

THE PYLORUS, PYLOROSPASM AND ALLIED SPASMS IN INFANTS *

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In studying the extensive literature of pylorospasm, one is impressed time and again by the striking uncertainty attending its diagnosis and the difficulty of differentiating this condition from organic stenosis and even from simple vomiting. Most writers on the subject have drawn attention to the diagnostic difficulties and have grouped their cases under the title of pylorospasm in a rather tentative spirit, because, all things considered, the symptoms seemed to point most clearly to a spastic condition. Indeed, diagnosis has not always been possible even after post-mortem examination. The problem, however, is essentially a clinical one, as the majority of cases recover and do not reach autopsy. Few require surgical intervention; so that this opportunity for studying the condition is also not frequently afforded.

As the result of clinical experience some observers have come to the conclusion that there is no pathognomonic sign or symptom which serves to differentiate functional from organic pyloric obstruction. On the other hand many have singled out a symptom or symptom-complex which they believe constitutes a significant distinction between the two groups of cases. These various criteria will be fully discussed in the body of this paper. The cases we report have been subjected to a test which was suggested nearly two years ago in a preliminary presentation of this subject¹—the passage of the duodenal catheter. We shall consider only pylorospasm and not organic obstruction of the pylorus, using as the basis of our report and conclusions some twenty cases of spasm which have been tested by means of the catheter and also studied from a clinical viewpoint. Under this heading of pylorospasm we have assembled cases which, in spite of obstruction at the pylorus, have permitted the passage of the catheter beyond the pyloric sphincter. It is assumed that whenever it is possible to insert a No. 15 (F.) catheter into the duodenum, organic stenosis is so slight that it can be disregarded from a clinical point of view. We do not mean to state that stenosis may not exist in such cases, but that, if we are to differentiate clinically between organic and functional conditions, the obstruc-

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1. Hess, A. F.: *AM. JOUR. DIS. CHILD.*, March, 1912.

tion in these instances must be regarded as spastic in nature and the disturbance as functional.

MEASURING THE NORMAL PYLORUS

In a consideration of the question of pyloric obstruction in infants, one of the first steps should be to ascertain, if possible, the normal functional diameter of the pylorus and the physiological variations from this form which occur at this early period of life. This question has been considered by many investigators. Various ingenious tests for measuring the lumen of the pylorus have been devised, especially by Pfaundler,² who has pursued this study with particular care. However, it must be borne in mind that all tests have been based on post-mortem examination and that they furnish purely anatomical measurements which cannot be regarded as functional. We have confined ourselves to tests *in vivo*. It may be recalled that in the preliminary study on infants a month or more of age it was found that a No. 15 (F.) catheter could be readily inserted past the pylorus. We have made further tests in this direction, using a series of catheters of increasing size and of the following circumferences: 15, 17, 18, 20, 22, 24 mm. We were absolutely unable to pass the No. 24 (F.); the No. 22 was passed occasionally in infants 6 months of age or over. On infants 2 to 3 months of age catheters measuring 15, 17 or 18 mm. could frequently be inserted beyond the pylorus, and exceptionally one having a circumference of 20 mm. From these tests it would seem that *the functional circumference of the pylorus at this age is about 18 mm. and the functional diameter about 6 mm.* It is realized that these figures are not mathematically correct; indeed, it is evidently impossible to lay down hard and fast measurements for the lumen of any sphincter. The sphincteric aperture was found to vary and not to observe a strict parallelism with the size of the infant. In the breast-fed infant, or in any robust, well-nourished baby, the pylorus as a rule has a greater tonicity under normal conditions than in the poorly nourished infant, where the general musculature is relaxed. However, these variations are not as great as, at the first glance, they would seem; the difference between permeability for a No. 18 and a No. 21 catheter is less than 1 mm. in diameter. It is of course perfectly possible that the pyloric musculature, which is highly elastic, is capable of further stretching or dilatation under exceptional pressure, and that, as in the case of Ibrahim,³ the pylorus, by assuming a slit-like form, may allow the passage of a coin or other object of a greater diameter. Such variations are inherent in

2. Pfaundler, M.: Bibliotheca Medica, 1898, Part 5.

3. Ibrahim, J.: Jahrb. f. Kinderh., 1913, lxxvii, Part 2, p. 199.

functional tests, which, we may repeat, by their very nature cannot be rigid or arbitrary.

Just a word as to the size of the pylorus of infants during the first week of life. An examination of about 100 unselected cases was carried out, including large and small infants, male and female, first-born and those of multipara, cases in which delivery had been easy as well as those in which instrumentation had been necessary. The caliber of the pylorus was found very constant—a No. 14 (F.) catheter could be passed without any difficulty, exceptionally a No. 15; the latter met with evident obstruction and was very tightly gripped by the sphincter. *The functional circumference of the pylorus in the new-born is therefore about 14 mm. and the functional diameter about 4.75 mm.*⁴

CONGENITAL PYLOROSPASM

So much for the normal. There are some abnormal cases in the new-born which would seem of especial interest in connection with a study of pylorospasm. This view can perhaps be brought out most clearly by detailing clinical notes of some illustrative cases:

Kaplan (male); first child; 7 pounds; 7¼ hours old. Not fed. Feb. 27, 1912.

2:34.—No. 14 catheter passed into stomach. Pharyngeal reflex (Ph.R.) increased. Marked Congo +++ fluid in stomach and throughout ten-minute test. Profuse secretion of saliva. Catheter sucked greedily.

2:50.—Catheter passed again. Ph.R. increased. Duodenum entered easily, marked grip. On entering stomach less grip, marked pharyngeal grip. Baby quiet.

3:06.—Reintroduced. Ph.R. increased. Some obstruction at pylorus, cardia and pharynx; most marked at cardia. Infant sneezed as catheter passed pylorus.

3:22.—Retraction into stomach, where Congo ++ fluid was found. Grip on catheter less when in stomach; still less when in esophagus.

Epicrisis: Marked pharyngeal, cardiac and pyloric reflex. Increased secretion of hydrochloric acid.

This case is cited because it illustrates in an unfed, new-born infant various signs that we shall have occasion to refer to later in connection with pylorospasm—the increase in the pharyngeal reflex, the association of this hypersensitiveness with increased reactivity of the cardiac and pyloric sphincters, and the hypersecretion of gastric juice.

4. The pylorus of an infant had no occasion normally to dilate to this extent. The "pyloric casts" of milk which can be aspirated from the duodenum (as referred to in an article on casein curds) have a diameter of 1 to 2 mm., and denote the normal diameter which the pyloric canal assumes during the passage of milk from the stomach into the duodenum. Pfandler found the inner circumference of the pylorus, measured after relaxation of the musculature, to be as follows: At birth 2.0 cm.; at 3 months, 2.4 cm.; at 6 months, 2.7 cm.; at 9 months, 3.0 cm.; at 1 year, 3.3 cm. A comparison shows, therefore, that these circumferences are far larger on the cadaver than during life.

A second case brings out some of these phenomena still more clearly. It is reported in abstract as there were nine separate tests:

- Baby Blum; 24 hours old. Weight 7 pounds 6 ounces.
- Test 1. Jan. 23, 1912. Pharynx reflex (Ph.R.) negative. Congo ++ fluid in stomach.
- Test 2. Jan. 24, 1912. Ph.R. increased.
- Test 3. Jan. 25, 1912. Ph.R. increased on three tests.
- Test 4. Jan. 26, 1912. Ph.R. increased.
- Test 5. Jan. 27, 1912. Ph.R. increased.
- Test 6. Jan. 29, 1912. Ph.R. negative. Pylorospasm. Could not enter duodenum without putting water into stomach (accessory method). Marked grip on catheter. Alkaline bile aspirated.
- Test 7. Jan. 30, 1912. Ph.R. negative. Indefinite whether entered duodenum.
- Test 8. Jan. 31, 1912. Ph.R. increased. Seemed to catch in pylorus. In a second test, carried out with the aid of accessory method, catheter was felt suddenly to pass the pylorus.
- Test 9. Feb. 1, 1912. Ph.R. increased. Could not enter pylorus without aid of accessory method.

Epicrisis: Repeated pharyngospasm and pylorospasm.

In this instance the spastic condition was almost constant, either as pharyngospasm or as pylorospasm. This same condition was met with in another case (No. 40) where nine tests were also made. In seven an increase of the pharyngeal reflex was found, at times associated with pylorospasm.

The spastic manifestations, however, are not always so constant. The following case illustrates this variability:

- Polack. Weight 7 pounds 7½ ounces. Fifteen hours old. Unfed.
- Test 1. Dec. 19, 1911.
- 4:13. No. 14 catheter passed. Ph.R. normal. 0.5 c.c. Congo +++ fluid.
- 4:15. Catheter reintroduced. Cardiospasm; definite obstruction 13 cm. from gums. Difficulty in passing pylorus, crying, no gagging.
- Test 2. Dec. 26, 1911.
- 4:18. Ph.R. increased. 1½ oz. slightly acid, Congo negative milk in stomach. No cardiospasm.
- 4:25. Reinserted, easily entered duodenum. 2 c.c. yellow viscid fluid; also pyloric casts.
- 4:40. Retracted; no free HCl in stomach.
- Test 3. Dec. 27, 1911.
- 3:25. Ph.R. increased. 1½ oz. Congo negative fluid in stomach.
- 3:32. Easily entered duodenum. Bile. Pyloric casts. No free HCl in stomach.

Epicrisis: In a test soon after birth marked cardiospasm and some pylorospasm was encountered. In two tests carried out a few days later these sphincters were found normal, but pharyngospasm was met with.

In addition to the cases cited or referred to above, other new-born infants were found to have an abnormal irritability of the pharynx, cardia or pylorus; eight cases in all, among one hundred infants tested during the first few days of life. We shall not at this time enter on the interesting subject of the interrelationship of these various forms

of spasm, as this phase of the subject will be considered at length when treating of spasm in later infancy. We wish merely to call attention to the presence of these spastic conditions at and soon after birth, at a period when post-natal influences have not played a part, and when all abnormal conditions must necessarily be considered congenital and perhaps hereditary. *These, then, are true cases of congenital pharyngospasm, cardiospasm and pylorospasm.* Similar phenomena may be met with during the first days of life, excited by post-natal intercurrent factors, by gastric disturbance or dyspepsia. One case of this nature was encountered on which seven tests were made (cited below in abstract), three previous to the alimentary disturbance and four subsequent thereto. Before the dyspepsia developed the infant seemed normal with the exception that pharyngospasm was encountered in one of three tests. Soon after the dyspepsia developed (as evinced by vomiting, fermented gastric contents and abnormal stools), the pharyngospasm increased and became constant, and pylorospasm was demonstrated by the duodenal catheter:

- Schneider, 5½ hours old. Unfed. Weight 7 pounds 12 ounces.
- Test 1. Jan. 22, 1912. Ph.R. increased. Salivation. Small amount of HCl.
 - Test 2. Jan. 23, 1912. Ph.R. normal. Catheter introduced three times.
 - Test 3. Jan. 24, 1912. Ph.R. normal. Entered duodenum. Pyloric cough.
 - Test 4. Jan. 25, 1912. Ph.R. normal. Stools greenish, with curds. Sour odor to stomach contents.
 - Test 5. Jan. 26, 1912. Ph.R. increased. Stomach contents curdled, acid odor. Stools green. Difficulty in passing pylorus. Could not enter in spite of many attempts. *Pylorospasm.* Accessory method used; felt sudden relaxation, entered duodenum. Catheter held, not ejected.
 - Test 5. Jan. 26, 1912. Vomits occasionally. Ph.R. increased. Catheter held tight when introduced into stomach. Difficulty in entering duodenum; succeeded only by means of accessory method. Infant fretted until catheter passed pylorus.
 - Test 7. Jan. 29, 1912. Occasional vomitings; curds in stool; slight prolapse of rectum. Ph.R. increased. Pylorospasm; accessory method necessary to pass pylorus.

Epicrisis: First tests normal except for pharyngospasm on one occasion. Dyspepsia followed by pylorospasm as well as pharyngospasm.

What is the later clinical history of these infants who manifest pharyngospasm, cardiospasm or pylorospasm almost from the hour of their birth; how do they pass through the first months of life, the critical period from the standpoint of pylorospasm? We have had an opportunity to follow five of these cases after they have been discharged from the maternity hospital. Owing to the usual difficulties which surround follow-up work in a large city, the surveillance in all cases was not as long as is desirable. All the infants were nursed throughout the period of observation. Three (Glaisier, Blum, Schneider) remained

entirely well throughout the first three months of life and thrived satisfactorily; one mother, however, reported that for a considerable period the baby (Schneider) vomited repeatedly. Little stress is laid on this indefinite report. The course was not so smooth in the progress of two of the infants: one (Plevner) began to vomit at irregular intervals when 1 month of age, the vomiting being projectile in character. This continued until he was 3 months of age. He was fairly nourished, not emaciated. Probably a mild form of pylorospasm existed, to which we shall refer below. The other infant (Fleischman), to whom we have not previously referred, showed cardiospasm, pylorospasm and gastric hypersecretion (6 c.c. Congo + + + fluid, free HCl 19, combined HCl 37), when examined at birth, on Nov. 18, 1911, before being fed. He began to vomit when about 2 months of age, irregularly, but daily. When visited on January 31, examination showed a fairly nourished infant, gastric area distended, no visible peristalsis. Propulsive vomiting seen. Catheter readily passed. On February 2, at the time of the second visit, some difficulty was experienced in passing the catheter. The vomiting was about the same, but became less marked and by February 16 had ceased. The baby continued to improve; it was last visited April 13.

It would seem that in some new-born infants there is a congenital tendency to spasm of the sphincters to which we have referred, and that clinically this condition may remain entirely latent or may manifest itself in a slight disturbance, such as occasional projectile vomiting, or may become evident following superimposed dyspepsia or other exciting cause. This then may be properly termed congenital pylorospasm. As we have seen, it is frequently latent, and associated vicariously with pharyngospasm and cardiospasm.

Before leaving this subject of spasm in the new-born, we wish to call attention to the fact that the tonus of the pyloric sphincter may be abnormal not only in a positive, but also in a negative sense; that instead of spasm the duodenal catheter may reveal a relaxed or atonic condition. This was noted in two instances. One has been referred to in quite another connection in a study of icterus neonatorum.⁵ The case (Seep, Case 16) was one of congenital family jaundice. The infant was saffron-colored and toxic. There was a marked insufficiency of the pyloric sphincter. Bile was found in the stomach in five of the six tests, and there was vomiting of bile. The catheter could be passed in and out of the duodenum without the least obstruction. Associated with the relaxation in this instance there was diminution of the pharyngeal reflex. Marked relaxation of the pylorus was encountered in

5. Hess, A. F.: *AM. JOUR. DIS. CHILD.*, May, 1912.

another case (Sapperstein) in which there was intense jaundice. It has been shown that these cases of jaundice are associated with a profuse excretion of bile into the duodenum; indeed, generally with a welling forth of the bile into the stomach.⁶ The abnormal patency of the sphincter would seem to result from this increased biliary secretion, to be based on the persistent alkalinity of the upper duodenum, which is acknowledged to hold the latch-string of the pylorus.

In these cases we were confronted with an atonic state of the sphincter, leading to *pyloric insufficiency* as the result of the local inhibition of the pyloric closing reflex. Another instance showed that we may encounter the same functional muscular insufficiency in the course of the examination of an infant otherwise apparently normal:

Qualler, 3 hours old. Weight 6½ pounds. Pale; not strong.

Test 1. Feb. 1, 1912. Ph.R. diminished. Marked saliva, free HCl in stomach.

Test 2. Feb. 2, 1912. Ph.R. diminished. Free HCl in stomach. Inserted catheter three times into duodenum with the greatest ease.

Test 3. Feb. 3, 1912. Ph.R. diminished. Catheter introduced into duodenum without meeting the least resistance.

Epicrisis: Diminished reflex of the pharynx and of the pylorus.

II.

Following these preliminary remarks concerning pylorospasm in the new-born, let us turn to a consideration of various points of interest encountered in the course of passing the duodenal catheter on a large number of older infants, and more especially in cases of pylorospasm. It seems preferable, in order to bring out saliently the various phenomena which we wish to discuss, to consider the subject from the standpoint of various isolated symptoms, rather than as a clinical entity. We shall therefore take up the following pathological symptoms, always bearing in mind that they rarely occur singly and that the subdivisions are purely artificial: pharyngospasm, cardiospasm, visible peristalsis, palpable tumor, gastric and duodenal hypersecretion, singultus, pylorospasm and allied spasms.

Many of the cases were seen at the Post-Graduate Hospital on the service of Dr. Henry D. Chapin, to whom I take pleasure in expressing appreciation for the privileges accorded me.

PHARYNGOSPASM

First, as to the occurrence of pharyngospasm, described in this connection by Finkelstein. One cannot pass a catheter on many normal infants, and especially on infants suffering from spasm of the pylorus,

6. Hess, A. F.: AM. JOUR. DIS. CHILD., October, 1913.

without having the attention drawn to the intimate relationship between the reflex of the pharynx and that of the pylorus. Frequently when the tip of the catheter engages the pyloric sphincter the infant begins to gag, and at each repetition of the procedure will react in the same way. We shall not attempt to give a physiological explanation of this connection. However, it is undoubtedly true that when the pyloric reflex is increased, the pharyngeal reflex generally is also increased, and that there is also at times a connection between the reflex at the cardia and the reflex at the pharynx. It will be remembered that we cited an instance in the new-born in which there was an insufficiency of the pyloric sphincter and also a lack of reactivity on the part of the pharynx (Seep case).

Associated with spasm of the pharynx muscles there may be gastric hypersecretion. In one instance, by instilling a small amount of normal hydrochloric acid into the duodenum and thus causing a contraction of the pylorus, a spasm of the pharynx was brought about. In the only instance in which hydrochloric acid was found lacking at birth⁶ the pharyngeal reflex was markedly diminished.

Pharyngospasm usually manifests itself as gagging, the well-known pharyngeal protective reflex which is encountered when one attempts to introduce any object past the pharynx. This reflex activity may vary somewhat in type. It may be merely a tonic spasm, without any gagging, the pharynx muscles contracting tonically and preventing the passage of the catheter. On the other hand, it may be accompanied by marked retching and gagging, persisting as long as the catheter is kept in place. This was met with but once in the new-born (Glaisier case). It is exceptional in infants, although common in adults. Or the pharyngospasm may be incited only after a second or a third passage of the catheter. These various manifestations are of interest but of no clinical importance. We wish, however, particularly to emphasize not only that there is a close relationship between pharyngospasm and pylorospasm, but that the pharyngospasm may be an important factor in these cases. In several instances it has resulted in vomiting immediately on the baby's being put to the breast or given the bottle. In one of these cases, in which bismuth was added to the milk, the Roentgen-ray showed that food had not entered the esophagus. The grip of the pharyngeal muscles in these cases is frequently so tight that the fluid cannot be passed through the catheter without considerable force; in one instance (Stark) a column of 30 cm. of water was insufficient to overcome the resistance. At times fluid cannot be aspirated until the catheter is withdrawn into the mouth. In citing cases we have referred to this phenomenon as the "pharyngeal retraction test." It is met with occa-

sionally in infants who appear otherwise quite normal, and therefore cannot be considered indicative of pylorospasm.⁷

CARDIOSPASM

In cases of spasm of the pylorus, associated or not associated with pharyngospasm, we may encounter cardiospasm. The frequency of cardiospasm under these conditions was emphasized in our preliminary article, and subsequent experience has served only to strengthen our opinion as to the frequency and importance of this symptom. Our remarks are based on the observation of eight cases in which there was cardiospasm. A few words seem in place regarding the physiology and the pathological physiology of this condition. V. Mikulicz observed in man that on the esophageal side such slight pressure as from 2 to 7 cm. of water was sufficient to drive air or water into the stomach. As a rule, the necessary pressure was less than that of a column of fluid which would fill the thoracic esophagus. The normal tonus of the cardia would therefore seem to be slight. As regards the control of the cardia, Cannon⁸ has suggested that "just as acid beyond the pylorus keeps the pylorus closed, so, likewise, acid in the stomach (beyond the cardia) may keep the cardia closed." Reviewing our tests from this point of view, we find that although some cases of cardiospasm were associated with gastric hyperacidity (cf. Udo case below), others undoubtedly were associated with a normal or subnormal degree of hydrochloric acid, as was demonstrated by a marked case of cardiospasm associated with pylorospasm:

David Ross, 7 weeks old. Weight 6 pounds 14 ounces. Breast fed for four weeks; since then $\frac{1}{4}$ milk, $\frac{3}{4}$ water. Has vomited and been constipated. In hospital two weeks, fed every three hours 4 ounces of a mixture of half milk, half water, with the addition of milk sugar. Has been vomiting almost every feeding until the last twenty-four hours. Fed $2\frac{1}{2}$ hours ago. Pale, nervous child. Pupils constantly dilating or contracting.

Nov. 13, 1911. Ordinary stomach tube passed to empty stomach. Difficulty in passing beyond 15 cm. (cardia). Stomach absolutely empty. "Duodenal ball-tube" then used, but could not be inserted beyond cardia, even after giving water (accessory method). Duodenal catheter passed. Obstruction again at cardia. Duodenum entered with some difficulty; 5 c.c. of thick, mucoid, bile-tinged fluid obtained in thirty-minute test. No free HCl in stomach.

Epicrisis: Marked cardiospasm unaccompanied by gastric hypersecretion. Pylorospasm slight or absent.

If even a soft catheter is introduced rapidly into the stomach, a mild grade of cardiospasm will be overcome and may be overlooked,

7. In one case the "duodenal ball-tube" encountered extraordinary resistance at about the level of the manubrium on attempting to withdraw it from the esophagus. It is difficult to explain this marked constriction. Possibly it was due to the pressure of an enlarged thymus, and the ball-tube may be of value in the diagnosis of this condition.

8. Cannon, W. B.: *Mechanical Factors of Digestion*, 1911, p. 39.

especially if attention is not paid when the level of the cardia is reached. When, however, a soft rubber tube with a metal ball at the end is introduced (the "duodenal ball-tube"),⁹ mild grades of this pathological condition are frequently encountered. The tonicity of the cardia varies greatly within physiological limits.¹⁰ However, if the sphincter grips the catheter so tight that we are unable to aspirate fluid until it is retracted into the esophagus (cardiac retraction test), we may consider that there is abnormal spasticity present, as, for example, in the following case, which is illustrative from this point of view, and also for the association of spasm of the pharynx, of the cardia, and gastric hypersecretion (cf. case A. W., reported in the previous paper):⁹

Annie Udo, 3 months, 7 pounds. Atrophic.

Test 1. March 15, 1912. History of vomiting. Fed at 3 o'clock.

3:30. Catheter passed. Ph.R. increased. Also spasm at cardia. Congo ++ fluid in stomach. Entered pylorus. Reintroduced. Cardiospasm again. Congo +++ in stomach. Entered pylorus; "cardiac retraction test." Fluid could not be aspirated until entered esophagus. Then 2 c.c. of bile obtained.

3:55. More cardiospasm. Congo ++ fluid in stomach.

Epicrisis: Pharyngospasm, cardiospasm, gastric hypersecretion.

Test 2. March 18, 1912. Fed at 12 o'clock.

1:10 Ph.R. increased and Congo ++ in stomach. Reintroduced. Congo +++ fluid.

1:15. Water could not be made to pass through catheter by gravity into stomach. All fluid Congo +++ markedly increased in quantity.

Test 3. March 20, 1912. Some retraction of head; rigidity of legs. Fed at 12 o'clock. Thirty-five-minute test showed pharyngospasm, cardiospasm and gastric hypersecretion, as in the two previous tests. Pylorus entered twice and bile obtained; but the condition of the sphincter could not be judged on account of the spasm of the cardia.

The obstruction at the cardia in this case was moderate. However, it may reach such a degree that we are unable to enter the stomach without passing a stylet through the catheter. We had this experience in two cases (McGee and Horowitz), one of which we shall cite:

James McGee, 3 months, 6½ pounds. Has vomited large quantities of blood. Fed three hours previous to test, 4 ounces half-milk with sugar, alternating with breast feeding.

Catheter passed. Ph.R. normal. Could not enter stomach until inserted a ureteral stylet through catheter. Stomach empty. No acid. Entered duodenum easily. Bile alkaline, ++, but could not aspirate it until retracted catheter past cardia.

Epicrisis: Marked cardiospasm (stylet). No pylorospasm found. Probably ulcer of the duodenum or stomach.

9. Hess, A. F.: *AM. JOUR. DIS. CHILD.*, May, 1911.

10. This can be ascertained by attaching a small rubber balloon to the end of the catheter, constituting what may be termed a "blind-dilatable-catheter." This can be introduced into the stomach, inflated to various degrees and then withdrawn, in this way measuring the maximal diameter of the cardia. By this means it will be noted that there is a marked variation in the size of the balloon which can be pulled through the cardia in different cases.

In both these cases, as well as in the Ross baby mentioned above, the stomach was found absolutely empty of food although the infant had been fed shortly before passing the catheter. This is typical of what may be termed "cardiospastic vomiting." It is such cases which have led to some of the enthusiastic reports concerning the value of gavage in pylorospasm.

GASTRIC HYPERKINESIS

(GASTRIC DISTENTION, VISIBLE PERISTALSIS, PERISTALTIC TUMOR)

We now come to the consideration of one of the most interesting and striking clinical signs of pylorospasm, one which until lately was believed to be of great significance in the differential diagnosis of this condition. We refer to the peristaltic waves which are frequently seen rolling over the gastric area from beneath the free border of the ribs on the left, to somewhat beyond the median line on the right, and to other gastric manifestations of hyperkinesis. The question at point has been whether visible peristalsis could occur when merely a spasm of the pylorus existed, or whether an organic obstruction was necessary for its production. Of late numerous writers have shown convincingly that this sign may be present in marked intensity where there is no organic stenosis. We shall therefore not discuss this question, regarding it as definitely settled, but shall turn our attention to this phenomenon in cases where the catheter was successfully passed into the duodenum, and where, therefore, obstructive hypertrophy of the pylorus can be ruled out. The question thus resolves itself, not as to whether organic stenosis must be present, but whether even a functional obstruction is essential to visible peristalsis.

This proposition can be answered decidedly in the negative. Upon several occasions we have seen classical peristalsis where there was neither the clinical history nor the clinical picture of spasm, and where repeated testing by means of the catheter revealed an unobstructed path from the stomach into the duodenum. We shall cite one case, selecting an infant which had been under close observation for some weeks before symptoms developed and which was under our care for some months thereafter:

Ephraim K. Admitted to the Hebrew Infant Asylum when 2½ weeks old. Five weeks old, 7¼ pounds. Grippe, followed by dyspepsia; vomiting. Casein masses in the stool. Visible peristalsis; hour-glass contraction of the stomach.

Test 1. March 5, 1912. Five c.c. of acid Congo + milk evacuated from stomach. Peristalsis ceased, although gastric area remained distended. Catheter in stomach did not cause peristalsis. Easily entered duodenum. Bile obtained.

Test 2. March 6, 1912. Alimentary intoxication. Child to be starved for twelve hours. Has not vomited. Observed two hours after feeding; no peristalsis. One ounce of water put into stomach. Immediately peristaltic waves, peristaltic tumor, and hour-glass contraction became visible. Forceful vomiting of the water alongside of catheter before it had entered the stomach. Peristalsis seemed to

be started by swallowing the fluid. Duodenum easily entered. Upon second attempt some cardiospasm. No peristaltic tumor when catheter was in stomach, in duodenum, or held in esophagus for a few minutes.

Test 3. March 8, 1912. Visible peristalsis, hour-glass formation. Some cardiospasm on passing catheter. No pylorospasm (duodenum easily entered).

Test 4. March 10, 1912. Conditions the same. Only occasional vomiting after middle of March. Peristaltic tumor was noted from time to time, even during convalescence. Infant was under observation until June 26.

Similar phenomena accompanying other cases of alimentary intoxication have been encountered. Quite recently the same signs were seen in an infant 1 year of age. However, it is not necessary that the alimentary disturbance be marked. A mild dyspepsia suffices at times to bring about visible gastric peristalsis. This is especially true if the infant is emaciated. On Aug. 21, 1913, an infant (Gordon) was admitted to the hospital suffering from mild dyspepsia. The abdominal wall was so thin that not only could peristaltic waves and a peristaltic tumor be seen, but even the slate-colored liver could be made out. There was, however, no obstruction at the pylorus. We mention this case of marked emaciation in order to advance this phase of the question for consideration. There can be no doubt that a thin parietal wall enables peristalsis to be more readily seen, but it is certainly a factor of marked secondary significance. We may encounter emaciation plus pylorospasm and nevertheless not see peristalsis. For example, Barbas, a 5-months-old infant, weighing less than 6 pounds, had marked propulsive vomiting since birth and gave evidence of pyloric obstruction in the course of the six tests which were carried out, but at no time displayed visible peristalsis in spite of the marked atrophic condition. In this infant the emaciation was marked, pylorospasm present but inconstant, visible peristalsis absent. However, the pylorospasm may be great and nevertheless not give rise to visible peristalsis. We shall cite in abstract a case of this kind, as it is frequently taken for granted that the spasm incites the marked peristalsis, the conception being that the contractions of the stomach become visible in the course of its efforts to overcome the obstruction at its exit:

Dede, 2 months old, weighing 6 pounds 9 ounces, was tested by means of the catheter five times. The obstruction was very great; in fact, at the second test it could not be overcome in spite of repeated efforts. Nevertheless visible peristalsis was at no time present.

From these and similar clinical experiences, combined with the direct testing of the pyloric sphincter by means of the catheter, we are not inclined to lay great stress on visible peristalsis or the peristaltic tumor as a sign of even a functional obstruction of the pylorus. It may be present where there is no obstruction, and may be missing even in atrophic infants, where the catheter cannot make its way past the pylorus into the duodenum.

We were able to approach this aspect of the question from another viewpoint. A catheter similar to the "blind-dilatable-catheter" referred to in connection with cardiospasm was inserted into the duodenum in poorly nourished babies. The balloon was dilated and the catheter retracted, so as to bring about an obstruction of the pylorus.¹¹ In this way we effected a mechanical obstruction at the pylorus. We can summarize our experiences by stating that although this procedure was carried out on several occasions for long periods, in no instance were we able to incite visible peristalsis.

In this connection we wish to touch on the relation of hydrochloric acid to peristalsis, leaving its more detailed consideration for the paragraph on hypersecretion. In the case of infants some months of age it was not found possible to produce peristaltic waves by instilling small quantities of normal hydrochloric acid into the stomach. However, in the new-born we occasionally succeeded by this means in bringing about ballooning of the stomach and slight peristalsis accompanied by restlessness. This was especially true in the case of nervous, new-born infants (*e. g.*, Rochman, a twin infant 1 day old, who started markedly at the sound of sharp noises. Instillation of 2 c.c. of 0.4 per cent. hydrochloric acid produced marked distention of the gastric area). This ballooning of the stomach is the mildest clinical form of a disturbance of the gastric musculature, of which visible peristalsis, peristaltic tumor (pseudo-tumor), and hour-glass formation are severer manifestations; it is frequently seen days before peristalsis develops, and persists when peristalsis is checked by means of emptying the stomach. Probably all these signs are merely evidences of an intensification of normal peristalsis.

It is difficult to discuss the etiology of gastric hyperkinesis. As we have stated, it is not due to spasm of the pylorus. It is rather a gastrospasm (Thomson), due in part to a hypersensibility of the gastric mucosa, as we must be led to infer from the fact that it is not seen when the stomach is absolutely empty. In this connection, however, it should be noted that where there was marked peristalsis which could be produced at will by introducing even a few cubic centimeters of food, the presence of the catheter in the stomach and within the pylorus did not cause visible peristalsis (*e. g.*, case of Ephraim K.). This was our common experience. Perhaps the presence of the catheter in the pharynx and esophagus may inhibit the muscular activity. This observation seems of practical interest in connection with the passage of the catheter for gavage or for duodenal feeding.

A word as to antiperistalsis. We have not observed it in any case which was proved by means of the catheter to be spastic in nature, so

11. This technic will be entered on in greater detail at another time.

that its consideration does not properly fall within the limitations set for this paper. Its value is greatly circumscribed by the fact that it is so rarely met with. Antiperistalsis, however, is frequently seen by means of the fluoroscope although not visible to ordinary inspection. The study of its occurrence as seen by the Roentgen ray seems far more promising from a diagnostic point of view than the observation of gastric retention, which cannot inform us of the nature of the pyloric obstruction.

Before leaving this subject, we would call attention to the fact that distention and peristaltic tumor of the large intestine are perhaps not infrequently mistaken for gastric manifestations. This has been our experience in several cases in which we have had the opportunity of passing the duodenal catheter. Recently this error was narrowly avoided by being able to palpate the catheter within the stomach above the site of dilatation. Caution should be observed in considering distention as gastric if it appears below a horizontal line drawn midway between the xiphoid and the umbilicus.

PALPABLE TUMOR

The consideration of the occurrence of a palpable tumor will not detain us long, as it was not met within any case of pylorospasm. Nor has it, so far as we know, ever been described where hypertrophy was not found. In this connection, however, a report by Churchman¹² of a palpable spastic tumor of the ileum, encountered at operation, is worthy of attention and reflection. Much depends on the anatomical position of the pylorus in determining whether or not it can be palpated. An hypertrophied pylorus may be rendered intangible by the liver, by the colon, by gastric distention, or by the tonicity of the abdominal muscles; on the other hand, it may be rendered more readily perceptible to the touch as the result of ptosis. We had expected that the normal pylorus would at times be palpable when it contained the catheter. In this, however, we were mistaken. Even in those exceptional cases in which emaciation allowed the palpation of the catheter within the stomach, it could not be followed far beyond the median line; at this point its outline eluded the touch, sinking dorsally beneath the liver.¹³

A "palpable tumor" would seem to signify a perfectly definite anatomical condition. Nevertheless, it is probable that fully as many errors have been made in this particular at operation, and perhaps at autopsy, as in the clinic. It is not always easy to differentiate between a pylorus which is spastic and one which is hypertrophied. The tendency, espe-

12. Churchman, John W.: Jour. Am. Med. Assn.,

13. In one case the catheter was felt within the stomach and also within the descending duodenum lying just external to the right kidney. However, it could not be palpated at the pylorus and within the first portion of the duodenum.

cially for the surgeon, is forthwith to consider the obstruction organic, and there is no doubt that in this way many cases of simple spasm have been reported as organic obstructions.

HYPERSECRETION (GASTRIC, DUODENAL)

It is well known that, associated with pylorospasm, we frequently find a hypersecretion of gastric juice. Indeed, some have attributed the spasm to the abnormal amount of acid or degree of acidity. However, this simple etiological relationship generally does not exist. This is evident from the fact that cases of pylorospasm are not infrequently met with in which there is no increase of hydrochloric acid; this type of case was described in the previous paper, and it has been referred to repeatedly in the reports of others. As further evidence that this interpretation is erroneous, we may add that the amount of hydrochloric acid has been found to furnish no criterion whatsoever as to the facility with which the duodenal catheter can be introduced. Recently we referred to this lack of association in connection with cases of "congenital gastric hypersecretion" of the new-born, and may amplify the statement by adding that in instances of gastric hypersecretion in older infants there may be no obstruction to the catheter and no symptoms significant of pyloric obstruction.

However, we do not mean to infer that hydrochloric acid plays no rôle in the tonicity of the pylorus and the gastric musculature. Test experiments at once convinced us that this view would be fallacious. In the case of a number of infants, varying in age from a few hours to a few months, we introduced into the stomach by means of a tube from 1 to 3 c.c. of 0.4 per cent. hydrochloric acid, and observed the clinical symptoms, the abdominal signs, and the effect as regards the passage of the catheter. The following is a brief summary of the results:

INSTILLATION OF 0.4 PER CENT. HYDROCHLORIC ACID INTO STOMACH

1. SCHRIEDER.—Nine hours old. Unfed. 2.5 c.c. HCl. Marked drum-like distention of stomach; intense cyanosis; repeated vomiting; restlessness; pain, no peristalsis; no hiccough; bowels moved frequently. Passed pylorus.
2. GOLDBABEN.—Seven hours old. 2 c.c. HCl. Rapid respirations; some pain; slight gastric distention; no peristalsis. No duodenal catheterization.
3. MISCHMAR.—Nine hours old. 2 c.c. HCl. Marked contraction of diaphragm forcing out epigastric area. No hiccough.
4. ROCHMAN.—One day old. 2 c.c. HCl. Vomiting, distention of left hypochondrium. No peristalsis.
5. BACONSTEIN.—Two days old. 2 c.c. HCl. Gastric distention; crying; pain. Slight bleeding. Catheterization not attempted.
6. GINSBERG.—Two and three-fourths days old. 2 c.c. HCl. Saliva decreased. Spastic contraction of diaphragm; hiccough; abdominal distention; increased respiration; no peristaltic waves; no pylorospasm.

Test 2.—Five and three-fourths days old. 1.5 c.c. HCl. Hiccoughs in three minutes; no pylorospasm; bile obtained; no vomiting.

7. BABY X.—Five days old. 2 c.c. HCl. Very restful infant. Twice 1 c.c.; no effect. Slight increase in respiration.

8. BERNSTEIN.—Six days old. 1.5 c.c. HCl. Distention of epigastrium; restlessness; pain which ceased on aspirating HCl; no bile; no increased peristalsis. Entered duodenum easily.

9. LEVINE TWIN.—One month old. 2 c.c. HCl. (Baby that has gastric distention and hiccough) 1 c.c. introduced twice. No effect.

10.—LEVINE TWIN.—One month old. 1 c.c. HCl. Some gastric distention; tonic contraction of diaphragm; pain; no hiccough; effect slight.

11. ARGOSE.—Three months old. Normal baby. Intense gagging, caused by putting 3 c.c. HCl into duodenum. Flow of bile.

From these tests it is evident that the introduction of hydrochloric acid, even in a small quantity, such as is normally present in the stomach of the new-born infant, is sufficient to excite motor and reflex phenomena. However, it should be noted that the pylorus seemed to be frequently the least affected part of the musculature of the stomach, the catheter readily passing the sphincter in spite of marked signs and symptoms of gastropasm. At times vomiting ensued, the gastric area became prominent, there was drum-like distention of the stomach, although no visible peristalsis. In addition, in fact preëminently, there were referred or reflex symptoms, such as gagging (pharyngospasm), hiccough, pain, increased rapidity of respiration, cyanosis. As was to be expected, the youngest infants proved to be the most responsive to the stimulus, reacting most intensely. It may be stated, therefore, that although we have clinical proof that hydrochloric acid cannot be considered the cause of pylorospasm, a small amount of acid is capable of inducing spastic phenomena in very young infants.

Just a word as to the duodenal secretion. As was to be expected, gastric hypersecretion was found to lead to duodenal hypersecretion, and the cases of pylorospasm manifesting the one form of secretory overactivity were found to evince the other. This condition has previously been termed "duodenal or pancreatic succorria." We may add that, just as there is a type of gastric hypersecretion not associated with spasm of the pylorus, so there is a form of pancreatic hypersecretion unaccompanied by gastric hypersecretion or by increased tonicity of this sphincter.

SINGULTUS

Singultus is a frequent symptom accompanying pyloric obstruction, more commonly met with than reports lead one to expect. Although it is evident that this disorder can possess no importance from a diagnostic point of view, it is nevertheless interesting as evidence of an extra-gastric

disturbance of innervation. In very young infants hiccough may be incited at times by passing the catheter through the pylorus, especially a large catheter. As has been noted above, it also may be produced by instilling a few cubic centimeters of normal hydrochloric acid into the stomach (Ginsberg case), and also occasionally by continued pressure on the gastric area. In this connection, mention may be made of similar reflex phenomena encountered in the course of passing the catheter. For example, in many infants, especially new-born infants, touching the pylorus with the catheter causes gagging, which can be brought about as often as the pylorus is impinged on. Or, again, passing the pylorus may lead to what we have termed in our notes, for the sake of brevity, a "pyloric cough" or "sneeze." Certain infants evince these reflex phenomena more readily than others, and in these the singultus, the cough, the sneeze or the gagging may follow each introduction of the catheter. It was found that these reflex phenomena may occur, however, to a far less extent, in connection with the cardiac sphincter. They are of interest in demonstrating the close reflex relationship between the pylorus and other organs, for example the diaphragm and the pharynx.¹⁴ These reflex arcs may have their centers in the spinal cord or even in the medulla, if we are to interpret the cyanosis noted in connection with the introduction of hydrochloric acid into the stomach of the new-born, as a manifestation of impulses conveyed to the respiratory center.

PYLOROSPASM AND ALLIED SPASMS

The classification of pylorospasm requires a few words of comment. From a clinical point of view it would seem that cases of this disturbance should be separated into two groups. The first comprises the cases usually regarded as typical, but which in our experience do not constitute a great majority. In these there is no apparent exciting cause for the disorder; it occurs under ideal feeding conditions; so that for the present they may be designated as primary. The history is familiar to all. In brief, it generally runs as follows: A normal breast-fed infant begins to vomit when a few weeks old; this vomiting increases in intensity and frequency, is markedly projectile in character, and leads to inanition. Generally the outcome is recovery. These cases vary widely in severity; in the moderately severe case the catheter is passed through the pylorus with difficulty, perhaps after a second or third attempt, and

14. This nervous interrelationship between the pharynx and the pylorus seems to be reversible: by exciting spasm of the pharynx (gagging) we induce closure of the pylorus; by passing the catheter through the pylorus we frequently excite gagging.

only with the aid of introducing water into the stomach (accessory method).¹⁵

The second category of cases is, as we have stated, sufficiently distinct to be classed separately. In these the hyperkinesis and spastic symptoms are secondary manifestations appearing as a complication of various disturbances, the most common of which are disorders of the alimentary tract. The history in this type is generally commonplace, merely reciting that the infant was bottle-fed and thrived until the sudden onset of repeated and forcible vomiting. However, this pylorospasm may supervene in the course of other disorders, as will be seen from the case we shall cite. This case is one of congenital obliteration of the bile ducts, and is quoted as an example of this secondary form of pylorospasm, because it had been repeatedly tested by means of the catheter before spasm developed and was controlled by post-mortem examination (autopsy protocol):¹⁶

Mary E., 3½ months old, 9 pounds 2 ounces. A patient with congenital obliteration of the bile ducts which had been in the hospital during the latter part of December, 1911. At that time the tube was passed on eight occasions and the cardiac and pyloric sphincters found normal. Free HCl was frequently present.

Feb. 7, 1912. Doing poorly; has been vomiting; vomiting expulsive in nature. Jaundice intense, stools clay-colored. Catheter passed: Congo +++ fluid in stomach. Marked cardiospasm; great difficulty in entering stomach. (Probably food has not entered stomach.) Difficulty in entering duodenum; "accessory method" had to be resorted to. Duodenal feeding with whey.

February 8. Still vomiting, as yesterday. Catheter passed, cardiospasm unchanged, pylorospasm less. Duodenal feeding.

February 9. Doing poorly. Vomiting almost continuous. Cardia and pylorus less spastic. Duodenal feeding.

Feb. 10. Exitus. Autopsy; stomach negative.

Epicrisis: Development of cardiospasm and pylorospasm in a case of congenital obliteration of the bile ducts.

15. In passing the duodenal catheter we now regularly make use of what has been previously described as the "accessory method." This consists in allowing warm water to flow into the stomach before the catheter is inserted into the duodenum. Water is drawn up into the glass aspirating bulb after the catheter is inserted to about the 22 cm. mark and, as it is seen to flow into the stomach (which may occur by gravity or by the aid of pressure applied by blowing into the bulb), the catheter is slowly inserted beyond the 25 cm. to the 35 or 40 cm. mark. The use of the water in this connection has several advantages: it not only renders the passage of the catheter easier, but it aids in judging whether the pylorus has been traversed; in the first place by stimulating the bile, so that we are more apt to aspirate a bile-colored fluid; second, through the knowledge that if the end of the catheter is in the duodenum, it is generally impossible to aspirate much of the water which has been put into the stomach, whereas if the end is in the stomach we are able to regain almost the entire quantity. Aspiration should be gentle; nothing is gained by applying forcible suction, but it may lead to slight bleeding. We may add that although the technic of duodenal catheterization is not difficult, nevertheless, like other examinations (for example, the inspection of the ear drum), it requires some practice. It should not be attempted for the first time on a case of pylorospasm.

16. Hess, A. F.: Arch. Int. Med., July, 1912.

From a clinical viewpoint this spastic condition may be termed *secondary pylorospasm*, in contradistinction to the classical *primary pylorospasm*. Usually the secondary cases run a shorter course, are milder, more transient, and offer less obstruction to the passage of the catheter. We have encountered primary cases in which it was impossible to traverse the pylorus, but no case of this intensity in the other group. The peristaltic waves and tumors and the character of the vomiting offer no points of difference.¹⁷ The prognosis in the one type of case depends mainly on the degree of inanition, in the other in a great measure on the primary disorder on which the spasm has been engrafted.

There is a large number of cases which we have not attempted to classify, including both breast-fed and bottle-fed infants—mild cases also characterized by repeated spastic vomiting. We have had an opportunity to pass the duodenal catheter on a considerable number of these patients and in this way to control the dubious diagnosis of pylorospasm. In these cases no obstructive spasm was encountered; in fact, it is solely as the result of negative catheterization that we have not included them under pylorospasm. We do not wish to state unreservedly that the pyloric sphincter is not involved in these disturbances; perhaps further tests will inform us. The following is a typical case:

Nov. 30, 1912. Three months' old infant (seen with Dr. Leopold). Weight 10 pounds 14 ounces. Bottle-fed. Under observation three weeks. For past two weeks projectile vomiting of food or even of water. No visible peristalsis.

Catheter passed three hours after feeding. Ph.R. negative; slight cardio-spasm found in first test. Congo ++ fluid in stomach. Catheter passed readily into duodenum; bile, pyloric casts.

Epicrisis: Continued projectile vomiting. Pylorus readily permeable.

ALLIED SPASMS

Is spasm of the pylorus encountered in general disorders of the nervous system? This is a question of interest from a diagnostic, and even more so from a pathogenetic, point of view. When we review our cases from this standpoint, we find that unless caution is exercised, they may be interpreted either for or against this hypothesis. Among the new-born we met with instances in which infants were exceptionally nervous (*e. g.*, Rochman twins, and Rotter, a 3-days-old baby), but the catheter could nevertheless be readily passed into the duodenum. On the other hand, one of the cases which we cited above (Weinstein) as an instance of "latent congenital pylorospasm" was certainly an exceptionally nervous baby. When we consider older infants, the study is simpler, although we may not be able to draw conclusions more sharply. In the course of the past two years the catheter has been passed on

17. The only peculiarity about projectile vomiting in infants is its infrequency. It is as a rule merely the type of vomiting common to adults.

infants suffering from meningitis, tetany, microcephalus, hydrocephalus, and other conditions, where the somatic nerves were involved, as shown by rigidity of the body, exaggerated reflexes, or increased mechanical and electrical irritability. Although in some of these cases it was found that there was an increased spasm of the pylorus, yet the frequent exceptions to this rule preclude the deduction that there is an essential association between the spastic condition of the superficial muscles and that of the alimentary tract. That this association occurs is the experience of all clinicians, as shown by the pharyngospasm and spastic vomiting so characteristic of meningitis. Of this relationship it seems unnecessary to cite specific instances. We shall cite, however, two examples of decreased tonicity where *a priori* we should have been led to expect hypertonicity:

1. Dec. 10, 1911. Gussie Yager, 9 months old. Suffering from pneumococcus meningitis. Spasm of upper and lower extremities, increased knee-jerk, marked trismus, making it difficult to separate the jaws, rigidity of neck, inequality of pupils, *tache cérébrale*. No vomiting.

In spite of the general rigidity, the catheter was passed at once into the duodenum and bile obtained.

2. Nov. 24, 1913. Charles Stein, marasmus, spasmophilia. Three months old, 7 pounds 15 ounces. Marked rigidity of arms, legs, neck; knee-jerk clonus.

Ph.R. increased. The catheter was passed directly into the duodenum. Later a No. 20 (F.) catheter passed the pylorus. Bile was obtained in both instances.

Let us reverse the viewpoint and, with this question in mind, survey our cases of pylorospasm. Here we encounter the same lack of uniformity; that is to say, we find pylorospasm where the infant showed no other signs of involvement of the nervous system, or, again, cases in which the infant showed a general nervous irritability (Souter, Malzman), and increased muscular rigidity and ankle clonus (Dede). In general, however, it may be stated that nervous disturbances are found more often associated with these various spasms of the sphincters than can be accounted for unless we grant them a place in the symptomatology of this condition.

Although vomiting and retention of food are valuable clinical symptoms of spasm of the pylorus, they are gross criteria and do not reveal a mild hypertonic condition of this sphincter. Catheterization has convinced us that pylorospasm may be present not only in the new-born but in older infants and yet produce no symptoms. The symptoms depend to a great extent on the persistence of the spasm of the pylorus. If the spasm is tonic in character, we shall have marked obstruction to the outflow of food into the duodenum. However, we may have definite increased tonicity of the pylorus and yet, if this increased spasm relaxes to allow the food to leave the stomach — in other words, if it evinces a clonic rather than a tonic character — there will be little or no gastric

disturbance. Our experience with catheterization of many hundreds of cases leads to the conclusion that, as regards the tonicity of the pylorus, there is no sharp line between the normal and the pathological, but rather a natural gradation such as we find in all functional conditions.

Throughout this paper we have mentioned pharyngospasm and cardiospasm as accompanying spasm of the pylorus or as occurring interchangeably with pylorospasm. There are other spasms of the viscera, and especially of the alimentary tract, which are met with from time to time in conjunction with pylorospasm. In one instance we found laryngospasm, as manifested by laryngeal stridor and retraction of the suprasternal notch (Stark case). In this same case there was anospasm, a condition which certainly occurs more often than is noticed. The spasm of the anal sphincter leads to the production of fissures and then to prolapse of the rectum. One of the new-born infants suffering from congenital pylorospasm had this condition. A case of spasm of the pylorus which we recently examined when it was convalescent also had fissures and prolapse, which must be regarded as the result of Nature's forcible efforts to overcome the spastic anal sphincter.

We are unable from personal experience to state whether enterospasm is frequently associated with pylorospasm. It is certain, however, that some of the infants (*e. g.*, Stark case) who suffer from spasm of the pylorus show increased intestinal peristalsis and also signs of abdominal pain. However, the inexplicable cases of colic which are encountered so frequently among breast-fed infants are generally not associated with gastric symptoms. In this connection we may add that we have read of but one case of intussusception accompanied by pylorospasm.

It is questionable whether, at the present time, we should group these various spasms and secretory disturbances under a title such as "vagotonia," which implies a definite etiological conception. In a recent case which we tested with atropin and epinephrin for a vagotonic condition, the reaction was negative; eosinophilia was also absent. However, whether we accept this anatomical classification or substitute a descriptive clinical term, it is evident that there is a condition manifested by spasmophilia of the alimentary tract, and that pylorospasm is a part of this neurosis and rarely met with as an isolated symptom.

CONCLUSIONS

The foregoing study is based on a considerable number of cases in which an obstruction was found to the passage of the duodenal catheter. As the catheter was able, nevertheless, to traverse the pylorus in all these cases, they were regarded as instances of spastic rather than of organic stenosis. All other cases have been excluded from consideration, including instances of pylorospasm in which the catheter could not be passed.

An effort was made to ascertain the diameter of the pylorus *in vivo*, as previous measurements of this sphincter have been based on post-mortem examination and must be regarded as purely anatomical in nature. As a result of many tests with catheters of various diameters, the conclusion was reached that *the functional circumference of the pylorus in infants 2 to 3 months of age is about 18 mm. and the functional diameter about 6 mm., and that in the new-born these measurements are about 14 mm. and 4.75 mm., respectively.*

Tests on new-born infants showed that even in these there is a distinct individuality in the tonicity of the pylorus. A few showed marked spasticity of the pharynx, of the cardia, of the pylorus, or of more than one sphincter. In other words, cases of *congenital pharyngospasm, cardiospasm and pylorospasm* were encountered. These conditions were found at birth, even before any food had been given, or secondary to some slight alimentary disturbance occurring in the course of the first few days of life. The progress of several of these babies was followed for the first months of life, and it was found that in some the spasm remained latent, but that in others spastic symptoms were manifested in later infancy, such as projectile vomiting and obstruction at the pylorus. Not only was pyloric spasticity encountered at birth, but, on the other hand, *pyloric insufficiency*, especially in cases of pronounced icterus neonatorum, where there is hypercholia; in these cases the bile welled past the pylorus into the stomach, and the catheter met with no resistance in its passage into the duodenum.

An interrelationship was found between pharyngospasm and pylorospasm. In some cases, pharyngospasm led to vomiting immediately after feeding, and in this way prevented milk from entering the stomach.

This same close relationship was found also as regards cardiospasm; and in the same way this disturbance at times prevented the entrance of food into the stomach, resulting in what may be termed "*cardiospastic vomiting*." Cardiospasm is far more frequent in infants than is generally recognized. It may reach even such a degree as to make it necessary to introduce a stylet into the catheter in order to pass the cardia. In mild cases, cardiospasm is able to obstruct fluid poured through the catheter, or to prevent the aspiration of fluid from the stomach. Cases were encountered in which the gastric hypersecretion seemed to be the cause of this spasm of the cardia; however, in others, there was no increase of hydrochloric acid, so that it cannot be considered an essential etiological factor.

Visible peristalsis and peristaltic tumor (pseudotumor) not only are not significant of organic obstruction, but even a spastic obstruction is not necessary for their production. Numerous cases were encountered with pronounced hyperkinesis of this description, where the catheter

met with no obstruction at the pylorus. This is especially true of cases of alimentary intoxication. Furthermore, as these signs may be absent where numerous tests convincingly demonstrate pylorospasm, we must conclude that there is no essential interrelation between obstruction at the pylorus and hyperkinesis. It was possible to produce peristalsis artificially in the new-born by instilling 2 c.c. of 0.4 per cent. hydrochloric acid into the stomach, and in older infants to induce distention or marked ballooning of the stomach by this means. The presence of the catheter did not lead to peristalsis, even where this sign could be brought to view by putting a small amount of liquid into the gastric cavity.

A palpable tumor was not encountered in any case in which the catheter could traverse the pylorus; nor did the presence of the catheter within the duodenum render the pylorus palpable.

Gastric hypersecretion is not the cause of these marked cases of pylorospasm. Cases were tested in which these two conditions were found associated, but also in which spasm existed without the accompaniment of gastric hypersecretion. Although the introduction of a small amount of hydrochloric acid into the stomach of the new-born was not sufficient to produce spasm of the pylorus, it led to marked reflex symptoms, e. g., gagging (pharyngospasm), hiccough, pain, increased rapidity of respiration.

In some cases of pylorospasm, those accompanied by gastric hypersecretion, duodenal hypersecretion or succorhea was also encountered.

Singultus is a frequent symptom of pyloric obstruction. It may be incited in new-born infants not only by allowing a small quantity of hydrochloric acid to enter the stomach, but by the passage of the catheter through the pylorus; the latter may also lead to pyloric cough. Singultus is interesting in this connection as an evidence of extra-gastric nervous involvement in this condition.

Pylorospasm should be subdivided into two groups, the *primary* cases, that is to say, those which occur in breast-fed infants without apparent exciting cause (the classical instances), and *secondary pylorospasm*, occurring as a complication of some other disturbance, generally alimentary in nature. The former are the more severe. However, the peristaltic waves and tumors may be equally marked in either.

Mild pylorospasm, cardiospasm and pharyngospasm were at times encountered in tetany and other nervous disturbances, indicating a spasmophilia of the alimentary tract.

Moderate spasm of the pylorus may exist, as proved by catheterization, and nevertheless evince no symptoms (latent pylorospasm), as the symptoms depend in a large measure on the frequency of relaxation of the spasm; that is to say, on its degree of tonicity or clonicity. There

is no sharp dividing line between the normal and the spastic pylorus: tonicity, hypertonicity, spasticity, are merely positive, comparative and superlative terms.

In addition to pharyngospasm and cardiospasm, other visceral spasms were found associated with pylorospasm, e. g., laryngospasm and anospasm, the latter leading to anal fissures and prolapse. Pylorospasm was found rarely as an isolated spastic symptom.

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