

skin is blue and cold; the knee-jerks can just be obtained on the left but not on the right side. No reaction to faradism can be obtained in the affected muscles. The appearance of the limbs is very suggestive of an anterior poliomyelitis. The condition of the limbs has slowly but steadily improved.

Passing now to the morbid anatomy of the disease, it may be briefly stated that in the first stage the lesion is characterised by engorgement and thrombosis of small vessels, perivascular exudation, minute extravasation of blood, and small round cell infiltration of the neighbouring tissues. In the second stage there is necrosis of the tissues from which the blood is cut off, and in the third stage absorption of the necrosed products with contraction and cicatrization. All observers who have examined the spinal cord will agree with regard to the morbid process, but there is by no means such general agreement with regard to the pathology of the disease, and the views held may be stated as follows: (1) that the condition is due to a definite specific infection producing an acute inflammation; and (2) that the condition is due to vascular thrombosis, dependent on some altered blood condition, such altered blood condition being due to various causes and not dependent on one specific infection. My object will be to place before you the pathological evidence which may be brought forward in support of these two views.

The first question to be discussed is: does thrombosis of the smaller vessels cause the changes above described—viz., engorgement of vessels, hæmorrhages, and perivascular exudation, and it has been stated by those who support the view that the condition is primarily inflammatory, that many observers have occluded the vessels of the spinal cord for varying periods and examined the changes so produced, but although they found marked chromatolytic changes in the cells they did not find perivascular exudation or hæmorrhage. Furthermore, they state that Dr. Leonard Hill ligatured the cerebral arteries in monkeys and the brains of these animals were examined by Dr. F. W. Mott at various periods after the operation, who found extreme chromatolysis of the cortical cells but no inflammatory change or hæmorrhage. Such an argument sounds almost conclusive and would at once negative the view that there is primary thrombosis, but it must be remembered that obliteration of a large vessel is by no means necessarily comparable to the condition which is produced by thrombosis occurring in smaller vessels. Far more to the point are the experiments of Prevost and Cotard (to whose work Dr. Hughlings Jackson kindly called my attention) with regard to the changes which take place in an infarcted area. They, by injecting fine tobacco powder into the vessels, succeeded in producing infarcts in various organs and they proved by these experiments that congestion, hæmorrhage, and exudation of cells were the early results of obliteration of small vessels. Having therefore established the possibility of such a condition as is found to be present in these cases of acute encephalitis and poliomyelitis being due to a primary thrombosis, the next point to show would be that the pathological process may be limited to the distribution of a single vessel.

If one therefore studies the vascular supply of the spinal cord it is found that the grey matter of the anterior horns receives its chief supply from branches of the anterior median artery, the white matter being supplied chiefly from vessels arising from the pia mater. The branches of this anterior median artery supply the whole of the grey matter of the anterior horns but not that of the posterior horns. Now, in the spinal cord from cases of infantile paralysis the line of demarcation between the affected and unaffected part is sharply defined and limited to the grey matter of the anterior horns—that is to say, the area of congestion or, in the later stages, of necrosis corresponds very closely to the area of the blood-supply of the anterior median vessel. It cannot be asserted that the process is always thus accurately limited, for it is well known that the vessels in the ventral portion of the spinal cord and outside the grey matter are often engorged and possibly thrombosed, and again in the grey matter small areas of softening are found which do not occupy the whole of the grey matter. Such conditions are easily explicable, since congestion of vessels commonly occurs round an infarcted area and the localised softening in the grey matter is due to the thrombosis occurring in the smallest vessels. The microscopic appearances of the softening of the grey matter of the spinal cord correspond closely with that due to thrombosis of small vessels in the brain. The very frequent occurrence of anterior poliomyelitis in the lumbar sacral region seems to be another point greatly in

favour of the view that the condition is primarily vascular, for it is well known that the grey matter of the anterior horns of the lumbar region is situated at a point most peripheral from its blood-supply—i.e., the blood derived from the vertebral artery has to travel the whole length of the anterior median artery, and, further, it has been shown by Moxon that the reinforcing arteries of the roots do not readily assist the supply of that part of the cord.

These, then, are the points in favour of the disease being directly due to a primary vascular thrombosis; in favour of the view that the disease is of direct bacterial origin can be quoted its prevalence during a certain period of the year, becoming epidemic as in the present year, and its occurrence in several members of a family in its various forms, either cerebral or spinal, of which a most interesting example has been published by Dr. W. Pasteur. None of these points, however, are antagonistic to the view here upheld, for this infection only supplies the cause of the blood change. Furthermore, in cases of spinal infection that can be shown to be due to bacterial invasion, the changes met with are not limited to the grey matter, but affect grey and white matter alike. My arguments have been drawn chiefly from the pathological examination of the spinal cord, as the opportunity for examination of that part of the nervous system most frequently occurs. But what I have said with regard to the nature of the lesion applies equally to those cases in which the medulla, pons, cerebellum, or cortex is affected, the lesion being a primary thrombosis of the finer and terminal arteries.

In conclusion, although there are many gaps to be filled up by further pathological investigation, I trust I have given you grounds for considering cases of acute encephalitis and acute poliomyelitis as clinically identical; pathologically they are identical. The more frequent recognition of these cases of encephalitis will explain many cases of so-called meningitis in which recovery more or less complete takes place.

## CONGENITAL HYPERTROPHIC STENOSIS OF THE PYLORUS AND ITS TREATMENT BY PYLOROPLASTY.<sup>1</sup>

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THE main points that we desire to put forward in this paper are: (1) that congenital hypertrophy of the pylorus is probably a far more frequent affection than is supposed; (2) that the condition is still not generally recognised, for the symptoms may easily be misinterpreted or overlooked; and (3) that the affection may be successfully treated by pyloroplasty. In support of the last proposition we furnish two illustrative cases. The condition that has been described principally under the cumbersome title of "congenital hypertrophic stenosis of the pylorus" or of "congenital gastric spasm" among other names, has really only been recognised for a very few years; and the literature of the subject, though tolerably voluminous, is confined to scattered pamphlets, papers, and brief reports. Most of the textbooks and standard works make no mention of the condition whatever, while a few refer very briefly to it. Specimens of the condition are not commonly found in museums, though the museum of St. George's Hospital contains three specimens. It by no means follows that the condition is exceedingly rare. Museum specimens are mostly derived from in-patients in our hospitals and the symptoms that these infants show lead rather to out-patient treatment.

In a paper read before this society on Nov. 8th, 1898, a résumé of 17 recorded cases collected from medical literature was given, together with details of two fresh cases and of a specimen in St. Bartholomew's Hospital museum. This gives a total of 20 cases only, although the first record of the affection dates back to 1841. Although only five

<sup>1</sup> A paper read before the Royal Medical and Chirurgical Society on Dec. 9th, 1902.

years have elapsed since this paper was written, the total number of cases now recorded is well over 50. No cases of operation were recorded in this first paper, while we have now obtained details of 19 cases of operation. Numerous instances of the condition have come under the notice of individual observers. Dr. John Thomson writes that he has met with eight cases in eight years. One of us has seen seven cases in the last five years. Of these seven cases six occurred in the Pimlico district and one at Hampstead. Reference to the Registrar-General's reports suggests strongly the probability that instances of the affection pass unnoticed.

The subjects of the affection under consideration, if untreated, died at about the third or fourth month. It is not unreasonable to assume that some of the 19,000 cases in which death is annually ascribed to "debility, atrophy, and inanition" are instances of this affection and it is highly probable that if attention becomes more generally drawn to the condition many more cases will be recognised and, it is to be hoped, successfully treated.

The following is a short summary of the seven cases above referred to, the date and age given being those at the time of death or of operation.

CASE 1.—May, 1897. The patient was a male, aged 14 weeks; death occurred nine days after admission to the hospital. His weight was 7 pounds 4 ounces.<sup>2</sup>

CASE 2.—May, 1897. The patient was a male, aged seven weeks; he died as an out-patient.<sup>3</sup>

CASE 3.—June, 1900. The patient was a female, aged three months; she died on the day after admission. Her weight was 6 pounds 3 ounces.<sup>4</sup>

CASE 4.—February, 1901. The patient, a male, aged nine weeks, was under treatment as an out-patient and was admitted into hospital under the care of a colleague. The child's weight was 4 pounds 6 ounces two days before death; he was said to have weighed 8 pounds at birth.<sup>5</sup>

CASE 5.—March, 1902. The patient was a male, aged two months; he was examined post mortem. He was under the care of Dr. F. H. Champneys who has kindly allowed us to make mention of the case.<sup>6</sup>

CASE 6.—June, 1902. The patient was a male, aged eight weeks (*vide infra*).

CASE 7.—August, 1902. The patient was a male, aged six weeks (*vide infra*).

All these cases were typical instances of the affection. The undue preponderance of males in this series is unimportant, for the larger series of collected cases shows that females are almost as often affected. One noteworthy fact is that a fatal issue results before the fourth month of life in infants not operated upon. The two fresh cases need be only briefly recorded. They are as follows:—

CASE 6.—The patient, a boy, was born on April 14th, 1902, and was described as "a lovely fat child." He was the fifth child of a mother, aged 39 years, who had had no miscarriages and had no difficulty in rearing her other children. For six weeks he was fed on condensed milk and for one week on diluted cow's milk. Vomiting began at the age of three weeks and persisted. The bowels were described as costive and as acting about once a day. On May 31st, at the age of seven weeks, he was admitted into the Belgrave Hospital for Children, having been vomiting continuously for two days. He was very wasted, weighing only eight pounds. The tongue was clean and the fontanelle was depressed. On June 4th he had vomited daily. Several feeds might be kept down and then a large quantity of curdled milk was brought up at once. A small amount of dry brown faecal matter was passed daily. There was a loss of five ounces in weight. Dilatation of the stomach and visible peristalsis were readily made out. On June 9th the vomiting had been more frequent. There was a loss of four ounces in weight. On the 10th pyloroplasty was performed by Mr. Dent. The details of the operation will be described later in this paper. No food was injected into the intestine during the operation.

*Feeding after the operation.*—The patient was immediately given a rectal feed of two ounces of peptonised milk and water, equal parts, and a few drops of brandy. These feeds were repeated every three hours day and night for six days, and the bowel was washed out once a day with saline solution. The injections were then not retained so well and were given less often, being finally omitted in another two days. By the mouth a teaspoonful of hot water was given every quarter of an hour for 30 hours. Then he received a like quantity of whey, the amount being doubled 48 hours later. On June 17th he was fed on peptonised milk and water and on June 23rd he began to take diluted cow's milk. The vomiting continued after the operation. At first the bulk of the hot water was returned. 12 hours after the operation some altered blood was brought up. A week later the vomiting ceased but up to the time of discharge he was occasionally a little sick. About 36 hours after the operation faecal matter and altered blood were passed per anum.

*Complications.*—Oedema of the feet began on June 15th and next day appeared in the face. It persisted for a week and was associated with a slight degree of albuminuria. It was probably due to a mild attack of desquamative nephritis from too much work being suddenly thrown upon the kidneys. The wound also gave way at the lower part. The edges of the wound were dry and in the child's debilitated condition showed at first little tendency to heal. No doubt the anterior wall of the stomach became adherent over a small area to the abdominal wall on either side of the lower part of the wound.

*Weight.*—Eight days after the operation the child weighed exactly a pound more than he did the day before the operation. Some of the gain was due to oedema. On June 29th the wound had quite healed and a week later the child was discharged in fairly good condition, but he did not assimilate his food well and actually weighed on discharge

FIG. 1.

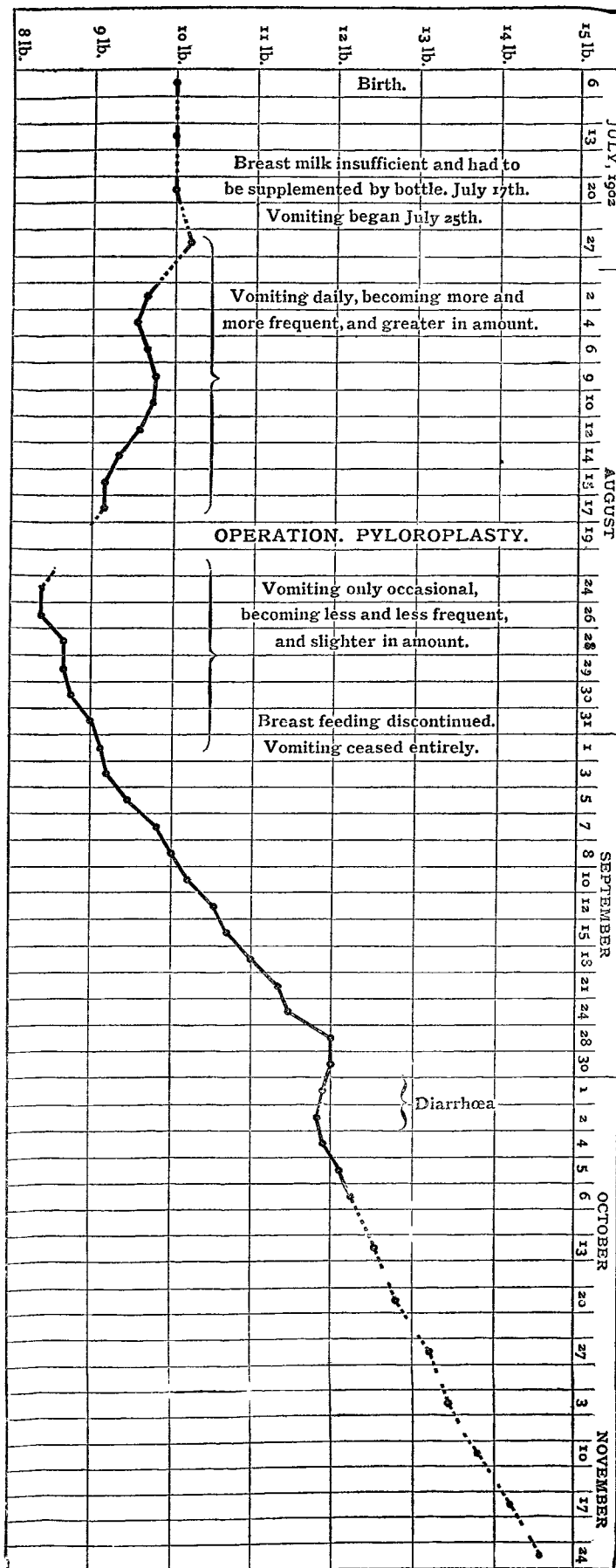


Chart showing progressive increase in weight after pyloroplasty.

<sup>2</sup> Transactions of the Royal Medical and Chirurgical Society, 1899, vol. lxxxii.

<sup>3</sup> Loc. cit.

<sup>4</sup> THE LANCET, July 28th, 1900, p. 256.

<sup>5</sup> Blackader: Brit. Med. Jour., 1901, vol. i., p. 765.

<sup>6</sup> Brit. Med. Jour., 1902, vol. i, 1340.

an ounce less than on admission. The food passed readily through the pylorus and he took it eagerly and without vomiting. It was hoped that fresh air would stimulate his assimilative functions.

*Subsequent history.*—The patient was readmitted on July 29th for an attack of diarrhoea due to unsuitable food. His weight was nine ounces more than on his discharge. For nearly three weeks his stools were not satisfactory and his weight kept almost stationary. On August 16th he weighed 8 pounds 10 ounces, and he then started improving, until on Sept. 3rd he had reached 9 pounds 10 ounces in weight and looked well and happy. He was sent out daily in charge of a sister and from some unexplained cause he unfortunately was seized with an attack of zymotic enteritis and died on Sept. 9th. The case may fairly be claimed as one of recovery from the original mischief. The pyloric orifice readily allowed the passage of food through it and the child was rapidly recovering from the marasmic state into which he had sunk before the operation. At the time the fatal attack began he was rapidly gaining weight, was digesting his food well, and looked like a normal healthy babe.

**CASE 7.**—The patient, a boy, was born on July 6th, 1902, and weighed 10 pounds. He was the third child, the two previous boys being strong and well. From the first the mother noticed that he did not take the breast readily like the previous children and that he was soon satisfied. On July 27th he weighed 10 pounds 6 ounces, but he then started severe vomiting and lost 12 ounces in four days. At first the vomiting was very bad, everything being brought up in from 10 minutes to an hour. The stools were variable and not noticed to be markedly small. During the first 10 days of life he was breast-fed, and then for a short period he was partially bottle-fed on account of pyrexia and a tender breast in the mother. On August 13th he was seen in consultation with Dr. James Morrison who had recognised the presence of some obstruction. The child looked ill, the eyes were sunken, the tongue was clean, and the weight was 9 pounds 6 ounces. The stomach was dilated and peristaltic movements could be seen passing onwards to the pylorus, there pausing, and then continuing onward down the duodenum. Deep down under the liver at the point of temporary pause in the peristaltic wave could be felt an ill-defined, rounded, moveable tumour. The last stool was greenish and contained a little faecal matter. Temporary measures in the way of diet and drugs were tried for a few days, but as the child steadily lost ground and the vomiting was characteristic pyloroplasty was performed by Mr. Dent on August 19th. A little altered blood was brought up during the next night. Faecal matter was passed on the third day and on August 28th the child was gaining weight. During the next four weeks he gained no less than 8 pounds. His recovery was steady and uneventful. The post-operative treatment and feeding were conducted on the same lines as in the other case.

The condition of this child (Case 7) who was in a good station of life, was far better than that of the patient in Case 6 at the time of operation. In this case the previous history and the early symptoms noticed could be thoroughly relied on, as the father was a medical man and the mother a highly observant woman. The only *contretemps* during the gestation period were that the mother had at the fourth month trouble with her teeth, some of which had to be stopped, and during the fifth and sixth months her two other children had whooping-cough, which gave rise to some anxiety. It is worth recording, though we lay no stress on what may be merely a coincidence, that the grandmother on the father's side lost a sister in infancy whose death was ascribed to "nothing passing through the stomach." This child "vomited everything." The cases hitherto recorded seem all isolated instances. Cases 6 and 7 seem to be the first in which the operation of pyloroplasty has been adopted for the relief of congenital stenosis of the pylorus in infants. Before discussing the choice of operation a few remarks may be offered on certain points in connexion with the affection.

*Diagnosis and symptoms.*—There is little that can be added to what has already been written on these points. The clinical histories in a large number of the recorded instances so closely resemble each other in every detail that a description of one is typical of all. Cases 6 and 7 are characteristic examples. Once established the symptoms will vary little. The rate of downhill progress is uniform, as evidenced by the steady loss of weight; and, after all, this is what would be expected in a process of death by starvation the result of mechanical obstruction. Some gastritis may, but only rarely, supervene; dilatation of the stomach is far more likely to ensue, but there are few other changes of moment. If any toxæmia, dependent on the constipation, is brought about the temperature may be irregular. One word of warning may be given on the question of diagnosis. We must not take it for granted that every infant suffering from vomiting and constipation is afflicted with this disease, though these are the main symptoms that attract attention. Such symptoms are, of course, common in infancy. The additional evidence afforded by dilatation of the stomach and the presence of visible gastric peristalsis is of the utmost value, but an absolute diagnosis can only be arrived at by very careful observation of the symptoms and of the course of the illness. The pyloric tumour, even when of considerable size, may not be perceptible. It will probably lie close to the middle line, and unless an anæsthetic is given for the examination

may not easily be felt. The difficulty in deciding the question of operation may be considerable. Some days' observation may be necessary to establish the diagnosis. On the other hand, the earlier the diagnosis is made the greater is the chance of recovery by surgical measures.

*Morbid anatomy.*—The essential abnormality, as all agree, consists in a marked excess of the muscular fibres encircling the pylorus.<sup>7</sup> There is also some increase of the longitudinal fibres, but, comparatively, to an insignificant extent. This thickening of the circular fibres constitutes merely a hyperplasia and of itself is insufficient to give rise to all the symptoms. Some authors have found, also, thickening of the submucous tissue. No writer, however, whether ascribing the stenosis to spasm or hyperplasia, has suggested that there is any antecedent inflammatory process. Dr. Thomson<sup>8</sup> describes a case which he examined post mortem and in which the "thickening" seems to have been purely an increase in the amount of submucous "lymphoid" tissue. Such a condition would clearly obstruct the passage of the gastric contents through the pylorus. Even though the muscular spasm of the sphincter were relaxed the loose redundant mucous membrane would impede the flow. Our experience leads us to believe that material thickening or increase in the submucous lymphoid tissue is exceptional in infants. This view is borne out by the sections figured and by others which we have examined. A single longitudinal reduplication of the mucous membrane, much more marked than any other fold, forms a conspicuous feature in many of the specimens. This prominent fold in its appearance may be compared to the verumontanum of the male urethra. Indeed, these stomachs in appearance and feel curiously resemble the dissected out bladder and prostate, the latter being comparable to the thickened pyloric portion.

*Choice of operation.*—It must be premised that the following remarks are intended mainly to apply to the pronounced cases of the affection, where operation seems to be indicated in the first few weeks of life. Various operations have been performed for the relief of the condition. As far as we have been able to ascertain from the records of published and unpublished cases, operation has been performed in 19 instances. The average age at which operation was performed in the first 18 cases was seven weeks.

*Pylorotomy.*—Pylorotomy has been performed on one occasion. This patient, aged nine weeks, died. There appears to be a general consensus of opinion among those who have written on the subject that pylorotomy is a needlessly severe operation. The fatal objection to it is that the operation must be prolonged, and in the case of abdominal operations on very young children it is essential to select the most rapid method likely to give good and permanent results. There is little need to elaborate the arguments against this method of surgical treatment, for it is not likely to be adopted again.

*Gastro-enterostomy.*—Gastro-enterostomy has been performed in nine cases. Four of the patients recovered and five died. In one of these patients Murphy's button was used and death resulted 30 hours after the operation from obstruction caused by the button. The time that is saved by the employment of Murphy's button is more than counterbalanced by the risk attending its use. An obvious objection is that the button, supposing that all goes on well, may drop ultimately into the stomach and not into the intestine. There would be no chance of its passing from the stomach through the stenosed pylorus. Even those who hold that the condition is purely due to spasm of the pylorus would admit the extreme improbability of the pyloric sphincter allowing the passage of so large a body as even the smallest Murphy's button. The argument that has been adduced in favour of using Murphy's button in certain cases of pyloric stenosis in adults, that even if it should drop back into the stomach it can be easily and safely removed by gastrotomy, need hardly be taken seriously. However favourable the operation of gastrotomy be in its results it can hardly be held justifiable to adopt a proceeding which will probably necessitate this second operation. While all are of one opinion as to the unsuitability of Murphy's button in these cases, most of those who have written about

<sup>7</sup> Finkelstein mentions a case in which the stenosis appeared to be due to increase in the longitudinal fibres. Possibly this appearance was owing to the section not being actually longitudinal.

<sup>8</sup> Thomson: On Congenital Gastric Spasm (Congenital Hypertrophy and Stenosis of the Pylorus), Scottish Medical and Surgical Journal, June, 1897.

the affection advocate the operation of gastro-enterostomy. Weill and Péhu,<sup>9</sup> e.g., say that gastro-enterostomy is essentially the operation to be preferred (*la méthode de choix*) from the surgical point of view. Robson and Moynihan<sup>10</sup> write: "The operation of choice in all such cases is clearly gastro-enterostomy." Löbker<sup>11</sup> seems to think that gastro-enterostomy is the only operation that can save life and other writers appear to hold similar views. Löbker founds his rather positive opinion apparently on two cases, one of which died and one recovered. *Ex cathedra* utterances of the kind do not advance knowledge and are surely premature when experience of the surgical treatment of the affection is still so limited. These quotations, by no means all that could be cited to the same effect, show a very decided consensus of opinion. At the same time the number of cases which have actually been submitted to operation is so small that the preference for gastro-enterostomy must clearly be founded on theoretical considerations rather than on actual experience. We are not concerned to deny the fact that gastro-enterostomy may bring about effectually the relief of all the symptoms. Our contention is that a similar result may be obtained by means of pyloroplasty and that this operation is, on surgical grounds, to be preferred. It would be unwise to draw any large deduction from a small number of cases, but it may be pointed out that of the nine cases in which gastro-enterostomy was performed more than half of the patients died.

The objections to our mind to the choice of gastro-enterostomy are: 1. That it necessitates a considerable exposure of the abdominal contents. 2. That the operation must necessarily be more protracted than either dilatation of the pylorus or pyloroplasty. All will agree probably that the gastro-enterostomy should be done by simple suture. In the case of a very young child the parts are so small that the delicate manipulation required by the operation, if efficiently performed, must take considerable time. The use of very minute Senn's bone plates or similar contrivance would scarcely shorten the proceedings. 3. That there is increased risk of protrusion of the intestine. 4. That the incision has to be prolonged further down towards the umbilicus. Wounds in the epigastric region, as is well known, heal most readily, and the resulting scar is strong without any tendency to subsequent ventral hernia. In a little child the upper part of the abdominal wall is probably further developed and the ventral plates are more closely approximated than lower down in the belly.

So far as we have been able to ascertain anterior gastro-enterostomy has been adopted in all the cases operated on. Posterior gastro-enterostomy, the better operation of the two, is open still more markedly, in the case of an infant, to the objections already urged. To our minds the operations of dilatation of the pylorus and pyloroplasty are both superior to gastro-enterostomy for these cases, and there is really not much choice between the two methods. Both can be done through a very small abdominal incision, which is situated high up in the epigastric region; both can be done in a short time and without even seeing any of the intestine, and therefore with the minimum of risk of protrusion of the abdominal contents. Both operations again bring about quite as complete recovery as gastro-enterostomy. It would probably be hardly fair in dealing with so small a number of cases to lay any stress on the fact that more recoveries have followed when these operations have been selected than when gastro-enterostomy has been performed.

Dilatation of the pylorus (some form of Loreta's operation) has been performed in six cases; four of these recovered and did well after. One died and in one case the child recovered from the operation but the ultimate result is not yet recorded. Pyloroplasty alone was performed in the two cases on which this paper is founded and in another recent case of which we have the details. Here, again, the child recovered from the operation but the case is still incomplete. A case of Sonnenburg<sup>12</sup> has often been quoted. He performed pyloroplasty for the relief of a condition of the kind, but finding that the subsequent result, as regards nutrition, was unsatisfactory later performed gastro-enterostomy. After this second operation the patient improved. But this was in a child six years of age. In our paper we are dealing only

with the condition as it is observed in infants. At the same time we fully allow that the case supports the views of those who favour the operation of gastro-enterostomy. The operation of pyloroplasty has been condemned by several of those who have written on the subject, as it appears to us, on altogether insufficient grounds. Monnier<sup>13</sup> describes pyloroplasty off-hand as unsafe and often impracticable on account of the thickness of the pyloric wall. Robson and Moynihan<sup>14</sup> say: "Pyloroplasty, on account of the great thickness of the pylorus and its rigidity in the whole circumference, is inapplicable." These authors make no reference to the operation of dilating the pylorus for this affection. Weill and Péhu<sup>15</sup> adopt the view of Abel<sup>16</sup> that pyloroplasty is out of the question on account of the induration of the myomatous tissue that constitutes the muscular hypertrophy.<sup>17</sup> Other authors also consider that the operation of pyloroplasty is inapplicable. The only authors who favour the Loreta method would appear to be Schmidt<sup>18</sup> and Thomson.<sup>19</sup>

To sum up, then, it would appear (1) that the balance of opinion is decidedly in favour of gastro-enterostomy on the ground that recovery follows and that the operation meets the necessities of the case; and (2) that pyloroplasty is not so much an unsuitable as an impracticable operation. Now this latter opinion is one that our cases seem clearly to disprove. Notwithstanding the extreme rigidity and thickness of the hypertrophied pyloric sphincter no difficulty whatever was found in our cases in sewing up the wound transversely. Indeed, the operation of pyloroplasty would be worthless and impracticable in almost all cases if rigidity and thickness of the wall constituted an insuperable obstacle to its performance. It would be extremely easy, of course, to perform pyloroplasty on a healthy normal stomach, but the operation is not called for in such cases. The operation is really very much easier when the thickness is due to muscular hypertrophy, as in congenital pyloric stenosis, than when the pyloric region is thickened, tough, and fibrous owing to inflammatory changes. In very young children it will be found that the stomach and duodenal walls can be approximated with exceedingly little tension and with no tendency whatever of the stitches to cut through.

A brief description of the operation performed in our two cases will serve best to explain the purely surgical grounds that we have for advocating pyloroplasty. We may premise that, whatever operation be chosen, a condition for success of the very first importance is the administration of the anæsthetic. It would be difficult to imagine a class of cases in which more depends upon the skill and judgment of the anæsthetist. Unless the patient is deeply under the influence of chloroform (which certainly appears to be the best anæsthetic) there is risk of protrusion of the intestine and rapidity of operating becomes a matter of great difficulty. On the other hand, in abdominal operations on very young children deep anæsthesia, unless most carefully induced and maintained, may lead to very sudden and alarming symptoms. Any interruption to the operative procedure while in progress would be a very serious matter, for if the patient is not deeply anæsthetised there is every likelihood of his recovering sufficiently to cry or to struggle. If any such event happens the intestines are likely to protrude at once with the most astonishing suddenness and force. In a case recorded by Stern<sup>20</sup> both of these troubles seem to have occurred. The child's breathing stopped just after the operation had begun; the anæsthetic was so badly borne that it had to be discontinued while the operation was completed; and the result was that the intestine protruded extensively, thus prolonging the operation and enormously increasing its severity. Distended

<sup>13</sup> Monnier: Deutsche Zeitschrift für Chirurgie, 1901, p. 361.

<sup>14</sup> Loc. cit.

<sup>15</sup> Loc. cit.

<sup>16</sup> Abel: Erster Fall von erfolgreicher Gastroenterostomie wegen angeborener stenosirender Pylorus-hypertrophie bei einem achtwöchigen Säugling. Münchener Medicinische Wochenschrift, Band xlv., 1899, p. 48.

<sup>17</sup> Loc. cit., p. 1102. "On ne peut y songer en raison de la dureté particulière du tissu myomateux qui constitue l'hypertrophie musculaire."

<sup>18</sup> XXXe Congrès de la Société Allemande de Chirurgie, 1901; also Ueber Hyperemesis Lactentium, ihr Verhältniss zur congenitalen hypertrophischen Pylorusstenose bzw. zum Pylorospasmus und ihre chirurgische Heilbarkeit durch Ueberdehnung des Pylorus; Archiv für Klinische Chirurgie von Langenbeck, Band lxxiii., 1901, p. 977.

<sup>19</sup> Thomson: Congenital Hypertrophy of the Pylorus and Stomach Wall. Edinburgh Hospital Reports, 1896, vol. iv., p. 115.

<sup>20</sup> Deutsche Medicinische Wochenschrift, Band xxiv., p. 601. September, 1898.

<sup>9</sup> Weill et Péhu: Un Syndrome gastrique particulier du nourrisson. Lyon Médicale, Dec. 9th, 1900.

<sup>10</sup> Robson and Moynihan: Diseases of the Stomach and their Surgical Treatment, 1901, p. 44.

<sup>11</sup> Löbker: Verhandlungen der Deutschen Gesellschaft für Chirurgie, Band xxix., Berlin, 1900, p. 148. (29ster Congress, April 20th, 1900.)

<sup>12</sup> Berliner Klinische Wochenschrift, Band xxxvi., 1899, p. 32



intestines, when protruded in a crying child, are not easily replaced without force. The chief trouble in this case lay in what Stern terms the "Repositionsschwierigkeiten." The patient died an hour or two after the operation was concluded. The success of our cases was largely due to the extreme care and skill with which the anæsthetic was administered, in the first case by Dr. H. Menzies, and in the second by Dr. G. P. Shuter. The surgeon is too often inclined to absorb all the credit of a successful operation, when a great part of it is really due to the anæsthetist.

If there be from any reason difficulty with regard to the anæsthesia, the operation that can be most rapidly performed and with the least incision is clearly the best to adopt. In our first case the abdominal wall was so exceedingly thin and the child so emaciated that as soon as the fibres of the rectus were separated the peritoneum almost burst open. There is no need to drag the pylorus up into view. If the distended stomach that presents be gently pressed back into the left flank the pylorus will almost immediately rise up into the wound without any traction. The feel and the appearance in these cases are very characteristic, and in both of our cases this portion of the stomach looked paler than natural. The peristalsis and distension excited by the exposure and the handling may be embarrassing, but the moment that the incision is made into the stomach the distension subsides and the rest of the operation is easy enough. The incision should divide freely the thickened tissues and extend well into normal structure on each side. An inch is really rather a short incision, and even in a very young child, if it be made considerably longer, there will be no difficulty found in approximating the wound transversely. In our second case some of the stomach contents, consisting of undigested and frothy milk, escaped but was easily prevented from getting into the peritoneal cavity. It was not thought wise to prolong the operation by washing out the stomach. At the upper and lower angles of the wound the mucous membrane was united to the coats of the stomach and the duodenum respectively. As the muscular wall retracts it slides back over the mucous membrane, causing the latter layer to project. There was a marked absence of any sub-mucous thickening and the mucous coat could have been drawn out with the greatest ease. The object of the two sutures mentioned was to prevent the cut mucous coat from crumpling up unduly and so creating obstructions when the pyloroplasty was completed. The widest part of the wound was united first and this could be done without the slightest injurious traction.

It matters little whether one or more of the sutures penetrate through the whole of the coats or not. If it be desired to examine the inner mucous surface the lateral parts of the wound can be widely separated and if need be the longitudinal fold of redundant mucous membrane, which is likely to be in the line of the greater curvature, can be excised. The introduction and closure of the first suture at the widest part of the wound are likely so to approximate the whole of the wound transversely that there is little trouble from escape of the stomach contents. There is no need to put in many sutures. Five or six for an incision one and a quarter inches in length are quite sufficient and the whole of the serous surfaces can be most effectively and safely apposed with this number. The multiplication of sutures is unwise, for it takes time and may bring about, by necrosis of the tissues subsequently, the very leakage that it is supposed to prevent.

No difficulty was found in either case in bringing the serous surfaces at the extreme angles of the transverse wound together in a perfectly satisfactory manner—i.e., the parts where the thickening and the toughness of the tissues were greatest were almost as easily sewn together as the central normal parts of the wound. The objection that has been taken to the operation on this ground, therefore, seems to us to be entirely disproved by practical experience.

If any embarrassment arises from the distended intestine, probably the transverse colon bulging up towards the wound, it can be controlled effectively by the simple device of irrigating with hot normal saline solution. This method is of the greatest value in all abdominal operations in children. Not only are the exposed parts kept warm but it will be found also that the distension subsides, the intestine, becoming heavy, sinks back into the cavity of the abdomen, while the serous surfaces are kept moist, which is a consideration of the highest importance. The suture of the abdominal wound, too, is rendered easier. Moreover, the absorption of the fluid is of the greatest

benefit to the child, for the thirst that so frequently constitutes a great source of distress after abdominal operations is greatly lessened. The fluid contents of the stomach show that the vessels have obviously been unable to absorb the watery constituents properly for some time. The emaciation is largely due to the drying of the tissues. The operation in the second case occupied only just over 20 minutes and a good deal of this time was taken up in suturing the abdominal wound. The time during which there was really any exposure of the abdominal contents was therefore very short. A practical point in the after-treatment consists in keeping the child on the right side as much as possible. This plan certainly seems to facilitate the passage of the stomach contents into the duodenum.

It was very noticeable in both operations that there was no transverse gaping of the wound when the incision was made through the sphincter. Yet this might have been expected if the muscle was in a state of spasmodic contraction. The cut surfaces, too, of the sphincter remained flat and not concave, as would have happened if the cut sphincter had retracted. The wound did appear to extend longitudinally to a slight extent, owing, of course, to muscular action.

We believe that pyloroplasty is in these cases preferable to dilatation for the following reasons. 1. It can be done at least as quickly. It has been recommended in Loretta's operation to perform the actual dilatation deliberately. In both operations an incision has to be made into the stomach and sewn up again. 2. It is a more definite proceeding and allows more range, as the length of incision can be graduated according to the condition found. 3. The lumen of the tube can be examined, and, if thought desirable, the longitudinal fold of mucous membrane can be removed. This fold will probably, if present, be found in a line with the greater curvature of the stomach. 4. The exact amount of injury done to the parts is known. There seems to be no advantage in performing what has been termed "submucous pyloroplasty." If there were any distension of the stomach this would be an embarrassing proceeding. It is better to divide all the coats.

*Etiology.*—The causation of the condition is still quite uncertain. Some hold that the condition is due to a primary hyperplasia of the muscular tissue, an overgrowth due to a fault in development. Others consider that the hypertrophy is secondary and results from over-exertion of the muscle, this being due to functional disturbance of the nervous mechanism of the stomach and pylorus. Dr. Rolleston<sup>21</sup> writes: "It seems reasonable to combine these views so far as to believe that there is some congenital hyperplasia of the pyloric sphincter and that spasm supervenes on this and is largely responsible for the symptoms manifested."

Although we do not profess to be able to make any material contribution to solving a question that is still in the nebulous regions of hypothesis, we submit a few considerations on the subject. The discussion of the causation is not a mere academic question. If the condition be due to pyloric spasm, as Pfaundler<sup>22</sup> maintains, in all cases the affection should be amenable to treatment short of operation; and the fact that medical treatment in marked cases has hitherto proved futile should not deter us from seeking for more efficient remedies than have hitherto been found. As in our view the condition is more probably due to a muscular hypertrophy which is not the result of spasm, we hold that while surgical measures are imperatively demanded in the strongly marked cases, they may also be with advantage adopted even in slight degrees of the affection. Undue delay, especially in cases that are not of the severest type, is likely to lead to dilatation of the stomach; and when the stomach is much dilated the results of operation of any kind are far less likely to be good. The food may be able to get out of the stomach, but it will not be properly assimilated.

Dr. Thomson<sup>23</sup> in a recent paper argues fully and with much ingenuity in favour of the hyperplasia being secondary to spasm. The argument in support of the contention that the hyperplasia of the muscle is secondary may be summed up briefly as follows. The stomach is not an inactive organ during intra-uterine life, but its contents—mainly the liquor amnii—pass through it into the intestine. As a result,

<sup>21</sup> Rolleston and Crofton-Atkins: Brit. Med. Jour., Dec. 28th, 1900.

<sup>22</sup> Zur Frage der sogenannten congenitalen Pylorusstenose und ihrer Behandlung. Wiener Klinische Wochenschrift, 1898, p. 1025.

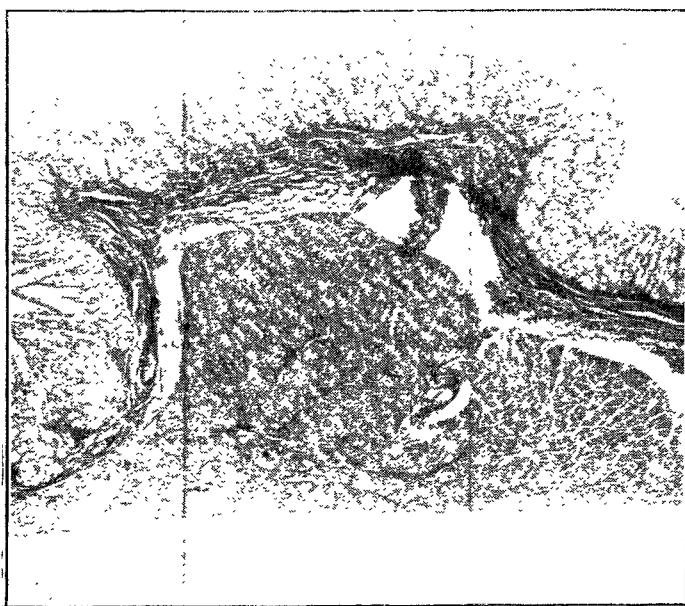
<sup>23</sup> On Defective Coördination in utero as a Probable Factor in the Causation of certain Congenital Malformations, Brit. Med. Jour., Sept. 6th, 1902, p. 678.

presumably, of derangement of the nervous mechanism there is incoördination; even slight disturbance of coördination may lead to greatly exaggerated exertion. If the incoördination is of a violent spasmodic kind it must inevitably result in great muscular hypertrophy. This theory seeks to explain, therefore, the congenital muscular hypertrophy as a result of muscular spasm commencing in intra-uterine life. In support of the opinion that the muscular hypertrophy is due to over-action it is urged that no other isolated deformity, or abnormality of the same nature, is met with as a congenital defect.<sup>24</sup> The excessive growth of the muscular tissue of the uterus which takes place during pregnancy is alluded to but dismissed at once as a thing altogether by itself. With regard to local giantism, such as is often seen of a digit or of the tongue, it is argued that such abnormalities are not parallel cases. A local giantism of the pylorus might be possible, but hardly a primary true hypertrophy of a muscle which forms only a portion of the pyloric structure. The weak point of the argument to our mind lies in the assumption that the muscular spasm is necessarily of so pronounced and prolonged a character as inevitably to lead to hypertrophy.

Dr. Thomson quotes John Hunter as pointing out that hypertrophy from repeated forcible contraction is a property common to all muscles and greater in involuntary than in voluntary muscles. This much may be granted at once, but the proof that any such repeated forcible contraction of the pyloric sphincter takes place, even after birth, in these cases is very far from complete. A pyloric sphincter, though exceedingly small and weak, might effectually close the orifice merely by non-relaxation at the proper time. The muscular fibres of the stomach that drive on the gastric contents into the duodenum do not act in a manner directly antagonistic to the sphincter, and there is no need therefore to assume that any excessive action of the sphincter is necessary to occlude the passage. Hypertrophy of the detrusor fibres, as would be expected, does occur after a time, but the efforts of these fibres to overcome the obstruction would lead rather to pouching of the stomach at the pyloric ring—a condition that is met with in adults—than hypertrophy of the sphincter, for the latter muscle, acting at an immense mechanical advantage, is not a direct opponent to the longitudinal and oblique muscular bands.

In answer to the challenge to cite any other instance of a local giantism or hyperplasia of a sphincter muscle, such as that of the pylorus, it may fairly be asked what other instances can be given of a sphincter muscle becoming hypertrophied to the same extent as a result of spasmodic action.

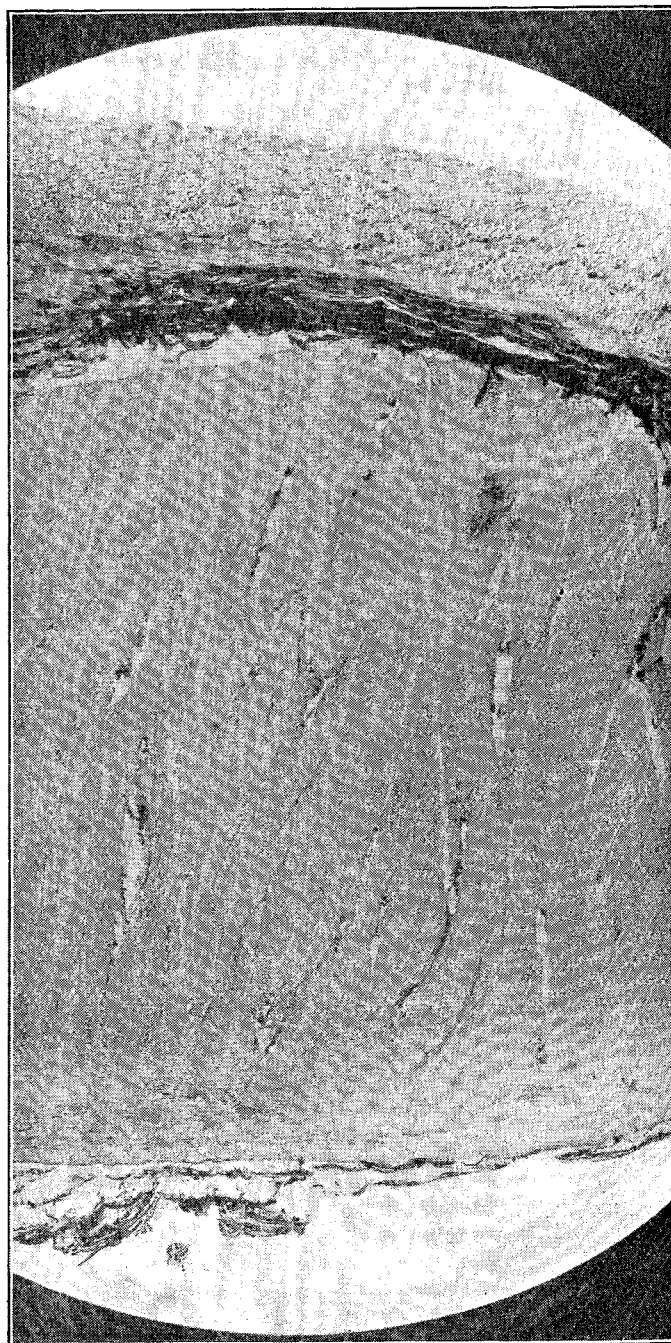
FIG. 2.



Longitudinal section through the normal pylorus of a child, aged about three months. The amount of muscular tissue is exceptionally large. The portion between the two lines corresponds nearly to the amount shown in Fig. 3.

The very term implies intermittent action. No such hypertrophy is seen in the case of the anal sphincter or in that of the bladder, or of the cardiac end of the stomach. But in the first two the tonic contraction is more constant. It has been urged that in the subjects of congenital hypertrophic stenosis the pyloric sphincter increases greatly during the first few weeks after birth. Still remarks that the pylorus cannot be felt until the fourth week. The

FIG. 3.



Longitudinal section through the thickened pylorus of a case of congenital pyloric stenosis. The patient was a child, aged about three months. The specimen has been reversed so that the duodenum would lie on the right hand. The condition is almost entirely due to an enormous increase of the circular fibres. There is considerable increase of the longitudinal fibres, but very little submucous thickening.

capacity of the stomach increases rapidly during the first few weeks after birth. Observers agree that the capacity of the stomach is about two and a half times as great at the fourth week as in the first week.<sup>25</sup> The muscular tissue, also, with increased functional activity, becomes more evident. The organ, therefore, would, as a whole, be more recognisable by the fourth week of life. But an enlarged pylorus could be detected earlier, though perhaps not clearly made out without an anæsthetic. Inasmuch as cases of congenital pyloric stenosis are uncommon, and the

<sup>24</sup> Possibly the sublingual fibromata of the newly-born that have been described by Italian surgeons may furnish a parallel case. These little tumours appear to be a purely local hyperplasia and hypertrophy of the mucous membrane. *Jahrbuch für Kinderheilkunde*, Band i., Heft 5, 1900, S. 532. Callari and Philippon, *Ueber das Sublinguale Fibrome der Säuglinge*.

<sup>25</sup> Compare *Traité des Maladies de l'Enfance*, tome deuxième (Maladies du Tube Digestif; Considérations pratiques sur le Développement Physiologique du Tube Digestif chez l'Enfant), par G. Variot, p. 296, 1897.

condition is rarely, in the absence of symptoms, suspected for the first two or three weeks, the tumour is not found because it is not looked for. As the child emaciates the detection of the tumour becomes easier, but this is no evidence of any rapid increase of the pyloric tumour. The more widely the affection becomes known the earlier will the pyloric thickening be detected.

Our knowledge of the nervous mechanism of the stomach is as yet so imperfect that it seems premature to found any hypothesis as to the causation on a theory of lack of coördination.<sup>26</sup>

The results of operative treatment throw but little light on the question. The success that has attended the various surgical measures is consistent with any of the explanations of the causation hitherto advanced. Forcible dilatation of the pylorus or pyloroplasty would overcome spasm or would restore the lumen of a passage that had been compressed by an excessive muscular development. At first sight it would seem natural to suppose that after a time the muscle would recover and that the spasm would return, and this might be held to favour the view that pyloric spasm is not the real factor. The sphincter ani, for example, recovers its power after forcible stretching. We can hardly imagine that forcible dilatation could bring about proper coördination, which depends on the innervation of the gastric muscles. Practically, the mechanical obstruction is relieved by the mechanical stretching or even more efficiently by pyloroplasty. Though it is premature at present to say that recovery is permanent, as far as experience goes the good effects may at least be prolonged for months or years. The fact that gastro-enterostomy may bring about recovery from all the symptoms may be held to favour the theory of spasm. Possibly the pyloric sphincter after this operation may revert gradually to its normal extent and functional efficiency, but there is no evidence as yet that it does so. After a successful gastro-enterostomy for a non-malignant condition of the pylorus the nutrition may become perfectly normal though the pyloric passage remains closed, and this benefit is even more likely to come about in a child than an adult.

On the whole, we are disposed to think that the balance of evidence is in favour of the hyperplasia being primary. The solution of the problem probably lies in the hands of the morphologist. Very little is known about the development of the upper part of the alimentary canal that lies in the abdominal cavity.

The thickness of the normal pyloric sphincter (Fig. 2) varies greatly as specimens prepared from the stomachs of children less than 12 months old will show. Our best thanks are due to Dr. W. J. Fenton for preparing the specimens, and to Dr. H. R. D. Spitta for the excellent micro-photographs made from them.

A full bibliography will be published in the next volume of the Transactions of the Royal Medical and Chirurgical Society.

## ON THE TREATMENT OF DIPHTHERIA BY THE INTRAVENOUS ADMINISTRATION OF ANTI-DIPHTHERITIC SERUM.

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THE use of antitoxin in the treatment of diphtheria may fairly be said to have passed its period of probation and to have become the commonly recognised method of treatment and there is now a consensus of opinion regarding the striking reduction in the mortality from this disease, especially in the earlier years of life, which has followed upon the adoption of the serum treatment.

Anti-sera differ from most powerful therapeutic remedies in that while the proportion of the anti-bodies present in different sera is inconstant, yet for therapeutic purposes this

does not interfere in any way with the exhibition of even very large doses as there is no evidence to show that any deleterious consequences result from the administration of large doses—from 20,000 to 80,000 units—beyond the temporary inconvenience caused by rheumatoid pains in the joints and muscles and by occasional cutaneous eruptions of an urticarial or erythematous kind. In fact, it would seem to be difficult, if not impossible, to give a fatal overdose of antitoxic serum. In illustration of the benign action of the serum it may be pointed out here that notwithstanding the large doses employed the amount of albumin present in the urine was not increased. On the contrary, in those cases in which large doses of serum were employed less albuminuria was found usually than in those in which smaller doses were given. This seems to strengthen the conclusion that the serum itself does not possess any toxic properties.

The marked reduction in the case-mortality in diphtheria effected since the introduction of the diphtheria antitoxin is now admitted by everyone, but great as this reduction has been the experience gained in the treatment of this disease in the City of Glasgow Fever Hospital, Belvidere, suggests that even a further fall in the case-mortality may be hoped for. The lines along which this improvement may be effected are twofold—(1) by the exhibition of larger doses than those commonly recommended and (2) in certain cases by the intravenous use of the remedy. The employment of larger doses of serum has been already advocated by several observers, but so far as I am aware no one has recommended the intravenous use of the remedy. In a paper dealing with the serum treatment of bubonic plague published in THE LANCET<sup>1</sup> I have advocated the intravenous use of Yersin's serum as a most useful adjunct to the subcutaneous injection of the remedy, and the encouraging results obtained in apparently hopeless cases of this disease suggested the employment of the same method of administration in the treatment of severe cases of diphtheria. Both diseases are due to the reception at a particular part of the body of a specific micro-organism which must be considered as the essential cause of the local lesion, whilst the general symptoms of the disease are brought about by the absorption into the system of a definite chemical poison or toxin which is formed by the life processes of the organism at the seat of inoculation. In plague<sup>2</sup> the subcutaneous injection of Yersin's serum is followed not only by a marked antitoxic effect, as evidenced by improvement in general symptoms, but when introduced into the lymphatic drain towards the bubo a directly bactericidal effect can be demonstrated, the organisms contained in the bubo showing evidence of degeneration very soon after the administration of the serum. When given subcutaneously, even in large doses, however, the effect of the serum appears to be chiefly a local one, degeneration occurring only in those organisms which lie within the area of injection. By the intravenous method the maximum influence of the serum on the tissues, and also on the organisms, is obtained with greater rapidity than when the serum is used subcutaneously and those bacilli which have overflowed from the primary focus of infection into the general circulation can be reached directly and similar degenerative changes be produced, whilst at the same time the circulating toxin is most effectively dealt with. The fact that the administration of even large doses of serum subcutaneously is not followed by a commensurate improvement suggests that the serum in its passage through the lymphatic vessels and glands undergoes a qualitative change whereby its power of neutralising toxin is considerably diminished. This may be due to (1) a selective action exercised by the lymphatic glands in filtering out the active constituent of the serum, or (2) to the fact that, as Ehrlich has shown, there are a definite chemical action and reaction between toxin and antitoxin, neutralisation going on more quickly and more effectively in concentrated solutions than in diluted ones. In the case of plague the local action of the subcutaneous injection of serum is probably directed in the first instance to the neutralisation of the toxin locally present in the bubo and its vicinity and also to inducing bacillary degeneration in the comparatively large numbers of organisms present in the primary lesion. Any surplus of antitoxic bodies which reaches the general circulation after passing through the lymphatic channels will probably be present in the blood in such a state of dilution as to be comparatively ineffective, especially in septicæmic cases of plague. By immediate introduction of

<sup>26</sup> Among the most recent views on the innervation of the stomach and pylorus are those of Openchowski who states: "*Pylorus and antrum*.—Central centres which cause constriction lie in the corpora quadrigemina; the fibres run almost entirely in the vagi. In the corpora quadrigemina are also centres for causing the pyloric sphincter to gape; apparently the path is down the cord and by the splanchnic nerves. It is of importance to know that the opening of the cardiac end in point of time coincides with contraction of the pylorus." Quoted by Tiegerstedt, *Physiologie des Menschen*, vol. i., p. 269, 1897.

<sup>1</sup> THE LANCET, June 22nd, 1901, p. 1746.

<sup>2</sup> Loc. cit.