Tech Coloproctol (2013) 17:117–123
DOI 10.1007/s10151-012-0882-x

TECHNICAL NOTE

Transanal single-port laparoscopic total mesorectal excision in the treatment of rectal cancer

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Received: 16 March 2012 / Accepted: 12 August 2012 / Published online: 31 August 2012

Abstract Our objective was to report of our first experience with transanal total mesorectal excision (TME) of rectal cancer using single-port equipment, a pure natural orifice transluminal endoscopic surgery (NOTES) procedure, and to discuss the advantages and disadvantages of the technique. A patient with rectal cancer was selected according to preoperative evaluation criteria. Purse-string sutures were placed into the rectum distal to the tumor using the procedure of prolapse and hemorrhoids (PPH) anoscope. A full-thickness incision of the rectal wall was made circumferentially below the purse string and a three-channel cannula was inserted. The artificial orifice was insufflated. The entire mesorectum was dissected upward according to the principles of TME. Pneumoperitoneum was created by opening the rectouterine pouch. The sigmoid colon and its mesentery were dissected, and the inferior mesenteric vessels were ligated and divided. After dissection of a sufficient length of sigmoid colon, the PPH anoscope and the three-channel cannula were removed. The rectum and sigmoid colon were brought out through the anus. The tumor was resected. After removal of the specimens, a stapled end-to-end anastomosis was fashioned between the rectum and the sigmoid colon. Operative time was 300 min. The mesorectum was completely removed with negative distal and circumferential margin. The final pathological stage was pT3N1M0, with one positive lymph node (1/12). The patient recovered uneventfully after surgery. Pure-NOTES performed as transanal single-port laparoscopic TME for rectal cancer appears to be feasible and safe.

Keywords Rectal cancer · Single-port laparoscopic surgery · Total mesorectal excision · Natural orifice transluminal endoscopic surgery (NOTES) · Hybrid transnatural orifice surgery

Introduction

Transanal total mesorectal excision is a surgical procedure compatible with the concept of natural orifice transluminal endoscopic surgery (NOTES). To date, surgeons have carried out clinical studies of combined transanal endoscopic microsurgery (TEM) or similar surgical procedures and laparoscopic technique, for example, hybrid-NOTES, and considered that this technique was feasible [1, 2]. Recently, other scholars performed pure transanal total mesorectal excision (TME), namely pure-NOTES experiments, on fresh cadavers and achieved satisfactory outcomes [3, 4]. However, to our knowledge, no clinical report about the latter technique has yet been published. Here, we present a first report of one case of pure transanal TME performed using single-port laparoscopy.

Case report

Patient's clinical characteristics

A 48-year-old-female (body mass index, 20 kg/m^2) was admitted to our hospital due to blood in stool and increased frequency of defecation for 3 months. The results of colonoscopy showed a cauliflower-shaped mass inside the

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rectum located 8 cm from the anus. The lumen was narrow; the mass was 3.5 cm in length and occupied half of the lumen. The colonoscope was able to pass through the narrowed lumen. The surface of the mass was ulcerated, hard, brittle, and bled easily. A biopsy was taken. The pathology report described grade II rectal adenocarcinoma. On physical examination, there were no palpable abdominal mass and no tenderness or rebound tenderness. Digital rectal examination revealed a mass 3.0 cm in diameter and about 8 cm from the anal margin. Carcinoembryonic antigen (CEA) was 4.45 ng/ml. There were no abnormal findings on plain chest X-ray. An abdominal computed tomography (CT) scan with contrast showed nodular thickening of the rectal wall 7.0 cm from the anal margin. The area involved was about 4.0 × 3.0 × 1.5 cm. Scattered small lymph node signals were observed within the peripheral fat. On three-dimensional CT, the length of the sigmoid colon was about 40 cm. No enlarged lymph nodes were found near the inferior mesenteric artery. The thicknesses of the mesorectum were 3.5 cm on the left, 3.0 cm on the right, and 1.5 cm anterior to the sacrum. The origin of the superior mesenteric artery was at the left side of the abdominal aorta, 27.7 cm from the anal margin. Preoperative CT staging of rectal cancer was T3N1M0. The distance between the iliac crest and the anal canal was 19 cm. According to our assessment, the length of the patient's sigmoid colon was suitable for a pure-NOTES procedure with a sufficient (≥10 cm) proximal margin and without the need for high ligation or mobilization of the splenic flexure.

Surgical instruments and materials

Equipment included high definition (HD) laparoscope (10 mm 30° rigid lens) (KARL STORZ Endoskopic, Germany); single-port laparoscopic instruments (provided by Hangzhou Tonglu Kangrilong Medical Device Company, Hangzhou, China); PPH Anoscope (ETHICON Endo-surgery, Inc., USA); homemade needle-tip electrocautery, ultrasonic scalpel (ULTRACISION. Harmonic Scalpel, ETHICON Endo-surgery, Inc., USA); LigaSure Vessel Sealing System (Covidien, Boulder, CO, USA); circular stapler (ETHICON Endo-surgery, Inc., USA); and Hem-o-lok laparoscopic clip applier (Teleflex Medical Durham USA).

Surgical technique

Preoperative preparation

The patient was given oral metronidazole (0.4 g tid) and oral norfloxacin (0.5 g) for 3 days prior to the operation. Polyethylene glycol was administered to the patient at 8 p.m. 1 day before the operation for bowel preparation. Prophylactic intravenous antibiotic (cephalosporin) was administered before the surgical procedure. After anesthesia, urethral and central venous catheters were inserted.

The patient was placed in a lithotomy position. The rectum was irrigated and sterilized with iodine. The patient was then placed in a 30° Trendelenburg position.

Transanal full-thickness rectal resection

The PPH anoscope was inserted into the anus and then was sutured and fixed to the perianal skin. The distance between the tumor and the anal margin was measured accurately to identify the distal cutting line of the rectum. In the present case, the distance between the tumor and the anal margin was 7 cm. The cutting line on the rectal wall was 4 cm from the anal margin. In an attempt to decrease the chance of cancer cell implantation, FuAiLe medical adhesive (Beijing Fuaile Science and Technology Development Company, Beijing, China) was sprayed on the surface of the tumor, the rectal cavity was closed by a silk purse string 1 cm from the inferior margin of the tumor, and then the medical adhesive was sprayed again. The rectal cavity was closed with a second silk purse string 1 cm from the former. The full-thickness rectal wall was excised with needle-tip electric scalpel 1 cm from the closed end (Fig. 1) to expose the rectovaginal septum (Denonvilliers fascia) and the presacral space.

Transanal dissection of the mesorectum (TME)

A uterus-lifting apparatus was inserted. A three-channel cannula was placed into the transected rectal incision through the PPH anal dilator (Fig. 2). Carbon dioxide (10 mmHg) was insufflated, and laparoscopic instruments were inserted to first dissect the presacral space.

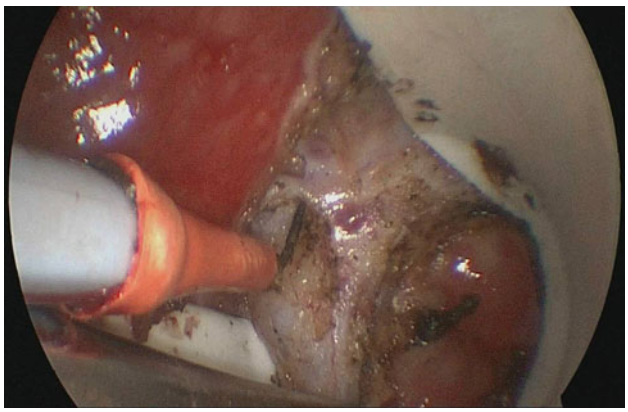

Fig. 1 The rectal cavity was closed with a purse-string suture, and a full-thickness resection of the rectal wall was performed with a needle-type electric scalpel through the PPH anoscope

Under pressure of the gas, this loose space was easily identified and could be dissected easily to the retroperitoneal space (Fig. 3). The rectovaginal septum was then dissected. This septum was relatively dense and the posterior wall of the vagina was carefully identified during the procedure. Dissection was carried out upward to the rectouterine pouch (peritoneal fold at the pelvic floor) and was continued laterally. Bilateral rectal ligaments were divided. The peritoneum was carefully cut open at the peritoneal reflection and the gas was insufflated into the abdominal cavity through the incision (Fig. 4). The small intestine within the pelvic cavity was pushed into the upper part of the abdominal cavity, and the rectum was completely mobilized. The rectum and sigmoid colon were then pushed into the abdominal cavity.

Transanal intraperitoneal operation

Along the abdominal aorta, the mesentery tissue was dissected upward to the root of the inferior mesenteric artery. Because a certain angle exists between the pelvic cavity and the abdominal cavity, the iliac vessels bulge along the margin of the pelvis, which limits the intraperitoneal operation. However, the peripheral tissue around the inferior mesenteric vessels and sigmoid mesentery is generally loose, so effective surgical exposure and complete isolation of the sigmoid colon can be achieved by carefully managing the direction and intensity of traction (Fig. 5). If necessary, curved single-port laparoscopic instruments can be applied. The mesenteric vessels were clipped by Hem-o-lok Ligating Clips (Weck Corporation, CO, USA) and divided (Fig. 6). The sigmoid mesentery was isolated and trimmed by the LigaSure Vessel Sealing System (Covidien, Boulder, CO, USA). Under the laparoscope, the sigmoid colon was revealed to be sufficiently long for tension-free anastomosis, and then the rectum and sigmoid colon were extracted through the anus (Fig. 7).

Fig. 2 The three-channel cannula (H-shape) is adapted inside the PPH anoscope

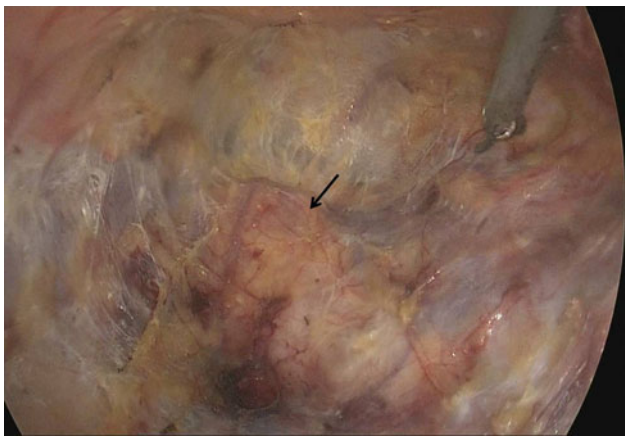

Fig. 3 Dissection of the presacral space to the retroperitoneal space. The bulging portion is the sacral promontory, and "tent-like" surgical field was produced by the gas. *Arrow* pointing to the sacral promontory

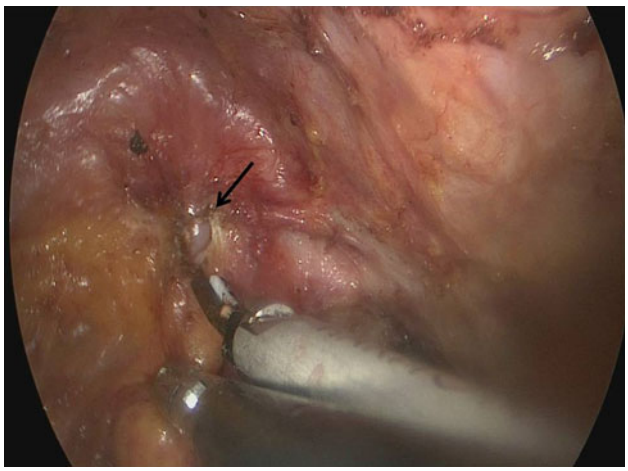

Fig. 4 Cutting open the uterorectal pouch at the peritoneal reflection. *Arrow* pointing to the peritoneal incision

Resection and reconstruction of the rectum

The sigmoid colon was excised 10 cm proximal to the upper margin of the rectal cancer. A stapler anvil was placed into the proximal end of the sigmoid colon, and then a purse-string suture was made and tied securing the l anvil that was pushed back into the pelvic cavity. The PPH anoscope was inserted again. A drainage tube was placed in the pelvis through the levators and the ischiorectal fossa. Another purse-string suture was made for the distal end of the rectum under direct vision and tied around the same anvil that was secured in the sigmoid colon (Fig. 8). An end-to-end anastomosis was performed using a No. 33 circular stapler.

Fig. 5 Isolation of sigmoid mesentery. Because mesentery is loose, strong traction must be applied for the dissection of the entire mesentery

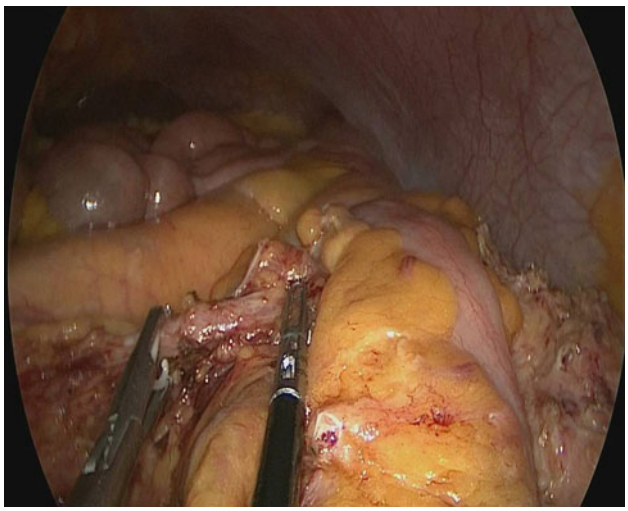

Fig. 6 Ligation of the inferior mesenteric artery. The operation confirmed that origin of the superior mesenteric artery was 27.7 cm away from the anal margin (the same as on the preoperative CT scan). So, the vessel could be clipped with Hem-o-lok Ligating Clips (36 cm)

Technical points

Application of the PPH anoscope facilitated the exposure and manipulation of the lower rectum. Suture and closure of the rectum distal to the tumor may prevent the overflow of the intestinal contents and avoid gas perfusion into the intestine. Gas insufflation can be carried out after installation of the three-channel cannula, which enlarges the space for operative manipulation and identifies the interstitial space more clearly. After complete dissection of the pelvic floor and presacral space, the upward dissection close to the posterior wall of the vagina allows to isolate the fold in the peritoneal reflection. The peritoneum can be

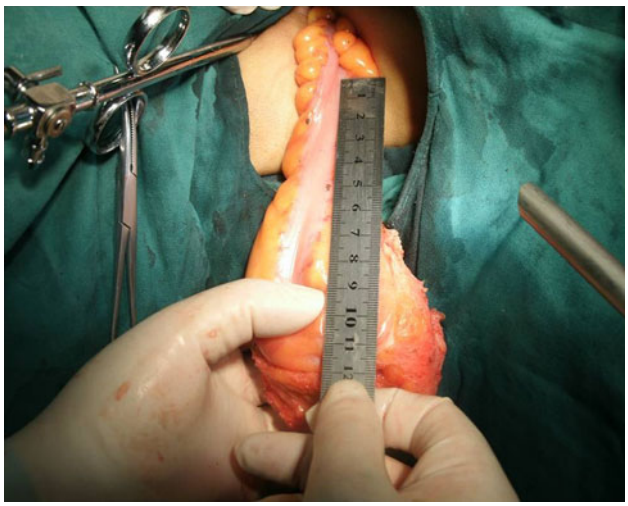

Fig. 7 The rectum was pulled out through the anus. The distance from the tumor and the proximal surgical margin was 10 cm

cut open at the peritoneal reflection to safely enter the abdominal cavity. Isolation of the sigmoid mesentery within the abdominal cavity can be progressively carried out along the retroperitoneal space. Effective traction and exposure are the key points. The PPH anoscope should be removed first and the rectal specimen may be taken out after enough anal dilation. The key point of intestinal reconstruction should be full-thickness purse-string suture of the rectal stump, which may ensure a reliable anastomosis. Because the anastomosis is close to the anal margin, it can be reinforced under direct vision.

Postoperative pathology and recovery

The total operation time of this case was 300 min, and the total blood loss was 50 ml of serosanguinous fluid and lipid droplets. The mesorectal fascia was intact. The pathological examination showed that the mass was a rectal adenocarcinoma (grade II, ulcer type, 4.0 × 3.0 × 1.2 cm in size), which invaded the fat tissue outside the intestinal wall. The upper and lower surgical margins of the rectum and the circumferential margin were all negative. One out of twelve lymph nodes within the fat tissue around the intestinal wall was positive. The patient recovered uneventfully after surgery. Enteral nutrition was started on postoperative day 2. Semifluid and normal diet was started on postoperative day 4 and day 7, respectively. Only a small amount of light bloody fluid was drained through the perianal drainage tube, which was removed on postoperative day 2. No anastomotic leakage or infection occurred. Defecation started from the second postoperative day. The patient developed anal incontinence that resolved spontaneously on postoperative day 4.

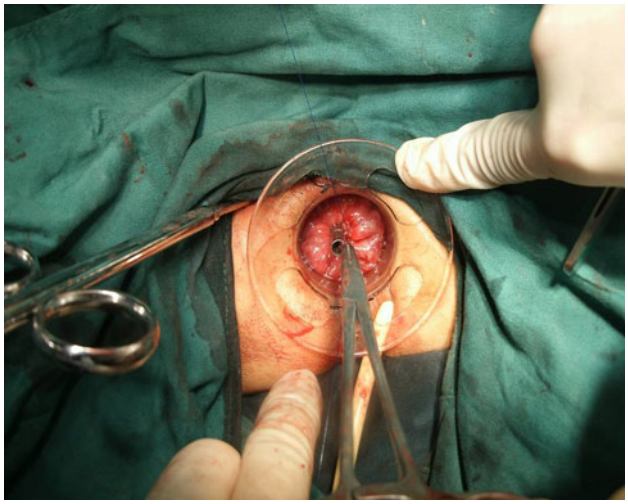

Fig. 8 A purse-string suture was placed at the proximal end of the sigmoid colon and at the distal stump of the rectum, to secure the anvil

Discussion

NOTES is a novel minimally invasive treatment. It pushes the concept of minimal invasiveness to new heights and is the most minimally invasive treatment method to date, a result of rapid progress of the therapeutic endoscopic technique in the last 10 years. Clinicians recognized that a natural orifice could be utilized as a route for intraabdominal surgery, making it possible to avoid surgical wounds on the abdominal wall. In the first years of the NOTES era, flexible scopes were used [5, 6]. However, application of flexible endoscopic NOTES technique is limited because of problems such as difficulty in wound closure after cutting open the organs, abdominal cavity infection, and difficulty in spatial orientation [6–9]. Just as surgeons became aware of these limitations, single-port laparoscopic surgery (SPLS) came into being. SPLS is carried out through a single, narrow umbilical port with reduced surgical trauma and better cosmetic results. Because of its rapid progress, SPLS can be extended to complicated radical resection of gastrointestinal tumors [10–13]. Given this progress, is it possible to carry out radical resection of a colorectal tumor with a single-port NOTES? As regards tumor location, single-port NOTES is most suitable for rectal tumors. TEM has already been successfully applied in the local resection of early-stage rectal tumors [14–16]. Can TME be performed transanally? This undoubtedly presents a challenge for surgeons. To date, some authors have completed clinical studies about performing TME using hybrid-NOTES [1, 2], namely dissecting the rectum using abdominal ports and removing the specimen through the anus. However, this requires an auxiliary abdominal incision to carry out abdominal inflation, observation, and dissection using the laparoscopic technique. Cid et al. [17] suggested that the single-port laparoscopic technique can be used for the treatment of early-stage rectal cancer or benign rectal tumors. Studies have recently investigated transanal NOTES of the rectum in cadavers. Fajardo et al. [3] first used TEM and single-port laparoscopic technique to perform pure transanal low anterior rectal resection in fresh cadavers and concluded that this kind of surgery was feasible and in accordance with oncological principles. Bhattacharjee et al. [4] carried out a similar experiment on 3 cadavers using modified TEM instruments and considered that pure transanal TME was feasible. The transanal procedure precisely identifies safe margins, provides an excellent operative field for dissecting the mesorectum, and reduces abdominal injury.

Our surgical team performed one case of pure transanal single-port laparoscopic TME on October 6, 2011. Several key points must be considered when performing this procedure. (1) It should be carefully confirmed before surgery whether the patient is suitable for pure-NOTES. It is most important that no contraindications to laparoscopic surgery exist and that the sigmoid colon is sufficiently long, the size of rectal tumor is not be too large, and the mesorectum is not excessively thick. In order to accomplish complete tumor resection, transanal removal of the specimen and reconstruction of the intestine should be evaluated thoroughly. (2) Infection and tumor cell implantation are potential complications of transanal tumor surgery. Oral antibiotics should be administered before surgery, adhesive materials should be sprayed on the tumor surface under direct vision, and the rectal cavity should be closed with sutures. (3) The surgeon should have sufficient training in SPLS and be familiar with anatomical landmarks, organs, and tissues under transanal vision. The main structures include the mesorectal fascia, rectovaginal septum, sacral promontory, and peritoneal fold. (4) "Down-to-up" mesorectal dissection, transanal intraabdominal manipulation, removal of the specimen, and intestinal reconstruction are more difficult than those of routine laparoscopic surgery. The surgeon should be familiar with single-port laparoscopic manipulation and experienced in the transanal removal of the rectal specimen and intestinal reconstruction. During complete isolation of the mesorectum, a certain order should be followed: the surgeon should first dissect the presacral space, then the rectovaginal septum, and finally the rectal lateral ligament. The presacral space should be dissected after gas insufflations during surgery. Because of gas pressure, a "tent-like" expansion will be found in front of the presacral space, elevating the pelvic organs and tissues automatically, and it is very helpful for the identification and dissection of related tissues. (5) When dissecting the rectovaginal space, the middle and inferior parts of the vagina are relatively dense and

dissection is also difficult. If we pay attention to the dendritic distribution of tiny vessels on the vaginal surface, vaginal injury is less likely. The septum on the upper part of the vagina is relatively loose, so dissection and exposure is relatively easy because these are fatty issues. (6) It is safe to cut open the peritoneum at the peritoneal reflection, and pneumoperitoneum can be produced through the peritoneal incision without injecting gas through another abdominal incision. The patient is placed in a 30° head-up supine position, and the rectum, sigmoid colon, and small intestine can be pushed into the abdominal cavity (lifting the uterus in female patients using a uterus-lifting apparatus) to obtain a satisfactory intraabdominal surgical field. (7) The root of the inferior mesenteric artery can be localized by preoperative CT scan (It was 27.7 cm from the anal margin in the present case). The conventional ultrasonic scalpel and Hem-o-lok laparoscopic clip applier can reach this point through the anus. Therefore, the root of the vessel can be treated through the anus. Dissection between the sigmoid mesentery, descending colon, and the transition area of the lateral peritoneum should be performed carefully. Curved single-port surgical instruments can be applied if necessary. The LigaSure device is recommended for dissecting the proximal end of the mesorectum. (8) Anal dilation should be carried out before removing the specimen. The specimen should be removed carefully. Circular staplers can be used for the reconstruction of the sigmoid colon and the rectum, and the purse-string suture of the rectal stump should be full thickness.

Advantages of this surgical procedure: (1) It has all the advantages of NOTES. There is no incision and this prevents incision-related complications. Postoperative pain is mild, recovery is quick, and the cosmetic result is excellent. (2) Treatment of the surgical margin is reliable. The distal edge of the tumor is clearly visualized to ensure adequate margin. In dubious cases, the distal edge can be immediately sent for frozen section analysis. The circumferential margin of tumor invasion is also easily identified. (3) Application of the PPH anoscope can make various inspections and manipulations within the rectal cavity possible under direct vision, and it also fits the three-channel cannula. (4) The three-channel cannula is used for gas insufflation to create the surgical cavity rendering manipulation accurate and easy. (5) Compared to the TEM technique, the SPLS technique is inexpensive, easy to manage, and can be widely utilized.

Shortcomings of this surgical procedure: (1) The possibility of infection and tumor spread may increase with tumor manipulation and should be prevented with appropriate measures. (2) Transanal intraabdominal manipulation, removal of the specimen, and intestinal reconstruction are more difficult than those of routine laparoscopic surgery. The surgeon should be familiar with SPLS and experienced in the transanal removal of the rectal specimen and intestinal reconstruction. (3) Temporary anal incontinence is a possibility, but usually resolves spontaneously about 1 week after surgery. (4) Not all patients are suitable candidates for this surgical procedure. If the tumor is relatively large, the mesorectum is relatively thick, the sigmoid colon is relatively short, and the anus narrow, then this kind of surgical procedure is not suitable.

Conclusions

Single-port laparoscopic transanal TME appears to be safe and feasible. It can be called a pure-NOTES procedure. The conventional single-port equipment can be properly applied to complete some relatively complicated cases using pure-NOTES. More cases and longer observation are needed to determine whether potential problems exist in the single-port laparoscopic transanal TME. Improvements in instruments and accumulation of experience may lead to the perfection of this surgical procedure. Regardless of whether pure-NOTES is applied or not, single-port laparoscopic transanal TME when compared to transabdominal surgery may reduce the difficulty of the surgical procedure and improve the quality of surgery especially for low or ultra-low rectal cancers. It is our belief that this surgical procedure is safe and feasible for treating rectal cancer and has potential value for further applications.

Conflict of interest None.

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