promote such stasis, but add to it a very troublesome acid intoxication.

Vegetable foods such as cauliflower, spinach, asparagus, potatoes, green peas and also the stewed fruits are, I believe, a very necessary addition in order to balance the high protein foods advocated by the essayist.

As Dr. Eustis has said, the pig is fattened on corn, but we do not make the mistake in feeding the pig that we make in feeding ourselves, of separating from the grain all of the husk. We do not feed him patent flour. Highly concentrated food must be balanced by food of large bulk and low nutritive value.

Dr. Wilkerson (closing).—My reason for reading this paper was to bring to the attention of the men in general practice this subject and get them to pay more attention to it, and to recognize the condition or conditions more frequently than they do now. These people can be treated by any physician; the vast majority of them can be relieved as successfully in the country as in a good hospital, and there are thousands of women who would be better off if the medical man would be a little more careful and a little more particular in recognizing and treating this particular condition.

COMPARATIVE STUDY OF GASTRIC MOTILITY AS DETERMINED BY THE ORDINARY TEST MEAL AND SIX-HOUR BARIUM RETENTION*

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and

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Secretion, motility and absorption are the chief functions of the stomach. From a clinical point of view the motor function is the most important; the secretory stands second, while that of absorption plays a comparatively unimportant role. Since the introduction of roentgenological methods of diagnosis, disturbances of the motor function of the stomach have assumed much more clinical significance. No gastrointestinal examination is complete without determining this function.

Numerous methods have been devised for the determination of the motor function. These may be grouped under three general heads:

1. Those which depend upon the application of the stomach tube with the use of a test dinner, test supper or test breakfast.

2. Indirect tests which consist of introducing into the stomach substances insoluble in acid gastric juice, but soluble in the alkaline intestinal media, where they are split up into simpler substances which can be recognized by tests in the excretion.*

3. Roentgenological methods: fluoroscopic and radiographic.

Although the x-ray has practically supplanted all of the indirect methods, the test meal is still considered the best by some of the greatest authorities. The oldest method is that of V. Leube,¹ which consists in washing out the stomach six or seven hours after a large meal (dinner).

Various test suppers have been advocated which include, among other foods, such articles of diet as rice, cranberries, raisins, currants, etc. The stomach is washed out in the morning to ascertain if any of these articles remain as residue. The Ewald test breakfast has been used for the same purpose by washing the stomach within two hours when it should be emptied, if the motility is not impaired.

The regular technic of an ordinary test breakfast has also been employed. This method is the most desirable and practical, in as much as both secretory and motor functions can be determined at the same time, and with one introduction of the stomach tube. However, two difficulties encountered in all the former methods, as suggested by W. Wolff, had to be overcome, namely:

1. The difficulty of removing the contents absolutely without residue.

2. The inability of determining in what proportion the food residue and the gastric secretions exist in gastric contents obtained.

It is therefore clearly evident that any method devised to completely empty the stomach of its contents will remove both objections, and make it possible to determine accurately both the secretory and motor functions by the usual test meal.

This can readily be accomplished by a method introduced several years ago by one of the writers,² which consists of aspirating the stomach contents by means of a partial vacuum apparatus.

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*(a) Ewald and Siever's salol test.

(b) Fleisher's iodine test.

(c) Winkler and Stein's iodipin test.

Since the introduction of Kussmaul's stomach pump, which is now of historical interest only, numerous methods and devices for aspiration and lavage have been in vogue. These comprise the Ewald and Boas bulbs, Friedlieb apparatus, Strauss apparatus, aspirating bottles, simple expression, etc. All these methods lack two salient features:

1. The ability of applying continuous suction.
2. The means of graduating the amount of suction employed.

Gross² in 1893 was the first to attempt to meet the latter requirement by attaching to a small stomach tube and a modified Politzer bag a U-shaped mercury manometer. This proved impractical, because the apparatus was too cumbersome, and a uniform degree of suction could not be satisfactorily obtained with an aspirating bulb.

The apparatus used in our clinic consists of a filter pump connected by means of heavy rubber tubing with an ordinary vacuum gauge to which is attached a specially constructed valve for adjusting the degree of vacuum. Uniform and continuous suction to any degree desired, as expressed in inches of mercury, can thus be obtained. The water spigot serves for coarse adjustment, the valve designated as the vacuum regulator for fine adjustment as well as for a safety device, which makes it impossible to exceed the amount for which it is adjusted. For withdrawing stomach contents an ordinary wash bottle (500 c.c. Erlenmeyer flask) is attached with heavy tubing to the apparatus which is set for a vacuum of five inches of mercury. A large size stomach tube (38 French) is connected with the wash bottle and also a piece of rubber tubing of sufficient length for one end to rest on the floor. Suction is started after the stomach tube is introduced by compressing the tube on the floor with the foot; it is released by removing the foot. Thus both hands are free to manipulate the tube.

The test meal employed is the one in use at the Mayo Clinic. It consists of six "Arrowroot Biscuits," a glass (200 c. c.) of hot water and an equal amount of cold water. The "Arrowroot Biscuits" have the advantage of being palatable, uniform in weight, and always thoroughly disintegrate

in the stomach, which is a matter of considerable importance for completely emptying the stomach. The test breakfasts are always given to the patients in the office and the time, until they are removed, is carefully recorded. The stomach is thoroughly washed out after aspirating the test meal in order to determine whether it has been completely emptied.

To patients with a history suggesting retention, a supper consisting of broth, steak or lamb chop, potatoes, and a roll is given the night before and one hour later a dozen or more seedless raisins.

Partial Vacuum Apparatus for Aspirating Stomach Contents

- A—Filter pump.
- B—Vacuum gauge.
- C—Vacuum regulator.
- D—Collecting flask.
- E—Rubber tube to floor for controlling suction with foot.
- F—Stomach tube.

These are always searched for as residue in the stomach washings, after the removal of the test meal the next morning.

Comparing the results of 100 consecutive test meals removed by the expression method or with the use of a Boas bulb with 100 consecutive test meals removed by the partial vacuum method, the figures show that with the former method the average content removed was 86 c. c., and the aver-

age time for the meal was approximately 45 minutes, whereas with the latter method the average content removed was 92 c. c., and the average time for the meal was approximately 51 minutes.

If allowance be made for the difference of time the contrast between the two methods is more striking. In a series of over 100 examinations the fifty-minute meals averaged 27 c. c. more than the sixty.

TABLE I—DUODENAL ULCERS

No.	Test Meal Min.	Amount C. C.	Six-hour Retention	Acidity Free Total
1	60	130	Small	76-92
2	50	70	0	4-18
3	60	50	0	70-90
4	60	110	Large	76-88
5	60	60	0	32-58
6	60	115	0	44-62
7	60	70	0	40-60
8	60	130	Medium	36-56
9	50	100	0	42-64
10	60	190	Small	48-60

The normal emptying time of the stomach is about two hours. It has been estimated that a stomach with normal motility should not contain more than 100 c. c. one hour after the usual test breakfast.

For retention studies both fluoroscopic and roentgenographic methods were employed. The barium meal which we have used is easily prepared and is quite acceptable to the patient. It consists of barium sulphate four ounces, contents of six-ounce can of unsweetened evaporated milk, two teaspoonsful of Mellins' food, and water to make one pint. It makes a smooth emulsion and gives a shadow of equal density throughout.

In our series of 102 cases studied for six-hour barium retention, 41 cases had the test meal removed in fifty minutes with an average of 107 c. c. contents and 61 in sixty minutes with an average of 80 c. c. contents. The fifty-minute group gave an average of 139 c. c. for the retention and 100 c. c. for the non-retention cases. The sixty-minute group had an average of 110

c. c. for the retention and 66.5 c. c. for the non-retention cases.

In undertaking this study we had hoped to establish some relation of the motor function of the stomach as determined by the complete removal of the gastric contents after a test meal in a given time, with six-hour barium retention. On the whole the results have been disappointing, although at the beginning of our observation it did appear as if there was a fairly constant relation between the amount of gastric contents after a test breakfast and six-hour retention. Further observations, however, have led us to change our view as to any constant relation between the two. This is probably due to other factors than pathological which influence the motor function, such as the psychic disturbance associated with an examination and the mechanical stimulation in passing a stomach tube causing spasmodic contraction.

TABLE II—GASTRIC ULCERS

No.	Test Meal Min.	Amount C. C.	Six-hour Retention	Acidity Free Total
1	50	200	Small	30-50
2	60	50	0	22-34
3	60	70	0	72-80
4	50	240	Large	36-56
5	50	25	Small	50-60
6	50	40	0	31-58
7	50	110	0	61-78
8	60	120	0	45-55
9	60	30	Medium (Hour-class)	20-40

The disparaging results were due to the fact that in one instance six-hour retention occurred with 25 c. c. gastric contents in fifty minutes, and in another instance there was no six-hour retention with 230 c. c. gastric contents, although the latter patient had some duodenal retention. However, excluding this case, our experience shows that six-hour retention occurs in all cases in which the stomach contents exceed 200 c. c. in fifty minutes or 150 c. c. in sixty minutes.

In certain groups of cases, data has been derived which seems to be of some clinical significance.

In ten cases of achylia gastrica retention occurred in only one case and this was accompanied by marked gastropptosis with atony, although in certain cases the amount of gastric contents were much above normal. Gastric carcinoma with stenosing lesions are not included in this group.

TABLE III—ACHYLIA GASTRICA

No.	Test Meal Min.	Amount C. C.	Six-hour Retention	Acidity Free Total
1	50	20	0	
2	50	190	0	
3	60	20	0	
4	50	150	Medium	
5	60	6	0	
6	50	30	0	
7	55	120	0	
8	50	50	0	
9	50	100	0	
10	60	10	0	

In a group of 10 cases diagnosed as active duodenal ulcer no six-hour retention occurred in any case with less than the normal hour limit of 100 c. c. Retention occurred in all cases except one with more than 100 c. c. There has been greater uniformity of results in this group than in any other which is in striking contrast to those obtained in gastric ulcer. In a series of nine cases six-hour retention occurred in four: two had 200 and 240 c. c. gastric contents, respectively; the other two had 25 and 30 c. c.. One of them was definitely due to hour-glass contraction and the other could not be accounted for.

Adhesions on the right side of the abdomen, involving the pylorus and duodenum, are common and form an interesting group. Six-hour retention occurs most frequently in this group, being present in ten of nineteen patients.

In one-half of the six-hour retention cases the motor function at the beginning of digestion was either normal or above normal, as indicated by the fact that the

stomach one hour after the test breakfast contained small amounts of 40, 45, 50, 60 and 70 c. c., respectively. The case with 40 c. c. had considerable six-hour retention. The adhesions were of gall-bladder origin and the patient suffered with chronic cholecystitis. The next case with 45 c. c. suffered with gall-stones and adhesions, as confirmed by operation. She had hour-glass contraction with small six-hour barium retention. In several of these cases it was noted fluoroscopically that the stomach emptied rapidly at first, although the six-hour plate still showed barium in the stomach.

TABLE IV—PYLORODUODENAL ADHESIONS

No.	Test Meal Min.	Amount C. C.	Six-hour Retention	Acidity Free Total
1	50	200	Medium	25-38
2	60	35	0	54-68
3	50	50	Small	24-38
4	60	100	0	20-20
5	60	110	Small	26-40
6	60	105	0	68-88
7	60	45	Small	66-88
8	75	100	Small	30-46
9	60	140	Medium	20-34
10	60	40	Medium	22-38
11	60	116	0	74-94
12	50	120	0	75-93
13	60	60	0	22-36
14	60	60	0	26-46
15	50	30	0	34-44
16	50	70	Small	6-36
17	50	120	0	38-50
18	60	160	Small	22-40
19	60	60	Small	54-76

These observations indicate that frequently in adhesions involving the pylorus and duodenum the power of the stomach to empty itself is at first increased and later diminished.

The degree of gastric acidity seems to have little or no influence upon the amount of gastric contents after a test breakfast or six-hour retention. No interpretation

should be made on this point without studying the acid curve by the Rehfuß method of fractional gastric analysis.

A discussion of the motor mechanism of the stomach and the factors influencing this function has been purposely omitted, since it does not come within the scope of this paper.

The results of these studies may be summarized as follows:

1. The motor function of the stomach can be determined by the complete removal of a standard test meal with the partial vacuum method.

2. There is no constant relation between the motor function as determined by the test meal method and six-hour barium retention.

3. Six-hour barium retention occurs after a motor meal if the stomach contents exceed 200 c. c. in fifty minutes, or 150 c. c. in sixty minutes.

4. The comparative results of the two methods are most uniform and constant in duodenal ulcer.

5. Six-hour barium retention occurs more frequently in adhesions involving the pyloro-duodenal region than in either duodenal or gastric ulcer.

6. There is very little evidence to show that the secretory function has any influence on the motor function in pathological conditions affecting the stomach and duodenum.

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DISCUSSION

Dr. S. K. Simon, *New Orleans, La.*—Dr. Beck has brought up a very valuable and practical point, and one that probably every one of us has had occasion to note in the course of clinical experience, and that is the discrepancy that exists between the test meal motility and the results of fluoroscopic or roentgenological studies of the gastric motility. The cause of this has been debated for and con a bit in the past. Ever since Goldston's studies on gastric motility we have had a clearer insight into the mode of action of the gas-

tric musculature. Since that time very important contributions have been made to this subject by Dr. Mills, of St. Louis; Dr. Franklin White, of Boston, and also Cannon, of Boston.

There is one thing in trying to understand the discrepancy in gastric motility by any test meal and the x-ray results. Gastric peristalsis is not synonymous with gastric motility. We often see, especially in duodenal ulcer, a sudden desire on the part of the stomach to empty itself rapidly just after the barium meal has been swallowed. There is a rapid emptying of the stomach and a very perceptible slowing down of the gastric musculature, so that the motility, although it starts off with a rush, may at the end be perfectly normal; that is, the stomach may take its full allotted time of six hours to empty itself. In that case there is increase or hyperstalsis produced immediately by the presence of the barium meal in the stomach and by the swallowing of food, so that in the earlier phase of digestion the stomach empties itself very rapidly, but for some reason loses that excitability and settles down to more normal motor functioning.

The barium meal is not a normal meal, and that might be one of the causes of discrepancy. Barium itself is a rather heavy substance and tends to gravitate to the lower part of the stomach, and probably gives the gastric musculature a great deal more difficulty in getting rid of it in the intestine than the ordinary food substances that are taken, or the substances which compose the average test meal, such as bread and water and other preparations. That might account in some way for the discrepancy.

There is another factor involved which engages my attention, and that is the secretory function of the stomach in connection with motility. I am firmly of the belief that there is a hypersecretion entirely independent of motility. Of course, in all delayed motility there is necessarily a hypersecretion because the gastric juice is secreted as long as there is food present in the stomach and only ceases when the stomach is entirely emptied of the food. Under certain circumstances, independently of the kind or amount of food, there is an oversecretion of the gastric juice. It is largely a reflex state dependent upon ordinary reflexes or neurological factors, and in those cases in which there is an excessive secretion of gastric juice the motility is delayed with the stomach tube, but the x-ray may show a normal emptying power. That type of discrepancy has impressed me frequently: gastric hypersecretion, the stomach tube showing after the ordinary test meal a very large amount of contents made up largely of gastric juice, while the same patient undergoing fluoroscopic study will show complete emptying of the stomach within six hours.

Dr. A. L. Gray, *Richmond, Va.*—My work is exclusively roentgenology, and when I get these cases I find they have gone the rounds not only of the general practitioner or family physician, but also of the gastroenterologist or surgeon. The remarks I am about to make will be from the standpoint of the roentgenologist only.

So often the cases that are referred to me are regarded as having had so much retention after a test meal. I have found, as these gentlemen have stated, in the absence of an organic obstruction at the pylorus, there is very little relation between the emptying time of the test meal and the emptying time after the barium meal. In our efforts to arrive at any definite conclusion in x-ray examination of the alimentary tract, it is absolutely necessary to adopt a definite technic. We can not expect to obtain the same results with a meal of barium and water, or barium and mucilage solution, as we expect from barium and a custard, or barium and Bulgarian buttermilk. Especially should we not expect the same results after meals of varying sizes. Until roentgenologists throughout the country adopt a standard meal we must of necessity get variations in our results. The meal that I use is entirely different from the one reported by Dr. Beck. The simplest meal that I can get that is palatable is the one that I prefer. I mean, of course, palatable to most individuals. That is Bulgarian buttermilk, not ordinary buttermilk, because it is too thin. Occasionally you get good thick buttermilk, but as a general rule ordinary buttermilk is entirely too thin and will not suspend the barium for any length of time. This Bulgarian buttermilk, if properly made, is nearly always about the same consistency, and it contains all of the proximate principles of food. After having decided on a definite sized meal, with a definite sized dose of barium sulphate, which in my personal technic is from two to four ounces, depending upon the size of the patient, you may expect, after giving this meal, to obtain a definite emptying time in a perfectly normal stomach under certain definite conditions.

One thing that has not been brought out is the difference in the emptying time due to psychic influences and to postural conditions. If a patient is kept in bed lying on the right side, the emptying time will be much more rapid than if the patient is kept in bed lying on the back. In order to obtain these relations between the test meal and the barium meal, we should have our patients in practically the same condition both psychically and posturally. I am inclined to think that perhaps testing the motility of the stomach under a test meal is just as valuable as it is under a barium meal, but for the sake of comparison we should have these things under exactly the same conditions.

Dr. Beck (closing).—In regard to the motor meal to which Dr. Gray referred, we recognize the fact that no motor meal has become definitely standardized, although in our series we use practically the same meal and technic throughout. The studies were made under the same conditions and in the same laboratory, as all the patients were examined in our private clinic and none of them were bed patients. Thus the postural factor has been eliminated.

THE PRESENT LIMITATIONS OF THE ROENTGEN RAY IN THE DIAGNOSIS OF GASTROINTESTINAL DISEASES*

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The title of this study must necessarily be accepted in a qualified sense, for some of the limitations of today may be soon removed. Furthermore, there enter into the question both the personal equation of the investigator and the degree of thoroughness and painstaking effort expended upon the problem at hand.

The roentgen investigation of various gastrointestinal disorders has won an assured position in the diagnostic field, so that no gastroenterologist would now have the temerity to disregard its worth or deride its constructive aid. Roentgenology has displaced no previous clinical methods nor attempted to minimize their value. In early cancer of the stomach, in most of the ulcerative, malignant or organic lesions of the alimentary tract, in incipient tuberculosis of the lungs, manifested mainly by digestive disturbances, and in misplacement of the abdominal viscera, its assistance is direct and positive. There are, however, certain pathologic states where the roentgen examination affords either no sure information, or what it does demonstrate must be by indirection or inference. It is just as well that we admit this, for as much harm may be done by unwarranted as by faulty diagnosis.

GALL-STONES AND GALL-BLADDER PATHOLOGY

This is one of the most serious limitations. It is almost impossible to show a pure cholesterin gall-stone; and the chance of showing the stones at all depends on their chemical constituents, their covering or their density. If many plates are taken, with varying penetration, the chances are more in favor of showing definite shadows than when few are taken. In one of my cases there were 24 plates taken, and while 23 were as bare as the desert of Sahara,

*Read before Southern Gastroenterological Association, meeting conjointly with Southern Medical Association, Thirteenth Annual Meeting, Asheville, N. C., Nov. 10-13, 1919.