SURGICAL ENDOSCOPY and Other Interventional Techniques

## TECHNIQUE

# Minilaparoscopy-assisted transrectal low anterior resection (LAR): a preliminary study

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**Abstract**

*Background* Natural orifice translumenal endoscopic surgery (NOTES) represents the evolution of surgery towards less invasive procedures. The feasibility of NOTES transrectal approach has increased its clinical applicability. This report describes a first series of mini-laparoscopy-assisted transrectal low anterior resection with double purse-string end-to-end circular stapler anastomoses.

*Methods* Between March and April 2012 three selected patients underwent transrectal minilaparoscopy-assisted natural orifice surgery total mesorectal excision for rectal cancer. All the oncologic principles of open/laparoscopic low anterior resection for rectal cancer were strictly fulfilled. Two patients underwent neoadjuvant treatment. Laparoscopic visualization and assistance was provided through one 10-mm umbilical port and two ports, one of which was used as stoma site (5 mm) and the other as a drain site (2 mm needle port). The specimen was transected transanally followed by the confection of double purse-string lateral/end-to-end anastomoses. There were no intraoperative complications.

*Results* Mean operative time was 143 min. Oral intake was initiated on the second postoperative day. Patients were discharged home by day 5. The pathology unit confirmed that distal and circumferential margins were free of tumor invasion, and quality of mesorectum resection was reported satisfactory. One patient had to be readmitted because of severe dehydration due to increased ileostomy output. The patient was discharged at the third day after the readmission without renal failure.

*Conclusions* In this preliminary report, transrectal minilaparoscopy-assisted low anterior resection was feasible and safe. Lateral/end-to-end anastomoses can be considered an interesting alternative to the double-stapling technique. However, it is necessary to further study and develop these procedures, along with careful patient selection, before transrectal low anterior resection may be considered for routine clinical use.

**Keywords** NOTES · MA-NOS · Minimally invasive surgery · Transrectal · Rectal cancer

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Surgical treatment has been in constant evolution with the aim of minimizing incisions regardless of the complexity of the operation. The continuous advances in flexible gastrointestinal endoscopic interventions, along with advances in minimally invasive surgery, have given way to alternatives that could further reduce the aggressiveness of surgery.

Natural orifice translumenal endoscopic surgery (NOTES) represents the evolution of surgery towards less invasive procedures.

There are a number of potential benefits from using NOTES, such as maintaining the integrity of the abdominal wall and reduction of the trauma associated with

conventional surgery. However, NOTES has the potential for many complications which relate to its technical limitations [1].

The safe execution of pure NOTES procedures has a series of limitations such as increased difficulty in closure of viscerotomies, absence of triangulation of instruments, and inadequate tissue retraction. These difficulties can be overcome with the use of minilaparoscopy instrument assistance. Since the first clinical NOTES procedure, a transgastric appendectomy reported in 2005, there have been many reported cases performed through hybrid procedures [2–5].

The efforts to develop NOTES approaches to the colon and rectum have led us to elaborate the first report of a hybrid transvaginal sigmoidectomy for the treatment of cancer, using transvaginal rigid instrumentation and minilaparoscopy instruments, a technique we have named minilaparoscopy-assisted natural orifice surgery (MA-NOS) [3].

To date, a pure NOTES colorectal resection, using transvaginal, transanal or transcolonic access, has not been reported in clinical practice. Some authors have described complete sigmoid colon mobilization, high vascular ligation, en bloc lymphadenectomy, and stapled end-to-end anastomosis performed by a single operator using transanal endoscopic microsurgery (TEM) instrumentation in cadavers and swine [6, 7].

Transrectal NOTES could have a significant advantage in avoiding abdominal extraction incisions in both males and females, and therefore represents the natural evolution of minimally invasive colorectal surgery.

We have reported the first case of NOTES transanal rectal cancer resection using TEM and laparoscopic assistance with coloanal anastomoses without postoperative complications in a 76-year-old woman, which supports the safety and feasibility of this approach [8]. In addition, we recently presented the first case of minilaparoscopy-assisted natural orifice total colectomy, trough a transrectal approach [9].

In this report we describe minilaparoscopy-assisted transrectal low anterior resection for the treatment of rectal cancer. In this procedure, we performed 33-mm circular stapler double purse-string anastomosis to avoid the effect of double-stapling technique, and we changed the TEM platform to a flexible single-port device. The preliminary clinical results are described.

## Patients and methods

The institutional Review Board of the Hospital Clínic of Barcelona approved the use of minilaparoscopy-assisted transrectal low anterior resection for rectal cancer in humans. Informed consent was obtained from patients after the risks and benefits of the procedure had been explained.

The procedure was performed by a team of colorectal surgeons with extensive clinical expertise in minimally invasive approaches to colon and rectal cancer including minilaparoscopy transrectal surgery [8, 9]. Transanal rectosigmoid resection included transabdominal laparoscopic assistance for visualization, dissection, retraction, and anastomoses control as needed during the transanal endoscopic dissection. All the oncologic principles of open/laparoscopic low anterior resection for rectal cancer were strictly fulfilled.

Between March and April 2012 there were three selected patients with rectal adenocarcinoma who then underwent transrectal MA-NOS TME excision with lateral/end-to-end double purse-string anastomoses for rectal cancer.

Diagnosis and staging were carried out in all cases by fibrocolonoscopy and biopsy, ultrasonography, pelvic and abdominal magnetic resonance imaging (MRI), chest computed tomography (CT) scan, and a functional anorectal study to verify anal sphincter condition.

Two patients underwent neoadjuvant treatment with radiotherapy, which was delivered to the pelvis with a three-field technique. The total dose was 45 Gy, with a daily dose of 1.8 Gy administered 5 days each week and chemotherapy with continuous 5-fluorouracil (5-FU) infusion, 225 mg/m$^2$/day, during 5 days, concomitant with radiotherapy, which they tolerated well. Patient and tumor characteristics are summarized in Table 1.

### Preoperative and anesthetic preparation

The day before surgery, patients underwent anterograde lavage (Bohm solution; Bohm Laboratories, Madrid, Spain). Prophylactic antibiotics (cefoxitin 2 g) were administered intravenously, and a thoracic epidural catheter was inserted for pain control. After induction of anesthesia, a central venous line, an arterial line, and a Foley catheter were inserted. The patient was placed in lithotomy

**Table 1** Preoperative characteristics of the patients

| Case no. | Age (years) | Gender | BMI (kg/m$^2$) | Tumor (cm from anal verge) | Tumor diameter cm (MRI) | CEA (ng/ml) | Neoadjuvant CRT | cTNM |
|---|---|---|---|---|---|---|---|---|
| 1 | 73 | Female | 24 | 10 | 3.6 | 6.4 | Yes | cT3N0M0 |
| 2 | 75 | Female | 16 | 9 | 2.2 | 2.4 | No | cT2N0M0 |
| 3 | 71 | Male | 25 | 10 | 2.5 | 5.2 | Yes | cT3N0M0 |

*CRT* chemoradiotherapy, *cTNM* clinical TNM stage, *CEA* carcinoembryonic antigen, *MRI* magnetic resonance imaging

position with stirrups; arms were tucked to the sides. Rectum was irrigated with 1 % diluted iodine solution.

## Surgical procedure

The abdomen was insufflated to pressure of 12 mmHg via a Veress needle inserted into the umbilicus. It was then removed, and a 10-mm port was inserted through the same incision for a 30° angle mini scope (3D EndoEYE 10-mm videolaparoscope; Olympus KeyMed, Europe). Two ports were inserted in both lower quadrants: a 5-mm port at the location marked for ileostomy confection on the right, and a 2-mm port at drain location. The abdomen and pelvis were inspected by laparoscopy for tumor invasion of the peritoneum and pelvic adhesions which might hamper proper dissection. Afterwards, the transrectal approach was initiated.

## Combined transrectal and laparoscopy dissection

The multiport rectal device (GelPOINT path transanal; Applied Medical, European Union) was inserted and sealed; $CO_2$ was insufflated to pressure of 9 mmHg (Fig. 1A). A three-dimensional (3D) flexible-tip endoscope (3D EndoEYE 5-mm flexible-tip videolaparoscope; Olympus KeyMed, Europe) was introduced through the single-port device.

A purse-string suture was placed through the rectal mucosa to tightly occlude the rectum with a margin 3–4 cm distal of tumor. Distal to the purse-string, a full-thickness rectal transection was initiated circumferentially using a monopolar Hook and bipolar dissecting instruments (Fig. 1B). Once inside the presacral plane, the mesorectum was mobilized and the posterior dissection proceeded cephalic in the avascular presacral plane in accordance with total mesorectal excision (TME) principles. This plane of dissection was extended medially, laterally, and interiorly to achieve circumferential rectal mobilization.

The peritoneal reflection was visualized and divided internally. The attached peritoneal rectum ligaments were divided transanally, thus entering the peritoneal cavity (Fig. 1C). The rectosigmoid junction was dissected by transanal approach under laparoscopic visualization.

When required, a Keith needle was inserted above the pubis into the abdominal cavity and used to retract the uterus.

Laparoscopic graspers were used to retract and aid the dissection of the rectosigmoid and expose the vascular pedicle (Fig. 2A). The inferior mesenteric vessels were transected at their base with vascular clips. The remaining mesentery was dissected and sectioned by 5-mm Ligasure device (Covidien).

In two cases, complete mobilization of the splenic flexure was required. This was performed mainly with laparoscopic assistance.

Prior to the opening of the peritoneal reflection via the transrectal access, a circumferential full-thickness purse-string was performed in the open distal rectal cuff (Fig. 3A).

## Lateral/end-to-end anastomoses and diverting stoma

After confirming that sufficient length of colon had been mobilized, the transanal single port was removed and the rectosigmoid was carefully exteriorized transanally.

The proximal colonic resection was performed extracorporeally in the conventional fashion with placement of a purse-string suture (AutoSuture Purstring 45; Covidien) and insertion of the 33-mm circular stapling anvil (AutoSuture EEA hemorrhoid and prolapse DST series; Covidien), into the proximal end of the sigmoid in two cases, and into the proximal lateral wall in one case (Fig. 3B). The closure of the distal end was performed with 60-mm blue load EndoGIA (AutoSuture; Covidien).
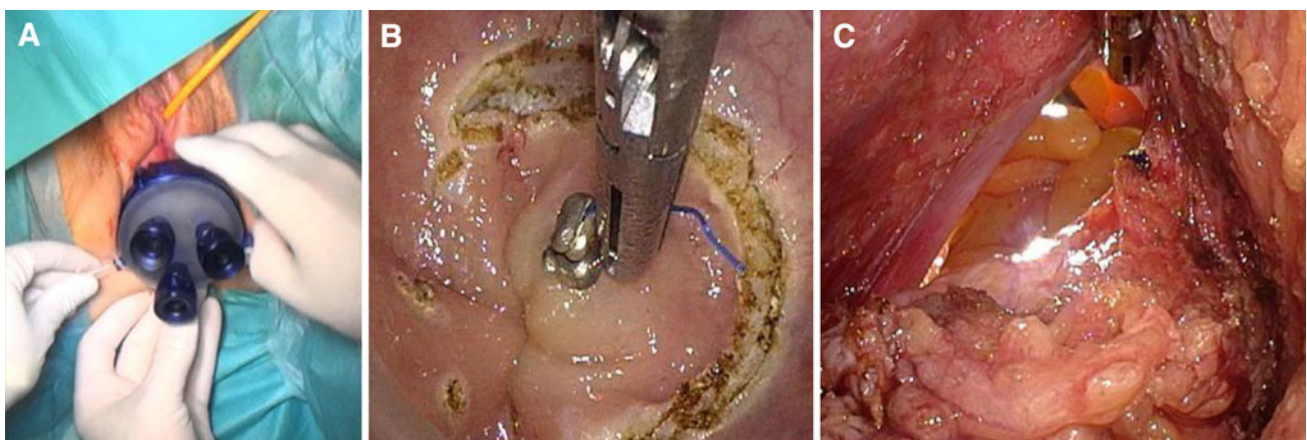


**Fig. 1** Transrectal dissection. **A** View of GelPOINT<sup>TM</sup> path transanal platform in place to facilitate access to the rectal lumen. **B** Full-thickness rectal transection below the purse-string. **C** Presacral plane view to complete the total mesorectal excision and the opening of the peritoneum
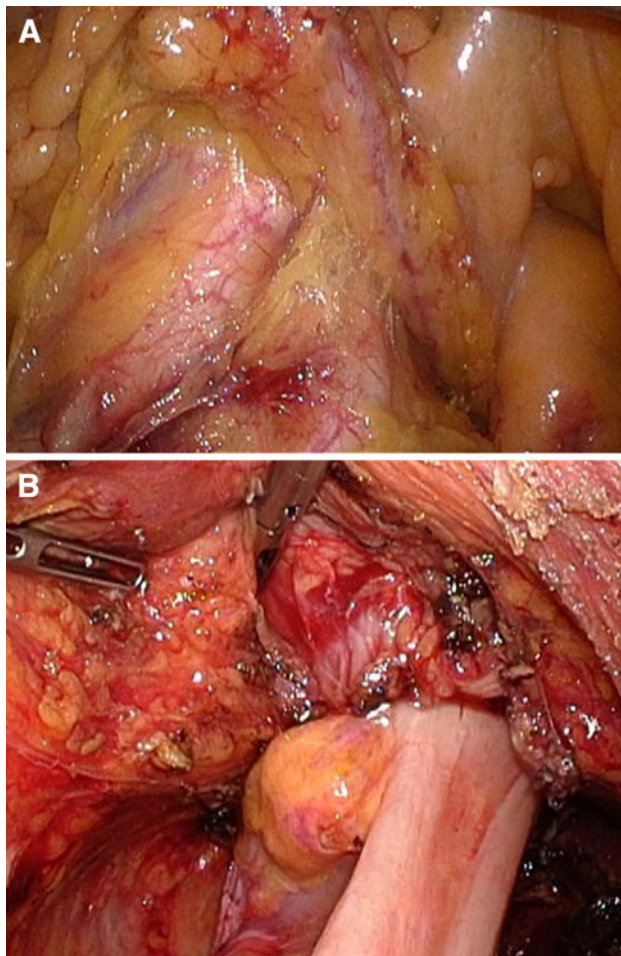
**Fig. 2** Laparoscopic assistance. **A** Visualization and control of vascular plane and ureter. **B** Laparoscopic assistance of anastomoses

The pelvis was irrigated with 1 % iodine solution, and hemostasis was checked. The proximal colon with the anvil was inserted transanally, and the Lone Star Retractor™ was positioned. The spike of the circular stapler (EEA hemorrhoid and prolapse DST series; Covidien, AutoSuture) was inserted transanally; and the purse-string was closed around the stapler (Fig. 3C).

With the assistance of the laparoscopic graspers, the anvil and the spike were connected in the correct position and a lateral/end-to-end anastomoses was performed under direct visual control with the laparoscope (Fig. 2B). Specimen donuts between the staple lines measured between 1 and 1.5 cm in length (Fig. 3D1, D2).

In all three cases the anastomoses were reinforced with transanal interrupted sutures. The anastomosis was tested using the pneumatic air leak test, without any complications.

In two cases, a loop of ileum was exteriorized and matured in a standard Brooke's fashion as a defunctioning ileostomy; for this procedure the right lower quadrant miniport site was used. In all three patients, a small suction

drain was placed in the deep pelvis and exteriorized through the left lower quadrant miniport site.

## Results

In all patients, endoscopic dissection of the mesorectum could be achieved entirely transanally up to the level of the peritoneal reflection at the rectosigmoid junction. Laparoscopic assistance was used for visualization and mobilization of the left-sigmoid colon, and was achieved in all cases with three ports.

Surgical, clinical, and pathological outcomes characteristics are summarized in Table 2.

The epidural catheter was removed on the second postoperative day, and pain was well controlled with oral analgesia without use of intravenous drugs.

In all three patients pathology confirmed that distal and circumferential margins were free of tumor invasion. In addition, in all cases the quality of mesorectum resection was reported as satisfactory.

One patient had to be readmitted because of severe dehydration because of increased ileostomy output; the patient was discharged without renal failure 3 days after readmission. The other two patients have no recorded complications or re-admissions at the follow-up checkups (15 and 30 days after the procedure). The abdominal scars were barely visible at the checkups.

## Discussion

Since the report of Kalloo et al. [10] announcing a successful liver biopsy via a transgastric approach, NOTES has represented the next step in the evolution of minimally invasive surgery.

The gastrointestinal surgery department of the Hospital Clínic of Barcelona is a referral centre for benign and malignant colorectal pathologies. Extensive experimental experience characterizes our commitment to constant research in minimally invasive surgical procedures, which then results in clinical applications. We have extensive experience with minimally invasive approaches to colon and rectal cancer [3, 8, 9].

Our first experience in hybrid NOTES was with the transvaginal approach. The advantages of using a combination of minilaparoscopy and a vaginal approach are evident, since large colorectal specimens can be adequately extracted transvaginally. However, our group has further continued investigation of transcolonic NOTES colorectal surgery, because we believe it has a significant advantage since it avoids abdominal incisions for extraction (in both males and females) and therefore represents the natural evolution of minimally invasive colorectal surgery.

**Fig. 3** Lateral/end-to-end anastomoses. **A** Full-thickness rectal purse-string prior to peritoneum open. **B** Transanal specimen exteriorization view with placement of a purse-string suture. **C** Transanal position of circular stapler device (EEA hemorrhoid and prolapse DST series, Covidien). **D1** Specimen with intact mesorectum and **D2** rectal donuts
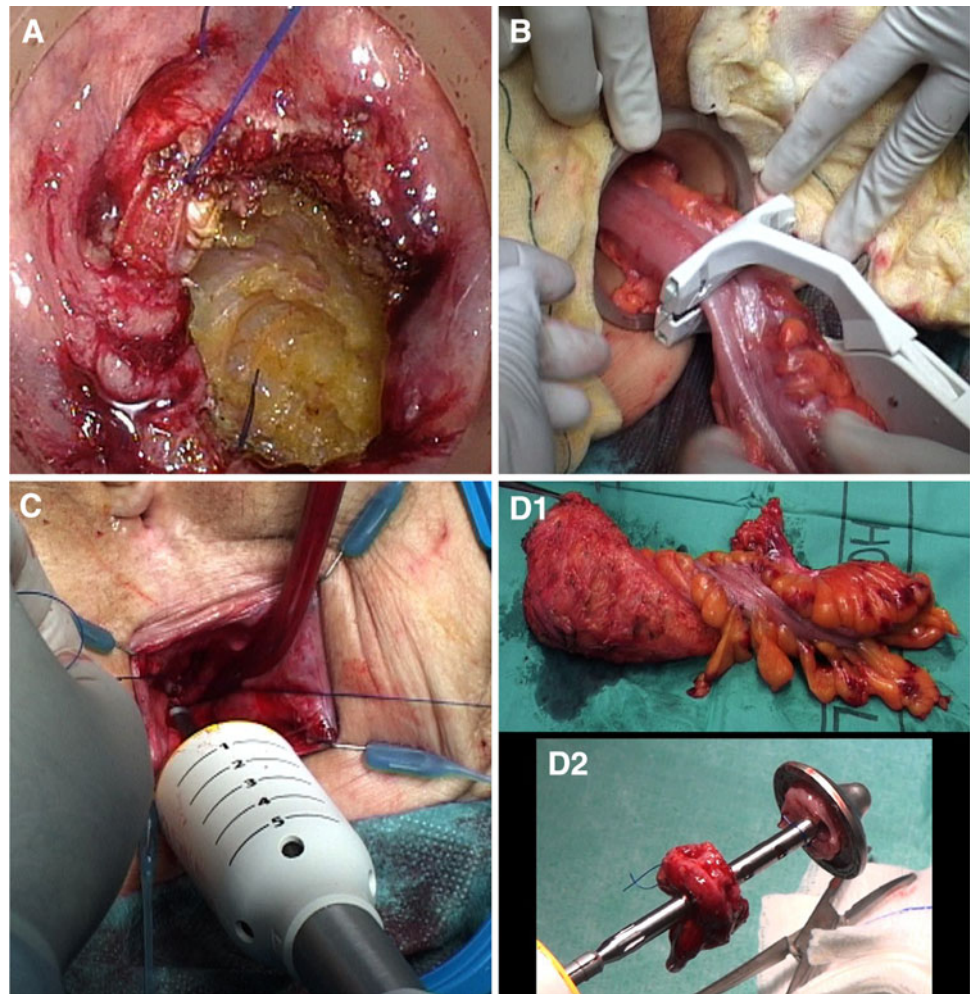


**Table 2** Operative, clinical, and pathological outcomes during transrectal minilaparoscopy-assisted low anterior resection

| Case no. | Operative time (min) | Estimated blood loss (ml) | Anastomoses | Anastomoses (cm from anal verge) | Protective ileostomy | Oral intake/ feces* (days) | Hospital days after surgery | Postoperative complications | pTNM |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 155 | 20 | L-E | 4 | Yes | 1/2 | 5 | None | pT3N0M0 |
| 2 | 150 | 15 | E-E | 5 | No | 1/3 | 4 | None | pT1N0M0 |
| 3 | 125 | 30 | E-E | 4 | Yes | 1/2 | 5 | Dehydration | pT3N0M0 |

*L-E* lateral-to-end, *E-E* end-to-end, *pTNM* pathological TNM stage

* Ileostomy debit or feces evacuate

A pure NOTES approach to colorectal resection with TME, using either transvaginal or transanal access, has not been reported to date. Transrectal NOTES offers the potential to perform translumenal colorectal resections through significantly smaller, or without (in the near future), abdominal incisions. In this series we have developed a new technique of hybrid transrectal NOS assisted by minilaparoscopy for treatment of middle rectal tumors.

Critical steps of this operation such as dissection and control of the inferior mesenteric vessels, dissection of the splenic angle, control of the ureter, and assistance in the construction of the anastomosis have been carried out using a hybrid approach (transrectal and minilaparoscopy assisted). Operative time is also optimized by performing the laparoscopic assistance simultaneously with transrectal time. In this series, we found not only that this approach

was feasible, but most importantly, that complete rectal dissection with high-quality TME could be performed transanally.

An important advantage of transanal NOTES for colorectal resections is the fact that the colotomy is not created through a healthy viscera but through the diseased organ, thus avoiding additional damage to healthy structures. It also allows for good oncologic distal margin by setting the length required in the initial transanal purse-string, and then in the donuts from the anastomoses. Another advantage is that it allows additional control via perineal approach to the mesorectum, via the plane of the prostate/seminal vesicles and vagina. This could represent a new perspective in tumors with invasion of the circumferential margin, for which a research protocol is of course warranted.

Nowadays, minimally invasive colorectal procedures such as laparoscopy-assisted colectomies have become popular, and prospective randomized trials have demonstrated their safe clinical application in oncologic disease [11, 12]. Laparoscopic surgery for rectal cancer has been considered technically more demanding when compared with that for colon cancer. In the COST trial [13] rectal cancer was excluded, and in the UK Medical Research Council Conventional versus Laparoscopic-Assisted Surgery in Colorectal Cancer (UK MRC CLASICC) trial [14] a higher incidence of positive circumferential margins after laparoscopic anterior resection for rectal cancer was observed. In our hospital, however, laparoscopic total mesorectal excision has been used without complications for the treatment of rectal cancer even with lateral lymph node metastasis or invasion to the adjacent organ. We believe it has the advantage of providing good visualization especially in a narrow masculine pelvis and it allows more precise autonomic nerve preservation [15, and unpublished data].

Tumor localization in the middle or lower third, with subsequent low anastomoses, is accepted as an important risk factor for anastomotic leakage [16, 17]. The leakage rate has ranged from 1.2 to 13.8 %, the most commonly reported rate being approximately 10 % [14, 18, 19]. This complication contributes not only to postoperative morbidity and mortality, but also to local recurrence and poor survival [20–22].

Transection of the rectum using intracorporeal stapling devices after TME is technically difficult because of their width, limited roticulation, and the need to use more than one load; failure of this step can directly result in increased anastomotic leakage. Few studies have analyzed the risk factors affecting leakage after TME laparoscopic surgery with double stapling anastomosis [23, 24]. A multicenter study conducted in Germany of laparoscopic rectal cancer resection suggested that laparoscopic low anterior resection should be abandoned because of the high anastomotic

leakage rate (13.8 %) [25]. However, other studies have reported no significant difference in anastomotic leakage between laparoscopic and open approaches for low anterior resection for rectal cancer [14, 26–28]. To avoid a high leakage rate in patients in whom two or three cartridges are used for rectal division, efforts must be made to remove the point where two stapler loads intersect. This can be achieved with the transanal circular stapler and could reduce anastomotic leakage [23, 24, 29–31].

To diminish the effects of these variables, technical difficulties, and additional skin incisions, we advocate the double purse-string lateral/end-to-end circular stapler technique performed via a transrectal approach as a very valid alternative in this regard. In this procedure, we have perfected the technique of anastomosis with the use of double purse-string using a prolapse and hemorrhoid circular stapler of 33 mm for the anastomosis. In this way we eliminate the multiple shots required to close the proximal end of the rectum. In addition, it allows us to add at least 1–1.5 cm of distal resection margin.

The construction of a covering stoma seems to effectively reduce the clinical impact of anastomotic leakage, and should be constructed in high-risk patients, such as those with very low colorectal anastomoses located 5 cm or less from the anal verge, mainly those who received preoperative chemoradiotherapy [32], such as those presented in this series.

We use 3D technology during transanal time, allowing us to improve the spatial and depth of vision of the access in the narrow transrectal space. Magnified imaging, obtained using laparoscopy and 3D cameras, is rather beneficial for dissection, transecting the rectum and performing safe anastomoses. When the spatial depth information is lost in a laparoscopic 2D image, this loss can be compensated to a high degree by an experienced surgeon and by the ability of the brain to interpret spatial depth cues, such as shadows, for estimation of spatial proportions [33, 34]. Three-dimensional surgical imaging systems provided stereoscopic depth cues; this effect increases precision for difficult tasks, and allows for faster and more accurate task performance for complex skills.

In this study we did not use TEM as a transanal platform, preferring a single-port device (GelPOINT path transanal; Applied Medical, European Union). Its pliable design with 40 mm diameter allows for an adjusted fit within the anal canal, with safe and atraumatic retraction for enhanced exposure and access. This may have less negative impact on anorectal function compared with TEM (40-mm rigid proctoscope). In some prospective studies, TEM has been associated with short-term anal dysfunction up to 6 weeks postoperatively [35, 36]. Other interesting advantages were that the deck on which the ports are anchored is broad and made of silicone, which allows

greater maneuverability and triangulation of the movements and the comfortable use of the flexible 3D camera; ports can be added or changed quickly, even an optional 12-mm port; and typically used laparoscopic instruments, including graspers, thermal devices, and needle holders, are used to perform the transanal dissection.

MA-NOS is an option that avoids the need for extra incisions and their related complications during resection of large intra-abdominal organs. Until better adapted devices are developed, such as longer, more flexible dissecting instruments, flexible transanal platform, and staplers and hemostatic instruments, we believe that minilaparoscopy assistance is mandatory to overcome surgical difficulties.

In summary, with improved surgical skill and instruments, NOTES approach will become more popular, and the safety of transrectal approach for middle and lower rectal lesions will likely continue to improve. We also believe that the safety and feasibility of colorectal anastomoses demonstrated in this series represents a technical improvement in the technique of transrectal NOTES. The potential advantages and benefits of this new method need to be strictly evaluated. NOTES instrumentation, careful patient selection, and long-term oncologic standardized reporting of its outcomes are all necessary. The challenge is to evaluate this approach in the light of evidence-based clinical practice. Only then will NOTES be incorporated into routine clinical practice.

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