen inches target plate distance (Coolidge tube backing up a ten-inch spark

gap) fifty milliamperes, eight seconds, filter two millimeters of brass.

Fig. 5. Radiogram of same watch made by exposure for fourteen minutes to fifty milligrams of radium element, four centimeters distance, no filter. Compare with Fig. 6.

Fig. 6. Roentgenogram made in one-twentieth of a second, fifty milliamperes of current and a focus-plate distance of eleven centimeters. No filter. Compare with Fig. 5.

itive as was the roentgen method sixteen or eighteen years ago.

Some simple experiments may serve to render more vivid the statements just made concerning the intensity and penetrating power of the roentgen rays. When a gold watch is placed upon a photographic plate and exposed alternately to a hard roentgen tube and to fifty or a hundred milligrams of radium element, it will be found that fifty milligrams of unfiltered radium element at a distance of fifteen inches from the plate require fifteen hours to make a satisfactory radiogram of the watch (Fig. 2), whereas the passage of six milliamperes of current, an amount ordinarily used in treatment work, through a Coolidge tube at a focus-plate distance of fifteen inches, gives a very distinct roentgenogram showing the internal works of the watch with surprising detail (Fig. 3), with an exposure of only six seconds.

When the radium is enveloped in a gold tube, such as has been employed for deepest therapy, twenty hours are necessary to accomplish with fifty milligrams of radium element what fifty milliamperes of current will do in eight seconds when filtered through two millimeters of brass (Fig. 4), the distance from the plate remaining fifteen inches in both instances.

When the fifty milligram tube of radium element is brought as near as four centimeters to the plate, which is less than the distance from the skin to the interior of most malignant tumors, it still requires fourteen minutes (Fig. 5) to produce the same change on the



Fig. 7. Photograph illustrating the tanning of the treated areas as a result of multiple-field roentgen radiation through filters in the course of deep therapy for a pelvic malignancy. Note that the discoloration of the skin is uniform indicating that nearly the same dosage of X-ray was given throughout all of the areas. This photograph demonstrates the accuracy with which it is possible to administer X-ray treatment.



Fig. 8 (at left). Very extensive carcinoma of the lower lip with invasion of the submental glands.

Fig. 9. Same case as Fig. 8, six weeks after the first treatment and three weeks after the second. Of course, such a case is hopeless so far as ultimate cure is concerned but there is no knowing what might have been done for the patient had X-ray treatments been given earlier.

plate through the watch as is obtainable with a very small quantity of roentgen rays in six seconds at ten times the distance.

With the X-ray tube, it is not possible to get so short a focus-plate distance as 4 centimeters. The shortest distance obtainable was 11 centimeters, yet at this greater distance (relatively four times) than with the radium element the experiment resulted in a much better exposed roentgenogram in one-twentieth of a second with fifty milliamperes of current, the tube backing up a ten inch spark gap.

The foregoing comparisons are not meant to depreciate the value of radium, which is a most welcome addition to our therapeutic agencies against cancer, but to encourage appreciation of a much less expensive and more generally available source of powerful radiant energy. We may repeat that the quantity of hard rays furnished by a roentgen apparatus is certainly very considerably larger than that of γ -rays from a powerful radioactive substance; and it is possible, therefore, in spite of the lesser penetration of roentgen rays, to achieve a high degree of intensity, even behind thick filters. Radium has many advantages peculiar to itself, especially that of being applicable within cav-



Fig. 10 (at left). Recurrent sarcoma involving the entire left side of the face, following two operations for sarcoma in the temporal region.

Fig. 11. The same case as Fig. 10, photographed three weeks later, illustrating the prompt results of intensive roentgentherapy, using hard rays and thick filter. The glandular enlargements have all disappeared. The patient died some months later from pneumonia which both he and his wife contracted at the same time. The characteristic organisms of pneumonia were found in both cases. Postmortem study of the thorax was not secured. There was found one small, hard nodule in the right maxillary region which was excised and carefully studied but the microscope showed only scar tissue, no malignancy.

ities and tumors, thus producing rays directly within the tumor and offsetting considerably the disadvantage of requiring a much longer time of application. Anyone fortunate enough to have both agencies at his command will utilize them in combination whenever possible.

Histologically there is no difference, according to Wickham and many others, in the changes produced by radium and the roentgen rays. Von Seuffert declares that radium, mesothorium, and roentgen rays are of about equal value in radiotherapy, both having their limitations in pathological processes that are too extensive. Pusey has not been able to see any difference whatever, so far as clinical effects are concerned. The radioepidermatitis described by Regaud and Nogier as occurring after the administration of very high doses of extremely hard roentgen rays, is quite analogous to the skin reaction which may follow the application of highly filtered γ -rays.

Practically, therefore, we may conclude that there is no question about the destruction of neoplastic cells in the human body as a result of exposure to both roentgen and



Fig. 12. A case of Hodgkin's disease referred by Dr. Joseph L. Miller. Before treatment.

radium rays, both of which have a high degree of penetration and intensity of biologic effect; and furthermore, that this destruction may be brought about in the deep tissues of the body, providing the therapist commands the necessary skill and experience in their application.

Why, then, are cures so infrequent?

In the first place, the treatment is usually inadequate. There are in this country literally hundreds of roentgen equipments presided over by men and women not prepared by education or experience to use them.

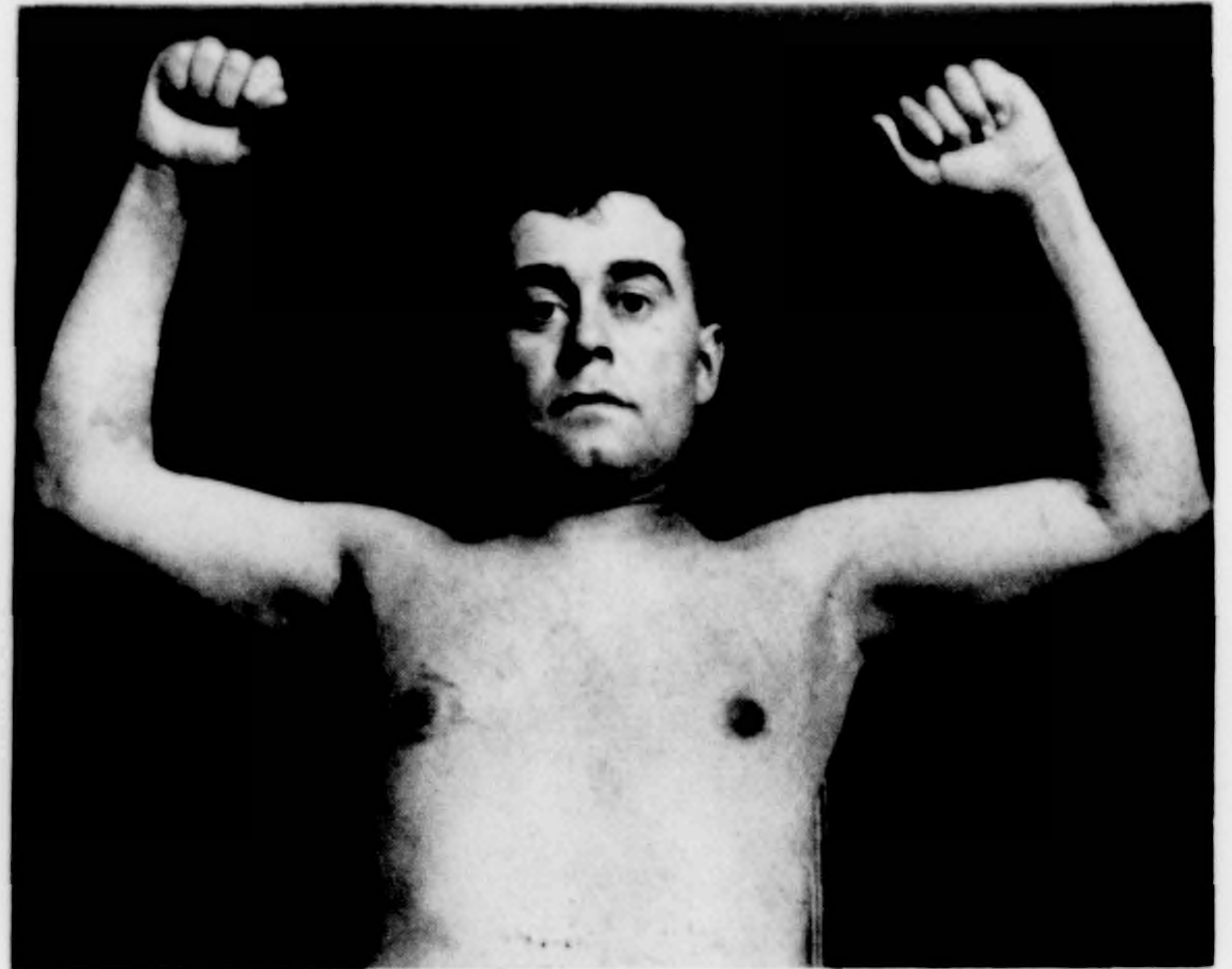


Fig. 13. The same case as in Fig. 12, after three months of deep roentgentherapy. The treatment was continued for seven months.

Very often the one in charge is not even a physician. Even though a physician, it does not follow that, being given charge of a roentgen installation, he is endowed with the necessary knowledge and experience to use it. And even the physician trained in diagnostic roentgen work may be woefully deficient in the therapeutic application of the ray.

In the second place, the destructive effect of the rays is purely local, at least so far as cancer is concerned. We have no proof of a



Fig. 14. Roentgenogram of the chest in the case of Hodgkin's disease which was made before treatment was started and at the same time as Figure 12. Note the marked mediastinal enlargement as well as the tracheal narrowing which is due to pressure of the enlarged cervical glands.



Fig. 15. Roentgenogram of the chest of the case of Hodgkin's disease taken seventeen months after Fig. 12, and more than a year after Fig. 13. The patient later developed an asthenic state and died about two and a half years after the beginning of treatment. The glands did not enlarge again.

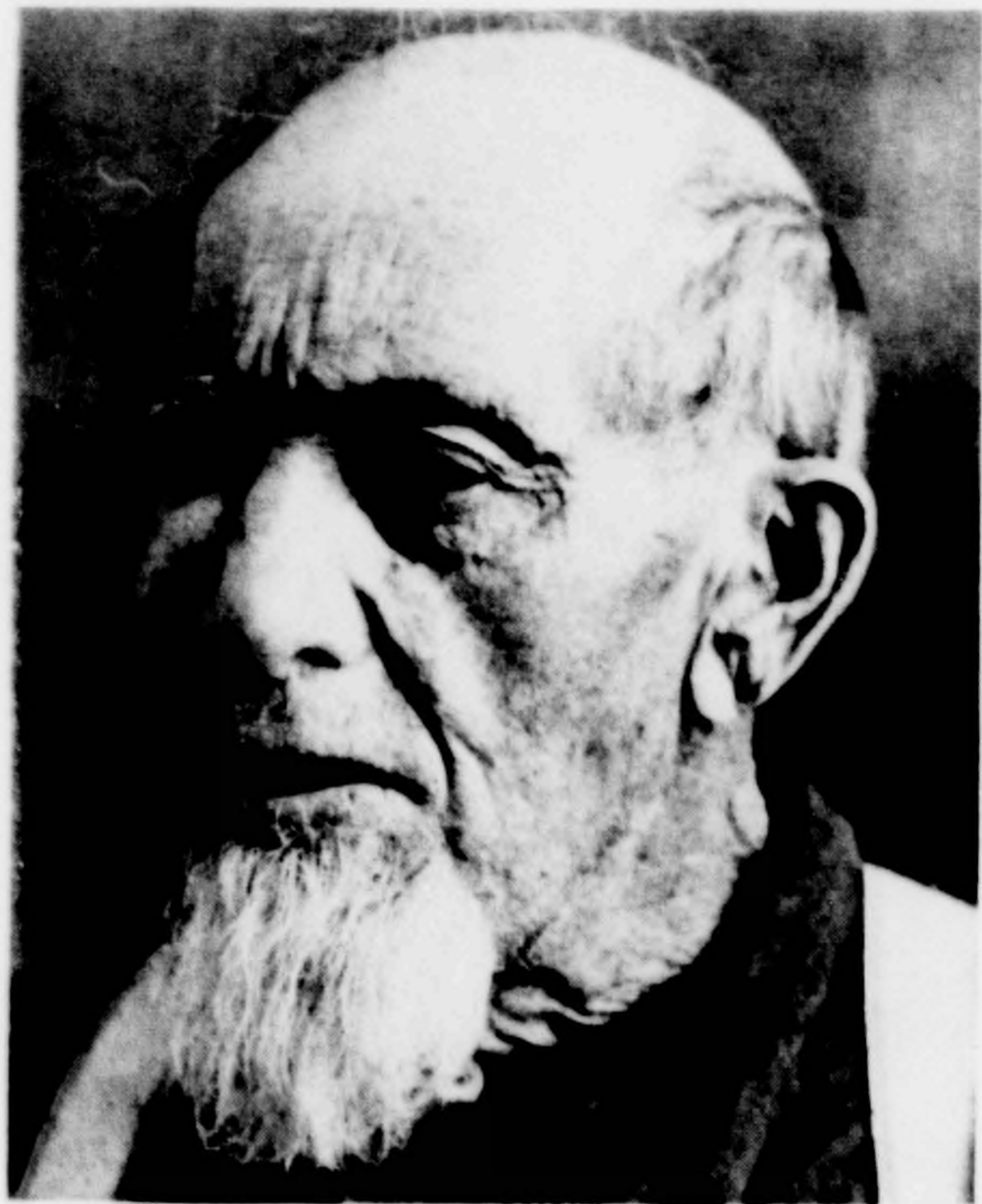


Fig. 16. A case of sarcoma of the right maxillary antrum with depression of the right half of the hard palate, protrusion of the right half of the face, deviation of the nasal septum toward the left, and occlusion of both nasal passages and pressure upward of the floor of the right orbit (see Fig. 17).

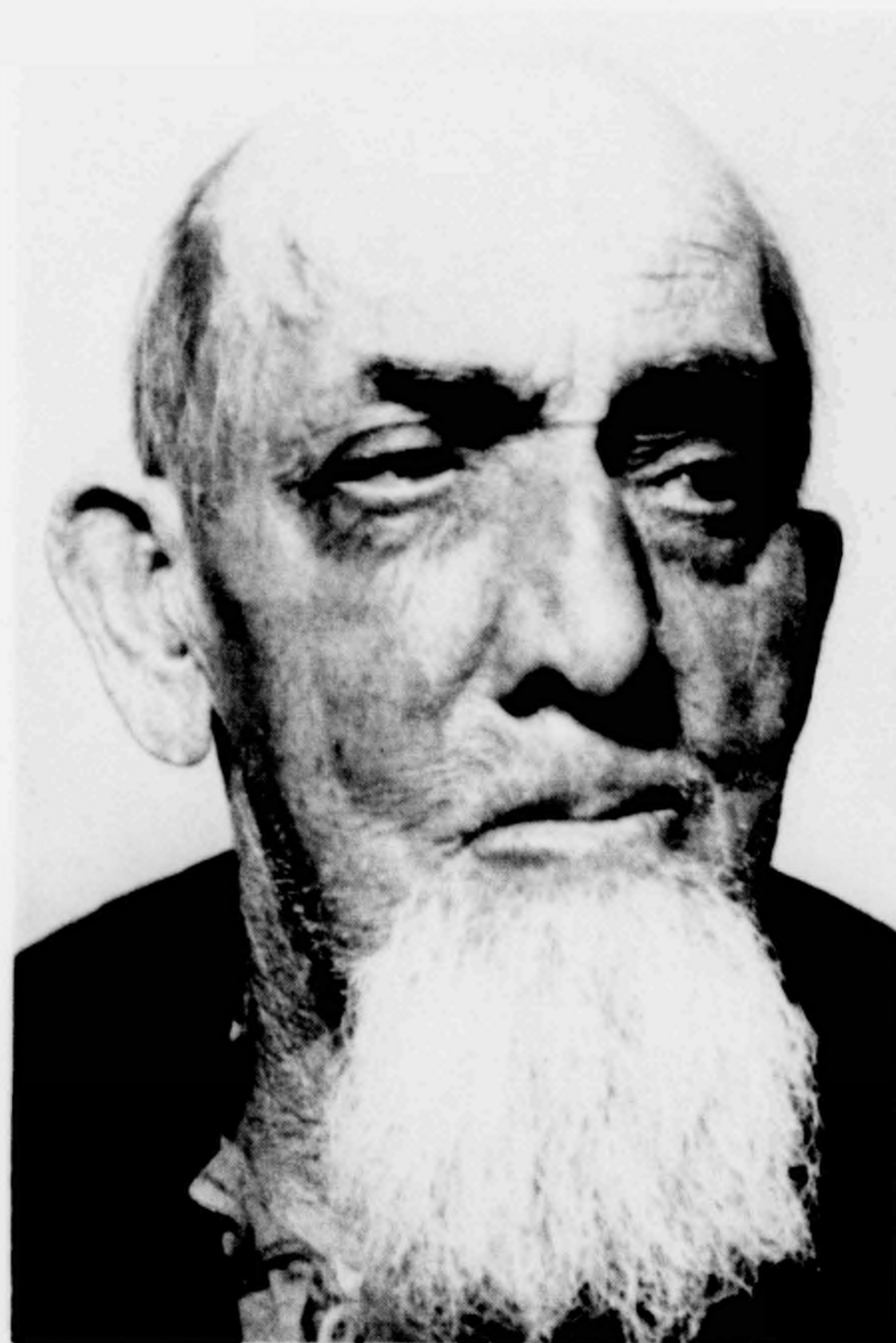


Fig. 17. After four series of intensive deep roentgen-therapy this patient discontinued treatment, being obliged to change residence. By this time the asymmetry of the face had disappeared, the depression of the right half of the hard palate was no longer noticeable, and the nasal passages were both open. The antrum was still opaque when compared with the left side. The patient was clinically cured. At his death, which occurred in a distant city about eighteen months later, the attending physician investigated and found no gross evidence of malignancy in the right maxillary antrum. Histological study was not made (see Fig. 16).

remote effect in malignant cases. As a rule, the progress of the disease is arrested for a while, perhaps even for years, but final recovery of the patient is rare, even though the demonstrable tumors may disappear under treatment. Often enough there are hidden foci of disease. It is quite within the range of possibilities that the blood-forming organs have suffered from substances formed in the tumor and possibly also as a result of the irradiation, to such an extent that the patient cannot recover in spite of the disappearance of the tumor.

But we do accomplish much that is infinitely well worth while. Although I am free to confess to my pessimism concerning roentgen or radium therapy as a means of effecting a permanent cure of malignancy, my remarks should not underestimate in the least the great helpfulness of this method in a palliative way. One of the first effects of treatment is the disappearance of pain, even of severe pain, sometimes not until after a prodromal exacerbation. Even in the most unfavorable cases, where the effect on the size of the tumor is only slight, quick and permanent relief from pain is often secured. Only rarely is the analgesic effect lacking. There is a de-

crease in the secretion from ulcerated surfaces, and generally the ulcers heal over. Pressure symptoms on neighboring organs diminish along with the decrease in the extent of the malignant mass. Venous stasis and œdema disappear; displaced parts resume their normal position. The patient's general health improves. With the return of appetite and ability to sleep, there is a corresponding increase in body weight. If toxic substances have been produced within the tumor, their effect upon the organism is suppressed, though at times an excessive amount of toxic substances may at first be generated through the destructive influence of the rays upon large masses of yielding tissue. Not only primary malignancies but also recurrent and metastatic lesions can be influenced in this way. Unfortunately the disease will soon reappear if there are hidden metastases;



Fig. 18 (at left). Carcinoma of the œsophagus at the level of the aortic arch. Note the barium residue and the irregular filling defect. A gastrostomy was done. Later a silk thread was swallowed, the lower end being hooked out of the stomach through the gastrostomy opening.

Fig. 19. Same as figure 18. A capsule containing fifty milligrams of radium element in a proper metallic filter surrounded by rubber was attached to the upper end of the



thread and by traction on the lower end drawn into the tumor area (at arrow). X-ray treatment was also applied from the surface. This case illustrates well the method of combining roentgen and radium therapy. Although the patient within two months was able to swallow solid food comfortably, he later committed suicide because the surgeon (very properly) refused to close the gastrostomy opening.

but even in these cases the patient usually enjoys a new lease of life, he is able to resume some or all of the duties pertaining to his station, and the development of complications is postponed.

The literature abounds in reliable reports of cases of inoperable and hopeless malignancies where such results have been secured. Hours would be required for the recital of the brief abstracts I have prepared from nearly three hundred articles upon this subject which have been published within the last three years. I am appending to this article a few illustrations of some of the striking results which we have obtained. Some of our most convincing cases are of deep-seated lesions which are not amenable to photographic demonstration. There is no doubt that in a considerable percentage of inoperable and recurrent malignant disease, the patient may be restored to subjective health and a period of usefulness, and the fatal end postponed so that in many instances final relief comes through some quicker, more merciful intermittent affection. Even should the patient

succumb to recurrent malignancy, its progress when it does appear is speedy and much less distressing than death by the primary lesion.

Unless the future should make the absolute cure of malignancy possible by means of ray treatment, for which our present sum of experience does not warrant any very vigorous hope, we must strictly adhere to the rule that neither radium nor the roentgen rays should replace or interfere with the surgical treatment of cancer. All operable cases should be submitted to surgical treatment, but this treatment should invariably be followed by systematic and adequate roentgen or radium therapy, or both. This treatment should be instituted as soon as possible after the operation, and applied as thoroughly as though we believed the disease still present in its entirety, the patient's sole prospect of cure depending upon the efficiency of our work. Not only should we treat the site of the original disease, but all the related areas in which recurrence is likely to occur. I have also for some years advocated pre-operative treatment whenever practicable, the pre-surgical application being

administered a week or ten days before the date set for operation.

In the treatment of inoperable malignancy, recurrent or metastatic lesions, every efficient means at our command should be employed, —a combination of methods. Surgery by the knife or heat destruction may take away masses of disease; and combined radiotherapy, radium internally and roentgen rays externally, will tend to destroy outlying foci, or at least retard their development.

The profession as a whole does not seem to appreciate the importance of palliative treatment in the case of cancer patients. A certain element of fatalism is seen in the attitude of many toward helpless cancer patients more than is noted in their dealings with other classes of incurables. What is needed is that the public should become sufficiently educated in the matter so that they will understand the necessity of submitting themselves early enough to radical surgical treatment. But these lesions are so often painless and symptomless in their early stages that even the medical profession itself is not yet sufficiently educated as to the imperious necessity of early diagnosis of malignancy. And the tragedy of it all is that for a long time to come we shall continue to see advanced cases of inoperable and hopelessly malignant disease which might have been cured or mitigated in their earlier stages. It behooves us, therefore, to encourage in every possibly way the

development of radiotherapy and, through friendly and constructive criticism, to lend our influence to the maintenance of the highest standards in our work and the attainment of the highest ideals.

SUMMARY

I do not believe in submitting operable malignancies to radiotherapy in place of surgery.

The use of the roentgen rays and radium, at least for the present, should be restricted to pre- and post-operative irradiation, and to the treatment of inoperable malignancies.

Radiotherapy does destroy cancer cells. This destruction can be brought about without serious injury to the neighboring normal tissues. The destructive effect is a deep one, both for radium and the roentgen rays. The roentgen rays have a much greater intensity and penetration than is usually appreciated. The ideal method is to employ a combination of radium and roentgentherapy in all cases of tumors affecting cavities of the body.

There is no question about the possibility of effecting a local cure of cancer in the human body. We lose our patients in the end because of inaccessible metastases. But in the way of palliation of suffering, prolongation of useful life and, in a few unexpected cases, clinical cure lasting a decade or longer, there is no other known therapeutic agency that can equal the results of radiotherapy.

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Adhesions of the Pelvic Colon*

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The purpose of this paper is to bring to your attention certain considerations relating to the function of the pelvic colon and the significance of adhesions of that region. Gynecologists must deal with the pelvic colon along with the other pelvic organs, taking their relations into account in estimating the importance of signs and symptoms of pelvic disease.

The shape and position of the colon deserve at present comparatively little attention—less than is usually accorded to them. Comparative studies on the identical patient under the identical circumstances easily demonstrate the variability of the position of the colon and what little reliance can be placed upon its location and shape as it may appear in a roentgenogram at any given time. This generalized remark applies with particular emphasis to the consideration of those portions of the colon which possess a long mesocolon, viz. the transverse and the pelvic colon.

*Read before the Section on Gynecology and Obstetrics, Michigan State Medical Society, at Houghton, Mich., Aug. 16, 1916.

I believe that in the great majority of cases the cause of constipation is to be found in the pelvic colon or rectum, although the subjective symptoms may seem to be more pronounced in the proximal colon. Doubtless, the constipating

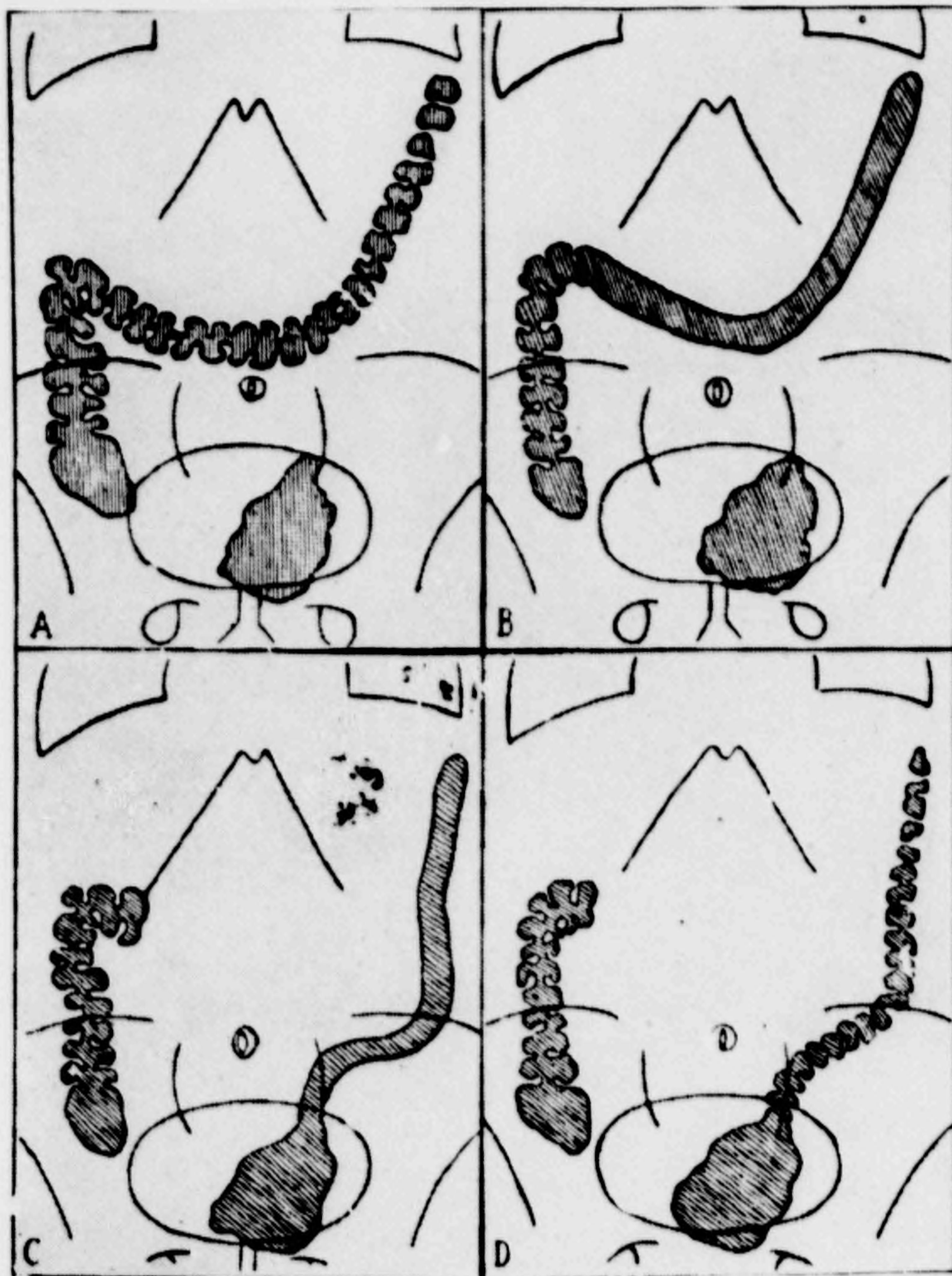


Fig. 1. Four drawings (after Holzkecht) illustrating the "mass" peristaltic movement. In A the colon is uniformly filled from cecum to splenic flexure and the indentations due to the haustral contractions are nicely seen. In B these haustral markings have disappeared from the hepatic flexure on. In C, a few seconds later, the content of the transverse colon has moved over into the descending and iliac colon, the haustral markings not yet having appeared. After some minutes, fifteen or twenty, the haustral markings are reappearing.

lesion is often a complex one and frequently associated with adhesions. Such adhesions are not only a cause of constipation, but often also a result of it, the situation thus assuming more or less the nature of a vicious circle.

The observations upon which this paper is based have been made on a large series of patients at the Battle Creek Sanitarium, the roent-



Fig. 2. Roentgenogram illustrating "mass" peristaltic movements such as are figured in preceding diagram.

gen observations being made in the Roentgen Department by my colleague, Dr. L. L. Jones, and myself, and the surgical operations being performed at the Sanitarium Hospital in the surgical services of Drs. Kellogg, Harris and myself.

In introducing this discussion, it may be well to review certain anatomical facts. Ac-

According to the newer terminology, the colon is divided into the following parts:

- (1) The *cecum*, being the portion below the ileocolic valve;
- (2) The *ascending colon* as far as the hepatic flexure;



Fig. 3. Roentgenogram made fifty hours after ingestion of the barium meal in a case of carcinoma of the descending colon. It will be noted that the barium is backed up in the proximal colon in a manner demonstrating the characteristic effect of exaggerated antiperistalsis. The densest mass is in the cecum and ascending colon rather than in the distal colon, just proximal to the tumor.

- (3) The *transverse colon*, being the portion between the hepatic and splenic flexures;
- (4) the *descending colon*, from the splenic flexure to the crest of the left ilium;
- (5) The *iliac colon*, from the crest of the

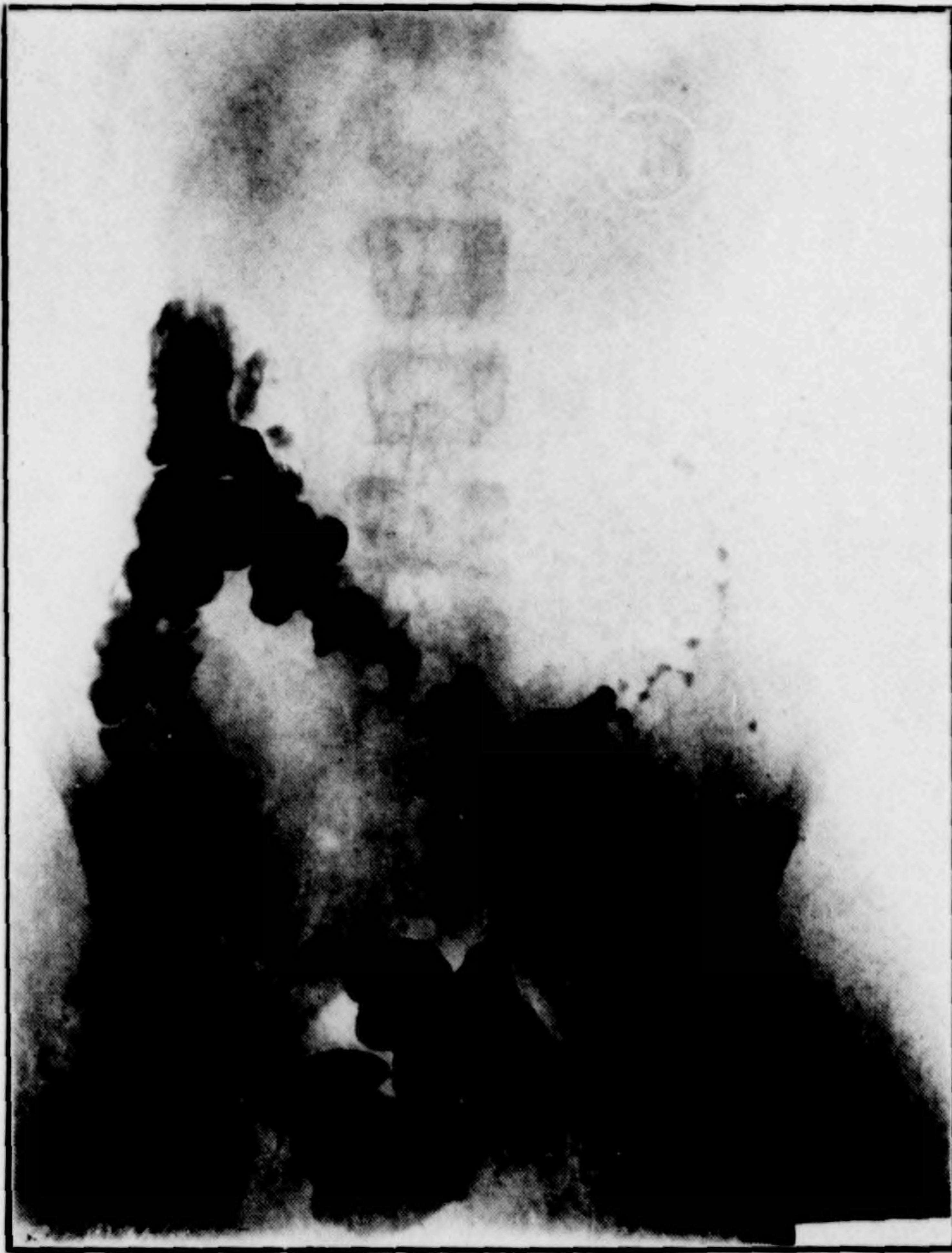


Fig. 4. Roentgenogram made twenty-six hours after ingestion of the barium meal. A certain portion of the barium has passed into the pelvic colon and rectal ampulla. The remainder is banked up in the colon, mostly in the proximal colon, in a manner characteristic of exaggerated antiperistalsis—in this case due to excessive tonicity of the distal colon. There was no pelvic colon obstruction in this case.

ilium to the inner border of the left psoas muscle;

(6) The *pelvic colon*, from the termination of the iliac colon at the inner margin of the left psoas muscle to the front of the body of

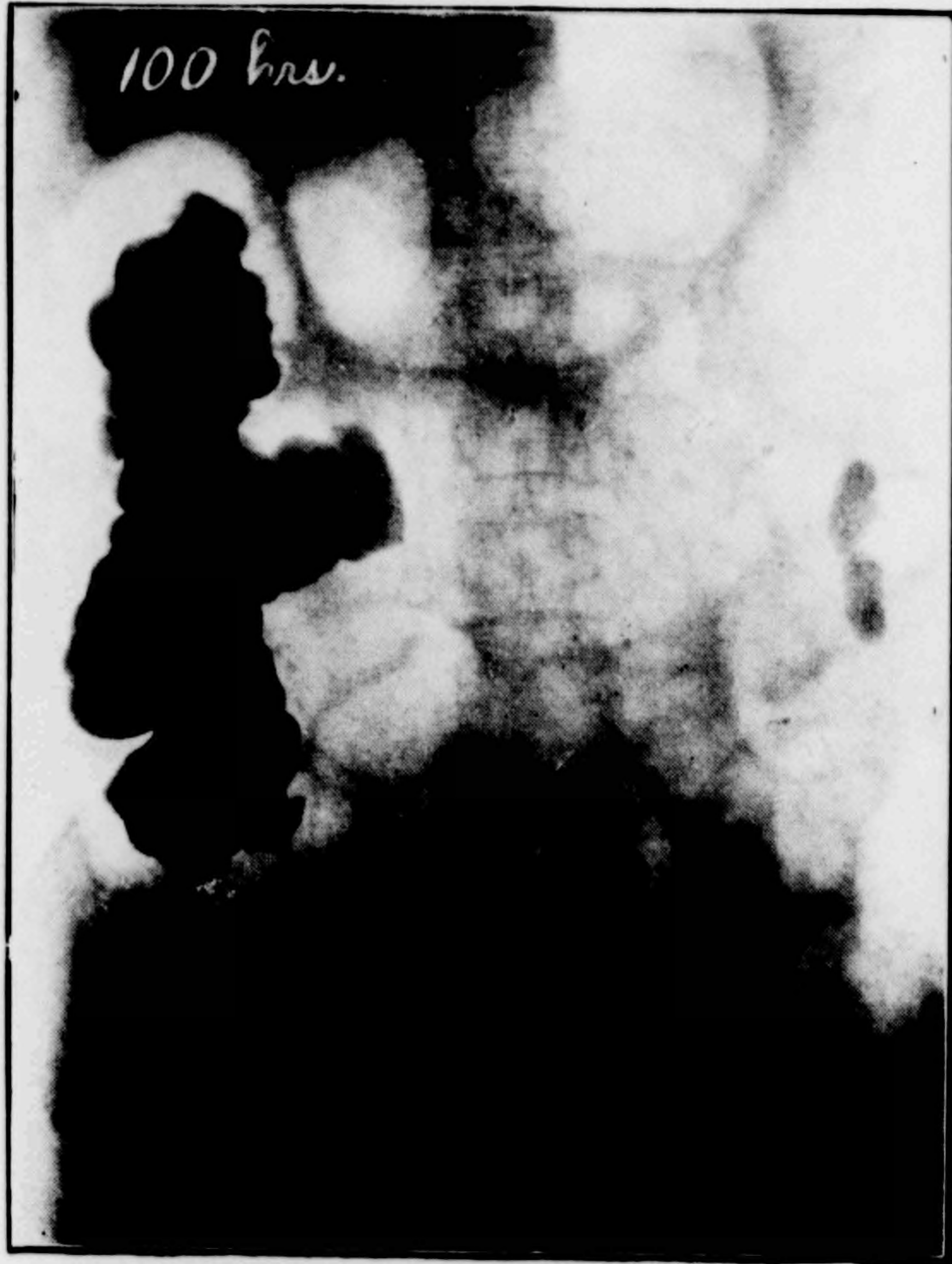


Fig. 5. Roentgenogram showing barium banked up in the proximal colon (cecum, ascending colon and first portion of transverse colon) one hundred hours after its ingestion.

The obstruction occurred in the pelvic colon, being due to adhesions associated with carcinoma of the uterus.

the third sacral vertebra, forming when empty an acute angle with the rectal ampulla. The length of the pelvic colon is variable, the aver-

age being 17 inches. It may be as long as 33 inches or as short as 5 inches.

The position of the pelvic colon is very variable. The following is modified from Cunning-



Fig. 6. A normal colon, enema-filled. The pelvic loop has risen up out of the true pelvis, demonstrating its mobility.

ham's description as its most common arrangement:

Beginning at the inner margin of the left psoas, it first plunges over the brim into the

pelvis, crossing this cavity from left to right. It next bends backward and then returns along the posterior wall of the pelvis toward the middle line, where it turns down and passes into the rectum.

The normal pelvic colon, when empty, lies in the posterior part of the pelvis immediately in



Fig. 7. Same colon shown in Fig. 6 a few minutes later after patient has expelled the enema. It will be observed that the success of the expulsive effort was ideal, the entire colon being emptied.

front of the rectum, but as it becomes filled it rises into the abdominal cavity so that the angle it forms with the rectum becomes less acute.

It is very important to note that the pelvic colon normally forms a freely movable loop,

its mesentery being longest in the middle of the loop and shortest at the extremities. We therefore expect to find the large bowel relatively fixed at the junction of the iliac with the pelvic colon (the iliopelvic junction) and at the junction of the pelvic colon with the rectum (the pelvirectal junction).

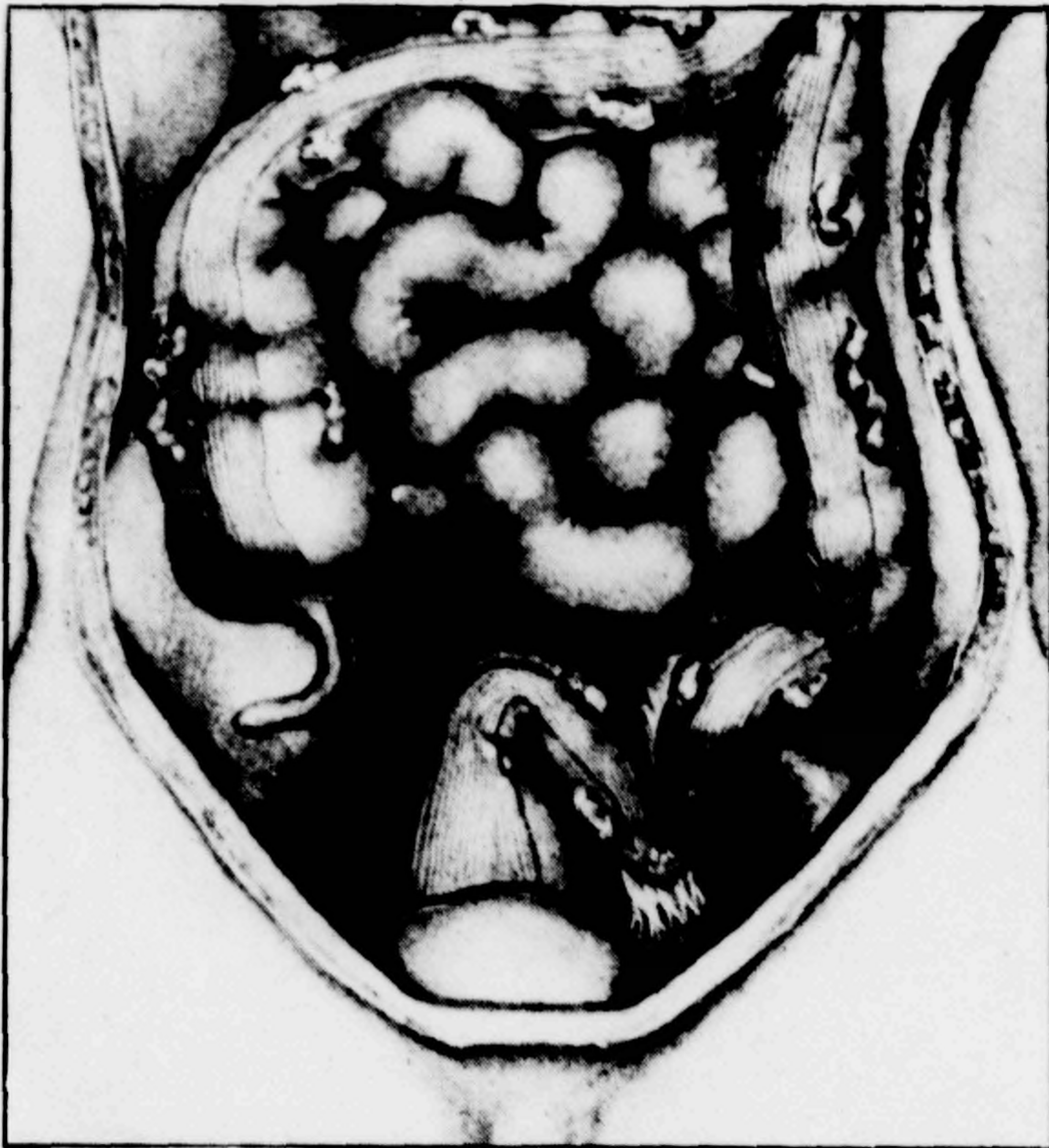


Fig. 8. A drawing (Tuttle) showing an acute flexure of the duodenum with adhesions involving the left tube and ovary. This is a graphic illustration of the usual manner in which pelvic colon adhesions interfere with the normal, free mobility of the pelvic loop.

The large intestine is normally emptied below the splenic flexure in the act of defecation, the proximal colon and right half of the trans-

verse colon being the seat of antiperistalsis, as has been shown by Cannon, Jacobi and others in animals, and by the experiments of myself (1) and others in man. As the result of these antiperistaltic influences, there occurs in the proximal colon a certain delay which permits

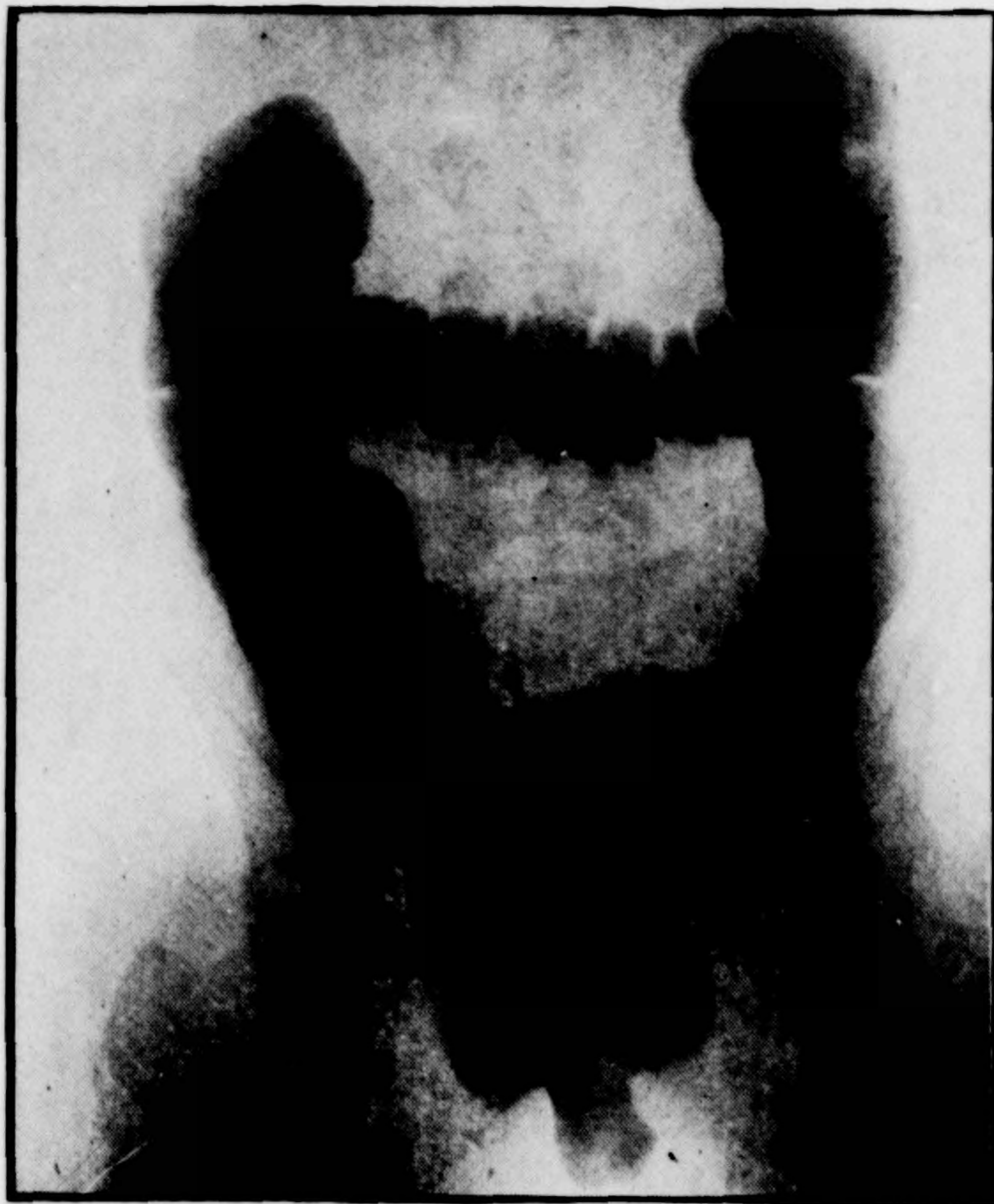


Fig. 9. Roentgenogram of an enema-filled colon in a case of adhesions of the pelvic loop with marked constipation.
See Fig. 10.

further digestive and absorptive processes to take place.

The transportation of food from this zone of antiperistalsis into the distal colon is principally brought about by the so-called "mass

movements," first described by Holznecht. By these mass movements, which are said to occur about six times daily, large boluses or masses of fecal matter are rapidly carried across the

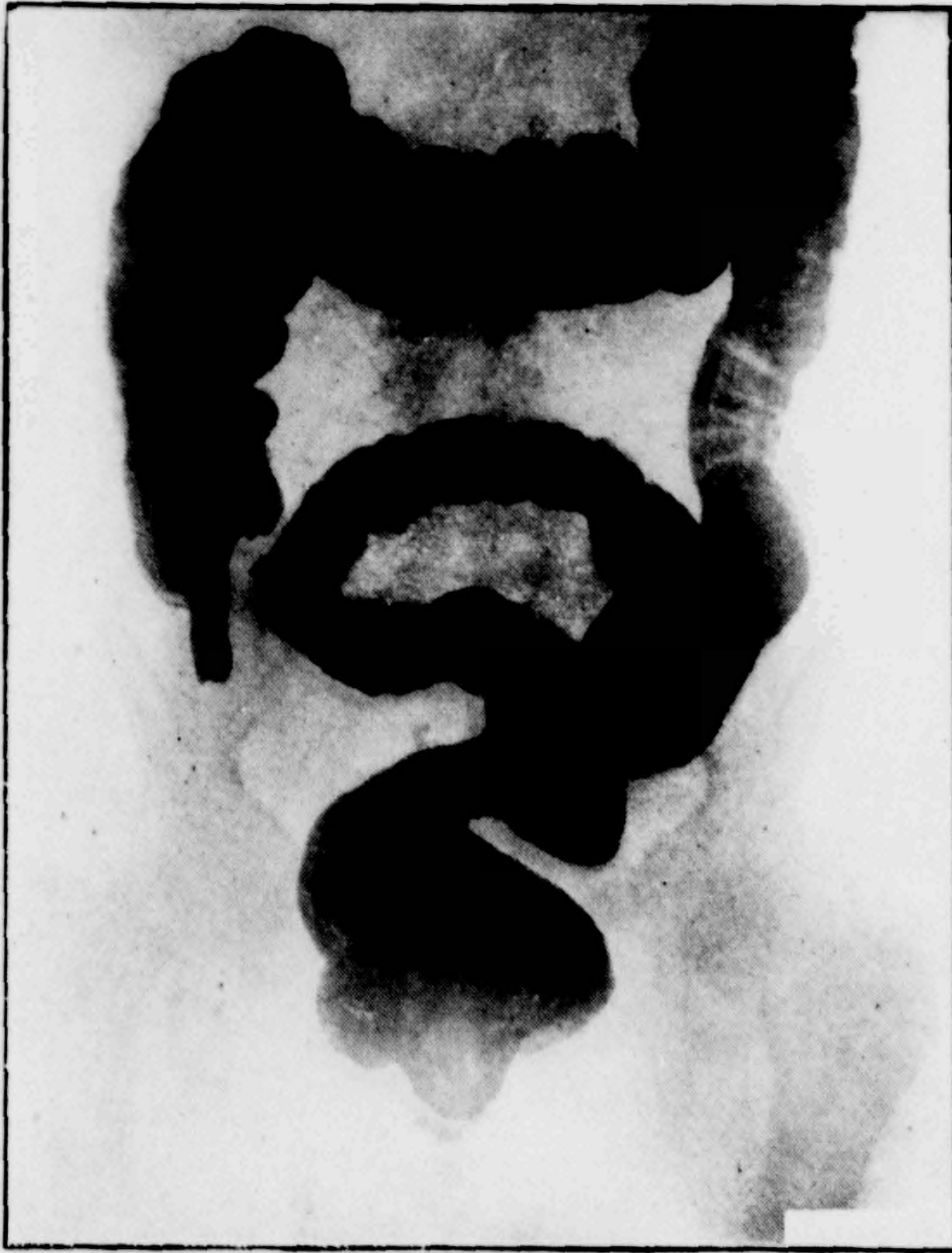


Fig. 10. Roentgenogram of same colon as shown in Fig. 9 after operation for release of adhesions of the pelvic loop with omental suspension of the loop thus mobilized. Almost complete relief of constipation.

transverse colon into the distal portion of the bowel.

Other movements by which the transportation of food occurs are the large pendulum move-

ments, first described by Rieder, and the small pendulum movements which are also called haustral contractions. The latter have been particularly well described by Schwartz. These lesser anastaltic movements do not, however, succeed in bringing about any very satisfactory propulsion of bowel content, this being largely



Fig. 11. Another case of pelvic colon adhesions where the adhesions, by their nature, seriously interfere with the evacuation of the contents of the colon. This case was completely relieved by operation.

brought about by the "mass" movements above referred to.

Normally, the descending and the iliac colon

are found either empty or containing only a small quantity of fecal matter in transit. The fecal material gradually accumulates in the pelvic colon above the pelvirectal flexure which,



Fig. 12. An enema-filled colon in a case of very serious constipation, a post-operative development, after hysterectomy. Ordinarily the patient should be able to expel practically the entire content of the enema-filled colon at one effort (Figs. 6 and 7). As it was the patient could only empty the contents of the lower portion of the rectal ampulla. (See Fig. 13).

as above stated, is formed by the junction of the pelvic colon with the rectal ampulla. Here there occurs a normal obstruction to the onward

passage of the feces, as O'Beirne was the first to show.

Until just before the act of evacuation, the rectum is normally empty, except occasionally for a few traces of fecal matter: remainders of the previous defecatory act. As more and more



Fig. 13. Enema-filled colon shown in Fig. 12 after the patient's most earnest effort to expel the enema. The hindrance evidently lies in the adherent rectal ampulla and lower pelvic colon.

fecal matter descends from above, the pelvic colon gradually fills from below upward. As it fills it rises, so that the acute angle it forms with the rectum, when empty, is obliterated and

the way is made easy for the propulsion of fecal matter into the rectum. As fecal matter thus begins to pass from the pelvic colon into the rectum, the resulting sensation of fulness leads to a desire to evacuate the bowels. Hertz draws attention to the fact that in the absence of any desire to evacuate at the proper time, this may be voluntarily produced by contraction of the abdominal muscles and diaphragm, forcing fecal matter into the rectum and thereby setting up certain impulses which pass to the defecatory center in the lumbar spinal cord, where they set in action the reflex acts necessary to complete the evacuation. Among these activities are strong peristaltic contractions of the colon, resulting in mass movements.

It was formerly believed that the strong peristaltic contractions of the large bowel, completing the act of defecation, were limited to that portion of the colon below the splenic flexure, but numerous observations on a large number of subjects after an opaque meal assure me that these powerful contraction movements frequently begin in the ascending colon and may even commence in the cecum. These powerful peristaltic movements are, I believe, identical with the peristaltic mass movements above referred to, by which food is propelled from the proximal colon into the distal colon. The most favorable time for observing mass movements is during or immediately after defecation. It is also noticeable that many of the patients in whom we have observed these mass movements have exclaimed at the time of

the movement that they felt as though they could move the bowels.

The normal defecatory act should clear the colon below the splenic flexure. When the colon is tested by the injection of the opaque enema,



Fig. 14. Another illustration of obstruction low in the distal colon. Roentgenogram shows colon fifty hours after the meal and immediately after the patient's persevering effort to evacuate the bowel. It will be observed that only the lower half of the rectal ampulla was emptied. This patient had been operated upon for the removal of the appendix without relieving the right lower quadrant symptoms which led to the operation.

the patient should be able to expel the entire enema content of the colon at one effort. When the pelvic colon is bound down by adhesions or fixed by the pressure of large pelvic tumors,



Fig. 15. Case of multiple diverticula of the colon with perisigmoiditis and tumor just below the brim of the true pelvis on the left side. The arrows point to a few of the diverticula, which show a barium residue from the meal given seventy-four hours previously. The present roentgenogram was made after an attempt to fill the colon by enema. Note the distension of the rectal ampulla due to the force required to send the liquid enema through the stenosed iliac colon.

the defecatory act fails to empty the pelvic loop.

In some cases there is absolute inability to expel fecal matter owing to anal fissures, hemorrhoids, rectal ulcers or atony of the rectal musculature. Such cases should be classified under rectal constipation. In another class of cases the patient can empty only the rectum below the pelvirectal junction, owing to a kind of invagination of the too redundant pelvic colon.

In a large percentage of cases we observe that the patient can empty the rectal ampulla and more or less of the pelvic loop, but no more. On re-examination, it is characteristic that the point of apparent hindrance is always the same, and may be described as occurring at the pelvirectal junction, the middle of the pelvic loop or just below the iliopelvic junction, as the case may be. Such hindrance is in my opinion definitely associated with fixation of the colon, usually by adhesions, and by careful fluoroscopic observation of the colon before and after normal defecation and in connection with the barium enema test, both during its injection and after its expulsion, we may definitely determine the presence of such binding adhesions. It may be wiser to speak of the condition as abnormal fixation, admitting that a certain degree of fixation may be normal.

When tested by the opaque enema, the ampulla suffers marked dilatation in cases of adherent pelvic colon, the amount of distention depending upon the degree of obstruction, the length of time it has existed, and whether or not the patient has made an earnest effort to

keep the bowel cleansed by enemas. Some of the most pronounced cases of rectal distention have been observed in patients who have practiced the injection of large enemas.

Enterospasm very often attends adhesions of the pelvic colon, but it may also, of course, be present as an expression of irritation of any other kind. Possibly the nodal bundle presiding over this segment of the colon is the seat of disease or irritation; or there may be a chronic colitis or a diverticulosis, or any one of a number of conditions simulating colitis or attended by this condition as a symptom.

The work of Keith is bringing forward a very attractive theory concerning the cause of enterospasm (2).

A persisting spastic contraction of the pelvic colon offers an obstruction which may be as serious in its resulting alimentary toxemia as an organic lesion. It is often noted that, associated with spasticity in the pelvic colon, there is a dilatation of the proximal colon leading ultimately to an atonic condition of the bowel musculature in the cecum and ascending colon, the patient's complaints being chiefly in reference to the cecum and ascending colon.

Many of these patients complain of pain in the cecal region, even after removal of the appendix. In fact, I believe the appendix is often unwisely operated on because of a chronic pain in the right lower quadrant. (I do not, of course, refer to operations for acute or recurring appendicitis). Some patients describe a chronic tenderness in both iliac regions. I am

convinced that the distress and pain so frequently described on the right side is more often due to chronic cecal stasis, whereby the appendix may become involved if the patient



Fig. 16. Roentgenogram showing colon tube coiled up in the rectum. This is the usual result when one attempt to pass a colon tube more than three or four inches into the bowel. It is impossible by manipulation to insert any colon tube higher than the junction of the iliac and pelvic colon, and this degree of success is unusual. The roentgenogram also shows some barium residue from a previous meal.

still possesses it, the cecal stasis being the result of obstruction in the distal (or pelvic) colon and the exaggerated antiperistalsis attending it.

Some cases of pelvic colon spasticity are seen to be associated with multiple diverticula, the detection of which I have fully considered elsewhere (3). Carcinoma of the pelvic colon or rectum is occasionally the associated lesion (4). Both carcinoma and diverticulosis are important causes of pelvic colon obstruction, aside from the enterospasm they may set up. No more space will here be devoted to these subjects, as my principal object in appearing before you is to urge the importance of adhesions of the pelvic colon, the importance of dealing with them surgically in properly selected cases, the great need of adopting an operative technic which will minimize the likelihood of such adhesions forming, and the inadvisability of operating for these adhesions, when carefully conducted roentgen studies fail to provide proof of obstruction. Most adhesions do not obstruct. It is well to take account of the fact that the pelvic colon is more or less fixed at its two ends, being freely movable in the middle of the loop. Hence, the adhesions will be most significant when they can be shown to involve the middle of the pelvic loop.

The method of dealing with these adhesions surgically is a vexing one and a problem to which we feel the last answer has not yet been given. In our work we have occasionally done an operation suggested by Dr. Kellogg by which the pelvic loop, when fixed, is supported in its lifted position by attachment to the omentum,

the latter being sutured to the anterior abdominal wall. This secures for the pelvic colon a swinging attachment which, though not fixing it, holds it out of the bottom of the pelvis. The results of this type of operation, though not done on a large series of patients, have usually been very satisfactory in the cases selected for surgical relief.

Emphasis should again be placed upon the fact that the mere determination of the presence of adhesions is not sufficient indication for operation: there should also be proof of the functional disturbance due to, or associated with, these adhesions, this disturbance resisting the various non-surgical measures indicated.

It also seems proper to raise a question as to the advisability of the practice of using the pelvic operations, such as hysterectomy. No objection is raised to covering raw surfaces by the pelvic colon, providing this organ is allowed to fall into its natural position in so doing; but one often sees the pelvic colon crowded down in this procedure in a manner that invites the very kind of disturbing adhesions to the discussion of which this paper is devoted.

I would also call to your attention once more the needlessness of using the colon tube for administration of enemata. Yates, of Detroit, read a paper before this section of this Society some ten years ago on this subject. In over seven thousand cases I have injected the entire colon by means of the enema, employing only the ordinary rectal point inserted just within the anal sphincter, the patient lying supine. Only in those cases of organic obstruction, for

instance, malignancies or tumors, did the enema fail to reach the cecum within a few minutes, under no more pressure than that afforded by having the enema container held about two feet above the patient. In the majority of cases two pints of enema sufficed to fill the colon, in rare instances three pints were required, but never more.

I will show you a number of slides demonstrating the impossibility of introducing the colon tube higher than the junction of the pelvic with the iliac colon. It is perfectly possible to introduce the entire colon tube into the bowel, but the tube curls around upon itself in the pelvic colon, distending it sometimes to a very distressing degree.

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ROENTGEN OBSERVATIONS ON THE
DUODENUM WITH SPECIAL RE-
FERENCE TO LESIONS BEYOND
THE FIRST PORTION

BY

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DUODENUM WITH SPECIAL RE-
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THE earliest roentgen studies of the alimentary tract following the ingestion of an opaque meal were carried out with special reference to the esophagus and stomach. Five or six years passed before there were reported any systematic studies on the duodenum, yet in spite of its later development, the roentgen findings in duodenal ulcer are more reliable and more accurate, even in the early stages, than in the investigation of gastric ulceration.

Of late, especially, has particular attention been given to the duodenum, with a resulting marked increase in the range of possibilities of diagnosis. Aside from ulcer of the duodenum, which has been fully considered by another speaker in this symposium, the following are conditions affecting the duodenum, or at least associated with the duodenum, in which the *x*-ray may afford diagnostic aid: duodenal obstruction; gall tract disease involving the duodenum, as by adhesions; certain stages of pancreatic disease; diverticula of the duodenum other than the diverticulum of Vater; dilatations and tumors relating to the ampulla of Vater. The writer has made no special effort to be exhaustive in the foregoing enumeration, but

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only to stimulate a discussion of some of the newer possibilities of duodenal roentgenology.

Before taking up the consideration of these various topics, it may be well to briefly review the anatomy of the duodenum and to decide upon terms for use in describing the various segments of this very interesting organ.

Anatomically, the normal duodenum is divided into four portions,—the first portion (pars superior, bulbus duodeni, the “cap”); the second portion (pars descendens); the third, horizontal portion (pars inferior); and the fourth, short portion (pars ascendens). The angle between the first and the second portions is called the genu superius; that between the second and third portions, the genu inferius.

In the adult, the duodenum passes backward, upward and to the right between the quadrate lobe of the liver and the neck of the gall bladder; it then curves sharply, descending along the right margin of the head of the pancreas, generally to the level of the upper border of the body of the fourth lumbar vertebra; again curving sharply it passes transversely across the vertebral column, inclining slightly upward. In its fourth portion, it ascends for about two and one half centimeters, ending at the duodeno-jejunal junction, which with the patient supine is opposite the second lumbar vertebra.

The first portion of the duodenum, usually called the bulb, extends from the pylorus to the neck of the gall bladder. It is the most freely mobile of the four portions. To

the upper border of the first half is attached to the hepatico-duodenal ligament. The bulb is in such close relation to the gall bladder that it is often found bile-stained after death, the stain being especially noticeable on its anterior surface. This makes it easy to understand why the duodenum is so often involved in adhesions following pericholecystic inflammation. The bulb, which normally measures five centimeters in length, is usually triangular in shape, the base of the triangle forming the duodenal side of the pyloric sulcus. According to L. G. Cole, the duodenal bulb has the shape of a cap surmounting the pylorus, corresponding in size and shape with the pyloric end of the stomach. Its outline is smooth-edged, usually triangular or elliptical in shape. The mucous membrane is smooth unless there is actual disease present, there being in the shadow no trace of the serrations due to the Kerkringian folds which characterize the remainder of the duodenum.

The pylorus is seen roentgenologically as a circular constriction separating the duodenal bulb from the pyloric end of the stomach. The sulcus thus formed is usually about a quarter of an inch in diameter, and is bisected by a narrow shadow (the pyloric canal) which connects the stomach with the bulb. Even when the pylorus is closed, this narrow channel, measuring about an eighth of an inch in diameter, is visible, owing to the adhesion of minute quantities of barium to its mucosa. This adhesion of opaque salt to the mucous lining of the pylorus has led

some into the error of contending that the pylorus is always open. When the pylorus is really open, the canal is seen to be widely distended, measuring as much as half an inch in diameter. The pyloric lumen thus visualized should occupy a midpoint in the sulcus in the gastro-duodenal shadow produced by the pyloric sphincter.

The duodenal bulb may occupy a position symmetrically above the stomach so that were one to cover the pyloric sulcus the shadow of the bulb would be seen to correspond in size and shape to the pyloric end of the stomach. Sometimes the bulb is not thus symmetrically placed; it may be pushed to the left by pressure of the liver, or pulled to the right by adhesions, or it may be held in its normal position while the pyloric end of the stomach is displaced to the right or left.

The second portion of the duodenum is nine or ten centimeters in length, and with the patient in the horizontal position, extends along the vertebral column from the first to the third or fourth lumbar vertebra. Though this part of the duodenum is normally without a mesentery and is considered fixed, it is astonishing how readily it responds in most cases to the pressure of the manipulating finger. It is also subject to considerable change in shape and position during the movements of forced respiration. Occasionally one is able to make out the insertion of the ampulla of Vater into which empty the common bile duct and the pancreatic duct, about eight or nine centimeters from the pylorus. This portion of the

duodenum invariably shows the serrations and feathery appearance due to the Kerkringian folds. Dwight found that the second portion of the duodenum may be very large, and yet not over-distended.

The duct of Wirsung and the common



FIG. 1. VISUALIZED SMALL INTESTINE, SHOWING DUODENUM, RIGHT UPPER; JEJUNUM, LEFT UPPER; AND ILEUM, LEFT LOWER.

Note the feathery appearance of the duodenum and jejunum, due to Kerkring's Valves. The shadow of the ileum shows conglomerate denser barium masses.

bile duct usually unite in a common channel to form a small oval or triangular cavity, known as the ampulla or diverticulum of

Vater. This cavity lies in the wall of the duodenum, measuring, on an average, four millimeters in length. According to Opie, it may measure as long as eleven millimeters, while in other cases it may not exist at all, the two ducts opening side by side in the common papilla. The average diameter of the duodenal opening of the ampulla is, according to Opie, 2.5 millimeters. Sometimes this diameter may even exceed the length of the diverticulum.

The third and fourth portions of the duodenum together measure from seven to ten centimeters in length. Like the second portion, these segments of the duodenum are practically fixed, being bound down to neighboring viscera and to the posterior abdominal wall by peritoneum, yet at times one is able to demonstrate an astonishing degree of mobility of the duodenal shadow. The fourth part and the duodeno-jejunal flexure are fixed by the suspensory muscle of the duodenum, called the ligament of Treitz.

Technic.—The patient, standing erect before the fluorescent screen, swallows a third of a glass of water into which has been stirred a heaping teaspoonful of barium sulphate. One watches particularly the pyloric region for the behavior of the first of the opaque mixture to reach it. This barium-water mixture usually begins to pass at once into the duodenum, so that one is able to show that the duodenum is more or less well visualized from the very beginning of the meal. This is followed by the usual barium meal, which, in the writer's prac-

tice, consists of one ounce of barium sulphate in a glass of hot malted nuts or hot malted milk, and one ounce in a glass of buttermilk, given cold. A brief further observation is made with the patient erect. He is then placed upon the horizontal table,



FIG. 2. MARKED DISTENTION OF THE DUODENUM, PATIENT LYING SUPINE.

The duodenum is widely filled, owing to saddling of the gastro-duodenal shadow over the spine. A duodenal ulcer is shown at arrows but there was no duodenal obstruction and no duodenal or gastric stasis. With the patient lying upon the face or standing there was no duodenal distention.

and if any delays are incurred, he is asked to spend the interim lying on the right side. When all is made ready so that the observation can begin the instant the patient turns on the back, he is asked to inhale, hold the breath and turn quickly upon the back. The observer with one hand makes pressure over

the duodeno-jejunal junction, at the same time pressing pylorusward the contents of the stomach. Special care is taken to compress the duodenum between the palpating hand and the spine, thus artificially obstructing the duodenum, and incarcerating its contents. The use of a wooden spoon device is an addition to the safety of this maneuver. This method of blocking off the duodenum, which the writer has practised for the last five or six years, can be accomplished more satisfactorily in the horizontal than in the upright position, although the technic for the upright position worked out by Holzkecht and Lippmann has a certain value. By pressure over the duodeno-jejunal junction, which is thus shut off between the spine and the compressing finger, the duodenum is easily filled from pylorus to duodeno-jejunal junction and its entire contour easily made out. The alternating waves of onward and retrograde peristalsis resulting from this temporary obstruction still further test the elasticity of the duodenal walls, so that one is no longer in doubt as to the presence or absence of deformities.

At irregular intervals, depending upon the mechanism which controls the opening of the pylorus, the duodenal bulb contracts, the contraction appearing about two centimeters beyond the pylorus. This contraction is occasionally seen to begin at the pylorus itself. This contraction in the bulb occurs when an antrum contraction is nearing the pylorus, usually when the antrum contraction wave is about an inch from the

pylorus. Serial roentgenograms, according to the method of Kaestle, further developed by Pirie, will demonstrate beautifully the nature of this duodenal bulb contraction. This is a ring contraction wave which carries a bolus of material usually the entire

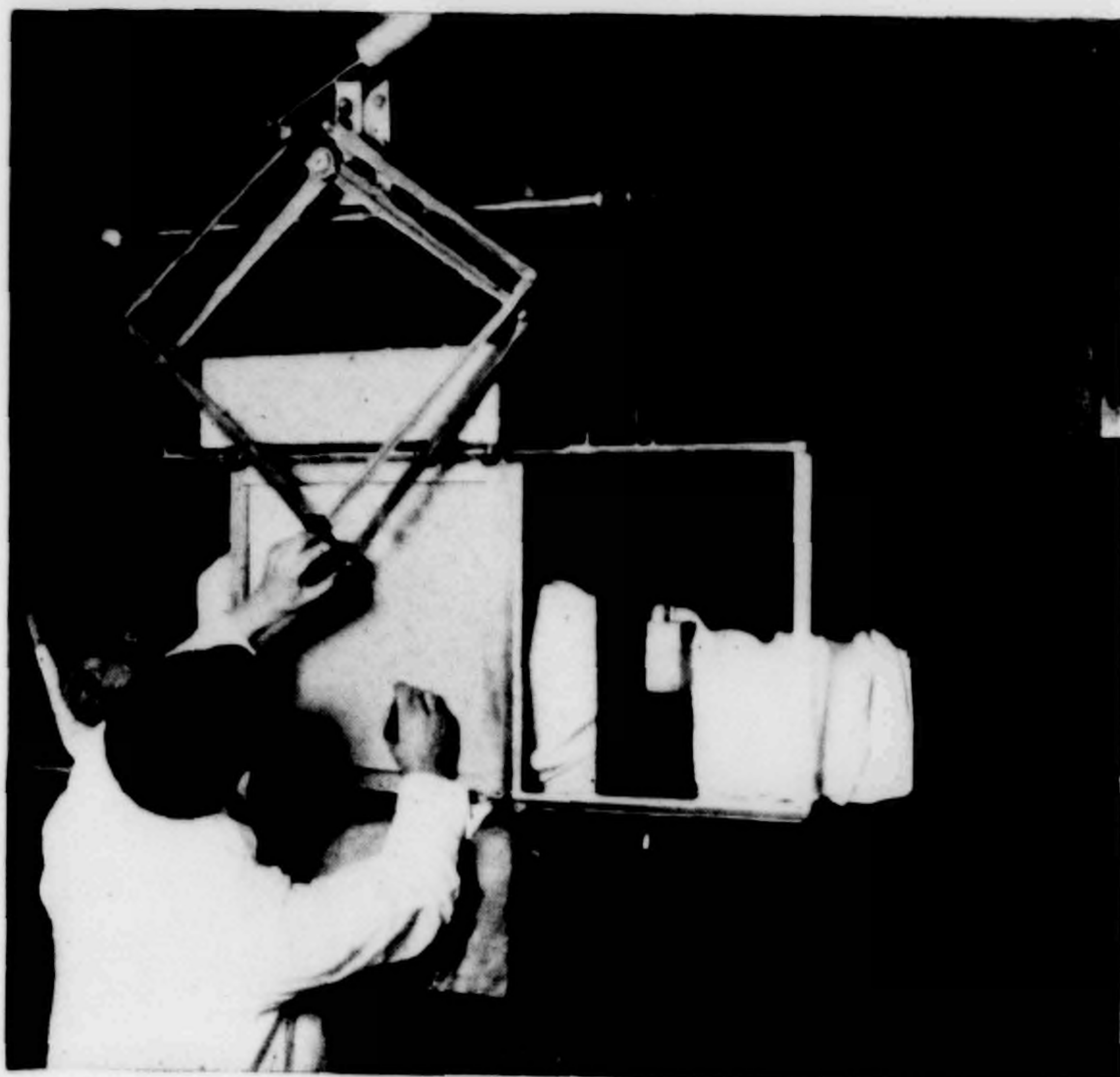


FIG. 3. AN ILLUSTRATION OF THE RIGHT LATERAL POSITION, SCREEN HELD VERTICALLY IN FRONT OF PATIENT.

This position is especially valuable in studying the duodenum and pyloric end of the stomach. (See Figure 12.)

length of the duodenum past the duodeno-jejunal junction. Were one to depend solely upon roentgenography for his roentgen findings, the appearance of barium traversing the duodenum in connection with one of these ring contraction waves might lead to an erroneous diagnosis of duodenal obstruction. One frequently sees reverse peristalsis in the duodenum. This is inde-

pendent of respiration, as can be seen by studies during suspended respiration. Although in obstruction of the duodenum one may observe reverse duodenal peristalsis, these waves are not necessarily pathognomonic of an organic obstruction. They may also be seen when an emaciated patient is lying upon the back and the duodenum is compressed by saddling across the spine.

A study of the duodenum with the patient in the right lateral position is also useful. The patient lies on the right side, with the screen held vertically in front of him. The rays penetrate from behind. This position is especially useful in studying the pyloric region, but also lends itself to a study of the duodenum.

Duodenal Obstruction.—Reference must be made to the theory of Lane's duodeno-jejunal kink, and its relation to the causation of duodenal ulcer. For present purposes it may suffice for the writer to state his unbelief that the so-called kink which one can demonstrate in a great many patients at the duodeno-jejunal junction, has any definite or constant relation to duodenal obstruction. That such an obstruction occasionally occurs is, of course, understood, but the writer can not believe that it is a common finding. Various others have advanced theories regarding the causation of duodenal stasis, as, for instance, by drag of the mesentery across the third portion of the duodenum (so-called mesenteric ileus).

The writer would only call attention to the fact that the so-called "writhing duodenum," believed by Jordan to be pathog-

nomonic of duodenal obstruction, is demonstrable in almost every thin patient when examined in the supine position and with the large opaque meals given by Jordan. It should further be remembered that the appearance of normal peristalsis in the duodenum may simulate obstruction, especially if one depends upon roentgenography alone. A true duodenal obstruction should be demonstrable on repeated examination and should seriously interfere with the passage of material past the seat of hindrance. Many cases of so-called "writhing duodenum," supposed to be due to obstruction at the duodeno-jejunal junction, exhibit also early filling of the upper small bowel and such extensive and complete distribution of bismuth throughout the entire small intestine, with clearance of both the stomach and duodenum within the normal time, that one can not entertain the idea of obstruction. Cases of true duodenal obstruction (below the pars superior) have been encountered only rarely in the writer's experiences,—not over twenty or twenty-five instances. These cases have, for the most part, been associated with ulcer or carcinoma on the posterior wall of the stomach with adhesions involving the duodenum or the jejunum in the neighborhood of the duodeno-jejunal junction.

One must exercise great care and judgment to distinguish duodenal stasis and duodenal dilatation from wide filling of the third portion of the duodenum, especially if the patient is examined in the supine position upon the horizontal fluoroscope, for

in this position, especially when the patient is poorly nourished, the duodenum saddles over the spine in such a way as to make a certain degree of obstruction at the duo-



FIG. 4. DUODENAL OBSTRUCTION, DUE TO ADHESIONS ATTENDING ULCER ON THE POSTERIOR WALL OF THE STOMACH NEAR THE PYLORUS; PATIENT ERECT.

deno-jejunal junction. This causes the appearance of alternating onward and retrograde peristalsis in the duodenum similar to that described by Jordan as "writhing duodenum" which he considers pathog-

nomonic of ileac stasis. These cases of pseudo-duodenal obstruction or even functional duodenal obstruction may be differentiated from the organic obstruction by the fact that they are seen only with the patient



FIG. 5. SAME CASE AS SHOWN IN FIG. 4, BUT SIX HOURS LATER; PATIENT ERECT.

in the supine position, whereas the organic obstructions are evident in all positions. This unusual visualization of the duodenum may be due, not to a spastic hindrance, but to too rapid delivery of gastric contents into the duodenum through pyloric insuf-

ficiency. This insufficiency may be associated with achylia or duodenal ulcer, or it may be due to adhesions or induration about the pylorus. When the duodenum is unusually filled under these circumstances, one rules out obstruction at the duodeno-jejunal junction if there is free filling of the first part of the jejunum. If the patient has been resting upon the right side for a few moments preceding the fluoroscopic observation or preceding the roentgenographic record, one is likely to find the duodenum unusually filled.

Duodenal obstruction may occur in connection with a rare anomaly of the head of the pancreas. Normally the head of the pancreas may involve a portion of the wall of the second part of the duodenum, but in certain rare cases the overlying is so great that the whole circumference of the bowel is enclosed by pancreatic tissue. This anomaly may result in obstruction, either congenital, or later in life as the result of inflammatory changes or tumor invasion. In one instance reported by Symington, the circumference of the distended duodenum where it was surrounded by the pancreas was two and a half inches, while above and below this point it was more than three times as large.

The writer considers that very seldom indeed do adhesions between the gall bladder and the duodenum result in duodenal obstruction. On the contrary, it seems that in most cases the emptying time of the stomach is unusually short. These adhesions are not always confined to the first

portion of the duodenum; they sometimes involve the duodenum extensively, producing a characteristic deformity which can be recognized by careful palpation under fluorescent screen guidance. When, as occurs in many fortunate cases, the gallstones



FIG. 6. EXTENSIVE CARCINOMA OF THE STOMACH, WITH PERIGASTRIC INVOLVEMENT NEAR THE DUODENO-JEJUNAL JUNCTION, WITH PRONOUNCED DUODENAL OBSTRUCTION AND DILATATION.

contain a sufficient portion of opaque salts, there is added accuracy to the roentgen findings.

Carcinoma of the Duodenum.—The writer has recognized only one case of carcinoma of the duodenum. This was a malignant tumor located about the papilla

of Vater, which was easily recognized by the special method of duodenal examinations described above. In a case personally reported to the writer by Lippmann, the findings were exactly identical, the tumor being located in the papilla of Vater, and being discovered with a similar technic.



FIG. 7. DUODENAL OBSTRUCTION, DUE TO ADHESIONS NEAR THE DUODENO-JEJUNAL JUNCTION.

No ulcer demonstrable. Ten hours required for emptying duodenum. Relieved by dividing adhesions.

Ulcer.—Ulcer of the duodenum beyond the first portion is of relatively rare occurrence, but with the technic described, it should be demonstrable. No cases have been recognized in the writer's work.

Differential Diagnosis Between Cholecys-

tic and Pancreatic Tumor.—A. W. Crane long ago called attention to the fact that an enlargement of the head of the pancreas might be inferred from studies of the



FIG. 8. PHYSIOLOGICAL APPEARANCE OF THE ACTIVE DUODENUM WHICH MIGHT SIMULATE DUODENAL OBSTRUCTION.

A bolus of food is being passed along the duodenum by peristalsis.

duodenum. By employing a modification of Crane's technic, the writer has, during the last few years, been able, in a few cases, to make a diagnosis of tumor of the head of the pancreas. Sometimes the distortion of the duodenal loop may be utilized in dif-

ferentiating between a tumor of the head of the pancreas and a tumor of hepatic or cholecystic origin, as will be illustrated by the following case:

Male, adult, Syrian, with a tumor in



FIG. 9. A CASE OF CHOLELITHIASIS WITH PERICHOLECYSTIC ADHESIONS INVOLVING THE DUODENUM.

Gallstones shown at arrows adjacent to the visualized adherent duodenum.

the right upper quadrant, was referred by Dr. A. E. Halstead for differential diagnosis. Underneath the right costal margin could be felt a rounded, partially compressible tumor, larger than one's fist. During inspiration the tumor seemed to move up and down. By compression its size could

be diminished by one-third. Study was made in view of the possibility of parasitic disease, but nothing was found. By exclusion, the diagnostic possibilities were finally

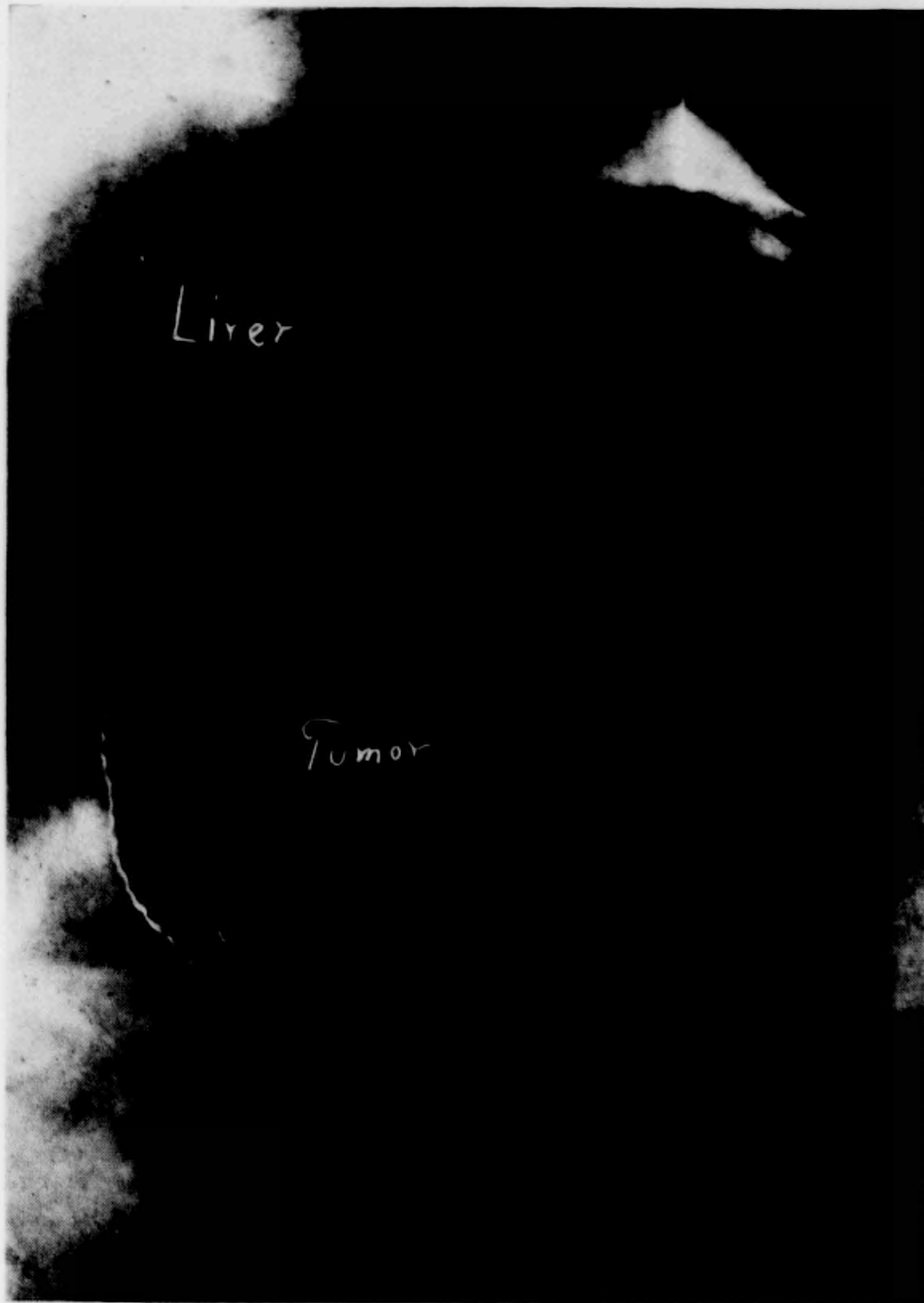


FIG. 10. TRACED ROENTGENOGRAM ILLUSTRATING DISPLACEMENT OF THE DUODENUM UPWARD AND TOWARD THE RIGHT IN A CASE OF TUMOR OF THE HEAD OF THE PANCREAS—IN THIS INSTANCE A LARGE PANCREATIC CYST.

Operation by Dr. A. E. Halstead (See Fig. 11)

reduced to a distended gall bladder or a pancreatic cyst.

After the patient had taken a few swallows of barium, it required only a brief

glance at the fluorescent screen to decide that the tumor was pancreatic instead of cholecystic. The duodenum was pushed upward and outward to the right in such a manner as to indicate clearly a tumor of the head of the pancreas. At operation, Dr. Halstead evacuated a large pancreatic cyst (Figs. 10 and 11).

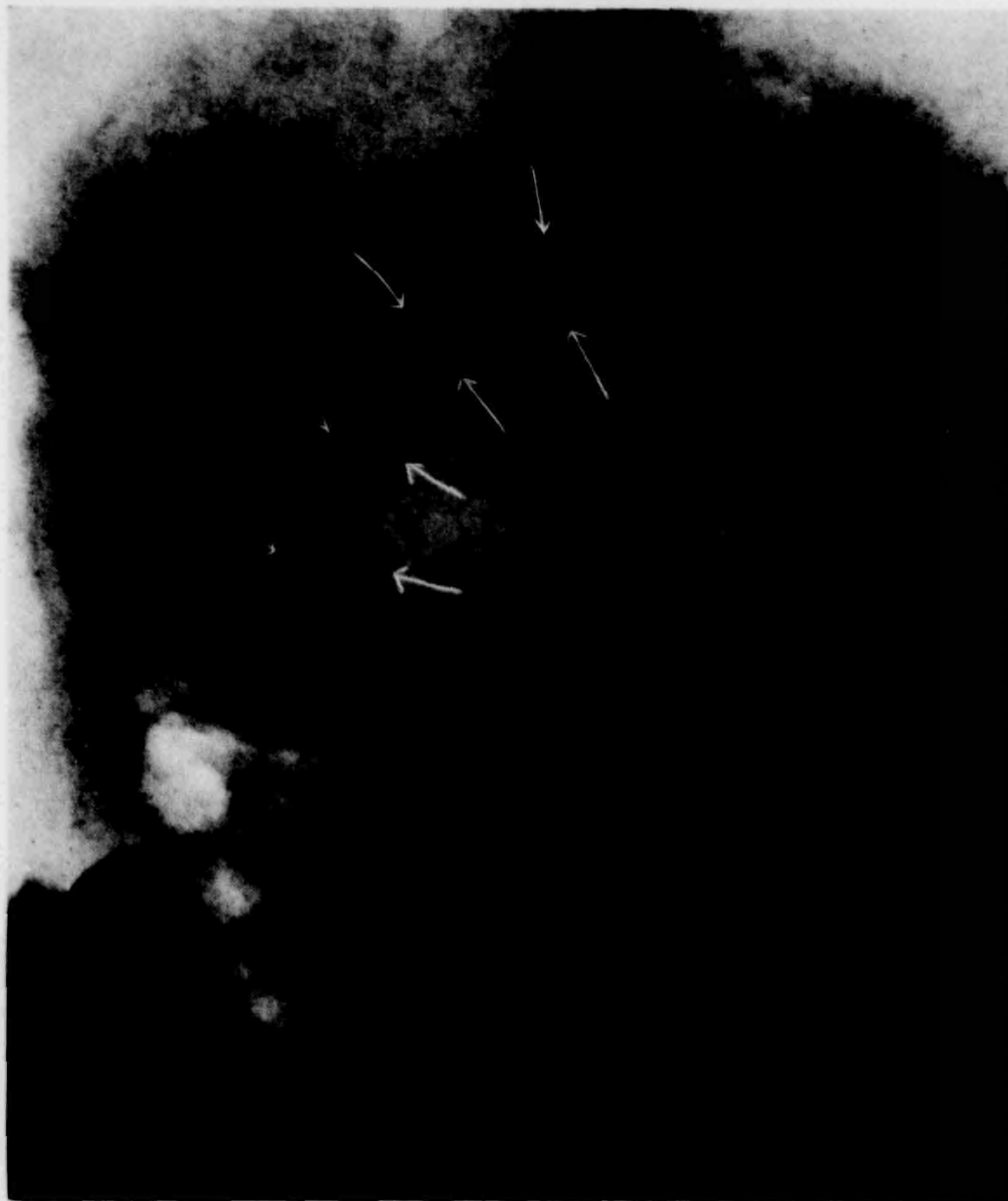


FIG. 11. ROENTGENOGRAM OF THE SAME CASE SHOWN IN FIG. 10, TWO HOURS AFTER THE MEAL.

The thin shadow of the dislocated duodenum is shown at the arrows.

In a similar case of query between cholecystic and pancreatic tumor, the diagnosis was clearly made in favor of the former, because the duodenum was displaced downward away from the liver, in

such a way as to suggest a large gall bladder. At operation by Dr. L. L. McArthur, there was found abundant evidence of malignant disease with enormous distention of the gall bladder and secondary involvement of the liver.

The writer has observed that whenever for any reason the pancreas is involved, there is quick clearance of the stomach after a barium meal, and unusual visualization of the duodenum. An exception must be made, of course, where there is a cicatricial or mechanical obstruction at the pylorus or in the duodenum. For instance, in cases of penetrating ulcers on the lesser curvature which involve the pancreas, the stomach empties quickly. In pancreatic carcinoma with adhesions to the duodenum, the stomach empties quickly, perhaps here on account of achylia. In several cases of duodenal or jejunal diverticula with penetration into the pancreas, gastric motility has been characterized by early clearance.

Duodenal Diverticula.—Real diverticula of the duodenum are of rare occurrence. One occasionally finds a sort of diverticulum associated with the scar of duodenal ulcer, or with pericholecystic adhesions, but these occur in the first portion of the duodenum. The ampulla of Vater is a sort of duodenal diverticulum, as its name would indicate. The writer has observed eight cases of real diverticulum of the duodenum, occurring in the pars inferior. The following are the details of one case:

The patient, female, age 45, applied for

treatment for a pain of six years' standing, located in the lower dorsal region. The pain was constant, and of late more intense, increased by lying down, and by making



FIG. 12. ROENTGENOGRAM MADE IN THE RIGHT LATERAL POSITION, PATIENT LYING UPON THE RIGHT SIDE, PLATE HELD VERTICALLY IN FRONT OF PATIENT, TUBE POSTERIORLY (See Fig. 3).

The duodenum is shown as a thin shadow, owing to compression by carcinoma involving the pancreas, gall bladder and pyloric end of the stomach.

pressure over the abdomen or over the spine. Vomiting was a frequent symptom.

Roentgen examination revealed an unusually large barium fleck (the size of a filbert) in the ampulla of Vater, persist-

ing for about nine hours, and a definite diverticulum of the duodenum in the pars inferior. This diverticulum was ovoid, measuring 2.5 x 5.0 cm. It retained food a little longer than the time required for



FIG. 13. A LARGE DIVERTICULUM OF THE THIRD PORTION OF THE DUODENUM.

(a) Pylorus, (b) Diverticulum, (c) Visualized ampulla of Vater. Operated case. (Dr. J. H. Kellogg).

emptying the stomach (six hours). There was very definite tenderness on accurate pressure over the head of the diverticulum which occurred upon the mesial side of the duodenum, and seemed to have a relation to the head of the pancreas. The other *x*-ray findings in the bowel were inconsequential.

The *x*-ray findings, together with other clinical data in the case, led to the diagnosis of chronic pancreatitis, possible gallstones and a diverticulum of the duodenum (see Fig. 13).

At operation by Dr. J. H. Kellogg, the



FIG. 14. LARGE DIVERTICULUM OF THE THIRD PORTION OF THE DUODENUM.

Traced roentgenogram from same plate shown in Fig. 15.

gall bladder was drained, the appendix removed, the incompetent ileocecal valve repaired, and the stomach and duodenum carefully examined. The diverticulum was found 5 cm. above the duodeno-jejunal junction, in the third part of the duodenum. The diverticulum extended upward behind

and into the substance of the head of the pancreas and lay in close approximation to the superior mesenteric vessels. The connection of the diverticulum with the pancreas was so intimate, and the surroundings



FIG. 15. SAME ROENTGENOGRAM SHOWN IN FIG. 14, BUT WITHOUT TRACING.

Operation by Dr. J. H. Kellogg.

so vascular, that it was not thought wise to remove it, especially since the patient's symptoms seemed to be due to a chronic pancreatitis and not to the diverticulum itself. The head of the pancreas was somewhat enlarged. At the last report, six months after the operation, the patient had remained free from the severe pain which first suggested pancreatic disease.

The first duodenal diverticulum was reported by Morgagni in 1761. Occasional references to this condition are encountered in the literature, especially by Roth, Schueppel, Pilcher, Hansemann, Hodenpyl, Keith, Jackson and Baldwin. Baldwin in 1911 collected in the literature and reported from his own observations eighty-two cases of duodenal diverticula. In many instances, the diverticula seemed to involve or take the place of the diverticulum of Vater, but in about half the cases the diverticula were entirely independent of the bile and pancreatic ducts and in eighteen cases they occurred in the pars inferior. In twenty-one of the eighty-two cases, the diverticula penetrated into the head of the pancreas. In many instances, from the description it is difficult to determine that the diverticula were not enlargements of the normal ampulla of Vater. Indeed, Keith reports a case of ptosis of the duodenum in which he considered that traction upon the common bile duct had produced a large diverticulum of the duodenum at the major papilla. It is noteworthy that in only a few of the cases of duodenal diverticula were there any clinical signs of an inflammatory process.

Dilatation of the Ampulla of Vater.— In considering the etiology of pancreatitis, it will be recalled, as Opie first suggested, that a small gallstone may lodge in a large diverticulum of Vater, obstructing the opening of the diverticulum into the duodenum and converting the diverticulum into a through channel from the common

bile duct into the pancreatic ducts. The forcing of infected bile directly into the pancreatic duct under such circumstances is doubtless a common cause of acute pancreatitis. That this obstruction may result from other causes than the impaction of gallstones is probable.



FIG. 16. ENORMOUS DIVERTICULUM OF THE THIRD PORTION OF THE DUODENUM SHOWN AT ARROWS.

Operated case.

Oddi has shown that there exists about the ampulla a sphincter formed by a thin layer of involuntary muscle. Is it not possible that spasm of this sphincter may occur under certain circumstances?

Williams and Bush (*Journal of Medical Research*, Vol. XVII, No. 1, October, 1907) suggest another mechanism, viz., that

the passage of gallstones may so dilate the opening of the diverticulum of Vater that intestinal contents may pass into the pancreatic duct, resulting in an inflammatory reaction. They cite numerous anatomical and experimental evidences that make it seem probable that some cases of acute pancreatitis have been caused in this way.

Edward Archibald, of Montreal, is a strong believer in spasm of the sphincter at the duodenal end of the ampulla of Vater as a cause of pancreatic disease. He believes that the irritation which results in this sphincteric spasm may be supplied by duodenal ulcer, which is not at all infrequent in cases of pancreatitis. That spasm should alternate with undue relaxation seems quite natural. The writer has seen perhaps fifteen cases where a very appreciable amount of opaque salt entered the ampulla of Vater. In the majority of instances, these cases have exhibited clinical signs of chronic pancreatitis. Is it not probable that there is a definite relation between dilatation of the ampulla of Vater and chronic pancreatic disease? If the dilatation of the ampulla be the result of chronic spasm of the common duct sphincter, then it is necessary to suppose, as Dr. Archibald suggests, a periodical undue relaxation of the sphincter in order to explain the entry of the opaque salt.

The formation of the ampulla of Vater and the termination of the common bile duct and the pancreatic duct may occur in at least six variations, as related by Robson and Cammidge. The *first* is the classical

type in which the last segment of the common bile duct, comprising all that portion of the canal contained in the thickness of the wall of the duodenum, passes obliquely through the muscular coat of the intestine



FIG. 17. DILATED AMPULLA OF VATER WITH STASIS LONGER THAN FOUR DAYS IN A CASE OF MULTIPLE DIVERTICULA OF THE COLON.

In this roentgenogram the colon is shown filled by the barium enema.

and then dilates into a little reservoir underneath the mucous membrane, into which the main pancreatic duct also opens, known as the ampulla of Vater. In the *second* type, the pancreatic duct joins the common

bile duct some little distance from the duodenum, but the ampulla of Vater is absent, the duct opening into the duodenum by a small, flat, oval orifice. In the *third* type, the two ducts open into a small fossa in the walls of the duodenum while the papilla of Vater and the ampulla of Vater are absent. In the *fourth* type, the papilla is well developed, but the ampulla is absent, the two ducts opening side by side at the apex of the papilla. In the *fifth* type, the common bile duct opens along with the duct of Santorini and the duct of Wirsung enters the duodenum separately. In the *last* type, the pancreas has three separate ducts opening into the duodenum, one only accompanying the common bile duct.

When the pancreatic and the common duct terminate in the first (the classical) type or in the second variety of termination, as above noted, the onset of pancreatitis in the case of common duct cholelithiasis or spastic contraction of the common duct sphincter will be favored. The duct of Santorini is present in less than half of all the cases, hence this duct can not be counted upon to act as a safety valve to the duct of Wirsung, when it is compressed.

In one of the writer's cases, the diverticulum of Vater appeared to be double. That this occasionally occurs is noted in the anatomies. This patient had not only multiple diverticula of the colon, but also multiple diverticula of the small bowel, two large ones, the size of pigeons' eggs, beyond the duodeno-jejunal junction. In still an-

other case of dilated ampulla of Vater, there were numerous diverticula of the jejunum, but none were found in the colon.

In any case, it is of extreme interest to note that in the majority of instances of dilated ampulla of Vater, as shown by the entry of barium at the time of the barium



FIG. 18. DOUBLE AMPULLA OF VATER.

(a) Double ampulla of Vater. (b) Large diverticulum of the duodenum near duodeno-jejunal junction. (c) Pylorus. Operated case.

meal, there have been clinical signs of chronic pancreatitis.

It is of further interest that in many cases showing dilated ampulla of Vater, there have also been demonstrated multiple diverticula of the colon, and in two cases multiple diverticula of the jejunum. In

some of these cases the symptoms of colonic diverticulosis were over-shadowed by epigastric symptoms strongly suggestive of a pancreatic lesion. Although the cases are as yet too few to warrant any deductions, it is



FIG. 19. GALL BLADDER VISUALIZED BY ENTRY OF BARIUM.

(a) Large diverticulum of the duodenum, third portion. (b) Gall bladder containing stones, visualized by entry of the barium following barium meal.

of great interest to recall that out of fifteen or sixteen cases of unusual patency of the papilla of Vater, with filling and stasis of the opaque salt in the diverticulum of Vater, about half the patients were clinically suf-

fering from chronic pancreatitis, whereas the other half had multiple diverticula of the colon, and some of them had symptoms of both lesions.

A close watch of similar cases with reports of findings by many observers will.



FIG. 20. GALL BLADDER (AT ARROWS), FILLED THROUGH CHOLECYSTENTEROSTOMY OPENING.

let us hope, soon permit definite conclusions as to the worth of this observation.

The question has also arisen as to the possibility of barium entering the common duct and passing into the gall bladder. It is not only possible, but quite the rule, for barium to fill the gall bladder after the

operation of cholecystenterostomy. The writer has demonstrated this in the two cases where he has had the opportunity to make a post-operative examination in such cases. The barium was retained longer than forty-eight hours in one instance, and in the other longer than four days. In one instance, the records of which will be shown on the screen, it is probable that barium entered the gall bladder and visualized gallstones which had previously been invisible roentgenologically. The patient did not consent to operation.

Some of the points in the foregoing pages are new as far as the roentgenological aspects are concerned. They are presented here not because they are settled facts, but in an effort to broaden the field of diagnostic possibilities with reference to the duodenum. The differential diagnosis of right upper quadrant lesions will ever be a most interesting and intricate subject, and if roentgenologists can bring to the internist any additional information by means of their special methods of study, they will be making a valuable contribution to the diagnostics of internal medicine.

Diverticula of Small Intestine, Other than Meckel's Diverticulum

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AMERICAN MEDICAL ASSOCIATION
FIVE HUNDRED AND THIRTY-FIVE NORTH DEARBORN STREET
CHICAGO

DIVERTICULA OF SMALL INTESTINE,
OTHER THAN MECKEL'S
DIVERTICULUM *

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Before the year 1912 it is not recorded that any case of duodenal diverticulosis had been discovered with the roentgen rays. Indeed, comprehensive search of the literature by Baldwin,¹ Buschi,² Wilkie,³ Fischer⁴ and others showed that the total number of known cases of diverticula of the duodenum did not exceed 100. Baldwin's Cornell series of fourteen cases of duodenal diverticula out of 105 necropsies was remarkable for the reason that so large a number as fourteen should be discovered among such a relatively small series. Diverticula of the jejunum and ileum had also been recorded in the anatomic literature, and at least one case discovered in the course of surgical operation, as recorded by Gordinier and Sampson. With an occasional exception these diverticula of the small intestine had been considered as merely of anatomic interest and without clinical import, for the majority of patients exhibited few if any evidences of pathologic interest in the diverticula other than their presence. There were some notable exceptions, which will be referred to later.

I presented my first series of four cases of duodenal diverticula discovered during the routine roentgen-ray examination of the gastro-intestinal tract, in the Scientific Exhibit of the American Medical Association

* From the Surgical Department of the Battle Creek Sanitarium.

* Read before the Section on Gastro-Enterology and Proctology at the Seventy-First Annual Session of the American Medical Association, New Orleans, April, 1920.

1. Baldwin: Duodenal Diverticula in Man, *Anat. Rec.* **5**: 121.

2. Buschi: Beitrag zur Untersuchung der Duodenaldivertikel, *Virchows Arch. f. path. Anat.* **126**: 121, 1911.

3. Wilkie: Duodenal Diverticula and Duplication of the Duodenal Wall, *Edinburgh M. J.* **11**: 219 (Sept.) 1913.

4. Fischer: Acquired Diverticula of the Bowel, *J. Exper. M.* **5**: 33, 1900.

in 1913. In September, 1915, I⁵ reported further on these studies before the American Roentgen Ray Society. In 1919, I presented roentgenograms in the Scientific Exhibit of the American Medical Association, representing twenty-five new cases, and again called attention to the frequency with which diverticulosis of the duodenum is associated with sacculations of other portions of the digestive tube and of the urinary bladder.

In the present communication I have attempted to sum up my cases and to draw some conclusions regarding the treatment indicated. I find that in 6,847 complete barium meal studies (meaning the routine observation of the opaque meal in its passage from mouth to rectum, followed by a supplementary barium enema), I and my associates have recorded characteristic evidence of duodenal diverticulosis in eighty-five cases, diverticulosis of the jejunum in four cases, and diverticulosis of the jejunum and ileum in one case. As suggested in the title of this paper, we have not included in these statistics any case of Meckel's diverticulum, although several have been found.

Up to April, 1920, the only other reported cases of duodenal diverticulosis roentgenologically discovered were as follows:

1. Forssell and Key,⁶ in 1915, reported the case of a woman operated on, May 13, 1914.

2. Basch reported a case in which Elsberg operated, Jan. 31, 1915.

3. Stewart,⁷ in 1916, reported several cases, verified by operation, found with the roentgen rays in 1915 and 1916.

4. Ritchie and McWhorter,⁸ in 1916, operated on a patient, June 30, 1916.

5. Reichmann,⁹ in 1916, reported a case of duodenal sacculation discovered with the roentgen rays.

5. Case, J. T.: Roentgen Observations on the Duodenum, with Special Reference to Lesions Beyond the First Portion, *Am. J. Roentgenology* **3**: 314 (June) 1916.

6. Forssell and Key: Ein Divertikel der pars descendens duodeni mittels Roentgenuntersuchung diagnostiziert und operativ entfernt, *Nord. med. Arch.* **48**, No. 2, 1915.

7. Stewart, W. H.: Roentgen Diagnosis of Obscure Lesions of the Gastro-Intestinal Tract, *Am. J. Roentgenol.* **3**: 202 (April) 1916.

8. Ritchie, H. P., and McWhorter, G. L.: Duodenal Diverticula, *Surg., Gynec. & Obst.* **25**: 485 (Nov.) 1917.

9. Reichmann: *Berl. klin. Wchnschr.*, 1916, p. 1118.

6. Roberts and Cole, in 1919, presented a series of cases at the 1919 meeting of the American Gastro-Enterological Association.

Doubtless there have been other cases; certainly in the future a large number will be found, now that the roentgen rays have made possible the early recognition of this interesting lesion.

As to diverticula of the jejunum and ileum, careful search has failed to reveal any reported case discovered roentgenologically and proved at operation. I believe my cases are the first on record. Two of my five patients have been operated on. In the other three the findings were so characteristically similar that no reasonable doubt can exist as to the diagnosis; but operative proof was not obtained.

DIVERTICULA OF THE DUODENUM

Frequency.—Necropsy reports quoted by Baldwin, Buschi, Davis,¹⁰ Wilkie, Fischer and others give varying figures as to the frequency of duodenal diverticula in man. One author claims as high a figure as 11 per cent. of all such sacculations of the alimentary tract. Linsmayer¹¹ found forty-five cases of duodenal sacculations in 1,367 necropsies (about 3 per cent.). Rosenthal¹² found three cases in 100 necropsies (3 per cent.). The Johns Hopkins Hospital statistics on 2,600 necropsies record thirteen diverticula other than Meckel's in the small intestine and eighteen in the colon. In my own series of 6,847 consecutive barium meal studies, duodenal diverticula were found in eighty-five cases (1.2 per cent., or in the proportion of 1 to 82. For comparison, it may be interesting to know that in the same series we found colonic diverticula in 138 cases, or approximately 2 per cent.

In Baldwin's Cornell series there were two diverticula in one case, the other thirteen being single. Buschi found thirty-five cases with a single diverticulum, thirteen with two, two with four, and two with five. In my series only one diverticulum was

10. Davis, N. S.: Diverticula of the Duodenum. Tr. Chicago Path. Soc. **9**: 1 (Feb.) 1913.

11. Linsmayer: Ueber Duodenaldivertikel, Verhandl. d. deutsch. path. Gesellsch. **17**: 445, 1914.

12. Rosenthal: Können Duodenaldivertikel eine klinische Bedeutung erlangen? Med. Klin. **4**: 1421, 1908.

recognized in seventy-eight cases, the other seven cases showing from two to four diverticula.

Size.—The diverticula vary in size from a pea to a hen's egg. Baldwin's largest diverticulum measured 5 cm. in diameter. In my series of eighty-five cases, the shadow of the barium-filled diverticulum measured more than 4 cm. in fourteen cases, and in one of our ten operative cases the excised diverticular sac measured 5 cm. in longest diameter. The average size of the sacculations in my series was 2.8 cm.

Position.—In Baldwin's Cornell series the sac originated in the first part of the duodenum in two cases, in the second portion in seven cases, and in the third portion in six cases. In my series the diverticula were thus distributed: first portion, seventeen cases; second portion (including those cases thought to be dilatations of the diverticulum of Vater), forty-nine cases; third portion and duodenojejunal junction, nineteen cases.

A knowledge of the position of the fundus of the diverticulum is of the greatest clinical importance, especially in relation to possible surgical procedure. When the fundus of the sac lies ventral to the head of the pancreas or apparently springs from or lies to the right or convex side of the duodenum, the surgical removal of the sac is comparatively simple; but serious complications arise in many cases if surgery is attempted for diverticula lying dorsal to the head of the pancreas or within the substance of that organ. Fairly accurate differentiation may be made from the roentgen screen findings, as will be described. In the series studied at necropsy by Baldwin and culled by him from the literature, the fundus of the sac was located ventral to the pancreas head in only a few cases (several of the series reported by Fleischmann); it penetrated the pancreas head in seventeen cases, was dorsal to the pancreas in fourteen cases, and in the remainder pointed toward but did not project into the head of the pancreas. Judging from the anatomic records we may in about half the cases expect the diverticulum to arise from the second portion of the duodenum, in the region of Vater's ampulla if not indeed involving it, with the fundus of the diverticular sac lying within the substance of the pancreas head or dorsal to it.

Sex.—In 61 necropsy cases, reported in the literature, where the age was known, 38 (62 per cent.) were in males, 23 (32 per cent.) in females. In the present roentgen-ray series of 85 cases, 34 (40 per cent.) were in males, 51 (60 per cent.) in females.

Age.—Acquired diverticula of the duodenum are most frequently found in later life. Buschi states that 80 per cent of such sacculations occur after the age of 50. Secher¹³ states that they have been found in infants. Simmonds¹⁴ says he has seen diverticula near the pylorus in very early childhood and therefore he concluded that they were congenital; he had seen them lower down in the small intestine only in old persons. In my series the average age has been 56 years.

Contents of the Diverticulum.—In two cases reported in the literature the sacs have contained gallstones, one in one instance, twenty-two in the other. Usually the contents are chymous. After an opaque meal, it is possible to find barium in the diverticulum for many hours and sometimes for several days. In one of my cases barium was still to be seen in the sac on the seventh day. Retention of barium beyond forty-eight hours is not unusual. The average emptying time of the sac in eighteen consecutive cases was eleven hours. The normal emptying time of the duodenum is from four to five hours.

Description of the Sac.—In the diverticula of our series which were removed surgically by Dr. J. H. Kellogg and myself, the muscularis was lacking over most of the sac in every instance. Of course we dealt only with large sacs, and it is entirely possible that study of smaller diverticula would have shown the presence of muscularis over the entire fundus of the sac. It would seem that the absence of muscularis over the larger sacs is due to the fact that this coat does not permit of sufficient stretching to cover the entire fundus, and it becomes thinned out or entirely missing at a short distance from the orifice of the diverticulum.

The opening between the duodenum and the sac may be large or small, rounded, fissure-like or irregular.

13. Secher: *Om Divertikler i Ventrikel og Duodenum*, Hospitalstidende **60**: 582, 1917.

14. Simmonds: *Verhandl. d. deutsch. path. Gesellsch.* **17**: 445, 1914.

When the opening is very large, it is naturally difficult to keep barium in the sac long enough to make roentgenograms showing the condition.

In many instances of diverticulosis of the second portion of the duodenum, the common bile duct and the pancreatic duct lie in very close relation to the wall of the sac, one or both sometimes traversing the lateral wall, or even emptying into the fundus of the diverticulum. In one instance of our series there was indubitable proof that barium taken by mouth found itself in a perivaterian diverticulum, possibly a dilatation of Vater's ampulla, and later passed into the gallbladder, visualizing gallstones which had previously been invisible to the roentgen rays.

I once saw at the Mayo Clinic a roentgenogram demonstrating the passage of barium from the duodenum into the hepatic ducts, beautifully outlining the larger biliary passages.

Pathology.—The subjoined report is typical for such diverticula as have been removed at operation:

A thin-walled sac, having the normal thickness of the intestinal wall for only 2 or 3 mm. about its orifice. Here it had all the layers of the normal intestinal wall; elsewhere the muscularis was missing. The mucosa and the muscularis mucosae were normal. The submucosa was thickened. There were occasional small groups of Brunner's glands; elsewhere the submucosa consisted of loose connective tissue richly supplied with blood vessels.

Numerous recently formed adhesions surrounded the diverticulum, which was freely movable when the adhesions had been divided. As already mentioned, the sac may contain one or more calculi. Pancreatic tissue may line the fundus. In the majority of cases there is no evidence of inflammatory change.

In a case reported by Akerlund,¹⁵ operation revealed marked swelling of the duodenal wall bordering the diverticulum, while the sac itself held a mass of necrotic pancreatic tissue which had resulted from an extension of the diverticulitis into the pancreatic substance lying next to the sac. In the preoperative examination of this case there was seen a large spherical diverticulum of the third portion of the duodenum in addition to a barium residue at the site cor-

15. Akerlund: Roentgenologiska duodenalobservationer, Hygeia **81**: 449, 1919.

responding to Vater's ampulla. On a reexamination a week later it was impossible to visualize Vater's ampulla. Two days later acute epigastric symptoms set in, and five days later the patient submitted to operation with the findings given above.

Akerlund's case parallels one of my own, already reported,¹⁶ in which at operation we were unable to excise the diverticulum because of its intimate adherence to the surrounding pancreatic tissue, where there was every clinical and gross pathologic evidence of a pancreatic involvement. In my case almost complete relief followed cholecystostomy.

There seems to be in some cases a suggestive connection between vaterian and perivaterian sacculations and chronic changes in the pancreas and biliary passages. Wilkie reported two cases in which such a diverticulum was in close anatomic contiguity with the common bile duct together with signs of stasis in that duct, without there being any intrinsic obstruction of its lumen. Rosenthal and Bauer¹⁷ have each recorded cases of duodenal diverticula in which the diverticulum was the seat of severe inflammatory changes and simultaneously Vater's ampulla was swollen, even glued together with mucus, causing dilatation of the pancreatic and biliary ducts. Akerlund advances the following theory as to the relation between diverticula of the duodenum and pathologic changes in the pancreas and biliary tract: When a duodenal diverticulum, which is usually conceived as being of direct or indirect congenital origin but prone to become enlarged later in life, has reached a certain size, then retention of the duodenal contents is likely to occur. This may lead to a catarrhal diverticulitis of varying intensity and with alternating swelling and relief of swelling about the papilla of Vater. In certain cases, then, it is possible for a secondary dilatation of Vater's ampulla to occur, with an insufficiency of the sphincter of Oddi. During the periods of insufficiency, infectious material from the duodenum is likely to enter the ampulla, perhaps even the pancreatic or bile ducts, with ultimately an inflammatory change in the pancreas.

16. Case, J. T.: Roentgen Observations on the Duodenum, with Special Reference to Lesions Beyond the First Portion, *Am. J. Roentgenol.* **3**: 314 (June) 1916.

17. Rosenthal and Bauer: Ueber das Duodenaldivertikel, *Wien. klin. Wchnschr.* **25**: 879, 1912.

Bauer cites the case of a man, aged 52. During several months the patients had suffered severe vomiting spells coming on from two to three hours after meals. In spite of a gastro-enterostomy, the patient died from persistence of the vomiting. At necropsy there was found marked dilatation of the stomach and the first part of the duodenum, apparently due to two duodenal diverticula, one as large as a hen's egg, filled with yellowish gray masses of chyme and mucus, compressing the lumen of the second portion of the duodenum in much the same manner as that in which an esophageal diverticulum may compress the esophagus. In another necropsy case cited by Bauer a duodenal diverticulitis caused a duodenal catarrh with resultant swelling and occlusion of Vater's papilla and stagnation of bile. In his first case roentgen-ray examination made before operation failed to disclose the diverticula; in the second case no roentgen-ray study was made.

In the majority of cases recorded in the literature and in most of my cases confirmed at operation there was very little to indicate pathologic changes in the wall of the sac. That such may develop, however, is clearly shown by the foregoing recital of cases and it is therefore important that in every case in which roentgenologic study develops proof of duodenal diverticulosis the question of surgical intervention should at least be considered. This is usually not difficult to decide, for in most of the cases likely to be found with the roentgen rays there will be found evidence of some surgical condition of the pancreas or biliary tract which will make inspection of the duodenum possible. The data given relative to the position of the fundus of the diverticulum should be recalled, however; for it will often prove a difficult matter to discover the diverticulum at operation, owing to its retroduodenal or retropancreatic location, and in many cases the inadvisability of making an extensive dissection to uncover the sac. When the sac lies ventral to the pancreas, its operative investigation will prove easy; when dorsal to the pancreas, mobilization of the duodenum is necessary.

Diagnosis.—As will be surmised from the foregoing, the diagnosis depends exclusively on the roentgen findings. So far as I know, no case has yet

been recognized before operation except on evidence furnished by the roentgen study. It is therefore appropriate to devote space to a detailed description of the necessary technic. It should be remarked that in general such diverticula are found in the roentgen investigation of individuals presenting right upper quadrant symptoms, sent in from the internist with a tentative diagnosis of duodenal ulcer, gallbladder disease, or chronic pancreatitis.

I described this technic, already then in use by me for five years, at the 1915 meeting of the American Roentgen Ray Society.

The patient, standing erect before the fluorescent screen, swallows a third of a glass of water into which has been stirred a heaping teaspoonful of barium sulphate. The pyloric region is carefully watched for the behavior of the first of the opaque mixture to reach it. This barium-water mixture usually begins to pass at once into the duodenum, so that it is more or less well visualized from the very beginning of the meal. This is followed by the usual barium meal, which in our practice consists of 1 ounce of barium sulphate in a glass of hot malted nuts or hot malted milk, and 1 ounce in a glass of buttermilk given cold. A brief further observation is made with the patient erect. He is then placed on the horizontal fluoroscope, and, if any delays are necessary, he is asked to spend the time lying on the right side so that gravity may aid in filling niches or sacculations in the pyloric zone. When all is ready so that the observation can begin the moment the patient turns over, the observer, standing at the patient's left, with his gloved left hand makes strong pressure over the duodenojejunal junction, at the same time pressing toward the pylorus the contents of the stomach (Fig. 1). The patient is then asked to inhale, hold the breath and turn quickly on the back, special care being taken the while to maintain compression of the duodenum between the palpating hand and the spine, thus artificially producing an obstruction near the duodenojejunal junction, and incarcerating the duodenal contents (Fig. 2). A wooden spoon may be used in place of the hand, if preferred.

This method of blocking off the duodenum, which I have practiced for the last ten years, can be accomplished more satisfactorily in the horizontal than in the upright position, although a similar technic worked out for the upright position by Holzknecht and Lippmann has a certain value. By pressure over the duodenojejunal junction, which is thus shut off between the spine and the compressing fingers, the duodenum is easily filled from pylorus to jejunum and its contour everywhere studied at leisure. The alternating waves of onward and retrograde duodenal peristalsis resulting from

this temporary obstruction still further tests the elasticity of the duodenal walls, so that one is not in doubt as to the presence or absence of deformities or extraduodenal shadows.

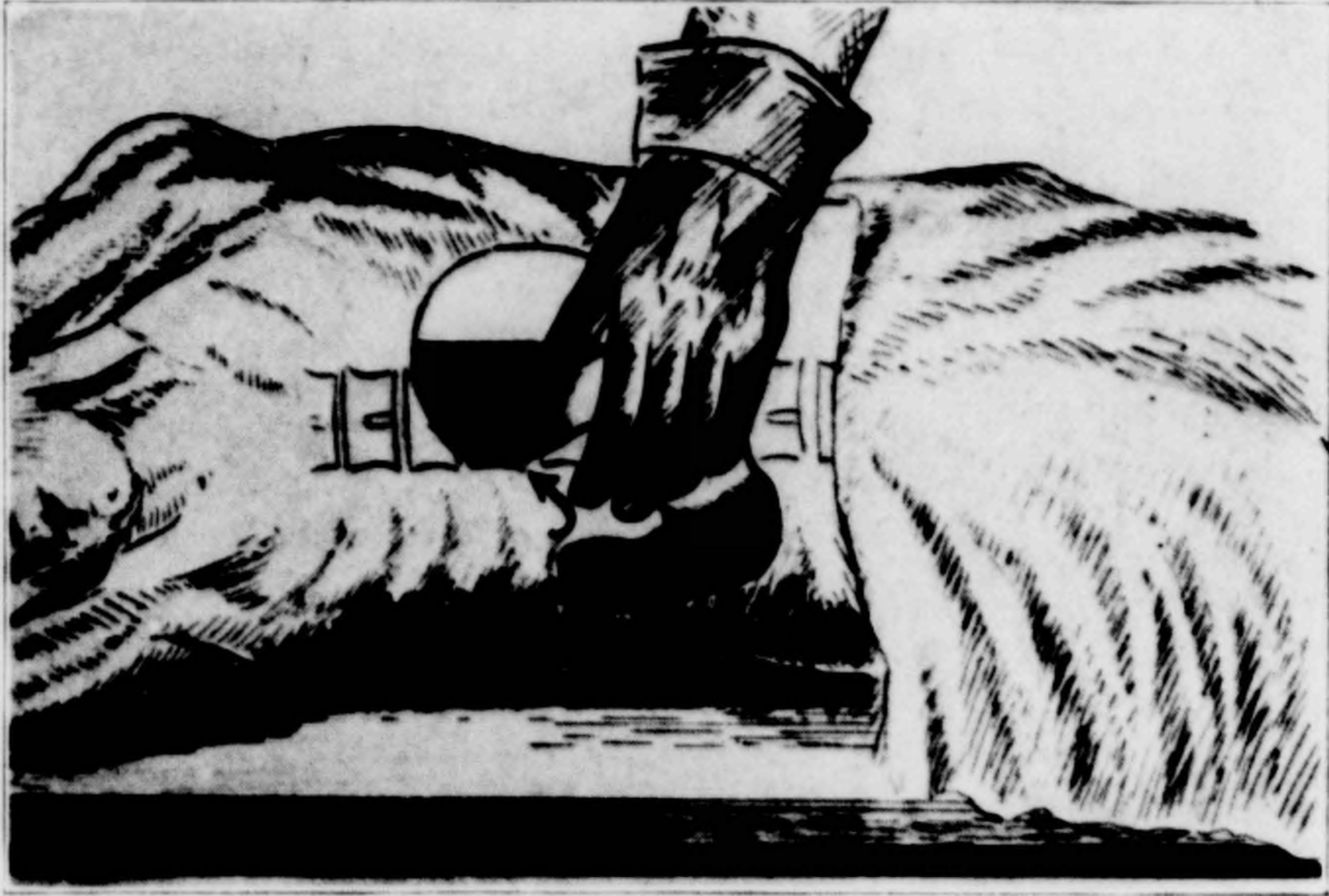


Fig. 1.—Preliminary manipulation.

The right lateral position is also useful, the patient lying on the right side, with the screen held vertically in front, the rays penetrating in the horizontal direction from behind.

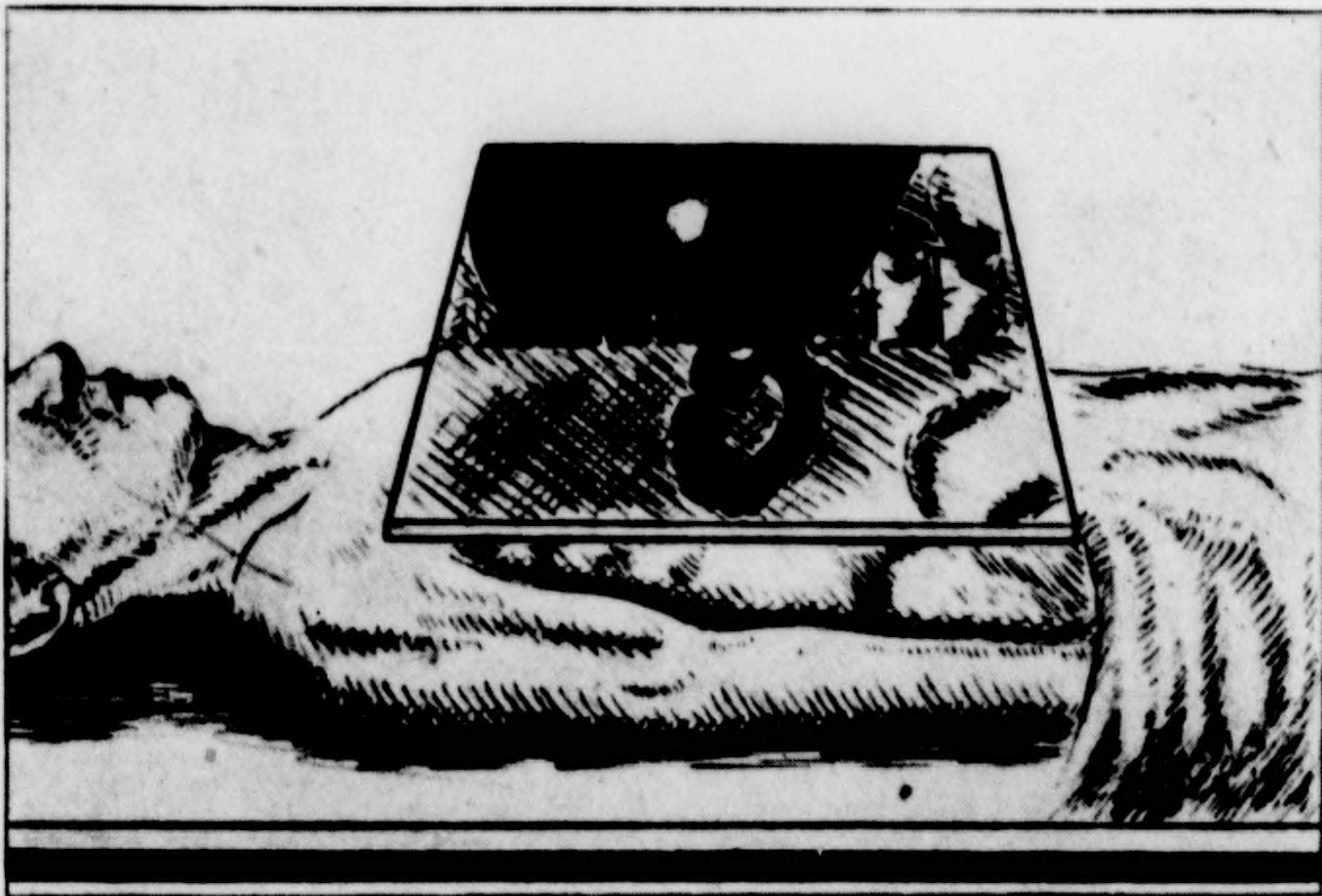


Fig. 2.—Position of patient when fluoroscopic observation is made.

Only by the use of this special technic have we been able, except by accident, to discover the diverticula of the third portion of the duodenum near the duodeno-

jejunal junction. Attention is called to the fact that this technic can be followed out only fluoroscopically. If one depends only on roentgenograms, the majority of the diverticula of the third portion will be hidden by the overhanging or overlying portion of the gastric shadow and escape detection.

Duodenal diverticula are suggested by the following roentgen findings: (1) a more or less spherical shadow



Fig. 3.—Enormous diverticulum of third portion of duodenum (shown by arrows) in case in which operation was performed.

lying near or within the concavity of the duodenal shadow; some are found on the convex side; (2) identity of this shadow as being separate from the duodenum, yet in definite relation to it; (3) sometimes persistence of the shadow for hours or even days after the clearing of the stomach; (4) in certain cases, movability of the shadow about a fixed point in the epigastrium; (5) usually, no point of tenderness

coinciding with the shadow, though this is by no means always true.

Having discovered a diverticulum, one should note (*a*) its exact location; (*b*) its size and general shape; (*c*) the dimensions of its orifice, whether narrow or free; (*d*) its mobility under the examining finger, guided by the fluoroscope; (*e*) the degree of retention;



Fig. 4.—Diverticulum of third portion of duodenum in case in which operation was performed.

(*f*) relation of the shadow to a point of abdominal pain on pressure; (*g*) caliber of the duodenum proximal and distal to the diverticulum; (*h*) emptying time of the stomach.

With diverticula of the first portion, the roentgen study should especially aim to settle the question of duodenal ulcer which so often occurs opposite and just caudad to the diverticulum. Diverticula lying to the

outer side of the first portion of the duodenum or the upper part of the second portion are very likely traction sacculations associated with gallbladder disease.

Diverticula have been classified as funnel-shaped, tubular, and spherical or globular. The first named are usually shallow, have a large orifice, and do not show barium content except as the duodenum is artificially distended by the special technic described above, or by the employment of a duodenal tube through



Fig. 5.—*a*, diverticulum of third portion of duodenum; *b*, visualized ampulla of Vater, in case in which operation was performed.

which barium mixture may be introduced after blocking of the duodenojejunal junction in the manner already mentioned. Even then a certain number of the shallow diverticula will doubtless be missed. The tubular or cylindric form is not common. The globular or spherical diverticula may have very small orifices; the smaller the orifice, the longer the retention. In some of my cases diverticula retained barium longer than seventy-two hours. In one case, at the end of

forty-eight hours it was possible under fluoroscopic screen guidance for the compressing fingers to express the opaque contents of the sac, which was immediately refilled when the patient swallowed another opaque meal.

Stasis in the diverticulum is significant. In the majority of first portion diverticula there were associated evidences of old ulcer or gallbladder region adhesions and relatively short retention in the diverticula. The emptying time of the stomach was, on the contrary, often prolonged, and in several instances, in our series, as in the cases reported by Ritchie and McWhorter and by Basch, gastro-enterostomy was all the surgery deemed wise, no attempt being made to excise the sac. In Ritchie and McWhorter's case the diverticulum was plicated. In diverticula of the second portion, the diverticular sacs being parivaterian or dilatations of the ampulla itself, the retention of barium beyond forty-eight hours was a frequent observation. In many of these cases we have found signs of a coexisting pancreatitis, with unusual patency and dilation of the ampulla of Vater, as has been confirmed by Akerlund and others. Diverticula of the third portion do not retain barium unless the communicating orifice is small, the degree of retention depending on the size of the opening. In one instance a large sac measuring 5 by 3 cm. retained barium longer than forty-eight hours.

Usually there was no tenderness on pressure over the barium-filled diverticulum. In a certain number of cases, however, especially with retention in the diverticulum and a syndrome characterized by distention, feeling of fulness, aching pain coming on from one to three hours after meals and persisting for one or two hours, regurgitation of sour fluid, and occasional nausea and vomiting, there seemed to be a definite coincidence between the diverticulum and a point of abdominal pain on pressure.

From the standpoint of possible surgical treatment, it is most important to determine whether the diverticulum lies ventral or dorsal to the pancreas or within the substance of this gland. Stereoscopic roentgenograms have been helpful in some cases. Careful manipulation of the patient with screen observation of the shadow movements as the tube is shifted about

under the table sometimes answers the question. But the most satisfactory data are obtained by manipulation of the abdomen with the gloved hand under screen guidance; if the manipulating fingers can move the diverticulum, changing its position or expressing its contents, it is usually easy to find the sac ventral to the pancreas at operation, and in properly selected cases to resect it.



Fig. 6.—Multiple diverticula of duodenum. Three sacculations indicated by arrows.

Treatment.—Although in the majority of cases seen at necropsy there have been few indications that treatment was needed, this cannot be stated as generally applicable to diverticula of the duodenum discovered with the roentgen rays. The latter category of patients are suffering from some more or less chronic digestive complaints, usually suggestive of right upper quadrant trouble, and there is always the possibility that there

may exist some well-defined connection between the diverticulum and the patient's symptoms. Sufficient evidence to warrant an operation on the duodenum or gallbladder may be found, in which case it will of course be in order to investigate the sacculation if possible, and to deal with it as may be indicated. It is further important to bear in mind that in order to make a roentgen diagnosis of duodenal diverticulum there must occur the entry and retention of duodenal contents into the sac. The cases already referred to in this paper have abundantly demonstrated that a duodenal diverticulum may cause severe and even dangerous symptoms, especially when retention occurs, giving rise to serious pathologic conditions developing in the diverticulum itself or in the contiguous tissues. This is increasingly apparent in direct proportion to the degree of retention. Duodenal contents were found in a diverticulum on the seventh day after an opaque meal in one of my cases. The evidence before us therefore strongly suggests that the diagnosis of a duodenal diverticulum may generally be considered as indicating surgical operation. This is more true when the roentgen findings indicate a diverticulum whose fundus lies ventral or caudad to the head of the pancreas, or in relation to duodenal ulcer or disease of the biliary tract; less true when the diverticulum is deeply situated, lying dorsal to the pancreas or within its substance.

When surgical treatment does not seem indicated, or for some reason cannot be carried out, one must be content with general hygienic care of the gastrointestinal tract with such special measures as will minimize the likelihood of inflammatory changes being set up by the retained duodenal contents, with resulting duodenitis and possible temporary occlusion of the papilla of Vater. With colonic multiple diverticula I have suggested the use of barium sulphate in dram doses three times a day one day of each week, in order to keep the diverticula filled with barium, thus occupying the space that might otherwise be filled with putrescible or infectious material of a more threatening character. In the majority of cases of duodenal diverticula it is not likely that any form of nonsurgical

treatment can have any appreciable effect on the contents of the sac or its likelihood to menace the patient.

JEJUNAL AND ILEAC DIVERTICULA

Less frequently than in the duodenum, yet more often than most of us appreciate, diverticulosis does

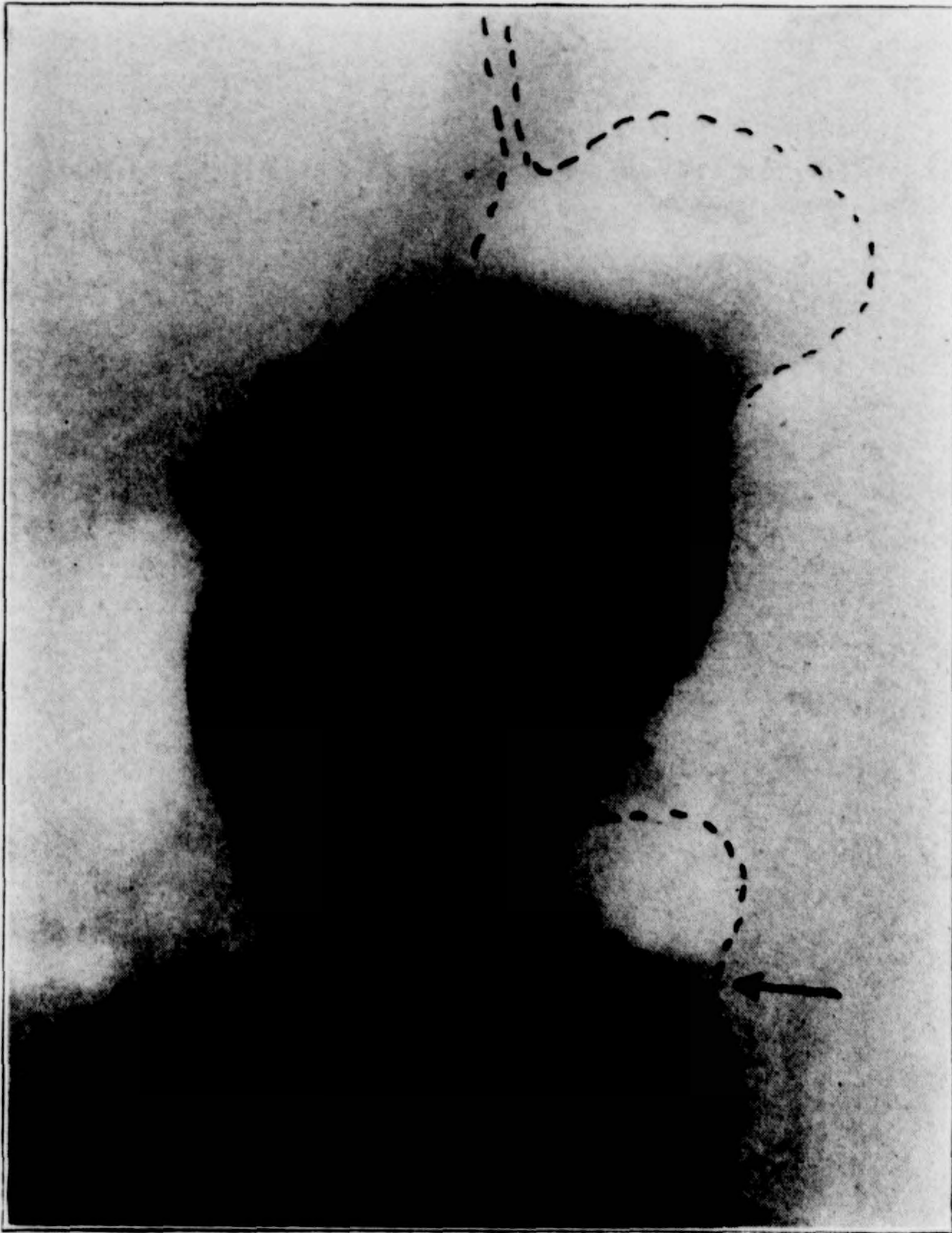


Fig. 7 (retouched).—Diverticulum of the jejunum (indicated by arrows), patient erect. Note fluid level with gas bubble above. Barium content of diverticulum. (To be compared with Figure 8.)

occur in the small intestine below the duodenojejunal junction. Seven of the eighty-five cases already cited as duodenal diverticula occurred at the duodenojejunal junction; possibly they should have been classified with the jejunal sacculations. In addition I have with the roentgen rays recognized five more cases of diver-

ticulosis of the jejunum and upper ileum. Two cases have been confirmed at operation (Figs. 7, 8 and 9); the other three presented the same characteristic roentgenologic findings, and there can be little doubt as to the accuracy of diagnosis.

Constituting perhaps even less of a menace to a patient than duodenal diverticula, and certainly much less than the multiple colonic sacculations so commonly found, jejunal diverticula may nevertheless become dangerous as the result of an acute inflammatory process within or around the sac. This possibility is well illustrated by the case of Gordinier and Sampson,¹⁸ reported in 1906:

The patient was a woman of 45. One of the diverticula had become inflamed and a diverticulitis resulted, with partial obliteration of the intestinal lumen. As the diverticulum extended between the folds of the mesentery, the latter became inflamed, thickened and puckered, thus causing an angular bending of the intestine with obstruction. The local peritonitis arising as a result of this gave rise to the formation of adhesions between the mesentery of the small intestine and the transverse colon and its mesentery, and thus kinked the transverse colon.

At operation thirteen diverticula were found in 40 cm. of intestine. The size varied from 0.5 to 1.5 cm. They were all on the mesenteric border and extended between the folds of the latter. In every instance a blood vessel extended over the surface of the diverticulum. One of the diverticula had become inflamed, and its base occluded, its patent distal portion having been converted into an infected cyst.

The following is a brief summary of the other cases of jejunal or ileac diverticula (other than Meckel's) which I have been able to find in the literature:

Bristow,¹⁹ in 1854, reported a case with a solitary false diverticulum of the ileum just above the ileocecal valve.

Wallman,²⁰ in 1858, found a case in which in a section of small bowel 48 cm. long there were thirty-seven diverticula, thirty of them lying between the folds of the mesentery.

Klebs,²¹ in 1869, found multiple diverticula numbering at least twenty in the small intestine of an old man, the sacculations lying between the mesenteric folds.

18. Gordinier, H. C., and Sampson, J. A.: Diverticula (Not Meckel's) Causing Intestinal Obstruction, *J. A. M. A.* **46**:1585 (May 26) 1906.

19. Bristow: *Tr. Path. Soc. London* **6**:191, 1854.

20. Wallman: *Virchows Arch. f. path. Anat.* **14**:202, 1858.

21. Klebs: *Handbuch d. path. Anat.* **1**:271, 1869.

Moore,²² in 1884, reported a case of multiple diverticula of the small intestine in a man, aged 40, the sacculations lying at the mesenteric attachment and including all coats of the bowel.

Buchwald and Janicke,²³ in 1887, described a case of true diverticulum of the jejunum in a boy of 6 years, probably congenital.

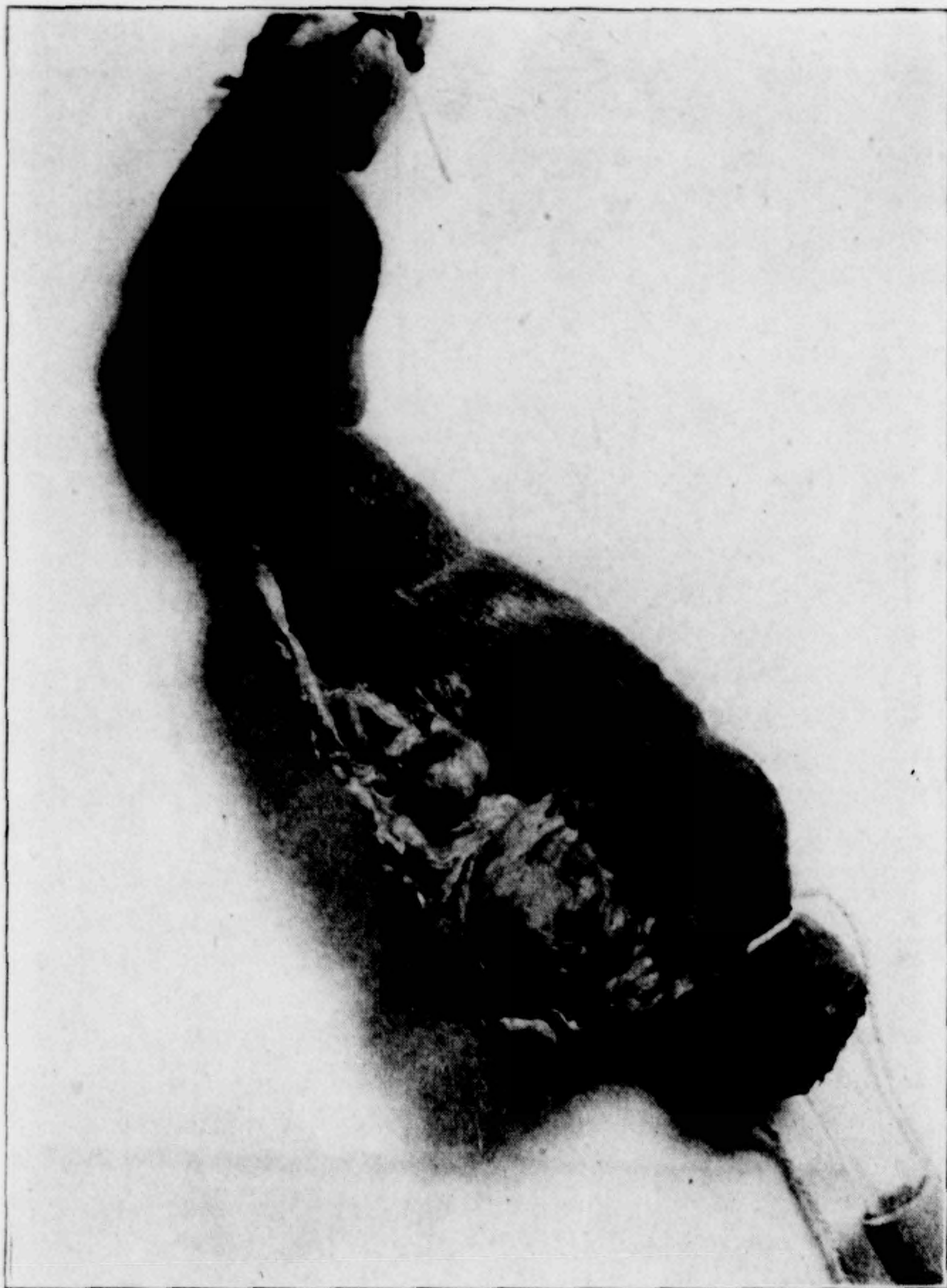


Fig. 8.—Resected jejunum containing several diverticula (see Fig. 7).

Birch-Hirschfeld,²⁴ in 1887, reported a case in which the ileum contained multiple diverticula scattered throughout its entire length.

22. Moore, Norman: Tr. Path. Soc. London, 1884, p. 202.

23. Buchwald and Janicke: Ueber Darmcysten, Deutsch. med. Wehnschr., 1887, No. 40, p. 868.

24. Birch-Hirschfeld: Lehrb. d. path. Anat. 2: 550, 1887.

Virchow,²⁵ in 1890, described a case of multiple diverticula of the jejunum in which some of the sacculations attained the size of a hen's egg.

Edel,²⁶ in 1894, reported a case in which there were seven diverticula in the jejunum varying in size from a hazelnut to an apple. This case also exhibited multiple diverticula of the colon.

Seippel,²⁷ in 1895, reported a case of jejunal multiple sacculations.

Hansemann,²⁸ in 1896, reported a diverticulum in the upper end of the jejunum of a boy of 14. There was accessory pancreatic tissue at the apex of the sac. Hansemann also reported a case in which more than 400 diverticula could be counted in the digestive tract, most of them being located in the jejunum and upper part of the ileum.

In 1899, Jach²⁹ and Nichols³⁰ each reported a case of multiple diverticula of the small intestine.

Fischer,³¹ in 1899, reported two cases: 1. In one, a piece of jejunum, 7.5 cm. long, showed a small oval diverticulum the size of a bean lying beneath the peritoneum between the folds of the mesentery. No other diverticula were found in the alimentary tract. Blood vessels ran over the serous covering of the diverticulum. 2. In the other case the first meter and a half of the ileum showed numerous large and small variously shaped diverticula, scattered along the mesenteric attachment. They varied in size from a split pea to half the diameter of the intestine. The larger sacs were often lobulated. There were large blood vessels running over their surfaces, the smaller ones looking as though blood vessels pierced their apexes or ran over their surfaces. There were signs of inflammation in the smaller diverticula. In all the sacs the muscular coat was very much thinned out, and in places entirely lacking.

Hodenpyl,³² in 1901, presented a case in which the duodenum and the upper part of the jejunum exhibited a number of thin-walled cysts, originating in diverticula, the cysts varying in size from a pea to a hen's egg.

Gordinier and Sampson, in 1906, described a case which came to operation and which I have already referred to in detail.

25. Virchow: *Verhandl. d. Berliner med. Gesellsch.*, 1890, p. 116.

26. Edel: *Ueber erworbene Darmdivertikel*, *Virchows Arch. f. path. Anat.* **138**: 347, 1894.

27. Seippel: *Ueber erworbene Darmdivertikel*, *Diss.*, Zurich, p. 21.

28. Hansemann: *Ueber die Entstehung falscher Darmdivertikel*, *Virchows Arch. f. path. Anat.* **144**: 400, 1896.

29. Jach: *Ueber Duodenaldivertikel*, *Diss.*, Kiel, 1899.

30. Nichols: *Philadelphia M. J.* **3**: 700, 1899.

31. Fischer: *Acquired Diverticula of the Bowel*, *J. Exper. Med.* **5**: 33, 1900.

32. Hodenpyl: *Two Cases of Multiple Spurious Diverticula of the Intestine*, *Proc. New York Path. Soc.*, 1899-1900, p. 182.

Boker,³³ in 1912, reported a very interesting case with two diverticula of the duodenum, multiple diverticula of the colon and a pressure diverticulum of the urinary bladder, in addition to multiple diverticula of the small intestine. One of the small intestinal diverticula showed ulceration and necrosis of the wall with an encapsulated peritonitis resulting.



Fig. 9 (retouched). — Barium-filled multiple diverticula of jejunum, patient erect. Arrows point to gallstones clearly seen in original roentgenogram. Operative proof.

I have not found in the literature any case of jejunal or ileac diverticulosis (other than Meckel's) in which a diagnosis has been made with the roentgen rays; so far as I can learn, the five cases of my series, in two

33. Boker: Ein interessanter Fall von zahlreichen Divertikeln des gesamten Darmtractus und der Harnblase, Diss., Kiel, 1912.

of which operation was performed, are the first recorded in which a diagnosis has been established with the roentgen rays, and two of them constitute the first cases in which the roentgen-ray findings have been corroborated by operative procedure. The three cases in which operation was not performed will not be given here; the other two cases follow:

CASE 1 (No. 96388).—A man, aged 61, entered, April 25, 1915, giving a history of "indigestion" for the preceding ten months. He complained of a feeling of pressure and distention of the stomach coming on immediately after meals, causing much discomfort and distress, relieved somewhat by belching. There was no pain, no nausea, and no vomiting. He had occasional "heartburn" about 2 a. m. During the last six months he had a great deal of intestinal flatulence which he was not able to relieve.

Roentgen-ray examination, June 10, revealed a sacculation in the small intestine, located apparently a few centimeters below the duodenojejunal junction, wherein food collected, distending the bowel until its shadow was at least 5 cm. in diameter, and coinciding accurately with the seat of the patient's subjective pain. Even before the barium meal was given there was noted a definite gas accumulation in the small bowel occupying the left upper quadrant; and in the midst of this gas distention there could be made out a fluid level about 5 cm. in width surmounted by a gas bubble similar to the normal air pocket of the stomach. The emptying time of this sac was from eight to ten hours (Fig. 7).

June 15, at operation by Dr. J. H. Kellogg and myself, there were found in the upper jejunum perhaps a dozen diverticula, most of them pea sized, but including one large one measuring 5 cm. in diameter. The gallbladder, stomach, duodenum and pancreas all appeared to be normal. There were external signs of inflammation about the intestine in the neighborhood of the large diverticulum. We removed about 36 cm. of jejunum commencing 18 cm. below the duodenojejunal fold. The patient made prompt recovery from the operation, but it was several months before he admitted relief from the symptoms for which the operation was performed.

Dr. Warthin, in reviewing this specimen, reported changes indicative of chronic low-grade inflammation of the mucosa of the large sac, which was, however, devoid of muscularis. The sac was located between the folds of the mesentery and in close relation to the large blood vessels. It was interesting to note that this large sac was the last of a series of diverticula occurring in a relatively circumscribed segment of upper jejunum, 36 cm. in length, without any obvious signs of obstruction except the retention within the diverticulum itself. The segment of bowel removed is shown in Figure 8.

CASE 2 (No. 92181).—A man, aged 73, on entry, July 18, 1914, gave a typical history of gallbladder disease. Roentgen-ray examination revealed an extraordinary condition of the small intestine, twenty-five or thirty sacculations occurring throughout the jejunum and upper ileum. With the patient in the erect position the larger diverticula were characterized by numerous fluid levels, each surmounted by an air pocket. Following a barium meal these diverticula were beautifully accentuated (Figure 9). Some of them measured 4 cm. in diameter. In addition there were shown multiple diverticula of the pelvic colon, and a large number of gallstones. This patient was later operated on at another institution, the gallstones removed, and the intestinal diverticula confirmed.

SUMMARY

1. Refinements of roentgen methods for study of the digestive tract permit the diagnosis of diverticulosis of the duodenum and small intestine in an increasingly large number of cases.
2. Duodenal diverticula occur most frequently in the second portion in the region of the ampulla of Vater; then in the third portion and duodenojejunal junction; less frequently in the pars superioris. They vary in size from a pea to a hen's egg, and frequently retain barium long after the stomach has been emptied of the opaque meal.
3. Usually considered as without clinical significance, it is shown that they are often associated with ulcer of the duodenum or disease of the gallbladder or pancreas; and when the seat of diverticulitis they may themselves constitute a serious menace to the patient.
4. Duodenal diverticula may be demonstrated with a high degree of accuracy with the roentgen rays. Such diverticula as retain barium for much longer than the time required to empty the stomach should be considered as probably indicating surgical intervention.
5. Owing to the location of the diverticulum in relation to the pancreas, it is not always possible to resect the sac; the roentgen study should furnish advance information relative to this unfavorable position.
6. In the majority of cases found at necropsy (before the day of the barium meal) there were few evidence of inflammatory change in the diverticular sacs; nowadays, however, the diverticula being dis-

covered with the barium meal studied are in patients, the majority of whom present right upper quadrant symptoms.

7. Jejunal and ileac diverticula, though much less frequently encountered, may constitute a serious danger to the patient; as the result of diverticulitis, mesenteritis may set up with inflammation, thickening and puckering of the mesentery, with accompanying obstruction or local peritonitis, or both.

8. A report of eighty-five patients with duodenal, and five with jejunal diverticulosis found with the roentgen rays in a series of 6,847 barium meal studies is given. Ten of the duodenal and two of the jejunal cases were confirmed at operation.

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THE X-RAY INVESTIGATION OF THE COLON

A REVIEW OF SOME RECENT LITERATURE

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FOR more than a decade the röntgen examination of the œsophagus and stomach has been extensively carried out in all the large clinics of Europe and, during the last half of this period, in the large American clinics. Pfahler was probably the first in this country to undertake extensive bismuth studies. The investigation of the colon by means of the X-ray is somewhat more recent, however, and only within the last two or three years has it been carried out with anything like the precision now attending the röntgen examination of the stomach.

The earlier studies of both the stomach and bowel were begun at a time when the question of ptosis of the abdominal viscera was receiving special attention. Hence the earlier gastrointestinal X-ray studies were carried on with special reference to form and position, a circumstance which undoubtedly led the medical profession to attach undue importance to the form and position of the colon.

With increasing experience, the morphological factors have shrunk in importance, while the problems relating to the functional behavior of the alimentary tract have assumed greater significance. Of all the various facts which can be learned about the stomach or bowel by röntgen examination, the question of ptosis, at least in the opinion of the writer, is the last one thought of and the one given the least consideration. In other words, ptosis is looked upon as a symptom, rather than a causative factor, although it is con-

ceded that in certain cases the ptosis, although at first a symptom, may later become part of a vicious circle and thus assume importance as a causative factor. The technique of the X-ray examination of the colon has been so far perfected that, with an accuracy that is almost uncanny, it is now possible to locate the adhesions and membranous attachments, most of which bear the name of some special surgical investigator; and yet even here the X-ray examination serves a much more valuable purpose in ascertaining the degree of interference with bowel function than in merely locating the position of adhesive bands. As Skinner (1) has stated, the stomach and colon are not chemical retorts, but functioning motile organs, and the position of the gastro-intestinal tube does not so much concern us, as its functions do.

Physiology of the colon (2). The introduction of the röntgen method, especially the work of Cannon, which was carried out largely on animals, has thrown much light on the peristalsis of the colon. The writer's observations in man have almost to the minutest detail confirmed the work of Cannon on animals, especially in regard to antiperistalsis. Cannon showed that the prevailing movement in the proximal colon was antiperistalsis, consisting of a movement of waves backward toward the cæcum. These antiperistaltic waves do not run continuously for a long time, but periodically, although a series of waves at the rate of perhaps five a minute can be seen con-

tinuing for four or five minutes. The distal colon has as its characteristic activity an onward movement, several kinds having been described. Haustral churning is occurring constantly in the distal colon, serving to keep the material in this region thoroughly mixed with the digestive fluids. This haustral churning, or segmentation, is analogous to the segmentation which occurs in the small intestine. Other movements of the bowel are the large pendulum movements of Rieder (3), consisting of a considerable dislocation, turning, and winding of those portions of the colon which have a long mesocolon, all of which occurs without any actual transportation of the contents of the bowel. These snakelike dislocatory movements occur in everybody in various degrees and with varying frequency.

It is probable that the principal propulsive movement in the colon, serving to move the bowel content from the proximal colon into and through the distal colon, is the mass movement first described by Holzkecht (4). This is a most striking phenomenon, and, when once seen, can never be forgotten. The bowel contents suddenly lose their haustral markings and are formed into an ovoid, sausage-shaped mass with perfectly smooth edges, and rounded at the ends. This mass travels at about twice the rate of peristaltic waves in the stomach, the distance traveled varying with the circumstances. As the mass comes to rest, the haustral indentations reappear, quickly if the bowel content be semifluid, more slowly if the bowel content is of firmer consistency. It is estimated that these mass movements occur about six times daily. Further studies on this mass movement have been reported by Barclay, Hertz, and Jordan, and by the writer. Before the introduction of the horizontal fluoroscope, these large colon movements were rarely observed. Holzkecht (4), in 1909, reported two cases; Fischl and Porges (5), in 1911, two cases; Barclay (6), in 1912, two cases; Schwarz (2), in 1913, two cases; and the writer (7), in 1913, reported thirty-seven cases in which this mass movement had been observed. In recent times, however, especially since the horizontal fluoroscope has come to be more extensively employed, this type of onward peristalsis has come to be recognized as being very common. Hertz and Barclay have both informed the writer that they now see this form of peristalsis frequently.

The filling of the stomach and the movements of the colon by respiration are important factors in the shifting of the contents of the colon. The writer's statement (7) that the content of the

colon can be shifted very little, if any, by palpation, is confirmed by the observations of Schwarz (2), who declares that even with strong pressure it is not possible to lift the content of the ascending colon into the transverse. The same holds true of the distal portion of the colon. In a few cases only was Groedel (8) able to affect a movement of the contents of the colon for short distances with a vibrator in full action. The well-recognized favorable influence of massage and mechanical vibration must, therefore, be produced indirectly by increasing the tone of the bowel muscle, rather than by any actual mechanical pressure of the bowel contents onward.

Various authorities have constructed tables showing the rate of passage of the barium meal through the alimentary tract. Summarizing these observations, we may conclude that following a meal in which barium sulphate constitutes the opaque substance, the stomach should be empty within four and one-half hours, the head of the barium column having reached the cæcum at that time. The entire barium meal should have passed into the colon by the eighth hour, or at most the tenth hour, at which observation the head of the barium column should have reached the middle of the transverse colon. The head of the barium column should reach the descending colon from nine to sixteen hours following the ingestion of the meal, and the colon should be practically empty of barium at the thirty-sixth hour. No purgatives should be given on the day immediately preceding the examination. The barium meal should be substituted for one of the ordinary meals, so that the rhythm of meals will not be disturbed.

Technique. The contrast material may be introduced into the colon either in connection with a meal or by enema. The writer recommends study of the colon following the meal as being more likely to give accurate information concerning the function of the bowel, reserving the injection of the barium enema for those cases in which there is a question of gross obstruction (carcinoma, tumors, adhesion bands, etc.) and for testing the function of the ileocolic valve. Following the barium meal the studies of the colon may be carried out at the ninth, twenty-sixth, thirty-second, and fiftieth hours.

Others prefer the barium enema after the method of Haenisch (9). The Haenisch enema consists of water one liter, bolus alba 300 grams, bismuth carbonate 75 grams, and water sufficient to make one liter.

The writer's formula (10) is as follows: To 2½ dr. of gum tragacanth, add about 1 oz. of alcohol.

Shake well. Add 20 oz. of warm water, and shake. Add 3 oz. of barium sulphate, then 20 oz. of water, shaking well each time. This mixture should be made up fresh shortly before using.

Holzknicht and Singer (11) give the following formulæ: (a) Barium sulphate clysmas. To one liter of boiling water, a suspension of two soup-spoonfuls of finest potato starch in three-fourths of a liter of cold water is added, and after being boiled again, 160 grams of barium sulphate and one-quarter liter of hot water is stirred with it. The mixture is then boiled for five minutes and cooled off to 112° F. This mixture can be preserved in the icebox several days. (b) The bismuth clysmas. To one liter of boiling water, a suspension of two tablespoonfuls of finest potato starch in a quarter of a liter of cold water is added. This is boiled again for five minutes and 120 grams of bismuth carbonate stirred in three-fourths of a liter of cold water is added to it without boiling again.

Jaugeas and Friedel (12) recommend a paste, especially for the investigation of the rectum and sigmoid. The paste consists of a mixture of vaseline and oil in equal parts, to which barium sulphate or bismuth carbonate is carefully incorporated in equal parts. This preparation can be injected with a syringe. The quantity of the injection varies with the importance of the segment to be explored. A liter usually suffices to reach the splenic flexure.

The technique prescribed by Haenisch for the injection of the colon under fluoroscopic control has not been materially improved by any of the more recent writers. Before the injection it is important that the bowel shall have been cleared out very thoroughly by means of appropriate laxatives or by thorough enemas or both. The patient lying supine upon the trochoscope, the barium suspension is placed in a container two or three feet above the patient, and is allowed to flow by means of gravity through an ordinary enema tube and rectal point into the bowel. A colon tube is quite unnecessary, a rectal point passed two or three inches into the bowel being sufficient. The temperature of the clysmas should be 100° F. The progress of the clysmas should be watched inch by inch as it ascends the colon. A pause in its progress may be caused by a kink in the rubber tubing or a clogging in the tube. At opportune moments during the inflow of the clysmas, manipulation under the screen may elucidate special points. Haenisch advises, after the examination, that the container from which the injection has been made be lowered and the enema allowed to return by gravity. The emptying of

the colon is also watched under the fluorescent screen and additional information may thus be obtained as to the exact site of an obstruction.

In discussing the advantage of this direct röntgenoscopic observation of the opaque clysmas over the observation after an opaque meal, or the observation of the enema after it has been injected, Haenisch (13) insists that it is just the observation of the filling of the colon in all its stages which permits one to recognize abnormal conditions of intestinal caliber with the greatest accuracy.

Stereoröntgenography of the alimentary tract has been extensively utilized by many workers. This method has especial value in the study of the colon, particularly the pelvic colon.

Colonic adhesions. Pers (14), of Copenhagen, claims to be the first to describe a technique for the detection of colonic adhesions. It is certain, however, that many others have already used the method which he describes. It was employed by Pfahler at least two years before Pers' publication. Pers called attention to the fact that the most common causes of adhesions of the colon are (1) ulcerous disease of the colon; (2) inflammatory disease of the colon or other organs of the abdomen; (3) trauma of the peritoneum from operations; (4) the adhesions due to modern fixation operations. Although in some cases the adhesions cause no symptoms, they often announce themselves by pain and obstruction. Patients with colonic adhesions are much to be pitied because the adhesions are often not recognized. While the history may point out the probable diagnosis, there is much uncertainty; and we now know, especially through the work of Eastman, Hertzler, Jackson, and others, that extensive bowel adhesions may occur as the result of chronic intestinal stasis, without any history of a definite inflammatory process.

With röntgenography, and especially röntgenoscopy, we are now able to determine whether the bowel is adherent to its surroundings, the site of the possible adhesions, and, if operation for relief of adhesions is done, to ascertain how far the operation is able to restore the motility of the intestine. The most common site of pericolic adhesions is, as will be reiterated later, in the iliac and pelvic colon, especially about the ilio-pelvic junction.

It is important to emphasize here the necessity for proper protection during screen examination. Both Pfahler (15) and the writer (16) have published warnings against the careless use of the X-ray in fluoroscopic work. The tube-holders must be very carefully protected with lead or an

equivalent thickness of other X-ray protective material. The time of exposure of the patient during fluoroscopic examinations is likely to be unusually prolonged beyond the danger limit; hence the greatest care should be exercised to avoid over-raying of the patient. As Skinner has recently remarked, few röntgenologists know how to use the foot-switch, intimating that continuous illumination of the screen is usually unnecessary, although often practiced.

One of the most important advantages of the fluoroscopic method in the study of the colon is the possibility of guided palpation under the fluorescent screen. This may be accomplished by the protected hand, or, preferably, with some palpatorium not opaque to the X-ray. Among the chief purposes of this palpation under the fluorescent screen are the determination of mobility, the relation of various shadows, and the identification of points of pain on pressure in relation to the bismuth shadows. Whether or not loops of bowel can be easily separated, the mobility of the cæcum, the appendix, the transverse colon, the pylorus, and the descending colon are all points which may be studied by the aid of the palpatorium almost as well as by manual palpation. Only those who have experienced the satisfaction of palpating the bismuth-filled stomach and bowel under the fluoroscopic screen can fully appreciate visualized abdominal palpation under fluoroscopic guidance, but unless the greatest caution is observed to insure adequate protection in röntgenoscopic work, great suffering and even loss of life may result from the wave of enthusiasm for fluoroscopic work which is now sweeping over this country.

Constipation. The röntgen study of constipation and its causes has led to a number of classifications. The classification of constipation by Schwarz (2) considers the hypokinetic and dyskinetic forms. In the former there is a lack of muscular tone and motor stimuli; in the latter there is excessive motility and antiperistalsis to a marked degree. The writer finds that it is in these cases that ileocæcal valve incompetency occurs most frequently, the spastic constipation and increased antiperistalsis resulting in overdistention of the cæcum, which is directly the cause of the ileocolic valve incompetency. The marked spasticity of the bowel in these cases causes the intestinal content to be seen as small isolated masses. Hertz has added the term dyschezia for those cases where the colon is found to be normally active, the food passing through it and reaching the rectum in the normal time, the delay being due to an abnormally distended

ampulla with blunting of the defecatory reflex. There may also be cases of congenital dyschezia dependent upon some defect in the muscle sense of the rectum.

It seems to the writer that some of the cases of so-called dyschezia are really due to adhesions of the pelvic colon, especially adhesions involving the pelvirectal junction. These adhesions prevent the normal uprising of the pelvic colon during defecation. In the writer's opinion, the cause of constipation is to be found, in the majority of cases, in the colon below the crest of the left ilium, that is, in the pelvic colon and rectum, the marked spasticity of this portion of the bowel being found almost invariably associated with adhesions.

Abdominal tumors. The röntgen diagnosis of intra-abdominal tumors by recognition of the resulting dislocation of the colon was first described by Stierlin (17). Since then a number of others have utilized this method of diagnosis. The abdominal organs are not well adapted for direct röntgen reproduction. The same is true of intra-abdominal neoplasms, tumors, and abscesses. Aside from the liver, the spleen and the larger subhepatic and subphrenic abscesses, the abdominal viscera are not easily visualized. The intestines may be filled with ray-absorbing substances or with gas. Certain hollow organs, as the bladder and kidneys, have been filled with collargol.

Certain groups of intra-abdominal neoplasms may be studied, however, by their dislocation of the colon. This method is useful only for those tumors which are in the immediate neighborhood of the colon, particularly tumors of the kidney, pancreas, psoas abscesses, and retroperitoneal sarcomata. Tumors of the kidney tend to dislocate the colon toward the midline. Tumors of the spleen usually occur in front of the colon, without displacing it. Tumors of the pancreas and retroperitoneal sarcomata usually dislocate the transverse colon downward. Psoas and iliac abscesses are shown by typical median dislocation of the cæcum and ascending colon. In large uterine tumors, the pelvic colon is compressed, while the cæcum and ascending and, particularly, the transverse colon are lifted upward. In ovarian cysts, the dislocation of the pelvic colon is not characteristic. Morse (18) records an instance of a sarcoma of the left kidney which could be located by the appearance of a mass between the spinal column and the colon filled with bismuth.

Ileocæcal tuberculosis. In 1911, Stierlin (19) reported that he had found in the röntgen exami-

nation a new diagnostic method for the recognition of even the early stages of ileocæcal tuberculosis. Schwarz (2) has recently voiced his unqualified approval of Stierlin's sign. Normally, it never happens that the ileum and also the transverse colon contain bismuth while the cæcum and ascending colon are empty. This vacancy in the shadow is not especially caused by the anatomical process, but by a hyperæsthesia of the excited mucosa, so that the colon does not permit the accumulation of the fæces, but frees itself promptly from it by visible contractions. Chronic ulcerative tuberculosis may occur in various portions of the colon, but it is usually combined with more or less severe strictures. These strictures may be ring-shaped, or may affect larger portions of the bowel which have the shape of a tube. The lung is usually involved in these cases.

Colitis. Catarrhal inflammation of the colon may be profitably studied by means of the X-ray, not so much to demonstrate the presence of the colitis as to show the portion of the bowel involved. Sometimes the spasticity attending the colitis involves the entire colon; more often it is localized to certain segments, as shown by the X-ray. Following the barium meal, the spasticity of the bowel is shown by the isolated, scyballous masses scattered throughout the segments. Following the barium injection, the spasticity is manifested by a narrowing of the smooth-edged shadow of the affected portion of the bowel.

Kienböck (20) cites Stierlin's statement that in ulcerative colitis the diseased portion of the bowel is always free from large quantities of barium and shows only a few long thin lines; the border lines of the intestine are parallel without the haustral markings, and they enclose between them a very clear area which has an increased gas content. Schwarz and Novascinski report similar findings. All of these authors regard the condition as hyperæsthesia of the quickly emptying colon with a small residue remaining upon the ulceration of the intestinal wall in long drawn out lines. Kienböck reports in detail three cases of ulcerative colitis — two with tuberculosis and one with dysentery.

In his conclusions he mentions the frequency of insufficiency of the ileocæcal valve in these cases. This has already been referred to by the writer.

In cases of mucous colitis, one may occasionally actually show strings of mucus in the bowel, thanks to the opaque salt which seems to find lodging in the twisted mucous shreds.

Appendix. Among the earliest studies are those of Holzknicht, Fittig and Weisflog, and

Jordan (21). A paper by the writer (22), in 1912, was the first American contribution to the röntgenology of the appendix. Since then there have been studies by George (23), Quimby (24), and Imboden (25), and by Rieder (26), Schwarz (27), Groedel (28), Cohn and Grigorjeff (29), and others in Europe. The general conclusion is that the normal appendix may fill with barium following the ingestion of a barium meal and occasionally following the injection of a barium clyisma. Provided the appendix fills, one may determine the presence or absence of adhesions, or kinks, or involvement of neighboring viscera, and the relation between points of pain on pressure and the appendical shadow may be judged.

The question of drainage seems to be most important. If the appendix fills and empties itself, it is not likely that the filling has any pathological significance. On the other hand, a poorly drained appendix possesses a potency for danger in proportion to the length of time it requires for emptying. Neither the acutely inflamed appendix nor the obliterated appendix can be shown following the barium meal. However, the conclusion is not warranted that the appendix is obliterated because it does not show in the röntgenogram. The appendix may lie retrocæcal in such a manner as to escape discovery, even under the most careful fluoroscopic manipulation.

Dietlen (30) has described insufficiency of the ileocæcal valve as an important symptom of chronic perityphlitis. This view is shared by a number of other European investigators. It seems, however, that chronic perityphlitis is only one of the conditions with which ileocæcal valve incompetency is associated.

Ileocolic valve insufficiency. In 1897, Max Hertz, of Vienna, while performing abdominal massage on a patient for colic-like pains in the ileocæcal region, observed peculiar symptoms which he could not explain otherwise than by the supposition that the contents of the cæcum might be pressed backward. After further studies on patients, as well as anatomical examinations, he described a symptom-complex of insufficiency of the ileocæcal valve which could clinically be found only in such patients as had disturbances pointing to the bowel, such as constipation, abdominal pains, and sometimes diarrhœa.

Schwarz (2) makes the statement that "these findings remained unnoticed or unbelieved until Case, in 1911, first demonstrated röntgenograms showing the retrograde filling of the ileum after the barium clyisma." In fact, the writer first called attention to this röntgen finding in 1909-

1910. Hænisch, Holz knecht and Singer, and Groedel soon confirmed these findings. Further articles have appeared on the subject by Dietlen (30), Rieder (3), Kellogg (31), Katsch (32), and the writer (33).

Insufficiency of the ileocæcal valve is best demonstrated by the retrograde filling of the terminal ileum by means of the barium enema following the evacuation of the barium enema by spontaneous defecation. Examination of the competency of the ileocæcal valve by means of the barium meal is unsatisfactory, although the writer has reported a series of more than sixty cases in which there was a reflux of ingested food from the cæcum back into the ileum.

The chief result of the incompetency is a prolongation of the emptying time of the ileum following the barium meal, although occasional cases will be found in which ileal stasis is due to stenosis of the valve or to kinks of the terminal ileum. Nevertheless, in the great majority of cases, in the opinion of Groedel (34), Kellogg, Schwarz, Jordan (35), the writer (33), and others, the increased stasis in the ileum is one of the direct results of ileocæcal valve incompetency.

In establishing the presence of insufficiency of the ileocæcal valve, Schwarz (2) uses irrigoscopy, taking care that only one liter of fluid is used, and that the irrigator is introduced only moderately high. Senn shows that even a normal valve may become insufficient by overdistention of the valve, and that any massaging maneuvers in the ileocæcal region are to be avoided. In order to make certain that the test will be absolute, the writer has, on the contrary, advised massaging maneuvers over the ascending colon in the anti-peristaltic direction, and the introduction of a sufficient quantity of the enema to make certain that the cæcum has been distended. Otherwise, occasionally an incompetency of the ileocæcal valve will be overlooked during the röntgen examination, and be revealed later at operation.

The writer (33) holds that the insufficiency of the ileocæcal valve is a symptom dependent upon obstruction lower in the bowel, and is not a disease in itself. Kellogg (31), Schwarz (2), Groedel (34), Dietlen (30), and others are of the same opinion. The true cause of insufficiency of the ileocæcal valve is the abnormal lack of tone of the structures which make up the valve — chronic overdistention of the right half of the colon, particularly the cæcum, as the result of which the loosening of the connective tissue is quite natural. This distention of the right half of the colon is usually the result of chronic obstruction of the colon, due either to adhesions of

the pelvic colon or to severe colitis with spasticity, both of which conditions lead to increased anti-peristalsis and distention of the cæcum. These conditions lead to stasis and chronic changes in the appendix. This observation led some European observers, particularly Groedel and Dietlen, to believe that there was a direct connection between insufficiency of the ileocæcal valve and chronic perityphlitis.

The writer (7) found insufficiency of the ileocæcal valve in one-sixth of fifteen hundred cases of constipation. Dietlen (30) found twenty-two cases out of one hundred. Singer and Holz knecht (11) found three out of fifteen. It seems that the percentage of cases of constipation presenting ileocæcal valve incompetency is nearly constant for different observers.

At the 1914 meeting of the American Medical Association (Section on Physiology and Pathology) the writer tabulated a series of twelve findings, most of them röntgenologic, which seemed to indicate beyond a doubt that the ileocæcal valve is normally competent, protecting the ileum from a reflux of cæcal contents. The first of these arguments is the observation first made by Cannon that the prevailing movement in the right half of the colon is antiperistalsis.

It is hoped that others will take up the study of this question, especially in children, to settle some of the questions which are not yet conceded by the surgeons.

Mobile, atonic cæcum. This condition, first described by Wilms, has been the subject of considerable study and no little controversy. Wilms, several years ago, gave up his operation for fixing the mobile cæcum. There is not sufficient space here to review all of the literature of this phase of the subject. Suffice it to say that much less importance is now being attached to the mobile, atonic cæcum, the general consensus of opinion being that it is the fixed, adherent bowel, rather than the mobile bowel, which is the seat of stasis and the source of symptoms.

Abnormal position of the colon. Congenital failure of the colon to rotate has been reported from the Mayo Clinic, by Stierlin, de Quervain, and several others. Hertz has reported one case of complete transposition of the viscera. The writer has seen one case. Doubtless there have been many unreported cases in which the röntgen examination has been utilized to demonstrate this anomaly.

Aberrancy of the sigmoid has been especially described by Pfahler. Special attention has been given the study of the pelvic colon by Pfahler, Jaugeas (12), and George and Gerber (36).

Aberrancy of the sigmoid is not especially abnormal, except through the enormous gas accumulations which are sometimes permitted. Pfahler shows that these gas accumulations may cause temporary obstruction by pressure against other loops of bowel.

Adhesions of the pelvic colon, especially about the iliopelvic junction, are more likely to be the real cause of constipation and resulting gas formation in these cases. The work of Eastman and others shows that extensive membraniform adhesions may result from extreme coprostasis without any visible constriction of the intestinal walls. Of course, these adhesions may also result from salpingitis and other forms of irritation of the pelvic peritoneum.

The method of Jaugeas (12) is especially valuable in revealing abnormalities of the pelvic colon. It is often extremely difficult to differentiate between the deformity of the colon resulting from extensive sigmoidal adhesions and the filling defects attending carcinoma.

Carcinoma of the colon. Schwarz (2) divides carcinoma of the colon into several classes:

1. Carcinoma with high grade stasis.
2. Carcinoma without stagnation of the contents of the colon.

In the first group, the patients present typical symptoms of chronic ileus. The abdomen is tense and expanded from the inflated bowel. The röntgen examination is indicated because the internist or the surgeon is not able to decide whether the obstacle belongs to the small or to the large intestine, a question upon the decision of which the manner and point of operative interference is considerably influenced.

It is probably wise to begin the examination in such cases with a barium enema, following it later, if necessary, by the ordinary barium meal. When the lesion is thought to be in the colon, the enema is likely to give the earliest information. The writer (37) has shown that even without the administration of barium it is possible, in most cases, to locate the site of the obstruction, thanks to the gas distention of the bowel almost universally present in these cases. If the central portion of the abdominal shadow is gas-distended, showing the peculiar, reticulated appearance characteristic of the small intestine, it is likely that the obstruction is not in the colon, but in the lower portion of the small intestine. If the cæcum and ascending colon are gas-distended, it is almost certain that the obstruction is in the colon and not in the small intestine.

In cases of obstruction beyond the hepatic flexure, the cæcum and ascending colon may form

an extremely dilated sack, the thickness of a man's arm, hanging low down into the pelvis. The content of the sack is usually fluid, and is easily recognized by its horizontal level, seen with the patient standing, which becomes undulating when the patient is shaken. Above this fluid level there is usually a high-grade gas-inflation of the hepatic flexure, interlaced with haustral lines. In the middle of the transverse colon there may be another accumulation of the liquid seen only with the patient standing. When the obstruction is in the pelvic colon, there may also be fluid levels at various points in the descending colon.

Except in the presence of stenosis, the colon can never contain such quantities of fluid. In cases of catarrh, or where there is liquefaction of the fæces in the colon, these liquids are soon emptied. Stationary spaces filled with fluid and gas are found only in stenosis, according to Schwarz.

Antiperistalsis, alternating with onward peristalsis, can be seen in the colon proximal to the lesion, associated with borborygmi. The liquefaction of the content of the colon can only be determined when the patient is examined in the upright position. If the patient is so weak that he can not stand, and it is necessary that the examination be made on the horizontal fluoroscope, a correct diagnosis can be made from the prominent, and sometimes really severe, distention of the colon. Even in this position, lateral studies, with the tube on one side and the screen on the other, with the patient flat upon his back, may serve to demonstrate fluid levels surmounted by gas accumulations. Severe, constant meteorism of the colon is a constant finding in organic colonic obstruction, although not pathognomonic of malignant obstruction.

In carcinoma of the large bowel, without stagnation of the content of the colon, the following may be stated as a summary of the findings (38):

1. Exaggeration of colonic antiperistalsis, giving the appearance of "peristaltic unrest" (Case) to the barium content above the site of the lesion, with arrest or hindrance in the onward progress of ingested barium.
2. Arrest or noticeable hindrance in the ascent of the barium column when giving the barium enema.
3. Coincidence of a palpable tumor with a point of hindrance to the barium meal or barium enema.
4. A filling defect in the shadow of the barium-filled colon. Frequently the filling defect is digitated, indicating a cauliflower growth. At times it may be annular so that one may diagnose an annular carcinoma.

5. The colon is often distended by gas and gas collections are seen surging backward and forward, owing to the alternations of peristalsis and antiperistalsis.

6. Marked ileal stasis when the neoplasm involves the cæcum, ileocæcal valve, or the first part of the ascending colon.

The hindrance to the ascent of the barium stream may be out of all proportion to the amount of actual obstruction. This seems hard to explain, owing to the fact that in nearly all cases the ordinary meal, as well as the barium meal, when taken by mouth, pass the tumor in compact as well as in liquid condition, whereas the lesion presents an almost insurmountable obstacle for the barium enema, causing the distal portion of the bowel to overflow, producing localized pain and tenesmus.

This difference between the behavior of the lesion to injecta and ingesta can be explained, according to Schwarz (2), only by the theory that the tumor has adapted itself, from the earliest stages, to the pressure of the stools from above, and that its funnel is shaped by the natural direction of the stools. On the other hand, the enema, which approaches suddenly from below, instead of from above, does not find the way prepared for this abnormal direction of passage, and the absolute resistance is established, thus giving rise to the picture of valve closure, because it occurs only retrogradely (*ventilverschluss*).

The overflowing of the portion of the bowel distal to the lesion, with localized pain and tenesmus, develops especially just below the point of stenosis. If the patient complains that the pain is severe, the irrigation should not be forced any further. Even the mere pressure from the irrigation might cause perforation of a disintegrating tumor.

One point to which attention is called by all writers on the subject is the necessity for repeating the examination after the lapse of a day or two, at least, in order to verify the findings.

One of the most important lessons pointed out by the foregoing summary of röntgen studies of the colon is that the X-ray investigation of any part of the alimentary tract must include a careful study of the entire digestive system. Just as in röntgenography of urinary calculi one does not feel justified in reaching conclusions without having carefully searched the entire urinary tract, so also in gastro-intestinal röntgenology one should not express any conclusions until the entire alimentary tract has been studied. The various segments of the alimentary canal present such an intimate interrelation governed by re-

flexes, not as yet any too well understood, that conclusions, especially when operative measures are to be based upon them, should be expressed only after the most thoroughgoing studies.

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**A CRITICAL STUDY OF INTESTINAL STASIS, INCLUDING NEW
OBSERVATIONS AND CONCLUSIONS RESPECTING THE
CAUSES OF ILEAL STASIS**

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A CRITICAL STUDY OF INTESTINAL STASIS, INCLUDING NEW OBSERVATIONS AND CONCLUSIONS RESPECTING THE CAUSES OF ILEAL STASIS¹

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WHILE Bouchard and Metchnikoff first furnished a rational explanation of the evil effects of intestinal stasis, it was Lane who first actually demonstrated these ill-effects by the good results of radical treatment. Whatever opinions may be reached by surgeons and internists regarding Lane's methods of dealing with alimentary toxæmia due to stasis in the intestine, the fact must be recognized that stasis does exist in a large number of cases, and that this stasis is sooner or later productive of far-reaching effects.

Not everyone who has intestinal stasis exhibits symptoms of alimentary toxæmia. Whether or not symptoms appear depends upon the integrity and functional capacity of the vital defenses of the body which normally deal with the products of intestinal putrefaction. In some cases, the defensive processes are able to destroy and eliminate even large quantities of putrefactive products; and intestinal putrefaction may exist to a marked degree and yet the patient show no signs of intestinal toxæmia. This fact is well known, of course, and attention is called to it here only for the purpose of emphasis.

As urged above, the fact of the common occurrence of intestinal stasis must be recognized and its importance conceded. The essential theme in Lane's teachings relates not so much to kinks or colectomies or short-circuitings as to the danger of continued stasis in the drainage system and the necessity of doing something, medically or surgically, to relieve it. Great credit is due this remarkable surgeon for the wave of interest in intestinal stasis which has swept over England and America, as evinced by the voluminous discussions which have been called forth in recent times, over this subject, which, as Keith puts it, is still but "a child of our ignorance." Pathologists, chemists, and bac-

teriologists have discussed the manner in which the poisons are formed and how they affect the body. Apparently it is not the poisons themselves which chiefly concern us, but the failure of the defenses of the body which should be constantly active against these poisons. Is it not, therefore, the rational thing to discourage the formation of the poisons in every possible manner, particularly through lessening the sojourn in the intestine of the material from which the poisons are formed?

The relation of pyorrhœa alveolaris and other forms of mouth infection to infectious processes within the bowel has been well established. The recent debate on alimentary toxæmia before the Royal Society of Medicine seems to make it clear that much of the bacteriological and biochemical work which has been published concerning the flora of the large intestine and their poisonous products needs further revision. The consensus of opinion seems to be that the poisons of alimentary toxæmia may, in many instances, be chemical protein derivatives of comparatively simple formulæ. There is evidently a certain relation between alimentary toxæmia and diseases of the eye, certain skin manifestations, and various other constitutional symptoms. This is generally accepted. The part of the subject still under controversy relates to peritoneal bands and their relation to kinks, intestinal stagnation, increased putrefaction, increased formation of poisons, etc. As to the cause of these bands, there is a wide divergence of opinion. The X-ray evidence which has been brought forward in support of the stasis due to these supposed kinks needs careful inquiry concerning certain sources of error, to which attention will be called later.

Through my institutional connections—the Battle Creek (Michigan) Sanitarium and

¹ Read by invitation before the New York Academy of Medicine, Annual Meeting, January 15, 1914.

St. Luke's Hospital, Chicago—unusual opportunities have been afforded me for the röntgenologic study of intestinal stasis. This opportunity has been especially rich in the surgical clinic of the Battle Creek Sanitarium and Hospital.

About two years ago the tentative rule was made that every case for which laparotomy was recommended should be subjected to a thoroughgoing röntgenologic examination before being sent to the operating room. These examinations were ordered, not only for the purpose of gaining all possible information regarding the pathological features of the individual case, but also for the purpose of checking up the conditions which, according to the röntgenologic examination, appeared to be normal, and also to check up the röntgenologic appearance of parts which, at operation, were found normal.

After the first few months of this temporary rule for routine X-ray examination before laparotomy, the results in the way of help to the surgeon, and especially in connection with the problems of intestinal stasis, have warranted the continuance of this rule. At the present time, with the exception of cases of acute appendicitis and ulcerations of the stomach or bowel where perforation seems imminent, practically every case for laparotomy is referred to the röntgen examining room prior to operation. Out of an experience covering bismuth-meal examinations of approximately three thousand cases, studied both after the ingestion of a meal and during and following the injection of a bismuth enema, I have had the opportunity to follow a large number to the operating table. Not only have the X-ray findings been checked up by the report from the operating room, but the röntgenologist has made it a point to be present as one of the assisting surgeons at as many of the laparotomies as possible. Thanks to this opportunity, I have accumulated a large amount of data concerning various portions of the alimentary tract which otherwise would not have been available. Inasmuch as many of the patients were operated on for gastric, gall-bladder, uterine, and other abdominal and pelvic conditions, often not associated with intestinal stasis, it

was extremely interesting to study the operative findings relating to kinks and torsions of the ileum and colon in connection with the motor function of the bowel, and particularly to note the frequency with which adhesions of the terminal ileum and colon were present in cases where, from the bismuth-meal examination or other clinical means of investigation, intestinal stasis had not been suspected, and in which there was no reason to believe the existence of ileal stasis. Relatively few of the patients were operated on directly for the relief of intestinal stasis.

In the experience of my colleagues and myself, it is with comparative rarity that radical surgery is necessary or profitable in dealing with intestinal stasis. Indeed, Dr. J. H. Kellogg, chief surgeon, has stated it as his belief that in scarcely more than one case of alimentary toxæmia in a hundred is short-circuiting with or without colectomy a warrantable operation.

Certainly there are exceptional cases in which dietetic and other non-surgical means have been tried thoroughly, and where short-circuiting, especially when an artificial ileocolic valve is made, has resulted in almost marvelous improvement. But the real pernicious stasis, the intestinal stagnation which is really damaging, it seems to us, is not colonic stasis, but ileal stasis. The early work of Lane dwelt more upon the stasis in the colon, but within the last four or five years his efforts have been focused on ileal stasis, and he agrees that it is of far greater importance than colonic stasis. Granting for the moment that the stagnation in the terminal ileum is due to adhesions about the terminal ileum, cæcum, or appendix, short-circuiting does not permanently relieve this ileal stasis unless a new ileocolic valve is made to act as a guard against the reflux of the contents of the colon back into the small intestine. In every case where I have made an examination with the X-ray, following the short-circuiting operation, I have observed retrograde peristalsis in the colon. In many of these cases there was also a reflux of colonic contents through the anastomotic opening into the small intestine, and the resulting stasis in the small intestine converted the terminal ileum into a

veritable colon; so that the patient, instead of having a colon five feet long, possessed a "colon" of indefinite length. In some such cases I have seen the terminal ileum having the caliber of the colon itself, so that when examined with the X-ray it was not easy to differentiate ileum from colon.

The chief purpose of this paper is to review the conditions which have thus far been advanced as causes of ileal stasis, and to lay emphasis upon a new cause of ileal stasis to which I first called attention in 1909.

Leaving out of consideration tuberculous and malignant disease in the neighborhood of the ileocæcal valve, there are, it seems to me, three efficient causes of ileal stasis.

The first cause, as suggested by Lane and later demonstrated röntgenologically by Jordan, consists in adhesions of the terminal ileum. Lane considered the ileal adhesions and stasis both secondary to stasis in the large bowel, giving rise to overloading of the cæcum and obstruction of the ileal effluent either by an acquired mesentery, an appendix hitching it up, or by simple stasis. But the acquired origin of the bands which Lane believes obstruct the ileum is questionable. According to Keith, during the third, fourth, and fifth months of foetal life, a profuse, adhesive process sets in,—a "regulated, embryological peritonitis,"—which leads to the cohesion of mesenteries and viscera to the posterior wall of the abdomen, probably the adaptation to the upright posture. The extent of this process is extremely variable. Keith states that in about one newly born child in every ten the process of adhesions will be found to have bound the mesentery of the lower part of the ileum to the iliac fossa, giving the appearances to which kinking of the ileum is attributed. These adhesions may become so extensive as to give rise to the so-called Jacksonian membrane. Keith recognizes, however, that all peritoneal adhesions in the ileocæcal region are not embryological and normal, but that occasionally in adults there are found adhesion bands which are not seen in a child at birth. These may properly be considered possible causes of ileal stasis. The majority of the adhesions, however, are in reality mere expressions of a

normal and healthy foetal process. This view of the matter has also been suggested by C. H. Mayo, Eastman, and others in America.

Ileal kinks are often found accidentally at operation, and, since they may vary within certain normal bounds, in cases where their presence has been entirely unsuspected, may we not properly inquire into the propriety of surgical treatment of these adhesion bands thus accidentally found, unless by previous clinical examination (particularly by means of the X-ray) stasis has been found to occur proximal to the so-called kink? Where obstructing kinks have been found, there was (1) a dilatation of the ileum proximal to the kink — not proximal to the ileocolic valve; (2) delay in the ileum beyond the nine or ten hours considered the limit of its normal emptying time; and (3) the stasis has occurred, as above noted, proximal to the kink — not proximal to the ileocolic junction.

Through the train of circumstances related earlier in this paper, I have examined many cases of ileal stasis which have come to operation (uterine tumors, gall-stones, gastric or duodenal ulcer, as well as some extreme cases where the operation was done for the relief of the stasis) where no adhesions were found about the terminal ileum.

Hence we must conclude that (a) there are certain forms of obstructing ileal kinks; but (b) there are numerous other cases which have come to operation for various causes, in which kinks have been found, where a carefully conducted X-ray examination has shown the absence of ileal stasis and where there were no other clinical evidences upon which to base a belief that ileal stasis existed. (c) There has been another class of cases in which ileal stasis existed and no adhesions have been found. Study of these cases has led to the conclusion that a large proportion of ileal stasis is due, not to kinking or adhesions of the terminal ileum, but to incompetency of the ileocolic valve, or to spasm of the ileocæcal sphincteric mechanism, or to a combination of these two factors.

2. Ileocæcal sphincter spasm as a cause of ileal stasis, I find, was suggested as long ago as 1908 by A. F. Hertz. In September, 1912, before the American Röntgen Ray Society,



Fig. 1. Lane's kink of the ileum. Röntgenogram twenty-four hours following the bismuth meal. The ileocæcal valve was incompetent. The behavior of this case suggests that the Lane's kink was merely an incident, and that the ileocæcal valve incompetency is the real cause of the stasis.

unaware of the work of Hertz on this point, I suggested that many cases of ileal stasis were due to spasm of the ileocæcal sphincter. As part of his contribution to the discussion of alimentary toxæmia before the Royal Society of Medicine in the spring of 1913, Hertz again suggests that ileal stasis may be caused by spasm of the ileocæcal sphincter.

In man, according to Keith, the musculature of the terminal portion of the ileum for the extent of nearly four inches above the ileocæcal valve, is endowed with a special tonic function, whereby it serves as a sphincter for the terminal foot of ileum. Keith originally suggested that the function of the sphincter was to assist in preventing the contents of the ileum from passing too rapidly into the cæcum. Others thought that its function was to act as a barrier against the regurgitation of the contents of the cæcum back into the ileum. Doubtless both functions are active, although the principal in-



Fig. 2. Lane's kink of the ileum, associated with adhesions of the appendix. Röntgenogram twelve hours post-cibum. Note the greatest distention of the ileum (*b*) is *distal* to the kink. The ileocæcal valve was incompetent. The arrows marked (*a*) point to the appendix, which lies across the ileum and is adherent to it.

fluence against the reflux of colonic contents is the muscular action of the ileocæcal valve when it is competent.

The ileocolic junction, then, consists of two mechanisms: one, the valve mechanism, which mechanically prevents a reflux of the colon contents back into the ileum; the other, the ileocæcal sphincteric mechanism which controls the rate of passage of the contents of the terminal ileum into the cæcum, and probably also assists in guarding against regurgitation of cæcal contents.

Following a bismuth meal, at least an hour elapses between the arrival of the first bismuth-mixed chyme at the end of the ileum and the passage of any appreciable quantity into the cæcum; and four or five hours, or more, after the last portion of the bismuth meal has left the stomach, the terminal ileum still contains bismuth. In other words, there normally occurs in the lower end of the ileum a delay where the chyme remains undergoing digestion for a longer period than in

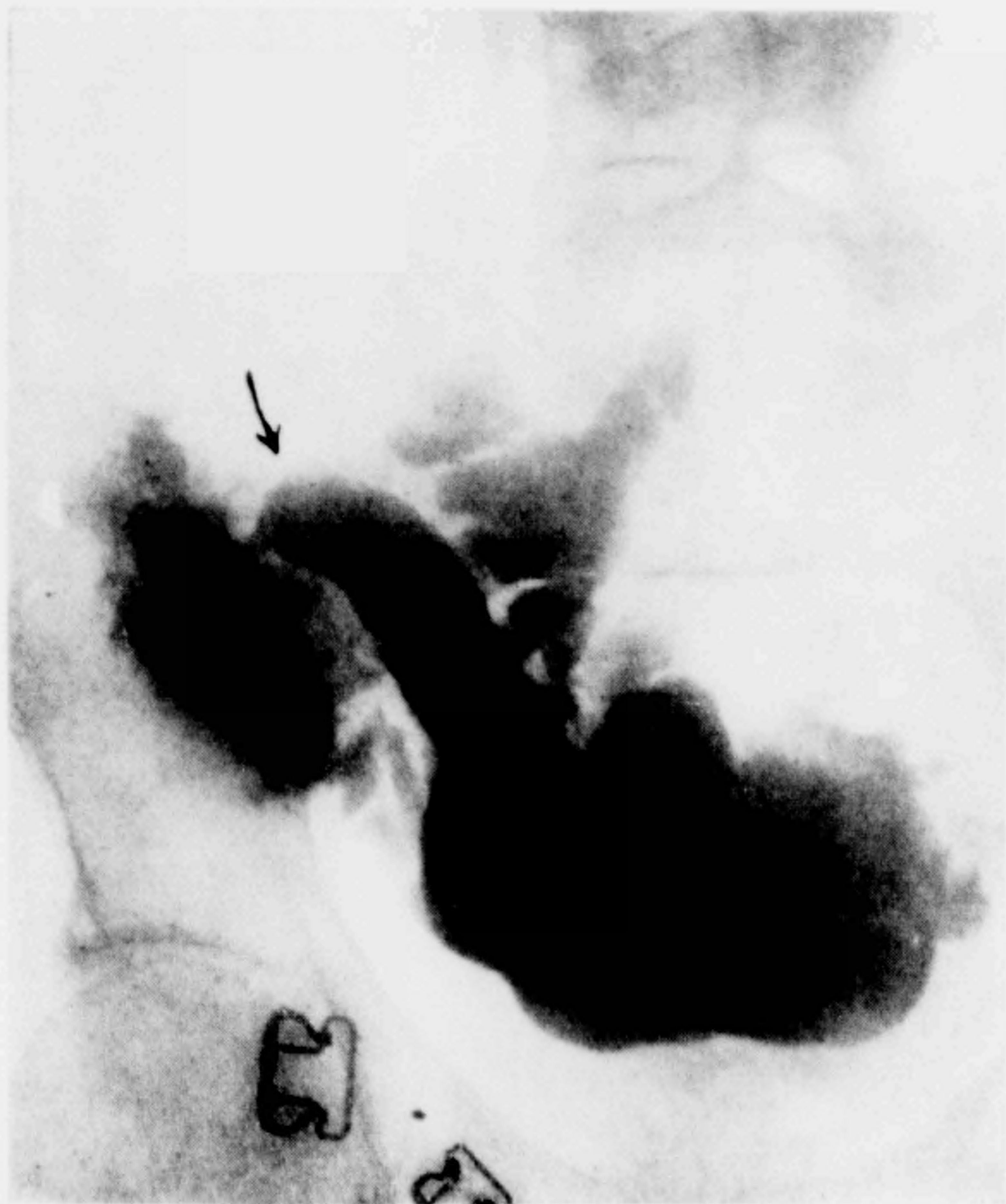


Fig. 3. Röntgenogram eight hours post-cibum, showing the terminal ileum widely filled and a trace in the caecum. The appearance of the terminal ileum just proximal to the ileocaecal valve is what the writer considers characteristic of spasm of the ileocaecal sphincteric mechanism.

the stomach. According to Hertz, a certain amount of ileal delay is thus "a normal, physiological condition of the utmost importance for adequate digestion."

The behavior of certain striking cases which have passed under our röntgenological and surgical observation strongly supports the idea that the normal ileal retention is increased in all conditions leading to spasm, probably most marked in acute appendicitis, less marked in chronic appendicitis. It is probable that other conditions, perhaps even adhesions of the terminal ileum, may also prolong the retention which, up to a certain degree, is normal in the terminal ileum.

3. As a new and additional cause of ileal stasis, I have suggested incompetency of the ileocolic valve. Kellogg, Groedel, Dietlin, Rieder, and others have since agreed on the importance of recognizing this condition.

In 1909, I began to notice the frequency with which the bismuth enema passed beyond the ileocolic valve. Looking back over our statistics, I find this percentage very con-



Fig. 4. Röntgenogram twelve hours post-cibum, showing marked stasis in the terminal ileum with an apparent ileal kink at the arrow (*a*) about three inches from the ileocaecal valve. The conical appearance of the terminal ileum at (*b*) just proximal to the ileocaecal valve is characteristic of ileocaecal valve incompetency, and when present one may prophesy that the ileocaecal valve will be incompetent to the enema. No kink of the ileum was found in this case, but the ileocaecal valve was markedly incompetent.

stant, about one out of every six gastro-intestinal cases showing incompetency of the valve. In 1911, I demonstrated röntgenograms showing incompetency of the ileocolic valve before the Gesellschaft für innere Medizin, Vienna, and shortly after, before the Royal Society of Medicine, Electrotherapeutic Section, London. Later, before the American Röntgen Ray Society, in 1912, also in 1913, I gave further papers on incompetency of the ileocolic valve. In 1912, I reported that out of a series of two hundred consecutive gastro-intestinal cases, one-sixth showed incompetency of the ileocolic valve as determined by the barium clysmas. In August, 1913, I reported more than two hundred and fifty cases of ileocolic valve incompetency in a much more extensive series (fifteen hundred), in each of which the competency of the ileocolic valve was tested. It should be noted that since these were gastro-intestinal cases referred for bismuth-meal examination, in-



Fig. 5. Marked gas distention of the abdomen, which is evidently in the small intestine, the colon being filled by the bismuth enema. This reticulated appearance of the abdominal shadow is characteristic of gas distention of the small intestine, and is nearly always associated with ileocaecal valve incompetency.

cluding suspected gastric ulcer, gastric carcinoma, duodenal lesions, gall-bladder disease, chronic appendiceal disease, adhesions, kinks, torsions, spasms, and tumors of the colon, the presence of the ileocolic valve incompetency in this relatively large proportion of cases is not surprising. The majority of the patients were constipated.

Physiologists and anatomists agree that the normal ileocaecal valve action successfully closes the ileum against the return of colonic contents, both gas and fluid. The proof of the existence of antiperistalsis, especially the proof that it occurs in man, increases the probability that the ileocolic valve should be competent under normal conditions. Our observations in connection with surgical work, as well as the observations of other surgeons during various abdominal operations, give abundant confirmation of the belief that the normal ileocaecal valve is thoroughly competent. The ileocaecal valve of the dog and of the pig are competent, withstanding enormous

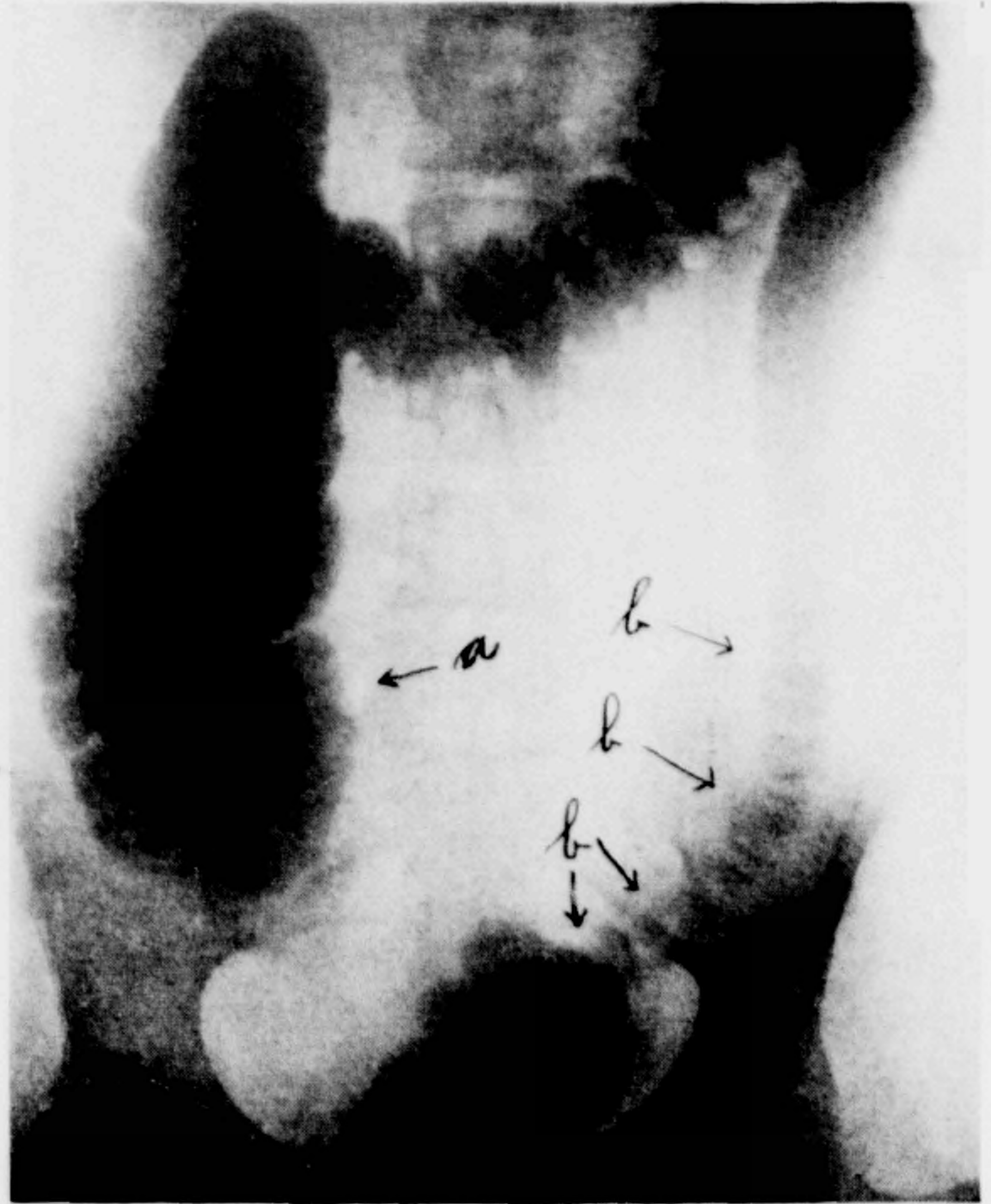


Fig. 7. Röntgenogram of the colon after bismuth injection. Ileum filled at (a) by reflux through the ileocaecal valve. Note the dilatation of the entire right half of the colon, associated with spasticity of the iliac and pelvic colon (b), so often associated with ileocaecal valve incompetency.

gas and fluid distention of the colon. Numerous experiments have been performed to determine the normal competency or incompetency of the human ileocaecal valve. The consensus of opinion is overwhelmingly in favor of its normal competency.

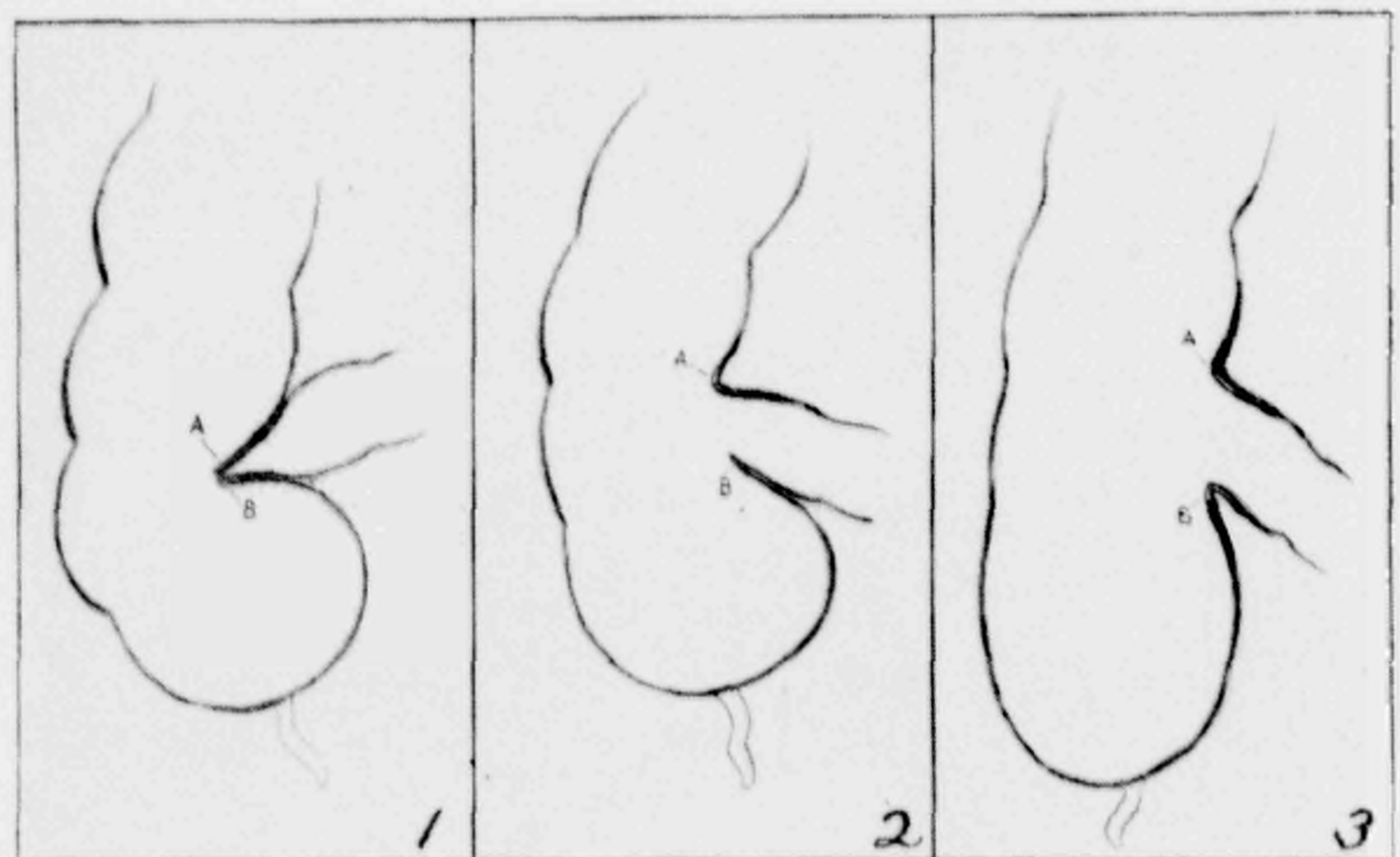


Fig. 6. Three figures (after Kellogg) illustrating ileocaecal valve incompetency: 1, normal ileocaecal valve; 2, incompetency of the valve associated with disinvagination of the upper lip; 3, incompetency of the ileocaecal valve with disinvagination of both lips.



Fig. 8. Röntgenogram after colon injection. Marked ileocecal valve incompetency, associated with spasticity of the descending, iliac, and pelvic colon. Several small diverticula of the pelvic colon.

In fifty or more individuals I have repeated the test of the competency of the valve on more than one occasion to determine whether or not the competency observed was transient or permanent. On some occasions the patients have been examined a third, and even a fourth time, the interval between the different examinations being, in several instances, as long as three months. Without exception, when the ileocolic valve has been found incompetent to the enema on one occasion, it has been found incompetent at all subsequent observations.

Ileocecal valve incompetency has been observed, not only after the clysis, but also (and this must have still greater significance) after the ingestion of the meal. In more than fifty cases I have definitely proved the regurgitation of ingested bismuth from the colon back into the small intestine. For instance, I have in numerous cases noted that the small intestine has been empty at the twelfth hour, all the bismuth-mixed content having passed on into the colon; yet observation the next morning has shown bismuth



Fig. 9. Röntgenogram after the colon injection showing the small intestine widely filled through the incompetent ileocecal valve. If one may judge the grade of incompetency by the degree of filling, and the degree of ileal stasis, the incompetency is very marked. Clinically the case was one of extreme alimentary toxæmia.

back in the terminal ileum, no new bismuth meal having been taken in the interim. This observation has been made repeatedly. If one doubts that the fact of incompetency is proved by the regurgitation of a bismuth enema into the ileum, he must certainly admit that the ileocecal valve should normally prevent the regurgitation of ingested food back into the ileum, especially ingested bismuth.

A further evidence of the fact of ileocecal valve incompetency is afforded by operative findings. In every instance where the ileocecal valve proved to be incompetent to the enema, at operation the surgeon noted gas or fluid distention of the terminal ileum, which was often present to a distressing degree in spite of thorough efforts at pre-operative bowel cleansing. It is an easy matter to test the competency of the valve at the time of operation by the following method: The ileum being clamped off by the fingers of an assistant or by carefully protected instruments some twelve or fifteen inches from the



Fig. 10. Ileocecal valve incompetency. Röntgenogram of the ileocecal region following the evacuation of the bismuth enema. The ileum widely filled. A few traces remain in the cæcum and ascending colon. The appendix was adherent to the terminal ileum. Removal of the appendix, shown in Fig. 11, cured the incompetency.

ileocecal valve, its contents are "milked" down through the ileocecal valve into the cæcum. The normal ileocecal valve prevents any regurgitation of the cæcal gas or fluid contents back into the ileum, even under considerable pressure, but the incompetent valve allows gas or fluid to pass back with readiness varying with the degree of incompetency.

Where the ileocecal valve has proved competent to the enema, the surgeon has, in the great majority of cases, confirmed this observation by the test described. There are occasional exceptions, however, in which the valve proved incompetent at the time of the operation in spite of the apparent normal competency to the barium enema. I think the failure to detect these cases by röntgenologic examination may be due to certain sources of error which are apparently unavoidable. These sources of error and the details of technique, were discussed in a paper before the American Röntgen Ray Society.¹

¹ Further Studies on the Ileocecal Valve and Appendix, read before the American Röntgen Ray Society, Annual Meeting, Boston, October, 1913.

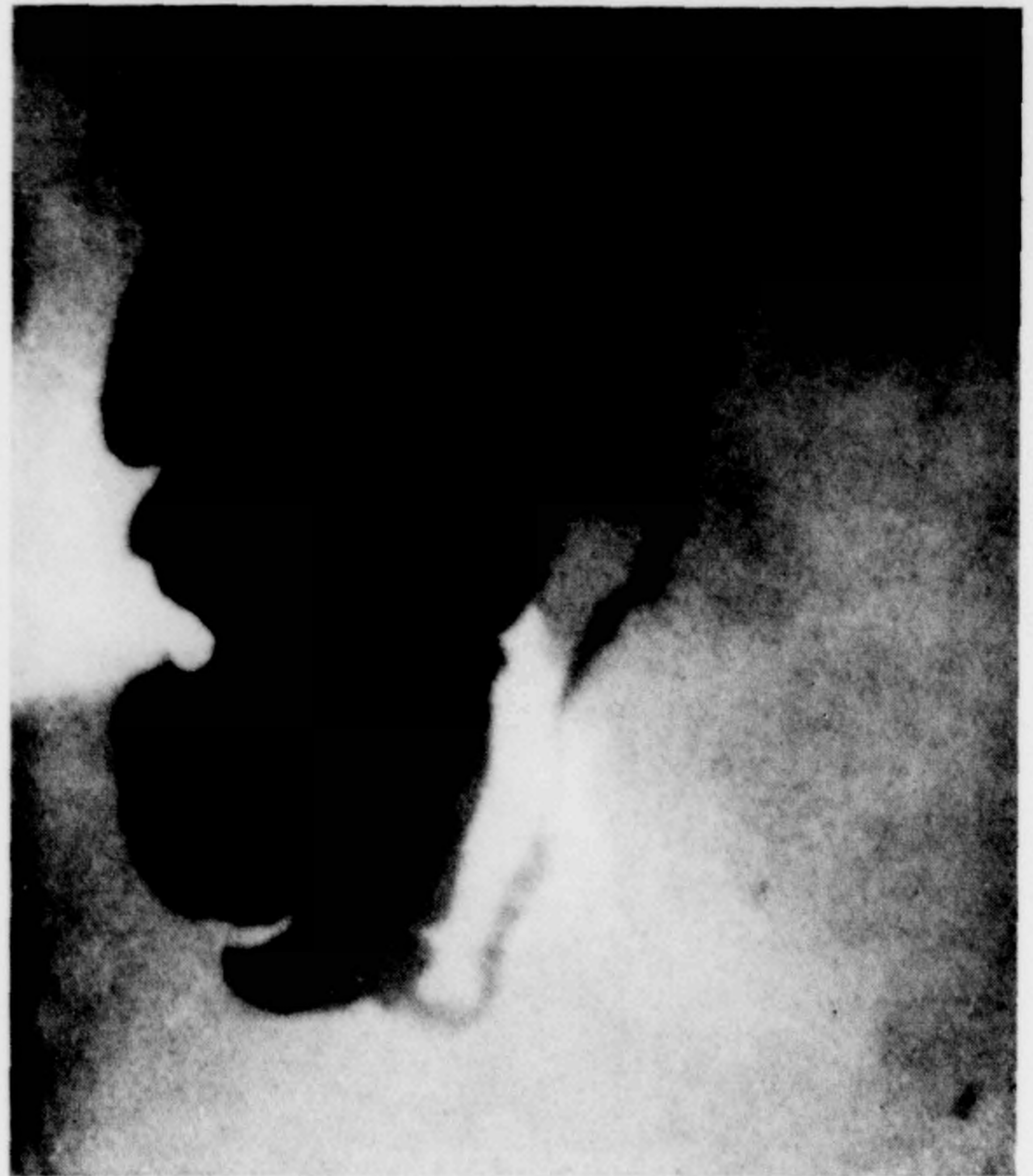


Fig. 11. Retrocecal appendix, adherent to the ileum, associated with ileocecal valve incompetency. The removal of the appendix restored the competency of the valve.

Still further proof of the normal competency of the ileocecal valve is presented in the fact that the incompetency thus shown at operation has been cured in a number of cases by a simple surgical procedure. This ingenious operation for restoring the competency of the ileocecal valve has been described by Kellogg in a recent paper.² The operation consists of skilfully placing several sutures in such a manner as to restore the invagination of the ileum without unduly narrowing its lumen. The operation is practically bloodless; it does not involve opening of the peritoneum, and it is quickly accomplished. At first Kellogg did not operate directly for the relief of the ileocecal valve incompetency. The operation was devised and performed in those cases which had come to operation for the relief of marked ileal stasis, supposedly due to ileal kinks, and yet where, at operation, no ileal kink was found. Kellogg has since then felt that the field of this operation was somewhat more extensive, and he has performed it up to the present writing (January 15, 1914) in an even hundred cases. The majority of these ileocæ-

² Surgery of the Ileocecal Valve, Surg., Gynec. & Obst., 1913, xvii, 563.



Fig. 12. Röntgenogram twenty-five hours post-cibum. The patient has had an ileosigmoidostomy. The transverse colon still retained a considerable residue on the third day. Retrograde filling of the colon has been the invariable finding in more than forty cases examined by the writer after ileosigmoidostomy.

cal valve repairs have been done in the course of operations for other causes, where the routine preliminary X-ray examination has shown ileal stasis to exist and where it appeared that the ileocæcal valve incompetency was the cause of the stasis.

The most convincing argument of the efficacy of this ileocæcal valve repair, and therefore of the important part ileocæcal valve incompetency plays as a factor in the production of ileal stasis, is found in the observation that whereas in all of these operated cases ileal stasis existed before operation, post-operative studies have shown that in every instance the emptying time of the terminal ileum has been markedly diminished and in the majority of the cases it has been reduced to seven or eight hours. Not only has there been röntgenological proof of lessened ileal stasis, usually lessened to within the normal limits, but there has been great improvement in the other clinical evidences of ileal stasis.

SUMMARY

While ileal stasis has been definitely shown to exist in connection with marked obstructing adhesions or kinkings of the terminal ileum, and while it is likely that spasm of the ileocæcal sphincteric mechanism may be another factor in the production of ileal stasis, it seems demonstrated that incompetency of the ileocolic valve offers a further and more tangible explanation of ileal stasis and that it is probably the essential causative factor in the majority of cases of stasis in the terminal ileum. Ileocæcal valve incompetency is almost invariably associated with the clinical evidences of intestinal stasis. Not all these patients have, as yet, a well-developed alimentary toxæmia. One writer has stated that, indeed, almost our only treatment, surgical or medical, is the "very primitive plan of keeping the bowels well cleared out." Short-circuiting and colectomizing operations are hazardous and often fail to cure. Appendicostomy has been performed by some surgeons. My experience in the röntgen study of these cases of intestinal stasis, both before and after operation, leads me to distinctly oppose the tendency toward operative interference for the relief of intestinal stasis. While we should not, for one moment, lose sight of what has been accomplished by surgical interference, yet according to Kellogg not more than one per cent of cases of intestinal stases are so severe that the operation of colectomizing or short-circuiting is justifiable. As Keith has stated, the colon is more of a misused than a useless structure, owing to the extraordinary changes which have taken place in the diet of man in civilized countries. Surgery should not be seriously considered as the cure for ileal stasis until a most thoroughgoing trial has been made of the various dietetic and mechanical measures at our command. If an operative measure seems advisable, recognition of ileocolic valve incompetence as a potent cause of ileal stasis may present a course of surgical treatment free not only from the dangers associated with short-circuiting with or without colectomy, but actually calculated to restore normal physiological function.