EXPERIMENTAL REFERRED PAIN FROM THE GASTRO-INTESTINAL TRACT. PART II. STOMACH, DUODENUM AND COLON

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INTRODUCTION

In the preceding paper of this series (3) observations on the pain resulting from inflation of the esophagus by small balloons were described. The general methods and purposes of the investigation were also outlined. The present communication deals with similar studies of referred sensation from the stomach, duodenum and colon.

STOMACH

Methods and material. A large balloon of thin rubber, so shaped that on inflation it assumed the general shape of the stomach, was constructed about the distal part of a mercury weighted stomach tube. The tube was passed into the stomach and then inflated by means of a large luer syringe fitted with a valve so that the amount of air introduced could be measured. The stomach tube was also connected with a U mercury manometer to measure pressure (see Fig. 1).

Sixteen subjects were studied. They were hospital patients and included people with and without stomach disorders. The following points were analyzed: (1) the amount of inflation necessary to produce pain, (2) the location of the pain, (3) the character of the pain, (4) the relation of pain to spontaneous sensations and to that produced by inflation of esophagus and duodenum and (5) the mechanism of the induced sensations. The results are summarized in Table I.

The character of the sensations. The main features of the referred sensation from gastric inflation was its indefinite quality. It was almost impossible to get exact descriptions from the subjects, but on the

whole the sensations resembled those encountered ordinarily from overloading the stomach—feelings of fullness, tightness or pressure with more or less of a painful element superimposed. In several cases there were reflex attempts to rid the stomach of the large foreign body by means of belching, or violent nausea and retching supervened. It was

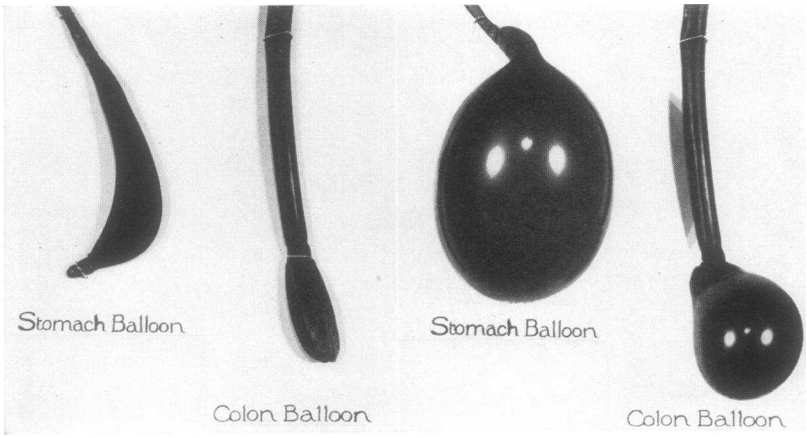


FIG. 1. STOMACH AND COLON BALLOONS—INFLATED AND COLLAPSED

of interest to observe how violently sick the subject could be as the result of a purely mechanical stimulus. When more than 600–700 cc. of air were introduced the stomach outline began to stand out as a visible fullness; in no case was there visible peristalsis. Case 14 is of interest insofar as no definite sensation resulted from distension with 1500 cc. of air. In other cases discomfort resulted (see Table I) from 200 to 400 or 500 cc. Except in Case 14, who seemed to be generally hyposusceptible to pain, no relation was found between the threshold stimulus and the patient's general nervous make-up or the presence of disease of the stomach. Cases 12 and 15, for example, with peptic ulcer responded very slightly to inflation.

When inflation was started the pressure in the bag rose rapidly to about 40 mm. Hg. and then usually remained at about this level. Apparently the stomach dilated readily on further introduction of air without exerting much increased pressure.

The location of the induced sensations. Inflation of the stomach gave sensations which were much less sharply localized than those from the

TABLE I

Abstract of case data and results of inflation of stomach

Case number	Minimum amount of air necessary to produce sensation	Site of sensation	Character of sensation	Results of further inflation	Remarks
1	1400 cc.	Just above and to right of umbilicus	Indefinite sensation of fullness. *No pain*		Chronic gastritis and anacidity. Patient's spontaneous complaint is that his stomach feels full as soon as he begins to eat. This is of interest in view of the large amount of air necessary to produce referred sensation
2	1500 cc.	Epigastrium	General feeling of fullness. *No pain*		
3	400 cc.	4 cm. below xyphoid and lower	"Sickish gas pain"	*600 cc.*—burning "sickish full feeling like when he overeats" *700 cc.*—nausea *1000 cc.*—belching *1200 cc.*—diffuse colic between xyphoid and umbilicus	Clinical diagnosis: Hyperacidity and indigestion. Low threshold for referred pain. Pain from stomach entirely unlike that from esophagus (see esophagus series—Case 16)
4	700 cc.	Half way between xyphoid and umbilicus radiating up towards left costal margin	"Painful tight feeling"	*1000 cc.*—"hurts" in epigastrium *1100 cc.*—severe pain—same place	A woman of 30 years who complained of indefinite abdominal pain. Does not describe artificial pain well but thinks it resembles her spontaneous pain and the pain from inflation of esophagus

TABLE I (*continued*)

Case number	Minimum amount of air necessary to produce sensation	Site of sensation	Character of sensation	Results of further inflation	Remarks
5	400 cc.	Epigastrium—half way down to umbilicus and up under costal margin	Diffuse discomfort—"Pressure"	*700 cc.*—pressure worse in same location followed by belching and violent nausea and retching	A woman of 34 years with gallstones and epigastric pain ½ to 1 hour p.c. relieved by vomiting. Artificial pain in same place and much like spontaneous pain
6	400 cc.	Above and to left of umbilicus	"Bloating"—no pain	*700 cc.*—slight pain below xyphoid *1100 cc.*—"pressure" half way between xyphoid and umbilicus *1400 cc.*—painful fullness in epigastrium *1500 cc.*—same	A man of 41 years with subacute combined sclerosis and anacidity. No digestive symptoms
7	500 cc.	Half way between xyphoid and umbilicus	"Burning, gnawing pain"	Sensation worse as pressure increased—at 1400 cc.—nausea	A man of 31 with duodenal ulcer. Says artificial pain resembles his spontaneous symptoms. Also similar to esophageal pain
8	200 cc.	Half way between xyphoid and umbilicus	"Slight pressure"	*400 cc.*—marked "pressure" *700 cc.*—severe cramp-like pain in same spot—felt like "cramps when bowels are going to move"	A woman of 26 years with cardiospasm. Artificial pain unlike spontaneous discomforts

TABLE I (*continued*)

Case number	Minimum amount of air necessary to produce sensation	Site of sensation	Character of sensation	Results of further inflation	Remarks
9	400 cc.	Left anterior axillary line at level of 7th rib	"A kind of ache"	On each increase of pressure had severe *pain in head*—at 1000 cc. severe pain along left costal margin	A man of 54 years with an obscure pain below left costal margin. Artificial pain in same place but unlike spontaneous
10	500 cc.	Half way between umbilicus and xyphoid	A painful fullness as when she has "eaten food and it disagreed." Not cramplike	*600 cc.*—pain very severe	A woman of 56 without digestive complaints. Stomach pain unlike esophagus pain
11	400 cc.	Half way between umbilicus and xyphoid	Feeling of "gas"	*1100 cc.*—diffuse pain below left costal margin	A woman of 32 years with "indigestion." Spontaneous symptoms unlike either induced stomach or esophagus pain
12	400 cc.	Umbilical region	"Pressure"	*1000 cc.*—pain about 10 cm. to left of umbilicus like a "side ache"	A man of 70 years with duodenal ulcer. Says he often has "side ache" like the induced pain. It is unlike esophageal pain
13	500 cc.	Epigastrium	Fullness—wants to belch	*900 cc.*—"full," can "hardly get breath." No pain *1300 cc.*—painful feeling all over region from xyphoid to umbilicus	A man of 66 years with catarrhal jaundice. Unlike esophageal pain

TABLE I (*concluded*)

Case number	Minimum amount of air necessary to produce sensation	Site of sensation	Character of sensation	Results of further inflation	Remarks
14	700 cc.	Half way between xyphoid and umbilicus	Very slight "pressure." No pain	*1500 cc.*—no sensation except vague general abdominal fullness	A man of 34 years remarkably insensitive to pain. Practically no reaction to marked inflation. See Case 34—esophagus series
15	1100 cc.	Just below xyphoid	Felt "stuffed"	*1500 cc.*—same, a little more marked	A man of 41 years with duodenal ulcer. Induced sensation not like spontaneous discomfort or like esophageal pain
16	500 cc.	Epigastrium	"Feels full all over"	*1200 cc.*—fulness and discomfort in epigastrium	A man of 54 years with peptic ulcer of esophagus. Induced sensation unlike spontaneous or esophageal pain

esophagus or duodenum. The subject usually placed his whole hand over the general area which was affected, but the sensation was usually described as deep and not on the surface. The dots in Fig. 2 show the centers of the areas indicated in the various cases; the total distribution of sensation corresponded roughly with the rectangular area. In no

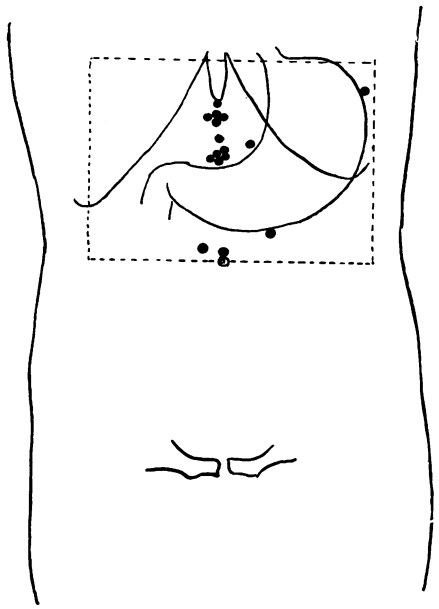
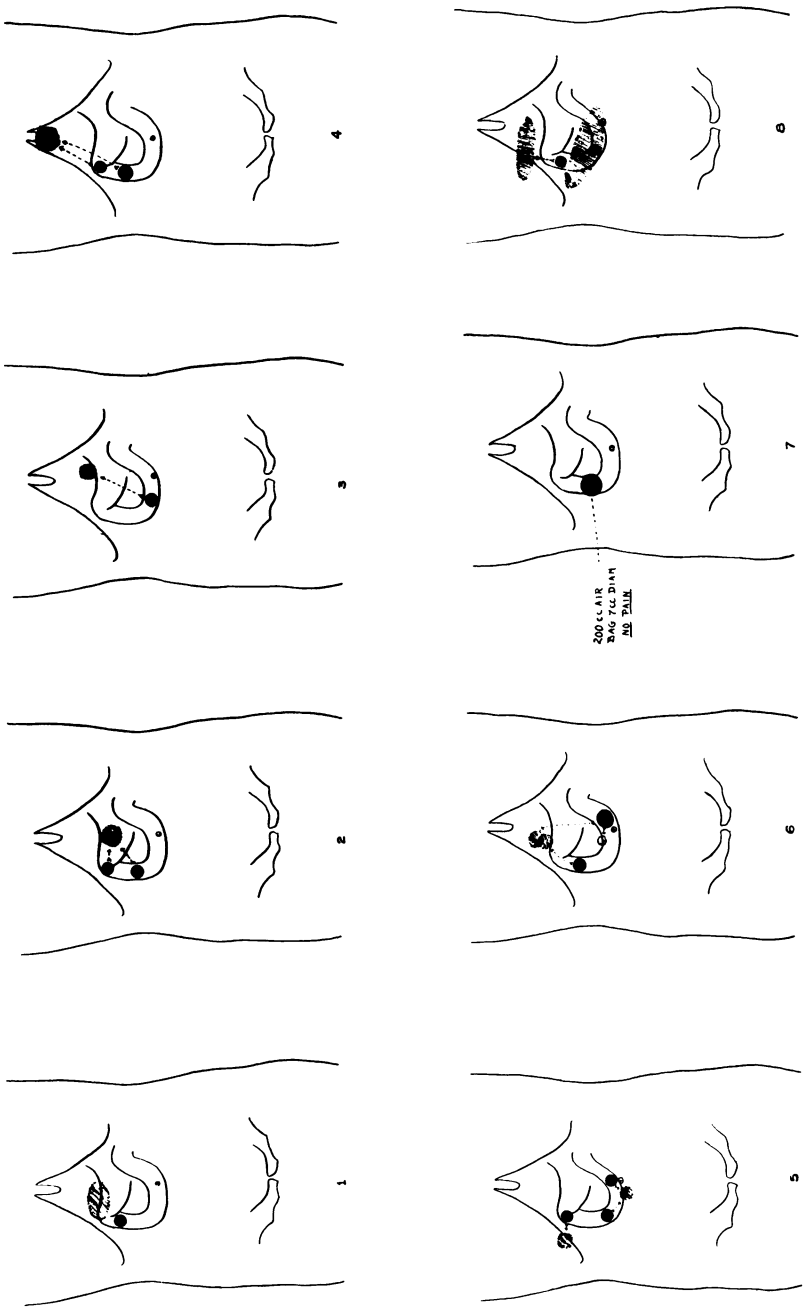


FIG. 2. EACH DOT INDICATES THE CENTER OF THE AREA OF REFERRED SENSATION FROM INFLATION OF THE STOMACH IN SIXTEEN CASES.

case did inflation of the stomach give pain much below the umbilicus or above the xyphoid with the exception of Case 9 who on each step in the inflation had severe pain in the temporal regions which was immediately relieved by releasing the pressure.

Relation of induced sensations to spontaneous discomforts and to esophageal and duodenal pain. In several cases (Cases 4, 5, 7, 12) the induced sensations were said by the patient definitely to resemble spontaneous discomforts. In Cases 4 and 7 the induced stomach sensation resembled that produced by inflation of esophagus. In other instances (see below) there was a resemblance between esophageal and duodenal pain. The point of interest and of clinical importance is the difficulty of identifying the site of the stimulus from the location of the referred sensation.


200 cc AIR
BAG 7½ DIAM
NO PAIN

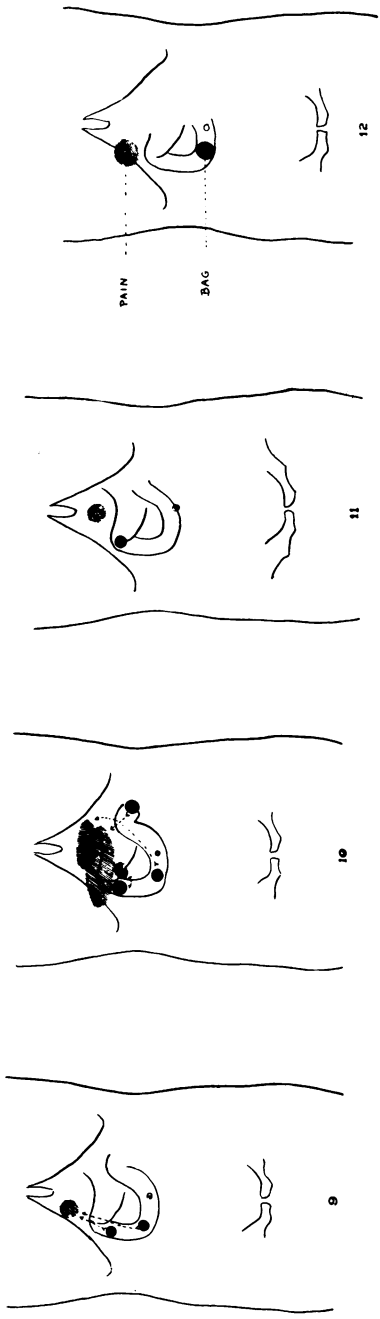


FIG. 3. REFERRED PAIN FROM INFLATION OF DUODENUM IN TWELVE CASES. The position of the bag is indicated by the solid black dots; the resulting sites of referred pain by the shaded areas.

Mechanism of the referred sensations. The abdominal surface area implicated by the referred sensations corresponded to the 7th, 8th and 9th dorsal segments. We interpreted the sensations as referred via the sympathetic. However, nausea and retching, and in Case 9 the pains in the head, seemed clearly to be reflexes through the vagus.

DUODENUM

Literature. Ivy, Vloedman and Keane (1) inflated the duodenum in three normal men with 50 cc. of air and produced nausea and chilliness. Strouse and Shamberg (2) carried out similar experiments in a larger series of people. In patients without abdominal disease they concluded that pain was localized at the position of the balloon whereas in cases of abdominal disease the results were variable or the patient's spontaneous pain might be reproduced. As will be seen below our experiments yielded somewhat different results.

Methods and material. A duodenal tube fitted with a balloon at its tip was used. The tube was passed in the usual manner and its position was verified under the fluoroscope. In a good many instances the balloon slipped back into the stomach as soon as inflation was begun so that only about one third of the experiments were successful. However, in twelve cases the procedure was carried out satisfactorily under fluoroscopic control. The exact position of the balloon, the amount of air necessary to produce sensation and the pressure in mm. of mercury, the character of the pain and other symptoms and the location of induced sensations were recorded. The subjects included hospital patients with and without digestive symptoms.

Results. The main features of the observations are summarized in Table II and in Fig. 3.

The character of the referred sensations. The character of the referred sensations was similar to that obtained on inflation of the esophagus and stomach—deep seated more or less indescribable unpleasant feelings into which entered, in various cases, elements of pressure, fullness, burning, aching or colic. In a general way the induced discomforts resembled those complained of by patients with indigestion, peptic ulcer, gallbladder disease or other abdominal disorders. They presented no specific features. In several cases nausea and vomiting were induced. On relieving the inflation the referred sensation always disappeared instantaneously and there were no after effects.

TABLE II

Summary of data from inflation of duodenum

Case number	Position of bag in duodenum	Volume of air and pressure necessary to produce sensation		Character of sensation	Location of sensation	Remarks
		Volume	Pressure			
		cc.	*mm. Hg.*			
1	2nd portion	150	100	"A severe sharp pain which doubles you up"	See Fig. 3	A man of 60 years with anacidity. Never any similar spontaneous pain
2	3rd portion	80	120	"A severe ache"	" " "	A man of 66 years with catarrhal jaundice. Never any similar spontaneous pain
	pyloric canal	40	100	same	" " "	
3	3rd portion	75		"A full cramplike feeling"	" " "	A man of 41 years with duodenal ulcer. Induced pain resembles spontaneous pain in character and location
4	1st portion	50	70	"Pain"	" " "	A man of 54 with peptic ulcer of esophagus and attacks of epigastric pain. Inducted pain resembles both his spontaneous discomfort and induced esophageal pain
	pyloric canal	50	70	same	" " "	
5	3rd portion	75	90	"A hot sticking pain" *Retching and vomiting*	See Fig. 3	A man of 60 years without spontaneous abdominal symptoms. Induced pain did not resemble esophageal pain. Outstanding reaction from both duodenum and esophagus is nausea and vomiting
	2nd portion	100	90	Severe "pain," same place		
	pylorus	50	100	Severe "pain," *nausea and vomiting*		
6	3rd portion	50	85	"Pain"—apparently a sharp colic	" " "	A man of 45 years with diabetes and obscure abdominal pain. Induced pain unlike spontaneous
	1st portion	75	85	same		

TABLE II (*continued*)

Case number	Position of bag in duodenum	Volume of air and pressure necessary to produce sensation		Character of sensation	Location of sensation	Remarks
		Volume	Pressure			
		cc.	*mm. Hg.*			
7	2nd portion	200		No sensation in spite of great inflation of bag which reached a diameter of 7 cm.	See Fig. 3	A man of 36 years with tape worm. No spontaneous abdominal symptoms
8	3rd portion	50	60	"A burning cramp"—*nausea*	" " "	A man of 27 years with "indigestion." Induced pain unlike spontaneous symptoms
	1st portion	50	60	same		
9	2nd portion	40	60	"Dull ache"	" " "	A man of 21 years with tape worm. No spontaneous digestive symptoms
		80	60	Severe sharp pain which doubled him up		
	1st portion	80	60	Same		
10	4th portion	120	80	Dull pain "like pressing on a sore"	" " "	A man of 52 years with old duodenal ulcer and catarrhal jaundice. No indigestion recently. Induced pain similar to old ulcer pain and in same region
	3rd portion	140	80	Same type of pain		
	2nd portion	130	80	A pressure feeling "like something stretched too big"		
11	pyloric canal	200	60	"Dull pressure"	" " "	A man of 65 with duodenal ulcer. Same location as "ulcer pain" but not so severe. Thinks it is same kind of pain
12	3rd portion	125		Severe pain	" " "	A man of 34 convalescent from pneumonia. No spontaneous digestive symptoms

The location of the referred sensations. Fig. 3 shows the location of the referred sensations in relation to the position of the balloon in each case and Fig. 4 shows the center of pain in all the cases and the

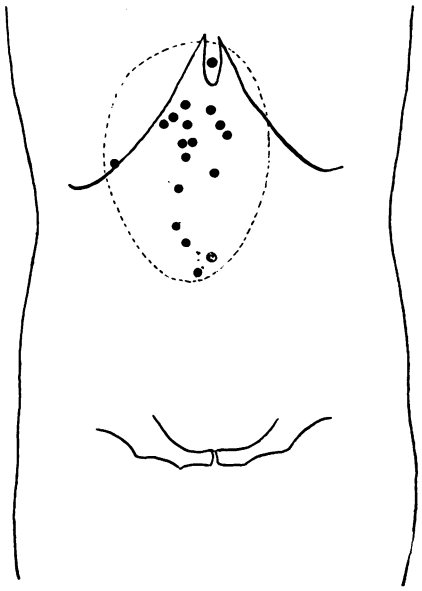


FIG. 4. DOTTED CIRCLE INDICATES TOTAL AREA IMPLICATED BY REFERRED PAIN FROM THE DUODENUM. Each dot indicates the site of pain from a single inflation.

total area which was implicated. It is seen that inflation of the duodenum may give pain from the xyphoid to the umbilicus although the right upper quadrant was most frequently referred to in these tests. We were unable to confirm Strouse and Shamberg's observation that in normals the pain was referred to the site of the balloon in contrast to other forms of reference in patients with intraabdominal disease; indeed in our cases there was no correlation of any sort. For the most part the referred pain was sharply localized (see diagrams) in contrast to the widely diffused sensations from the stomach. However the stomach and duodenal areas overlapped (see Fig. 7).

The degree of inflation necessary to produce pain. Table II shows that pain appeared in different cases with variable degrees of inflation—from 40 cc. to 200 cc. of air. The pressure in the bag also varied con-

siderably. Case 7 had no sensation even after the introduction of 200 cc. of air. It was impossible to correlate these variations with any clinical features such as presence or absence of disease of the duodenum, certainly the three cases of duodenal ulcer were not specially sensitive to inflation.

The relation of induced to spontaneous pain and of gastric esophageal and duodenal pain. Table III shows in summary these relations. In several cases inflation of duodenum reproduced the patient's spontaneous symptoms; in some instances these also seemed identical with induced pain from the esophagus. Obviously one should not go too far in drawing conclusions from statements of patients as to subjective sensations, but a point of great clinical importance is brought out insofar as one clearly must be very cautious in diagnosing the site of origin of a pain from its situation alone.

COLON

Great difficulties were encountered in introducing the balloon (see Fig. 1) into the large bowel and our observations are confined to inflations of the left colon and sigmoid. In order to prevent coiling of the tube in the rectum, which otherwise invariably occurred it was necessary to introduce the tube into the sigmoid through a proctoscope and then to attempt to pass it further. Successful observations, with the position of the bag checked by fluoroscopy, were obtained in nine patients with miscellaneous disorders, and except for Case 8 without bowel disease. We had found no reference in the literature to similar experiments on the intact bowel. Since this paper was completed we have learned that Chester M. Jones, of Boston, has presented a communication to the Cosmopolitan Club at their meeting on February 27, 1930, dealing with the problem of referred pain from the bowel as the result of inflation by means of balloons. From personal communication with Dr. Jones it appears that he has obtained results essentially similar to ours. It should also be pointed out that his present studies are the outgrowth of similar work on the esophagus which he reported several years ago at the meeting of the American Society for Clinical Investigation (5). Our work is therefore to be regarded as consequent and not antecedent to his.

Results. The results are summarized in Table IV and Figs. 5 and 6.

TABLE III

Relation of induced to spontaneous pain

Case number	Spontaneous discomfort	Induced pain		
		Esophagus	Stomach	Duodenum
1	None		All different	
2	None	Like duodenal	Unlike esophageal or duodenal	Like esophageal
3	Epigastric discomfort	Like duodenal and spontaneous discomfort	Unlike spontaneous or induced pains	Like esophageal and spontaneous discomfort
4	Epigastric discomfort	Like duodenal and spontaneous discomfort	Unlike spontaneous or induced pain	Like esophageal and spontaneous discomfort
5	None	Nausea and vomiting		Nausea and vomiting
8	Epigastric discomfort	Unlike duodenal or spontaneous pain		Unlike esophageal or spontaneous pain
10	Epigastric discomfort			Like spontaneous discomfort
11	Epigastric discomfort			Like spontaneous discomfort

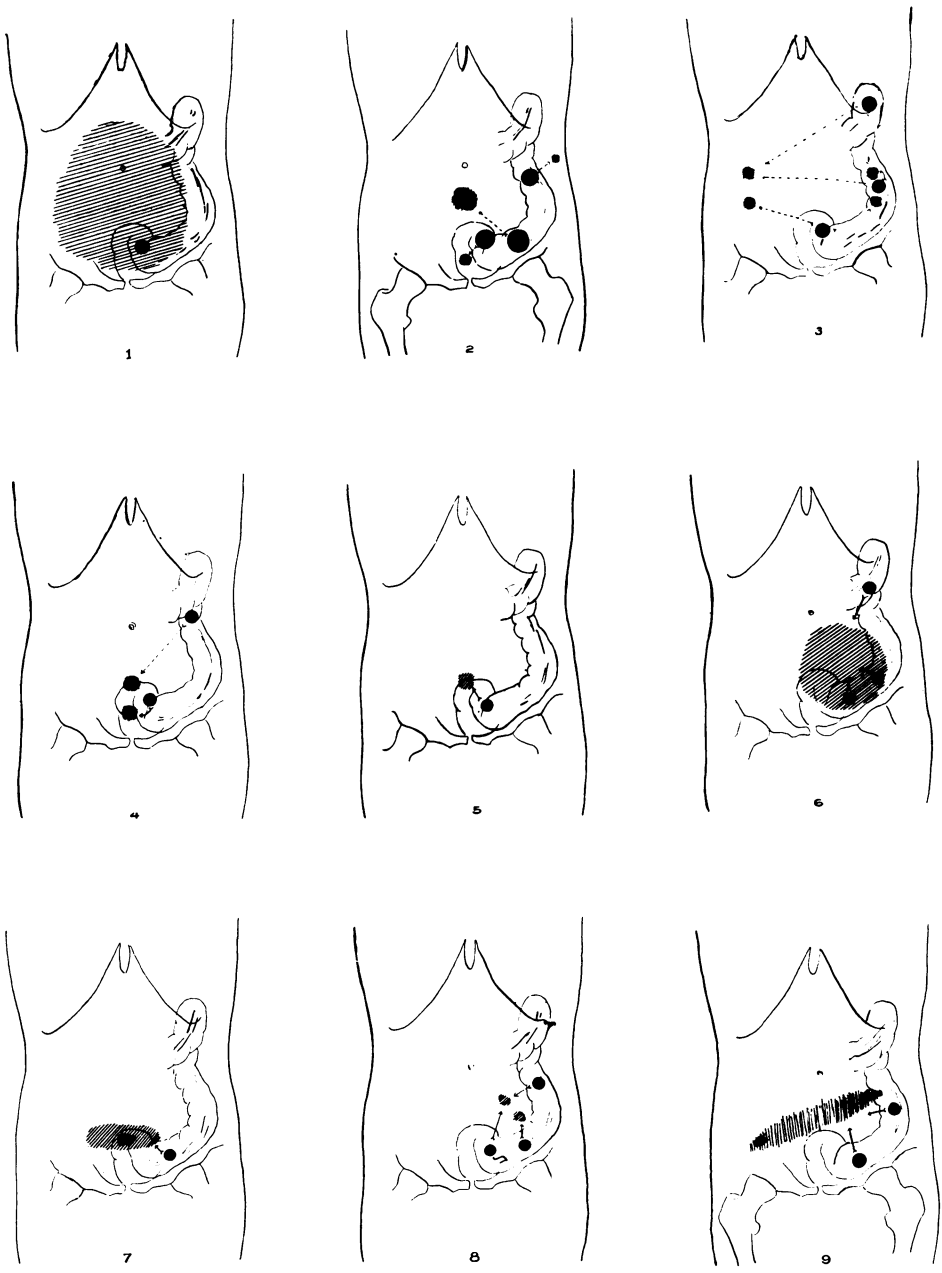


FIG. 5. REFERRED PAIN FROM INFLATION OF COLON AND SIGMOID IN NINE CASES. The solid black dots show the position of the bag; arrows point to shaded areas which indicate the resulting areas of referred pain.

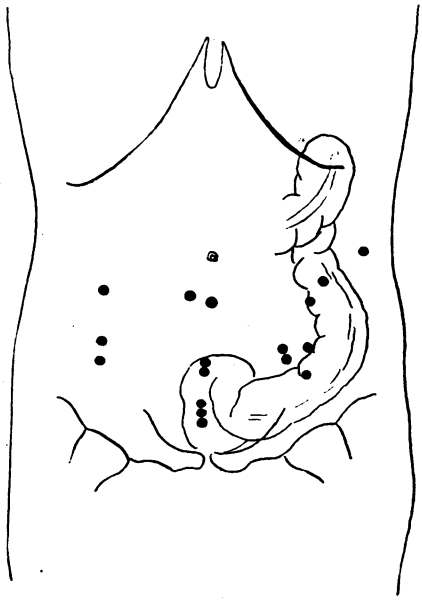


FIG. 6. REFERRED PAIN FROM COLON. Each dot indicates the center of referred pain from a single inflation.

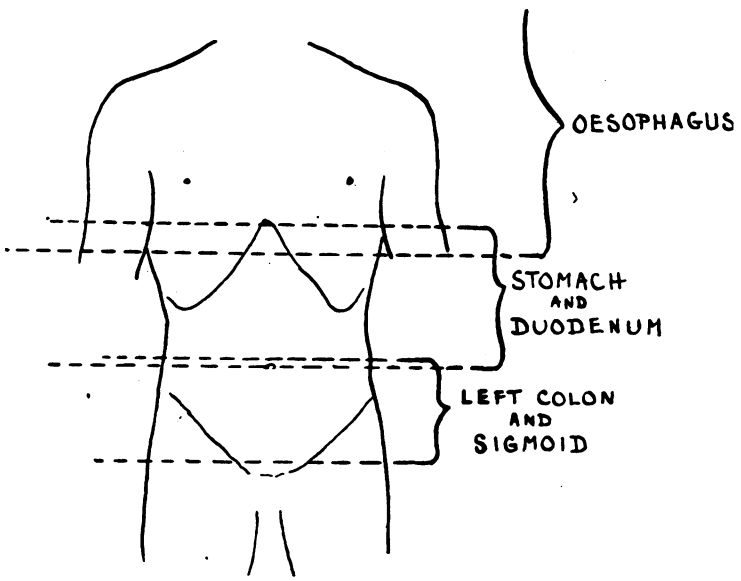


FIG. 7. AREAS OF REFERRED PAIN DEMONSTRATED BY INFLATION OF BALLOONS IN THE GASTRO-INTESTINAL TRACT.

TABLE IV

Summary of data from inflation of colon

Case number	Amount of air	Site of balloon	Character of pain	Site of pain	Remarks
	cc.				
1	500	Sigmoid	Diffuse, transient pain as air was introduced	See Fig. 5	Angina pectoris
2	150	Half way up left colon	"Pressure pain"	" " "	Aortic insufficiency
	150	Sigmoid (mid)	Same		
	150	Sigmoid (lower)	Same		
3	150	Splenic flexure	"Pain"	" " "	Normal
	150	Half way up left colon	Same		
	150	Sigmoid	Same		
4	200	Splenic flexure	Pain like "before he has to go to stool"	" " "	Indigestion—no bowel trouble
	150	Sigmoid	Same	" " "	
5	?	Sigmoid	"Pain"	" " "	Normal
6	100	Splenic flexure	Severe pain—"a kind of cramps"	" " "	Chronic constipation
	100	Lower end of colon	Same		
	100	Sigmoid	Same		
7	20	Sigmoid	Pain "like an awful stomach ache"	" " "	Peptic ulcer? No bowel trouble
8	100	Half way up left colon	"Like gas pain"	" " "	Gastritis and anacidity. Recurring diarrhea with gas pains and indigestion. Induced pain resembled spontaneous discomfort
	100	Sigmoid			
	300	Recto-sigmoid			
9	100	Lower colon	A "gassy distended feeling"	" " "	Pleurisy—no bowel symptoms
	100	Sigmoid	Same		

Referred sensations of the same general sort as those originating in the stomach or duodenum were obtained—more or less indescribable deep discomforts involving elements of fullness, pressure or colic and obviously related to sensations normally experienced in connection with movement of the bowel. As a rule pain appeared with about 100 to 200 cc. of air but in Case 7, 20 cc. sufficed and in Case 1, 500 cc. were necessary. We were unable to correlate these variations with any other features of the case. In some instances the pain was sharply localized as regards surface distribution as in Case 5; in others there was a wide indefinite area as in Cases 1 and 6. In Fig. 6 each dot indicates the center of the area of referred sensation from a single inflation. It is seen that the whole area from umbilicus to pubis is implicated and that there was no definite relation between the site of the stimulus and the site of referred pain. Of special interest, for example, was Case 9 who with the bag in the descending colon felt pain in the right lower quadrant. In some cases the bag could be moved quite a distance without altering the position of the pain (Case 3). It is evident how uncertain it would be clinically to draw inferences as to the location of a lesion from the site of pain alone. As soon as the bag was drawn from the sigmoid into the upper rectum and inflated there a new type of sensation resulted, namely a pain low in the back similar to that experienced when the bowels are about to move.

SUMMARY AND DISCUSSION

These experiments show in brief that by inflating various parts of the gastro-intestinal tract with balloons referred sensations may be produced which fall under the general heading of pain. More in detail, these sensations may be described as deep seated fundamental more or less indescribable forms of discomfort into which enter elements classed by the subject as pressure, fullness, distension, tightness, cramps or burning. In many cases the subject recognizes the induced sensation as similar to spontaneous discomforts encountered in his past experience and likens them to the sensations of overeating, of indigestion, of desiring to go to stool, etc. For the most part the induced sensations seemed to be referred to segmental areas via the sympathetic, although in some cases nausea, vomiting and remote pain as in the head or face probably represented vagal reflexes.

The main object of our studies was to throw light on clinical problems particularly with reference to the relation of site of pain to its point of origin, and it was brought out almost consistently that the superficial distribution of the referred sensations was remote from the site of the stimulus. One may mention, for example, pain in the suprasternal notch from inflation of the lower end of the esophagus, pain in the gallbladder region from inflation of the 3rd portion of the duodenum and pain in the lower mid-abdomen from inflation of the splenic flexure. While the total areas of referred sensation from esophagus, duodenum and colon are different, they overlap to some extent (see Fig. 7) so that at times it may be difficult to tell, for example, whether pain originates in the esophagus or in the upper abdominal viscera.

These facts seem to sustain the thesis laid down in the preceding paper (3) that symptoms of this sort occurring in patients do not by themselves enable one to make a diagnosis of the underlying disorder. This concept, even if not generally accepted at present, is not a new one and was championed by Sir James Mackenzie: "Attempts are continually being made to classify affections of the stomach, and the lack of agreement in these classifications is merely due to the fact that attempts are made to differentiate what can not be differentiated. This will be realized when the nature of stomach symptoms is considered. Apart from some characteristic vomits (blood, mucus), and certain changes indicated in the position of the organ (and these refer only to a minute proportion of the cases), all the symptoms are of a reflex nature, pain, cutaneous and muscular hyperalgesia, muscular contraction, vomiting and air suction. As any adequate stimulus may suffice to produce these symptoms, and as this adequate stimulus may arise from the most various causes, trivial or severe, it follows that there is a great similarity in the symptoms in diseases of the most varied kinds" (4). If all this be true it would seem to be sounder practice to admit the limitations of "digestive symptoms" in diagnosis and to realize that unless more conclusive evidence can be obtained by x-ray study or in other ways it is unwise to set up criteria which actual experience shows to be unsound.

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