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EXPERIMENTAL STUDIES IN INTESTINAL HEALING OF THD DOG

IV OBSERVATIONS ON THE VARIOUS TYPES OF ENTEROTOMY

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Single-layer and double-layer longitudinal or transverse closure techniques for enterotomy were compared in 6 clinically healthy, mongrel dogs. Each enterotomy technique was made in the jejuno-ileum of the same dog at 15~20 cm intervals. No leakage occurred with any enterotomy technique. The transverse closure, though less lumen-narrowing than the longitudinal one, produced a marked bending at the site of enterotomy and histologically and angiographically, showed an irregular arrangement of muscularis and their vessels at the enterotomy site. The single-layer, resulted in earlier healing with slight lumen-narrowing than did the two-layer closure methods, had a severe adhesions formation. It is our view that the two-layer longitudinal closure is safer than other methods tested.

INTRODUCTION

In the dog, enterotomy is most frequently used to remove intestinal foreign bodies, unless the injury of the intestinal wall is highly advanced[3,9]. The intestine proximal to the obstruction site is opened by a longitudinal incision, and a longitudinal closure is usually performed[1,2,5]. However, under certain circumstances, a transverse closure, i.e. suturing the incision transversely to the axis of the gut, is made.[1,9]

In the previous study of this series, it was clarified that the single-layer suture pattern for intestinal anastomosis had various advantages over the conventional two-layer method in the dog.[4] In this study, we dealt with various types of enterotomy in the dog.

MATERIALS AND METHODS

In this study, 60 enterotomies were performed in 6 clinically healthy, mongrel dogs (3 males and 3 females), aging from 1 to 2 years. The pre- and

postsurgical treatments have been provided previously[8].

The animals were anesthetized with intravenous sodium pentobarbital, 25 mg per kg of body weight. After opening the abdomen with a midline incision, small intestine was brought out of the incision. The first 2-cm longitudinal incision, 15~20 cm proximal to the cecum, along the antimesenteric border of the intestine was made, and the others each followed 10 cm proximal to the preceding. Six dogs each received a total of 10 enterotomies (tab. 1).

TABLE 1 *Suture methods used in this study*[*1]

TYPE	SUTURE METHODS
I	Albert-Cushing suture
II	Schmieden-Cushing suture
III	Submucosal suture[*2]+Czerny suture
IV	Cushing suture
V	Czerny suture

*1 The five suture methods were used in both the longitudinal and the transverse closures.
*2 HOFFER & JENSEN (1973)

The two dogs were sacrificed at 7, 14 and 21 days after the operation, respectively. For the gross, histological, and angiographic observations, the same procedures as in the previous report, were made[8].

RESULTS

Gross findings (tabs. 2 & 3)

All the 60 enterotomies showed good union at the enterotomy site, and no leakage occurred in any of the enterotomy.

Table 2 represents the intraluminal protrusion, adhesions formation, and abnormal bending at the enterotomy site in the two groups given the longitudinal closure (30 cases) or transverse closure (30 cases). The longitudinal closure was less likely to produce intraluminal protrusion at the enterotomy site than was the transverse closure. No difference in adherence between the enterotomy site and adjacent loops of bowel was seen between both closures. The formation of abnormal bending at the enterotomy site was far more prominent with the transverse closure than with the longitudinal closure.

Table 3 shows the gross features of two groups given the two-layer closure (types I and II) or the single-layer closure (types IV and V) with respect to the intraluminal protrusion, adhesions formation, and abnormal bending at

TABLE 2 *Comparison of gross findings in the transverse closure (30 cases) and longitudinal closure (30 cases)*

GROUP		INTRALUMINAL PROTRUSION	BENDING FORMATION	ADHESIONS FORMATION
Transverse closure	Absent	5	8	3
	Absent to slight	8	5	4
	Slight	7	4	5
	Moderate	9	10	10
	Marked	1	3	8
Longitudinal closure	Absent	10	15	1
	Absent to slight	7	8	3
	Slight	4	2	11
	Moderate	9	3	7
	Marked	0	2	8

TABLE 3 *Comparison of gross findings in the two-layer closure (24 cases) and single-layer closure (24 cases)*

GROUP		INTRALUMINAL PROTRUSION	BENDING FORMATION	ADHESIONS FORMATION
Two-layer closure	Absent	0	15	2
	Absent to slight	2	0	5
	Slight	6	4	8
	Moderate	15	4	5
	Marked	1	1	4
Single-layer closure	Absent	12	11	1
	Absent to slight	7	0	2
	Slight	3	3	6
	Moderate	2	7	7
	Maked	0	3	8

the enterotomy site, each group containing 24 cases. The intraluminal protrusion was more produced in the two-layer closure, and the formation of adhesions was more prominent in the single-layer closure. Both closures showed no difference in abnormal bending formation.

A slight lumen narrowing at the site of enterotomy was found in the two-layer longitudinal closure on the 7th and 14th day, but was not present on the 21st day after the operation. The fate of the inner silk suture and the healing process at the enterotomy site in the two-layer closure at each

sacrificed day, were almost same as those previously reported in the two-layer end-to-end[7] or side-to-side intestinal anastomosis[8].

Histological findings (figs. 1～4)

Comparing the two-layer closure and the single-layer closure, the most distinguished finding was the mucosal regeneration at the enterotomy site; in took 14～21 days for the two-layer closure to complete the mucosal union, while it did 7 days for the single-layer closure. Cell infiltration at the site of enterotomy in the two-layer closure (types I and II) almost disappeared at 14 days after the operation, and on the 21st day they increased again along with the disintegration of the protruded tissue into the lumen. This finding is identical with that obtained in the side-to-side intestinal anastomosis[8].

In the single-layer closure (types IV and V), the enterotomy site frequently showed a very thin joined layer of connective tissue (200 μ) on the 21st day, which suggests the possible danger of anastomotic disruption.

In the transverse closure, an irregular arrangement of the muscularis, especially of the muscularis mucosae was noted at the enterotomy site. The transverse closure tended, in general, to form wider connective tissue between the cut ends of intestine than did the longitudinal closure. The enterotomy site of type III rather resembled those of types IV and V in shape.

Angiographic findings (figs. 5～16)

On the longitudinal section, a disorder in direction of the vessels on both sides of enterotomy line, was noted in the transverse closure and a vascular regeneration along the enterotomy line was noted in the longitudinal closure. On the 21st day, the site of enterotomy in the transverse closure was like that of the adjacent healthy bowel. The vascularity in the longitudinal closure was more dense with the single-layer closure (types IV and V) than with two-layer closure (types I and II).

On cross section, the transverse closure, especially with the two-layer closure showed the disorder in direction of the vessels at the enterotomy site, as seen in longitudinal section. The angiographic changes with the time course in the transverse closure, were similar to those reported in the end-to-end intestinal anastomosis[7]. In the longitudinal closure, vascular regeneration was more advanced with the single-layer than the two-layer; with the single-layer closure, a complete vascular contact between the serous blood vessels of each side was generally seen at 7 days after the operation and on the 21st day good vascularity was maintained in the mucosa and submucosa.

In both the transverse closure and the longitudinal closure, the regeneration of new blood vessels at the enterotomy site, was more delayed with the

two-layer than with the single-layer.

Discussion

In this series of experiments, the operation was performed in the normal intestine of clinically healthy dogs. However, it must be considered that healing would be more delayed in the damaged intestine than in the normal intestine.

In this study, no anastomotic disruption was seen in any of the enterotomies; however, a potential hazard of anastomotic disruption in the single-layer closure was suspected from the histological and angiographic findings. Therefore, for the clinical application of the single-layer enterotomy, the omental reinforcement of the enterotomy site or the employment of some prosthesis inserted into the intestinal lumen,[4] is advisable in order to prevent anastomotic disruption.

Annis & Allen (1967) and Leonard (1968) recommended transverse closure to prevent narrowing of the lumen at the enterotomy site. However, in this study, the anastomotic lumen of the enterotomy site in the longitudinal closure, even with the two-layer closure, was gradually expanded as time progressed, and there was no evidence of stenosis at 21 day after the operation. In contrast, the transverse closure invariably formed the marked bending at the site of enterotomy, and the greater amount of connective tissue approximating the both cut ends was generally seen.

Although Fukuhara (1973) reported that the disturbance in transport of intestinal contents did not occur in the antiperistaltic anastomosis, if the reversed intestinal loop was short enough, it is our impression that the irregularly arranged muscularis at the junction of enterotomy would affect the normal peristalsis to some extent. The longitudinal closure using Cushing suture, if it forms at the enterotomy site as little a turn-in as possible, is preferable to the transverse closure in clinical use.

In fact, the single-layer closure, as pointed out by Orr, healed a little better than did the two-layer closure. Considering the severe adhesions formation and the possible danger of anastomotic disruption from the very thin unioned place in the single-layer closure, the two-layer closure seems to be safer method than the single-layer closure.

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EXPLANATION OF PLATES

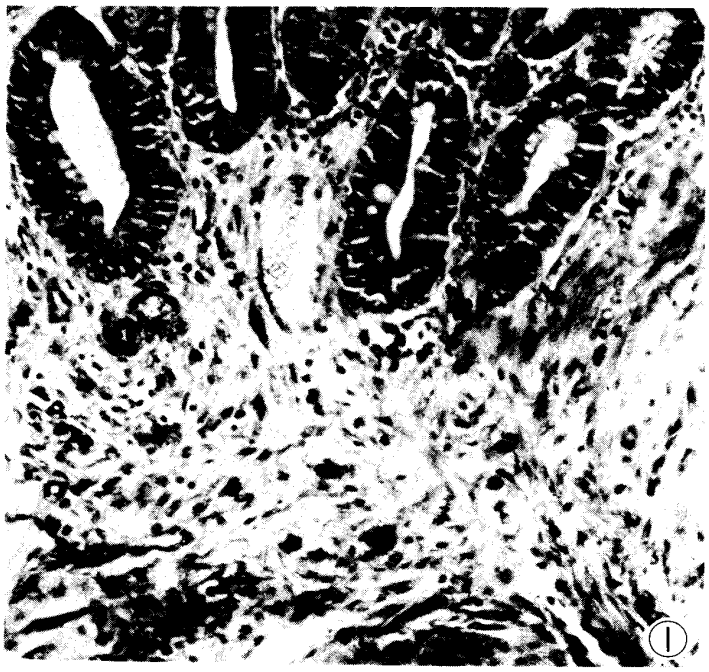
PLATE I Histological findings of enterotomy
Hematoxylin and eosin

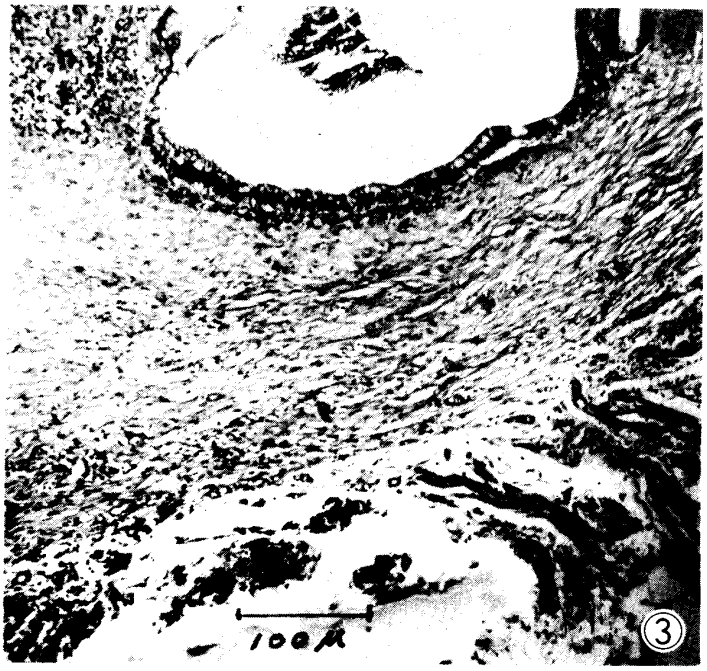
Fig. 1 Seven-day after the operation, longitudinal closure (type IV), showing the re-formed mucosa ×350

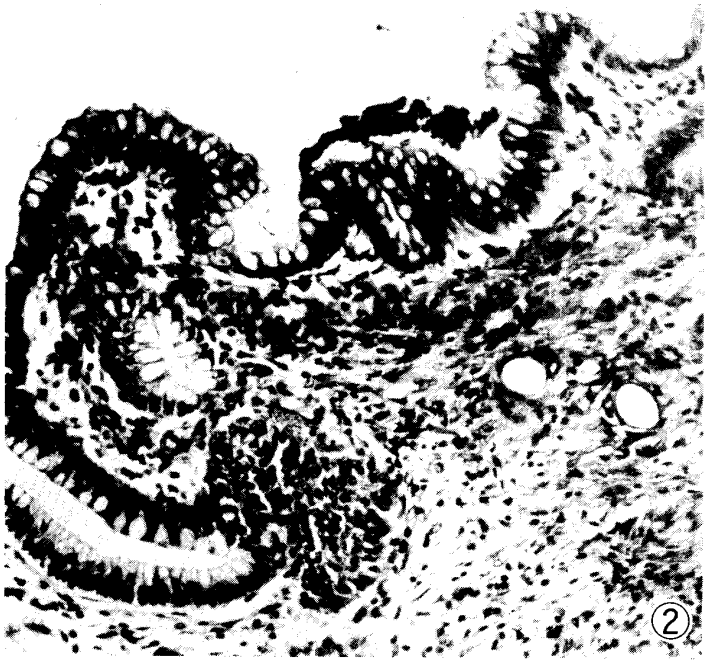
Fig. 2 Twenty-one-day, longitudinal closure (type I), showing the re-formed mucosa ×350

Fig. 3 Twenty-one-day, longitudinal closure (type V) Note the thin connective tissue as small as 200 μ in width ×140

Fig. 4 Seven-day transverse closure (type I), showing the irregular arrangement of muscularis ×350




100μ



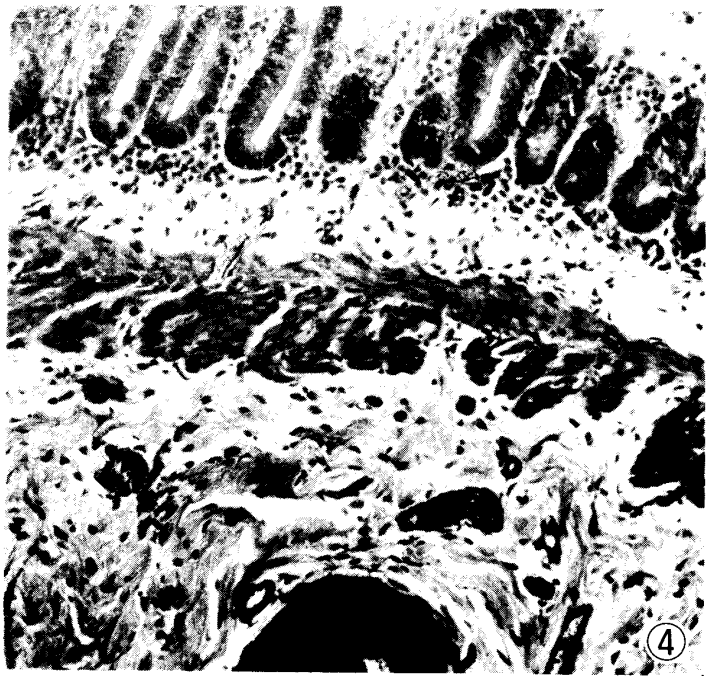


PLATE II Angiographic findings of enterotomy (longitudinal section) ×4.2

Fig. 5 Twenty-one-day, transverse closure (type I)

Fig. 6 Seven-day, transverse closure (type II)

Fig. 7 Fourteen-day, transverse closure (type III)

Fig. 8 Fourteen-day, longitudinal closure (type I)

Fig. 9 Twenty-one-day, longitudinal closure (type III)

Fig. 10 Seven-day, longitudinal closure (type IV)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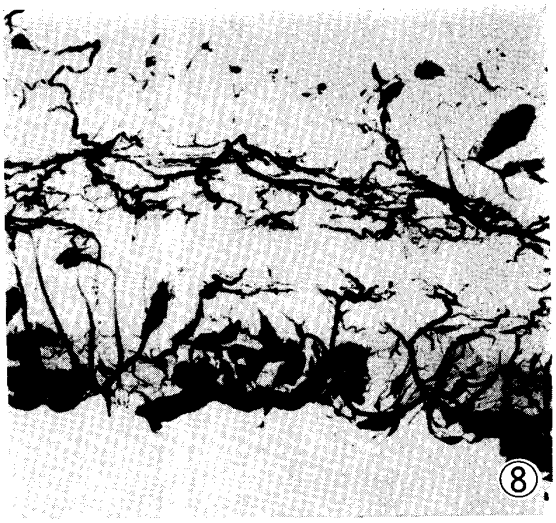
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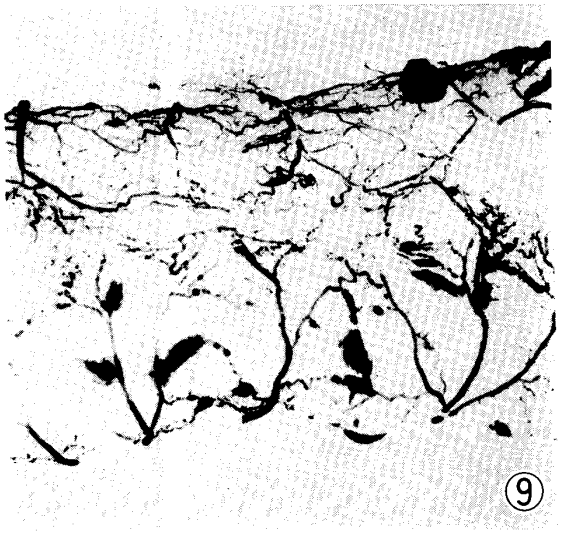
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PLATE III Angiographic findings of enterotomy (cross section) Specimen shown on figure 11 was taken quite close to the end of enterotomy line, and specimens shown on figures 12~16 taken from the center of enterotomy line. ×6.7

Fig. 11 Twenty-one-day, transverse closure (type I)

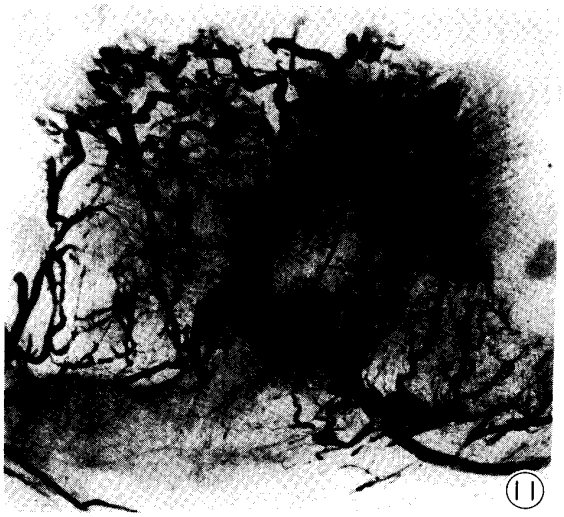
Fig. 12 Seven-day transverse closure (type I)

Fig. 13 Fourteen-day, transverse closure (type IV)

Fig. 14 Seven-day, longitudinal closure (type III)

Fig. 15 Fourteen-day, longitudinal closure (type V)

Fig. 16 Twenty-one-day, longitudinal closure (type V)



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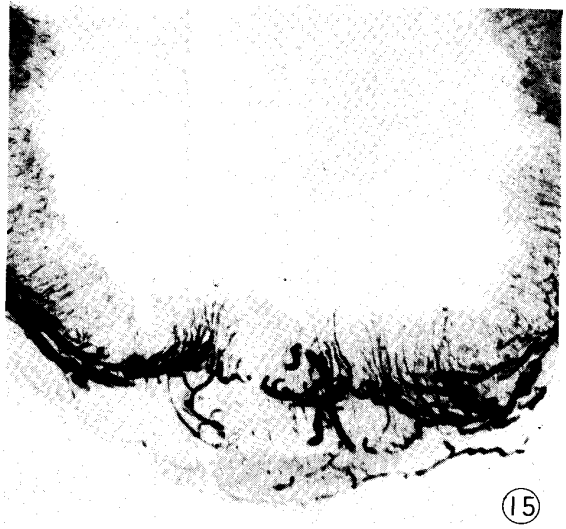

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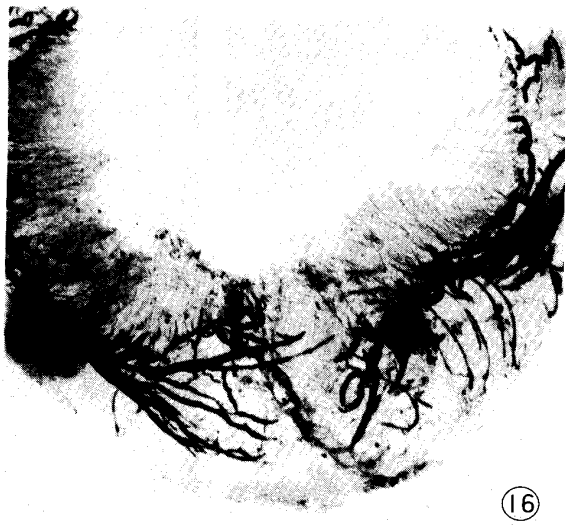

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