Colonoscopy-assisted percutaneous sigmoidopexy: a novel, simple, safe, and efficient treatment for inoperable sigmoid volvulus (with videos)

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Background and Aims: Many patients with sigmoid volvulus are old with co-morbidities, making elective surgery prohibitive. Colonoscopic management is often successful but volvulus often recurs. We devised a method of colonoscopy-assisted percutaneous sigmoidopexy as an alternative method to prevent recurrence of sigmoid volvulus. This study aimed to assess its safety and effectiveness.

Methods: Patients with sigmoid volvulus American Society of Anesthesiologists physical status classification ≥3 or Barthel index <30 were included. We excluded patients with intestinal necrosis and those who were unable to be repositioned but who could undergo intestinal resection. Colonoscopy-assisted sigmoidopexy was performed under radiographic observation. First, a colonoscope was inserted to the fixation site. A site for percutaneous puncture of the colon was identified by transmitted illumination and finger pressure. An exploratory puncture through the abdominal wall was made with a 23-gauge cattelan needle with the patient under local anesthesia, followed by a skin incision. Sigmoid fixation was then performed using a 2-shot anchor device that allows the sigmoid colon to be sutured to the abdominal wall. Fixation was repeated at 5 to 10 sites (average 8.8). The primary outcome measurement was sigmoid volvulus recurrence within 12 months. The secondary outcome measurement was adverse events.

Results: Eight patients received colonoscopy-assisted sigmoidopexy, and no sigmoid volvulus recurred during the 12-month follow-up period. One case of postoperative subcutaneous emphysema was successfully managed with conservative therapy.

Conclusion: Colonoscopy-assisted sigmoidopexy was an effective, safe alternative method to prevent the recurrence of sigmoid volvulus.

INTRODUCTION

Sigmoid volvulus is a serious condition that, if untreated, can result in colonic vascular insufficiency leading to death from necrosis or perforation.[1] Early-stage treatment consists of endoscopic colonic repositioning. However, the recurrence rate ranges from 30% to 90%.[1-4] The definitive treatment is sigmoidectomy but this is associated with a mortality rate averaging 8% (range, 0%-15%).[1] Many patients with volvulus are elderly and, because of high surgical risk, receive only colonoscopic therapy; recurrences are common requiring repeated endoscopic repositioning.

Minimally invasive treatments to prevent the recurrence of sigmoid volvulus have been devised, including laparoscopic-assisted endoscopic sigmoidopexy,[5] laparoscopic-assisted mesosigmoplasty,[6,7] percutaneous endoscopic colostomy,[8-11]

Abbreviations: ASA-PS, the American Society of Anesthesiologists physical status classification; BMI, body mass index.

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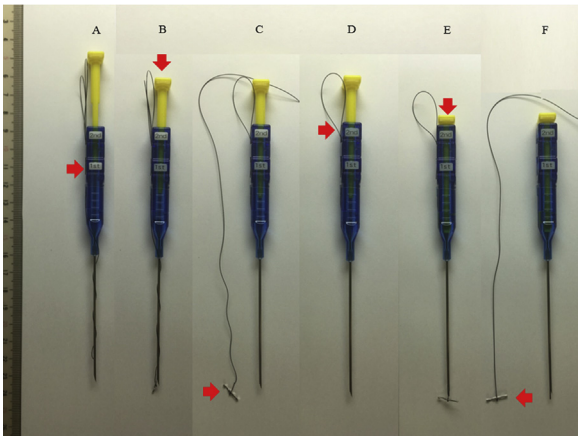

Figure 1. Two-shot anchor with the T bar. Two threads are contained in one injection needle, each with a metal stick. By pushing the button labeled with the *red arrow* in (**A**) and pushing the yellow plunger at the top (**B**), the thread with the metal bar separates from the tip (**C**). Next, the button indicated by the *red arrow* in (**D**) is pressed followed by pressing the yellow plunger at the top again (**E**); the second thread separates (**F**). Connecting these 2 threads fixes it in one place.

and percutaneous endoscopic sigmoidopexy using T fasteners.[12] Laparoscopic procedures require that patients be candidates for general anesthesia. Success obtained by securing the colon to the abdominal wall with sutures requires as many ligations as there are fixation points. Although percutaneous endoscopic colostomy is considered minimally invasive and can be performed with the patient under local anesthesia, it involves the "pull" technique in which an enterostomy is established via the anus and is associated with a high incidence of adverse events in the perioperative period. For example, 1 study of 27 cases reported wound infections or peritonitis in 77% of patients with a 30-day mortality of 26% (7 deaths).[8] Infection after percutaneous endoscopic colostomy is thought to be related to contamination of the wound associated with transanal introduction and placement of the percutaneous endoscopic colostomy tube.[13,14]

The current method was an attempt to avoid the adverse events associated with percutaneous endoscopic colostomy by directly fixing the movable sigmoid colon to the abdominal wall using the 2-shot anchor device devised originally to anchor the stomach to the abdominal wall during percutaneous endoscopic gastrostomy (Olympus, Tokyo, Japan) and applying this by direct, percutaneous puncture from the skin. The device consists of 2 threads contained within an injection needle with a metal stick. By pushing the button labeled with a red arrow in Figure 1A and pushing the yellow plunger at the top (Fig. 1B), the thread with the metal bar separates from the tip (Fig. 1C). Next, the button labeled with the red arrow in Figure 1D is pushed by pressing the yellow part at the top a second time (Fig. 1E), causing the second thread to separate (Fig. 1F). When the 2 threads are connected, the anchor is fixed in place. In contrast to T fasteners, this approach provides long-term fixation because the sutures are buried subcutaneously. Colonoscopy-assisted, percutaneous sigmoid colon fixation is minimally invasive and is done with the patient under local anesthesia, providing sterile long-term colonic fixation. We propose colonoscopic sigmoid fixation as an alternative method to prevent recurrent sigmoid volvulus.

METHODS

Study design

The study was approved by the ethics committees at the International University of Health and Welfare Hospital (approval no. 13-B-97), according to the Helsinki Declaration. Written informed consent was obtained from all patients or their families.

Patients

The study was conducted from January 2014 to January 2019; all participants were patients diagnosed with sigmoid volvulus at the outpatient department of this hospital. The inclusion criteria were patients for whom sigmoidectomy was considered too dangerous based on an American Society of Anesthesiologists[13] physical status classification (ASA-PS) of $\geq$3 or a Barthel index[14] <30. The exclusion criteria were patients who were considered to be at high risk of fatality despite successful colonoscopy-assisted sigmoidopexy, patients with suspected intestinal necrosis, and patients unable to undergo endoscopic repositioning. Patients who did not wish to undergo the treatment after receiving an explanation of the details of the study were also excluded.

Procedures

On the day before the procedure, reversal of the sigmoid torsion was carried out using an endoscope (CF260 series; Olympus, Tokyo, Japan) under radiographic guidance (Integris CV; Philips, Amsterdam, the Netherlands). A transanal ileus tube (Sumitomo Bakelite, Tokyo, Japan) was positioned in the descending colon for decompression. After sigmoid repositioning, cleansing of the digestive tract was achieved using polyethylene glycol lavage administered via a nasogastric tube. If the cleaning effects were poor, lavage was carried out with water administered through the transanal ileus tube. Urethral catheterization was done before treatment to collapse the urinary bladder. On the day of the procedure, we administered cefmetazole (1 g) before and after surgery to prevent infection, pethidine hydrochloride (35 mg) for pain relief, and flunitrazepam (0.4 mg) as a sedative. The local anesthesia was 1% xylocaine.

This procedure was performed by 2 physicians (operator and endoscopist) and 2 nurse assistants. We used 4 techniques to identify the optimal locations for fixation. First, radiologic colonography was used to place a pair of Pean forceps on the body surface such that the tip of the forceps met the tip of the endoscope (Fig. 2A). A

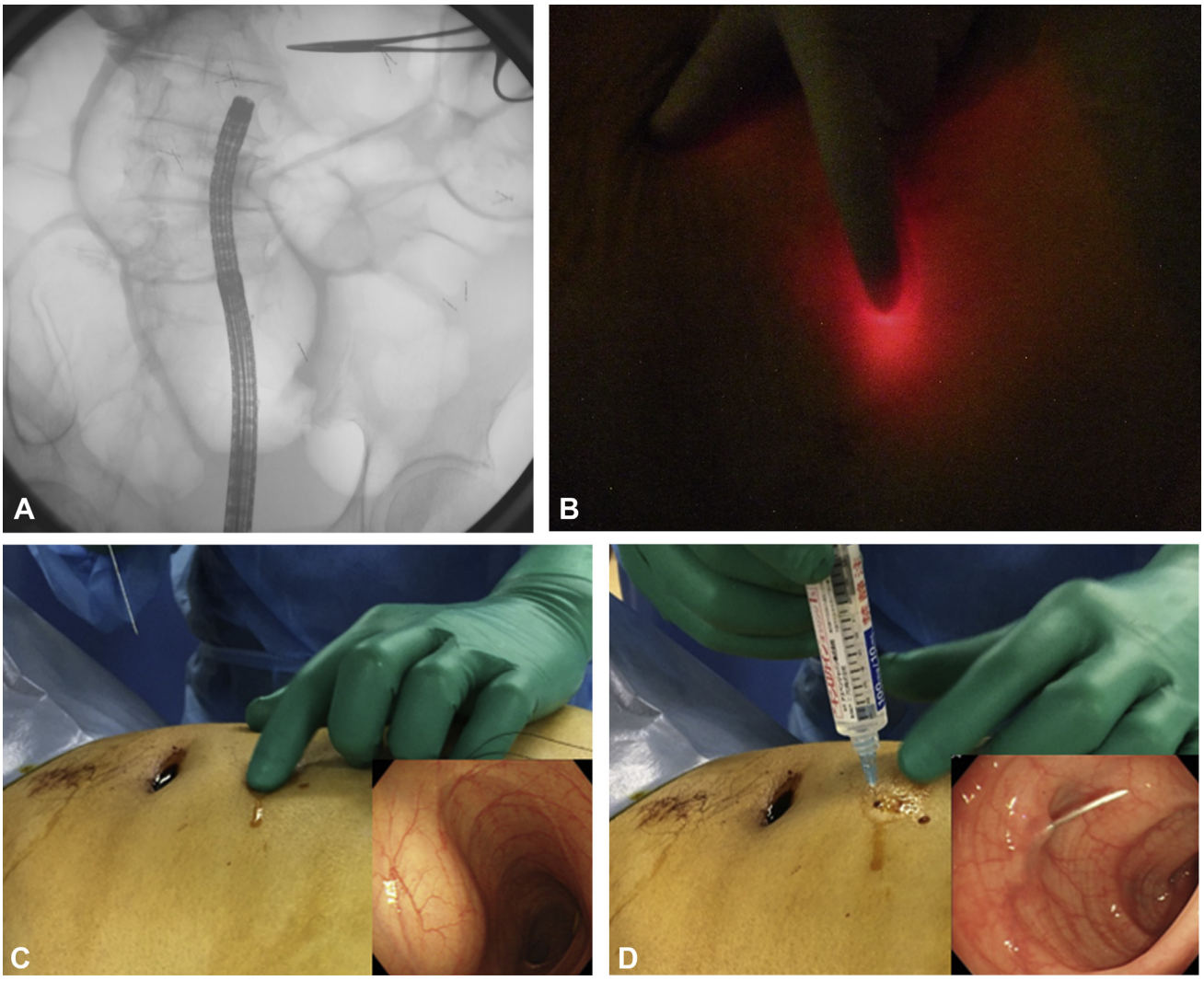

Figure 2. A, Using radiography, we confirmed the position of the tip of the colonoscope. **B**, The site for puncture was confirmed by transmitted illumination. **C**, When the abdominal wall is pressed with a finger to determine the site for puncture, the wall of the sigmoid colon is pressed. **D**, Exploratory puncture with a 23-gauge needle into the sigmoid colon.

transmitted illumination test (Fig. 2B) and an abdominal wall finger test (Fig. 2C) were carried out at this site. Finally, an exploratory puncture was made using a 23-gauge cattelan needle to confirm the site for puncture and fixation (Fig. 2D). The first puncture of the sigmoid colon was started from the S top. After that, the distal side of the sigmoid colon was consecutively punctured on the abdominal wall at the point of best transillumination.

Infiltration anesthesia with 1% xylocaine was carried out at the puncture site identified by the above 4 methods, and a cutaneous incision approximately 2 mm in length was made using a scalpel. The wound was enlarged using the Pean forceps, and an exploratory puncture was again made using a 23-gauge cattelan needle. Using the puncture needle for reference, a 2-shot anchor was inserted into the interior space of the sigmoid colon (Fig. 3A) (Video 1, available online at www.giejournal.org), the nylon thread with a metal bar attached to the end was detached (Fig. 3B) and pulled toward the surface of the body (Video 2, available online at www.giejournal.org). Using the same technique, we perforated the sigmoid colon with a 2-shot anchor from skin tissue a few millimeters from the first (Fig. 3C), and the 2 nylon threads emerging onto the surface of the body were ligated 5 times subcutaneously. The skin incision was closed with Steri-Strips (3M Japan, Tokyo, Japan) (Fig. 3D). The same process was repeated as necessary 3 to 5 cm nearer the anus, for a total of 5 to 11 abdominal wall fixation sites.

After the procedure, CT colonography was done to confirm that no other organs (particularly the small intestine) were trapped between the sigmoid colon and the abdominal wall (Fig. 4A and B). On the day after the procedure, blood tests and plain abdominal radiography (Fig. 5) were performed to ensure the absence of intestinal obstruction or peritonitis, after which meals were commenced. If the patient could not ingest food,

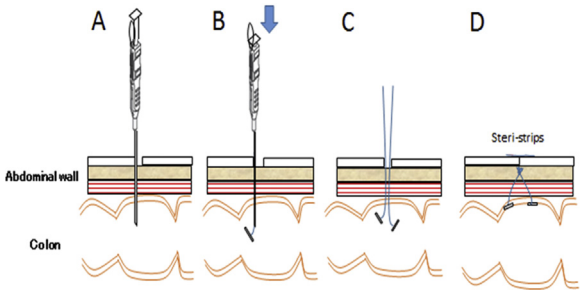

Figure 3. Schematic diagram of sigmoid colon fixation using the 2-shot anchor. **A**, The endoscope inside the lower intestinal tract confirms that the 2-shot anchor has pierced the abdominal wall and the colon wall and is inside the colon. **B**, The thread with metal bar attached is detached and pulled. **C**, Another 2-shot anchor is inserted from the same wound, and the thread is detached and pulled in the same way. **D**, Threads are ligated 5 times and the skin is covered with tape.

enteral nutrition was administered by gastrostomy or percutaneous transesophageal gastro-tubing (Sumitomo Bakelite, Tokyo, Japan). Magnesium oxide and lubiprostone (Mylan EPD G.K., Tokyo, Japan) were used regularly so that the stools scored the equivalent of 5 to 6 on the Bristol Stool Form Scale. On day 5 postoperatively, the Steri-Strips were removed and the wounds were left open (Fig. 6).

Study outcomes

The following outcomes were evaluated: proportion with successful completion of the procedure, procedure time, time required for sigmoid colon fixation, intraoperative adverse events, postoperative adverse events, relapse rate at 1, 3, 6, or 12 months, and abdominal symptoms after colonoscopy-assisted sigmoidopexy. The main outcome measurement was the rate of sigmoid volvulus recurrence within 12 months after colonoscopy-assisted sigmoidopexy. The secondary outcome measurement was adverse events.

RESULTS

During the study period, 12 patients were diagnosed with sigmoid volvulus. Three were in good physical health (ASA-PS class 1) and were prioritized for surgery. Another patient continued to be treated with endoscopic torsion correction as needed.

Eight patients were enrolled for colonoscopy-assisted sigmoidopexy (5 men and 3 women). The median age of the patients was 72.5 years (range, 43-93 years). The median body mass index (BMI) was 17.9 kg/m^2 (range, 15.6-20.2 kg/m^2). Seven patients had BMI of 18 kg/m^2 or less, and 1 patient had a BMI between 18 and 25 kg/m^2. There were no patients with BMI of 25 kg/m^2 or more. ASA-PS classifications were as follows: class 2, 1 patient; class 3, 4 patients; and class 4, 3 patients. The median Barthel index was 10 (range, 0-55). All cases had a history of sigmoid volvulus (range, 2-15 times). The medical history of underlying neurologic disorders was Alzheimer-type dementia in 3 cases, schizophrenia in 2 cases, mental retardation in 2 cases, and stroke in 1 case. Histories of previous abdominal surgery were ventriculo-peritoneal shunting in 1 case and laparoscopic cholecystectomy in 1 case. Antithrombotic agents were used in 2 patients but were halted before the procedure.

The procedure was completed successfully in all cases; local anesthesia was possible in all cases. Median procedure time of colonoscopy-assisted percutaneous sigmoidopexy was 72.5 minutes (range, 25-90 minutes), median time required for fixation was 16 minutes (range, 10-39 minutes), and median number of fixations was 9.5 (range, 5-11 minutes).

The median observation period for the present study was 25.5 months (range, 4-38 months). No sigmoid volvulus recurrence occurred during the observation period after colonoscopy-assisted percutaneous sigmoidopexy (194 person-months). Wound status was good during follow-up, with no infections. The metal T bars that hold the 2-shot anchor in place were examined by plain abdominal CT during follow-up, and no changes were seen with respect to position at the time of the procedure in any patient. No aggravation of abdominal symptoms such as diarrhea, constipation, or intestinal obstruction occurred.

The only intraoperative adverse event was subcutaneous emphysema in 1 patient, which appeared to be related to the air injection during the endoscopic procedure. The temperature never exceeded 37.2°C, and it resolved with only observation. No serious adverse events such as peritonitis, small intestine injury, intra-abdominal abscess, or intestinal obstruction occurred. There were no surgical wound infections.

DISCUSSION

We devised a minimally invasive procedure, colonoscopy-assisted percutaneous sigmoidopexy using the 2-shot anchor system originally designed for fixation of the gastric wall to the abdominal wall. Using this device, we were able to prevent sigmoid volvulus recurrence. The presence of an elongated intestinal tract that can move freely within the abdominal space and a narrow mesentery base, which is the axis about which torsion occurs, favors development of sigmoid volvulus.[15-17] The need we addressed was to devise a minimally invasive method to permanently fix the mobile intestine to the abdominal wall to prevent torsion and thus obviate the need for intestinal resection or enterostomy.

The number of recurrences from the first volvulus until this treatment among the 8 patients ranged from 2 to 15 (median, 1.5) during observation periods ranging from 36 to 180 months (median, 7.5 years); there were no

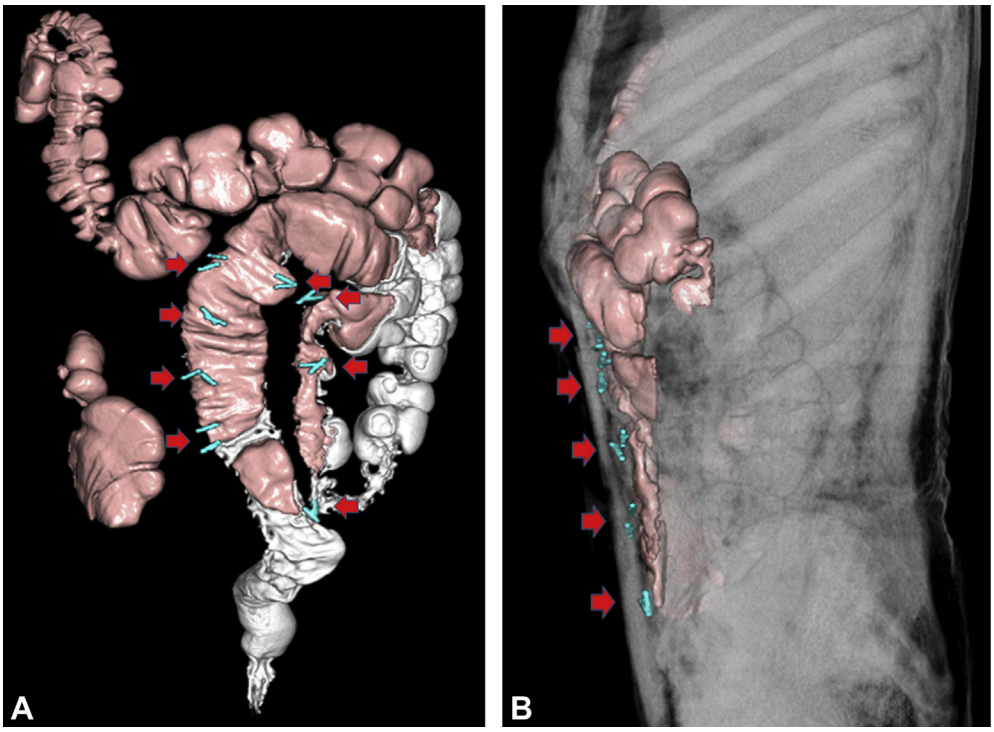

Figure 4. CT colonography showing the fixation site of the sigmoid colon to the abdominal wall. **A**, Front view; **B**, lateral view.

recurrences after endoscopic therapy. Therefore, we believe the treatment is effective despite the small sample size. As with any new minimally invasive procedure, the time from introduction to becoming routine first-line treatment is dependent on demonstration of its safety and efficacy after use in many centers. Although there were no early postoperative adverse events or postoperative sequelae, more experience with many more patients is needed to understand the risks and nature of postoperative long-term adverse events such as adhesions or internal hernia due to the fixation of the sigmoid colon. One limitation is that this procedure cannot currently be used if patients whose other organs (small intestine, transverse colon, uterus, etc) are located between the abdominal wall or a sigmoid colon fixed in position due to previous surgery. With further experience, this procedure may become applicable as the first-line treatment for patients without intra-abdominal adhesions.

Colonoscopy-assisted percutaneous sigmoidopexy offers the following advantages with respect to previously reported methods for preventing torsion. First, colonoscopy-assisted percutaneous sigmoidopexy is straightforward. Puncture with a 2-shot anchor is a simple operation allowing the sigmoid colon to be fixed to the abdominal wall with 2 threads placed subcutaneously. In the present study, once the fixation location is decided, each fixation procedure requires approximately 1 minute such that the entire procedure, including finding safe places to fix the colon and the actual fixing of the colon in 5 to 11 places can be completed rapidly (median time required for fixation was 16 minutes).

Second, colonoscopy-assisted percutaneous sigmoidopexy is minimally invasive. The procedure involves skin incisions of approximately 2 mm in length, percutaneous puncture of the sigmoid colon, and fixation, which can all be done using local anesthesia, obviating the need for general anesthesia. Sigmoid colectomy, which is the most radical procedure for sigmoid volvulus, is reported to take around 90 minutes.[18] The present procedure does not involve surgical incision to the abdomen (such as with use of a laparoscope), sigmoid colectomy, or inosculation, and has a short procedure time with low invasiveness. As a result, few postoperative adverse events were encountered.

Third, colonoscopy-assisted percutaneous sigmoidopexy is sterile.[19-21] The present technique of direct puncture from a clean body surface was done to prevent postoperative infection after colonoscopy-assisted percutaneous sigmoidopexy. Abdominal infections occur frequently after percutaneous endoscopic colostomy[8] and likely result from contamination of the abdominal region as a result of transanal introduction and placement of the enterostomy tube.[13,14] No case of intra-abdominal infection or localized peritonitis was encountered in this study. Although 8 patients represent a very small cohort, our technique appears likely to overcome the problem of abdominal infection with percutaneous endoscopic colostomy.

Fourth, postoperative care after colonoscopy-assisted percutaneous sigmoidopexy is straightforward. Other devices placed in the abdomen with fixation by percutaneous endoscopic colostomy[8-11] or sigmoidopexy using T

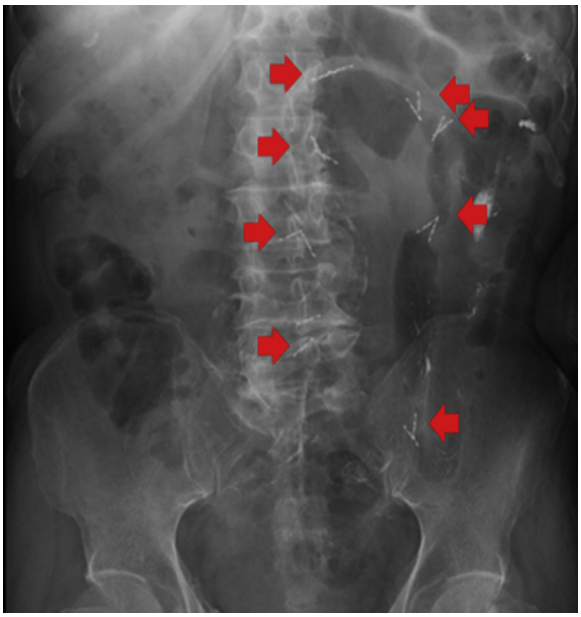

Figure 5. Abdominal radiograph showing the devices for fixation to the abdominal wall (*red arrows*).

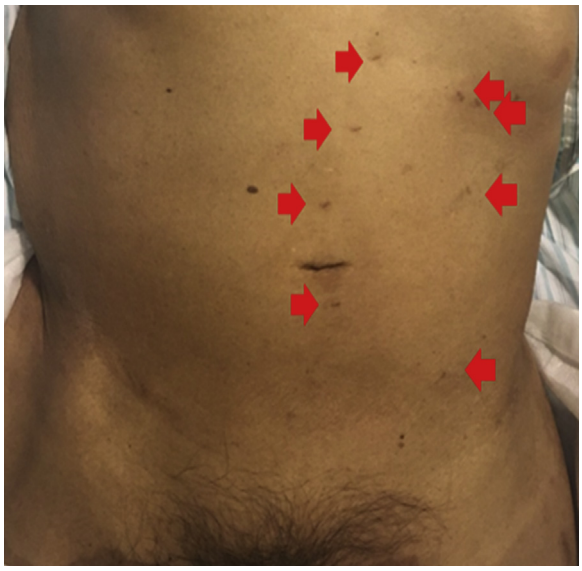

Figure 6. *Red arrows* showing several sites of buried subcutaneous sutures with 2-shot anchors on the abdomen. The wounds can be seen as small scars.

fasteners[12] require management. However, in the present method, the fixation thread is buried subcutaneously, and practically no postoperative wound treatment is needed.

Finally, the most important point is the long-term torsion-preventing effect of colonoscopy-assisted percutaneous sigmoidopexy. The median observation period for the present study was 25.5 months (range, 4-38 months) with no case of sigmoid volvulus recurrence in 194 patient-months of follow-up. Given that all the patients had a preoperative history of recurring sigmoid volvulus and no recurrence was seen during long-term follow-up, the present procedure appears highly effective and CT showed no change in the position of the T bars from the 2-shot anchor with respect to the position at the time of the procedure in any of the patients. In addition, no abdominal symptoms such as diarrhea, constipation, or intestinal obstruction occurred and no reduction in colonic function occurred as a result of fixation.

Performing colonoscopy-assisted percutaneous sigmoidopexy from the surface of the body required a number of innovations. To puncture and fix the sigmoid colon in the correct position and reduce the risk of mistaken puncture, we identified puncture sites using direct radiographic observation. The puncture site was identified radiographically by the tip of the endoscope and the tip of a pair of forceps placed on the surface of the body (Fig. 2A), and light was shone on the body surface by transmitted illumination from the endoscope (Fig. 2B). The site at which the transmitted illumination emerges was pressed by the fingers, and the endoscope was used to confirm that the intestinal tract was being pressed (Fig. 2C). Only then, was a 23-gauge cattelan needle inserted into the sigmoid colon from skin (Fig. 2D). Thus, 4 consecutive checks are used in combination to ensure correct identification of the puncture site.[22,23] In practice, no cases of puncture in the wrong place occurred in the present study. The only intraoperative adverse event was a case of subcutaneous emphysema, which improved with conservative treatment.

One limitation in the present study was that participants consisted only of Japanese individuals from a single institution. In particular, many of the patients were of slim physique with BMI of 18 kg/m^2, and the enlarged intestinal tract was readily identified from the surface of the body by means of the transmitted illumination test. However, evaluation with this test may prove more difficult in obese patients, where the abdominal wall is thicker. The procedure may be technically more challenging in Western countries where the average BMI is higher, when patients have poor ASA scores, and are very poor surgical candidates

To verify the usefulness of the present procedure in patients with low tolerance for surgery, a multicenter study with a large number of patients examining the real effectiveness and presence of any rare adverse events would be desirable. Furthermore, the procedure is minimally invasive and does not involve intestinal resection, and is likely to be beneficial not just for patients with low tolerance for surgery but also for all patients with sigmoid volvulus. We would expect clinical trials to establish the usefulness of the procedure. Because the number of cases is small and the follow-up period is as yet limited, longer follow-up as well as multicenter confirmation of the efficacy will be required to validate the method. In particular, the role of the procedure in obese patients (BMI $\geq$30 kg/

m^2), and those with intestinal adhesions or with a history of surgery may need to be evaluated in the future.

CONCLUSION

Colonoscopy-assisted percutaneous sigmoidopexy after fixation of repositioned sigmoid volvulus prevented recurrence of sigmoid volvulus. Although investigations with more cases are needed, the present procedure appears useful for preventing recurrence of sigmoid volvulus in patients with low tolerance for surgery.

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