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MINIREVIEWS

Endoscopic management of sigmoid volvulus in children

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Abstract

Sigmoid volvulus (SV) is extremely uncommon in children and is usually associated with a long-standing history of constipation or pseudo-obstruction. An early diagnosis and management are crucial in order to prevent the appearance of hemorrhagic infarction of the twisted loop, avoiding further complications such as necrosis, perforation and sepsis. In patients with no evidence of peritonitis or ischemic bowel, treatment starts with resuscitation and detorsion of the SV, accomplished by means of sigmoidoscopy and concomitant rectal tube placement. The bowel is then prepared and surgery is undertaken electively during the same hospitalization. We report a detailed review of the literature focusing on technical details, risks and benefits of endoscopic management of SV in childhood.

Key words: Sigmoid volvulus; Contrast enema; Children; Endoscopy; Surgery

Core tip: Authors provide a detailed review of the literature focusing on technical details, risks and benefits of endoscopic management of sigmoid volvulus in children.

Parolini F, Orizio P, Bulotta AL, Garcia Magne M, Boroni G, Cengia G, Torri F, Alberti D. Endoscopic management of sigmoid volvulus in children. *World J Gastrointest Endosc* 2016; 8(12): 439-443 Available from: URL: http://www.wjgnet.com/1948-5190/full/v8/i12/439.htm DOI: http://dx.doi.org/10.4253/wjge.v8.i12.439

INTRODUCTION

Sigmoid volvulus (SV) is extremely uncommon in children and is usually associated with a long-standing history of constipation or pseudo-obstruction[1,2]. Patients with SV present redundant sigmoid colon with a narrow mesenteric attachment to posterior abdominal wall, allowing the close approximation of two limbs of sigmoid colon and making it prone to torsion around the mesenteric axis. Less frequently, predisposing factors are Hirschsprung's disease (HD) and roundworm infestation, especially in smaller children. Presentations can range from acute to recurrent abdominal pain, often relieved by passage of stool or flatus[2,3]. An early diagnosis and management are crucial in order to prevent the appearance of hemorrhagic infarction of the twisted loop, avoiding further complications such as necrosis, perforation and sepsis[1-4]. If no signs of bowel ischemia and perforation are present, endoscopic decompression and detorsion of the volvulus has been proposed as the first step of treatment, followed by elective surgery with sigmoid resection and primary anastomosis[2,4]. We report a detailed review of the literature focusing on technical details, risks and benefits of endoscopic management of SV in children.

REVIEW

Multicenter studies on endoscopic management of SV in children are lacking. The initial PubMed search yielded 39 potentially relevant articles on the topic. Inclusion criteria were articles that reported original data on endoscopic management of SV in children younger than 18 years and they clearly reported the method of endoscopic treatment. Titles and abstracts of the identified publications were checked and reviewed against the predefined inclusion criteria, and afterward, the full text articles was reviewed[5]. Finally, 6 eligible articles were enclosed in the review, encompassing a total of 81 cases (Table 1)[1,2,6-9]. All but one studies were single institution case reports or case presentation (classes of evidence Ⅲ and rating scales of evidence E)[5]. Only one multicenter study was found, encompassing 13 cases[1]. Another study provided a detailed retrospective review of 63 children with SV published in literature from 1940 to 1999[8]. HD was associated in 13 out of 81 patients (16%). All patients of this series underwent endoscopic detorsion; the procedure was successful in 56 of cases (69%). Although this limited pediatric experience, evidence suggests that endoscopic management of SV should be considered the first step of treatment of these patients, followed by definitive elective surgery. Operative and technical details of endoscopic management thereby originated from a larger adult experience, as more than 1000 cases of endoscopic detorsion are reported[3,4].

ENDOSCOPIC MANAGEMENT OF SV IN CHILDREN

Which patients should be endoscopically managed?

All selected studies agree that emergency surgery is obviously indicated when the patient has clinical or radiological evidence or suspicion of peritonitis or perforation, which may clinically manifest as melanotic stool during anamnesis or rectal examination, guarding or rebound tenderness during abdominal examination[10]. In this subset of patients, the surgical procedure is chosen on the basis of the history, clinical presentation and intraoperative findings[10-12]. On the contrary, when signs of bowel ischemia and perforation are ruled out and a pediatric endoscopy service with high expertise or endoscipic guard with experience in pediatric procedures are available, endoscopic decompression and detorsion should represent the initial step of treatment in order to relief symptoms and to prepare the patient to semi-elective surgical exploration[1-6]. Surgery in emergency situations, when the general condition of the patient is suboptimal and the bowel is not prepared, is reported to carry higher complication rate[13].

How should the patient be prepared?

All selected studies agree that patients should actively be resuscitated by means of nasogastric suction and correction of fluid-electrolyte imbalance. Nasogastric intubation is necessary in order to allow gastric decompression, relief of symptoms and bowel rest and identification of the stomach on X-ray[1,10,11]. Broad spectrum antibiotic covering anaerobic bacteria should be administered immediately after admission. In patients with no evidence of peritonitis or ischemic bowel, water-soluble contrast enema is advisable before the endoscopy, in order to confirm the diagnosis and to rule out other causes of obstruction, such as intussusception[8]. Successful temporary reduction of SV by contrast enema is reported in up to 77% of the cases; moreover, enema could also facilitate preparation of both patient and bowel for subsequent endoscopy and surgery[8,9].

What is necessary to perform a safe procedure?

The procedure should be performed under general anesthesia in operating room[1]. This fact is different compared with adults, in whom the procedure could be safely performed under sedation in endoscopic suite. Different types of pediatric flexible colonoscopes less than 12-mm are commercially available. They are equipped with 3.2-mm biopsy channel, which allows the use of operative devices as biopsy forceps, snares and needles. Unfortunately, these instruments are more suitable for children 2 years and older (weight over 12-15 kg), and, as colonoscopes specifically designed for infants and toddlers do not exist, pediatric upper

Table 1 Endoscopic management of sigmoid volvulus in childhood

Ref.	No. of patients	Demographic	Associated anomalies, *n* (%)	Endoscopic detorsion success rate, %	Recurrence rate, %	Surgery
Salas *et al*[8]	1	M, 13 yr	Irritable bowel syndrome	100	100%, 2 d later	Sigmoidectmoy with colostomy and Harmann's pouch
Salas *et al*[8]	63	M:F = 3.5:1, mean age 7 yr	Hirschsprung's disease: 11 (58%) Imperforate anus in 2 (11%)	47	53%	Sigmoidectomy: 19 (38.7%); Sigmoidopexy: 11 (22.4%) Colostomy: 15 (30.6%)
Ton *et al*[7]	1	M, 16 yr	-	100	100%	Open sigmoid colectomy
Patel *et al*[2]	1	M, 14 yr	Chronic constipation	100	100%	Sigmoidectomy
Colinet *et al*[1]	13	M:F = 0.85:1, mean age 12.8 yr	Mental retardation : 2 (15.3) Myopathy: 2 (15.3) Chronic intestinal pseudo-obstruction: 2 (15.3)	100	50%, from 3 d to 3 mo later	Sigmoidectomy 12 (84.6%)
Clermidi *et al*[6]	1	F, 11 yr	Cornelia de langes	100	100%, 2 d later	Open sigmoidectomy
Parolini *et al*[9]	1	F, 10 yr	Functional constipation	100	100 (%)	Sigmoidectomy and sigmoidopexy

M: Male; F: Female.

GI video endoscopes can be used. It is assumed that is more difficult to study the sigmoid colon with these instruments, but their smaller diameter prevents excessive stretching of the intestinal wall, especially in newborns and infant. Nevertheless, in this series endoscopic management of SV was not attempted in children younger than 6-year-old. Rigid colonoscopes should not be used, as in all but one selected studies[3] they are generally associated to higher risks of perforation and lower volvulus reduction successful rate[12-14].

Endoscopic procedure

Sigmoidoscopy is best performed with patient in the Sims or left lateral decubitus position. Hips and knees are partially flexed and the right knee is positioned above the left one[12-16]. The pediatric endoscopist should stand between the light source and the back of the patient. Digital rectal examination is advisable, in order to lubricate the anal canal, relax the rectal sphincter and give an initial assessment of the effectiveness of the bowel preparation. The lubricated tip of the scope should be gently introduced into the rectum by flexion of the right index finger, guiding it into the anus at a 90° angle. The less amount of air is insufflated, in order to avoid the stretching of bowel loops and to reduce the patient's discomfort after the procedure[16]. The evaluation of the colorectal mucosa should be performed during the withdrawal of the instrument. Liquid in the rectum should be aspirated *via* the sigmoidoscope for a clearer view. The sigmoidoscope is then advanced into the rectum under direct vision. The rectum is gently insufflated to provide good visibility and to facilitate identification of rectosigmoid junction, which represents the area of most difficulty during the examination. To overcome this step the endoscope should be advanced beyond the valve of Houston, then the tip should be deflect upwards and, with gentle clockwise torquing, slowly advanced beyond the rectosigmoid junction. Spirally twisted or converging colon mucosa ("whirl sign") at the rectosigmoid junction indicates the distal point of torsional obstruction[10-12]. The endoscope should be gently advanced through the apex of the converging mucosa into the dilated sigmoid colon. Ischemic changes of the mucosa or gangrene should be noticed and represent an absolute indication to discontinue the endoscopy and to convert to surgery[2-6]. On the contrary, the management of children in whom endoscopic examination shows borderline ischemia is controversial[10-12]. Once the dilated sigma is decompressed and the endoscope is in the descending colon, endoscopic detorsion of the decompressed volvulus is obtained performing by clockwise rotation and shortening of the endoscope by the right hand. Only occasionally, the pressure of the air causes detorsion with reduction of the volvulus. If detorsion does not occur, the spiraling rectal mucosa is followed upward to the apex, and a soft rectal tube is passed up through this under direct vision[15,16]. The tip of the endoscope can also be used to apply a constant pressure at the apex of the twist, which can lead to detorsion and decompression[2]. A successful deflation is accompanied by a large amount of release of gas and liquid stool from the anus[1]. Eventually, rectal suction biopsies should be obtained, as HD has been reported in up to 17% of cases of SV in infancy[8,17].

Is rectal tube placement necessary?

Evidence suggests that the placement of a rectal tube for 24-72 h helps to stabilize the patient further and prevents an early relapse of volvulus[1]. After the placement of a guide wire (0.035 inch), a multiple side ports guiding catheter is advanced through the endoscopic channel into the descending or transverse colon. Several devices are available and used in the adult setting for treatment of acute non-toxic megacolon, pseudo-obstruction and colonic strictures, including the 14 Fr Colon Decompression Set (Cook Inc, Bloomington, Indiana, United States) and 7 Fr, 8.5 Fr and 10 Fr Marcon Colon Decompression Set

(Cook Inc). Endoscopic exchange was performed by gently pulling back the endoscope over the guidewire while advancing the guide wire. The drainage catheter was then advanced over the guide wire overcoming the point of the obstruction, and eventually the guidewire is removed through the drainage catheter[1,16,17]. Placement of a larger red rubber catheter per rectum alongside the scope is suggested when colonic decompression kit is not available. When the tip of the catheter is visualized, biopsy forceps passed through the work channel of the scope are used to grasp the tip of the catheter and advanced it as far as necessary. The drainage catheter is taped over the perianal skin and should left in place for 1-3 d before surgery[1].

The role of percutaneous endoscopic sigmoidopexy

Described in the first time by Choi *et al*[18] in 1998, percutaneous endoscopic sigmoidopexy (PES) has been proposed in order to prevent recurrence of volvulus for elder patients who otherwise had contraindication for elective surgery and general anesthesia. PES is performed using the percutaneous endoscopic gastrostomy technique. Nevertheless, as only one fixation point may be insufficient for preventing SV, Ito *et al*[19] reported PES with multiple fixation points in a 86-year-old patient with recurrent SV. The sigmoid colon was fixed at six points to the abdominal wall using non-absorbable sutures, with the fixation knots buried subcutaneously, obviating the need for suture removal. Pinedo *et al*[20] reported two patients in whom sigmoidopexy was performed percutaneously under sedation in the endoscopy suite. Fixation to abdominal wall was obtained using also T-fasteners in a triangular disposition in the colon; the T-fasteners were cut at the skin after 4 wk. According to evidence, the experience of PES in pediatric settings is extremely limited, and this procedure should be reserved only for the small subset of children whit recurrent SV and high anesthesiological risks for open surgery.

Is surgery necessary?

After successful endoscopic reduction of the colon, the recurrence of SV was achieved in up two thirds of the cases. The largest data in adult population is provided by Atamanalp, who reported a 46-year experience with 952 patients with SV, in whom primary endoscopic derotation was successfully performed in 77% of patients, with the highest success rate in rigid sigmoidoscopy group (78.1%) compared with flexible sigmoidoscopy group (76.4%). A 4.5% of early recurrent rate was reported, and all the patients of this series eventually underwent elective or emergent surgical treatment[3]. In the pediatric review of Salas and colleagues, proctosigmoidoscopy and endoscopic rectal tube placement was attempted in 53.5% of cases, with a success rate of 47%[8]. Basing to the limited pediatric experience, we suggest that the initial endoscopic decompression and subsequent semi-elective operation results in a satisfactory outcome in managing SV. Waiting for surgery, a 48-72 h interval seems adequate for bowel preparation and optimization of the patient's clinical status[1,21]. Definitive semi-elective surgery is strongly recommend during the initial hospital admission for most of the patients[1]. Clinical evidence of peritonitis or perforation, unsuccessful endoscopic detorsion, gangrenous or ischemic bowel endoscopically evident obviously necessitates emergency surgical intervention[1,22].

What are the risks of the endoscopic procedure?

Inability to endoscopically endorse the SV is an indication for immediate surgical intervention. Shaft-induced perforations during endoscopy are due to a big loop formation. In these cases perforations are usually larger than expected and located on the antimesenteric wall. Tip perforations are smaller and typically occur when the "sliding by" technique is used inappropriately or a tip is trapped in wide diverticula or imbedded into mucosa when orientation is lost. Excessive air pressure perforation has been documented primarily in patients with strictures of the left colon, but are extremely uncommon in children[17,18]. In the historical review in adult setting provided by Atamanalp, iatrogenic perforations during endoscopy were recorded in 14 patients (2%); mortality rate of endoscopy was 0.05%[3]. Interestingly, no complications occurred during endoscopy were recorded in this review of pediatric series. To prevent excessive air insufflation water-immersion colonoscopy for SV was reported in adults[10-13]. Nevertheless, according to evidence, the experience of water-immersion endoscopy in pediatric settings is extremely limited, especially in emergency setting.

CONCLUSION

Sigmoid volvuls in extremely uncommon in children and operative and technical details of endoscopic management is borrow by the larger adult experience. If no signs of bowel ischemia and perforation are present, water contrast enema followed by endoscopic decompression and detorsion of the volvulus represents the initial step of treatment also in pediatric setting. Nevertheless, the procedure requires a high degree of pediatric endoscopy expertise and is associated to high rate of early recurrence even when successfully performed. Elective surgery with sigmoid resection, primary anastomosis and sigmoidopexy is mandatory also in children successfully managed by endoscopic decompression and detorsion.

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MINIREVIEWS

Single port laparoscopic liver surgery: A minireview

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Abstract

Nowadays, the trend is to perform surgeries with "scarless" incisions. In light of this, the single-port laparoscopic surgery (SPLS) technique is rapidly becoming widespread due to its lack of invasiveness and its cosmetic advantages, as the only entry point is usually hidden in the umbilicus. The interest in "scarless" liver resections did not grow as rapidly as the interest in other scarless surgeries. Hepatopancreatobiliary surgeons are reluctant to operate a malignant lesion through a narrow incision with limited exposure. There are concerns over adverse oncological outcomes for single-port laparoscopic liver resections (SPL-LR) for hepatocellular carcinoma or metastatic colorectal cancer. In addition, getting familiar with using the operating instruments through a narrow incision with limited exposure is very challenging. In this article, we reviewed the published literature to describe history, indications, contraindications, ideal patients for new beginners, technical difficulty, advantages, disadvantages, oncological concern and the future of SPL-LR.

Key words: Single-port laparoscopic surgery; Single-port laparoscopic liver resection; Minimal invasive liver surgery; Laparoscopic liver resection

Core tip: This manuscript highlights the indications, contraindications, technical difficulties, advantages and disadvantages of the single-incisionlaparoscopic (SIL) liver surgery. The authors wanted to share their experience of SIL liver surgery by this review and to create a referrence review for new beginners.

Karabicak I, Karabulut K. Single port laparoscopic liver surgery: A minireview. *World J Gastrointest Endosc* 2016; 8(12): 444-450 Available from: URL: http://www.wjgnet.com/1948-5190/full/v8/i12/444.htm DOI: http://dx.doi.org/10.4253/wjge.v8.i12.444

INTRODUCTION

Laparoscopic liver resection is performed on benign and malignant liver tumors. Preliminary oncological results of liver resection have demonstrated that laparoscopic techniques are as effective as open procedures in a select group of patients[1-4]. Laparoscopic liver surgery has been shown to be superior to open surgery in terms of intraoperative blood loss, pain control, duration of hospital stay, resumption of oral intake, and com-

Table 1 Baseline characteristics of small case series about single port laparoscopic liver resection

Ref.	Type of article	Year	Country	No. of patients by diagnosis			Type of Surgery				Child-Pugh classification of HCC patients
				Benign Lesion	HCC	Metastatic tumor	Right hepatectomy	Left hepatectomy	LLLS	Nonanatomic resection or segmentectomy	
Shetty *et al*[14]	Case series	2011	South Korea	-	23	-	1	1	4	17	No data
Pan *et al*[18]	Case series	2012	China	3	4	1		3		5	A (4)
Aikawa *et al*[21]	Case series	2012	Japan	2	5	1	-	-	-	8	A (3) B (1) C (1)
Hu *et al*[22]	Prospective, randomized, controlled study	2014	China	18	-	-	-	-	14	-	No data
Wu *et al*[24]	Case series	2014	China	13	2	2	-	1	8	8	No data
Aldrighetti *et al*[25]	Case-matched analysis	2012	Italy	5	6	2	-	-	13	-	No data
Karabicak *et al*[27]	Case series	2016	Turkey	3	2	4	-	-	2	7	A (1) B (1)

HCC: Hepatocellular carcinoma; LLLS: Left lateral liver sectionectomy.

plication rates[5-8].

Laparoscopic metastasectomy and left lateral sectionectomy are widely performed and accepted as the gold standard treatment for liver tumors in many hepatobiliary centers[9]. Major hepatectomies, such as left and right hepatectomies or extended left and right hepatectomies, are performed laparoscopically by experienced hepatobiliary surgeons[1,3,6,7,10].

Nowadays, the trend is to perform surgeries with "scarless" incisions. In light of this, the single-port laparoscopic surgery (SPLS) technique is rapidly becoming widespread due to its lack of invasiveness and its cosmetic advantages, as the only entry point is usually hidden in the umbilicus[11-13].

As advances in laparoscopic liver resections have been slower than laparoscopic resections of other organs, the interest in "scarless" liver resections did not grow as rapidly as the interest in other scarless surgeries. Moreover, single-port laparoscopic liver resection (SPL-LR) has a significant learning curve, which can make surgeons reluctant to perform it[14-18].

The most difficult part of this technique is getting familiar with using the operating instruments through a narrow incision with limited exposure[12,14,18,19]. Surgeons with experience in both open and laparoscopic liver surgery are best suited to perform this challenging procedure[14-18].

Those who intend to start performing SPL-LR have to be very selective in choosing first patients during the learning curve so as to not fail. A surgeon should combine his/her experience in both laparoscopic liver resection and SPLS for other organs such as gallbladder when performing the SPL-LR, especially during the initial stages of the learning curve[14-19].

HISTORY

SPL-LR is a newly emerging technique, and it is still limited in practice. The development of special instruments to facilitate this technique have made liver resection feasible and safe, but surgeons have been slow in applying this technique[14-16].

The first report of SPL-LR, published by Aldrighetti *et al*[19] in 2010, was a left lateral sectionectomy for a single colorectal metastasis. After the publication of this, many case reports and a few short series about SPL-LR and two case-matched analysis of traditional laparoscopic liver resection and SPL-LR were published[14-18,20-27]. Table 1 shows baseline characteristics of small case series about SPL-LR. We published the first SPL pericystectomy for liver hydatid disease[26].

INDICATIONS AND CONTRAINDICATIONS

Patient selection is of paramount importance for SPLS. The aim of SPLS is to reduce the operative trauma and to make the smallest possible incision (2.5 to 5 cm) that will allow the extraction of the resected specimen (Figure 1). Tumors that require a big incision to remove the resected specimen are against the SPLS mentality[17,19,20,28]. It is mandatory to select the appropriate patient for this procedure, based on the size, malignancy potential and the location of the tumor[15,29].

SPL-LR has been performed for many different benign and malignant lesions such as liver adenoma, focal nodular hyperplasia, hemangioma, hydatid cyst, giant simple cyst, intrahepatic biliary stones, cystadenoma, metastatic liver lesions and hepatocellular carcinoma (HCC)[14,17,19,20,24,26,27,30].

The ideal lesions for SPL-LR are peripherally located superficial tumors[17,21]. Wu *et al*[24] recommend SPL-LR for patients with benign liver tumors that are less than 10 cm in diameter and located in segments Ⅱ and Ⅲ. Hu *et al*[22] recommends localized benign left lateral liver disease as a suitable candidate for SPL-LR, because laparoscopic left lateral sectionectomy (LLLS) is technically less demanding. They also mention that

Figure 1 A 2-cm umbilical single-port incision.

Figure 2 Fragmentation of the specimen without extension of the single-port incision.

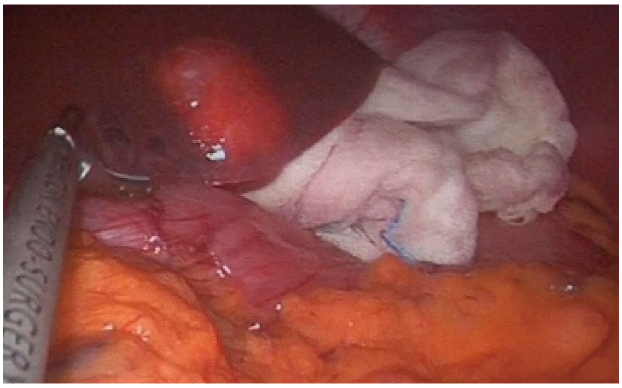

Figure 3 A peripherally located benign lesion.

the resection specimen of benign liver diseases can be fragmented and retrieved without requiring the addition or extension of a trocar incision (Figure 2).

In our experience with the hydatid cyst, the cyst can at times be large enough to totally replace the left lateral section. In cases where the cyst can be totally removed by left lateral sectionectomy, we prefer to use SPL-LR. Once the SPL left lateral sectionectomy performed, the cyst is placed into the retrieval bag and then, the cyst content can be aspirated through the incision while it is in the bag; this enables the collapsed cyst wall to be easily pulled out from the small incision without having to enlarge it.

Malignant tumors bigger than 5 cm are not suitable for SPLS, as the incision required to extract the specimen itself would defeat the purpose of such a procedure[14-18]. Ideally, malignant liver lesions that are suitable for SPL-LR are less than 5 cm in diameter and located in the left lateral sector; alternatively, they are smaller than 2.5 cm in diameter and located at the surface in segments Ⅳ, Ⅴ or Ⅵ[24].

IDEAL PATIENTS FOR BEGINNERS

Beginner surgeons have to be very cautious while choosing the ideal patients for SPLS. Surgical candidates have to be carefully selected to optimize the benefits of this technique[14-18,24]. One should never forget that, during the learning curve, it is difficult to obtain the angles necessary for parenchymal transection with instruments parallel to each other[12,14,31]. That is why obese patients, patients who require big lesions or lesions located deep in the parenchyma, or cirrhotic patients are not good candidates to start with[14,24,31].

Gkegkes *et al*[32] advise to start SPL-LR with the peripherally located lesions. The surgeon can then move on to anatomical resections and, finally, proceed to major hepatectomies before he/she can gain sufficient experience with SPL-LR. Wu *et al*[24] recommend starting with the lesion in the left lateral section or anterior and inferior liver segments (Ⅳ anterior, Ⅴ and Ⅵ), since minimal mobilization of the liver is necessary in these locations.

Geller *et al*[31] recommend the ideal patient to be a thin, young female with a 3-4 cm hepatic adenoma, where cosmesis is of prime concern. Aikawa *et al*[21] and Aldrighetti *et al*[25] recommend that new surgeons start with the liver tumors located in the left lateral section, away from the hilum or anterior right hepatic segment.

We recommend that during the learning curve, beginners of this technique start with the peripherally located benign lesions to decrease the failure rate (Figure 3). The first few patients should not be cirrhotic patients, as the new surgeon can cause harm and jeopardize the patient's oncological safety.

We preferred to start performing SPL-LR on patients with peripherally located liver hydatid cysts since it is one of the most common benign liver tumors. Laparoscopic pericystectomy is the ideal surgical treatment for such a location[26].

SPL-LS IN CIRRHOTIC PATIENTS

Laparoscopic liver surgery has already been shown to decrease intraoperative bleeding and postoperative general complications, such as ascites and wound infection, without worsening the oncological outcome in well-selected cirrhotic patients[33-35].

The decrease in abdominal wall trauma in SPLS could be especially useful for cirrhotic patients. SPL-LR has been performed in well-selected cirrhotic patients with a medically and oncologically good outcome[14,21,23].

Figure 4 Conflict between the surgeon and the camera holder extracorporeally.

A peripherally located small HCC is appropriate for SPL-LR, since the surgery can be performed without prolonging the operation time or increasing bleeding so as to avoid deterioration after the surgery[14,16,23].

One has to be cautious with trans-umbilical incisions for the single port, as it can cause severe bleeding due to large umbilical veins. Gaujoux *et al*[17] recommends making incisions through the rectus abdominis muscle or in the supraumbilical position to avoid bleeding from large umbilical veins.

PORT TYPES

The first single-port device created for SPLS is the SILS port system (Covidien, Mansfield, MA), which has three access channel, and which is suitable for a 2.5 cm incision. Nowadays, there are many different types of port devices suitable for 2.5 to 5 cm incisions with three or four access channel, each having advantages over the others[18,21,32]. The ideal port has to have flexible access parts to reduce the overlapping of the instruments[14,32]. The size of the port has to be chosen according to the size of the liver to be resected. The port size should not be smaller than the malignant tumor since, eventually, the incision will need to be enlarged[20,21].

TECHNICAL DIFFICULTIES

SPLS has some technical problems that are peculiar to operating through a single-port[12,14,32]. The main problems of this technique are instrument crowding, the absence of triangulation, the parallel field of view, and a two/three instrument restriction depending on the port choice[12-14,19,22,24,27,31,35].

Having all the instruments and the camera inserted parallel to each other within the single port causes restricted range of movement and conflict between the surgeon and the camera holder, both intracorporeally and extracorporeally[12,16,26,32,36] (Figure 4). The absence of triangulation makes laparoscopic manipulation more complicated and troublesome[22,25,31]. The "sword-fighting" is unavoidable, but this adversity can be decreased by cross-handling the instruments, using single ports with a large outer cap or self-retaining sleeves, and using curved and articulating instruments and flexible scopes[12,16,17,22,37,38].

Another apparent difficulty with SPL-LR is bleeding, which is the most common reason for conversion to traditional laparoscopy or open surgery[32,36]. Experience and careful patient selection are the mainstays of preventing this complication[14,22,25]. Prevention of major bleeding during parenchymal resection is an important step in SPL-LR, since the instruments are limited and the room is too narrow for manipulations[13,22,31,38]. Weiss *et al*[39] showed reduced bleeding during single-incision laparoscopic minor liver resection with inline radiofrequency pre-coagulation (Habib 4X).

If acute massive bleeding occurs, it is very difficult to stop parenchymal bleeding by SPLS. Shetty *et al*[14] reported that suture ligation is too time-consuming to control bleeding during SPL-LR due to inadequate instrument angles and extremely uncomfortable needle-handling. Unless the bleeding cannot be treated, conversion to laparoscopy or laparotomy is required[13,22,24,38].

Selection of the umbilicus for the single-port placement allows hiding the incision while achieving the resection. The transumbilical route is not appropriate for all patients, since the distances between the umbilicus and the liver vary from case to case. The entry of the port should be selected based on the patient's body type and the location of the lesion[14,18,22] (Figure 5).

RESECTION TYPES

The development of new single ports, articulating special instruments and laparoscopic surgery experience facilitate this technique. In experienced hands, the SPL anatomical liver resection has become feasible and safe in carefully selected patients[14-17,22,25].

Lesions limited to the left lateral sector of the liver are the most appropriate for this technique. SPL left lateral sectionectomy has been the main type of resection for such lesions[22,25,37]. In this situation, the instruments are already aligned to the intended liver parenchyma transection plane, which helps to avoid "dueling swords" between the surgeon and the camera holder. Also, suspensory ligaments aid in surgical site exposure[17,22,25,40].

SPLS has been performed for different types of resections such as living donor liver harvesting, right hepatectomy, extended left lobectomy, left hepatectomy, left lateral sectionectomy, proximal left hemihepatectomy-segmentectomy, pericystectomy, wedge resection, liver cyst deroofing, biliary exploration, and pericystectomy for hydatid cyst[14,17,18,24,26,41-43].

ONCOLOGICAL CONCERNS

There are concerns over adverse oncological outcomes for SPL-LR for HCC or metastatic colorectal cancer. Few publications about SPL-LR for malignant lesions

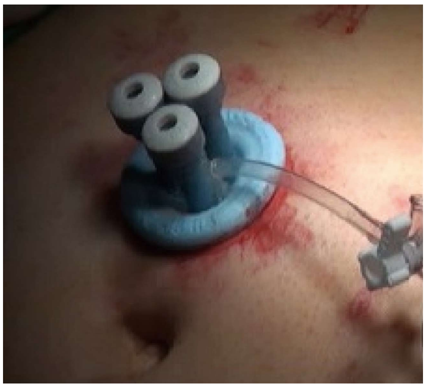

Figure 5 The entry of the port should be selected based on the patient's body type and the location of the lesion.

are available; a majority of them are case reports, and a few of them are short case series. The role of SPL-LR for malignancy is reported for small HCCs and solitary liver metastasis[15,17,21]. Shetty *et al*[14] showed that, in the hands of experienced hepatobiliary and laparoscopic surgeons, SPL-LR is oncologically as safe as conventional laparoscopy in a variety of well-selected cases.

Strict oncological principles should not be compromised simply to achieve a SPL-LR. Free resection margins have to be achieved with the "no touch" technique[9,16,28,44]. Shetty *et al*[14] recommend making 5 cm incisions for SPL-LR in patients with malignant lesions, as this would make surgical handling relatively easy. By making a 5-cm incision, the necessity of the unfamiliar articulating instruments for the resection of the malignant tumor decreases. A 5-cm incision is usually large enough to deliver the specimen while maintaining its contours[14].

ADVANTAGES

The advantages of SPL-LR usually include a hidden incision, minimization of abdominal trauma, less postoperative pain, quicker recovery, earlier resumption of normal activities, and shorter hospital stays compared to conventional surgeries[14-16,24,30]. Small case-control series comparing the SPL limited liver resection and the LLLS showed similarities in operating times, blood loss, length of stay and intra- and post-operative complications[25,30].

SPL-LR may be especially appealing in cirrhotic patients with HCC as it reduces the risk of complications such as ascites and wound infections, which can deteriorate the patient's condition after a conventional liver resection[14,23].

Tayar *et al*[15] mentioned that after laparoscopic wedge resections of a liver tumor, one of the trocar incisions is usually enlarged for the specimen removal. They emphasize that this is an advantage of SPLS since, at the end of the surgery, the single-port incision will be used to extract the specimen. Therefore, the surgery can be completed without the need for an additional three or four ports.

An alternative to SPL liver surgery is multiport laparoscopic liver resection. Whenever necessary, one can easily convert single-port to standard laparoscopy if one encounters difficulty during the liver parenchyma resection[17,22,31].

DISADVANTAGES

SPL liver surgery has some very well-known disadvantages when compared with conventional laparoscopic surgery. The articulating specific surgical instruments may be necessary during deep parenchymal resection, which may not be easily available in all institutions, thus increasing the cost of the operation[15,21,22,32].

Colorectal cancer solitary small liver metastasis is an indication for SPL-LR. Performing this technique in a patient with a history of previous surgery may not always be possible because of the severe intra-abdominal adhesions (Figure 6). The presence of severe adhesions can diminish the number of patients suitable for this technique, even if the tumor is small and peripherally located. For such patients, conventional laparoscopy is the preferred technique. After making the umbilical incision for the single port, we usually make blunt and sharp dissections under direct visualization to create enough space for the port and the instruments.

SPL liver surgery has a significant learning curve that initially increases the operation time, the conversion rate and complications[14-18,21,22,25,31]. Aikawa *et al*[21] shortened the SPL-LR time by using multi-functional devices such as division, hemostasis, irrigation and suction.

The location and size of the malignant lesion is crucial. Malignant lesions bigger than 5 cm are considered to be a contraindication for this technique[14,18,24,45]. Anatomic resection of tumors located deep in the liver or in the posterior right lobe are not suitable for this technique, either[18,24,35].

Moreover, patient-related restrictions can diminish the application of SPL-LR. Longer single-port instruments may be necessary in obese or tall patients. Extremely obese patients may not be suitable for SPLS, because the depth of the subcutaneous fatty tissue may not allow the placement of the single port. Single-port site hernia has been reported to be higher in obese patients[15].

More blood loss can occur in cirrhotic patients during SPL-LR than during laparoscopic liver resections or major hepatic resections, especially during the learning curve[14,18,31]. In our experience, articulating tissue sealer shortens the operation time, decreases blood loss and reduces the size of unnecessarily removed liver tissue, particularly in cirrhotic patients.

CONCLUSION

SPL-LR is a new and emerging technique. Initially, surgeons were reluctant to perform this technique due to concerns about the oncological safety in malignant

Figure 6 A single-port laparoscopic liver resection incision a patient with a previous history of colon resection.

liver lesions[16,22,24,36]. However, the development of special instruments and ports have facilitated this technique and made it a feasible, effective and safe alternative to conventional laparoscopy for the treatment of peripherally located benign or malignant liver lesions in cautiously selected patients[14-18,22,24-26,45].

SPL-LR should be performed by surgeons with expertise in both liver and advanced laparoscopic surgery in centers where laparoscopic liver resection is routinely performed[14, 22-26].

There are a limited number of studies comparing single-port and conventional laparoscopic liver resections, each with a very small sample size owing to strict patient-selection criteria due to safety concerns. Additional indications and contraindications of single-incision laparoscopic liver resections need to be stated in the light of large randomized studies[22,25,32]. Larger, particularly randomised studies are especially necessary to determine whether SPL-LR is safe and feasible for massive hepatic resections and resections of bigger malignant tumors[14-18,25,45].

Studies comparing the oncological outcome and complication rates between SPL-LR and conventional laparoscopy, and between SPL-LR and conventional liver surgery, will determine the future of this emerging technique.

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ORIGINAL ARTICLE

Retrospective Study

Effectiveness of clip-and-snare method using pre-looping technique for gastric endoscopic submucosal dissection

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Author contributions: Yoshida N designed and performed the research and wrote the paper; Doyama H designed the research and supervised the report; Ota R, Takeda Y, Nakanishi H, Tominaga K, Tsuji S and Takemura K supervised the report.

Institutional review board statement: This study was reviewed and approved by the Institutional Review Board of Ishikawa Prefectural Central Hospital No. 544.

Informed consent statement: Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to treatment by written consent. For full disclosure, the details of the study were published on the home page of Ishikawa Prefectural Central Hospital.

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Abstract

AIM: To evaluate efficacy and safety of clip-and-snare method using pre-looping technique (CSM-PLT) for gastric endoscopic submucosal dissection (ESD).

METHODS: In the CSM-PLT method, a clip attached to the lesion side was strangulated with a snare, followed by application of an appropriate tension to the lesion independent of an endoscope. Twenty consecutive lesions were resected by ESD using CSM-PLT (CSM-PLT group) and compared with a control group, including 20 lesions that were resected by conventional ESD. The control group was matched based on the size and location of the lesion, presence of pathologic fibrosis, and experience of endoscopists. Total procedure time of ESD, proportion of *en bloc* resection, and complications were analyzed.

RESULTS: The total procedure time for the CSM-PLT group was significantly shorter than that for the control group (38.5 min *vs* 59.5 min, P = 0.023); all lesions were resected *en bloc* by ESD. There was no significant difference in complications between the two groups. Moreover, there was no complication in the CSM-PLT group. In one large lesion (size: 74 mm) that underwent extensive CSM-PLT during ESD, we used an additional CSM-PLT on another edge of the lesion after achieving submucosal resection to the maximum extent possible during initial CSM-PLT. In two lesions, the snare came off the lesion together with the clip after a sudden pull; nevertheless, ESD was successful in all lesions.

CONCLUSION: CSM-PLT was an effective and safe method for gastric ESD.

Key words: Endoscopic submucosal dissection; Clip-and-snare method; Pre-looping technique; Endoscope; Dissection

Core tip: This was a retrospective matched-pair analysis to evaluate the efficacy and safety of clip-and-snare method using pre-looping technique (CSM-PLT) for gastric endoscopic submucosal dissection (ESD). CSM-PLT is one of the traction methods that was developed to perform gastric ESD more effectively. Compared with conventional ESD, ESD using CSM-PLT had significantly shorter total procedure time (38.5 min *vs* 59.5 min, P = 0.023). With regard to proportion of *en bloc* resection and complications, there was no significant difference between the groups. Hence, CSM-PLT is a promising method for gastric ESD.

Yoshida N, Doyama H, Ota R, Takeda Y, Nakanishi H, Tominaga K, Tsuji S, Takemura K. Effectiveness of clip-and-snare method using pre-looping technique for gastric endoscopic submucosal dissection. *World J Gastrointest Endosc* 2016; 8(12): 451-457 Available from: URL: http://www.wjgnet.com/1948-5190/full/v8/i12/451.htm DOI: http://dx.doi.org/10.4253/wjge.v8.i12.451

INTRODUCTION

Endoscopic submucosal dissection (ESD) was developed in the late 1990s for the purpose of *en bloc* and less invasive resection of early gastric cancer[1]. In the earliest years, some problems including difficulty of the procedure and high risk of complications were encountered. Over the years, ESD has evolved to become an easier and safer procedure due to establishment of strategies, improvement of devices and injection solution[2], and use of CO_2 insufflation pump[3].

Although ESD is performed for early gastric cancer, which satisfies the indication criteria of Japanese guideline[4], difficulty in technicalities of the procedure are still occasionally encountered. The difficulty of gastric ESD depends on the size and location of a tumor, presence of ulceration, or the endoscopist's skills. Therefore, an innovative technique is necessary to constantly make ESD a safer and more effective procedure, regardless of the characteristic of the lesions or skills of the operator.

Traction method has been described as a technique for an effective ESD; with this technique, an appropriate tension is applied to the lesion to visualize the submucosal layer and effectively perform submucosal dissection. Recently, several traction methods have been reported for use in gastric ESD such as internal traction[5], medical ring[6], clip-with-line (including "dental floss clip traction")[7-10], use of double-channel endoscope[11], external grasping forceps[12], magnetic anchor[13,14], and the double-scope method[15]. Each method has its advantages and disadvantages[16]; therefore, the most ideal method has not yet been established.

Recently, as new traction method, the clip-and-snare method (CSM), has been reported. CSM is a concept that includes "clip and snare lifting"[17] and "yo-yo technique"[18]. In this technique, the clip attached to the side of the lesion is strangulated with a snare, followed by application of an appropriate tension to the lesion independent of an endoscope. CSM does not only facilitate control of the degree of strength but also of the direction of traction by pulling and pushing the snare. The major difference between "clip and snare lifting"[17] and "yo-yo technique"[18] is the course through which the snare passes. The snare passes through the oral cavity in the "clip and snare lifting"[17], whereas it passes through the nostril in the "yo-yo technique"[18]. Conventional CSM[17,18] entails the use of forceps to derive the snare to the clip; this technique is not easy, particularly for lesions in the upper third of the stomach. We improved this method with a new and easy technique for snare derivation, which we reported as pre-looping technique (PLT)[19] to simplify the CSM technique during gastric ESD on all sites.

The aim of this study was to evaluate the efficacy and safety of CSM using PLT (CSM-PLT) for gastric ESD.

MATERIALS AND METHODS

General

This retrospective study was conducted at the Ishikawa Prefectural Central Hospital, a tertiary referral center in Japan. In accordance with the Declaration of Helsinki, the protocol was approved by the Institutional Review Board of the said institution. Patients were not required to provide informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to treatment by written consent. For complete disclosure, the details of the study were published on the home page of Ishikawa Prefectural Central Hospital.

In this manuscript, we reported a retrospective matched-pair comparison of ESD using CSM-PLT with conventional ESD.

Lesion selection

From January 2014 to March 2014, 20 consecutive gastric lesions resected by ESD using CSM-PLT were included in the CSM-PLT group. From 1033 gastric lesions resected by conventional ESD between January

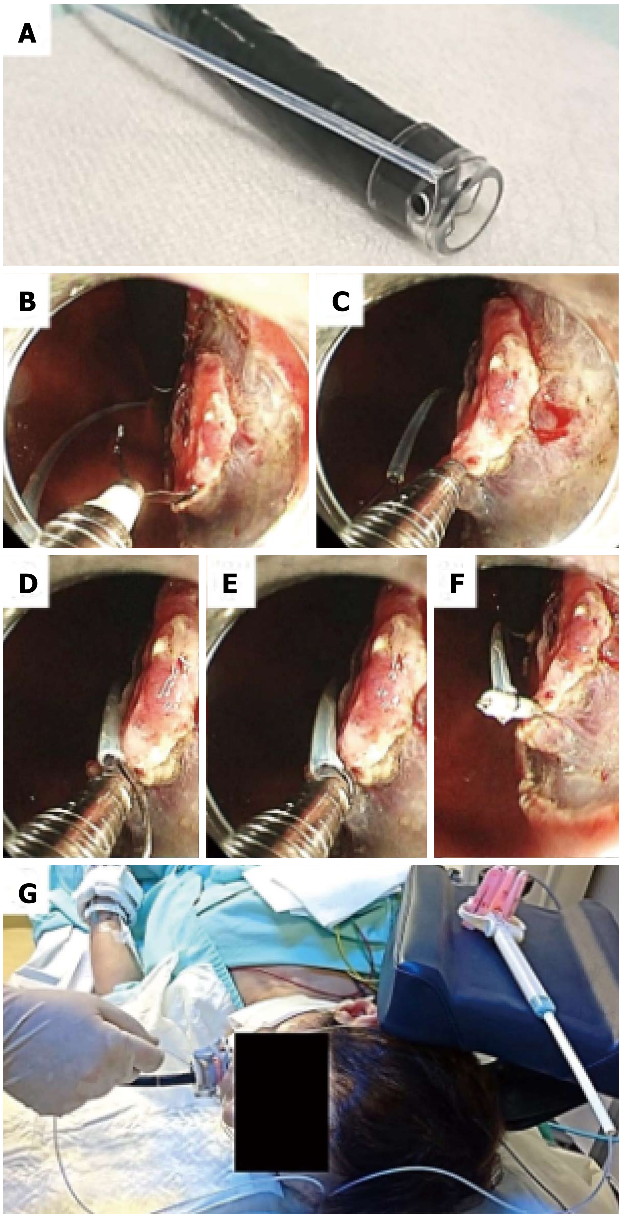

Figure 1 Clip-and-snare method using pre-looping technique. A: The transparent cap is tightened with a snare from the outside of the endoscope (pre-looping technique) after completion of a circumferential incision; B: A tumor is seen on the lesser curvature of the upper third of the stomach. The endoscope is bent to a maximum. A hemoclip with a reusable clip deployment device is inserted through the endoscope channel and is used to grasp the edge of the tumor while avoiding its detachment from its deployment device; C, D: The pre-looped snare is loosened from the transparent cap and moved along the device toward the hemoclip; E, F: The hemoclip is tightened with the snare and released from the clip deployment device; G: The endoscopist can apply appropriate tension to the lesion using the snare independent of the endoscope. The slider of the snare is fixed with clothespins.

2009 and December 2013, we set a control group that included 20 lesions, which matched those of the CSM-PLT group in terms of tumor size, location, pathologic fibrosis, and endoscopist's experience with ESD. The location and presence of pathologic fibrosis were completely matched. Regarding the location of the lesion, the stomach was divided into the following three longitudinal sections: Upper, middle, and lower; the cross-sectional circumference of the stomach was divided into four equal parts according to the Japanese classification of gastric cancer: Lesser curvature, greater curvature, anterior wall, and posterior wall[20]. Depending on the experience of endoscopists on ESD, further matching was performed. ESD experience was classified into "3 years or under", "more than 3 years and less than 7 years", and "7 years or over". To minimize differences in specimen size, definitive matching was performed. Lesions that extended to the esophagus or duodenum were excluded.

Endoscopists

The endoscopists who performed ESD in this study had enough knowledge and skills related to conventional gastric ESD. To ensure the quality of gastric ESD, all of the participated endoscopists were required to have a level of knowledge and skills commensurate with those of a specialist accredited by the Japan Gastroenterological Endoscopy Society. In actuality, they had an experience of 4 years or more in gastroscopy. Endoscopists with less than 7 years of experience performed ESD procedures under the supervision of experts with more than 7 years of experience. For the CSM-PLT group, we retrospectively collected consecutive data immediately after the establishment of CSM-PLT. Therefore, all endoscopists who participated in the study had little experience on the established CSM-PLT.

ESD using CSM-PLT

A single-channel endoscope (GIF-Q260J; Olympus Co., Tokyo, Japan) with a disposable transparent cap (D-201-11804, Olympus Co.) on the endoscopic tip was used. A mixture of saline solution, 0.4% sodium hyaluronate, and indigo carmine was injected into the submucosal layer surrounding the lesion, and a circumferential incision was made using an insulation-tipped scalpel (IT knife2, Olympus Co) on ENDO CUT Q mode (effect 2) of the electrosurgical generator (VIO300D, ERBE Co, Tübingen, Germany). The endoscope was withdrawn and the transparent cap was tightened with a snare (SD-221U-25, Olympus Co.) from the outside of the endoscope (Figure 1A); this technique was named PLT[19]. Then, the endoscope and snare were reinserted into the lesion before inserting a hemoclip (HX-610-090, Olympus Co.) with a reusable clip deployment device (EZ CLIP, Olympus Co.) through the endoscope channel. The hemoclip was used to grasp the edge of the tumor while taking utmost care to avoid complete detachment from its deployment device (Figure 1B). The pre-looped snare was loosened from the transparent cap and moved along the device toward the hemoclip (Figure 1C and D). The hemoclip was tightened with the snare and released from the clip deployment device (Figure 1E and F). After this, the endoscopist was able to apply an appropriate tension to the lesion using the snare independent of the endoscope and could incise the submucosal layer effectively (Figure

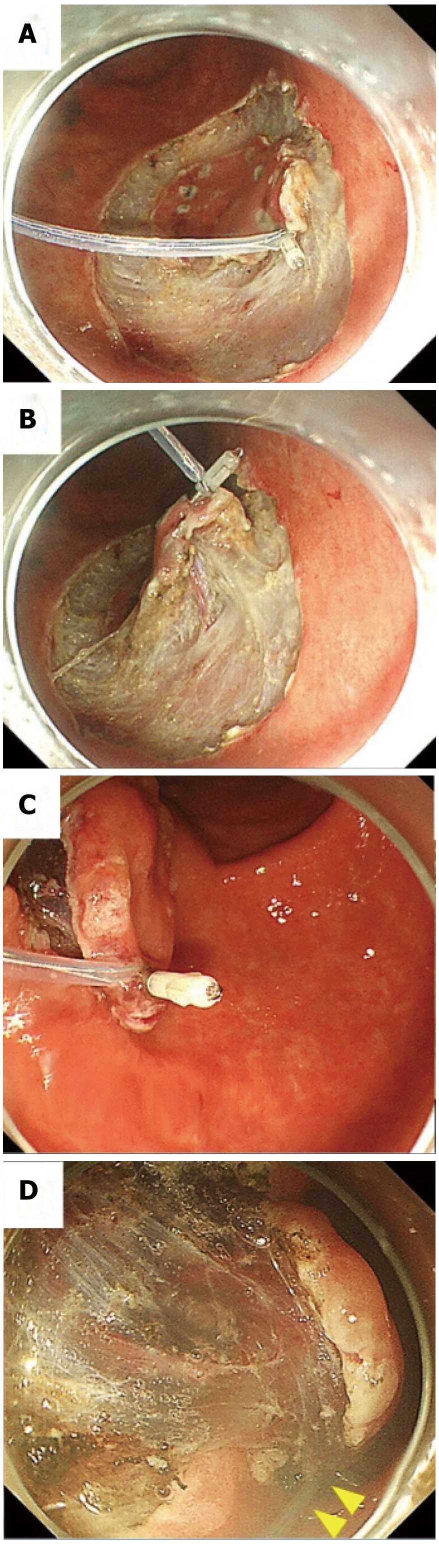

Figure 2 Pushing and pulling by the clip-and-snare method. A: Clip-and-snare method using pre-looping technique (CSM-PLT) for a tumor located on the greater curvature of the middle third of the stomach; B: The endoscopist is able to obtain good visibility of the submucosal layer by pulling the snare; C: CSM-PLT was performed for another tumor located on the anterior wall of the middle third of the stomach; D: The endoscopist is able to obtain good visibility of the submucosal layer by pushing the snare (yellow arrowheads).

1G). The submucosal layer was dissected using an IT knife 2 on SWIFT COAG mode (effect 4, 60W) of VIO300D. Because the snare had moderate rigidity, the endoscopist could not only pull but also push the lesion through the snare (Figure 2). Fixing the slider of the snare with clothespins reduced the number of assistants needed for the procedure (Figure 1G). The use of an overtube was not necessarily required. All ESD procedures were performed under unconscious sedation without intubation. We used midazolam, pentazocine, and propofol for appropriate sedation during ESD.

Data evaluation

The primary endpoint of this study was comparison of total procedure time of gastric ESD. As secondary endpoints, the proportion of *en bloc* resection and complications were evaluated.

All videos of ESD procedure have been stored in an electronic archive. From these recorded videos, we measured the total time of the procedure from precutting up to tumor removal. *En bloc* resection was defined as a one-piece resection of the entire lesion that was endoscopically recognized. Complications included intractable bleeding during ESD, perforation during ESD, delayed perforation, delayed bleeding, and anesthesia-related complications. Intractable bleeding during ESD was defined as operative hemorrhage that required more than 1 min for hemostasis. Delayed perforation was defined as perforation occurring after the day of ESD. Delayed bleeding was defined as bleeding from an ulceration of ESD, which manifested as hematemesis or melena after the day of ESD. Anesthesia-related complications were defined as circulatory disturbance (systolic blood pressure $\leqslant$ 90 mmHg or heart rate $\leqslant$ 50 beats/min) or respiratory depression (oxygen saturation $\leqslant$ 90% in spite of appropriate oxygen support) that were associated with anesthesia and occurred during the procedure.

Statistical analysis

All descriptive comparisons between the CSM-PLT lesions and their matched controls were made by Wilcoxon signed-rank test for continuous variables and by McNemar test or Bowker test for categorical variables. All *P* values calculated in this study were two-sided and were not adjusted for multiple testing. *P* values of < 0.05 were considered to be statistically significant. All analyses were performed using the statistical software JMP 11 (SAS Institute Inc., Cary, NC, United States). The statistical methods of this study were reviewed by Dr. Kunihiro Tsuji from the Department of Clinical Chemotherapy, Ishikawa Prefectural Central Hospital, Ishikawa, Japan.

RESULTS

According to match pairing, the demographics of both groups were completely similar in location, ulceration, specimen size, and experience of operators (Table 1). Additionally, macroscopic type, histologic type, and

Table 1 Comparison of lesion characteristics in patients who underwent gastric endoscopic submucosal dissection *n* (%)

	CSM-PLT group (*n* = 20)	Control group (*n* = 20)	*P* value
Location			1.000
Upper third	7 (35)	7 (35)	
Middle third	7 (35)	7 (35)	
Lower third	6 (30)	6 (30)	
Macroscopic type			0.475
0-Ⅱa	8 (40)	7 (35)	
0-Ⅱb	2 (10)	0 (0)	
0-Ⅱc	10 (50)	13 (65)	
Specimen size in mm, median (range)	35.5 (25-74)	34 (23-75)	0.999
Ulceration	1 (5)	1 (5)	1.000
Histologic type			0.783
Adenoma	4 (20)	2 (10)	
Tub1	14 (70)	15 (75)	
Tub2	2 (10)	2 (10)	
Por	0 (0)	1 (5)	
Tumor depth			0.655
Mucosal	17 (85)	18 (90)	
Submucosal	3 (15)	2 (10)	
Experience of ESD, yr			1.000
≤ 3	6 (30)	6 (30)	
4-6	10 (50)	10 (50)	
≥ 7	4 (20)	4 (20)	

Tub1: Well-differentiated adenocarcinoma; Tub2: Moderately differentiated adenocarcinoma; Por: Poorly differentiated adenocarcinoma; CSM-PLT: Clip-and-snare method using pre-looping technique; ESD: Endoscopic submucosal dissection.

Table 2 Comparison of clinical outcomes between the two techniques of gastric endoscopic submucosal dissection

	CSM-PLT group (*n* = 20)	Control group (*n* = 20)	*P* value
Total procedure time in minutes, median (range)	38.5 (8-145)	59.5 (19-132)	0.023
En bloc resection, number of lesion (%)	20 (100)	20 (100)	-
Complications			
Intractable bleeding during ESD, number of times, median (range)	0 (0-4)	1 (0-5)	0.086
Perforation during ESD, number of lesion (%)	0 (0)	0 (0)	-
Delayed perforation, number of lesion (%)	0 (0)	0 (0)	-
Delayed bleeding, number of lesion (%)	0 (0)	2 (10)	0.157
Anesthesia-related complications, number of lesions (%)	0 (0)	0 (0)	-

CSM-PLT: Clip-and-snare method using pre-looping technique; ESD: Endoscopic submucosal dissection.

tumor depth were comparable in both groups.

The total procedure time for the CSM-PLT group was significantly shorter than that for the control group (38.5 min *vs* 59.5 min, *P* = 0.023). All lesions were resected *en bloc* by ESD. There was no significant difference between the two groups with regard to the complications. In particular, there was no complication in the CSM-PLT group (Table 2).

In one large lesion (size: 74 mm) that underwent CSM-PLT during ESD, we used an additional CSM-PLT on another edge of the lesion after achieving the maximum possible submucosal resection during initial CSM-PLT. In two lesions, the snare came off the lesion together with the clip after a sudden pull; CSM-PLT was performed again for one lesion, whereas the other lesion did not undergo additional CSM-PLT because submucosal resection was almost completed with initial CSM-PLT.

DISCUSSION

The results of this retrospective study have demonstrated that CSM-PLT was able to shorten the total procedure time for gastric ESD without a decline in the proportion of *en bloc* resection and no increase in complications. A Shortening of the procedure time is clinically significant because it facilitates reduction in dose, duration of exposure, and risks of sedative use during ESD. Furthermore, a shortened procedure time can reduce the working hours of medical staff, including physicians and nurses. Consequently, a reduction in the cost associated with ESD can be expected, as Suzuki *et al*[10] showed in their article.

We considered two reasons for the shortening of ESD procedure time by CSM-PLT. First, when we lifted the mucosal layer by applying an appropriate tension to a lesion edge, we were able to obtain good visibility of the submucosal layer. Good visualization facilitated the identification of blood vessels and of the dissection line on the submucosal layer. Easy visualization of vascular structures resulted in easier hemostasis and pre-coagulation of vessels at a risk of bleeding. Identification of the dissection line greatly contributed to incision speed and safety. In this regard, it is necessary to understand that compared with conventional ESD, in ESD using CSM-PLT, the muscular layer may be elevated by traction. Accordingly, to avoid perforation during ESD using CSM-PLT, resection after recognizing a proper dissection line is more important. Second, the taut submucosal layer with traction allowed endoscopists to incise it with less power such as that for cutting a taut paper with a knife. These advantages are thought to be common among the other traction methods.

CSM-PLT is more advantageous than other traction methods. First, it not only facilitates the control of the degree of strength but also of the direction of traction. With the use of CSM-PLT, we could coordinate a two-way direction by pulling and pushing the snare, although the double-scope method would be more controllable[15]. In contrast, internal traction[5] and medical ring[6] cannot coordinate both traction strength and direction. Clip-with-line[7-10] can only pull but not push a lesion. Because traction adjustment is the most important factor in the traction method, this point was a major advantage of CSM-PLT. Second, PLT[19], which is a new method for the delivery of a snare, made it easy to perform CSM for lesions on all sites of the stomach. Because the delivery of a device for traction is difficult for lesions located on the upper third of the stomach, performing conventional CSM or other traction methods, such as external forceps method[12], is usually a challenge for such lesions. In one report involving one conventional CSM for intragastric proximal lesions, the procedure was successful in only one lesion on the corpus[18]. PLT facilitated grasping of the clip by the snare, particularly in cases wherein the clip was attached to the anal side of the tumor on the upper third of the stomach (Figure 1). In this report, we performed CSM-PLT and accomplished ESD for seven upper third lesions. Furthermore, PLT enabled the use of CSM even in ESD without an overtube; this would be an advantage for institutions where an overtube is not usually used. Third, because snare and hemoclip are common devices in almost all institutions where ESD is performed, CSM-PLT may be easily reproducible.

However, there are some disadvantages of CSM-PLT. Interference between the endoscope and snare may occur to some extent, despite the use of a thin snare with a maximum external diameter of 1.8 mm. A snare may detach from the lesion together with the clip when the endoscope is manipulated roughly. In fact, this situation occurred in two cases in this study. To avoid this, it is necessary for endoscopists to move the endoscope with care. It would also help if an assistant secures the snare tube on the mouthpiece of the patient during considerable manipulation of the endoscope by the operator. In addition, the incurred costs of the clip and snare are also a limitation of the method.

As Imaeda *et al*[16] described in their review, each of the several traction methods reported has both advantages and disadvantages. It is generally considered that traction method is useful for ESD, but it is unknown which technique is the best at present. As the advantages and disadvantages differ among the techniques, sufficient understanding of each method is needed for choosing the optimal procedure for an endoscopist and an institution. We are certain that CSM-PLT can become one of the promising alternative traction methods for gastric ESD.

There were several limitations of our study. First, it was conducted as a retrospective, single-institution study. Second, the sample size was small and subgroup analysis was not feasible. There were few lesions, such as large lesions or lesions with ulceration, which were typically difficult to treat by conventional ESD. In this study, we could not examine the efficacy and safety of CSM-PLT on these refractory lesions. At present, we are increasing the number of cases and we plan to clarify the characteristics of lesions for which CSM-PLT would be more effective. Third, because the control group in this study included lesions that were resected conventional ESD, we cannot be certain whether CSM was more useful than the other traction methods. Further prospective, multi-institutional studies are warranted to confirm the efficacy and safety of CSM-PLT.

In conclusion, the CSM-PLT was an effective and safe technique for gastric ESD. CSM-PLT is a promising method, and we believe that it can contribute to further development of ESD.

COMMENTS

Background

Endoscopic submucosal dissection (ESD) is one of the standard treatments for early gastric cancer. However, ESD is complicated and difficult. Therefore, a technique that will facilitate ESD is desired.

Research frontiers

Several traction methods, which apply appropriate tension to the lesion in order to visualize the submucosal layer, have been described as techniques for an effective ESD.

Innovations and breakthroughs

Clip-and-snare method using pre-looping technique (CSM-PLT) is a type of traction method. CSM-PLT enables control of the degree and two-way direction of traction with the use of commonly available devices, such as hemoclip and snare.

Applications

CSM-PLT is considered to be effective when endoscopists who are able to perform conventional ESD apply it for lesions which conventional ESD have been intended for.

Terminologies

CSM (clip-and-snare method): A genetic term for a traction method that facilitates control of traction to the lesion with the use of a snare, which strangulates a clip attached to the lesion. CSM-PLT: CSM using pre-looping technique, which is a new technique for snare delivery, facilitates easy performance of CSM for lesions on all sites of the stomach.

Peer-review

This is a very interesting and very well done case-control study which tries to evaluate a new additional method for shortening the time spent during ESD and for making it easier and safer.

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