

Transanal natural orifice transluminal endoscopic surgery total mesorectal excision in animal models: endoscopic inferior mesenteric artery dissection made easier by a retroperitoneal approach

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Purpose: We report the performance of natural orifice transluminal endoscopic surgery (NOTES) low anterior resection in animals using transanal total mesorectal excision (TME) with laparoscopic assistance and endoscopic inferior mesenteric artery (IMA) dissection.

Methods: Four pigs weighing 45 kg each, and one dog weighing 25 kg, underwent surgery via a transanal approach. The rectum was occluded transanally using a purse-string suture, approximately 3–4 cm from the anal verge. The rectal mucosa was incised circumferentially just distal to the purse-string. A SILS or GelPOINT port was inserted transanally. Transanal TME was assisted by laparoscopy and proceeded up to the peritoneal reflection. More proximal dissection, including IMA dissection, was performed along the retroperitoneal avascular plane by endoscopy alone and facilitated by CO₂ insufflation. The IMA was clipped and divided endoscopically. The mobilized rectosigmoid were exteriorized transanally and transected. A colorectal anastomosis was performed using a circular stapler with a single stapling technique.

Results: Endoscopic dissection of the IMA was successful in all five animals. The mean operation time was 125 minutes (range, 90–170 minutes). There were no intraoperative complications or hemodynamic instability. The mean length of the resected specimen was 14.4 cm (range, 12–16 cm).

Conclusion: A NOTES retroperitoneal approach to the IMA with CO₂ insufflation and intact peritoneal covering overcame the difficulties of retraction and exposure of endoscopic dissection in animals.

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Key Words: Natural orifice transluminal endoscopic surgery, Retroperitoneal approach, Total mesorectal excision, Inferior mesenteric artery

INTRODUCTION

Natural orifice transluminal endoscopic surgery (NOTES) is a new method of using a natural orifice to access the intra-

abdominal space. Despite experimental and clinical studies, however, NOTES has encountered many complex obstacles and technical limitations associated with endoscopic surgery, including limitations in endoscopic tools, less precise move-

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ments, and relatively poor ability to steer the flexible scope [1-4]. Rather than adhering to pure NOTES or waiting for the development of more sophisticated instruments, these problems have led to the development of a hybrid NOTES technique, utilizing specific endoscopic or laparoscopic skills [5]. For example, peroral endoscopic myotomy (POEM) has become an established therapeutic option for the treatment of achalasia [5-8], and transanal total mesorectal excision (TME), a hybrid of transanal NOTES and single port laparoscopy, is a new, minimally invasive type of surgery used for colorectal resection [9-13].

Although transanal TME may represent an extension of traditional intersphincteric resection, most surgeons are unfamiliar with the bottom-up approach to pelvic anatomy. The major anatomic obstacles limiting instrument access are the acute angle at the sacral promontory and more proximal structures [14,15]. Although the hybrid technique has overcome some of the limitations of NOTES, transanal NOTES TME may not be considered NOTES. While following the basic concept of NOTES, using a natural orifice as an access route, the most critical steps in transanal NOTES TME are performed using laparoscopic instrumentation. In addition, it is difficult for individual laparoscopic instruments to blindly enter and pass through a narrow and curved tunnel on the dissected plane. Specifically, inserting instruments to the point being dissected can result in breakdown of the mesorectal envelope. This study was therefore designed to determine whether endoscopic dissection of the inferior mesenteric artery (IMA) is feasible and safe in transanal TME with laparoscopic assistance in animal models.

METHODS

All animal experiments were performed in the Animal Laboratory of Konkuk University, Korea, from May to September 2013. The study protocol was approved by the Institutional Animal Care and Use Committee (IACUC) of Konkuk University (IACUC No. KU13146).

Animal preparation

NOTES low anterior resection was performed on five live animals, four pigs weighing 45 kg each and one dog weighing 25 kg. The animals were fasted overnight before the procedure. General anesthesia was induced with intramuscular Telazol 5 mg/kg + xylazine 2 mg/kg, and the animals were intubated. Anesthesia was maintained with isoflurane (1.5%–3.0%) and oxygen (3.0 L/min). Tap-water enemas were administered through a rigid proctosigmoidoscope until the effluent was clear.

Surgical procedures

The rectum was occluded transanally using a purse-string suture, approximately 3–4 cm from the anal verge. The rectal mucosa was incised circumferentially just distal to the purse-

string. A SILS or GelPOINT port was inserted transanally. Rectal and mesorectal dissection was performed using electrocautery or an energy device (Ligasure, Covidien, Norwalk, CT, USA). Transanal TME was assisted by laparoscopic instruments and proceeded up to the peritoneal reflection. A 5-mm laparoscopic camera (Karl Storz Endoscopy, Tuttlingen, Germany) and two instruments were used via the working ports (two 5-mm ports). When the peritoneal reflection was visualized, the peritoneum of the rectosigmoid was kept intact until subsequent IMA dissection was completed. Proximal dissection was continued along the retroperitoneal avascular plane via transanal endoscopic dissection alone, which was facilitated by CO₂ insufflation. Mesocolic dissection and IMA pedicle isolation were achieved using a coagrasper (FD-410LR, Olympus Co., Tokyo, Japan) and clipped using endoscopic clips (hx-600-90, Olympus Co.). After completion of the IMA dissection, the peritoneal lateral attachments of the rectosigmoid, sigmoid, and descending colon were divided using a needle knife (Wilson-Cook Medical Inc., Winston-Salem, NC, USA). When the rectosigmoid colon was fully mobilized, it was exteriorized and transected. A colorectal anastomosis was performed using a circular stapler with a single stapling technique. The anastomosis was inspected using a colonoscope. Intraoperative variables were recorded, including operation time, procedural complications, and length of rectosigmoid mobilized. The surgical procedures are summarized in a video (Supplementary material).

RESULTS

All five animals underwent transanal TME with laparoscopic assistance and a pure NOTES technique for IMA dissection and division (Fig. 1). Adequate anatomic exposure around the IMA was facilitated in all five by retroperitoneal insufflations of CO₂. The pneumoretroperitoneum facilitated endoscopic dissection



Fig. 1. Procedure of NOTES low anterior resection (Video clip can be operated via <http://www.astr.or.kr/src/sm/astr-87-1-s001.mpg>).

and showed an upward traction effect on the IMA pedicle. Thus, endoscopic dissection could be performed without laparoscopic assistance. Endoscopic dissection and division of the IMA using a needle knife and clipping using an endoscopic clip device were successfully performed in all animals. Overall, the mean operation time was 125 minutes (range, 90–170 minutes), and the mean length of the specimen was 14.4 cm (range, 12–16 cm). There were no intraoperative complications or episodes of hemodynamic instability.

DISCUSSION

To date, a multitasking platform and promising tools for the performance of pure NOTES procedures via endoscopy have not yet been developed or are not yet ready for clinical use [16]. Thus NOTES techniques may remain experimental or preclinical, with laparoscopic surgery being sufficient for minimally invasive performance of almost all intra-abdominal procedures. NOTES has therefore evolved into hybrid NOTES, with each step optimized for safe and realistic performance according to the specific indication [5]. Clinically, the POEM technique is used to treat achalasia [6-8], and transanal NOTES TME is utilized for colorectal resection [10-13].

Despite transanal NOTES TME being a new, minimally invasive surgical method of colorectal resection, laparoscopic instruments have difficulty overcoming the acute angle at the sacral promontory and performing more proximal colon dissection and mesenteric mobilization [14,15]. In our experience, these difficulties with laparoscopic instruments are increased when the operative field is outside the pelvis. Aspirating smoke makes the operative field collapse, and the instruments are likely to collide with each other and to be difficult to handle during more proximal dissection. Furthermore, passing instruments through the narrow pelvis may damage the envelope of the dissected mesorectal fascia and the presacral venous plexus. A type of overtube may be necessary to protect the narrow dissected structure and to allow instruments free access from the anus to the point being dissected.

The traditional intraperitoneal approach requires additional traction using combined laparoscopic or transgastric endoscopic assistance for adequate exposure of the operative field [17,18]. Transgastric endoscopic assistance has been reported to significantly extend the length of the rectosigmoid mobilized transanally, with mean lengths of the specimen and mobilized colon obtained with transgastric endoscopic assistance of 9 cm and 15.6 cm, respectively [15]. In comparison, the mean specimen length we obtained by endoscopy alone was 14.4 cm. Laparoscopic assistance during transanal TME is required for retraction, colonic mobilization, and dissection and division of the IMA [10,12,13,19]. Endoscopic instrumentation alone is considered to be of limited utility for tissue retraction.

The IMA pedicle was divided using a laparoscopic stapler or energy device via the anus or planned stoma site. However, the situation could differ when performing procedures retroperitoneally rather than intraperitoneally. First, CO₂ insufflation facilitates dissection of the surgical planes [17]. Since it was important to keep the peritoneum intact until IMA division and dissection were completed, the tissue was retracted upwardly like a parachute without laparoscopic or additional endoscopic assistance. Thus, CO₂ insufflation and intact peritoneal covering enabled endoscopy alone to dissect the IMA pedicle and lateral attachments.

A retroperitoneal endoscopic approach has been used as a transanal NOTES TME procedure [20], a method similar to ours for complete retroperitoneal mobilization of the left colon and mesenteric vessels without entering the abdominal cavity. That study, however, used a novel endoscopic surgical platform (IsisScope, Karl Storz) or laparoscopic instruments to dissect the IMA and retrieve lymph nodes. In addition, the IMA and IMV were controlled with a laparoscopic vessel sealing device, endoscopic clips, or a ligature made with the IsisScope. Although we found that endoscopic clipping of the IMA was safe, endoscopic clips have been reported to be unreliable for vascular and ductal ligations [21]. Secure vascular control may require an energy device for IMA division because of the current limitations of endoscopic instruments. Although endoscopic manipulation is technically demanding and time-consuming, its benefits include the close-up magnified view provided by the endoscope and a lack of collision between instruments, allowing an anatomically precise dissection. Moreover, a retroperitoneal approach made endoscopic dissection easier.

The present study had several limitations. Although swine have a narrow pelvis and a steep angle at the sacral promontory, their pelvic anatomy differs from that of humans. The pelvis of swine is simpler and shorter than that of humans, whereas the mesentery of humans is much bulkier and denser, thus making it more difficult to manipulate endoscopically. It is uncertain whether this technique for pure endoscopic division of the IMA pedicle can be replicated in a human cadaver. Currently, laparoscopic assistance is still necessary for IMA pedicle handling and more proximal dissection over the sacral promontory. However, a retroperitoneal approach and endoscopic control of the major vessel may improve the dependence of NOTES TME on laparoscopy.

In conclusion, transanal TME and a pure NOTES technique for IMA dissection were technically feasible and safe in animals. A retroperitoneal approach with CO₂ insufflation and intact peritoneal covering enabled endoscopy alone to dissect the IMA pedicle and lateral attachments without laparoscopic or additional endoscopic assistance. This technique should be evaluated in human cadavers.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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SUPPLEMENTARY MATERIALS

Supplementary material (video clip) can be found via <http://www.astr.or.kr/src/sm/astr-87-1-s001.mpg>.

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