THE SYNDROME OF MILD REVERSE PERISTALSIS *

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Digestion seems to suffer very little from disturbances of secretion. Many physicians have commented on the fact that we often discover achylia gastrica accidentally in patients who have no complaint to make about their digestion. The great obstacle to making an early diagnosis of cancer of the stomach is the fact that although the mucous membrane may be almost or entirely gone, these patients ordinarily have no symptoms until the growth is large enough to block the pylorus. They will then have trouble until a channel sloughs through the tumor, after which they may be perfectly comfortable again. Similarly, there may be no complaint of indigestion after extensive resection of the bowel. Men have lived in comfort, except for an occasional diarrhea, after removal of one half of the small intestine. As Taylor[1] has aptly said, we seem to have "duplicate plants" for chemical digestion. If pepsin fails, the pancreatic ferment can come to the rescue, and when that is shut off, the gastric and intestinal ferments can, between them, do remarkably well. On the chemical side, the factors of safety are large; on the mechanical side, there is only the one muscular tube which cannot be replaced.

The conclusion, then, and it is one of the most important that the gastro-enterologist should keep in mind, is that gastro-intestinal symptoms are motor symptoms—they arise when the normal progress of the food is disturbed. We can conceive, now, of four types of motor disturbance: (*a*) speeding up of the current; (*b*) slowing; (*c*) complete stoppage, and (*d*) reversal. It is strange how little thought has been given in medical literature to the last-named possibility. We know that when a loop of bowel is distended or stimulated at any point, it can send off impulses in both directions, just as a stone thrown into a canal sends waves upward as well as downward.[2] That retrograde progress from anus to pharynx can rapidly take place has been well known since the time of Galen. All physicians have observed fecal vomiting in ileus; and many have seen the vomiting of suppositories and enemas by nervous women.[3] I have talked with a number of intelligent persons who objected to their nutrient enemas because of the bitter taste of the peptones given. Dr. Emge of this city tells me that after severe pelvic operations it has been his custom to give coffee enemas, which soon tinge the vomitus. The first time it happened he thought it was due to hemorrhage, but chemical analysis showed that it was coffee and not blood. This article could be filled with such observations culled from medical literature.[4]

It is now well known that barium enemas almost always flow back into the ileum and sometimes even into the duodenum.[5] I have seen liquid and gas pass rapidly from the colon to the duodenum in cats. The animals were anesthetized and their abdomens opened under salt solution. In order to produce this backflow, the rectum was tied off, and the colon filled with a thick soup. After this part of the bowel had become very irritable and highly tonic through its efforts at emptying, some of the material would be rushed well up into the small intestine. We know that reverse peristalsis is normal in the right half of the colon; and the return of feces from the rectum to the upper colon has been observed.[6] Boldireff and others have shown that the regurgitation of duodenal contents into the stomach is a physiologic and common occurrence.[7]

Granting, then, that reverse transport[8] of material is a common happening in the tract, and that its severe manifestations, such as fecal vomiting, are generally known, we must face the probability that milder forms are passing unrecognized. A few years ago we were diagnosing hyperthyroidism only in the cretin and in the equally deformed myxedematous; today we look for the "formes frustes" in which there is perhaps some drowsiness, a dry, hairless skin or a deficient menstrual flow. In the following paragraphs I wish to discuss briefly a few symptoms which are often found together, or alternating one with the other in the same patient, and which I believe indicate mild reverse peristalsis. The most important ones and those about which I feel surest are vomiting, regurgitation, heartburn, belching, nausea, "biliousness" and coated tongue.[9] Less important and more doubtful are globus, foul breath, and the feeling of fulness immediately after the beginning of a meal.

This article is, in many ways, a sequel to one previously published.[10] Those who have read that article will undoubtedly find it easier to understand the arguments advanced at this time. The principal point to be remembered is that the digestive tract is a muscular tube in which material moves from regions of high tone, high rhythmicity and high irritability to regions of lower tone, lower rhythmicity and lower irritability. The presence of food or of an irritating lesion in any part of the tract tends to raise the tone and irritability of that point, and in this way the normal gradient may be upset. The following experiments of Hess and Kelling may help to explain what is meant by the gradient of forces in the tract. Hess[11] put a small balloon into the bowel of a dog. A string fastened to the balloon ran out of a gastric fistula and over a pulley. At the end of the string was a little bag which could be filled with shot until its weight stopped the progress of the balloon. Eighteen cm. from the pylorus, 228 gm. were needed to balance the pull exerted by the muscle; 20 cm. farther down the pull was only 90 gm., and 12 cm. below, or 50 cm. from

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1. Taylor: Digestion and Metabolism, Philadelphia, Lea and Febiger, 1912, pp. 152, 153.

2. Cannon, W. B.: Am. Jour. Physiol., 1909, **23**, xxvii; The Importance of Tonus for the Movements of the Alimentary Canal, Arch. Int. Med., October, 1911, p. 117.

3. In a case reported by Treves, enemas of castor oil and methylene blue solution were vomited within ten minutes of their administration. He operated, expecting to find a gastrocolic fistula, but found no such cause for the phenomenon (Lancet, London, 1898, **1**, 643). A review of the literature reveals that a surprising number of these patients have been operated on for supposed gastrocolic fistulas.

4. Weber, F. Parkes: Brain, 1904, **27**, 170. Langmann: Jacobi Festschrift, New York, 1900, p. 375. Schloffer: Beitr. z. klin. Chir., 1898, **24**, 392.

5. Quimby: Am. Jour. Roentgenol., 1914, **1**, 403.

6. Schwarz: München. med. Wchnschr., 1912, **59**, 2155. Drummond: Brit. Med. Jour., 1914, **1**, 240.

7. Boldireff states that in animals which have fasted for some time, intestinal juice will run out of a gastric fistula continuously in large amounts, from 100 to 300 c.c. in fifteen hours (Zentralbl. f. Physiol., 1904, **18**, 457).

8. The term "retrograde transport" will be used in a unmber of places in which the present state of our knowledge does not permit me to say that actual reverse peristalsis occurs. More work will have to be done before we know in all cases just what type of contraction causes material to move orad.

9. Leube has discussed just these symptoms under the title "Nervous Dyspepsia" in an excellent article in the Verhandlungen des Kongresses für innere Medizin, 1884, **3**, 204.

10. Alvarez, W. C.: The Motor Functions of the Intestine from a New Point of View, THE JOURNAL A. M. A., July 31, 1915, p. 388.

11. Hess: Deutsch. Arch. f. klin. Med., 1886-1887, **11**, 105.

the pylorus, the pull was 75 gm. In a man with a jejunal fistula, I found a similar marked decrease in the pull exerted by the muscle as the balloon went down the intestine. The sluggishness of the ileum was in marked contrast to the great irritability of the jejunum. Kelling[12] has shown a reversal of these forces in dogs in which the ileum was tied just above the ileocecal sphincter. Next day, a manometer tied into the active ileum, 20 cm. above the obstruction, showed pressures varying between 10 and 20 cm. of water; while in the jejunum, the pressure was from 0 to 5 cm. It can easily be seen that under such conditions, fluids would flow backward toward the stomach.

At times, the gradient may perhaps become leveled. In a number of cases of duodenal ulcer, I have watched contraction rings appearing in various parts of the stomach and dying out again, apparently unable to advance as waves in the direction of the ulcer. A still commoner finding with duodenal ulcer and chronic appendicitis is the stomach that fails to empty itself after six hours, in spite of active peristalsis and a patulous pylorus. Roentgenologists used to speak of pylorospasm in these cases, but more and more they are realizing that the pylorus is not always at fault. Those who have learned to milk a cow will understand more easily what I mean, when they remember that it is not powerful and rapid squeezing that brings the milk, but a coordinated contraction beginning at the base of the teat and spreading downward. Many think when the barium meal does not advance that there must be either a contracted area ahead or else that the muscle is atonic. The following experiment shows that neither of these conditions need be present:

A rabbit was anesthetized (with urethan) and its abdomen opened under salt solution. The lower ileum was pinched with a hemostat so that the tissues were slightly bruised. After five or six hours, the bowel above the pinch was found distended with fluid, and contracting powerfully here and there. In spite of this activity and the fact that the lumen of the bowel was in no way occluded, nothing had been able to approach within 15 cm. of the injured, hypertonic region.

In my previous paper, I discussed upsets in gradient due to irritating lesions and to the introduction of food or other substances into the lower part of the tract. Since then, some work on smooth muscle has suggested another and possibly a very important way in which the gradients may be upset. I was able to show that the aboral progress of waves over the stomach is due, at least in part, to the fact that the latent period of the muscles around the cardia is less than that of the muscle in the pyloric antrum.[13] The muscle at the cardia is very sensitive to trauma or to adverse conditions, while that in the antrum is so hardy that it will often react better after it has been for forty-eight hours in the ice-box. This peculiar difference in the muscle from the two ends of the stomach is probably responsible for the fact that the gradient of latent period is actually reversed in distempered or sickly dogs. In these animals, the disease toxins apparently injure the sensitive cardiac muscle to such an extent that it reacts very sluggishly to strong currents. The antral muscle, on the other hand, generally contracts even more promptly than in normal animals. It seems very probable that this reversal of the gradient has something to do with the unwillingness of these dogs to take food.[14] Recent work, yet unpublished, shows that a similar reversal takes place in the gradient of latent period in the intestine in these diseased animals.

Very similar observations have been made on the heart. In the ascidian, the heart is a straight tube, one end of which acts for a while as pace-maker because it is the region of highest rhythmicity. It suffers most from fatigue, however, so that before long the other end of the heart is left with the higher rhythmicity; this now takes the lead, and the blood current is temporarily reversed. A similar upset takes place from time to time in the selachian heart.[15] Although the gradient is more stable in the hearts of higher forms of life, it has recently been discovered with the string galvanometer that a number of supposedly normal dogs have atrioventricular rhythm, that is, the gradient of rhythmicity in their auricles is reversed[16] In some human cases, a reversal has been observed which has righted itself as the patient improved in general health.[17] It seems to me very likely that the steepness of the gradient of forces in the gastro-intestinal tract varies a great deal, not only in different people, but at different times in the same person. The dyspeptic who goes on a vacation probably develops a steeper gradient; rough food will then be carried along without "hanging up" anywhere; his indigestion will go and his bowels will move normally.

Perhaps we can explain in this way the nausea and vomiting of nervous, worn-out women. Some of the most striking manifestations of reverse peristalsis are observed in the hysterical. Roentgenographic examinations and exploratory operations often reveal nothing to account for the trouble, and it can be cured only by rest and overfeeding.

VOMITING

The progress of gastro-enterology has been greatly hampered by the idea that the stomach is the organ of digestion. Even physiologists have been so blinded by this idea that very few of them have paid any attention to the behavior of the intestine during vomiting. My own experience soon convinced me that vomiting may begin with increased tone and activity in the jejunum.[18] I was able to confirm Ewald's statement that in ileus the stomach is filled with intestinal contents long before fecal vomiting appears.[19] Vomiting has been produced in dogs by reversing stretches of jejunum, so that the current would set backward toward the stomach. These dogs could be kept alive and comfortable if fed soft foods slowly. Large meals or rough food would be rejected.[20] It has been

12. Kelling: Ztschr. f. Biol., 1903, **44**, 249.
13. Alvarez, W. C.: Am. Jour. Physiol., 1916, **41**, 321.
14. Alvarez, W. C.: Am. Jour. Physiol., 1917, **42**, 430, 446.
15. Bottazzi: Ztschr. f. Physiol., 1902, **43**, 404.
16. Eyster and Meek: Heart, 1913-1914, **5**, 119.
17. Williams and James: Heart, 1913-1914, **5**, 112. Hart: Ibid., 1912-1913, **4**, 128.
18. Openchowski (Zentralbl. f. Physiol., 1889, **3**, 4), in describing vomiting says, "In the beginning, great activity of the intestine" (anfangs starke Unruhe der Gedärme). Poensgen says waves have been observed to travel from the duodenum on to the stomach in vomiting (Motor Verricht. d. menschl. Magens, 1882, p. 8). Similar statements have been made by Wepfer, quoted by Brinton (Cyclopedia of Anatomy and Physiology, London, 1859, **5**, 317) and by Müller (Handbuch der Physiologie, 1835, **1**, 485). Boldireff noted, during some experiments, that periods of intestinal activity were often accompanied by vomiting (Zentralbl. f. Physiol., 1904, **18**, 489). I once attended a child with severe recurrent vomiting in whom the attacks were preceded by violent intestinal peristalsis and borborygmus loud enough to be heard across the room. I have also seen vomiting of the food given through a jejunal fistula. Such feeding must be done very slowly with the food exactly at body temperature. Vomiting has been observed also in feeding by duodenal tube (Stockton: Diseases of the Stomach, New York, D. Appleton & Co., 1914, p. 81).
19. Ewald: Berl. klin. Wchnschr., 1907, **44**, 1416.
20. Mühsam: Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1900, **6**, 460. Enderlen and Hess: Deutsch. Ztschr. f. Chir., 1901, **59**, 240.

shown repeatedly that the vomiting is not due to the irritation of bile and pancreatic juice in the stomach,[21] so I believe it must often be due to, and part of, the reverse peristalsis beginning in the bowel. It should be noted that vomiting is often severe with low intestinal lesions and that it may be entirely lacking in serious gastric disease, such as ulcer and carcinoma (without pronounced pyloric obstruction).[22]

Vomiting is often severe in pregnancy and with some lesions of the pelvic organs. I refer here not to the so-called "toxemic" but to the "reflex" or "nervous" type of vomiting. I believe the uterus in some way influences and raises the tone, irritability and activity of the lower part of the bowel, so that there is a tendency to reverse peristalsis. The greater activity of the colon may be due to its sharing in the hyperemia of the pelvic organs.[23] It is conceivable also that there may be a spread of tone along the pelvic nerves. Elliott and Barclay Smith found that they could raise the tone of the midregion of the colon, and produce anastaltic waves by stimulating these nerves in animals.[24] This tendency to reverse peristalsis in pregnancy was well recognized by Campbell[25] who suggested that we utilize it in giving nutrient enemas in the vomiting of pregnancy. He felt sure that these enemas would be carried well up into the small intestine where they could be digested and absorbed. It is interesting that the ancients also recognized this tendency to anastalsis. The Brugsch papyrus advises, as a test for pregnancy, the giving of pounded watermelon in milk; if the woman has flatulence only and no vomiting, she is not pregnant.[26] Hippocrates used "hydromel" in much the same way.[27] It is not a bad idea that an irritant not sufficient to upset a normal tract might be able to reverse one that already was tending that way.

It seems to me that those who ascribe the vomiting of pregnancy to toxins derived from the fetus do not pay enough attention to the fact that exactly similar phenomena are seen in many women on the first day of menstruation, at the menopause and with some pelvic diseases, such as dragging displacements, fibroids and pus-tubes. There is a large literature on this subject, and the symptoms enumerated are those discussed in this article. They often disappear immediately after hysterectomy, ventrofixation, etc. I have seen similar disturbances in a few men with large prostates and distended bladders.[28] It does not do any good to call these troubles "reflex" when the path cannot be pointed out. Gaskell's research has absolutely demolished Robinson's idea that the solar plexus is an "abdominal brain" with reflex centers.[29] The stormy vomiting and dynamic ileus often seen after pelvic operations may be due to a great and sudden increase in the irritability of the colon. One may also explain in this way the severe gastro-intestinal upset seen sometimes after injury to the testis.[30]

REGURGITATION

Vomiting shades off into regurgitation in many cases.[31] People will taste certain foods all day; particularly fats, which tend to return from the bowel into the stomach.[32] Often in duodenal ulcer, gallbladder disease and chronic appendicitis there will be regurgitation of bile-stained fluid before breakfast. Some women regurgitate only at the beginning of the menstrual period. Troublesome regurgitation may cease a few minutes after the patient has a bowel movement. The distention of the pelvic colon may have been keeping that region overactive and causing it to give off reverse waves.[33] These waves need not be so powerful that they sweep material along before them. Some time ago, while recording the activities of seven different regions of the rabbit's intestine on the same drum, I found that short peristaltic rushes here and there were originating in ripples that were coming, unnoticed by the naked eye, all the way from the pylorus.[34] In the same way, I believe it probable that ripples coming from a full and overactive colon, or from the irritable ileocecal region in appendicitis, will run up the bowel and show themselves in the stomach and esophagus as waves of acid regurgitation. The objection may be raised that the connective tissue block at the pylorus which prevents the spread of gastric waves on to the duodenum will likewise prevent the upward spread of reversed waves. I think, however, that since my records from the cat's intestine show that ripples beginning in the duodenum generally coincided with, and probably were part of, waves arriving at the pylorus, it is quite possible that ripples going in the opposite direction can also pass the barrier.

The following case is very suggestive: A constipated infant regurgitated so much that her pillow was always soaked. After weeks of this her bowels suddenly became a little loose, and the day this occurred, the mother was surprised to find the pillow perfectly dry. It remained that way for over a week, until the bowels became constipated again. Apparently the establishment of a good current downward instantly

21. The duodenum has been closed off in man so that all secretions had to go through the stomach on their way to the jejunum, and yet there was no trouble (Moynihan: Brit. Med. Jour., 1901, **1**, 1136). Chlumski performed similar operations on dogs without causing them to vomit (Beitr. z. klin. Chir., 1898, **20**, 519-523). Cholecystogastrostomy in man and dogs does not produce vomiting (Oddi: Confer. Clin. ital., Milan, 1897, **1**, 77). See also Kolbing: Beitr. f. klin. Chir., 1902, **33**, 518. Ledderhose: Arch. f. klin. Chir., 1899, **59**, 153. Wiedemann: Beitr. z. klin. Chir., 1914, **89**, 594. Rosenberg: Arch. f. d. ges. Physiol., 1898, **73**, 419.

22. Faulhaber and von Redwitz: Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1914, **28**, 157. Cohnheim and Dreyfus produced vomiting in dogs by distending a balloon in the intestine. They found that a slowing of gastric motility could easily be effected by irritating the bowel, whereas it was not observed after the production of a severe gastritis. They point out that we must look more to the intestine for the cause of gastric disturbances (Ztschr. f. physiol. Chem., 1908, **58**, 56, 82).

23. Carnot and Glenard noticed while perfusing the excised intestine that its activity was greatly increased when the blood flow was more rapid (Compt. rend. Soc. de biol., 1912, **72**, 496, 661). An increased activity of the colon might account for the looseness of the bowels in many women during menstruation.

24. Elliott and Barclay Smith: Jour. Physiol., 1904, **31**, 282.

25. Campbell (Tr. Am. Gynec. Soc., 1878, p. 268) says that the woman with pregnancy or pelvic disease has an irritable tract in which "response is usually by inverted rather than by direct action: eructation, regurgitation, nausea, vomiting, constipation, far more frequently than diarrhea and other manifestations of downward action. The tract gets into the habit of retrostalsis."

26. Neuberger: History of Medicine, London, 1910, **1**, 29.

27. Hippocrates: Adams' Translation, New York, **2**, 242.

28. Herschell describes three cases of vomiting in men with retention of urine; two were cured by beginning the catheter life, the other by operation (Med. Press and Circ., 1905, **130**, 559). See also Hutchinson, Brit. Med. Jour., 1910, **1**, 485. Stockton: Diseases of the Stomach, New York, D. Appleton & Co., 1914, p. 129. Peyer: Samml. klin. Vortr., 1890, p. 3182. Austin: Diseases of the Digestive Tract, St. Louis, 1916, p. 52.

29. Gaskell: The Involutary Nervous System, London, 1916.

30. An inflamed hydrocele, contusion of the testicle, or operation for hemorrhoids may bring about the picture of acute ileus (Müller: Deutsch. Arch. f. klin. Med., 1912, **105**, 37).

31. Austin: Diseases of the Digestive Tract, St. Louis, 1916, p. 337. Cohnheim: Digestive Disorders, Translated by Fulton, Ed. 3, Philadelphia, J. B. Lippincott Company, 1914, p. 244. Valentin: Lehrbuch der Physiologie, 1847, **1**, 273. Paterson, in describing a case of chronic appendicitis, said: "Thirteen or fourteen years ago the patient began to suffer from 'risings in the stomach,' and seven years ago he began to suffer from attacks of vomiting" (Proc. Roy. Soc. Med., 1910, **3**, Surg. Sect., p. 193).

32. Alvarez, W. C.: The Motor Functions of the Intestine from a New Point of View, THE JOURNAL A. M. A., July 31, 1915, p. 388, Notes 43 and 44.

33. Smith and Lewald say, "The frequency with which colic accompanies regurgitation is suggestive of their commoin origin." The waves causing regurgitation may arise in the overactive part of the intestine where there is colic (Am. Jour. Dis. Child, April, 1915, p. 271).

34. Alvarez, W. C.: Am. Jour. Physiol., 1915, **37**, 273.

stopped all regurgitation upward. The ancients not only gave purges to stop vomiting, but they stopped excessive purgation by giving emetics.[35]

HEARTBURN

Before giving my views as to what heartburn is, I must emphasize what it is not. A good many years ago I was surprised to find that only a small proportion of the patients complaining of sour stomach and heartburn have an actual increase in their total acidity and free hydrochloric acid. Titration of the burning fluid that was being regurgitated often showed subacidity, and gastric analyses made during periods of discomfort did not show values any higher than those made during periods of relief. A review of the literature showed that similar observations have been made by every writer who has done any work on the subject.[36] As far back as 1884, Reichmann[37] stated clearly that although it might be customary for laymen and physicians to ascribe heartburn to an increase in gastric acidity, such an increase could only occasionally be demonstrated.

This fact is not so surprising when we remember that almost all of those who have put from 0.5 to 2 per cent. hydrochloric acid into the human stomach by tube agree that the mucous membrane cannot sense it as pain or heartburn.[38] At most, there is a slight feeling of warmth. A number of writers assert that the diseased stomach is so hyperesthetic that it can feel the acid. Talma and his pupils found in a few cases with possible ulcer that the acid would cause pain, rarely burning.[39] This idea of a hyperesthetic mucous membrane has been discredited, however, by the work of Hurst,[40] Löwenthal[41] and Schür,[42] who showed that persons with ulcer, demonstrated later at operation, could not feel the acid any more than normal persons can. It might also be remarked that heartburn is not a common complaint with gastric ulcer. Recently the work of Ginsburg, Tumpowsky and Hamburger[43] indicates that pain felt by ulcer patients on the introduction of acid is due not to a direct irritation of the nerve-endings, but to powerful contractions set up by the acid. Some writers adopted the idea of "hyperaciditas larvata"—a hyperacidity which is present long enough to produce symptoms, but which disappears about the time the stomach tube is passed. Schmidt thought the persons with pain and heartburn must have lost a protecting layer of mucus over the gastric lining.

It seems to me that the true explanation is the one given by Reichmann[37] thirty-three years ago. He had people swallow a little gelatin-coated sponge on the end of a string. This was left for ten minutes in the esophagus just above the junction of the middle and lower thirds. It was found that the fluid expressed from the sponge was acid in the persons who had heartburn and alkaline in normal controls. He concluded, therefore, that heartburn is due to the regurgitation of more or less acid gastric juice through a relaxed cardia into the esophagus. This view has been held independently by a number of observers. Some doubt has been cast on it by the work of Hurst,[40] who states that the esophagus is not sensitive to acid. This seems strange in view of the fact that those who have experimented with acid have had to give it by stomach tube so as to avoid burning sensations in the pharynx and esophagus. The lower pharynx seems to be much more sensitive than the esophagus, and most persons feel the heartburn in the back of the throat.[44] Further work is needed before we know just where and how the acid causes burning. Some of my patients who take dilute hydrochloric acid complain of burning, others do not. I have experienced severe and typical heartburn after drinking "acidol"[45] in water. Some nervous women complain at times of a burning feeling in the epigastrium, as if the stomach were "on fire." This is probably an entirely different thing—a paresthesia which at times moves down over the right hip, showing that it has nothing to do with the stomach.

To my mind the most suggestive thing about true heartburn is its well known association with belching and regurgitation. Patients often say they feel the burning when the fluid comes up. Occasionally it is worse when the sufferer is lying down, perhaps because the gastric juice can then more easily run back up the esophagus. It is often brought on by eating fats which, as I have already pointed out, favor regurgitation. This may be due to the fact that they depress gastric activity while at the same time they stimulate the bowel. Many men suffer from heartburn after using tobacco. In habitués, some regurgitation of gastric juice probably represents the nausea and vomiting of the neophyte.

Many persons with heartburn are relieved by taking alkalis. These drugs may do good in two ways: first, by neutralizing the acid in the stomach, and secondly, by enabling the patient to belch so noisily and satisfactorily that he does not feel the need of doing it again for the rest of the day or night. When there is no regurgitation and belching, there is rarely any heartburn. The fact that many people with subacidity are relieved by soda shows that its virtues are not due entirely to its antiacid effect. I have seen a few persons who were made worse by alkalis and were immediately relieved by the administration of hydrochloric acid. I was led to try this by Cannon's[46] observation that an increase in gastric acidity closes the cardia

35. Paulus Aegineta: London, 1847, **3**, 489, 499. Hippocrates also recognized the possibilities of reversing the current. He says, "In confirmed diarrhea, vomiting, when it comes on spontaneously, removes the diarrhea" (Adams' Translation, New York, **2**, 252).

36. Schütz made a careful study of 830 cases, and concluded that only a small percentage of people with hyperacidity have symptoms (Wien. med. Wchnschr., 1906, **56**, 2241-2410). See also Steele, J. D.: The Relation of Excessive Gastric Acidity to Gastric Symptoms, THE JOURNAL A. M. A., Aug. 18, 1906, p. 496. Stockton: Diseases of the Stomach, New York, D. Appleton & Co., 1914, p. 157. Palfrey: Am. Jour. Med. Sc., 1913, **145**, 796. Lockwood: Diseases of the Stomach, Philadelphia, Lea & Febiger, 1913, pp. 461, 465. Von Noorden: Ztschr. f. klin. Med., 1904, **53**, 2. Gross, M. H., and Held, I. W.: Ulcus Ventriculi, Arch. Int. Med., March, 1914, p. 445. Verhaegen: La cellule, 1897, **12**, 70. Illoway: Arch. f. Verdauungskr., 1902, **8**, 135. Blankenhorn, M. A.; Harmon, G. E., and Hanzlik, P. J.: Some Clinical Physiologic and Chemical Observations on Ptomain Poisoning from "Creamed" Codfish, Arch. Int. Med., January, 1916, p. 140. Kauffmann: Ztschr. f. klin. Med., 1905, **57**, 491; Arch. f. Verdauungskr., 1907, **13**, 622. Leube: Verhandl. d. Cong. f. inn. Med., 1884, **3**, 215.

37. Reichmann: Berl. klin. Wchnschr., 1884, **21**, 769.

38. Hertz: Proc. Roy. Soc. Med., 1910, **3**, Surg. Sect., p. 101. Carlson and Braafladt: Am. Jour. Physiol., 1914, **36**, 163. Ginsburg, Harry; Tumpowsky, Isidor, and Hamburger, W. W.: Contributions to the Physiology of the Stomach, XXX, The Newer Interpretation of the Gastric Pain in Chronic Ulcer, THE JOURNAL A. M. A., Sept. 30, 1916, p. 990. Zimmermann: Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1909, **20**, 445. Löwenthal: Berl. klin. Wchnschr., 1892, **29**, 1188. Schür: Med. Klin., 1911, **7**, 919. Schmidt: Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1908-1909, **19**, 278. Bönniger: Deutsch. med. Wchnschr., 1908, **45**, 396.

39. Talma: Ztschr. f. klin. Med., 1884, **8**, 407.

40. Hurst: The Sensibility of the Alimentary Canal, London, 1911, p. 12. (In a recent letter the doctor tells me he has changed his name from Hertz to Hurst.)

41. Löwenthal (Note 38, fifth reference).

42. Schür (Note 38, sixth reference).

43. Ginsburg, Tumpowsky and Hamburger (Note 38, third reference).

44. On numberless occasions I have seen barium-containing milk thrown quickly and forcibly back into the upper part of the esophagus. This seemed to be due to powerful contractions of the muscle near the cardia. It must be remembered that sensations derived from the esophagus between the clavicles and nipples may be referred either upward into the throat or downward to the epigastrium (Boring: Am. Jour. Psychol., 1915, **26**, 34).

45. Hydrochloride of betain, which liberates hydrochloric acid in solution.

46. Cannon: Am. Jour. Physiol., 1908, **23**, 105.

more tightly, and prevents regurgitation into the esophagus. It is possible that some persons have congenitally relaxed or patent cardias. Kelling[47] has observed this with the esophagoscope. This seems the more likely when we remember that the cardia is not a well formed sphincter like the pylorus. In many of the lower vertebrates it is practically absent.

If heartburn is due to regurgitation of gastric contents into the esophagus, why is it that the food that comes back into the mouth sometimes tastes so fresh and good that it can be chewed and swallowed again, while at other times, in the same person, it is fluid, bitter and intensely acid? It is now well known that there are three physiologically distinct parts of the stomach: the fundus, which holds the food practically motionless, often in layers as it comes in; the muscular antrum, which breaks the food down into a purée and mixes it with the gastric juice, and the canalis gastricus, which carries fluids along the lesser curvature and out into the duodenum. I believe the regurgitated food that tastes fresh has come from the top of the pile in the fundus. The burning fluid comes from the antrum or even from the duodenum,[48] and has probably traveled up the gastric canal.

Heartburn is often very severe and trying in pregnancy, when it may take the place of vomiting. It may be a prominent symptom on the first day of menstruation, with pelvic disease, and at the menopause.[49] Care must be taken, however, to rule out cholecystitis in these cases. Heartburn may be marked in chronic appendicitis, duodenal ulcer and gallbladder disease—in all of which I think it represents reverse peristalsis from the lesion.

BELCHING

We must first distinguish three types: first, a gurgling sensation which some people feel running up the esophagus; second, involuntary regurgitation of gas from the stomach, and third, a voluntary swallowing of air which goes about half-way down the esophagus only to be brought up noisily again. The people with the third type sometimes get some air into the stomach and feel much better when they get it up again. It seems to me as if they were scratching themselves with the air. Often, as with scratching, the more the victim does, the more he wants to do, so that the only way in which to get some relief is to desist until the desire has passed off.

Although the first two forms are more important clinically, I believe the third one also indicates a tendency to reverse peristalsis. These patients should not be sneered at and simply called aerophagics—they are uncomfortable, and feel that they would be relieved if they could only get up one final enormous belch. Sometimes they secure this by taking a little sodium bicarbonate, and the relief obtained is very real. A man who has been pacing the floor at 2 a. m., suffering with acid regurgitations, will suddenly belch successfully, or vomit a little fluid, and five minutes later he will be dropping off to sleep. The relief obtained is so out of proportion to the amount of air or liquid voided that the main result must be the quieting down of the tract after the reverse waves have succeeded in running out. I can only compare it to the tremendous psychic and physical relief that comes to a sensitive person who reaches a toilet after he has been restraining a rectum full of gas for hours at some public gathering. The violent peristaltic contractions cease instantly, and the whole body quiets down.

I think all roentgenologists will agree that people do not belch because they have an unusual amount of gas in their stomachs. In seven years' experience, I have seen but one such case. It is also fairly well recognized by thinking physicians that fermentation of the gastric contents can play no part in the causation of belching. The stomach empties so rapidly that the bacteria have no time in which to multiply sufficiently. Sometimes the roentgen ray reveals a large amount of gas in the splenic flexure, pushing up the left leaf of the diaphragm. Naturally, in such cases, no amount of belching can ever bring relief.

Although it is true that many chronic belchers are highly sensitive, nervous persons who are constantly feeling queer things in various parts of their bodies, I would emphasize the fact that careful study of their digestive tracts will often show ulcer, periduodenal adhesions, gallbladder disease or appendicitis. These lesions must be held responsible for the epigastric discomfort and the tendency to reverse peristalsis.

NAUSEA

Nausea is ordinarily the precursor of vomiting. It is strange how little has been written about such a common symptom. The best article I have found is by Boas.[50] He notes that it is associated with intestinal lesions in which there is abnormal peristalsis, and that in many cases, the stomach probably has nothing to do with it. My own impression has been that nausea is brought out most pronouncedly by reverse tendencies beginning low down in the bowel. Thus, it is often marked in acute inflammation in the lower colon, in acute and chronic appendicitis, and in low intestinal obstruction. As is well known, it is severe in pregnancy and in other disturbances of the pelvic organs. It may be very annoying at the menopause, and Boas has seen it persist for a long time after hysterectomies. The pronounced nausea of some hysterical women may be due to associated pelvic disease. Nausea has been observed also in men with enlarged prostates and distended bladders. I have seen it as the first and, for months, the only symptom of carcinoma of the pelvic colon.

On the other hand, I have never seen or read of it with esophageal disease or with the regurgitation due to cardiospasm. It is usually absent, or only a minor complaint, in diseases of the stomach and duodenum. It has been produced in dogs by the injection of irritant salt solutions through fistulas into the duodenum or jejunum. The dogs appeared to be nauseated when the fluid regurgitated into the stomach.[51] Patients suffering with nausea have sometimes described it so vividly as coming in ascending waves that I have wondered whether they might not be feeling actual reverse waves in the bowel.

The nausea and vomiting caused by disgusting mental impressions, by rolling movements, as at sea, and by cerebral disease might conceivably be due to a reversal of the gradient in the gastro-intestinal tract brought about by an unequal or dissimilar action of the vagus on different parts of the stomach and

47. Kelling: Ztschr. f. Biol., 1903, **44**, 254.
48. Schilling found in six cases that the regurgitated fluid was alkaline. In one man who had hypersecretion and hyperacidity, the fluid which gushed from his mouth seemed to be pure duodenal juice (Zentralbl. f. inn. Med., 1915, **36**, 501).
49. A review of the literature reveals that, if anything, the gastric acidity is lowered in these disorders.
50. Boas: Berl. klin. Wchnschr., 1909, **46**, 1101.
51. Cohnheim and Dreyfus: München. med. Wchnschr., 1908, **55**, 2484.

bowel.[52] A review of the literature on the vagus shows that this is not improbable. May[53] found the inhibitory effects more pronounced on the cardiac than on the pyloric end of the stomach. Stimulation of the vagus has produced regurgitation of intestinal contents into the stomach and even vomiting.[54] Very similarly, in the heart of the frog or turtle, vagal stimulation tends to reverse the impulse because it depresses the sinus and leaves the auriculoventricular region active. This is more likely to occur in hearts which have been experimented with awhile and in which the sinus region has become disproportionately fatigued.[55]

Some people experience nausea when constipated, and are relieved immediately after emptying the rectum. Nausea may be associated with diarrhea also, if the bowel is trying to clear itself both ways from some irritated region. It is very common to see nausea produced by cleansing enemas. In one of my patients this occurs only if the enema is made irritating by the addition of much salt or soap. Incidentally, Nothnagel and others[56] have shown that the addition of salt to liquids injected into the bowel will cause them to travel much farther up the tract. It is interesting that the ancients gave hellebore by mouth to purge and by rectum to produce vomiting.

COATED TONGUE AND FOUL BREATH

It is commonly supposed that the tongue, in some sympathetic way, reflects the condition of the gastric mucous membrane. I can find no proof of any kind for these views. They seem to be based on the idea, unfortunately still too prevalent, that most gastro-intestinal upsets are due to a gastritis. Recent, more exact necropsy studies, and the examination of tissues secured at operations have failed to reveal the expected changes.[57] Inflammatory changes were strikingly absent even in the stomachs of a series of alcoholics dying in delirium tremens.[58]

It seems to me that by far the best explanation of the coated tongue has been given by Kast.[59] He gave lycopodium powder in sealed capsules to a number of persons, and was able to recover the typical spores in the mouths of most of them the next morning. I have repeated these experiments, and have found no difficulty in confirming them. In one case, of a woman who regurgitates a good deal, particularly during the menstrual period, the tongue's coat became yellow from the lycopodium.

It is possible that the particles on the tongue may come from even below the stomach. Grützner and others[60] have shown in animals and in man that lycopodium spores or other finely divided and easily recognizable material, given in enemas, will travel in a few hours from the rectum to the stomach. Closely corresponding to these experiments are those of Uffenheimer, Dieterlen and others,[61] who found that tubercle and prodigiosus bacilli injected by rectum could be recovered from the pharynx a few hours afterward, when every precaution had been taken to prevent the animals from licking themselves anywhere or touching their feces. Transmission through the blood stream was also fairly well ruled out.

Laymen and physicians often hold the view that the bad breath associated with "biliousness," a coated tongue, a "dark brown taste" and constipation is due to the exhalation of absorbed toxins. The experiments previously quoted show that the foul breath may just as easily be due to the presence of actual colonic material on the back of the tongue. If these reverse currents are so strong in apparently normal persons, it would not be surprising if they were stronger in the diseased. It goes without saying that these reverse currents must not be blamed for the coated tongue or foul breath in any particular case, until other possible causes in nose, mouth and pharynx have been ruled out.

GLOBUS

Some of us have been unfortunate enough to swallow while a wave or regurgitation was coming up, and we have felt a painful, tearing feeling as the two waves met. It seems to me that this may be the mechanism of globus.[62] Some persons describe it as a wave ascending or descending along the esophagus. It is suggestive that the hysterical, who are supposd to suffer most from globus, often exhibit the most pronounced symptoms of intestinal antiperistalsis.

A FEELING OF FULNESS AFTER TAKING A FEW MOUTHFULS OF FOOD

In rare cases this will be due to shrinkage of the stomach, brought about by extensive carcinoma or ulcer. Ordinarily, persons with this symptom will be found to have large or even baggy stomachs. Carlson's experiments agree with those previously reported in showing that the sensation of fulness does not originate in the gastric mucosa.[63] Leven and Barrett[64] have commented on the fact that persons who wake in the morning with the feeling that their dinner has not passed on really have empty stomachs, as shown by the roentgen ray. Similarly, Hurst[65] has found empty stomachs when the patients were sure that they were filled with gas. He found some patients with gastroenterostomy who complained of a feeling of fulness if their stomachs emptied too rapidly into the bowel. Similar distress is caused by feeding too rapidly through a jejunal fistula.

This complaint of fulness is common with chronic appendicitis, in which it is often associated with other signs of back-pressure. Just as the taking of a little food causes the terminal ileum to empty into the cecum,

52. It is not generally known that large branches of the vagus go directly to the upper part of the jejunum (Alvarez, W. C.: Am. Jour. Physiol., 1915, **37**, 276. Mackenzie: Proc. Roy. Soc., 1915, **9**, Electrother. Sect., p. 7; Jour. Anat. and Physiol., 1917, **51**, 287. Gaskell [Note 29]).

53. May: Jour. Physiol., 1904, **31**, 264.

54. Heidenhain: Hermann's Handbuch der Physiologie, 1887, **5**, 1. Meyer: Ibid., **5**, 444. Miller: Jour. Physiol., 1911, **41**, 409.

55. Gault: Am. Jour. Physiol., 1917, **43**, 22-41. Drugs which act on vagus endings or ganglion cells are most effective in the sinus region (Flack: Jour. Physiol., 1910, **41**, 64).

56. Nothnagel: Beitr. z. Physiol. u. Path. d. Darmes, 1884, 20. Cannon: Mechanical Factors of Digestion, London, 1911, p. 150. Rolleston and Jex-Blake: Brit. Med. Jour., 1903, **2**, 68.

57. Beitzke: Verhandl. d. deutsch. path. Gesellsch., 1914, **17**, 433.

58. Hirsch, E. F.: The Gastric Mucosa in Delirium Tremens, Arch. Int. Med., March, 1916, p. 354.

59. Kast: Berl. klin. Wchnschr., 1906, **43**, 947.

60. Grützner: Deutsch. med. Wchnschr., 1894, **20**, 896. Swiezynski: Deutsch. med. Wchnschr., 1895, **21**, 514. Reach: Prag. med. Wchnschr., 1902, **27**, 549. Bernheim, Albert: Movements of Intestines, THE JOURNAL A. M. A., Feb. 16, 1901, p. 429. Hemmeter: Arch. f. Verdauungskr., 1902, **8**, 59. Hemmeter believes the particles travel along the mucous membrane of the intestine. Part of this retrograde transport might be due to the movements of the villi recently described by Hambleton. It might be similar to the cleansing activities of the cilia in the bronchi (Hambleton: Am. Jour. Physiol., 1914, **34**, 446. Brinton: Cyclopedia of Anatomy and Physiology, 1859, **5**, 354).

61. Uffenheimer: Deutsch. med. Wchnschr., 1906, **32**, 1853. Dieterlen: Centralbl. f. Bakteriol., Part 1, Orig., 1907, **45**, 385. Meyer, Karl: Personal communication to the author.

62. Marshall Hall likened globus to colic, produced by conflicting waves distending the intestine between them (Lancet, London, 1857, **1**, 82). The ancients thought it was due to a wandering of the uterus up into the neck (Neuberger: History of Medicine, London, 1910, **1**, 106).

63. Carlson: The Control of Hunger in Health and Disease, Chicago, 1916, p. 111.

64. Leven and Barrett: Arch. d. mal. d. l'app. digestif., 1907, **1**, 142.

65. Hurst: The Sensibility of the Alimentary Canal, London, 1911, pp. 22, 28.

a failure of this emptying to take place may delay the emptying of the stomach and duodenum, and may, I believe, cause this feeling of fulness.[66]

BILIOUSNESS

It is well known by thinking physicians today that we have no reason for ascribing this syndrome to hepatic insufficiency. It has probably derived its name from the fact that these persons often find bile in regurgitated or vomited material. It has already been pointed out that the presence of a certain amount of bile in the stomach is normal, and any excess would not indicate disease of the liver so much as an increase in reverse peristalsis. Persons who get severe "bilious" attacks with vomiting, nausea, regurgitation of bile, coated tongue, headache, etc., will, I think, be found ordinarily to have a chronic appendicitis. Their symptoms are really those of reversed intestinal activity.

The relief that these persons may derive from a dose of calomel is not due to any action on the liver,[67] but, I believe, to a restoration of the normal currents down the tract. In milder cases, the back-pressure may be due to constipation—the current cannot go forward, so it tends to be reversed. It seems to me that a laxative brings instant relief, not by clearing out toxins, but by removing the material which was obstructing and irritating the colon.

CONCLUSION

An attempt has been made to explain a number of gastro-intestinal symptoms in the light of recently acquired physiologic knowledge. I believe that the underlying cause of all of them is a reversal of the currents in the tract. Thus, vomiting is often due to reverse peristalsis in the intestine; regurgitation is a mild form of vomiting; heartburn is due to the regurgitation of gastric juice into the upper esophagus; belching is closely akin to regurgitation; nausea is probably one of the ways in which we perceive reverse peristalsis; "biliousness" is the common name for the reverse peristalsis syndrome; a coated tongue and foul breath are often the results of regurgitation; globus is due to reverse waves in the esophagus, and the feeling of fulness after taking a few mouthfuls is often due to back-pressure in the intestine.

Those who may feel that I have appropriated nearly all of the gastro-intestinal symptoms for this syndrome are asked to remember that if, as seems likely, symptoms are produced almost entirely by disturbances in the motor functions, we should be most conscious of, and most annoyed by, the severest possible form of such disturbance, namely, a reversal of the current.

The question may also be asked, If reverse peristalsis is so common, why do we not see more of it with the roentgen ray? Moreover, how can signs of reverse peristalsis appear from time to time during the progress of digestion, when food is actually going down the tract? First, it must be remembered that most of the disturbances are due probably to ripples coming up the tract. Any oarsman knows that a wave will not carry his boat more than a few feet unless he is very near a shelving beach. My records have shown that ripples can come down the intestine long distances without forwarding the contents, and can then break into strong waves which rush material along before them. I see no reason why similar ripples cannot travel upward in the wall of the bowel until they show themselves as waves in the stomach and esophagus. When the gradient of forces in the tract is poor, waves can probably travel in either direction. When the stomach is full and active, it will be easier for waves to proceed aborally; when the stomach and small intestine are empty and the colon is full, the waves will more easily ascend. Moreover, animal experiments indicate that the gradient may not be upset to the same extent in all parts of the tract, so that, for instance, reverse waves might be present in the stomach, and normal ones in the bowel. Similarly, the heart that is beating with nodal rhythm sends the blood in the proper direction, although the ventricles are contracting before the auricles. It is conceivable that ripples can ascend the digestive tract even when the gradient is not reversed. To explain what I mean, I will point to the case of a large river like the Missouri, which undermines its banks in places until tons of earth tumble in. In the lower stretches of the river, where the current is not rapid, such a commotion might cause ripples to run a quarter of a mile uphill, and over water flowing in the opposite direction.

Another reason why we cannot expect to see much reverse peristalsis with the roentgen ray is that even normally we cannot follow the food in the small intestine after it leaves the duodenum, and before it reaches the terminal ileum. Actual reverse transport of material has been observed in those parts of the tract which are accessible to roentgenographic study. Twice I have seen definite reverse peristalsis in stomachs free from organic disease. Subsequent operation revealed the cause to be, in one, appendicitis, in the other, duodenal ulcer. More important than visible reverse waves are the reversed impulses that hold back the barium here and there in the tract, in spite of the fact that the muscle is active, and the tube ahead is unobstructed. These are the conditions we see every day.

Many physicians today are satisfied when they have appropriately labeled each case as a "gastritis," a "hyperacidity" or a "biliousness." Their work then ends, as each label carries with it a certain string of prescriptions and, perhaps, a diet. I believe that this paper will have been well worth writing if it helps at all in making men dissatisfied with some accepted ideas, and more inclined to think in terms of disturbed physiology. Such thinking must make for better therapeutics. The physician will more often seek for and find the lesion that is irritating the bowel and giving off the reverse waves. More often, also, will he see the hopelessness of medical "tinkering," and will call in the surgeon at once. If such radical treatment is inadvisable or impossible, he will use a smooth, cellulose-poor diet, which will flow more easily along the impaired gradient. He may, perhaps, be able to improve the gradient by resting and overfeeding the patient. Later, when the pharmacologist gets to thinking along these lines, he may find for us drugs which will restore the downward currents, either by increasing the activity of the upper part of the tract or by decreasing the activity of the lower parts. I hope soon to publish the report of work indicating that some laxatives do alter the gradient in these ways.

177 Post Street.

66. Alvarez, W. C.: The Motor Functions of the Intestine from a New Point of View, THE JOURNAL A. M. A., July 31, 1915, p. 388, Note 66.

67. All pharmacologists agree that calomel is not a cholagogue.