THE MOTOR FUNCTIONS OF THE INTESTINE FROM A NEW POINT OF VIEW *

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According to modern textbooks the small bowel is a tube whose structure and physiologic characteristics are much the same from one end to the other; and material is supposed to move aborally because of the myenteric reflex, or Bayliss and Starling's "law of the intestine." According to this law,¹ "Excitation at any point of the gut excites contraction above and inhibition below"; and it can easily be seen how this mechanism must favor the aboral progress of material through the intestine.

Cannon² has warned us, however, that this reflex and normal peristalsis are not the same, nor is it always in control of the mechanism of the bowel. A moment's thought will show that this must be true; otherwise food once introduced into the duodenum would never stop in its rush to the anus. My own graphic records of peristaltic rushes, secured with six or seven enterographs, rarely show any relaxation before the oncoming wave. On the contrary, powerful contractions appear below, which serve to stop the rush from going too far.

Unfortunately, the stimuli ordinarily used to elicit the reflex have been traumas—pinches, sudden distention by balloons, etc., and little effort has been made to see what happens above and below the normal loopful of digesting food.³ Much might be said about the difficulties met with by those who have studied this reflex; about the narrow limits (2 to 3 cm. on either side of the stimulus) within which it ordinarily is operable, but it would be beside the point. The existence of the reflex has been well established; but we do not know how far it enters into normal peristalsis, and we must admit that this explanation for the downward progress of food through the intestine is not sufficient in itself. Perhaps for this reason the "law of the intestine" has been of little help to the gastro-enterologist in the solution of his problems. "It does not govern the rhythmic contractions of the small intestine, the rhythmic peristalsis and antiperistalsis of the colon, and probably not the rhythmic waves of the stomach. . . . For these activities the tonic contraction of the wall of the canal is all-important."⁴

FUNCTIONAL DIFFERENCES IN THE VARIOUS PARTS OF THE INTESTINE

A number of writers⁵ in the past have noticed differences in muscular strength and tone—differences in

rhythm and irritability—in the various parts of the bowel; but they did not seem to realize the importance of their findings, and their writings certainly have had no effect on our conception of the motor functions of the intestine. My own study of these functional differences in the various parts of the intestine of animals soon suggested to me that they might play a large part in the passage of material through the tract. The contents of a muscular tube so constructed would probably move from the more active, irritable and powerful regions above to quieter, less sensitive segments below, where the muscular coats are thinner and less tonically contracted. Reverse peristalsis would hardly occur unless the lower parts of the bowel could be stimulated to an activity greater than that ordinarily found in the upper stretches.

We think of the heart today, not as pump with purely mechanical valves, but as an elaboration of the primitive tube in which the rhythmic power of each segment varies inversely as does the distance from the sinus.⁶ So important is this difference that the current is reversed in the simpler types of heart if the aortic end be made to beat faster.⁷

Similar experiments have been performed with segments of the digestive tract. The direction of peristalsis in the crop of *aplysia*, a large marine snail, can be changed at will by increasing the tension at one end or the other.⁸ Cannon⁹ has shown that waves will course over the excised stomach of a frog or cat in either direction, depending on the location of a pulsating tonus ring. Still more pertinent is the experiment in which he dipped the aboral end of a short loop of small intestine into a weak solution of barium chlorid, and by thus raising its tone, reversed the direction of peristalsis.¹⁰ Stimuli which raised the tone in the middle of such a loop sent off waves in both directions.¹¹

The few references I have been able to find to the motor functions of the digestive tract in the lower forms of life show how much the progress of food through their simple tubes depends on local differences in tone and rhythmicity.¹² It is harder to recog-

Arch. f. path. Anat., etc., Berl., 1887, cix, 281; Biedermann: Arch. f. d. ges. Physiol., 1889, xlv, 372 and 379; Floel: Ibid., 1885, xxxv, 161; Lüderitz: Arch. f. path. Anat., etc., Berl., 1889, cxviii, 24 and 32, and others. Differences in the driving power have been shown by Hess: Deutsch. Arch. f. klin. Med., 1886-7, xl, 105. A balloon in the dog's intestine was fastened to a thread which came out of a gastric fistula and ran 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 228.5 gm. were needed; 38 cm. from the pylorus 90.4 gm. were needed; 50 cm. from the pylorus 75.5 gm. were needed.

6. Erlanger: Arch. Int. Med., 1913, xi, 334.

7. Gaskell: Schäfer's Textbook of Physiol., London, 1900, ii, 184.

8. Von Brücke: Arch. f. d. ges. Physiol., 1905, cxviii, 209.

9. Cannon: Am. Jour. Physiol., 1909, xxiii, cxvii.

10. Cannon: Am. Jour. Physiol., 1912, xxx, 119.

11. Cannon: Am. Jour. Physiol., 1909, xxiii, xxvii. "A ring at the cecum repeatedly sends off downward running waves; a new ring made now near the terminus of these waves starts reversed waves; and a tonic ring made midway in the proximal colon not infrequently will originate waves which pass away in both directions." Cannon: Arch. Int. Med., 1911, viii, 419.

12. See papers by Bottazzi on the *Aplysia*, a large marine slug: Jour. Physiol., 1897-98, xxii, 481, and v. Brücke: Arch. f. d. ges. Physiol., 1905, cxviii, 202; Bottazzi on some fishes, Ztschr. f. Biol., 1902, xliii, 364, and Hardy and McDougall on lower crustaceans, Proc. Cambridge Philosoph. Soc., 1893, viii, 41. A valuable point brought out in these studies and, I believe, largely applicable to man, is that material does not press up to and pack against the sphincters. The real barrier is not the sphincter, but a ring of muscle with high tone and inherent rhythmicity, placed around or just above the valve. This not only blocks impulses coming down, but starts up reverse waves that protect the sphincter from being put under pressure. I have shown how the sacculus rotundus may protect the ileocecal sphincter of the rabbit. Alvarez: Am. Jour. Physiol., 1914, xxxv, 184. A similar thickening has been described in man by Keith: Jour. Anat. and Physiol., 1903, xxxviii, 7, and Elliott: Jour. Physiol., 1904, xxxi, 158. The greater tone of the lower end of the colon in man serves the same purpose, probably, as do the pulsating tonus rings that guard the anus in the above-mentioned fishes and crustaceans.

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1. Bayliss and Starling: Jour. Physiol., 1899, xxiv, 110.

2. Canon: Am. Jour. Physiol., 1912, xxx, 125.

3. "What causes the myenteric reflex to appear or not, when material is present, is as yet undetermined," Cannon: Am. Jour. Physiol., 1912, xxx, 125.

4. Cannon: The Mechanical Factors of Digestion, London, 1911, p. 195.

5. For some of the literature, particularly in regard to differences in rhythm, see Alvarez: Am. Jour. Physiol., 1914, xxxv, 177; *ibid.*, 1915, xxxvii, 266. Differences in muscular thickness in different parts of the small intestine have been noted by Monks: Ann. Surg., 1905, xlii, 549; Bérard: Cours de physiologie, Paris, 1849, ii, 285; Jonnesco: Poirier et Charpy's Traité d'anat. humaine, Paris, 1901, iv, 284; Flint: Textbook of Human Physiology, New York, 1895, p. 234, and others. Differences in sensitiveness to various stimuli have been observed by Schillbach:

nize this simple mechanism in the much elongated and more specialized gut of a mammal, but there is considerable evidence that short nerve paths through Auerbach's plexus, and longer paths through the mesentery and ganglia keep the stomach and cecum as close together, functionally, as they are in a snail or a frog.¹³

CLOSE CONNECTION OF VARIOUS PARTS OF TRACT

The use of a number of enterographs at one time, particularly in the cat, has shown me how immediate is the response of one part of the tract to changes in tone and activity in another. In addition, what might be called ripples, invisible to any one watching the bowel, can plainly be seen on the records, running in a few seconds from the pylorus to the colon. Now and then these ripples show themselves as short, diastaltic rushes, much perhaps as a swell from the ocean striking a shallow shelf suddenly becomes a comber. Without the graphic record no one would think of associating a short rush 200 cm. from the pylorus with a particular gastric contraction or with a sudden cessation of colonic activity. Bayliss and Starling have well said that, "every point of the intestine is in a state of activity, which can be played upon and modified by impulses arriving at it from all portions of the gut above and below."¹⁴ The promptness with which a mouthful of food introduced in the stomach causes material to pass through the ileocecal valve¹⁵ or to rush through the colon,¹⁶ shows that the human intestine also acts very much as a short unit.

THE THEORY

Returning, then, to the idea of a tube with greater tone and rhythmicity at the oral end, it is apparent that a rise of tone at the upper end, due to the introduction of food or to irritating lesions, would hurry the aboral progress of food; while a similar rise at the lower end should slow the current or even reverse it. A rise anywhere in the middle of the tube should cause material to flow both ways from that point.

A more rapid current might be brought about also by lowering the tone of the lower end.¹⁷ If the gradient of forces should become a horizontal line, no progress could be made, no matter how great the activity throughout the tube.¹⁸

While much work yet remains to be done on animals before such a theory can be firmly established, it seems worth while, at this time, to go over the literature of

the laboratory worker, the clinician, the surgeon, and particularly of the radiologist, to see how well this hypothesis accords with the facts already at hand. Physiologic methods (Roentgen ray, gastric analysis, etc.) in the hands of the clinician have been yielding results that are not to be despised even if Dame Pathology did arrange the experiment; and an ill-assorted collection of observations awaits only the systematizing touch of a basic theory.

That the rhythmic segmentation of food anywhere in the tract is associated with a rise of tone has been well proved.¹⁹ That irritating lesions also raise the local tone is the daily experience of the radiologist. The spastic pylorus or hour-glass stomach with adjacent ulcer, and the hypertonic stomach and duodenum in duodenal lesions bear witness to this point.²⁰

The word tone may have to be used rather loosely in this paper for the sake of brevity. We cannot tell yet what part other factors—such as differences in rhythm and irritability—play in altering the gradient of forces through the tract.²¹ The words higher and lower, which will appear frequently in the following pages, refer to differences in tone and muscular force and have absolutely no relation to position in the abdomen, or to gravity. I trust no one will misunderstand or forget this point. There are enough surgeons already who tinker at the bowel as if it were a coil of rigid tubing always held in one position. The intestine is a muscular organ and "material does not move along the canal unless the pressure is greater on one side of it than on the other."²²

THE EFFECTS OF FOOD INTRODUCED AT THE UPPER END OF THE TRACT

It may sound like a Hibernianism, but food does go down the tract more easily because it is put in at the upper end. The rise of tone there probably makes the gradient of forces steeper down the intestine.²³ A contrast meal will go down the bowel faster if followed by more food a few hours later.²⁴ This second meal probably keeps the gradient steeper than usual by maintaining the high level of the gastric tone.

There is some evidence that pleasurable psychic stimuli still further raise this tone. Several observers have noticed that contrast meals leave the stomach more rapidly if they are made palatable.²⁵ "Sham

13. Roith describes two cases in which rectal injections brought about movements in the upper colon although the bowel in between was completely severed. Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1913, xxv, 208. Marbaix produced inhibition of gastric emptying by filling the jejunum, even after complete section of the duodenum, La Cellule, 1898, xiv, 283. Surmont and Dubus obtained immediate responses from the colons of dogs and cats by stimulating the duodenum, even after removing sections of ileum, Arch. d. Mal. l'App. dig., 1912, vi, 181.

14. Bayliss and Starling: Jour. Physiol., 1899, xxiv, 116.

15. Hertz: Jour. Physiol., 1913, xlvii, 55. I have observed the promptness of this reflex many times. Cole's observation—see note 66—is also very striking.

16. Meyer-Betz has seen the colon empty into the ampulla almost immediately after the patient took some food. Immediate postprandial desire for stool, or even diarrhea in children and some adults, is well known. München. med. Wchnschr., 1912, lix, 2717.

17. Material seems to go through the small intestine faster than usual when there is a large fistula in the terminal ileum or cecum. There seems ordinarily to be a retarding influence from the highly tonic colon. See Demarquay: L'Union med., 1874, xviii, 906; and Macewen: Lancet, London, 1904, ii, 998.

18. Katsch concludes that there is no proportion between the intensity of peristalsis and the progress of material through the tract. At times the food will move with ease through long stretches of an almost passive bowel, and yet the violent contractions produced by drugs like pilocarpin may have little forwarding effect. Ztschr. f. exper. Path. u. Therap., 1913, xii, 287 and 233. Bayliss and Starling, Jour. Physiol., 1900, xxvi, 126, and Kelling, Ztschr. f. Biol., 1903, xlv, 240, have shown that the waves frequently put no pressure on the contents of the gut.

19. Cannon: Arch. Int. Med., 1911, viii, 421. Mall: Johns Hopkins Hosp. Rep., 1896, i, 45. "If the intestine is at rest it is anemic, small and long; when digesting it is hyperemic, large and short." I have placed two markers 3.5 cm. apart on an active and apparently stretched piece of bowel and have found them 8 cm. apart later when this region had emptied and quieted down.

20. "I have always believed that the severity of the spasm resulting from an ulcer was dependent on its irritability and not on its size." Barclay: Arch. Roentg. Ray, 1913, xviii, 235. Schmieden gives it as a rule that, in ulcer, the healthy parts of the stomach contract; in carcinoma, the diseased parts. Arch. f. klin. Chir., 1911, xcvi, 265.

21. "The tonic state is fundamental. I have repeatedly attempted to call forth rhythmic contractions, both in the atonic colon and in the atonic stomach, by distention, but without success. The tonic state is therefore quite as important as the internal pressure; indeed, it is the condition for the existence of that pressure." Cannon: Am. Jour. Physiol., 1911, xxix, 242. See also Arch. Int. Med., 1911, viii, 417.

22. Cannon: Mechanical Factors of Digestion, London, 1912, p. 76. According to Keith, there is enough muscular tissue in the colonic wall of man to form a mass as large as the biceps of a blacksmith's arm. Brit. Jour. Surg., 1915, ii, 584.

23. During active digestion, the gradient of rhythm is made steeper by a rise in the duodenal region and a fall in the ileum. Alvarez: Am. Jour. Physiol., 1915, xxxvii, 277.

24. Hertz: Arch. Roentg. Ray, 1912, xvii, 216.

25. Hertz: Arch. Roentg. Ray, 1912, xvii, 219. See also Haudek and Stigler, who speak of slow gastric emptying when the food is taken without appetite, Arch. f. d. ges. Physiol., 1910, cxxxiii, 159. Also Gilmer: Centralbl. f. Roentgenstr., etc., 1911, ii, 235. Takahashi showed that cats' stomachs emptied half as fast when the animals were fed with a spoon as when they ate by themselves. Arch. f. d. ges. Physiol., 1914, clix, 389. Sailer believes that the bismuth meal leaves the stomach quicker if the patient drinks it than if it is put in by a tube, Univ. Penn. Med. Bull., 1906, xix, 136.

drinking," particularly in thirsty animals, will cause water to leave the stomach of a dog much faster than it otherwise would.²⁶ It will also prevent the back-flow into the stomach which occurs when fat is put into the duodenum through a fistula.²⁷ The latter observation is explained if the pleasure of drinking has raised the tone of the stomach above that of the duodenum.

It is a common observation that patients who have vomited albumin water and other bland liquids for days may cease when given solid food. Good nurses are well acquainted with this trick and often stop post-anesthetic vomiting with a little dry toast. Attacks of "cyclic" vomiting in children may also be stopped in this way.²⁸ I hope later to present evidence that vomiting is often a manifestation of reversed currents due to the presence of an abnormally high tone in the jejunum.²⁹ Water would probably not alter these conditions enough, as it passes rapidly into the intestine without having much effect on gastric tone. Solid food, however, can raise the tone of the stomach sufficiently to restore the normal gradient and to send the currents downward again.³⁰

Cannon stated clearly in 1906 that "in whatever manner the pylorus may act under normal conditions, that action certainly can be overcome in abnormal states."³¹ The other factors may simply modify the chemical control. For instance, increased pressure from above, brought about by a pleasant psychic influence,³² or by distending the stomach,³³ will cause the pylorus to open before the chemical conditions are right. Cohnheim and Dreyfus³⁴ found in a dog, that when little food was present, 10 c.c. of stomach contents injected into the duodenum closed the pylorus for from ten to fifteen minutes; but when the stomach was full of fluid, the same stimulus stopped the flow for from only one to one and one-half minutes. The distention of the duodenum by a balloon,³⁵ the irritation of the bowel by strong saline solutions,³⁶ or the simple presence of neutral food in the upper half of the

small intestine³⁷ will retard by hours the emptying of the stomach.

As Cannon reminds us, many of these observations can have little to do with physiology: food ordinarily shoots through the duodenum without distending or irritating it very much, but I believe they have much to do with pathology; and are of particular significance to those of us who, as clinicians, are dealing with abnormal states. It is unfortunate that all the efforts to explain the peculiarities of gastric emptying with gastric and duodenal ulcer and with carcinoma have been based on the chemical reflex alone. Von Bergmann and others have shown how impossible it is to trace any connection between the varying rates of emptying and the degrees of acidity in the individual cases.³⁸ We know also that the stomach gets along very well with complete achylia; and, although the emptying is a little more rapid, the intermittent spurts are very similar to those seen under normal conditions.

The slowing of gastric emptying by distending, irritating, or putting food into the bowel is explainable if we think of the intestinal tone as having been raised above that of the stomach. When the bowel empties and its tone falls, the stomach can empty again. The physiologic studies have not left it entirely clear as to whether the delay in gastric emptying is due to an inhibition of peristalsis or to pyloric spasm. A similar confusion is found in the clinical literature on six-hour stasis, where the terms pylorospasm, pyloric stenosis and gastric atony have been used almost interchangeably. Only a few men have observed closely enough to note that the stomach often fails to empty in the presence of active and powerful peristalsis, even when the pylorus is easily patent, as shown by palpation under the screen.³⁹ Such a condition is explainable if the tone of the intestine is equal to that of the stomach. Material may then churn back and forth; the pylorus may be open, and yet no progress can take place.⁴⁰

This balancing of forces between the stomach and intestine is probably at the bottom of many well-known phenomena. The ill effects on some people of eating between meals may be due to the slowing of the gastric emptying caused by the presence of the previous meal in the small intestine. In order to show duodenal stasis, Jordan⁴¹ gives a bismuth meal an hour or so after

26. Best and Cohnheim: *Ztschr. f. physiol. Chem.*, 1910, lxi, 116. The dog has an esophageal fistula in the neck so that water or food swallowed does not reach the stomach, hence the term "sham-feeding."

27. Best and Cohnheim: *Ztschr. f. physiol. Chem.*, 1910, lxi, 125.

28. McClure: *Am. Jour. Dis. Child.*, 1914, vii, 48. Hahn: *Med. Klin.*, 1911, vii, 1452. Tohler: *Deutsch. med. Wchnschr.*, 1914, xl, 1042. Bartlett: *Am. Jour. Dis. Child.*, 1914, vii, 310.

29. I have graphic records from cats, and from a man with a fistula, showing that a marked rise in the tone of the jejunum preceded spontaneous vomiting. Strange to say, almost all writers on vomiting have apparently forgotten that there is such a thing as an intestine. Physicians think they can stop vomiting if only they can keep food out of the stomach. Cohnheim and Dreyfus produced nausea and vomiting in dogs repeatedly by distending the small intestine with a balloon. *Ztschr. f. physiol. Chem.*, 1908, lviii, 56. Hirsch produced vomiting in dogs by giving solutions of organic acids. Acetic acid was most active in this regard, apparently because it had the least effect on the stomach and the most marked stimulating effect on the intestine. This produced back currents as shown by the flow of bile into the stomach. A weaker impulse, as from lactic acid, caused only a delay in gastric emptying. *Centralbl. f. klin. Med.*, 1893, xiv, 380. That nausea is associated with a drop in gastric tone has been observed by Barclay: *Brit. Med. Jour.*, 1910, ii, 539.

30. After the stomach has been quiet for some time with bismuth water, I have often seen it contract and start up active peristalsis immediately after the patient had eaten a small cracker.

31. Cannon: *Am. Jour. Med. Sc.*, 1906, cxxxi, 569.

32. Cohnheim and Dreyfus: *Ztschr. f. physiol. Chem.*, 1908, lviii, 57.

33. Marbaix found that 250 c.c. of water left his stomach twice as fast if he put in 250 c.c. of air on top of it. *La Cellule*, 1898, xiv, 280. Rieder comments on the more rapid emptying of the full stomach. *München. med. Wchnschr.*, 1904, li, 1550. Turck marvels that a small test-breakfast will remain in an atonic stomach longer than will a large Leube meal. *THE JOURNAL A. M. A.*, 1904, xlii, 815. Lüdin found that food taken after a contrast meal may hasten gastric emptying. *Deutsch. med. Wchnschr.*, 1913, xxxix, 1239. See also Moritz: *Ztschr. f. Biol.*, 1901, xlii, 585.

34. Cohnheim and Dreyfus: *Ztschr. f. physiol. Chem.*, 1908, lviii, 58.

35. Tohler: *Ztschr. f. physiol. Chem.*, 1905, xiv, 185.

36. Cohnheim and Dreyfus: *Ztschr. f. physiol. Chem.*, 1908, lviii, 58. Four per cent. solutions of sodium chlorid and magnesium sulphate put into the upper bowel through a fistula caused diarrhea with marked slowing of gastric emptying, nausea and even vomiting.

37. An introduction to the literature on this subject may be had through the articles of Best and Cohnheim: *München. med. Wchnschr.*, 1911, lviii, 2732. Marbaix: *La Cellule*, 1898, xiv, 268. V. Mering: *Verhandl. d. Congr. f. inn. Med.*, 1893, p. 476. Hirsch: *Centralbl. f. klin. Med.*, 1893, xiv, 377. Baumstark and Cohnheim: *Ztschr. f. physiol. Chem.*, 1910, lxi, 484. Baumstark: *Ztschr. f. physiol. Chem.*, 1913, lxxxiv, 437. Thomsen: *Ibid.*, p. 425.

38. Von Bergmann, G.: *Centralbl. f. Roentgenstr.*, etc., 1913, iv, 3. See also Faulhaber and v. Redwitz: *Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1914, xxviii, 192.

39. Holzknecht and Haudek: *Fortschr. a. d. Geb. d. Roentgenstr.*, 1914, xxi, 634.

40. Cannon and Blake state clearly that after pyloroplasty the function of the pylorus is taken over by the active contractions of the duodenum. *Ann. Surg.*, 1905, xli, 708. Dagaew removed the powerful pyloric end of the stomach, expecting that this would allow the food to run promptly into the bowel. Just the reverse happened; there was marked delay which seemed to be due to the lack of pressure from above to overcome the resistance of the active intestine. As we should expect, the usual regurgitation into the almost empty stomach was much exaggerated. *Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1913, xxvi, 179. Marbaix speaks of the contest between the stomach and intestine. *La Cellule*, 1898, xiv, 283. The larva of *Ptychoptera contaminata* has no pyloric valve, so van Gehuchten says the small intestine, in all its length, takes up the rôle of sphincter. *La Cellule*, 1890, vi, 277.

41. Jordan: *Arch. Roentg. Ray*, 1913, xviii, 231. He has seen strong contractions forcing the contents back into the duodenum. He told Barclay that, under ordinary conditions, he does not see such stasis. "The Stomach and Esophagus," London, 1913, p. 57. Hess found, in one experiment, that a balloon put through a fistula into the duodenum of a dog did not go forward as usual. This apparently was accounted for by the presence of food in the ileum at the time. *Deutsch. Arch. f. klin. Med.*, 1866-7, xl, 105.

the patient has eaten his dinner. By that time the tone of the intestine has been raised by the presence of food and the contrast meal is held back when it reaches the duodenum.

It has been observed repeatedly that, at the close of gastric digestion, when the tone of the intestine is still high and that of the stomach has probably fallen, duodenal contents flow back into the stomach. This is particularly the case when much fat has been eaten.⁴² The explanation for this lies probably in the fact that while the tone and motility of the stomach are markedly impaired in the presence of oils,⁴³ the intestine may, at the same time, be even stimulated by the fatty acids split off in pancreatic digestion.⁴⁴

It is a common observation that a stomach will empty quite rapidly to a certain point, after which there is little change for hours. At first, through its greater tone or better reaction to distention, the stomach is probably stronger than the intestine. Later, the actively digesting bowel becomes too strong for the half-empty stomach, and there is little change until the intestine empties, or more food is put into the stomach.

Anything that tends to keep up the tone of the intestine will exaggerate this type of gastric emptying. I have seen it frequently in those cases, particularly of appendicitis, in which the ileum empties very slowly. This so-called "late pylorospasm" is quite characteristic also of duodenal ulcer.⁴⁵ There, I believe, the increased tone of the stomach, plus the stimulus of food, overcomes the hypertonic duodenum and brings about rapid emptying at the beginning. After this, a small residue remains in the stomach for hours, or until the next meal, presumably because the ulcer keeps the duodenum from relaxing to its proper tone level, below that of the stomach.⁴⁶

INTRODUCTION OF FOOD AT THE LOWER END OF THE TRACT

According to the theory, food introduced at the lower end of the tract should retard the progress of material coming down from above and might even reverse the current. There is ample proof in the literature that both these things happen. Clinically, it is well known that an enema given shortly after a meal is likely to cause colic, nausea, and, in sensitive people, even vomiting.⁴⁷ Radiologists know that enemas must not be given after a bismuth meal if they are to tell anything about the emptying time of the stomach or the rate of passage through the small intestine.

42. Boldireff states that in animals that have been fasting for some time, the intestinal juice will run out of a gastric fistula continuously. This back-flow can be accentuated by giving fatty acids and fats or by injecting some 0.1 per cent. HCl into an intestinal fistula. *Centralbl. f. Physiol.*, 1904, xviii, 457. Rehfuess, Bergheim and Hawk found bile present in the fasting stomachs of most of the normal students studied. *THE JOURNAL A. M. A.*, July 4, 1914, p. 11. Years ago Kussmaul said "Offenbar gelangt die Galle viel leichter in den leer als in den vollen Magen." *Samml. klin. Vortr.*, Inn. Med., 1880, No. 62, p. 1651.

43. V. Tabora says the stomach may be quiet for hours when full of fat. *Centralbl. f. Roentgenstr.*, 1911, ii, 247. Cannon says the waves were a little slower and shallower. *Am. Jour. Physiol.*, 1907, xx, 315.

44. Bokai: *Arch. f. exper. Path. u. Pharmacol.*, 1887, xxiv, 158. For further discussion of this subject and references to the literature see Cannon: *Am. Jour. Physiol.*, 1907, xx, 315.

45. Carman: *THE JOURNAL A. M. A.*, March 28, 1914, p. 980.

46. This may be the explanation for Cannon and Murphy's observation that food did not begin to leave the stomach for five or six hours after section and suture of the duodenum, some 10 inches below the pylorus. *Am. Jour. Med. Sc.*, 1906, cxxxi, 569.

47. Trousseau and Sydenham have discussed this point. The latter warns us that clysters become emetics in cases of ileus and typhoid where there is already a tendency to a reversal of intestinal action. *Clin. méd.*, Paris, 1865, iii, 28; Sydenham Soc. Edit., London, 1848, i, 67, 68 and 194.

The few times I have ordered rectal feeding I have had to give it up on account of nausea and vomiting, which ceased only when the enemas were stopped. To illustrate: A woman with a blood pressure of 220 mm. of mercury and no clinical or radiologic signs of ulcer, before or since, had been passing tarry stools for several days. Rectal feeding and a Murphy drip were started, and only a little water was given by mouth. Fearful nausea began, and soon she was vomiting large amounts of blood-stained fluid. No blood reached the anus while she was being fed per rectum. The vomiting became so serious that we then left the rectum entirely alone and gave her solid food. Nausea and vomiting stopped with the first mouthful and did not return. Tarry stools appeared again. Apparently the blood, oozing somewhere in the middle of the digestive tract, could be sent in either direction by raising the tone of either end.

Rolleston and Jex-Blake⁴⁸ collected ninety-six cases of gastric ulcer fed per rectum alone and found that twenty-six patients vomited on one or more occasions. They noticed that the giving of cleansing enemas to these rectally fed patients frequently produced nausea and retching, and, in a few cases, it brought on vomiting. There are enough cases in the literature in which the enemas were actually vomited, or in which the patient objected to the constant taste of the peptonized foods.⁴⁹

Several observers have noticed an increased tendency to colonic anastalsis after the giving of enemas.⁵⁰ The Roentgen ray has shown how frequently enemas will pass through the ileocecal valve and run up the small intestine even to the stomach. As would be expected from the theory, this is more likely to occur when some lesion in the colon has already raised the tone of the lower end of the tract.⁵¹

FOOD PUT INTO THE MIDDLE OF THE BOWEL TENDS TO MOVE BOTH WAYS

My experiences with jejunal feeding have not been entirely satisfactory on account of the nausea and vomiting which occurred from time to time.⁵² Food put in at the fistula has even been returned by mouth; and in most of the cases the discomfort could be relieved only by simultaneous mouth feeding. Here again vomiting was stopped probably by raising the tone of the stomach to its normal position above that of the jejunum. Nausea, vomiting and pain were present in another case until a simultaneous Murphy drip of glucose and salt solution was stopped, and some food given by mouth. The patient had no further trouble until one day when he had a cleansing enema.

48. Rolleston and Jex-Blake: *Brit. Med. Jour.*, 1903, ii, 68. Bine and Schmall have given up rectal feeding on account of such experiences, *California State Jour. Med.*, 1914, xii, 364.

49. Parkes-Weber: *Brain*, 1904, xxvii, 170, and Langmann: *Jacobi Festschr.*, New York, 1900, p. 375, give a good introduction to the literature on this subject.

50. Cannon: *Mechanical Factors of Digestion*, p. 150. In one cat an enema of warm water caused continuous anastalsis in the colon for one hour and twenty minutes. Ordinarily such waves appear from time to time only. See also Nothnagel: *Beitr. z. physiol. u. path. d. Darmes*, Berl., 1884, p. 20.

51. Case finds incompetency of the ileocecal valve associated most frequently with the increased antiperistalsis of hypertonic constipation, and with obstruction and disease of the colon. The incompetency of the valve is not a disease in itself; it is secondary, and due to a loss of tone in the muscle making up the valve. He quotes a number of authors who agree with him. *Arch. Roentg. Ray*, 1915, xix, 380 and 383.

52. Kelling speaks of the stagnation of food in the stomach, feeling of fullness and tendency to vomiting in jejunal feeding. *Ztschr. f. Biol.*, 1903, xlv, 248. "In the majority of cases, direct nutrition through the duodenum is a delusion. The chyme, or the greater part of it, is regurgitated into the stomach, as can be demonstrated fluoroscopically"; *Therapeutics of the Gastro-Intestinal Tract*, Wegele, Gross and Held, New York, 1913, p. 272.

It is common knowledge that vomiting is often associated with diarrhea. A small boy who has eaten all the blackberries he can pick is likely to vomit three quarters of the amount some hours later; and shortly after, the remainder is voided in loose movements. Presumably, enough of the irritant mess gets into the jejunum at the start to prevent the stomach from emptying.⁵³ Finally the tone becomes high enough in the upper bowel so that it can clear itself both ways. Strong psychic stimuli may bring about diarrhea and vomiting in the same way, if they raise the tone of the upper jejunum at the point where it is so richly supplied with vagus branches.⁵⁴

IRRITANT LESIONS

The motility of the tract is affected by irritating lesions, much as the theoretic considerations would lead us to expect. One of the best roentgenologic signs of duodenal ulcer is the presence of the head of the bismuth column in the descending colon after six hours. This is not pathognomonic of ulcer, but points to some irritation of the duodenum or the closely related gall-bladder and pancreas.

It appears also with hypertonic stomachs, due in some cases apparently to vagus disturbances. Another factor in the causation of this hypermotility is the rapid outpouring of food from the stomach in duodenal ulcer, achylia gastrica and some cases of gastro-enterostomy.⁵⁵ The greater distention alone may stimulate the upper bowel to greater activity, much as a large enema has more effect than a small one.

The problems of motility with lesions at the upper end of the tract are complicated by the fact that the whole region from cardia to jejunum seems to have its tone raised by a lesion in the duodenum, or in the embryologically related bile passages, liver and pancreas. This is shown by the hypertonic stomachs and the hour-glass contractures so frequently seen in these cases.⁵⁶

The reaction of the stomach to ulcer is also complicated by so many factors that I will not try to discuss the subject at this time. The stomach is often atonic and quiet with pyloric ulcer;⁵⁷ possibly the waves are blocked by the tonus ring caused by the lesion. Actual reverse waves are often seen, particularly when the bismuth is taken at a time when a previous meal is in the intestine.⁵⁸ Under these conditions, as we have seen, there is a considerable tendency to back-flow at the upper end of the tract.

That gastric anastalsis is seldom seen with duodenal ulcer⁵⁹ is due probably to the almost complete break in continuity of the muscular coats at the pylorus.⁶⁰ This

barrier deserves more study, as it may be of immense importance to us in blocking undesirable waves coming up from the intestine, and in protecting the bowel from undue influence from the powerful pyloric portion of the stomach.

Jonas has shown that just as intestinal hypermotility and even diarrhea may appear when the stomach empties too rapidly, hypomotility of the bowel and constipation are seen with lesions interfering with the opening of the pylorus. He speaks of the stomach as the "*Haupt-motor*" for the intestine.⁶¹

Lesions in the course of the bowel, such as tuberculous ulceration, render the affected area so irritable that the bismuth meal goes through very rapidly, and this region appears to be empty.⁶² The bowel is often empty for some distance above an obstruction, showing that there is a powerful repelling effect.⁶³ For the same reason, in appendicitis, the last few coils of ileum may be empty; or the lower limit of the bismuth, instead of showing a bulging shoulder, tapers to a point. The obstruction is not mechanical, it is dynamic. It is becoming generally recognized that a kink in the bowel has little effect unless it becomes irritated in some way. The marked differences in severity, amount of vomiting, etc., between acute ileus and that arising slowly may depend partly on the degree to which the cause of obstruction irritates the bowel, raises the local tone and reverses the current.⁶⁴

The commonest lesion near the ileocecal valve is appendicitis; and this, as is well known, can generally be diagnosed by the presence of marked ileac stasis. I believe chronic appendicitis disturbs digestion mainly through its effect in raising the tone of the terminal ileum; and operations give relief only as they remove all sources of irritation from this region.⁶⁵ A rise of tone here has a retarding effect that extends upward even to the stomach, which is frequently

61. Jonas: Arch. f. Verdauungskr., 1912, xviii, 769. Agéron holds similar views, *ibid.*, 1911, xvii, 584. Dagaew found that food reached the lower ileum in thirteen hours instead of six after removal of the strong pyloric muscle. Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1913, xxvi, 179. Cohn found in a case of complete removal of the stomach and vagus endings that food went very slowly through the bowel, reaching the cecum only after twenty-four hours. Berl. klin. Wchnschr., 1913, l, 1393. Cole has noticed that the cecum fails to empty for a long time if the patient does not eat after the contrast meal, Am. Jour. Med. Sc., 1914, cxlviii, 110.

62. Stierlin: Centralbl. f. Roentgenstr., 1911, ii, 254. Case describes the emptiness of the cecum in cecal tuberculosis. Arch. Roentg. Ray, 1915, xix, 381. Kienbock discusses the subject at more length in Fortschr. a. d. Geb. d. Roentgenstr., 1913, xx, 231. Nothnagel says food is rushed through sections of bowel that have been inflamed and made irritable by the injection of concentrated salt solutions. Beitr. f. Physiol. u. Path. d. Darmes, 1884, p. 39.

63. Kirstein: Deutsch. med. Wchnschr., 1889, xv, 1000. Kelling: Ztschr. f. Biol., 1903, xlv, 249. Reichel: Deutsch. Ztschr. f. Chir., 1892-93, xxxv, 551. Nothnagel: Beitr. z. Physiol. u. Path. d. Darmes, 1884, p. 29. Quirot: Thèse de Paris, 1909, p. 25. These men have all remarked on the contracted, empty state of the bowel above the obstruction, and the signs of anastalsis a long distance above. Shimodaira: Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1910, xxii, 229, and Maleyx, Thèse de Paris, 1912, have written monographs on the well-known distention and ulceration of the cecum with obstruction in the lower colon.

64. Kirstein: Deutsch. med. Wchnschr., 1889, xv, 1001, thinks acute ileus is not the result of closure of the bowel but of its mal-treatment. When he cut the ileum across and sewed it up, the food went on down the intestine and packed against the obstruction. The dogs did not vomit, and finally died of starvation. When, however, he pinched the bowel with an elastic ligature, the food was turned back in the duodenum and the dogs were very sick. Treves says that in acute intussusception, violent symptoms of obstruction may run their course without there having been produced any actual occlusion of the bowel. He believes the symptoms are due to what he calls peritonism, Intestinal Obstruction, New York, 1902, p. 2. These mechanical factors should not be lost sight of, although the recent work on intestinal obstruction shows the problem to be quite complicated.

65. Barclay: Brit. Jour. Surg., 1915, ii, 645. According to the theory, we would expect to find hypermotility in the colon with appendicitis. Deaver says diarrhea is present in about 13 per cent. of cases. It is met with more often in children. Appendicitis, Philadelphia, 1905, p. 226 and 244. That it is not seen more frequently is due probably to the powerful repelling effect from the lower colon.

53. Baumstark has shown that fermented food put through fistulas into various parts of the intestine will greatly slow the emptying of the stomach. Ztschr. f. physiol. Chem., 1913, xxxiv, 437.

54. Alvarez: Am. Jour. Physiol., 1915, xxxvii, 276.

55. Hertz: Ann. Surg., 1913, lviii, 466, and Moynihan: Abdominal Operations, Philadelphia, 1906, p. 221, have seen even fatal diarrhea after gastro-enterostomy when the stomach emptied too rapidly.

56. Hertz: Guy's Hosp. Rep., 1907, lxi, 403. Case: Jour. Michigan State Med. Soc., 1913, xii, 577. Carman: THE JOURNAL A. M. A., March 28, 1914, p. 980. Eisler: Centralbl. f. Roentgenstr., etc., 1912, iii, 320. Schlesinger: Berl. klin. Wchnschr., 1912, xlix, 1223. Holzknecht and Luger: Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1913, xxvi, 669.

57. Barclay says when he cannot provoke any gastric peristalsis he always suspects a lesion at the pylorus, Brit. Med. Jour., 1910, ii, 539. Carman: THE JOURNAL A. M. A., March 28, 1914, p. 980. Kreuzfuchs believes that hypertonus of the pyloric end causes hypotonus of the body of the stomach, Wien. med. Wchnschr., 1912, lxii, 1073. The blocking of waves by a tonus ring is described by Cannon: Mechanical Factors in Digestion, p. 188.

58. Haudek: Wien. med. Wchnschr., 1912, lxii, 1061.

59. Once in ninety cases, Haudek: Wien. med. Wchnschr., 1912, lxii, 1061. Carman has never seen it. THE JOURNAL A. M. A., March 28, 1914, p. 980.

60. Cunningham: Tr. Roy. Soc. Edinburgh, 1905-7, xlv, 9. Brinton: Diseases of the Stomach, London, 1859, p. 268.

dilated and atonic. The duodenum is often dilated, and material stagnates either in the "cap" or just above the duodenojejunal junction.⁶⁶ That this is not due to kinks or adhesions is shown by the fact that the swallowing of a mouthful of solid food generally causes this bismuth to whisk over into the jejunum. This region has also been found normal at subsequent operation in several cases. I have seen active reverse peristalsis in the duodenum due to the ileac stasis alone.

Back pressure from the intestine must be looked for in all cases of gastric atony or deficient emptying when no lesion can be found near the pylorus. Several writers have emphasized the importance of gastric dilatation as an early sign of intestinal obstruction. It can be detected with the stomach tube and Roentgen ray some time before the reverse currents are strong enough to cause the typical vomiting.⁶⁷

There is a so-called gastric type of carcinoma of the lower colon in which nausea, vomiting and gastric dilatation are the early symptoms of the ascending influences.⁶⁸ The descending ones show themselves later in tenesmus and protrusion of the rectal mucosa.

CONSTIPATION

In sensitive people and in children, constipation may cause vomiting which will yield promptly to a laxative. These patients may feel stuffed after a few mouthfuls, on account of the reverse influences.⁶⁹ Conditions seem to be somewhat as they are in baseball when the bases are full and the batter has made a hit: there is no use of his running if the runner on third refuses to come "home." The intestine may also be thought of as a railroad under control of a block system. Just as food in the stomach forces material through the ileocecal valve or into the rectum when the tract in between is empty, the stagnation of material in a lower block will hold up the food for several blocks above.

Future experiments must show how much actual reverse waves or ripples have to do with the process. The reverse influences seem to skip over regions in which the waves are catastatic to cause anastalsis above. The direction of peristalsis may change also from time to time in the same stretch of bowel. All these observations are explainable in the light of the theory.

A large part of what is called "biliousness" and "autointoxication" may be due to this tendency to reverse peristalsis when the colon remains filled and active. "Biliousness" derives its name from the

appearance of bile in regurgitated material, and this would be more liable to occur when the tone of the intestine is higher than that of the stomach. Much of the satisfaction that the "bilious" get from a dose of calomel may be due to the setting of a strong current down the tract again. The symptoms in the "auto-intoxicated" ordinarily clear up within a few minutes after emptying the rectum, and no toxin could be eliminated at that rate.

There seems little doubt that normally the tone of the rectum and sigmoid is higher than that of the cecum and ascending colon.⁷⁰ This tends to protect the anal sphincter and to keep feces out of the ampulla except during those times when the pressure from the upper part of the tract is very great. Material which is forced over into the rectum may even be returned to the transverse colon if defecation is postponed.⁷¹ The commonest cause of constipation is probably an increase of this tone which makes the gradient steeper up to the rectum.⁷² Case has found adhesions irritating the pelvic colon in a number of these cases.⁷³

Hemorrhoids and painful fissures may cause constipation not only on account of the fear of pain at defecation but by raising the tone of the rectum, and thereby keeping the sigmoid and ampulla empty. This holding back is often shown by a large accumulation of gas in the splenic flexure. This is so constant a finding that I have come to regard a large tympanitic Traube's space as almost diagnostic of hemorrhoids.

CONCLUSION

It was natural that when the Roentgen ray first threw light on conditions in the digestive tract, the striking defects, as seen in carcinoma and ulcer, and the marked ptoses, so different from what anatomists had taught us to expect, should have occupied the center of the stage. Soon the more thoughtful radiologists began to realize that it was only occasionally that they could see the lesion, or, more correctly, a cast of the lesion. In the large proportion of cases they could only suspect the presence of some irritant from the altered motility in different parts of the tract. Finding marked ptoses and kinks every day in people with good digestions, they began to see that a stomach might empty just as satisfactorily when in the pelvis as when above the navel. As Case says, "with increasing experience, the morphological factors have shrunk in importance, while the problems relating to the functional behavior of the alimentary tract have assumed greater significance."⁷⁴

Some good may be done by this article if it helps at this time to bring about a more physiologic point of view in gastro-enterology; if it induces more men to think of the tract as a unit, and to study it from one end to the other before they make diagnoses, or attempt repairs at any one point. Good men are still reporting statistics on gastric ulcer, six-hour stasis, etc., without making mention of conditions even as far away as the gallbladder. Surgeons are doing gastro-enterostomies on baggy stomachs when the offending appendix should come out instead. How much better it would be to explore the tract carefully before beginning work on

66. I have observed these things many times. See articles by Borgbjrg: *Verzgerung der Magenentleerung bei Darmkrankheiten*, *Arch. Verdauungskr.*, 1911, xvii, 706. Bassler: *THE JOURNAL A. M. A.*, Oct. 24, 1914, p. 1469. Eisen, *Ibid.*, p. 1228. Barclay: *Arch. Roentg. Ray*, 1913, xviii, 234. Paterson and other surgeons have seen at operation marked dilatation of stomach and duodenum in many cases of appendicitis. *Proc. Roy. Soc. Med. London*, 1910, iii, *Surg. Sect.*, p. 197. Of 482 cases with gastric stasis due to ascending influences, only twenty-one showed retention after the removal of appendices or the restoration of normal conditions in the bile tract. Smithies: *Am. Jour. Med. Sc.*, 1915, cxlix, 187. Cole says, "I have observed time and time again that if, after the contents of the stomach and 'cap' have remained stationary for some time, the ileum be partly evacuated, a rehabilitation of duodenal peristalsis will be established forthwith and food may be seen . . . passing through the jejunum." *Am. Jour. Med. Sc.*, 1914, cxlviii, 109. Barclay has made similar observations. *Brit. Jour. Surg.*, 1915, ii, 643.

67. Ewald: *Berl. klin. Wehnschr.*, 1907, xlix, 1416. Cataldi: *Polichinco*, Rome, 1914, xxi; *abstr.*, *THE JOURNAL A. M. A.*, Jan. 23, 1915, p. 378.

68. Quirot: *Thse de Paris*, 1909. Hedblom and Cannon's experiments are in accord with these clinical observations. When they irritated the colons of cats with croton oil, the stomachs emptied very slowly in spite of active peristalsis; and there was great retardation in the small intestine also. *Am. Jour. Med. Sc.*, 1909, cxxviii, 520.

69. Hertz found patients could eat little at a time and complained of a sense of fullness when the stomach emptied too fast after a gastro-enterostomy. This disagreeable sensation was less after taking castor oil, apparently because the jejunum emptied faster, *Ann. Surg.*, 1913, lviii, 466.

70. Rost: *Verhandl. d. deutsch. Gesellsch. f. Chir.*, 1912, p. 169.

71. See a very interesting article by Campbell: *Tr. Am. Gynec. Soc.*, 1878, p. 286. Also Schwarz: *Mnchen. med. Wehnschr.*, 1912, lix, 2155.

72. Singer and Holzknecht: *Mnchen. med. Wehnschr.*, 1911, lviii, 2536. Keith: *Brit. Jour. Surg.*, 1915, ii, 581.

73. Case: *Arch. Roentg. Ray*, 1915, xix, 380.

74. Case: *Arch. Roentg. Ray*, 1915, xix, 375.

some part which, as Mayo says, may be the fire-alarm and not the fire.

In the last two years I have found it a very useful rule to remember that: *an irritating lesion slows the progress of food coming toward it from above and hastens the progress of food that has passed it.* This has helped in analyzing many unusual cases. For instance, a number of signs may point to a duodenal ulcer, yet the usual hypermotility is lacking. Further study may show that this has been neutralized by the back pressure from a chronic appendix.

In such a short paper little can be done except to present views that can be discussed in more detail later. Such papers that may follow can more easily be seen then in their relations to the whole problem. More proof can be adduced for many of the statements made here, and objections can then be taken up.

In closing I wish gratefully to acknowledge my indebtedness to Dr. Cannon of the Department of Physiology at Harvard, to Dr. Pope of the Surgical Research Laboratory at the University of California and to Dr. Whipple of the Hooper Research Foundation who, one after the other, in the last two years, have so generously afforded me the opportunities to work on this problem.

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ABSTRACT OF DISCUSSION

DR. L. B. WILSON, Rochester, Minn.: I should like to ask Dr. Alvarez to tell us briefly what the factors are which he has been able to use experimentally in increasing the tonus, and those which he has been able to use experimentally in decreasing the tonus; and how he knew that he increased and decreased the tonus under those conditions.

DR. WALTER C. ALVAREZ, San Francisco: My reasons for believing that the tone of the bowel is raised by the giving of food or by irritating lesions are given in the paper. I have some evidence that irritation, or the presence of food, can alter the gradient of rhythm. In one rabbit with a very active and irritable cecum, the lower ileum contracted eighteen times per minute instead of the usual eight or ten. Considerable reverse peristalsis could be produced in this animal by injecting a little of the cecal contents into the terminal ileum, hence possibly the gradient of tone had also changed. The theory will be placed on a much firmer foundation when we know more about the way in which the tone is graded from one part of the tract to the other. In this paper I have had to assume that it follows somewhat the gradient of rhythm already established. Work is now being done on this and other phases of the problem. In the meantime it does seem permissible to call attention to the beautiful way in which a large number of observations fit into such a theory as is here presented.

Policemen Assist Health Department.—An experiment in cooperation between the police department through its patrolmen and the health department has been in progress since May 17, in Health District No. 1, in the lower East Side of Manhattan. The work has gone smoothly from the start, the policemen are interested in the work and the results obtained are better. Complaints and requests for assistance of various kinds submitted by physicians, field nurses and food and sanitary inspectors of the district are assigned with brief verbal explanations to the outgoing squad of patrolmen. The assignments are simple and call only for an "O.K." or "Not O.K." by the patrolman and clerical work is avoided. The policemen are also instructed as to sanitary nuisances and what action to take in regard to them. The time required of the patrolmen is not over ten minutes a day for such assignments and talks. Arrangements are under way to give instruction in sanitary matters of new policemen by the Bureau of Public Health Education of the Department of Health. The work of the patrolmen has been of great assistance to the department.

SPINAL CORD COMPRESSION FROM LEPTOMENINGEAL CYSTS

WITH A REPORT OF TWO CASES *

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The two cases which are incorporated in this report, and about which revolves the discussion of the subject of nonparasitic cysts of the leptomeninges of the spinal cord, are found to be quite uncommon, even though a most thorough search of the literature is made. The bulk of the reported arachnoidean cysts have for their etiology either the cysticercus or echinococcus, which means that they are multiple and complicated. Moreover, it is highly important that the simple, nonparasitic cysts like those which I am placing on record be recognized early, so that immediate proper operative intervention may be instituted. Then a fair prognosis may be offered.

A plea for an early recognition of the nature of the trouble is a chief motive for placing before the profession a report of my two interesting and instructive cases.

The first patient was in an extreme paraplegic state when first observed. Operative treatment improved her condition but not in a satisfactory manner. The second patient came under my observation in an earlier stage, and with a prompt operation and good after-care made a much better recovery.

REPORT OF CASES

CASE 1.—The patient (V. J., single, aged 37, tailoress) was referred to me for diagnosis by Dr. Gray, who performed the operation at St. Margaret's Hospital, which she entered July 10, 1912. She complained of inability to walk on account of a paralysis in the lower extremities, pain about region of lower ribs, feeling of numbness in the legs, and loss of control for urination and defecation.

Family.—Father is living, aged 87. He is suffering from a recent progressing senile enfeeblement. Mother died of pneumonia at the age of 73. Patient has three living brothers, all well; two brothers died, one at 22 and the other at 44 of tuberculosis. There are two healthy living sisters. One sister died of "heart disease" at 49, and another of tuberculosis at 23.

Past Illness.—Patient has had measles and epidemic parotitis. The menses were established at the age of 15. There has been some dysmenorrhea but no leukorrhea. Since the age of 16 there have been attacks of "stiff neck" lasting two or three days. Seven years ago there was an eruption below the knees without itching. There was some backache and headache at the time, but no sore throat, alopecia nor subsequent pains. Recovery was prompt.

Present Trouble.—The onset dates from about July, 1909, when patient awoke one morning with a feeling of numbness in the right leg. There was much difficulty in walking and no work was done for one week. Then followed a period in which she was able to work but there was present always a numbness and trouble in walking. Sharp pains around the waist and in the lower chest appeared early. Three weeks before entering the hospital the condition grew rapidly worse and the patient became bedridden. The left leg had become severely involved also. A loss of rectal control and urinary retention with a subsequent overflow and dribbling had appeared. Uncontrollable jerkings of the legs had been present a few weeks. There had been no headaches or vomiting.

* Read before the Section on Nervous and Mental Diseases at the Sixty-Sixth Annual Session of the American Medical Association, San Francisco, June, 1915.