Surgical Significance of Pyloroplasty with Special 
Reference to Electromyographic Findings 

By 

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(Received for publication, November 28, 1964)

This paper deals with the effect of pyloroplasty on the motility of the stomach observed by the use of electromyography. Twenty adult dogs were subjected to the Heineke-Mikulicz type pyloroplasty and the electromyographical study was carried out on the motility of the stomach following the operation.

When the pyloroplasty was done on the normal stomach, peristaltic movement of the stomach was seen slightly weakened.

Transection and anastomosis of the body or antral portion of the stomach was followed by the increase in peristaltic movement distal to the anastomotic line and the multiple discharges of the antiperistalsis were also observed. Under these conditions, addition of the pyloroplasty remarkably reduced the discharge of antiperistalsis. It is presumed that the clinical significance of the pyloroplasty as an additional procedure to vagotomy or various kinds of gastric surgeries is the reduction of abnormally excited condition of the antrum as well as antral spasm and antiperistalsis.

Although pyloroplasty or pyloromyotomy is often applied to various types of gastric surgery to moderate or suppress the sphincter function of the pylorus,1-8 the theoretical basis for this is still equivocal. Some surgeons intend such an additional operation to be a preventive for spasm of the pylorus which, they believe, is an occasional untoward result of vagotomy or other surgical intervention to the stomach, while others expect from such a procedure widening of the gastroduodenal junction and the resulting better drainage of the stomach as a compensation for a postoperative impairment of its motility.

To contribute to this problem, the authors have studied electromyographically the effect of pyloroplasty on the motor function of the canine stomach. This paper evaluates the surgical significance of pyloroplasty on the basis of the experimental results.

METHODS

Twenty adult dogs, weighing from 6 to 15 kg, were used in this experiment.
The animals, with the stomach emptied by fasting, were fixed in supine position in a laboratory maintained at the temperature between 25 and 28°C, anesthetized with thiopental sodium administered intravenously and laparotomized by a midline incision. A group of five dogs (Group I) then received pyloroplasty alone. In the other 15 dogs (Group II), pyloroplasty was performed after transection and anastomosis of the stomach at a level several centimeters oral from the pyloric ring. The technique for pyloroplasty was that of Heineke-Mikulicz; the anterior aspect of the pylorus was longitudinally incised, about 2 to 3 cm in length, to reach the lumen and the incision was closed transversely. Anastomosis of the divided stomach, in the Group II dogs, was accomplished with two layers of suture, a continuous fullthickness suture followed by Lembert-Albert sutures.

In all of the Group I dogs (immediate pyloroplasty) and in nine of the Group II dogs, the stomach so treated was subjected to electromyography for the following two to five hours. In remaining six cases of Group II, however, the abdomen was closed after transection and anastomosis of the stomach without additional pyloroplasty; these animals were re-laparotomized after 3 to 15 days for electromyography, pyloroplasty (delayed pyloroplasty) and subsequent electromyography. The electromyogram was recorded by bipolar lead (the distance between electrodes 1.5–3.0 cm) with an amplifier (Multi-channel Electromyograph, San’ei Sokki Co.) and an electromagnetic oscillograph (Yokokawa Electric Co.). The time constant was fixed at 1.5 sec. The normal electromyogram of the canine stomach as recorded by this method was already described in detail by Shiratori et al.9,10 and Moriya11 in our department.

RESULTS

1. Group I

In the Group I dogs, pyloroplasty to the normal stomach was followed by a little weakening of the grossly recognized peristaltic movement. As shown in Fig. 1, the peristaltic discharges after pyloroplasty were normoperistaltic and in this respect resembled those prior to pyloroplasty. The discharge interval, however, was slightly prolonged by pyloroplasty as indicated in Table I.

2. Group II

As reported by Shiratori12 and Sugawara13 elsewhere, transection and anastomosis of the gastric body or antral portion of the stomach considerably modifies the motor function of the stomach. The portion of the stomach distal to the line of transection and anastomosis (to be referred to hereafter as the infra-anastomatic portion) undergoes a tonic change and exhibits antiperistaltic movements with extraordinary frequency, while the portion proximal to the line of transection and anastomosis (supra-anastomotic portion) demonstrates normoperistaltic movements with little change from the preoperative ones. In accordance with
these gross findings, peristaltic discharges in the supra-anastomotic portion are almost exclusively normoperistaltic but those in the infra-anastomotic portion are predominantly antiperistaltic (Fig. 2). Before pyloroplasty, the rate of antiperistaltic discharges in the infra-anastomotic portion ranged between 66 and 100 per cent (the average 81 per cent) of all peristaltic discharges observed, as shown in Table II.

When pyloroplasty was performed on such a transected and anastomosed stomach, the antiperistaltic discharges in the infra-anastomotic portion decreased much in frequency and became overwhelmed by normoperistaltic ones, as seen in Fig. 3. As shown in Table II, the relative frequency of anti-
Fig. 2. Gastric electromyograms after transection and anastomosis of the stomach. Peristaltic discharges in this case are normoperistaltic in the supra-anastomotic portion but antiperistaltic in the infra-anastomotic portion.

<table>
<thead>
<tr>
<th>No.</th>
<th>Normoperistaltic discharge</th>
<th>Antiperistaltic discharge</th>
<th>Normoperistaltic discharge</th>
<th>Antiperistaltic discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discharge interval (sec)</td>
<td>Relative frequency (%)</td>
<td>Discharge interval (sec)</td>
<td>Relative frequency (%)</td>
</tr>
<tr>
<td>1</td>
<td>—</td>
<td>0</td>
<td>26.5</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>19.7</td>
<td>17</td>
<td>20.3</td>
<td>83</td>
</tr>
<tr>
<td>3</td>
<td>24.3</td>
<td>30</td>
<td>23.7</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>22.5</td>
<td>25</td>
<td>24.8</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>18.3</td>
<td>17</td>
<td>20.6</td>
<td>83</td>
</tr>
<tr>
<td>6</td>
<td>20.5</td>
<td>30</td>
<td>23.8</td>
<td>70</td>
</tr>
<tr>
<td>7</td>
<td>23.3</td>
<td>0</td>
<td>27.6</td>
<td>100</td>
</tr>
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<td>8</td>
<td>22.7</td>
<td>34</td>
<td>26.8</td>
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</tr>
<tr>
<td>9</td>
<td>20.5</td>
<td>18</td>
<td>25.6</td>
<td>82</td>
</tr>
<tr>
<td>Average</td>
<td>21.4</td>
<td>19.0</td>
<td>24.6</td>
<td>81.0</td>
</tr>
</tbody>
</table>

Peristaltic discharges in the infra-anastomotic portion of the stomach was 10 to 42 per cent after pyloroplasty, representing an about 50 per cent decrease as compared with the frequency before performance of pyloroplasty. Pyloroplasty in
this group of dogs was also followed by a prolongation of the discharge interval in the infra-anastomotic portion of the stomach, the average increments being 1.6 sec for normoperistaltic discharges and 0.9 sec for antiperistaltic discharges.

Fig. 3. Effect of immediate pyloroplasty on the electromyogram of the transected and anastomosed stomach (Group ‡II). Note that the peristaltic discharges in the infra-anastomotic portion, which were antiperistaltic before performance of pyloroplasty, became normoperistaltic after pyloroplasty.

Delayed pyloroplasty On observation at 3 to 15 days after transection and anastomosis of the stomach, the supra-anastomotic portion of the stomach revealed normoperistaltis, and infra-anastomotic potion both normoperistaltis and antiperistaltis with a preponderance of the former. Electromyographically, the relative frequency of antiperistaltic discharges in the infra-anastomotic portion of the stomach was 25.2 per cent on an average (Table ‡III). The frequency was thus much less as compared with that immediately after transection and anastomosis, but was still considerably large.

When pyloroplasty was performed in such a stage, the frequency of antiperistaltic discharges in the infra-anastomotic portion of the stomach was further decreased, as demonstrated in Fig. 4. As shown in Table III, the average frequency of the antiperistaltic discharges became 6.5 per cent after pyloroplasty, showing a 18.7 per cent decrease from that before pyloroplasty. Pyloroplasty prolonged the discharge interval by 1.5 sec in normoperistaltic discharges and by 0.9 sec in antiperistaltic ones on averages.

DISCUSSION

The above experimental results may be summarized as follows:
1) Pyloroplasty on the normal stomach results in a moderate reduction of
Fig. 4. Effect of delayed pyloroplasty on the electromyogram of the transected and anastomosed stomach (Group II). Electromyograms in this figure are those recorded in the infra-anastomotic portion. Duration between transection and anastomosis of the stomach and pyloroplasty is three days in No. 20 dog and five days in No. 25 dog. Note the effect of pyloroplasty to inhibit occurrence of antiperistaltic discharges.

Table III. Effect of Delayed Pyloroplasty on EMG in the Infra-anastomotic Portion of the Transected and Anastomosed Stomach (Group II)

<table>
<thead>
<tr>
<th>No.</th>
<th>Days after transection and anastomosis</th>
<th>On re-laparotomy (before pyloroplasty)</th>
<th>After pyloroplasty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Normoperistaltic discharges</td>
<td>Antiperistaltic discharges</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discharge interval (sec)</td>
<td>Relative frequency (%)</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>18.4</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>21.5</td>
<td>83</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>19.1</td>
<td>68</td>
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<tr>
<td>4</td>
<td>5</td>
<td>20.0</td>
<td>81</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>18.7</td>
<td>63</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>21.3</td>
<td>89</td>
</tr>
<tr>
<td>Average</td>
<td>19.8</td>
<td>74.8</td>
<td>23.2</td>
</tr>
</tbody>
</table>

the motor function of this organ, as revealed by weakening of the macroscopically recognized peristaltic movement and a slight prolongation of the interval between peristaltic discharges.

2) When the stomach is transected and anastomosed at a level between the gastric body and the antral area, antiperistaltic discharges become predominant in the infra-anastomotic portion. The relative frequency of the antiperistaltic
discharges in this case is lowered significantly by addition of pyloroplasty, apparently indicating that pyloroplasty can reduce excitement of the pylorus that is provoked by transection and anastomosis of the stomach. This is also true for delayed pyloroplasty, that is, when pyloroplasty is accomplished after the lapse of time since performance of transection and anastomosis of the stomach.

The Heineke-Mikulicz pyloroplasty\(^1\) was originally proposed as a surgical treatment of pyloric obstruction due to duodenal ulcer. Although it was also expected that the operation might reduce acidity of the stomach because of its effect to improve gastric emptying and promote backflow of alkaline duodenal juice, this subsequently proved not to be true so far as pyloroplasty \textit{per se} was concerned. Thus, pyloroplasty alone is no longer considered a modality of operation for peptic ulcer, but it has become employed as an auxiliary procedure to vagotomy, proximal gastrectomy, segmental gastrectomy, sleeve mid-gastric resection and other types of ulcer operations.

In respect to the significance of pyloroplasty as an additional operation to various types of gastric surgeries, there is a general agreement of opinion that the operation certainly diminishes or eliminates stagnation of the gastric content that is due to a postoperative change in the motor function of the stomach. However, inasmuch as the postoperative impairment of the motor function is various according to the type of operations, the theoretical basis for pyloroplasty may also greatly vary according to the type of principal operation to which pyloroplasty is added. If pyloroplasty is added to such a gastric surgery that depresses the motility of the stomach, the significance of pyloroplasty apparently is in that it gives better emptying of the stomach by providing a widened exit. Pyloroplasty in this case is a drainage operation, as it was intended in its first introduction to gastric surgery. If pyloroplasty is added to a gastric surgery which may result in spasm of the pylorus, in contrast, its significance of course differs from the above case.

It may be appropriate to review briefly here the change in the motor function of the stomach after a number of gastric operations to which is usually added pyloroplasty. Vagotomy, to begin with, was applied to clinical surgery for the first time by Exner (1911)\(^{14}\) who intended palliation of pain in a case of tabetic gastric crisis. Subsequently, Dragstedt and Owens (1943)\(^{15}\) introduced vagotomy as a treatment for peptic ulcer on the basis of acid reduction. However, it has been recognized, as was expected from neurophysiology of the vagal nerve, that vagotomy not only reduces acid secretion but also impairs considerably the motor function of the stomach, leading to stagnation of the gastric content. It is for this reason that vagotomy has become less and less popularly accepted as an independent operation for peptic ulcer and is today performed almost always in combination with gastric surgeries including pyloroplasty, gastrojejunostomy and, above all, gastric resection.

Such a historical fact implies that the significance of pyloroplasty as an
additional operation to vagotomy is chiefly in that it widens the gastroduodenal
junction and thus compensates the stomach from reduction of its motility, that is,
the significance as a drainage operation.

On the other hand, Carlson and Litt,16 and Thomas and his associates37 claimed
that vagotomy elicited an abnormal tonic excitement, or even spasm, of the
pylorous and this was the cause of stagnation of the stomach following vagotomy.
Consequently, they believed the significance of pyloroplasty to relieve the
pyloric spasm. Oi7 has also elucidated that vagotomy, beyond popular belief, is
not always followed by depression of the motor function of the stomach. The
motor function, according to him, often remains unchanged or, though less
frequently, is even accelerated after vagotomy. The effect of vagotomy upon the
motor function of the stomach is thus still a matter of controversy and,
consequently opinions are still divided regarding the theoretical aspect of
pyloroplasty as an additional operation to vagotomy. However, the authors
incline to the view that the gastric motility is usually depressed by vagotomy, as
evidenced in a previous experiment by Kono18 of the authors’ department.

Little information has been available as to the gastric motility after
proximal resection or segmental resection of the stomach which preserves
the antral area, the site of the most active peristaltic movement. This
consequently means that the theoretical basis for pyloroplasty in combination
with these operations has been quite obscure so far. A recent electromyographic
study at the authors’ department has shown that when the stomach is transected
in the upper antral area or in the lower gastric body and then anastomosed to
restore the continuity, the motility of the infra-anastomotic portion is greatly
modified; the pylorus is abnormally excited and elicites antiperistaltic discharges
with extraordinary frequency.12,13 In this connection, it has been shown in the
present experiment that the incidence of antiperistaltic discharges in the above
case is largely reduced by addition of pyloroplasty. This fact may be interpreted
to suggest that pyloroplasty is capable, to some extent, to correct abnormal
excitement of the pyloric region that is due to surgical intervention to the middle
or upper portion of the stomach.

The present experiment has also revealed that pyloroplasty to the normal
canine stomach results in a slight reduction of the peristaltic movement. In
their electromyographic and X-ray cinematographic observations of the rabbit
stomach, Ono and his collaborators19 also found that pyloroplasty remarkably
inhibited the motor function of the pylorus and antral area and delayed emptying
of the stomach, although pyloromyotomy of the Ramstedt type exerted little
effect upon the motility of the stomach. These facts apparently suggest that
pyloroplasty to the normal stomach is not only useless but also even harmful
with respect to gastric emptying. In other words, the significance of pyloroplasty
as a drainage operation seems to be limited to the case of lowered gastric motility.
It should be noticed here that although vagotomy\textsuperscript{17} as well as transection and anastomosis of the stomach\textsuperscript{11} significantly change the motor function of the stomach, the motility never completely disappears after these and other gastric operations. Postoperative examinations after proximal or segmental resection of the stomach combined with pyloroplasty, accomplished for peptic ulcer, have revealed, as will be published elsewhere, that the motility of the stomach is comparatively well preserved even after these operations and plays a primary role in emptying the stomach; it has been observed in these cases that the gastric content is actively transported into the duodenum in accordance with peristaltic movement of the gastric remnant. Accordingly, it is estimated that pyloroplasty in these cases does not act to positively drain the gastric content but, probably, does facilitate gastric emptying by assisting effective performance of the motility of the postoperative stomach.

Thus, the surgical significance of additional pyloroplasty seems to greatly vary according to the type of gastric surgery to which it is added. However, it should be emphasized here that, as clarified by this series of experiment, pyloroplasty favorably influence emptying of the gastroduodenal junction but also by functional regulation of the motor function of the stomach, e.g., by ceasing postoperative abnormal excitement of the pylorus and inhibiting occurrence of antiperistaltic movements.

References

7) Om. Peptic Ulcer of the Stomach (Jap.), Nankodo, Tokyo, 1957.