

## Everson and Ligation of a Diverticulum: Report of an Inspirational Case and Subsequent Animal Study

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### Abstract

Although most patients with colonic diverticula have no symptoms, perforation or bleeding can be troublesome. Recently, we treated an elderly patient with a diverticular perforation of the sigmoid colon who required a loop colostomy and later resection of the diseased colon. Between the operations, the colostomy resembled a sea slug with horns, which represented eversions of the diverticula. This interesting phenomenon suggests that diverticula may be everted as pseudopolyps and ligated endoscopically. Therefore, the procedure was tested on a Landrace pig, of which the large bowel wall was pulled with an endoscope at 9 different sites using forceps (n=6) or suction (n=3) and ligated. Four days later, reexamination revealed total necrosis at 8 sites and ulceration at 1. The animal was well. The bowel removed 2 weeks later showed mucosal fold convergences without perforations.

Our procedure can be used for prophylactic or therapeutic treatment of patients with colonic diverticula.

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**Key words:** diverticulum, colon, animal study, colonoscopy, treatment

### Introduction

Diverticulosis of the colon is common, affecting 3% to 14% of the Japanese population and 5% to 45% of people in Western countries, especially after the age of 40 years, although only a low percentage of affected individuals develop complications<sup>1–3</sup>. Early diagnosis of diverticulosis is important because complications, such as bleeding, abscess formation, and perforation, can be life-threatening<sup>1–4</sup>. Deciding whether patients with diverticulosis should be treated conservatively or aggressively with nonsurgical or surgical measures is frequently

difficult<sup>1,4–7</sup>. Even when colonic diverticula are recognized before complications develop, it is difficult to predict whether an individual diverticulum will bleed or perforate. Recently, we treated a patient with perforation of a diverticulum in the sigmoid colon who required a temporary loop colostomy and resection of the diseased colon with simultaneous anastomosis. Interestingly, the colonic loop resembled a sea slug with polyp-like horns due to the difference in pressure between the inside and outside of the abdomen, which suggests that it may be possible to treat diverticula by eversion and ligation before complications arise.

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### Case Report

An 80-year-old woman complained of fever and severe pain in the left lower quadrant 3 days before admission to our hospital in December 2003. Physical examination revealed an inactive, pale, febrile patient with guarding in the left lower quadrant, and computed tomography of the abdomen revealed a pelvic abscess and diverticula in the sigmoid colon with wall thickening. Emergency laparotomy disclosed a perforated diverticulum of the sigmoid colon and was followed by thorough lavage, construction of a sigmoid loop colostomy in the left lower pararectal site, and drainage of the *cul de sac*. Four months later, the patient underwent closure of the stoma, resection of the diverticula-containing diseased colon, and simultaneous anastomosis; she was discharged after 2 weeks. During the loop colostomy procedure, we observed that the loop resembled a sea slug with polyp-like horns, which were caused by eversions of the opened loop wall and diverticula in response to the pressure difference between the inside and outside of the abdomen (**Fig. 1**). This phenomenon suggests that it is possible to ligate everted diverticula in a prophylactic manner. In the clinical setting, because safety is the primary concern the everted diverticula and the surrounding normal wall including the muscle layers is pulled in and ligated at the normal wall, because colonic diverticula have no muscle layers. Thus, we created an endoscopic technique to pull or suction and subsequently ligate the colonic wall, and we used this technique to ligate sections of the intestinal wall of a pig after eversion, which was performed by pulling with forceps or by suction.

### Materials and Methods

A female Landrace pig weighing 32 kg was prevented from eating food for 36 hours (water was not withheld), anesthetized with an intravenous injection of pentobarbital (pentobarbiturate) after intramuscular injection of medetomidine (medetomidine hydrochloride), and given an enema with 500 mL of water just before the endoscopic procedure. A fiberoptic endoscope (GIF-2T200;

Olympus Medical Systems Corp., Tokyo) connected to a monitor (CV-260; Olympus Medical Systems) was introduced to a depth of 20 to 60 cm from the anus. We then passed the forceps (FG-14P; Olympus Medical Systems) and a ligation system (ligating apparatus, HX-21L-1; set of ligatures; Quick-Loop, MAJ-339; Olympus Medical Systems) through separate channels in the endoscope. A part of the colonic wall was grasped and pulled with the forceps through the ligatures (**Fig. 2**), and the head of the pulled wall, which represented an everted diverticulum, was tied. Another part of the wall was also ligated with a suction and ligation system; the lucent tube cap (MH-595; Olympus Medical Systems) was used to suck the wall within the ligature. The animal was allowed to eat and drink *ad libitum* immediately after the treatment without intravenous or intramuscular administration of antibiotics, analgesics, or any other drug. We performed an endoscopic examination 4 days after these procedures, and the pig was killed after 2 weeks for pathological and histological examinations of the large bowel. The histological slides were stained with the hematoxylin and eosin or with EMG stain.

### Results

The endoscopic ligation was performed at 9 sites in the large intestine of the pig (**Fig. 3a**). The forceps pulling method was performed at 6 different sites, in some cases with a short distance between the site of ligation. We used the suction method to ligate the aspirated heads at three different sites. Four days after the procedures, the second endoscopic examination revealed complete necrosis of the heads (**Fig. 3b**). Eight ligatures remained at their original sites, while 1 site showed no ligated head or ligature but did show ulceration. During the entire 2-week observation period, the animal had no problems with eating or elimination and did not present any symptoms, such as suffering, inactivity, and bloody or tarry stool.

Fourteen days after the procedures, examination of the abdomen after laparotomy and after the pig was killed did not disclose any inflammation or fluid collection. The approximately 50-cm-long distal segment of the large intestine was resected for examination. The serosa the specimen did not show

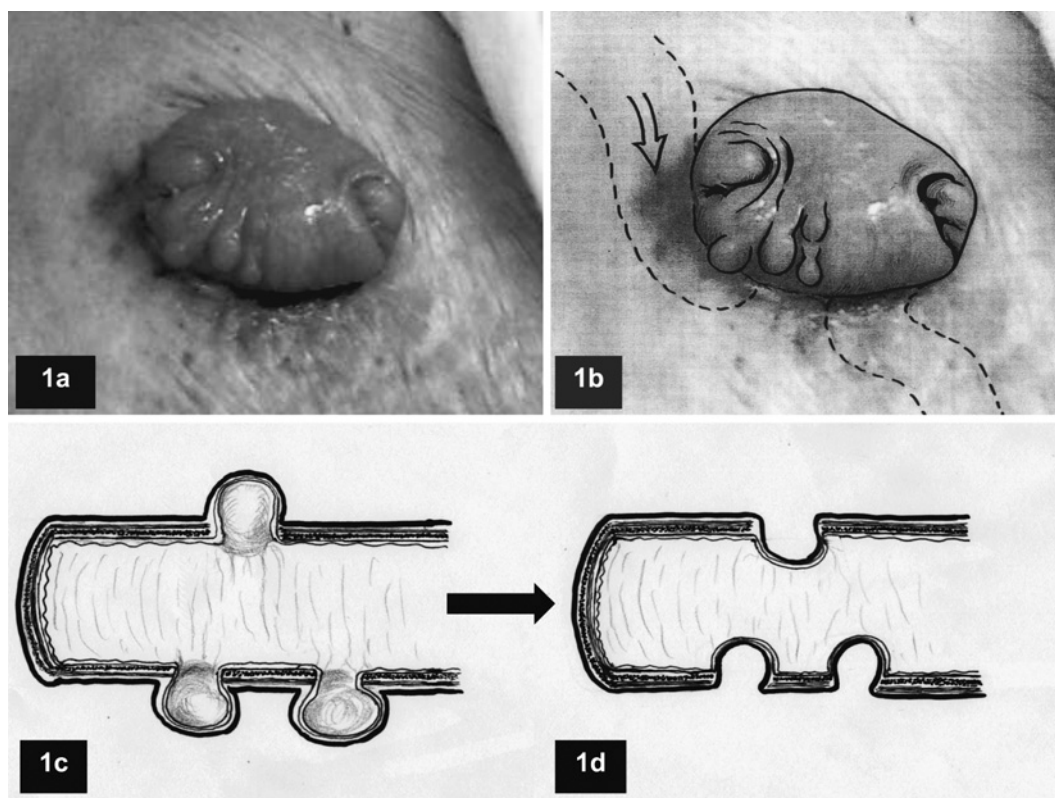


Fig. 1 Diverticula of the sigmoid loop colostomy everted owing to the pressure difference between the abdominal cavity and the room atmosphere (a, b). The diagram illustrates the idea of converting diverticula (c) to pseudopolyps (d) by eversion.

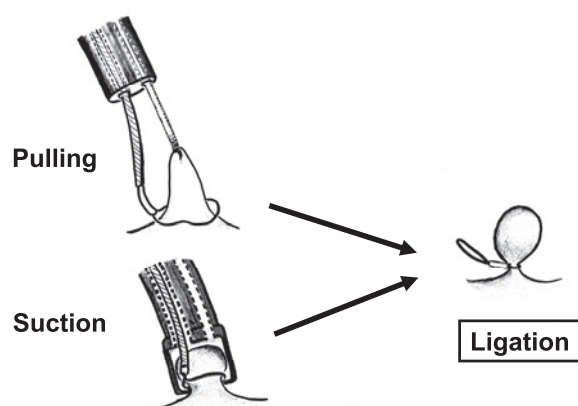


Fig. 2 Endoscopic pulling of the colonic wall with the forceps or suction technique is followed by ligation, such that the diverticulum is everted and ligated.

any inflammatory changes, except for slight fibrous tissue infiltration where the second endoscopic examination revealed the ulceration. The mucosa showed multiple fold convergences at each site of ligation (Fig. 4a and b). The histologic examination of the ligated site did not reveal any ulceration but

did show interruptions of the mucosal and muscle layers which were replaced with granulation tissue (Fig. 4c and d). Only 1 site showed a small ulcer with mild thickening of the wall by inflammatory cells without perforation.

### Discussion

We speculated that it might be possible to treat a diverticulum endoscopically by pulling or sucking and ligating the diverticulum as if it was a polyp because we had observed the interesting phenomenon that a patient's loop colostomy resembled a sea slug with protruding horns that were due to eversion of the diverticula. In our trials and study of the large intestine of a Landrace pig, all the procedures were performed easily and safely at 9 different sites without eventual symptoms or negative events being experienced by the animal. Only 1 of the 9 ligated sites appeared to be ulcerated on the second endoscopic examination, which was performed 4 days after the procedure.

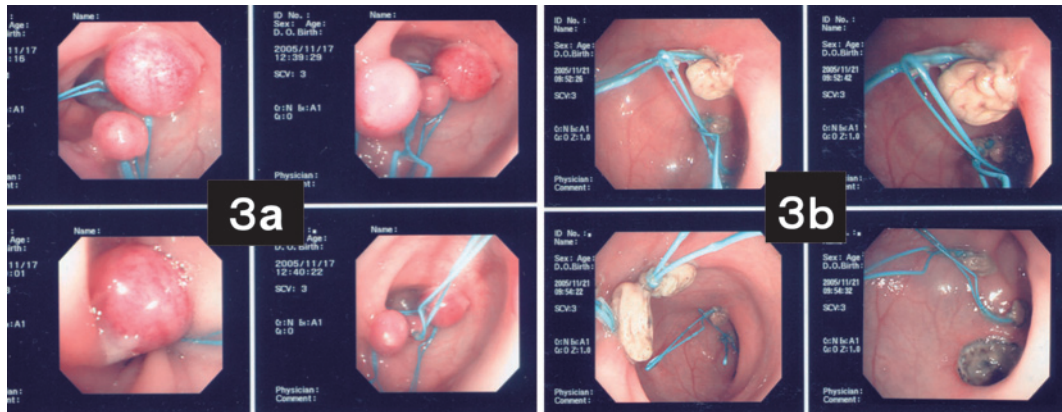


Fig. 3 Endoscopic examination in the large intestine of an animal showed multiple ligations of the wall which resemble polyps (a). Each ligation following pulling or suction is completed within a few minutes; a blue thread is left at the base of the head. Endoscopic examination 4 days after ligation shows yellowish and deflated heads (b). All the heads with the threads at the base are necrotic, except for 1 head that was lost with ulceration (right lower quadrant).

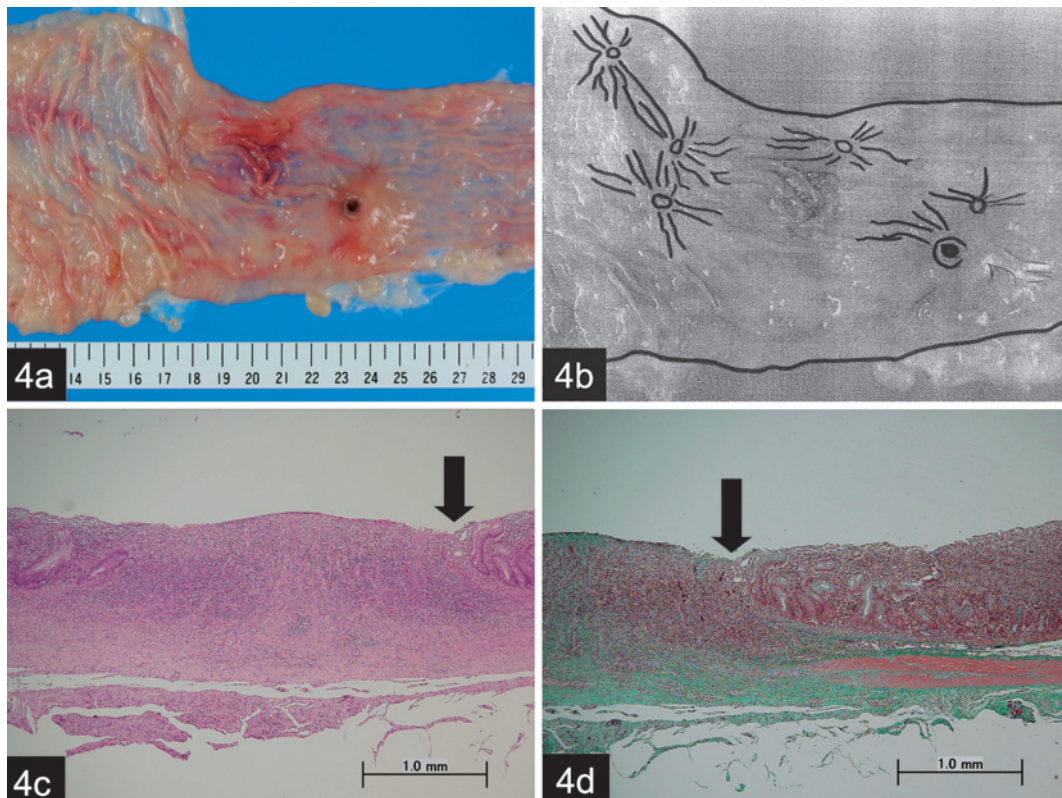


Fig. 4 Mucosa of the resected colon showing multiple ligation scars forming convergences and 1 case of ulceration (a: specimen; b: schema), and histologic section showing interruptions of all layers replaced with inflammatory cells (c: hematoxylin and eosin staining, 10×; d: EMG staining 10×).

The ulceration may have resulted from the ligation being too tight to remain on the neck for more than 3 days. If the head had been ligated less tightly, the head of ligation might have remained avoiding the ulceration as the other 8 sites, which

were observed to have converging mucosal folds after 14 days.

This endoscopic ligation technique is applicable to patients with silent diverticula, with bleeding diverticula, or with a history of other diverticular

complications. Although 10% to more than 30% of patients with diverticula have symptoms, diverticulitis will recur in 60% of patients with an initial episode of diverticulitis treated conservatively, and the second episode is associated with higher rates of morbidity and mortality<sup>1,3</sup>. The apparent prevalence of colonic diverticula increases with age, and a high-residue diet and barium enema are thought to be protective measures<sup>1,7</sup>. However, these measures are not completely effective at keeping diverticula silent. Once a patient with infection or hemorrhage of a colonic diverticulum is treated successfully, the patient will probably expect that the same or another diverticulum will not bleed or become infected in the future. Part of this expectation can be fulfilled by our endoscopic ligation technique to prevent the diverticulum from hemorrhaging, although treating an infected diverticulum with this technique may prove to be difficult as the inflamed diverticulum cannot be easily or safely everted by pulling. If a diverticulum is infected, it should be treated with our suction and ligation technique only after complete resolution of the infection. Our technique of pulling a diverticulum at the bottom with the forceps or catching it with the suction tube cap and ligating it with the loop seems to be significant in terms of ease of use, rapidity, reliability, and safety. As shown by the histologic examination of removed specimens, all layers of the intestine were removed after endoscopic ligation and completely replaced with fibrous tissue. The technique could be safely applied clinically if a colonic diverticulum was everted by pulling or sucking and ligated at the normal colonic wall line beyond the diverticular orifice. This rapid technique is a boon for patients with uncertain bleeding from a diverticulum or multiple bleeding diverticula that require multiple ligations. In addition, our pulling technique is the first of its kind to be reported in the literature. None of the various methods used to treat a bleeding diverticulum, including interventional radiology, surgery, endoscopic hemostasis using epinephrine injection, electric coagulation, and clipping, are as completely successful as ligation techniques<sup>1,5-8</sup>. Recently, Farrell et al.<sup>9</sup> developed the ligation band technique, which

is safe and reliable but requires much time to perform multiple ligations. In contrast, our technique using the Quick-Loop ligature requires only a few minutes for a single ligation, with a 1-minute interval before another ligation can be performed.

In the present study, we have described the interesting phenomenon of the colostomy of a patient with diverticula which resembled a sea slug with horns comprising the natural eversions of diverticula and we described successful endoscopic procedures for pulling or suctioning and subsequently ligating different parts of the large intestine of a pig. We emphasize the significance of applying our endoscopic eversion and ligation technique to cases of noncomplicated, bleeding, or recovering diverticula.

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