Effect of Vagotomy or Splanchnicectomy on the Motility of the Canine Stomach with Transection-anastomosis

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Transection-anastomosis of the canine stomach generally caused frequent development of vigorous anti-peristalsis in the portion distal to the anastomosis. With the use of electromyography, effect of vagotomy or splanchnicectomy on this alteration of the gastric motility was studied.

Vagotomy or splanchnicectomy caused little change in the gastric motility of the dogs in which transection of the stomach had not been performed previously. On the contrary, frequent occurrence of anti-peristalsis was observed distal to the anastomotic line when the transection-anastomosis was performed at the corpus-antrum border of the stomach. Furthermore, no noticeable change in the frequency of anti-peristalsis of the stomach was seen in spite of combined vagotomy or splanchnicectomy on the dogs which had previously been subjected to the transection-anastomosis of the stomach.

The results obtained in the present experiments revealed that the development of anti-peristaltic discharges after the transection-anastomosis was not related to the severance of gastric innervation, but may closely be related to the excitation of the gastric wall per se caused by the transection of the stomach as reported previously.

Previously, Moriya of our department reported that the frequency of anti-peristaltic discharges of the stomach in a normal dog was merely two per cent of the total discharges while the rest of 98 per cent was normo-peristaltic. Subsequently, Kono reported that vagotomy or splanchnicectomy caused little difference in the development of anti-peristaltic discharges of the stomach in dogs. Sugawara noticed that the transection-anastomosis of the canine stomach elicited frequent anti-peristaltic discharges and strong peristalsis in the segment distal to the anastomotic line. In his experiment, the problem still remains unsolved whether the hypermotility of the stomach as mentioned above can be referred to the effect of gastric denervation or the effect of transecting the stomach wall. With the use of electromyography, the present experiment was designed to depict the effect of vagotomy or splanchnicectomy on the canine stomach which had been subjected to the transection-anastomosis resulting in a frequent occurrence of anti-peristalsis and hypermotility in the portion distal to the anastomosis.

Received for publication, May 1, 1967.

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MATERIALS AND METHODS

A total of 44 adult mongrel dogs were used throughout the experiments. Following 24 hours' fasting, they were anesthetized by an intravenous injection of 25 mg/kg of thiopental sodium, and fixed in a supine position at the room temperature of 25° to 28°C. The stomach was exposed through an upper midline incision.

Action potentials of the stomach were led by two bipolar electrodes placed on the anterior wall of the stomach alongside its longitudinal axis. Each bipolar electrode was made of two silver needles which were fixed to the body of the electrode 2 to 3 mm apart. Distance between the two bipolar electrodes was kept from 15 to 30 mm. These electrodes were connected to a San-ei* Universal Myograph and San-ei Pen Writing Recorder with the time constant set at 0.05 seconds.

The dogs were divided into five groups and the following experiments were undertaken.

A. Vagotomy

Bilateral supradiaphragmatic truncal vagotomy was performed through the opening of the left seventh intercostal space on dogs placed on a respirator.

* Group I. Vagotomy was performed immediately after the completion of transection-anastomosis of the stomach in six dogs. Transection was made at the corpus-antrum border of the stomach or on the line slightly distal to this level, because the transection of this portion causes a manifest increase of anti-peristalsis of the antrum as Sugawara stated previously. End-to-end anastomosis was done in such a manner: the cut-edges of the posterior wall was approximated by a running Albert suture and those of the anterior wall in two layers by a continuous mucosal suture and interrupted sero-muscular sutures.

* Group II. Transection-anastomosis was performed immediately after vagotomy in seven dogs.

* Group III. Vagotomy was performed in 12 dogs and they were subjected to transection-anastomosis after the intervals between 11 to 56 days.

B. Splanchnicectomy

The greater splanchnic nerves were severed bilaterally between the diaphragm and the both adrenals.

* Group I. Splanchnicectomy was performed immediately after the completion of transection-anastomosis of the stomach in 14 dogs.

* Group II. Within 10 to 70 days following splanchnicectomy, transection-anastomosis was performed in five dogs.

* San-ei Instrument Co., Ltd.
RESULTS

Normo- and anti-peristalsis of the stomach can be observed electromyographically, as illustrated in Fig. 1. As shown in the figure, two bipolar electrodes, A and B, were placed parallel to the longitudinal axis of the stomach so that the electrode A is situated proximal to the electrode B. In the case of normo-peristalsis, spike potentials are first caught by the proximal electrode A, recorded on the upper row of the tracing, and shortly later, downward transmitted spike potentials are caught by the distal electrode B and are recorded on the lower row of the tracing (Fig. 1, a). In the case of anti-peristalsis, however, the spike potentials are first caught by the electrode B, recorded on the lower row of the tracing and then the electrode A catch the upward transmitted spike potentials which appear on the upper row of the tracing (Fig. 1, b).

Thus by using a set of electrodes, normo- and anti-peristalsis can clearly be distinguished electromyographically. The rates of normo- and anti-peristalsis are expressed in per cent of a hundred peristalses observed in each preparation. The results are summarized as follows.

A. Vagotomy (Table 1)

Group I. Vagotomy immediately after the completion of transection-anastomosis of the stomach (6 dogs). Electromyogram of the stomach taken immediately after laparotomy is shown in Fig. 2 a, as a control. The rate of normo-peristalsis in the six cases ranged between 95.5 and 100% with the average of 97.4%. Anti-peristalsis was observed at rates ranging between 1.6 and 4.5% with the average of only 2.6%.
Then, the transection-anastomosis was performed and the electromyogram was taken immediately after the anastomosis from the portion distal to the anastomosis. The result is shown in Fig. 2 b and in I of Table 1. Normoperistalsis was seen in the six cases in 0 to 51.0% with the average of 16.9%. The rate of anti-peristalsis ranged from 49.0 to 100% with the overall average of 83.1%.

**Table 1. Electromyographic findings of canine stomach (Groups I-III)**

<table>
<thead>
<tr>
<th>Method</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>After transection</td>
<td>After transection and vagotomy</td>
<td>After vagotomy and transection</td>
<td>After vagotomy and transection</td>
</tr>
<tr>
<td>Incidence</td>
<td>After vagotomy</td>
<td>After vagotomy</td>
<td>After vagotomy</td>
</tr>
<tr>
<td>Normoperistalsis</td>
<td>16.9%</td>
<td>14.6%</td>
<td>97.2%</td>
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<tr>
<td>Anti-peristalsis</td>
<td>83.1%</td>
<td>85.4%</td>
<td>2.8%</td>
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</table>

Group I: Electromyogram was taken immediately after transection-anastomosis and additional vagotomy.

Group II: Electromyogram was taken immediately after vagotomy and additional transection-anastomosis.

Group III: Electromyogram was taken 11 to 56 days after vagotomy and consecutive transection-anastomosis.

![Fig. 2](image)
Lastly, vagotomy was done and again the incidence of normo- and anti-peristalsis was studied electromyographically. The result is shown in Fig. 2 c and in Table 1. Normo-peristalsis observed in the six cases ranged from 0 to 38.0% with the overall average of 14.6%. The rate of anti-peristalsis was from 62.0 to 100% with the average of 85.4%. The rate of anti-peristalsis increased by 6.0 and 10.0% respectively in two cases but decreased by 2.0 to 11.9% in the remaining four cases. Taken together, though the average rate of anti-peristalsis increased by 2.3%, there was no definite tendency at all. Thus, it has become clear that combination of vagotomy with transection-anastomosis of the stomach has no obvious effect on the development of antiperistalsis.

**Group II. Transection-anastomosis immediately after vagotomy (7 dogs).** Electromyogram of the stomach taken immediately after laparotomy is shown in Fig. 3 a. The rate of normo-peristalsis in the seven cases was between 94.5 and 100% and averaged 99.0%. Anti-peristalsis was seen in two out of the seven cases at a rate between 2.0 to 5.5% and the overall average was merely 1.0%.

Following these preliminary observations, vagotomy was performed and the electromyographic study was continued. The results is shown in Fig. 3 b and in II of Table 1. The rate of normo-peristalsis in the seven cases ranged from 85.8 to 100%, averaging 97.2%. The average discharge interval was 12.2 seconds after...
vagotomy and this was shorter than that before vagotomy. The rate of anti-
peristalsis averaged 2.8%.

Successively, transection-anastomosis was performed on the vagotomized
stomach, and the electromyogram was taken from the portion distal to the
anastomosis as shown in Fig. 3 c and in II of Table 1. The incidence of anti-
peristalsis increased in all the cases at the rate from 27.0 to 100%, averaging 61.3%.
Normo-peristalsis was seen in all the seven cases except one case with the overall
average of 38.7%.

These results have revealed that the rate of normo- and anti-peristalsis before
and after vagotomy show little variations. However, it is greatly changed follow-
ing transection-anastomosis of the stomach to remarkable increase of anti-peri-
stalsis in the portion distal to the anastomosis.

Group III. Vagotomy followed by the transection-anastomosis at interval of 11 to
56 days (12 dogs). Electromyogram taken between 11 and 56 days following the
date of vagotomy is seen in Fig. 4 a and in III of Table 1. Normo-peristalsis was
observed between 88.0 and 100% in the 12 cases with the overall average of 98.7%.
Anti-peristalsis was seen in only two out of the 12 cases with the overall average of
1.3%.

a) After vagotomy

![Fig. 4 a](image)

b) After vagotomy and transection

![Fig. 4 b](image)

After the above-mentioned observation, additional transection-anastomosis on
these vagotomized stomachs brought about the following changes (Fig. 4 b and
Table 1-III). Frequent occurrence of anti-peristalsis was seen in all the cases in
36.0 to 100% and averaged 68.7%, while normo-peristalsis was observed at the
rate from 2.0 to 64.0% and averaged 31.3%.

Out of these observations, it was revealed that in both immediate and late
observations after vagotomy, gastric movement was predominantly normo-peristal-
tic, while transection anastomosis on the vagotomized stomachs developed frequent anti-peristaltic discharges in the portion distal to the anastomosis. Electro-myographically, the peristalsis in the portion proximal to the anastomosis was normo-peristaltic following vagotomy, and combination of transection-anastomosis did not alter the pattern of peristaltic movement (Fig. 5, a and b).

B. Splanchnicectomy (Table 2)

Group I. Splanchnicectomy immediately after the completion of transection-anastomosis (14 dogs). Electromyogram taken from 14 dogs immediately after laparotomy is shown in Fig. 6 a. Normo-peristalsis was seen from 90.6 to 100% and averaged 97.1%. Anti-peristalsis was seen from 0 to 9.4% with the overall average of 2.9%.

Following this control observation, transection-anastomosis was performed. As shown in Fig. 6 b and in Table 2-I, the rate of normo-peristalsis in the portion distal to the anastomosis ranged from 0 to 77.8% and averaged 52.9%. The rate of anti-peristalsis ranged between 22.2 and 100% in 14 cases with the overall average of 47.1%.

Successively, splanchnicectomy was performed on the stomachs with transection-anastomosis. The results are shown in Fig. 6 c and in Table 2-I. The rate of normo-peristalsis seen in the portion distal to the anastomosis ranged between 0 and 75.7% in the 14 cases and averaged 56.0%. Antiperistalsis was seen from 24.3 to 100% and the average rate was 44.0%.

Comparing the rate of anti-peristalsis before and after splanchnicectomy, there was a mean decrease of 3.1%. This was not, however, a constant tendency, because there was an increase of 12.0 to 22.1% in the seven cases and a decrease
of 15.0 to 21.4% in the other seven cases. Therefore, it seemed likely that combination of splanchnicectomy with transection-anastomosis of the stomach did not bring about any definite changes in the development of anti-peristalsis.

**Group II.** *Splanchnicectomy followed by the transection-anastomosis at intervals of 10 to 70 days (5 dogs).* Electromyogram taken 10 to 70 days after splanchnic-
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Table 2  Electromyographic findings of canine stomach (Groups I and II).

<table>
<thead>
<tr>
<th>Method</th>
<th>I</th>
<th>II</th>
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</thead>
<tbody>
<tr>
<td>Incidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normo-peristalsis</td>
<td>52.9%</td>
<td>56.0%</td>
</tr>
<tr>
<td>Anti-peristalsis</td>
<td>47.1</td>
<td>44.0</td>
</tr>
<tr>
<td>After transection</td>
<td>96.7%</td>
<td>18.0%</td>
</tr>
<tr>
<td>and splanchnic nerve section</td>
<td>3.3</td>
<td>82.0</td>
</tr>
<tr>
<td>After splanchnic nerve section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and transection</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Group I: Electromyogram was taken immediately after transection-anastomosis and additional splanchnic nerve section.

Group II: Electromyogram was taken 10 to 70 days after splanchnic nerve section and consecutive transection-anastomosis.

Electromyogram in the portion proximal to anastomosis showed rhythmic normo-peristaltic discharges before the transection (Fig. 8 a). Following the transection-anastomosis, normo-peristaltic discharges were again observed pre-

Fig. 8
dominantly, and there was no difference in the rate of normo-peristaltic discharges before and after the transection-anastomosis (Fig. 8 b).

**DISCUSSION**

In the present experiments, the rate of anti-peristalsis of normal canine stomachs averaged only 1.0% in agreement with the observations reported by Moriya and Sugawara. The effect of vagotomy on the normal canine stomach was that anti-peristalsis developed at the rate of 2.8% in the immediate observation and 1.3% in the late observation 11 to 56 days after vagotomy. Similarly, the rate of anti-peristalsis observed 10 to 70 days after splanchnicectomy was 3.3%. From these observations, it was revealed that vagotomy or splanchnicectomy, when performed on the normal canine stomach, did not change the rate of anti-peristalsis. Furthermore, the frequent occurrence of anti-peristalsis following the transection-anastomosis of the stomach was not influenced by deprivation of gastric innervation.

When the transection-anastomosis at the corpus-antrum border was done on the vagotomized stomachs immediately or 11 to 56 days after the date of vagotomy, the rates of anti-peristalsis developing in the portion distal to the anastomosis were 61.3% in the immediate observation and 68.7% in the late observation, respectively. Conversely, vagotomy in succession to the transection-anastomosis merely changed the rate of anti-peristalsis from 83.1 to 85.4%. Bilateral splanchnicectomy followed by the transection-anastomosis between 10 and 70 days later elicited anti-peristaltic discharges at a rate of 82.0%. Under the condition where the anti-peristalsis was observed at a rate of 47.1% immediately after transection-anastomosis, further addition of splanchnicectomy scarcely changed the rate of anti-peristalsis, which was 44.0% and only 3.1% less than that before splanchnicectomy.

These results indicate that the development of anti-peristalsis is influenced neither by vagotomy nor by splanchnicectomy, but obviously associated with transection of the stomach. Concerning the relationship between gastric innervation and gastric motility, the presence of automatism has been assumed in the resected stomach or in the resected and perfused stomach which is deprived of gastric innervation. On the other hand, it is generally known that gastric motility is more or less controlled by gastric innervation.

In the light of the vagal effect on gastric motility, some claim that vagotomy induces a state of hypomotility or gastric atony, while others assert that vagotomy is followed by hypertonicity of the antrum, increased gastric motility or uninfluenced gastric motility. As stated above, the effect of vagotomy on gastric motility has been a matter of controversy, though the majority of investigators are of opinions in favor of an effect of vagotomy in inducing a state of gastric atony.

According to the authors’ observation, vagotomy was followed by shortening of discharge intervals as well as by reduction in gastric motility in agreement
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with the results previously reported by Kono. In observations after the stated intervals, it was also confirmed that some developed a remarkable dilatation and hypotonicity in the corpus and fundic area, while macroscopically increased peristaltic movements were found in the antrum. From these observations, the author reached the conclusion that vagotomy induced a state of hypotonicity with reduced gastric motility which ultimately resulted in delayed gastric emptying due to gastric dilatation and spastic contraction of the pyloric region. This differs from Wangensteen’s concept that delayed gastric emptying seen after segmental gastric resection can be attributed to vagal denervation of the antral portion.

In regard to the effect of splanchnicectomy on the gastric motility, there is no generally accepted opinion. Some observed hypertonicity and increased peristaltic movement, while others observed reduction in gastric motility or no noticeable changes. It is, however, generally acknowledged that the splanchnic nerves have an inhibitory action on gastric motility. Kono observed a prolongation of discharge intervals on the electromyogram and, macroscopically, hypertonicity and increased peristaltic movement of the stomach after splanchnicectomy. The authors also confirmed that discharge intervals were prolonged when measured 10 to 70 days after splanchnicectomy. Therefore, it is concluded that splanchnicectomy induces slight hypermotility of the stomach.

As described above, various investigations have been made to confirm the effect of gastric denervation on gastric motility. None of these, however, has ever referred to the development of anti-peristalsis in relation to gastric innervation or denervation. According to Moriya and Sugawara, the rate of anti-peristalsis seen in the normal canine stomach is quite low and ranges from 2 to 5%. Shiratori reported that transection-anastomosis of the stomach caused frequent occurrence of anti-peristalsis in the portion distal to the anastomosis. In a subsequent and precise investigation made by Sugawara, the rate of anti-peristalsis was found as high as 84.2% immediately after the operation. The cause of high incidence of anti-peristalsis may be explained either by simultaneous denervation of the gastric wall at the time of transection or by excitation of automatism of the gastric wall per se induced by transection.

In support of the view that the cause of anti-peristalsis lies in transection of the gastric wall, Sugawara obtained the following result. When the stomach was transected along the corpus-antrum border, anti-peristalsis occurred actively in the distal antrum at a rate of 84.2%, while transection in the upper body of the stomach elicited anti-peristalsis in the portion distal to the anastomosis in merely 6.8%. He assumed that higher incidence of anti-peristalsis caused by low transection was related to the change of excitability of the gastric wall which varied according to the level of transection.

The authors also observed, in a group of dogs which were subjected to the high transection-anastomosis followed by splanchnicectomy, that the rate of anti-peristalsis was lower, since the level of transection was higher than in the rest of the groups. This suggests that along with the effect of transection, the
level of transection has great influence on the development of anti-peristalsis. In other words, provided that the development of anti-peristalsis is related to the effect of gastric innervation, the level of transection, regardless whether it is made in the upper or lower part of the stomach, will not make any difference in the rate of anti-peristalsis. The results obtained in the present study made it clear that the transection of the gastric wall was the major factor influencing the development of anti-peristalsis, whereas the influence of gastric innervation was quite obscure.

In clarifying the point, similar observations made by Gruber,24 and Shiratori and Kinoshita25 on transecting the ureter seem worth mentioning. Gruber24 studied automatic movement of the extirpated swine ureter and reported that transection of the ureter caused anti-peristalsis in the distal segment at the rate of 71.9%. Shiratori and Kinoshita25 transected the canine ureter and observed that peristalsis in the proximal segment was all normo-peristaltic, while peristalsis in the distal segment was all anti-peristaltic. These findings were similar to what was observed in the present study and indicated essentially identical behavior of the ureter and stomach.

In conclusion, it may be accepted that the development of anti-peristalsis in the portion distal to anastomosis is not related to the severance of gastric innervation but closely associated with transection of the gastric wall itself.

References

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