Significance of Pyloromyotomy and Pyloroplasty

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A series of experiments was carried out to clarify the significance and indication of pyloromyotomy or pyloroplasty as a drainage operation obtaining the following results. Pyloromyotomy suppresses the state of abnormal excitation of the pyloric portion, resulting in the decrease of contraction pressure of the pylorus, when an incision is done long enough. Pyloroplasty after Heineke-Mikulicz, however, is more effective as a drainage operation. The fundamental significance of pyloromyotomy seems to be in reducing the contractile force of the circular muscle at the pyloric region maintaining the sphincteric function. And that of pyloroplasty is in its effect in sacrificing the sphincteric function of the pylorus and in widening its lumen to result in a greater drainage effect. Thus, pyloroplasty is indicated when severe excitation of the remaining pyloric portion is present and the powerful drainage effect is desired even sacrificing the sphincteric function of the pylorus. On the other hand, pyloromyotomy has an indication when the less drainage effect seems sufficient and preservation of the sphincteric function of the pylorus is needed. —— pyloromyotomy; pyloroplasty; drainage operation; electromyogram

It has been known that the occurrence of delayed gastric emptying due to the abnormal excitation of the pyloric portion is very common after the segmental and proximal gastric resections which retain the pyloric ring. To facilitate the better gastric emptying, it becomes necessary to add a drainage procedure such as pyloromyotomy or pyloroplasty. In performing pyloromyotomy or pyloroplasty, one may yet raise questions concerning the proper length of an incision, the functional difference between these procedures, or relating to the indication or selection of these drainage procedures. To meet these questions, we have done a series of experiments and obtained the following results.

MATERIALS AND METHODS

Thirty-five adult mongrel dogs weighing about 15 kg were used for the experiments. The stomach was exposed through an upper midline abdominal incision under thiopental sodium anesthesia after 24 hours' fasting. Two bipolar silver-electrodes were used for taking electromyogram. One electrode was fixed on the anterior wall of the stomach 1 cm proximal to the pyloric ring and close to the greater curvature. Another electrode was fixed 4 cm proximal to the pyloric ring. To measure the contractile force of the

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Fig. 1. Method of experiments. Electrode B was fixed on the anterior wall of the stomach 1 cm proximal to the pyloric ring and electrode A was fixed 4 cm proximal to the pyloric ring. A rubber balloon 1×1×3 cm in size was introduced and placed inside of the pyloric ring.

Experiment 1 As the pyloromyotomy, a Ramstedt type incision of 3 cm in length was performed in the following two groups of dogs. In the first group (5 dogs), we studied electromyographically the effect of pyloromyotomy done on the normal stomach which had not been subjected to any preceding preparations. In the second group of 5 dogs, we studied electromyographically the effect of pyloromyotomy on the abnormally excited pyloric portion produced by the transection of the stomach between the corpus and antrum (Sugawara 1964, Shiratori et al. 1968).

Experiment 2 First of all, status of abnormal excitation of the pyloric portion was produced by transecting the stomach along the corpo-antral border. Then, the stepwise pyloromyotomy was made. In the first group (5 dogs), incision was made for 1 cm starting from the pyloric ring, then the incision was extended up to 3 cm proximally, by 1 cm each in the following two steps. In the second group (5 dogs), we reversed the direction of incisions starting at the point 3 cm proximal to the pyloric ring and extended the incision in three steps until it reached to the pyloric ring. In each step, we recorded the contraction pressure and electromyogram of the pyloric portion.

Experiment 3 In this experiment, we attempted to evaluate the effect of pyloroplasty of the Heineke-Mikulicz type. A longitudinal incision, 4 cm in length, was made 3 cm on the antrum and 1 cm on the duodenal side. In the first group of 5 dogs, the effect of pyloroplasty on the normal stomach was observed electromyographically. In the second group (5 dogs), the effect of pyloroplasty on the transected stomach was observed electromyographically and by measuring contraction pressure.

Experiment 4 This part of the experiment was performed to compare the effect of pyloroplasty and pyloromyotomy from the standpoint of the contraction pressure. In this group of 5 dogs, the contraction pressure of the pyloric portion was recorded serially in three steps: 1) transected stomach, 2) transection plus pyloromyotomy, and 3) transection and pyloroplasty which was transformed from pyloromyotomy.
RESULTS

Experiment 1. Our recent understanding is that, electromyographically, discharge interval is prolonged and the propagation velocity increases as the gastric motility becomes more active, and that the incidence of anti-peristaltic discharge becomes high when the pyloric portion is abnormally excited. Clinically, it is not uncommon to see spasm-like contraction of the pyloric portion accompanied with anti-peristalsis. Therefore, we regarded the frequent occurrence of anti-peristaltic discharge as an index of abnormal excitation of the pyloric portion, and also took the prolongation of the discharge interval and increased propagation velocity as indices of hypermotility of the stomach.

At first, we observed the effect of pyloromyotomy done on the normal stomach which had not been subjected to any other preceding preparations. Discharge interval and propagation velocity of normo-peristalses observed before pyloromyotomy were 14.0 sec and 6.1 mm/sec, respectively. Immediately after pyloromyotomy, discharge interval slightly shortened to 13.6 sec and the propagation velocity was 6 mm/sec. When we studied the specimens again two weeks after the previous observation, further shortening of the discharge interval to 13.4 sec and slowing of propagation velocity to 5.1 mm/sec were noticed (Fig. 2).

In short, an addition of pyloromyotomy on the normal canine stomach showed a tendency of decreased pyloric motor function. In the next place, immediately after transection, anti-peristaltic discharges were developed in the pyloric portion at the rate of 80%. Further addition of pyloromyotomy markedly reduced the incidence of anti-peristaltic discharge as low as 30%. Mean discharge interval of anti-peristalses was 27.8 sec after transection and it was shortened to 23.5 sec following additional pyloromyotomy (Fig. 3). Therefore, it seems quite probable that abnormal excitation of the pyloric portion usually seen after transection of the stomach can definitely be suppressed by the addition of pyloromyotomy.
Fig. 3. Incidence of anti-peristaltic discharges after pyloromyotomy following gastric transection. There was no incidence of antiperistaltic discharge in the control. Immediately after transection, high incidence of anti-peristaltic discharges and prolonged discharge interval were observed. Further addition of pyloromyotomy markedly reduced the incidence and shortened the discharge interval.

Fig. 4. Stepwise pyloromyotomy and contraction pressure. Transection produced a sharp rise in contraction pressure. When the pyloromyotomy incision, 1 cm in length, was made on and from the pyloric ring, contraction pressure fell in a high degree. Extension of the incision line 1 cm each in the following two steps resulted in further reduction of the pressure. Conversely, stepwise extension of the pyloromyotomy incision toward the pyloric ring gradually reduced the contraction pressure and lastly, 1 cm extension over the pyloric ring resulted in the sudden fall of pressure.

Experiment 2. Fig. 4 shows the detailed analysis of the findings of the Experiment 2. Transection prior to additional pyloromyotomy produced a sharp rise in contraction pressure up to 32 mm of water. When the pyloromyotomy
incision, 1 cm in length, was made on and from the pyloric ring, contraction pressure fell to 11.5 mm of water. Extension of the incision line, 1 cm each in the following two steps, resulted in further reduction of the pressure to 9 and 8.5 mm of water, respectively (Fig. 5). Conversely, stepwise extension of the pyloromyotomy incision toward the pyloric ring gradually reduced the contraction pressure from

![Fig. 5. Contraction pressure curve before and after pyloromyotomy (from pyloric ring). High contraction pressure is demonstrated right after transection of the stomach and 1 cm incision over the pyloric ring results in the distinct fall of pressure. Extension of the pyloromyotomy incision to the total length of 2 to 3 cm gradually reduces the contraction pressure.](image)

Fig. 5. Stepwise pyloromyotomy and incidence of anti-peristaltic discharges. Before transection and pyloromyotomy, there was no incidence of anti-peristaltic discharge. After transection, high incidence of anti-peristaltic discharges was observed. One centimeter pyloromyotomy over the pyloric ring markedly reduced the incidence of anti-peristaltic discharges and extension of an incision to proximal 2 and 3 cm in total length further but gradually reduced the rate. On the other hand, when the stepwise extension of the myotomy incision was done toward the pyloric ring, corresponding rates of anti-peristaltic discharges were gradually reduced and after total of 3 cm incision the incidence was markedly reduced.

![Fig. 6. Stepwise pyloromyotomy and incidence of anti-peristaltic discharges.](image)
the control value of 48 to 32.5 and further down to 29.5 mm of water after two steps of 1 cm incision. Lastly, 1 cm extension over the pyloric ring resulted in the sudden fall of pressure to 11 mm of water (Fig. 4).

Changes in the incidence of anti-peristaltic discharges are seen in Fig. 6. Before transection, there was seen no incidence of anti-peristaltic discharge and pyloromyotomy gave no significant influence. After transection, anti-peristaltic discharges were seen at the rate of 75%. One centimeter pyloromyotomy over the pyloric ring reduced the incidence of anti-peristaltic discharges as low as 35% and extension of the incision to proximal 2 and 3 cm in total length further but gradually reduced the rate down to 15% and 5%, respectively. On the other hand, when the stepwise extension of the myotomy incision was done toward the pyloric ring, corresponding rates of anti-peristaltic discharges were: 0% initially, 70% after transection, 60% after 1 cm pyloromyotomy, 40% after total of 2 cm incision and 10% after total of 3 cm incision. These data clearly show that pyloromyotomy is most effective when incision is made right over the pyloric ring. It is also known that the extension of the incision apart from the pyloric ring further but gradually reduces the pyloric contraction pressure. Findings of electromyography also showed quite similar tendency.

*Experiment 3.* In the first group of dogs, we studied the effect of pyloroplasty on the normal stomach. As shown in Fig. 7, mean discharge interval and propagation velocity of the normo-peristalses were 13.4 sec and 10 mm/sec, respectively. After an addition of pyloroplasty, discharge interval was shortened to 12.5 sec and propagation velocity was 9.8 mm/sec. When the same dog was studied two weeks after an additional pyloroplasty, a marked delay in propagation velocity to 4.5 mm/sec was recognized, and the discharge interval somewhat shortened to 12.5 sec in comparison with the control value. In summary, it was learned that pyloroplasty on the normal stomach slightly suppresses the motor function of the
Fig. 8. Incidence of anti-peristaltic discharges after pyloroplasty following gastric transection. High incidence of anti-peristaltic discharges and prolonged discharge interval were observed after transection. An addition of pyloroplasty markedly reduced the incidence and the discharge interval was also shortened.

pyloric portion and this tendency becomes more evident with lapse of time as we studied after two weeks.

In the second group of dogs, we studied the effect of pyloroplasty on the pyloric portion which had been subjected to transection of the stomach to produce the status of abnormal excitation.

As shown in Fig. 8, a high incidence of anti-peristaltic discharges was observed at the rate of 80% after transection which had been nil prior to the transection. In this condition, an addition of pyloroplasty markedly reduced the incidence of

Fig. 9. Contraction pressure after pyloroplasty following gastric transection. High contraction pressure at the time of transection was markedly decreased after addition of pyloroplasty.
antiperistaltic discharges down to 15%, and the discharge interval of anti-peristalsis was also shortened from 24.4 to 20.8 sec.

As shown in Fig. 9, decrease in contraction pressure of the pyloric ring area was noticed from 45 mm of water at the time of transection to 5.5 mm of water after an addition of pyloroplasty. As has been revealed in the previous experiment, it is evident that the abnormal excitation and high contraction pressure of the pyloric ring area is weakened by the addition of pyloroplasty.

Out of the results mentioned above, it seems clear that the pyloroplasty, when performed on the normal stomach, slightly weakened the motor function of the pyloric portion. The most remarkable effect of pyloroplasty in reducing the excitation or contraction pressure of the pyloric portion is seen when it is performed on the stomach which shows abnormal excitation of the pyloric portion with high contraction pressure. Taken together, the significance of pyloroplasty is its effect in sacrificing the sphincteric function of the pyloric portion with resultant greater drainage effect.

**Experiment 4.** As shown in Fig. 10, the contraction pressure of the pyloric ring area reduced from 41.6 mm to 9.8 mm of water after the pyloromyotomy was added. Subsequently, when the pyloromyotomy was changed to pyloroplasty in the same dog, the change reduced the contraction pressure of the pyloric ring area down to 5.5 mm of water. Pyloroplasty shows a greater effect in reducing the high contraction pressure which occurs following gastric transection than pyloromyotomy. Namely, it is well understood that pyloroplasty is more effective in drainage than pyloromyotomy.

Fig. 10. Effect of drainage procedures on contraction pressure. Pyloroplasty was more effective than pyloromyotomy in reducing the high contraction pressure occurring at the time of gastric transection.
DISCUSSION

Since the first pyloromyotomy had been performed by Rammstedt (1912) for congenital pyloric stenosis, and pyloroplasty by Heineke-Mikulicz (1888) for cicatrical stenosis, these two procedures have been utilized by many surgeons in clinical medicine. However, explanation of significance of the fundamental principle of these procedures in experimental animals is lacking, although clinical observations are frequently made. A drainage operation should be selected considering the mechanism of the passage disturbance; i.e., pyloric stenosis due to congenital hypertrophy of the pylorus in children or due to duodenal ulcer, and delayed gastric emptying due to abnormal excitation of the pylorus.

Shiratori (1965) reported that the delayed gastric emptying and dilatation of the esophagus due to anti-peristalsis and increased peristaltic motion in the small remaining stomach following proximal gastric resection were relieved by pyloroplasty. He also reported from his animal experiment in search of the significance of pyloroplasty that it suppressed incidence of anti-peristalsis and increased peristaltic motion. Nishijima (1965) found in his pyloroplastied patients following cardia resection that gastric emptying was rapid because of insufficient condition of the pyloric sphincter, and concluded that the significance of pyloroplasty and pyloromyotomy lied in their lowering effect of pyloric pressure due to deterioration of the sphincteric function. Meanwhile Ono (1965) reported that the cooperative motion in the antrum of the remaining stomach following pyloromyotomy was restricted to be in the state of 'hypokinesis', and myotomy should not be done routinely because an addition of myotomy clearly restricted the cooperative motion. He further stated that acceleration of gastric emptying after cardia resection was due to enlargement of the lumen with resultant lesser friction against gravity. Furthermore, Oi et al. (1966) stated from their experimental work on pyloric function that pyloroplasty and pyloromyotomy belonged to the same type of operation, and their significance lied in enlargement of the lumen. They continued to state that the idea of cutting the sphincter that acts against gastric emptying is not rational, and any drainage operation is necessary on the basis of the view that anti-peristalsis in the stomach following cardia resection represents ataxic state of gastric motor function and anti-peristalsis would not occur if the ataxic state is relieved.

In this regard, the authors consider the significance of drainage procedures as follows. Originally, pyloromyotomy has been used for congenital hypertrophic pyloric stenosis in children in which abnormal excitation of the pyloric portion is present. In other words, the effect of pyloromyotomy is not too conspicuous when the pyloric portion is not excited, but the procedure suppresses the excitation and the contraction pressure of the pyloric portion when there is abnormal excitation. Complete suppression of abnormal excitation following pyloromyotomy is not expected unless the muscular incision is long enough, although cutting of the sphincteric muscle proper is often effective. Hence, we consider the significance of pyloromyotomy is in lowering the abnormal excitation and sphincteric function
of the pyloric portion, but not in enlarging the lumen if at all.

Pyloroplasty has its significance not only in enlarging the lumen but also in deterioration of sphincteric function of the pyloric portion thus acting for more effective drainage. Therefore, indication of these two drainage procedures is different. It seems that pyloroplasty is indicated when more effective drainage is expected in the markedly excited pyloric portion even at the sacrifice of the sphincteric function, and pyloromyotomy is indicated when preservation of the sphincteric action is desired and not too powerful drainage effect is expected in a marked excitation of the pylorus.

References