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ORIGINAL ARTICLE

Pure transanal total mesorectal excision for rectal cancer: experience with 55 cases

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Abstract

Background: Although the anatomic difficulties of laparoscopic surgery for rectal cancer have been resolved by hybrid transanal total mesorectal excision (h-taTME), a completely incisionless surgical procedure has not yet been developed. This study was performed to explore the efficacy of pure taTME (p-taTME) without laparoscopic assistance as a completely non-invasive surgical procedure for rectal cancer.
Methods: We retrospectively evaluated all patients with rectal cancer who underwent p-taTME between December 2015 and April 2018. Relevant patient characteristics and clinical information including the surgical procedure, specimens, pathological characteristics, and patients' post-operative state were analysed and the feasibility of p-taTME in patients with rectal cancer was assessed.
Results: Fifty-five patients who had undergone p-taTME were included in this study. They comprised 32 (58.2%) men and 23 (41.8%) women with a mean age of 65.6 ± 10.6 years and mean body mass index of 23.4 ± 3.3 kg/m^2. The median surgical time was 180.0 (range, 130–360) min and estimated blood loss was 25.0 (range, 15–80) mL. The commonest post-operative complication was varying degrees of faecal incontinence (56.4%). However, such incontinence greatly improved after pelvic-floor-function-rehabilitation exercises and did not seriously affect the patients' quality of life.
Conclusions: p-taTME is a relatively safe and incisionless procedure for patients with middle and low rectal cancer, especially in those with obesity or a narrow pelvis. However, further studies of the indications and long-term efficacy are needed to verify the suitability of this procedure.

Key words: pure taTME; rectal cancer; surgery; incisionless

Introduction

The history of surgical treatment of rectal cancer spans more than 200 years and can be divided into the following five eras according to its development and changes throughout this time period: (i) local resection era (1739–1908), which was initiated by the French surgeon Faget in 1739 [1] and improved by the British

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surgeon Allingham in 1879; (ii) Miles abdomioperineal resection with end colostomy era (1908–1939), which was performed by Miles in 1908 [2] and remains a classic procedure for treating rectal cancer; (iii) sphincter-sparing rectal resection era (1939–1979), the representative surgery of which is the Dixon procedure [3], also called low anterior rectal resection; (iv) total mesorectal excision (TME) era (1979–1990), which was initiated by Heald [4], greatly reduced the post-operative recurrence rate and became the gold standard for the treatment of rectal cancer; and (v) minimally invasive surgery era (1990 to present), which, along with the widespread use of laparoscopy, was first performed in 1991 by the American surgeon Jacobs [5].

With the continuing development of minimally invasive procedures, endoscopic surgery is being increasingly favoured by surgeons. The development of laparoscopic surgery has resulted in laparoscopic-assisted colorectal resections (LAC/LAR), hand-assisted laparoscopic surgery, and laparo-endoscopic single-site surgery. Many studies have shown that laparoscopic-assisted rectal resection for rectal cancer has good oncological outcomes and is associated with less post-operative pain and intra-operative bleeding, shorter length of hospital stay, faster recovery, and excellent cosmetic outcomes [6–9]. However, poor visualization during pelvic dissection and difficulty in utilizing laparoscopic instrumentation, especially in men with small pelvises and obesity, can result in higher rates of positive circumferential resection margin (CRM) and poor lymph-node extraction [6, 10, 11]. Moreover, the associated duration of anaesthesia may lead to post-operative circulatory and respiratory-system dysfunction and a higher incidence of perioperative complications [12].

The ‘down-to-up’ procedure was developed by Buess in 1983 and is termed transanal endoscopic microsurgery (TEM) [13]. Transanal minimally invasive surgery was subsequently developed [14] and finally natural orifice transluminal endoscopic surgery was established [15]. These techniques have been combined as the transabdominal transanal approach to treating rectal cancer. One such approach—hybrid transanal TME (h-taTME)—has been previously described [16–19]; however, this procedure is not completely non-invasive and the surgical time is relatively long. Therefore, the challenge has been to achieve a balance between minimally invasive procedures, high-quality oncological specimens, and shorter surgical times. The purpose of this study was to standardize the pure taTME (p-taTME) procedure without laparoscopic assistance by utilizing a completely transanal approach for rectal cancer, assess the difficulties and surgical outcomes of this procedure, and report its feasibility for clinical application.

Patients and methods

Patient selection and data collection

This retrospective research included all consecutive patients with middle or low rectal cancer who had undergone p-taTME in Shangdong Linzi District People’s Hospital from December 2015 to April 2018. All surgical procedures were performed by experienced colorectal surgeons according to the principles of good clinical practice. Relevant pre-operative, intra-operative, and post-operative clinical data including relevant patient and tumour characteristics, surgical procedure, surgical specimens, pathological characteristics, and post-operative complications were recorded and analysed. Post-operative incontinence was assessed by the Cleveland Clinic Florida Faecal Incontinence Score (CCF-FI), which defines 0 as normal, 1–10 as mild incontinence, and 11–20 as severe incontinence (Table 1). This retrospective observational study was approved by the local Institutional Review Board (Ethical No. 201510005) and all patients provided written informed consent to the surgical procedure after receiving an explanation of its benefits and risks.

Table 1. Cleveland Clinic Florida Faecal Incontinence Score [19]

Type of incontinence	Frequency				
	Never	Rarely	Sometimes	Usually	Always
Solid	0	1	2	3	4
Liquid	0	1	2	3	4
Gas	0	1	2	3	4
Wears pad	0	1	2	3	4
Lifestyle alteration	0	1	2	3	4

Rarely, ≤1 time per month; Sometimes, ≤1 time per week and ≥1 time per month; Usually, ≤1 time per day and >1 time per week; Always, ≥1 time per day.
Total score: 0, perfect; ≤10 and >0, mild incontinence; ≥10 and <20, severe incontinence; 20, complete incontinence.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (i) rectal adenocarcinoma or high-grade cancer *in situ* proved by pathological examination of a biopsy; (ii) mid or low rectal cancer (2–10 cm from the anal verge, low rectal cancer being defined as within 5 cm of the dentate line and mid rectal cancer as 5–10 cm from the dentate line); (iii) age ≥18 years; (iv) no distant metastasis to the liver or lung and no peritoneal implantation metastasis; and (v) consent to the surgery by both the patients and their families. The exclusion criteria were as follows: (i) poor general condition that was not improved by pre-operative treatment or serious concomitant diseases preventing tolerance of surgery; (ii) any contraindication to creating a pneumoperitoneum, such as severe infection; (iii) intestinal obstruction or performative peritonitis caused by a tumour; (iv) conditions that could lead to uncontrolled bleeding, such as coagulation dysfunction or portal hypertension; (v) pregnancy or extensive adhesions in the abdominal cavity; or (vi) advanced tumours invading adjacent organs.

Pre-operative preparation

A total of 137.15 g of polyethylene glycol electrolyte powder (Wanhe Company; Shenzhen, Guangdong, China) was dissolved in 2,000 mL of drinking water and drunk by the patients between 18:00 and 20:00 the night before surgery to clean the intestines. They subsequently drank 800 and 400 mL of a 12.6% maltodextrin fructose drink (CTFH; Yancheng, Jiangsu, China) to supplement their energy 10 and 2 h before surgery, respectively. All patients received antibiotic prophylaxis with 2 g of intravenous cefoxitin (Zhijun, Shenzhen, China) 30 min before the operation.

Surgical technique

A standardized p-taTME surgical procedure was performed by three experienced colorectal surgeons. With the patient in the lithotomy position and after induction of general anaesthesia, a urinary catheter was inserted under sterile conditions and routine disinfection of the lower abdomen, perineum, bilateral thighs, rectal cavity, and vagina (for female patients) was performed with an iodophor.

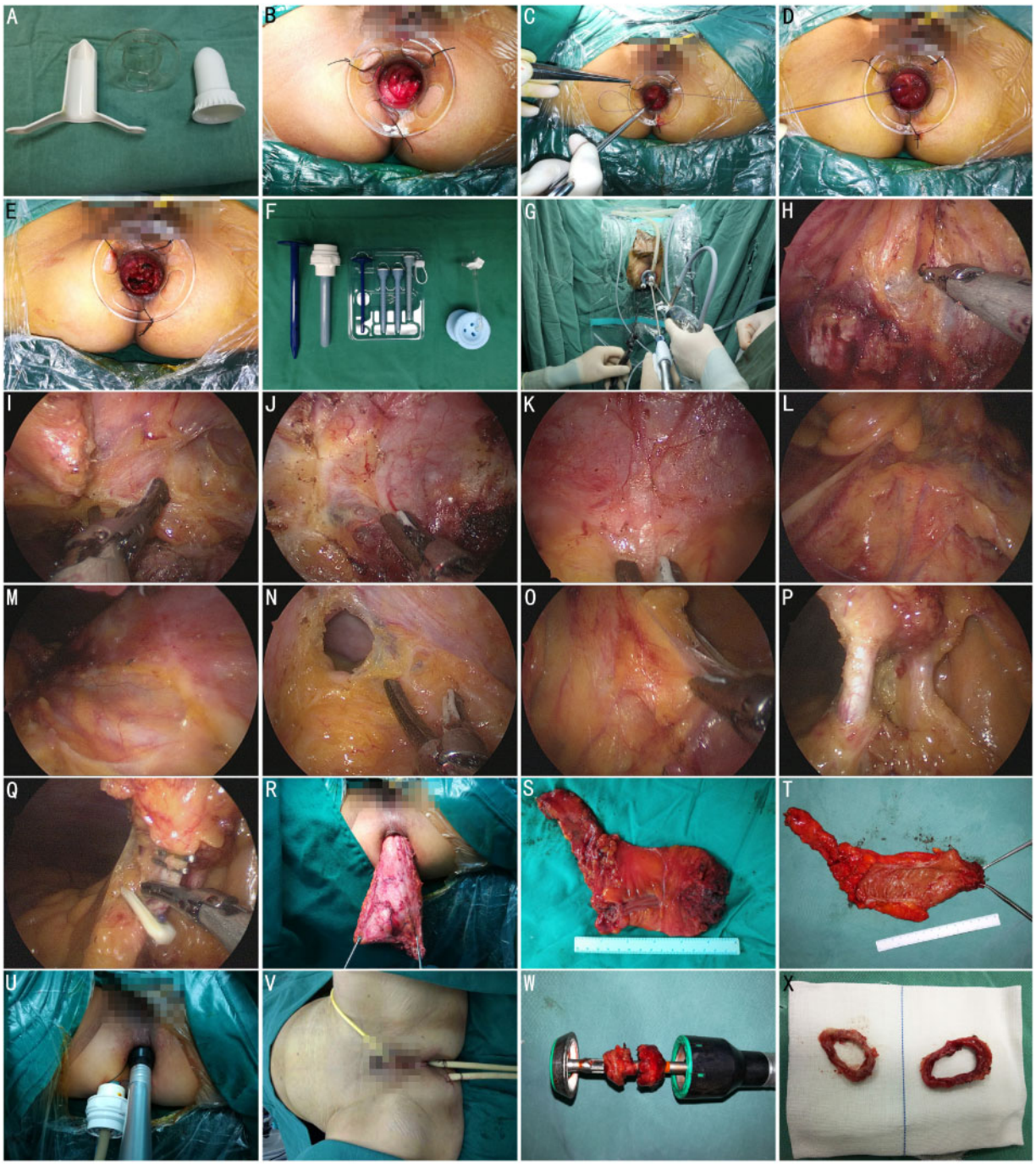

Figure 1. Pure transanal total mesorectal excision procedure. (A) Circular anal dilator. (B) Fixation of anal dilator to perianal skin. (C) Placement of purse-string suture. (D) Completion of purse-string suture. (E) Circular sectioning of the posterior rectal wall of the rectum. (F) Triport device. (G) Implementation of the surgical instruments. (H) Separation of the posterior retrorectal space from the rectum. (I) Separation from the right space of the rectum. (J) Separation from the anterior space of the rectum and exposure of the cervix. (K) Opening of Denonvilliers' fascia. (L) Exposure of the sacral promontory. (M) Exposure of both ureters. (N) Incision in the peritoneal reflection. (O) Entrance into Toldt's space. (P) Exposure of the root of the inferior mesenteric artery and vein. (Q) Ligation of the inferior mesenteric artery and vein. (R) Removal of free bowel through the anus. (S) Surgical specimen. (T) Dissection of the surgical specimen. (U) End-to-end anastomosis of the sigmoid colon and rectum. (V) End of the surgery. (W) Proximal intestinal ring. (X) Distal intestinal ring.

A transparent circular anal dilator (CAD33; Kewei, Changzhou, China) was placed in the anus (Figure 1A). The inner core of the dilator was then removed and the device fixed with sutures to the perianal skin (Figure 1B). Next, a semicircular anoscope was inserted into the anal dilator and a 2–0 prolene purse-string suture placed 2 cm from the distal edge of the tumour under direct vision (Figure 1C and D). For very low tumours—that is, those within 2 cm of the anus—the position of the purse-string suture could be reduced to 1 cm from the distal edge of the tumour as appropriate. The rectum was irrigated with normal saline. Circular sectioning of the full-thickness rectal wall was performed in the distal 0.5 cm of the purse-string using an ultrasound knife (Johnson & Johnson, New Brunswick, NJ, USA) after the purse-string line had been tightly occluded.

The posterior retrorectal space was then entered through the posterior rectal wall (Figure 1E).

A multiport rectal device (SILS-Triport; Covidien, St. Louis, MO, USA) (Figure 1F) was inserted and sealed, carbon-dioxide insufflated to establish the extraperitoneal operating space, and the pressure maintained at 12 mmHg. A 30° scope (Karl Storz GmbH & Co. KG, Tuttlingen, Germany) (Figure 1G) and other surgical instruments were then introduced through the single-port device. The tissue was dissected from the posterior retrorectal space to the proximal part of the rectum. Then the lateral and anterior walls of the rectum were sequentially dissected. Careful attention was paid to protecting both ureters and pelvic-nerve plexuses (Figure 1H–J). When mobilizing the anterior aspect of the rectum, tissue separation was first performed behind Denonvilliers' fascia until the seminal vesicle (male) or cervix (female) was exposed and an incision was then made anterior to Denonvilliers' fascia (Figure 1K). The mesorectum was completely separated in accordance with TME principles until the sacral promontory in the posterior region had been reached (Figure 1L). Both the ureters were then dissected laterally (Figure 1M), after which an incision was made in the peritoneal reflection, thus accessing the abdominal cavity (Figure 1N).

The incision was rapidly expanded and a pneumoperitoneum created for intraperitoneal exploration. The patient was then placed in the Trendelenburg position with a slight inclination to the right. The small bowel was mobilized out of harm's way and the dissected rectum placed in the abdominal cavity. The rectosigmoid colon was then mobilized to the origin of the inferior mesenteric artery and vein (Figure 1O), which was ligated with a Hem-o-lok (Sunstone, Hangzhou, China) (Figure 1P and Q). If necessary, the sigmoid colon, partial descending colon, and even the splenic flexure were mobilized.

The Triport was then withdrawn and the freed bowel was removed through the anus (Figure 1R). The sigmoid colon was transected 10–15 cm from the proximal end of the tumour (Figure 1S and T). The proximal bowel was oriented to ensure that there was no torsion and then an end-to-end sigmoid-to-rectum anastomosis was performed using a 33-mm circular stapler (Johnson & Johnson) (Figure 1U); a 28-mm rubber drainage tube was placed 3 cm from the right posterior side of the anus, extending to the presacral region (Figure 1V). The integrity of the proximal and distal intestinal anastomotic (rings) was checked (Figure 1W and X) and the surgical specimen sent for pathological examination. The video of the entire procedure can be seen in the Supplementary Materials.

Statistical analysis

For continuous variables, the normally distributed data are presented as mean ± standard deviation, whereas the non-normally distributed data are expressed as the median and range; binary and categorical variables are presented as number and percentage. All data were analysed using the Statistical Package for the Social Sciences v.23 (IBM, Armonk, NY, USA).

Results

Patient characteristics

The study cohort comprised 55 patients with middle or low rectal cancer who had undergone p-taTME. All procedures were performed without conversion to open surgery. Relevant patient characteristics are shown in Table 2. The patients comprised 32 (58.2%) men and 23 (41.8%) women with a mean age of 65.6 ± 10.6 years and mean body mass index of 23.4 ± 3.3 kg/m^2. The median distance from the anal verge to the tumour edge was 55.0 (range, 30–100) mm. Forty-two (76.4%) patients had low rectal cancer and 13 (23.6%) mid rectal cancer. Most tumours were located in the posterior lateral rectum.

Table 2. Relevant characteristics of 55 patients with rectal cancer who underwent p-taTME

Demographics characteristic	Data
Age, mean ± SD, years	65.6 ± 10.6
Sex, *n* (%)	
Male	32 (58.2%)
Female	23 (41.8%)
BMI, mean ± SD, kg/m^2	23.4 ± 3.3
Concomitant disease, *n* (%)	
Hypertension	2 (3.6%)
Diabetes	5 (9.1%)
RF	1 (1.8%)
IHD	1 (1.8%)
Previous abdominal surgeries, *n* (%)	
Yes	1 (1.8%)
No	54 (98.2%)
ASA classification, *n* (%)	
I	9 (16.4%)
II	45 (81.8%)
III	1 (1.8%)
Distance from anal verge, median (range), mm	55.0 (30–100)
Tumour location, *n* (%)	
Lower	42 (76.4%)
Middle	13 (23.6%)
Tumour position, *n* (%)	
Anterior	10 (18.2%)
Posterior	18 (32.7%)
Lateral	22 (40.0%)
Circumferential	5 (9.1%)

ASA, American Society of Anesthesiologists; BMI, body mass index; IHD, ischemic heart disease; RF, respiratory failure; SD, standard deviation; p-taTME, pure transanal total mesorectal excision.

Surgical procedures

The median time of the procedure was 180.0 (range, 130–360) min. The procedure was performed in four stages as follows. The procedure for prolapse and haemorrhoid (PPH stage) was defined as from the placement of the purse-string suture to circular sectioning of the full-thickness rectal wall, the extraperitoneal stage from separation of the perirectal space to incision of the peritoneal reflection, the intraperitoneal stage from entering the abdominal cavity to removal of the specimen, and the anastomosis stage from bowel anastomosis to the end of the surgery. The median times for these four stages were 20.0 (range, 20–25) min, 82.0 (range, 45–185) min, 54.0 (range, 30–125) min, and 33.5 (range, 27–35) min, respectively. The median estimated total blood loss was 25.0 (range, 15–80) mL. All patients underwent end-to-end anastomosis of the sigmoid colon and rectum with a 33-mm stapler and drainage of the presacral region (Table 3).

Histopathological and oncological outcomes

The median length of rectal specimens was 108.0 (range, 70–183) mm. The median number of lymph nodes retrieved was 17.0 (range, 11–34); 19 (34.6%) of the patients had lymph-node

Table 3. Surgical variables of 55 patients with rectal cancer who underwent p-taTME

Surgical characteristic	Data
Operative time, min, median (range)	180.0 (130–360)
PPH stage	20.0 (20–25)
Extraperitoneal stage	82.0 (45–185)
Intraperitoneal stage	54.0 (30–125)
Anastomosis stage	33.5 (27–35)
Estimated blood loss, mL, median (range)	25.0 (15–80)
Anastomosis, *n* (%)	
Hand-sewn	0 (0.0%)
Stapling	55 (100.0%)
End-to-end	55 (100.0%)
Other	0 (0.0%)
Distance from anastomotic to anal verge, mm, median (range)	32.5 (4–50)
Drainage tube, *n* (%)	
Yes	55 (100.0%)
No	0 (0.0%)

PPH, procedure for prolapse and haemorrhoids; SD, standard deviation.

Table 4. Pathological characteristics of surgical specimens of 55 patients with rectal cancer who underwent p-taTME

Specimens and pathological characteristic	Data
Length of resected specimen, mm, median (range)	108.0 (70–183)
Quality of specimens, *n* (%)	
Grade 3: complete	50 (90.9%)
Grade 2: nearly complete	3 (5.5%)
Grade 1: incomplete	2 (3.6%)
No. of retrieved lymph nodes, median (range)	17.0 (11–34)
No. of positive	0.0 (0–12)
Positive, *n* (%)	19 (34.6%)
Tumour size, mm, mean ± SD	39.8 ± 13.9
Proximal margin, mm, mean ± SD	61.2 ± 27.3
Distal margin, mm, mean ± SD	18.5 ± 12.9
CRM, mm, median (range)	14.5 (1–45)
Positive, *n* (%)	0 (0.0%)
Pathological stage, *n* (%)	
T category	
T0	2 (3.6%)
Tis	1 (1.8%)
T1	5 (9.1%)
T2	21 (38.2%)
T3	21 (38.2%)
T4a	5 (9.1%)
N category	
N0	36 (65.5%)
N1a	7 (12.7%)
N1b	3 (5.5%)
N2a	4 (7.3%)
N2b	5 (9.1%)
M category	
M0	55 (100.0%)
M1	0 (0.0%)
High-grade dysplasia polyps	3 (5.5%)
I	21 (38.2%)
IIa	9 (16.4%)
IIb	3 (5.5%)
IIIa	3 (5.5%)
IIIb	11 (20.0%)
IIIc	5 (9.1%)
Resected grade, *n* (%)	
R0	55 (100.0%)

CRM, circumferential resection margin; SD, standard deviation.

metastases. The mean tumour diameter was 39.8 ± 13.9 (range, 2.2–83.0) mm and the rate of positive CRM was 0 (0%). Of the polyps exhibiting high-grade dysplasia, 3 (5.5%), 21 (38.2%), and 19 (34.6%) were pathological stages I, II, and III, respectively (Table 4).

Perioperative outcomes

Most patients were able to commence ambulation on the first post-operative day. They began oral intake 2–3 days post-operatively and resumed a regular diet 4–8 days post-operatively. Flatulence or defecation first occurred at 1–3 days post-operatively. The most common post-operative complications were various degrees of faecal incontinence, this being mild in 27 (49.1%) patients and severe in 4 (7.3%) according to the CCF-FI (Table 1) [19]. In all cases, incontinence improved with pelvic-floor-function-rehabilitation exercises and did not seriously affect the patients' quality of life. Low anterior resection syndrome occurred in 14 (25.5%) patients. One patient developed a pelvic infection and two an anal stricture. The pelvic infection resolved after conservative treatment including fast, parenteral nutrition, and antibiotics. The anal stricture resolved after digital dilatation. The median lengths of hospitalization and post-operative hospital stay were 12.0 (range, 9–21) days and 9.0 (range, 7–13) days, respectively. During post-operative follow-up, one patient developed multiple hepatic and abdominal metastases and eventually died of multiple organ failure (Table 5).

Discussion

We summarize our experience of p-taTME as follows. First, exposure of the rectum and anus, implementing the procedure and instruments used for prolapse and haemorrhoids, is achieved conveniently and quickly, especially when performed using a purse-string suture. The purse-string suture should be located in the mucosa or submucosa, not more deeply, because it is otherwise difficult to tighten and easy to inadvertently sever during the subsequent procedures. Second, a 5-mm-diameter endoscopic camera is selected to maximize the operating space and reduce interference between instruments. Connection of an aspiration to the SILS-Triport eliminates accumulation of 'surgical smoke'. When we first started performing this procedure, a specific person oversaw this device setup; however, we subsequently designed a foot switch that can be controlled by the endoscope assistants, increasing convenience and reducing the number of staff required. Additionally, a 1-m-long plastic endoscope sheath is connected to the pneumatic tube; this helps to cushion and stabilize the pressure of the pneumoperitoneum. We find this more effective than constant pressure insufflation and thus worthy of more widespread use. Third, when the peritoneum is opened, the pelvic space instantly becomes smaller because the pressure in the abdominal cavity increases. During this process, the incision that has been made in the peritoneal reflection acts like a valve and the pneumoperitoneum pressure fluctuates greatly, making exposure difficult; we call this the 'dark period'. At this stage, the free segment of the rectum should be quickly inserted into the abdominal cavity through the peritoneal fissure. Although this creates more space for the pelvic component of the

Table 5. Post-operative variables of 55 patients with rectal cancer who underwent p-taTME

Post-operative characteristic	Data
Out of bed activity, days, median (range)	1.0 (1–1)
Begin oral intake, days, median (range)	2.0 (2–3)
Regular diet, days, median (range)	5.0 (4–8)
Begin fart or defecation, days, median (range)	2.0 (1–3)
Withdrawal urinary catheter, days, median (range)	3.0 (2–4)
Withdrawal drainage tube, days, median (range)	7.0 (6–10)
Post-operative analgesia, days, median (range)	1.0 (1–1)
Urinary functions, *n* (%)	
Normal	55 (100.0%)
Abnormal	0 (0.0%)
Faecal incontinence, median (range)	2.5 (0–16)
Pre-operative	
Normal	55 (94.5%)
Mild incontinence	3 (5.5%)
Severe incontinence	0 (0.0%)
Post operation	
Normal	24 (43.6%)
Mild incontinence	27 (49.1%)
Severe incontinence	4 (7.3%)
ARS score, median (range)	11.0 (0–64)
No ARS	41 (74.6%)
Mild ARS	8 (14.6%)
Severe ARS	6 (10.9%)
Post-operative complications, *n* (%)	
No	26 (47.3%)
Pelvic infections	1 (1.8%)
Stricture of anus	2 (3.6%)
Incontinence	29 (52.7%)
ARS	14 (25.5%)
Hospital stay, days, median (range)	12.0 (9–21)
Post-operative hospital stay, days, median (range)	9.0 (7–13)
Post-operative chemoradiotherapy, *n* (%)	
No	24 (43.6%)
Chemotherapy	16 (29.1%)
Chemoradiotherapy	15 (27.3%)
Follow-up, months, mean ± SD	11.6 ± 7.7
Recurrence and metastasis, *n* (%)	
Yes	1 (1.8%)
No	54 (98.2%)
Survival, *n* (%)	
Alive	54 (98.2%)
Dead	1 (1.8%)

ARS, anterior resection syndrome; SD, standard deviation.

procedure, it can temporarily block the peritoneal fissure so that the pressure is higher in the pelvis than in the abdominal cavity, improving pelvic exposure and making the surgery easier to perform. Fourth, at the initial stage of dissociating the mesorectum, we separate from the posterior to the side of the rectum and converge at the anterior. With increasing experience, however, we realized that identification of the lateral mesorectal space is relatively difficult and accordingly changed the separation sequence so that we first separated the posterior and anterior regions and then the confluence on the side. These steps are helpful in identifying the lateral clearance. Additionally, right-handed surgeons, for whom separation of the right mesorectal space is difficult, can cross their left and right hands so that the right hand always operates the ultrasonic knife; this minimizes instrument interference. Fifth, to protect the patient's voiding and sexual functions, Denonvilliers' fascia should be exposed as far as possible. The posterior aspect of Denonvilliers' fascia should be separated until the seminal vesicle (male) or cervix (female) is crossed, then the fascia should be cut transversely and separated anteriorly. Sixth, upon completion of the entire TME dissection, if the surgery is difficult, a 10-mm trocar can be placed in advance in the position where a presacral drainage tube would later be inserted in the right posterior part of the anus to facilitate exposure and performance of the procedure. Seventh, when the ongoing process of separation extends into the abdominal cavity and over the sacral promontory, it becomes increasingly difficult to aim the surgical instruments and endoscope lens at one point because the relationship between them becomes increasingly more parallel the farther away the operating point is from the anus. Using the right hand to operate the 10-mm trocar and the left hand to operate the SILS-Triport solves this difficulty. Eighth, because of the unique surgical field during this procedure, the inferior hypogastric plexus posterior to the inferior mesenteric artery can be clearly displayed, preventing nerve damage during surgery. Ninth, the crucial step of isolation of the sigmoid mesentery is difficult because it is hard to completely flatten the mesentery and the view at the anus is limited. This directly affects the intestinal blood supply and determines the quality of the anastomotic stoma. Our experience has taught us that, after the inferior mesenteric artery and vein have been ligated, separation should be performed toward the distal rather than the proximal side. In addition, the length of the sigmoid should be accurately evaluated by colonoscopy, CT, and MRI pre-operatively, to provide evidence for the separation and resection site of the sigmoid colon. Finally, it is necessary to place the inner purse-string suture at the distal end of the rectum before anastomosing the rectum and sigmoid. When we first started performing this procedure, we began the suture at the 3 o'clock point and continued clockwise with the patient in the lithotomy position; the most difficult part of the procedure was suturing the anterior wall. With increasing experience, we now begin the suture at the 10 o'clock position and advance from the intestinal mucosa to serosa. We have also changed the needle's direction (intestinal serosa to mucosa) when suturing to the six points and ensure that the entry and exit sutures are located on the mucosal side to ensure the quality of the purse-string. A presacral drainage tube is placed through the 10-mm trocar before anastomosis of the rectum and sigmoid to avoid anastomotic injury.

As reported by Williams [20], the distal rectum, around which the levator ani is wrapped, is difficult to reach under direct vision and is termed 'no man's land' in rectal-cancer surgery. Thus, complete TME is difficult to perform in this region. Leonard *et al.* [21] have also reported that the closer the tumour is to the anus, the more difficult it is to accomplish TME; accordingly, the rates of CRM positivity and local recurrence are high. Fortunately, the 'down-to-up' transanal approach, especially the popular taTME procedure, provides a perfect solution to this problem.

p-taTME has risen to the forefront of surgical treatment of rectal cancer since this no-incision procedure was first reported by Zhang *et al.* [22] in 2013. Rouanet *et al.* [23] performed taTME on 30 men with narrow pelvises and stated that the procedure is feasible in patients with adverse anatomy such as an unusually narrow pelvis. In 2013, Heald [24] predicted that an era of low rectal dissection and transanal endoscopic approaches is coming. The recovery of the 55 patients with rectal cancer who underwent p-taTME at our research centre was generally

satisfactory according to the various post-operative variables investigated.

The above modifications and associated skills have enabled us to shorten the surgical time for h-taTME and the subsequent post-operative hospital stay compared with that achieved by other researchers [18, 25]. Moreover, for p-taTME, the time taken to recover post-operatively is shorter than after other procedures. Although the most common post-operative complication was varying degrees of incontinence, this improved with pelvic-floor-function-rehabilitation exercises in all cases and did not seriously affect any patient's quality of life.

Conclusions

The new procedure of p-taTME is safe and feasible for patients with middle or low rectal cancer. However, this was a relatively small study. Larger controlled studies are needed further obtain reliable data. Additionally, long-term outcomes, including prognosis, defecation status, and urogenital function, are unknown and require further follow-up. In the future, larger numbers of accumulated cases should be summarized and analysed to obtain more evidence-based data on the long-term effects of the surgery. We firmly believe that the 'down-to-up' transanal approach of p-taTME is a revolutionary development in rectal-cancer surgery.

Supplementary data

Supplementary data is available at *Gastroenterology Report* online.

Authors' contributions

G.Y. and G.L. conceived of and designed the study. X.M.W., G.Y., Z.R., and R.C.G. performed the surgery. R.W. and L.Y.C. participated in the post-operative management of patients. X.M.W. and Y.Y.X. collected data and contributed to data analysis. Y.Y.X., Z.R., and R.C.G. contributed to interpretation of data. G.Y. and G.L. participated in streamlining of the study protocol. R.W. and L.Y.C. supervised the data-collection process. Y.Y.X. and Z.R. participated in recording and editing of videos. X.M.W., Y.Y.X., G.Y., Z.R., R.C.G., R.W., L.Y.C., and G.L. contributed to drafting of the article. All authors contributed to revision of the article and approved the final version.

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Conflicts of interest

The authors declare that there are no conflicts of interest in this study.

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