ORIGINAL ARTICLE

No-Scar Transanal Total Mesorectal Excision

The Last Step to Pure NOTES for Colorectal Surgery

Joël Leroy, MD, FRCS; Brian Donncha Barry, MD, FRCSI; Armando Melani, MD; Didier Mutter, MD, PhD; Jacques Marescaux, MD, FRCS(Hon), FJSES(Hon)

Hypothesis: Because of the concerns over the operative platform, accidental organ injury, and viscerotomy closure, natural orifice transluminal endoscopic surgery (NOTES) currently remains an experimental technique. Transanal NOTES for colorectal surgery overcomes all of these issues; however, all of the reports to date have used hybrid laparoscopic techniques. We demonstrate herein the first case, to our knowledge, of pure transanal NOTES colorectal surgery.

Design: Case report.

Setting: University hospital.

Patient: The patient was a 56-year-old woman with a midrectal neoplasia.

Intervention: Pure transanal NOTES total mesorectal excision with a coloanal anastomosis and without a diverting stoma. Using a transanal endoscopic operation device as a surgical platform, we created a viscerotomy distal to an endoluminal purse-string suture. We performed a total mesorectal excision using a "bottom-up" approach. The sigmoid colon was mobilized by a posterior, retroperitoneal approach and the colon was divided intraperitoneally. A hand-sewn, side-to-end, coloanal anastomosis was performed. Because the viscerotomy was incorporated into the anastomosis, the concerns of both accidental organ damage and viscerotomy closure were abrogated.

Results: The procedure was completed entirely by a transanal fashion. We successfully mobilized the rectum, mesorectum, and sigmoid colon. The specimen length was more than 20 cm. The patient required minimal analgesia and her pain was nonabdominal.

Conclusions: To our knowledge, the first pure transanal NOTES total mesorectal excision with retroperitoneal sigmoid mobilization and coloanal, side-to-end anastomosis was successfully performed using what we called a Peri-Rectal Oncologic Gateway for Retroperitoneal Endoscopic Single Site Surgery (PROGRESSS). This monumental case could pave the way for a new era in pure transanal NOTES for colorectal surgery.

JAMA Surg. 2013;148(3):226-230. Published online November 19, 2012. doi:10.1001/jamasurg.2013.685

Author Affiliations: IRCAD/EITS, Strasbourg, France.

DESPITE THE INITIAL FLURRY of interest after the advent of natural orifice transluminal endoscopic surgery (NOTES), the concerns over the surgical platform, accidental organ injury, and viscerotomy closure have hindered the advancement of the technique beyond the arena of experimental surgery.[1,2] Transcolonic NOTES has been performed using animal models for

See Invited Critique at end of article

a number of procedures including peritoneoscopy, cholecystectomy, ventral hernia repair, and even pancreatectomy.[3-6]

Since the initial cadaveric and animal experiences with transanal NOTES for colorectal surgery, researchers have been attempting to perform these techniques on humans.[7-9] Recently, hybrid NOTES procedures have been performed in humans.[10-12] In all cases, a hybrid laparoscopic technique with 1 to 3 transabdominal trocars was used, and inferior mesenteric artery ligation and retroperitoneal and mesocolic mobilization were performed using mostly standard laparoscopic techniques with patients receiving a diverting stoma.

Pure transanal NOTES for colorectal surgery has remained elusive until now. After several years of developing transanal NOTES techniques in animal, cadaveric, and hybrid NOTES/laparoscopic models, we now present the first case, to our knowledge, of pure transanal total mesorectal excision (TME) in a female patient.

METHODS

With internal review board approval, we selected a patient with an early, low rectal tu-

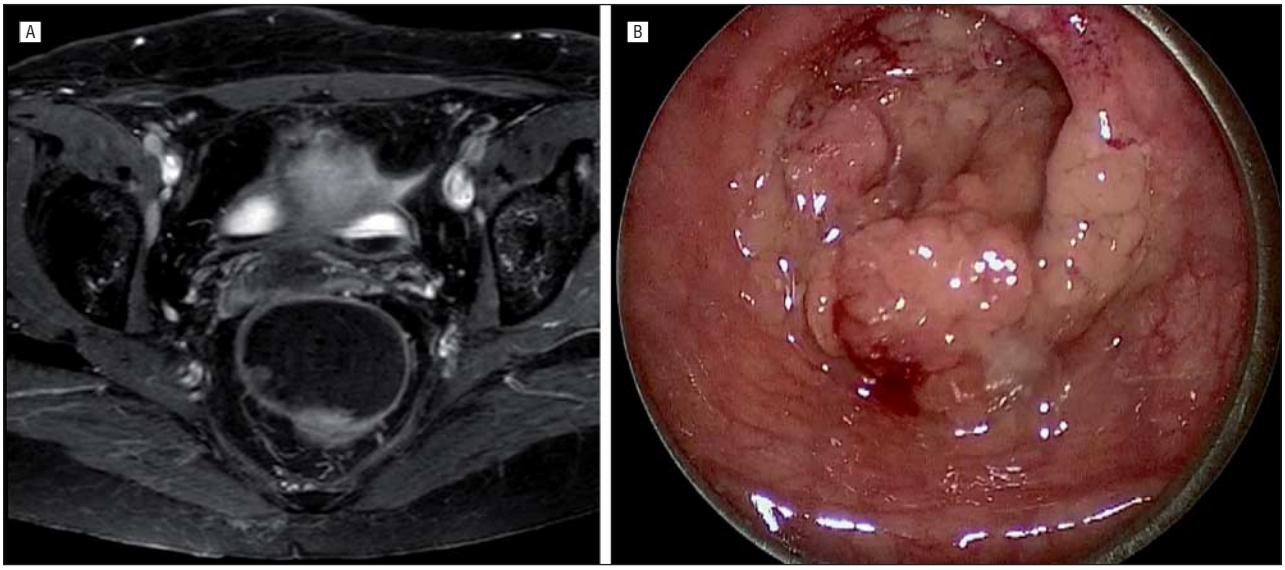

Figure 1. Magnetic resonance image of the rectal tumor (A) combined with the intraluminal view (B).

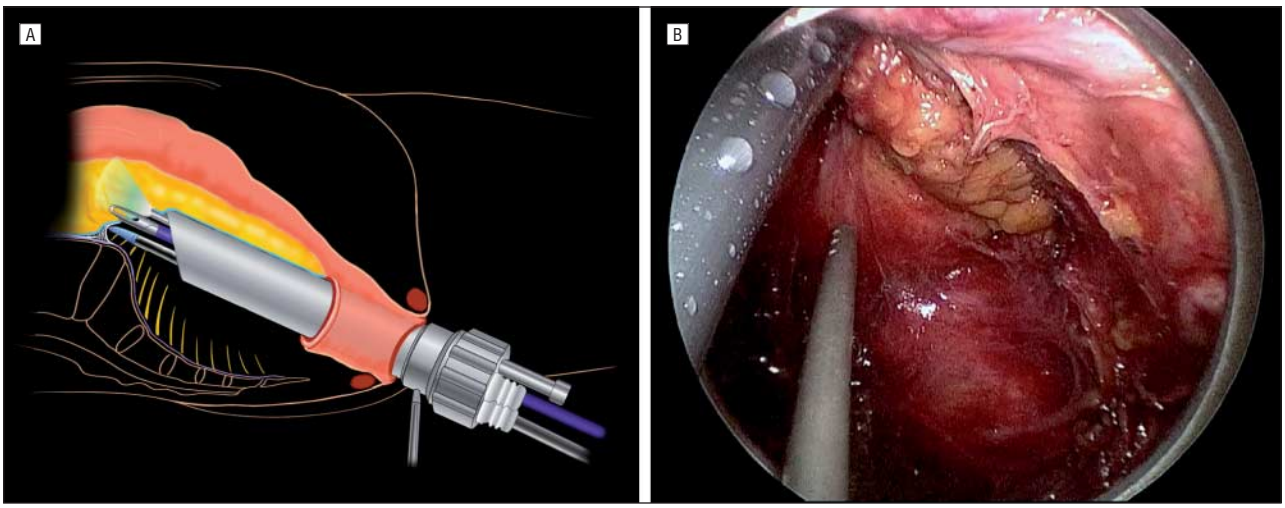

Figure 2. Schematic of retroperitoneal dissection with the transluminal transanal endoscopic operation device (A) and intraoperative view of the retroperitoneal approach at the sacral promontory (B).

mor. After careful explanation of the experimental nature of the surgery, the benefits, risks, and alternatives were discussed in detail. The patient was a 56-year-old woman. She was found to have a large, 5-cm-long, posterior, hemicircumferential tumor of the mid-third of the rectum (**Figure 1**). Preoperative endorectal ultrasonography showed a T1 carcinoma and a pelvic magnetic resonance image, a T2 tumor (**Figure 2**), while the histological analysis demonstrated a tubulovillous adenoma. Despite the biopsy specimen being negative for carcinoma, because of the large size of the tumor, the disparity with the radiological staging, the high probability of discovering a carcinoma, and the difficulty of preserving bowel continuity after an initial incomplete resection, it was decided at our oncological multidisciplinary meeting to perform an oncological rectal resection (ie, a TME). A pure transanal approach seemed a logical advancement following our experience in the field of NOTES and the experience of other authors who have demonstrated the benefits of a transanal approach (combined with a transabdominal approach) for the mobilization of the distal rectum, (ie, the TATA [transanal transabdominal] technique).[13]

PROCEDURE

The patient underwent our standard preoperative preparation: 3 to 8 days of low-residue diet, admission the day before the procedure, and enemas the day before the procedure. The patient was positioned in the lithotomy/Lloyd Davies position. The surgical platform used was a transanal endoscopic operation (TEO) device (Karl Storz Endoscopy). After positioning the TEO device, we performed an initial proctoscopy, identified the level of the tumor, and placed a purse-string suture distal to it (to prevent any fecal and/or cell contamination during the case). The rectum was then scored circumferentially and a posterior rectotomy, performed from the 2-o'clock to the 10-o'clock positions. The initial plane of dissection was at the 6-o'clock position, just posterior to the Waldeyer fascia. Once adequate space was created posteriorly, the TEO device was advanced through the viscerotomy and used as a retractor to aid with the dissection of the remainder of the posterior and lateral rectum. At the proximal portion of the Waldeyer fascia,

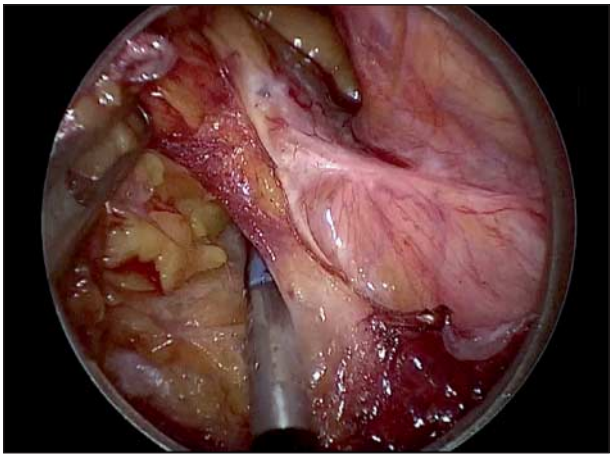

Figure 3. Intraoperative view of the transanal approach to mobilizing the sigmoid mesocolon.

the "Holy Plane" was entered. This plane was then continued proximally to the sacral promontory. At this point, we changed from the "short" to the "long" TEO device (**Figure 3**). Dissection was continued laterally, paying particular attention to avoid the pelvic nerves and ureters. Once the posterolateral portion of the rectum was completely mobilized, the division of the anterior portion of the viscerotomy was completed. Then the rectovaginal plane was dissected up to the level of the peritoneal reflection and then through the peritoneum, into the pouch of Douglas. The rectum was then advanced cephalad, through the peritoneal defect, via the pouch of Douglas, into the peritoneal cavity. This cephalad mobilization then allowed for the adequate tenting of the sigmoid mesentery and peritoneal attachments. The sigmoid mesocolon was then mobilized anteriorly from the retroperitoneum using the plane between the Gerota fascia and Toldt fascia until the root of the mesosigmoid, at the level of the left colic artery, was reached. The medial and lateral attachments of the mesosigmoid were divided as high as possible including along the descending colon. Once adequate length was mobilized, the specimen was delivered transanally. With the specimen now pulled transanally, the TEO device was reinserted transanally, parallel to the bowel. This allowed for further mobilization of the proximal bowel. The resection site was then identified. The superior hemorrhoidal artery was ligated and divided distal to the left colic artery (a "low-tie" technique). Subsequently, the sigmoid mesentery was ligated and divided and the bowel, transected with an articulating linear stapling device. The specimen was then delivered and the standard of the TME, inspected. The Lone Star retractor (Cooper Surgical) was then inserted, and a side-to-end, coloanal anastomosis was fashioned transanally with 3/0 polyglyconate sutures.

POSTOPERATIVELY

The patient received our enhanced recovery program and standard analgesia was offered (in the form of paracetamol and oral opiates). Sips of fluid were allowed the night of surgery and diet was commenced the next day. The patient was encouraged to mobilize as much as possible.

RESULTS

The procedure was successfully completed. It was performed completely by a pure transanal NOTES approach. No abdominal incisions, trocars, "grasping" needles, or proximal stomas were used. The whole procedure was completed within 190 minutes. There was minimal blood loss, no fecal soilage, and no adverse incident during the case.

In the initial postoperative period, the patient required only paracetamol for pain control. She had only mild, vague abdominal pain on questioning and on examination had a soft, nontender abdomen. She was easily able to mobilize.

On day 3, the patient began not feeling well. A computed tomography scan demonstrated a small pelvic collection. A computed tomography–guided drain was placed and this revealed a simple hematoma. Direct microbiological analysis demonstrated no bacteria but after culture, a contamination of *Escherichia coli*, but no other anaerobe, was found in the hematoma. This incident did result in a delayed patient discharge.

The histological analysis revealed a very large polyp ($4 \times 3 \times 2.2$ cm after histological fixation [specimens are 50% larger prior to fixation]) that was a tubulovillous adenoma with low-grade dysplasia. The specimen length was 20 cm and included 16 lymph nodes. There was no invasive nature demonstrated despite what the magnetic resonance image and endoanal ultrasonography had reported.

COMMENT

Transanal perirectal dissection is not new and has recently been combined with single-port access approaches.[13,14] The mobilization of the retroperitoneal attachments of the mesosigmoid and descending mesocolon before freeing lateral and medial attachments of the mesocolon is new. It is a technique we have developed and evaluated in both porcine and cadaveric models.[15] Since the development of NOTES, there have been many challenges. The main concerns that have hindered the widespread adoption of the technique are the surgical platform, accidental organ injury, and the viscerotomy closure. Pure transanal NOTES specifically for colorectal surgery overcomes many of the problems and concerns that impede the adoption of NOTES for the following reasons: (1) the anus is an easily accessible natural orifice with a short distance to the site of operation; (2) the TEO system provides a solid surgical platform that can easily be manipulated as required (Figure 3); (3) because the viscerotomy is made in a section of bowel being removed, there is no accidental organ injury; (4) the viscerotomy is incorporated into the anastomosis (or removed in the case of a circular stapling technique) so the concern of an additional viscerotomy closure site is removed; (5) the technique allows for in-line operating but is adaptable to retroflexed views if required; (6) it uses currently available laparoscopic instrumentation; and (7) it uses a surgeon's innate laparoscopic abilities.

Previous attempts at this technique have used hybrid laparoscopic techniques, with all patients receiving defunctioning stomas. Sylla et al[10] performed a hybrid transanal rectal resection for a T2N2 adenocarcinoma 6 cm from the anal verge on a 76-year-old female patient with a body mass index of 20 (calculated as weight in kilograms divided by height in meters squared) who had had

neoadjuvant chemoradiotherapy. The setup used was a transanal TEO device with a 1 × 5-mm trocar in the right lower quadrant and 2 × 2-mm "needle-port" trocars situated at the umbilicus and the right lower quadrant. The inferior mesenteric artery was ligated at its origin with an Endo GIA (Covidien) (inserted transanally) and a hand-sewn, end-to-end, coloanal anastomosis (proximal sigmoid to distal anorectal cuff with a coloplasty pouch) was performed. The patient also had a defunctioning ileostomy performed. Zorron et al[11] also performed hybrid techniques but used 2 different methods. In the first method, they performed perirectal NOTES access with TME using a standard flexible colonoscope. This technique was performed on a 54-year-old male patient with a 90% stenosing tumor 8 cm from the anal verge. The anastomosis was formed with a circular stapling device in a standard laparoscopic fashion. The pelvis was drained and a defunctioning colostomy, constructed. The second technique used a transanal single-port access (using a TriPort [Olympus]) for the dissection of the TME. This was performed on a 73-year-old female patient with an obstructing tumor 4 cm from the anal verge. She had previously undergone a defunctioning loop transverse colostomy. An end-to-end, hand-sewn, coloanal anastomosis (with coloplasty pouch) was then performed. In both cases, the proximal colonic mobilization and inferior mesenteric artery ligation were performed using a standard laparoscopic 3-port technique. Tuech et al[12] have performed a combined transanal and transabdominal single-port access approach. They used a single-port access device (Endorec; Aspide Medical) to perform a transanal TME and subsequently performed the mobilization of the descending colon, splenic flexure, and inferior mesenteric artery ligation using another single-port access device through the future ileostomy site. This was performed for a T1 tumor 3 cm from the dentate line in a female patient. The anastomosis was fashioned using a hand-sewn technique. In all but one of these cases, the patients had advanced tumors (either obstructing or with lymph node metastases), they all had 1 or 3 laparoscopic ports inserted, and they all had defunctioning stomas created.

Our procedure was successfully completed in a purely transanal NOTES fashion. There were no abdominal incisions and no insertion of any transabdominal trocars or any other transabdominal "grasping" devices. A purely transanal approach could avoid the transabdominal complications of pain and hemorrhage with improved cosmesis. The whole procedure took 190 minutes. The patient had minimal pain postoperatively and required only paracetamol intermittently. She was able to mobilize the evening of surgery, tolerated fluid the night of surgery, and resumed diet the next day (as expected). Her bowels opened on postoperative day 2. Unfortunately, she developed a pelvic hematoma. This was picked up on computed tomography scan after the patient was not feeling well on day 3. After this was drained, she made an uneventful recovery. She voluntarily only mentioned pain from her drain site and not her abdomen. She did not have any difference in continence or defecation after the procedure. We are prospectively evaluating functional outcome and quality of life in our series.

One of the difficulties with a bottom-up approach is that the sacral and fascial propria layers are fused distally and posteriorly to form the Waldeyer fascia. While it is possible to separate these layers during a traditional TME (through an open or laparoscopic approach) and remain in the Holy Plane, unfortunately, the same cannot be said for the bottom-up approach. During this approach, the plane just posterior to the Waldeyer fascia is initially used until the true Holy Plane can be entered more proximally. While this portion of the operation does not represent a true TME (because the dissection is just posterior to the correct plane), it is, however, still oncological. This was evident on general inspection of the specimen and also in the identification of 16 lymph nodes on histological examination (≥12 lymph nodes required for accurate staging).[16] We did not perform a "high tie" in this procedure. Since its conception more than a century ago, there has been no conclusive evidence to show superiority over the alternate "low-tie" technique.[17,18] Concerns about the involvement of apical nodes that would be "missed" in a low-tie technique were addressed by Kanemitsu et al,[19] who demonstrated that no pT1 tumors of the sigmoid colon or rectum had any evidence of apical lymph node metastatic disease.[19]

The current ways of dealing with early rectal cancers are resectional surgery (in the form of a TME), transanal endoscopic microsurgery (TEM), and possible endoscopic techniques (eg, endoscopic mucosal resection). When TEM was compared with resectional surgery, it was reported to be safer with similar outcomes.[20] Transanal endoscopic microsurgery was demonstrated to have a shorter operative time and hospital stay with lower morbidity, reoperation, stoma formation, and mortality rates. The local recurrence rate was much higher (24%) compared with TME (0%). There was no significant difference in overall or cancer-specific survival. While TEM does appear to be comparable with resection surgery without the morbidity risk, the recurrence rate of approximately 25% is very high and the outcomes for recurrences are very poor. Doornebosch et al[21] have demonstrated that the 3-year outcomes for recurrent T1 rectal cancers, initially treated by TEM, were 58% for cancer-specific survival and 31% for overall survival. When endoscopic mucosal resection was compared with TEM for large polyps (not cancer), it was shown that while it was achievable as a day case procedure (as compared with TEM, which required admission for 3 days), the recurrence rate was 3 times that of TEM.[22] Therefore, while novel and potentially less invasive ways of dealing with early rectal cancers exist, the recurrence rates are very high with potentially disastrous oncological outcomes. For this reason, resectional surgery (TME) still remains the gold standard.

One of the main concerns for this approach to colorectal surgery is the risk of infection from transrectal surgery. The effects of transrectal surgery on inducing infection can be seen in the results of both TATA surgery and natural orifice specimen extraction. The TATA procedure has recently been reported to have a pelvic abscess rate of only 2.5%.[23] In natural orifice specimen extraction, recent reports of peritoneal fluid contamination levels have demonstrated that in patients whose colons

were opened (for transanal extraction) vs divided (by a linear stapling device) the contamination rates were 100% and 88.9%, respectively, though no increase of clinical complications was reported.[24,25]

One of the main factors in the successful completion of this operation was the ability to use high-definition cameras and screens. This system was found to be far superior to standard-definition systems of the past. In fact, standard laparoscopic and endoscopic video equipment would not allow for adequate definition of the tissue planes required for a bottom-up TME. It is essential to develop tools particular to the surgical technique being performed because this allows for standardization of the technique. We are currently developing novel surgical platforms and instrumentation to further develop pure transanal NOTES as well as working with "augmented reality" to try and develop the image-guided techniques of the future.

The potential advantage of this approach is that it combines the perioperative benefits of a minimally invasive approach with the oncological benefits of major resectional surgery. This case is a monumental achievement that highlights years of surgical research and development. While the development of NOTES has otherwise slowed, its application in pure transanal colorectal surgery is intuitive.

Accepted for Publication: August 21, 2012.
Published Online: November 19, 2012. doi:10.1001/jamasurg.2013.685
Correspondence: Joël Leroy, MD, FRCS, IRCAD/EITS, 1 Place de l'Hôpital, 67091 Strasbourg, France (joel.leroy@ircad.fr).
Author Contributions: *Study concept and design:* Leroy, Barry, and Melani. *Acquisition of data:* Leroy and Barry. *Analysis and interpretation of data:* Leroy, Barry, Mutter, and Marescaux. *Drafting of the manuscript:* Leroy and Barry. *Critical revision of the manuscript for important intellectual content:* Leroy, Barry, Melani, Mutter, and Marescaux. *Administrative, technical, and material support:* Leroy. *Study supervision:* Melani, Mutter, and Marescaux.
Conflict of Interest Disclosures: None reported.

REFERENCES

1. Kalloo AN, Singh VK, Jagannath SB, et al. Flexible transgastric peritoneoscopy: a novel approach to diagnostic and therapeutic interventions in the peritoneal cavity. *Gastrointest Endosc*. 2004;60(1):114-117.
2. Marescaux J, Dallemagne B, Perretta S, Wattiez A, Mutter D, Coumaros D. Surgery without scars: report of transluminal cholecystectomy in a human being. *Arch Surg*. 2007;142(9):823-826, discussion 826-827.
3. Fong DG, Pai RD, Thompson CC. Transcolonic endoscopic abdominal exploration: a NOTES survival study in a porcine model. *Gastrointest Endosc*. 2007; 65(2):312-318.
4. Pai RD, Fong DG, Bundga ME, Odze RD, Rattner DW, Thompson CC. Transcolonic endoscopic cholecystectomy: a NOTES survival study in a porcine model (with video). *Gastrointest Endosc*. 2006;64(3):428-434.
5. Fong DG, Ryou M, Pai RD, Tavakkolizadeh A, Rattner DW, Thompson CC. Transcolonic ventral wall hernia mesh fixation in a porcine model. *Endoscopy*. 2007; 39(10):865-869.
6. Ryou M, Fong DG, Pai RD, Tavakkolizadeh A, Rattner DW, Thompson CC. Dual-port distal pancreatectomy using a prototype endoscope and endoscopic stapler: a natural orifice transluminal endoscopic surgery (NOTES) survival study in a porcine model. *Endoscopy*. 2007;39(10):881-887.
7. Whiteford MH, Denk PM, Swanström LL. Feasibility of radical sigmoid colectomy performed as natural orifice translumenal endoscopic surgery (NOTES) using transanal endoscopic microsurgery. *Surg Endosc*. 2007;21(10):1870-1874.
8. Sylla P, Willingham FF, Sohn DK, Gee D, Brugge WR, Rattner DW. NOTES rectosigmoid resection using transanal endoscopic microsurgery (TEM) with transgastric endoscopic assistance: a pilot study in swine. *J Gastrointest Surg*. 2008; 12(10):1717-1723.
9. Leroy J, Cahill RA, Perretta S, Forgione A, Dallemagne B, Marescaux J. Natural orifice translumenal endoscopic surgery (NOTES) applied totally to sigmoidectomy: an original technique with survival in a porcine model. *Surg Endosc*. 2009; 23(1):24-30.
10. Sylla P, Rattner DW, Delgado S, Lacy AM. NOTES transanal rectal cancer resection using transanal endoscopic microsurgery and laparoscopic assistance. *Surg Endosc*. 2010;24(5):1205-1210.
11. Zorron R, Phillips HN, Coelho D, Flach L, Lemos FB, Vassallo RC. Perirectal NOTES access: "down-to-up" total mesorectal excision for rectal cancer. *Surg Innov*. 2012;19(1):11-19.
12. Tuech JJ, Bridoux V, Kianifard B, et al. Natural orifice total mesorectal excision using transanal port and laparoscopic assistance. *Eur J Surg Oncol*. 2011; 37(4):334-335.
13. Marks G, Mohiuddin M, Goldstein SD. Sphincter preservation for cancer of the distal rectum using high dose preoperative radiation. *Int J Radiat Oncol Biol Phys*. 1988;15(5):1065-1068.
14. Gaujoux S, Bretagnol F, Au J, Ferron M, Panis Y. Single port access proctectomy with total mesorectal excision and intersphincteric resection with a primary transanal approach. *Colorectal Dis*. 2011;13(9):e305-e307.
15. Leroy J, Diana M, Barry B, et al. Perirectal Oncologic Gateway to Retroperitoneal Endoscopic Single-Site Surgery (PROGRESSS): a feasibility study for a new NOTES approach in a swine model [published online July 1, 2012]. *Surg Innov*. doi:10.1177/1553350612452346.
16. Nelson H, Petrelli N, Carlin A, et al; National Cancer Institute Expert Panel. Guidelines 2000 for colon and rectal cancer surgery. *J Natl Cancer Inst*. 2001;93 (8):583-596.
17. Moynihan BG. The surgical treatment of cancer of the sigmoid flexure and rectum. *Surg Gynecol Obstet*. 1908;6:463-466.
18. Lange MM, Buunen M, van de Velde CJH, Lange JF. Level of arterial ligation in rectal cancer surgery: low tie preferred over high tie. a review. *Dis Colon Rectum*. 2008;51(7):1139-1145.
19. Kanemitsu Y, Hirai T, Komori K, Kato T. Survival benefit of high ligation of the inferior mesenteric artery in sigmoid colon or rectal cancer surgery. *Br J Surg*. 2006;93(5):609-615.
20. De Graaf EJ, Doornebosch PG, Tollenaar RA, et al. Transanal endoscopic microsurgery versus total mesorectal excision of T1 rectal adenocarcinomas with curative intention. *Eur J Surg Oncol*. 2009;35(12):1280-1285.
21. Doornebosch PG, Ferenschild FT, de Wilt JH, Dawson I, Tetteroo GW, de Graaf EJ. Treatment of recurrence after transanal endoscopic microsurgery (TEM) for T1 rectal cancer. *Dis Colon Rectum*. 2010;53(9):1234-1239.
22. Barendse RM, van den Broek FJ, van Schooten J, et al; TREND study group. Endoscopic mucosal resection vs transanal endoscopic microsurgery for the treatment of large rectal adenomas. *Colorectal Dis*. 2012;14(4):e191-e196.
23. Marks J, Mizrahi B, Dalane S, Nweze I, Marks G. Laparoscopic transanal abdominal transanal resection with sphincter preservation for rectal cancer in the distal 3 cm of the rectum after neoadjuvant therapy. *Surg Endosc*. 2010;24 (11):2700-2707.
24. Costantino FA, Diana M, Wall J, Leroy J, Mutter D, Marescaux J. Prospective evaluation of peritoneal fluid contamination following transabdominal vs. transanal specimen extraction in laparoscopic left-sided colorectal resections. *Surg Endosc*. 2012;26(6):1495-1500.
25. Leroy J, Costantino F, Cahill RA, et al. Laparoscopic resection with transanal specimen extraction for sigmoid diverticulitis. *Br J Surg*. 2011;98(9):1327-1334.