

One could hardly determine the exact mechanism of such an injury, but we concluded, from the manner in which the heavy aponeurotic band was twisted about the femur, that there was first a dorsal dislocation with further extreme outward rotation, which caused avulsion of the trochanter, after which there was an inward rotary movement which coiled the

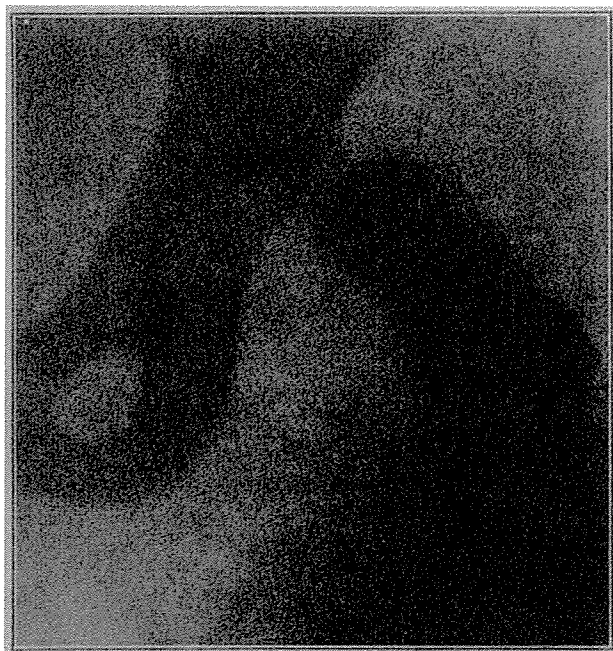


Fig. 2.—Dorsal dislocation after dislodgment of head in perineum.

heavy aponeurosis about the neck and shaft prior to perineal lodgment. This tense sheet or band was obviously the factor in tenaciously holding the head against the inner aspect of the tuber ischii.

This case illustrates how futile were our efforts to reduce and, from the excellent result, that possibly it



Fig. 3.—Condition six months later: reduction with callus from stripped periosteum.

might be wise to resort to open reduction in certain instances after moderate attempts have failed.

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Complement Fixation in Goiter.—The blood of some patients who show symptoms of exophthalmic goiter binds complement in the presence of an antigen made from normal thyroid glands.—J. Koopman, *Proc. New York Path. Soc.* 21:56 (Jan.-May) 1921.

THE ELECTROGASTROGRAM AND WHAT IT SHOWS *

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After several years spent in devising special apparatus and overcoming technical difficulties, I am now getting good records of the action currents in different parts of the stomach and bowels of laboratory animals. The first report of this work has already been published.¹ The records in that article show that the electrograms obtained by leading off from various parts of the stomach and bowel to an exceedingly sensitive d'Arsonval galvanometer resemble closely the kymographic records obtained by attaching light levers to

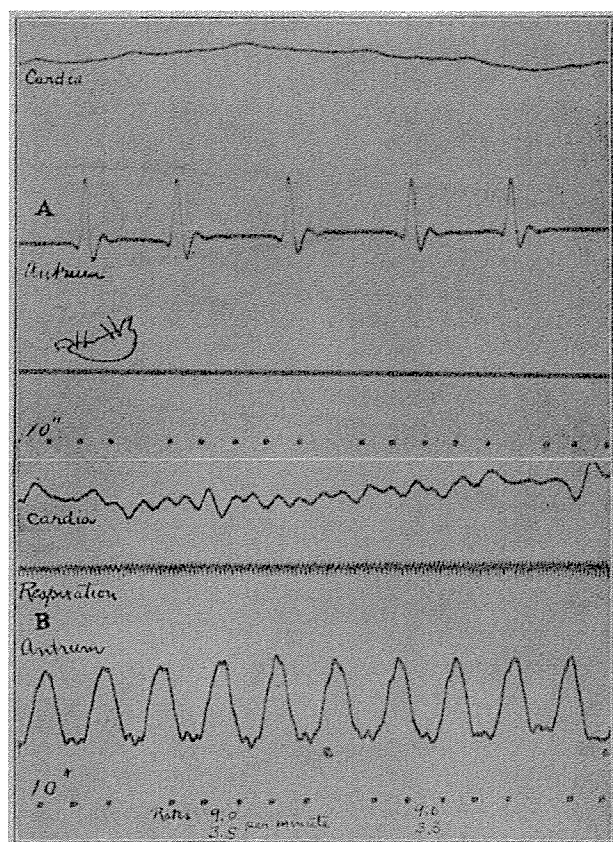


Fig. 1.—A, simultaneous electrogastrograms from the excised stomach of a cat placed in a bath of warm oxygenated Locke's solution. The small diagram shows the location of the electrodes. In this and in all subsequent graphs an upward movement indicates a negativity of the oral electrode. Note smaller waves between the main ones on both records. B, simultaneous electrogastrograms from the stomach of a cat under urethane anesthesia and with the abdomen opened under warm Locke's solution. There appears to be a complete dissociation between the activities of the two parts of the stomach. The time record represents ten seconds, with a twenty second interval every minute.

those parts or to bits of muscle excised from them. This resemblance is striking, as regards not only the rate of contraction but also the general form and amplitude of the curve.

We have, then, at our disposal a new method with which to study the activities of the digestive tract. One of its great advantages is that records can now be obtained at all times even from stomachs and bowels

* From the George Williams Hooper Foundation for Medical Research, and the Department of Medicine, University of California Medical School.

1. Alvarez, W. C., and Mahoney, L. J.: *Am. J. Physiol.* 58: 476-493 (Jan.) 1922.

which seem to be motionless. Hitherto, physiologists have often been hampered by the visceral paralysis which results from opening the abdomen, but it is seen now that the resultant splanchnic stimulation can abolish the visible contractions without stopping the rhythmic currents. To use a mechanical simile, the underlying chemical processes seem to go on after the nerves have thrown out a sort of "clutch" between them and the contractile substances in the muscle.

THE GASTRIC PACEMAKER

Naturally, the first question to be asked of the new method was: Where is the gastric pacemaker and just how do the waves run over the stomach? Although, as often happens, the work has been more fruitful in new puzzles than in answers to the original one, certain observations may briefly be reported at this time.

Previous work had made me feel that the pacemaker would probably be found on the lesser curvature near the cardia, because the muscle excised from that part shows a greater rhythmicity than that of any other part of the stomach. Furthermore, it had seemed to me most probable that the waves which we see arising here and there about the middle of the stomach have really come as ripples from this pacemaker. The electrogastrograms now show clearly that this is often the case, and that definite electrical disturbances are traveling over the fundus when no movement of the muscle can be detected even with a magnifying glass. With suitable apparatus, however, I have been able to show that the muscle does move, usually through distances of only a few thousandths of an inch. Sometimes, as in the irritable stomachs of persons with duodenal ulcers, these waves beginning near the cardia are so deep that we can easily see them with the roentgen ray and without magnifying devices.

DIFFERENT TYPES OF PERISTALSIS

If all the gastric waves began at one point and traveled evenly to the pylorus, the problem would be relatively simple; but, unfortunately, the records, and we already have a hundred yards of them, show all sorts of irregularities. There are shifts of the pacemaker, sometimes even to the pyloric region; there are contractions appearing here and there which do not seem to set up any traveling disturbances; there are waves which travel half way across the stomach only to be blocked suddenly at some point (Fig. 2 B); and there are at times systoles of the stomach as a whole. Confusion arises not only on account of the number of these different types of gastric peristalsis but also on account of the sudden changes from one type to the other.

The problem of analyzing the records is complicated still further by the fact that the rate of travel of the waves down the stomach seems to vary markedly from time to time. One set of waves may take seven seconds each to go from the cardia to the antrum, while shortly afterward another set may take twenty-one seconds each. This irregularity, together with the fact that two or three waves are often traveling over the stomach at the same time, makes it very difficult to identify and correlate the deflections which appear in records taken simultaneously from different parts of the organ.

DISSOCIATION OF FUNDUS AND PARS PYLORICA

Still more puzzling and surprising is the discovery that the body of the stomach and the pyloric antrum

can contract with separate rhythms, much as the dissociated auricle and ventricle do after complete heart-block. I had not been getting electrogastrograms long before I found a number in which the cardiac record showed from three to four times as many deflections as the antral (Fig. 1 B). Now, although my previous work had led me to look on the stomach as a combined crop and gizzard, that is, two organs with different functions and different types of muscle, I was not prepared for quite so much dissociation of activity. Furthermore, it had never occurred to me that twelve

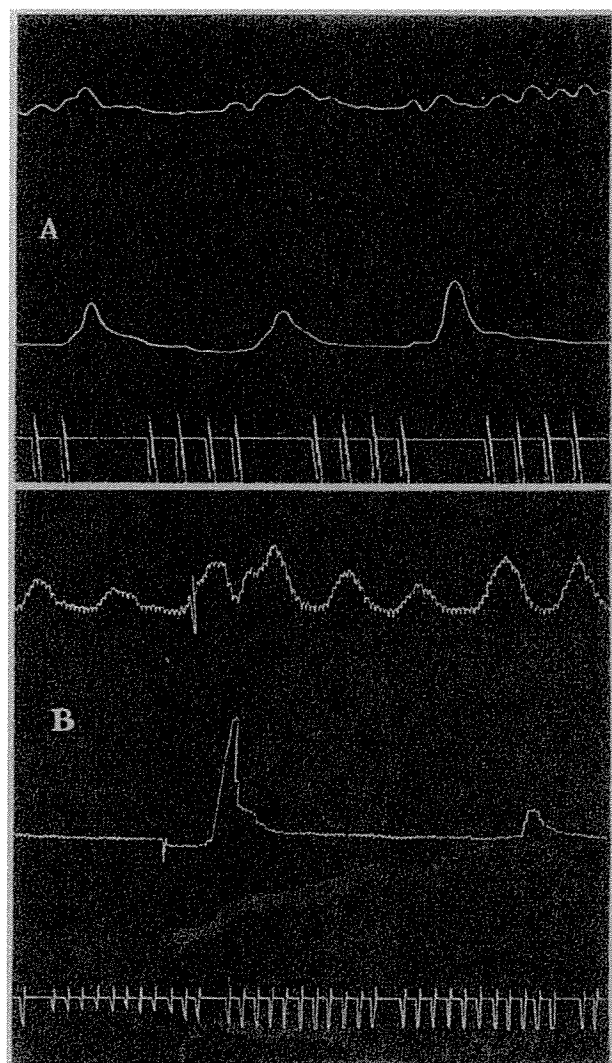


Fig. 2.—A, record obtained by fastening light levers to the peritoneal surface of the excised stomach of a dog, kept in warm Locke's solution. Note in the upper, fundus, record small frequent waves superimposed upon the larger ones. The lower record is from the pyloric antrum. B, record obtained by fastening delicate enterographs to the peritoneal coat of a sickly rabbit's stomach. The animal was under urethane and had its abdomen opened in a large tank of warm Locke's solution. The upper record is from the preantrum; the lower, from the antrum a centimeter away. Note the block with occasional escape. The small waves on the preantral record are respiratory in origin. The time record represents five seconds.

contractions a minute could appear in a stomach over which three waves a minute are passing. Hence, I felt the need for checking, as soon as possible, the accuracy of the electrogastrogram with simple mechanical methods. That is now being done in my laboratory:

simultaneous kymographic records are being obtained from different portions of the stomach, and I can already say that there is no doubt about the dissociation at times between the activities of the fundus and the pyloric antrum, or about the ability of the gastric muscle to respond to two or more rhythms at the same time (Fig. 2 A). When we come to think of it, this should not be surprising, because we know that rush waves travel down the small intestine from time to time over

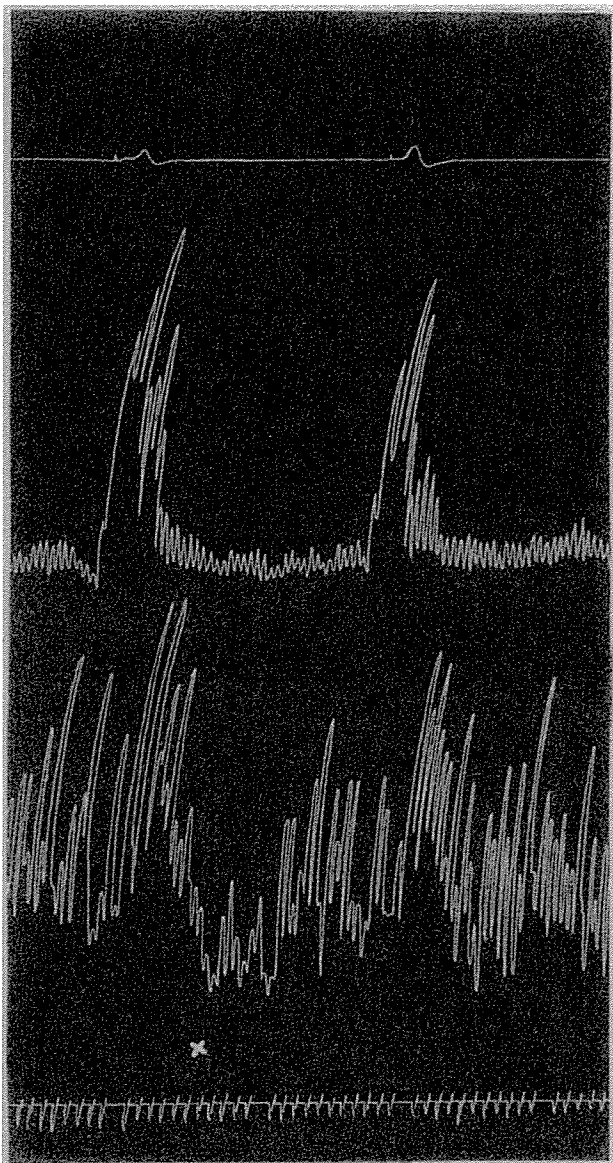


Fig. 3.—Mechanical records obtained by fastening enterographs to the peritoneal surface of the pyloric antrum, first portion of the duodenum, and duodenum 20 cm. below the pylorus. The animal was a rabbit, under urethane, and with the abdomen opened under Locke's solution. Note the large tone changes in the duodenum when gastric waves approach the pylorus. At x, the drop in tone shows that a rush wave has just passed on its way down the bowel.

muscle which is not only contracting from ten to twenty times a minute, but is responding constantly to marked tonus changes. Incidentally, the work of Palugyay,² who screened the stomachs of men and women lying head downward at an angle of 45 degrees, suggests

strongly that the small, frequent fundus waves are present sometimes in man.

PYLORIC BLOCK NOT ABSOLUTE

Another interesting point brought out with the new methods is that the stoppage of the gastric waves at the pylorus is not so complete as has hitherto been thought. We can see now that the approach of a wave in the pars pylorica is the signal for the appearance of a strong tonus wave in the first portion of the duodenum (Fig. 3). If this can be shown to occur also in man, we shall take a step forward in explaining the production of the pain in duodenal ulcer.

The new records show, moreover, that the rush waves down the bowel always originate in a gastric contraction which, as we have seen, raises the tone of the duodenum. Furthermore, the needs of the bowel seem often to affect the intensity of gastric peristalsis. Thus, when the duodenum has been contracting actively for some time, trying to send a rush wave down the bowel, the stomach seems often to come to its aid with one or two powerful waves. At other times, a sudden increase of activity in the lower bowel will temporarily stop the gastric waves.

I have long suspected from watching peristalsis in man and animals that some sort of disturbance travels well out ahead of the visible wave, and I can now show it clearly in the records. This observation may have considerable importance because, when the pylorus is a little more irritable than usual, its latent period is likely to be shortened. The muscle there will respond out of its turn, and its contraction will block the main part of the wave before that can bring force to bear on the sphincter. I believe that we can in this way account for the failure of some stomachs to empty properly in spite of good waves and the absence of any visible obstruction at the pylorus.

THE HUMAN ELECTROGASTROGRAM

I had not been working long with the galvanometers before I began experimenting to see what could be done on man. I first proved to my satisfaction that good electrogastrograms could be obtained by applying non-polarizable electrodes to the shaved abdominal walls of rabbits. The apparatus was then used on a little old woman whose abdominal wall was so thin that her gastric peristalsis was easily visible. This was very convenient, as we could see where to place the electrodes and we could also make a mark on the record every time a wave passed by. A glance at Figure 4 will show that although one of the records, derived presumably from the pars pylorica, has three deflections a minute, corresponding to the gastric waves, the other one has from eleven to twelve deflections superimposed upon waves corresponding to the visible ones. This record looks so much like many of those obtained from the cardiac region in cats and dogs that I strongly suspect that its deflections are due to small contractions in the upper part of the stomach. My efforts to get similar records from other persons with better muscled abdominal walls have not been so successful. In some, no deflections were seen, while in others only a respiratory record could be obtained. Better results may later be obtained by amplifying the delicate currents.

Some records are now being obtained with an intra-gastric electrode which can be introduced very much like an Einhorn tube. As modifications are still being made in this instrument, I will reserve its description

2. Palugyay, J.: Arch. f. d. ges. Physiol. 187: 232, 1921.

for a later paper. Suffice it to say that it is a small calomel electrode, 4 mm. in diameter and 2 cm. long. With this apparatus, we can record the gastric contractions of patients with achlorhydria but, as I feared, we have had no success with persons with normal acidities. The voltage produced by slight differences in the concentration of acid bathing the instrument are so great that I doubt very much whether anything can ever be done along these lines.

COMMENT

We see, then, that a study of the action currents of the stomach and bowel has already brought to light a

that they are to be looked for under certain conditions; and, thirdly, that they give rise to certain symptoms. To illustrate, we may some day be able to say that the desire to belch is associated with one type of peristalsis; the relief obtained by taking a little soda is due to the institution of another type; the pain of ulcer to yet another type, and so on, just as the heart specialist, after long experience with the electrocardiograph, can now make shrewd diagnosis of fibrillation, heart block, and so forth, on the basis of the symptoms or the feel of the pulse. Since writing this little prophecy, I have been delighted to see a start made toward its fulfilment in the excellent paper of Reynolds and McClure.³ They have been screening patients with ulcer for hours at a time, watching to see what happens when pain comes and goes, and they have observed that the onset of such pain often coincides with a change from one type of peristalsis to another. These differences in type have been observed by roentgenographers for years, but no one has taken the time to correlate them with symptoms as Reynolds and McClure have done.

SUMMARY

The first steps have been taken in working out the technic of electrogastrography. The records show that many of the waves which seem to begin in the lower third of the stomach have come as shallow ripples from a pace-making region near the cardia. There are, however, a number of different types of gastric peristalsis, and the stomach can change suddenly from one to another.

At times, there seems to be a dissociation between the activities of the fundus and the pars pylorica. The fundus can contract several times to the antrum's once. Small, frequent waves are sometimes superimposed upon the larger, slower ones. These findings have been confirmed with mechanical recording devices.

Marked blockage of the waves has been observed often in the preantral region.

The conduction time of waves traveling down the stomach shows wide variation.

Marked tonus changes occur in the duodenum coincident with the arrival of gastric waves at the pylorus. This observation may throw light on the production of pain in duodenal ulcer.

The peristaltic rushes down the bowel are shown to originate in gastric waves.

The first human electrogastrograms are here presented.

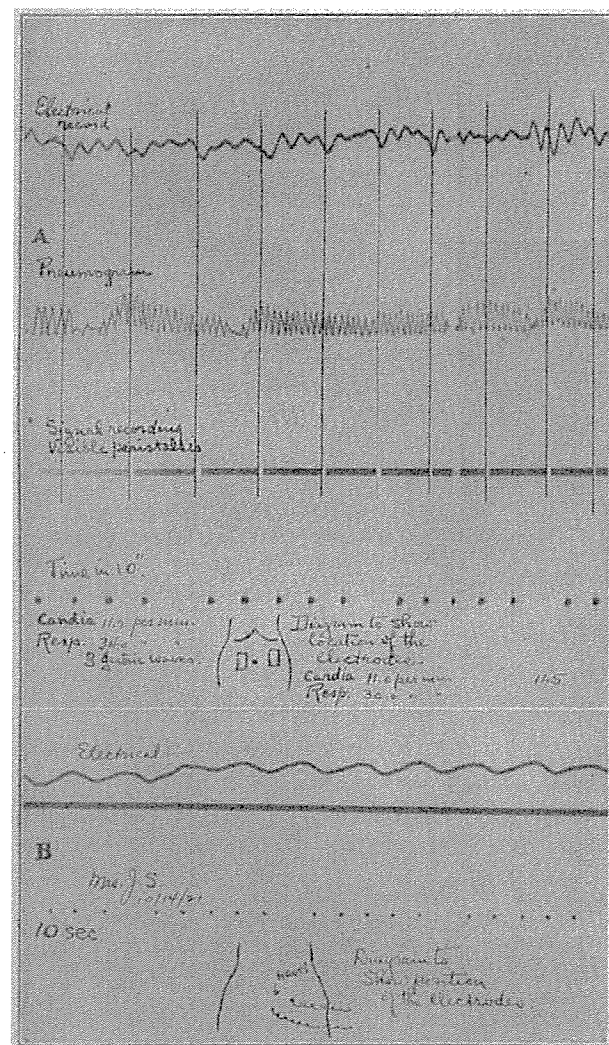


Fig. 4.—Human electrogastrogram. A, the small, frequent fundus type of deflection superimposed upon larger deflections which correspond in time with the visible gastric waves. B, the antral type of deflection. The small diagrams show the location of the electrodes on the abdomen.

number of interesting things. Still better, perhaps, it has offered us a number of puzzles for solution and has caused us to ask many questions. The future alone will tell us how common the irregular types of peristalsis are in man, and whether they are normal variations or definitely pathologic.

Perhaps the most important service such studies are likely to render the clinician is the demonstration, first, that certain peculiar types of peristalsis exist; secondly,

3. Reynolds, Lawrence, and McClure, C. W.: Motor Phenomena Occurring in Normal Stomachs, in the Presence of Peptic Ulcer and Its Pain, as Observed Fluoroscopically, *Arch. Int. Med.* 29:1 (Jan.) 1922.

Psychotherapy in Hiccup.—Recently a boy, aged 8 years, while undergoing the desquamating period of scarlatina was attacked with a sharp, rapid, violent hiccup. It persisted several days, and by preventing sleep, caused alarm. Since it proved defiant to the methods usually employed for treating this symptom, I decided to try a psychotherapeutic measure. It was strongly impressed on the patient's mind that the ingestion of a teaspoonful of red medicine, resulting by mixing two drugs, would effect a cure. He was also told that any color other than red would be noneffective. Then, phenolphthalein and magnesia magma were combined in the patient's presence, resulting in the formation of the red medicine. The boy opened his eyes wide, and eagerly drank a dose of the mixture with the result that the singultus stopped immediately and did not recur.—D. J. CALICCHIO, Cambridge, Mass.