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Transanal total mesorectal excision for rectal cancer: a preliminary report

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Abstract
Background Currently, the majority cases of the novel down-to-up transanal total mesorectal excision (TaTME) were performed in a hybrid approach with conventional laparoscopic assistance because of less operative difficulty. However, although cases are limited, the successes of TaTME in a pure approach (without laparoscopic assistance) indicate that the costly and less mini-invasive hybrid TaTME could be potentially avoided.
Methods In the present single institutional, prospective study, we attempted to demonstrate the safety and feasibility of this approach in rectal cancer by evaluating the short-term results of our first 20 TaTME cases. For the majority of cases, we adopted a strategy that laparoscopic assistance was not introduced unless it was required during the planned pure TaTME procedure.
Results A total of 20 patients (12 males and 8 females) were analyzed in this study, including 11 cases (55 %) of pure TaTME and 9 cases (45 %) of hybrid TaTME. Overall, the median operative time was 200 min (range 70–420), along with a median estimated blood loss of 50 ml (range 20–800). Morbidity rate was 20 % (one urethral injury, two urinary retentions, one anastomotic hemorrhage and one mild anastomotic leak). The median number of harvested lymph nodes was 12 (range 1–20). All specimens were intact in mesorectum without positive distal and circumferential resection margins. Among the 15 patients who were preoperatively scheduled to undertake pure TaTME, four patients (26.7 %) required converting to laparoscopic assistance. Moreover, among these 15 patients, the results of the comparative analysis between female and male subgroups favor the former, suggesting easier operation in them.
Conclusion This preliminary study demonstrates that TaTME in rectal cancer is safe and feasible. The strategy of not introducing laparoscopic assistance unless it is required while performing the planned pTaTME should be cautiously explored. Further studies with larger sample size and longer follow-up are warranted.

Keywords Rectal cancer · NOTES · Laparoscopic assistance · Transanal · TME

Although dramatic evolvement of treatment modalities has been achieved, the battle against colorectal cancer has still a long journey to go given that it remains the third most deadly cancer globally. Regardless of advancement of pre- and postoperative chemotherapy and/or radiotherapy, surgical resection with high quality still plays the most important role in resectable cancer with the most illustrative example being total mesorectal excision (TME). It has been regarded as the gold standard for surgical resection of rectal cancer because of its substantial improvement of local recurrence and survival [1].

Apart from curability, minimization of trauma is another important direction that currently colorectal surgeons are

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pursuing. During the past decades, numerous evidences including those from multicenter randomized control studies have demonstrated the advantage of mini-invasive of laparoscopic rectal cancer surgery, without compromise of resection quality and oncologic outcome [2, 3]. Furthermore, laparoscopic surgery has evolved from multiple ports to single site so as to achieve maximized effect of mini-invasiveness [4]. Nevertheless, the so-called natural orifice transluminal endoscopic surgery (NOTES) represents the utmost form of mini-invasive surgery [5]. Recently, this concept has been successfully applied in rectal cancer surgery, in a combination of TME and single-port laparoscopic technique [6–8]. Opposite to the conventional way, this revolutionized approach is transanally from bottom to up; therefore, it is called transanal TME (TaTME) [9, 10].

As one of hottest spots in the field of rectal surgery, recently tens of studies with favorable short-term morbidity and resection quality have been reported [11, 12]. However, most of these cases were performed with assistance of standard laparoscopy (hybrid TaTME, hTaTME) as a compromised option [13–20], because pure TaTME (pTaTME) without assistance is supposed to be infeasible due to the limitations of instrumentation and technique. However, strictly speaking, hTaTME does not represent the true meaning of NOTES. Given that totally more than ten cases have been reported to accomplish the "mission impossible" of pTaTME [5, 21, 22], the costly and less mini-invasive hybrid TaTME could be potentially avoided.

In an initial stage, we had successfully performed pTaTME, or pure transanal endoscopic surgery (PTAES) as we previously called in several swine and then human cadavers with satisfactory outcome (unpublished data, see Fig. 1). Afterward, we began enrolled patients in a preliminary single-arm prospective study (ClinicalTrials.gov, identifier: NCT02236884). Herein, we analyzed the short-term results of our first 20 cases, aiming to evaluate the safety and feasibility of this novel approach.

Methods

Patients

Selected patients with biopsy-proven adenocarcinoma or high-grade dysplasia that was scheduled to undertake radical surgery were eligible. All lesions were located 3–12 cm from the anal verge. Exclusion criteria included those presenting recurrence and metastasis; cT4b tumor that requires multi-visceral resection or abdominoperineal resection; and presenting intestinal obstruction or perforation, synchronous colorectal cancer, fecal incontinence, history of inflammatory bowel disease (IBD) and familial adenomatous polyposis (FAP). All patients had undergone systemic assessment before surgery, such as thorough colonoscopy, pelvic MRI and/or endorectal ultrasonography, thoracoabdominal CT scan and sphincter manometry. According to the preoperative MRI staging, neoadjuvant therapy (chemoradiation, chemotherapy alone) was indicated in patient with T stage $\geq$T3, and/or with N (lymph node)-positive, and/or with threatened CRM (circumferential resection margin).

Patients were enrolled after the approval of the institutional review board. All patients had been given full explanations of the benefit and adverse risks of the procedure, and informed consent had been obtained from each patient.

Operative technique

The patient was placed in an extended lithotomy position and prepared as a combined trans-abdominal and transanal surgery in case of laparoscopic assistance or conversion to open surgery. After digital anal dilation and perineal disinfection, a metal circular retractor with six radiating sutures was applied to fully expose the anorectum (Fig. 2A).

Pure TaTME

For palpable low tumor, its distance from anal verge was measured (Fig. 2B) and intersphincteric dissection (ISR) was required for the extremely lower tumors (located around anorectal ring). One or two 2/0 Prolene purse strings were placed to tightly occlude the rectal lumen. Depending on tumor height, it was either placed under direct vision (Fig. 2C) or after introducing the *SILS Port* (Covidien, Mansfield, MA) (Figs. 2D, 3A), but at least 1 cm from the tumor must be guaranteed. Meanwhile, a rubber tube was introduced through the ischiorectal fossa as an extra mini-trocar for suction or counter-retraction by the assistant and severed as a pelvic drainage postoperatively (Fig. 3). In case of shedding tumor cells, lavage with large volume of iodine was performed before insufflating CO_2 to create a peumo-anorectum (about 10–12 mmHg). Conventional laparoscopic instruments such as high-definition laparoscope (KARL STORZ Endoskopic, Germany), harmonic scalpel (Ultracision; Ethicon Endosurgery, Cincinnati, OH) and graspers were introduced via the multi-channel single port. Then a full-thickness circumferential dissection or extension of the intersphincteric plane (if ISR had been done) toward the perirectal plane was performed. The dissection was first started posteriorly and got access to the presacral plane, as this cotton-like avascular plane (Fig. 4A) was easier to identify, which was consistent with the "holy plane" of TME [1]. The embryological plane was then extended either laterally or

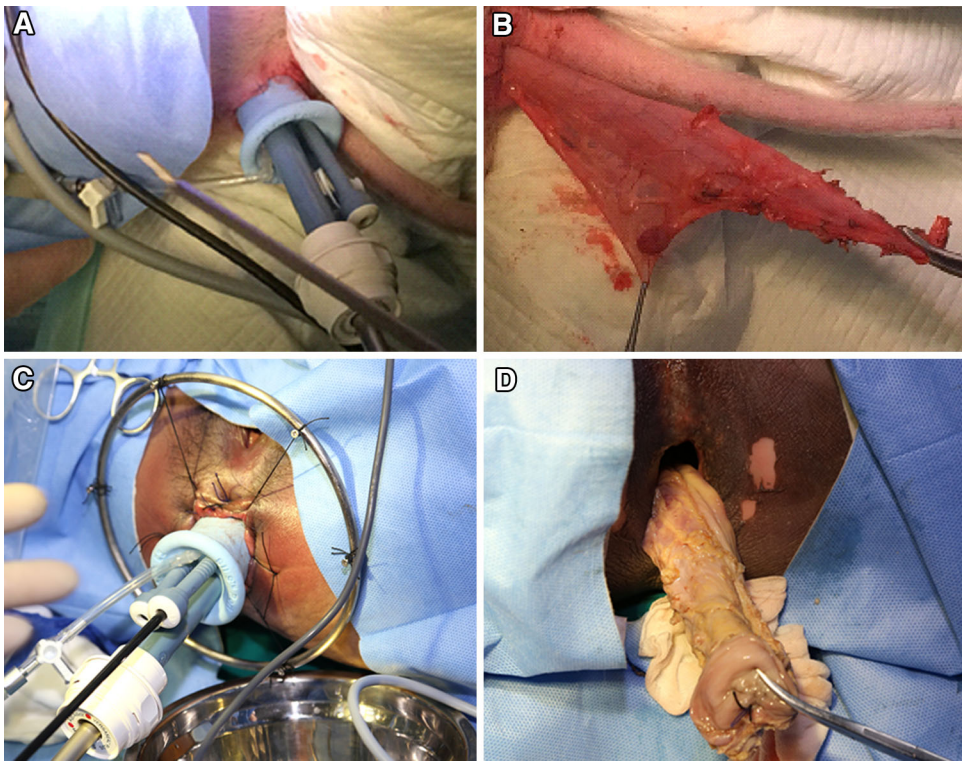

Fig. 1 Preclinical experiments of swine (**A**, **B**) and cadaver (**C**, **D**)

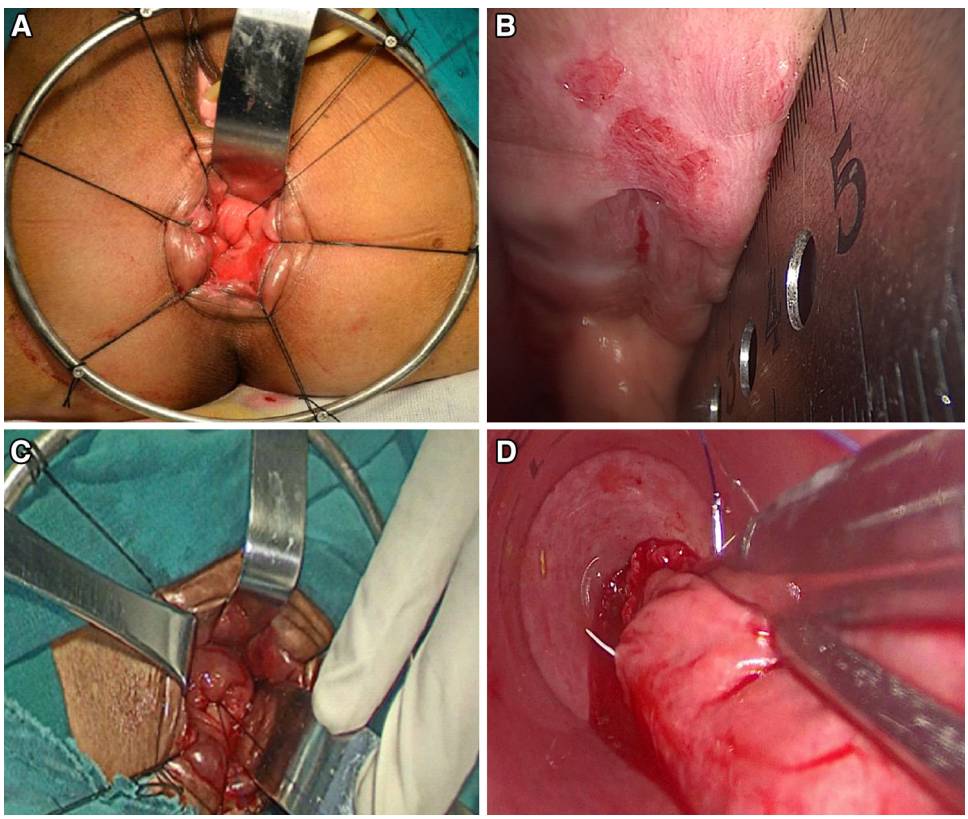

Fig. 2 **A** A metal circular retractor with six radiating sutures is applied to expose the anorectum. **B** Distance from the anal verge is measured for low tumor. **C** For low tumor, a purse-string suture is placed to occlude the rectum under direct vision. **D** For higher tumor, purse string is placed via transanal platform

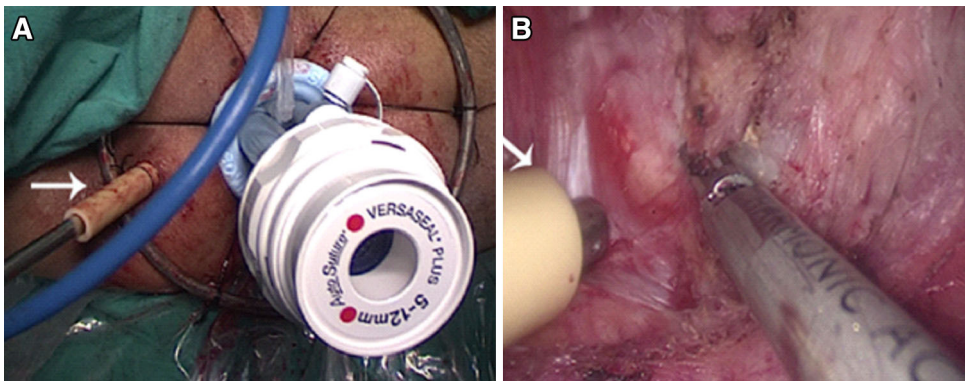

Fig. 3 **A** SILS Port (Covidien, Mansfield, MA) is installed. **B** A rubber tube (*white arrow*) is introduced through the ischiorectal fossa into the anorectum, serving as a mini-trocar

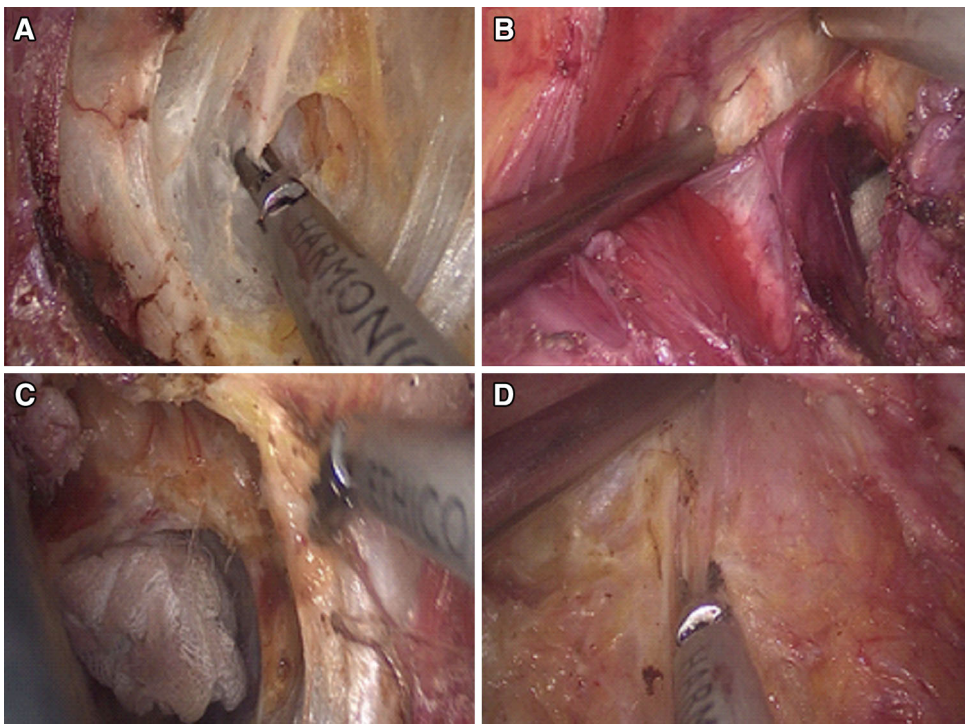

Fig. 4 Transanal total mesorectal excision. **A** Posterior dissection; **B** lateral dissection (*right side*); **C** lateral dissection (*left side*); and **D** anterior dissection

anteriorly in a sequence depending on specific situations, while the whole procedure was progressed proximally (Fig. 4). Particularly, in the anterior dissection of male patient with tumor located in the anterior aspect of rectal lumen, the Denonvilliers' fascia was resected, whereas it was preserved for non-anterior tumors, for the sake of safe resection margin (Fig. 4D). The peritoneal reflection was reached anteriorly but was not cut open to set up pneumoperitoneum until the extraperitoneal rectum had been mobilized to the most extent. Then patient was rotated to a position with head and right side down and the mobilized rectum was reversed into the peritoneal cavity, which facilitated the followed free up of attachments between the sigmoid mesocolon and the retroperitoneum. After the inferior mesenteric vessels (IMV) were skeletonized, it was ligated and divided using Hemolok Clips (Weck Corporation, CO, USA; Fig. 5A). The medial and lateral attachments of the descending colon were then divided to the greatest degree (Fig. 5B), making sure adequate length of colon could be pulled through the anus (Fig. 5C). After delivering the specimen extracorporeally, an end-to-end straight stapled anastomosis (CDH29, Ethicon Endo-surgery, Cincinnati, OH) was fashioned (Fig. 5D), but for tumor requiring a total ISR without adequate residual rectal stump, a handsewn anastomosis was performed, as mentioned by Chen et al [13].

Trans-abdominal laparoscopic assistance

If the above procedure was not smoothly progressed, i.e., encountered intraoperative complications; had difficulty to ligate IMV and mobilize proximal colon; and require

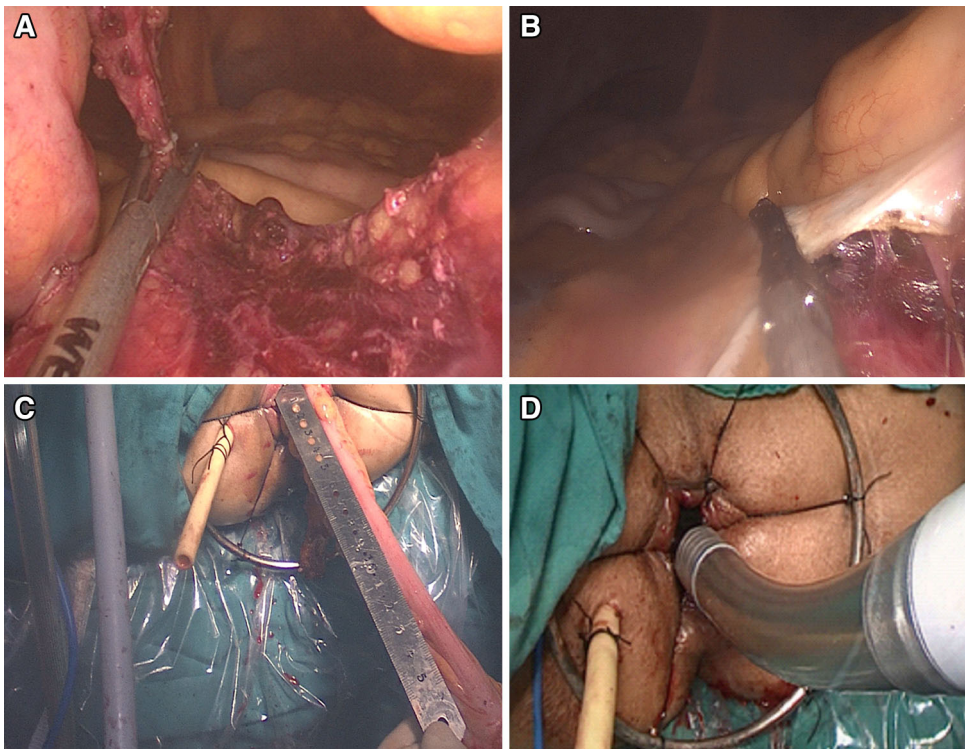

Fig. 5 **A** The inferior mesenteric artery is ligated. **B** The medial attachment is dissected when mobilizing the descending colon. **C** The colon is pulled through the anus to deliver the specimen extracorporeally. **D** End-to-end straight anastomosis is fashioned using a circular stapler (CDH29, Ethicon Endosurgery, Cincinnati, OH)

mobilization of splenic flexure (MSF) to obtain adequate colonic length, standard laparoscopic assistance was then introduced. Also, if a combined abdominal surgical procedure such as splenectomy was planned or the patient was originally scheduled to undertake hTaTME, laparoscopic surgery was introduced, usually after the finish of extraperitoneal mesorectal mobilization by the above pTaTME. Generally, the conventional multi-port technique which placed one 10-mm port in the umbilicus and two to three 5-mm ports in both lower quadrants was utilized; in two cases, the single-port technique which placed a *SILS Port* in the future ileostomy site as described by Velthuis et al. [15] was attempted. With laparoscopic assistance, the complications and the difficult part encountered by pTaTME mentioned above were handled from up to down by a one-team approach or in a simultaneous approach by two teams, as reported by Chen et al. [13]; meanwhile, the transanal dissection was re-oriented and rendezvoused in the proper plane. The followed specimen extraction and anastomosis were the same with pTaTME, but mostly, a diverting loop ileostomy was constructed which was usually closed 3 months later.

Assessment and statistical analysis

The primary focus of this study was the short-term results relevant to safety and feasibility, such as perioperative morbidity and oncological resection quality. Clavien–Dindo classification [23] was used to evaluate morbidity. High-quality photographs of the specimen and operation video of each patient will be saved for quality monitoring. Length was measured in fixed specimens. Completeness of mesorectum was independently assessed by the pathologists who grossly graded the mesorectum as complete, near complete and incomplete, as described by Nagtegaal et al. [24]. A positive circumferential resection margin (CRM) and distal resection margin (DRM) were defined as tumor cells within 1 mm of the resection margin. After discharging, patients were more extensively followed than patients undertook conventional surgery, including physical examination, CEA measurement, thoracoabdominal CT scan, pelvic MRI, colonoscopy, anal manometry, and evaluation of function and life quality.

Data were prospectively collected and recorded in a well-maintained database. Quantitative variables are expressed as means ± standard deviations or medians (ranges) and compared by Student *t* test; categorical variables are expressed as counts (percentages) and compared by chi-square test or the Fisher exact test where appropriate. All data analyses were performed by SPSS software, version 18.0 (SPSS, USA).

Results

In the 8-month period (between July 2014 and January 28, 2015), a total of 20 patients had been operated with TaTME technique, including 11 cases (55 %) of pTaTME

and 9 cases (45 %) of hTaTME. Demographics of the patients and characteristics of tumors are summarized in Table 1. Among the 12 male and 8 female patients, the mean age was 58 years old (range 36–84) with a mean BMI of 22.3 kg/m^2 (range 16.7–27.5). There were 14 cases (70 %) of low rectal cancer (distance between the lower tumor margin and anal verge $\leq$6.0 cm) with a mean distance of 6.0 cm (range 3–12). Six patients (30 %) had received neoadjuvant therapy.

The perioperative results are listed in Table 2. Among the nine cases of hTaTME, five were not preoperatively scheduled to undertake pTaTME because of patients' selection (4) and required splenectomy (1). Due to the great variations among cases, operative time and estimated blood loss were expressed as medians (ranges), which were 200 min (range 70–420) and 50 ml (range 20–800), respectively. One intraoperative transfusion and one postoperative transfusion were required. Partial ISR was done in four cases, whereas no total ISR was performed. All cases were fashioned in end-to-end stapled anastomosis. Ileostomies were routinely constructed in hTaTME cases (not performed in one patient who strongly requested for no stoma and his risk of leak was not considered high). Postoperatively, the patient who suffered from urethral injury required an urethroplasty 1 month later, but gradually recovered and discharged in the postoperative 64th day with minor urinary dysfunction. Urinary retention with delayed Foley catheter removal occurred in two hTaTME patients (12.5 %). One pTaTME patient had readmission within 30 days because of delayed anastomotic hemorrhage and was treated conservatively. One asymptomatic leak was found by CT scan in his first follow-up in a pTaTME patient, whose only complaint was mild incontinence.

The pathologic outcome is summarized in Table 3. The median number of harvested lymph nodes (LN) was 12 (range 1–20), while 65 % ($n = 13$) of patients had lymph nodes exceeded 12. No case had an incomplete mesorectum, or positive DRM or CRM.

As we felt pTaTME was easier to accomplish in female patients, a subgroup comparison between the female and male subgroups among the 15 patients who were originally

Table 1 Preoperative characteristics of patients and tumors

Characteristic	Value
Gender	
Male/female	12/8
Age, years, mean ± SE (range)	58.6 ± 12.8 (36–84)
BMI, kg/m^2, mean ± SE (range)	22.2 ± 2.3 (16.7–27.5)
ASA classification	
I–II	16 (80 %)
III–IV	4 (20 %)
Previous abdominal surgery	3 (15 %)
CEA > 5 ng/ml	3 (15 %)
DAV, cm, mean ± SE (range)	6.1 ± 2.4 (3–12)
Low rectal cancer	14 (70 %)
Tumor location	
Anterior	4 (20 %)
Lateral	5 (25 %)
Posterior	8 (40 %)
Circumferential	3 (15 %)
Neoadjuvant therapy	6 (30 %)
(y)cTMN	
TisN0	2 (10 %)
T1-2N0	9 (45 %)
T3N0	3 (15 %)
T1-3N1-2	6 (30 %)

SE standard error of the mean, *BMI* body mass index, *ASA* American Society of Anesthesiologists, *CEA* carcinoembryonic antigen, *DAV* distance from anal verge, *cTMN* clinical TMN stage, *Tis* carcinoma in situ

Table 2 Perioperative outcome

Characteristic	Value
pTaTME	11 (55 %)
hTaTME	9 (45 %)
Planned hTaTME	5 (25 %)
Conversion to Lap	4 (20 %)
Single-port Lap	2 (10 %)
OT (min)	200 (70–420)[a]
EBL (ml)	50 (20–800)[a]
Transfusion	2 (10 %)
Partial ISR	4 (20 %)
MSF	3 (15 %)
Ileostomy	8 (40 %)
Overall morbidity	5 (20 %)
Intraoperative complications	
Massive bleeding	1 (5 %)
Prostate and urethra injury	1 (5 %)
Postoperative complications	
Dindo I–II	4 (20 %)
Dindo III–IV	1 (5 %)
Readmission within 30 days	1 (5 %)
Mortality within 30 days	0

pTaTME pure transanal TME, *hTaTME* hybrid transanal TME, *Lap* laparoscopic assistance, *Single-port Lap* trans-abdominal single-port laparoscopic assistance, *OT* operative time, *EBL* estimated blood loss, *ISR* intersphincteric resection, *MSF* mobilization of splenic flexure, *Dindo* Clavien–Dindo classification

[a] Data are expressed as median (range)

Table 3 Pathologic results

Characteristic	Value
LN harvest	12 (1–20)[a]
Length of specimen (cm)	10.5 (5–15)[a]
pTMN	
CR	2 (10 %)
Tis	2 (10 %)
I	10 (50 %)
II	4 (20 %)
III	2 (10 %)
Tumor size (cm)	2.8 (0–4.5)[a]
Distal margin distance (mm)	10 (5–25)[a]
Circumferential margin (mm)	12 (3–19)[a]
CRM $\leq$ 1 mm	0
Mesorectal resection quality	
Complete	18 (90 %)
Near complete	2 (10 %)
Incomplete	0

LN lymph node, *pTMN* pathologic TMN stage, *CR* complete remission, *Tis* carcinoma in situ, *CRM* circumferential resection margin

[a] Data are expressed as median (range)

scheduled to pTaTME was conducted, see Table 4. It showed that all of the four cases (26.7 %, 4/15) who were converted to have laparoscopic assistance were in male group (main information of them is listed in Table 5) because of the following reasons: prostatic and urethral injury accompanied by massive hemorrhage of about 800 ml (1); unsatisfactory exposure accompanied by mild hemorrhage (2); having resistance to deliver specimen due to a bulky mesorectum (3). Moreover, operative time, estimated blood loss and yield of LN s all favor the female group, although the last one does not reach statistical significance. Furthermore, the 11 pTaTME cases of our study were compared with those in previous studies, which are summarized in Table 6.

Until the latest follow-up of March 2, 2015, in a median follow-up of 5 months (range 1–8), no recurrence has been found. Anal function was evaluated among patients who have returned for follow-up in the postoperative 3 months, who have had their stoma reversed and have finished adjuvant chemotherapy. Totally 15 patients were qualified. The median bowl movement was two times (0–6) per day, while median Wexner score was 5 (3–11). Six (40 %) patients reported symptomatic stool fragmentation and difficult evacuation.

Discussion

Using anus as an access for rectal cancer surgery is not novel, but the combination of transanal NOTES and TME is. Unlike NOTES cases in other fields which usually chose orogastric tract or vagina as accesses [25, 26], transanal access has several advantages: Firstly, the rectum which is cut open is the diseased organ that has to be resected; secondly, the closure of the opening is much easier and integrated with anastomosis. In fact, before the recognition of TaTME, some authors had directly attempted a "down-to-up" intersphincteric dissection for low rectal cancer, however, without using a transanal platform for further

Table 4 Comparison of the male and female subgroups among the 15 patients who are scheduled to pTaTME

Characteristic	Male subgroup ($n = 9$)	Female subgroup ($n = 6$)	p value
Age (years)[a]	66.2 ± 8.8	49.6 ± 11.3	0.007
BMI (kg/m^2)[a]	22.8 ± 2.3	20.6 ± 2.4	0.098
Previous abdominal surgery[b]	1 (11.1 %)	1 (16.7 %)	1.000
DVA (cm)[a]	5.6 ± 1.8	8.1 ± 2.8	0.057
Diameter of tumor (cm)[a]	3.0 ± 1.2	2.3 ± 1.2	0.330
NeoT[b]	1 (11.1 %)	1 (16.7 %)	1.000
Conversion to Lap[b]	4 (44.4 %)	0	0.103
OT (min)[a]	275.2 ± 86.1	135.0 ± 46.9	0.003
EBL (ml)[a]	244.4 ± 250.5	48.3 ± 29.2	0.047
Transfusion[b]	1 (11.1 %)	0	1.000
Complications[b]	2 (22.2 %)	1 (16.7 %)	1.000
Length of specimen (cm)[a]	10.8 ± 3.4	11.2 ± 2.4	0.300
LN harvest[a]	9.0 ± 4.9	12.0 ± 7.3	0.350

BMI body mass index, *DAV* distance from anal verge, *NeoT* neoadjuvant therapy, *Lap* laparoscopic assistance, *OT* operative time, *EBL* estimated blood loss, *LN* lymph node

[a] Data are expressed as mean ± standard deviation and compared by Student's t test

[b] Data are expressed as count (%) and compared by the Fisher exact test because of limited events

Table 5 Detailed information of the four male patients who are converted to have laparoscopic assistance while performing pTaTME as planned

Characteristic	#1	#2	#3	#4
Gender	Male	Male	Male	Male
Age (years)	67	62	64	64
BMI (kg/m^2)	22.7	27.5	23.8	23.5
Comorbidity	BPH	Type 2 DM	BPH	No
Location of tumor	5 cm from AV, circumferential	5.6 cm from AV, posterior	6 cm from AV, 2/3 circumferential	4 cm from AV, anterior
Diameter of tumor (cm)	4.5	1.5	3.5	1.5
Initial TMN stage	cTisN0M0	cT2N0M0	cT2N0M0	ycT3N1aM0
NeoT	No	No	No	Yes
OT (min)	420	200	350	330
EBL (ml)	800	150	200	50
Transfusion	Yes	No	No	No
Reasons of requiring Lap	Prostatic and urethral injury accompanied by massive hemorrhage	Having resistance to delivery specimen due to bulky mesorectum	Unsatisfactory exposure accompanied by mild hemorrhage	Unsatisfactory exposure accompanied by mild hemorrhage
Length of specimen (cm)	6.5	15	12	10
Harvested LN	7	9	12	14
pTMN	pT1N1M0	pT1N0M0	pT1N0M0	ypT0N0M0
Completeness of mesorectum	Near complete	Complete	Near complete	Complete
Ileostomy	No	Yes	Yes	Yes
Outcome	Required urethroplasty	Uneventful	Uneventful	Uneventful
LOS (days)	95	29	15	18

BMI body mass index, *BPH* benign prostatic hyperplasia, *DM* diabetes mellitus, *AV* anal verge, *NeoT* neoadjuvant therapy, *OT* operative time, *EBL* estimated blood loss, *Lap* laparoscopic assistance, *LN* lymph node, *LOS* length of hospital stay

proximal extension [27, 28]. Regardless of whether rigid transanal endoscopic microsurgery (TEM) platform [29] or flexible transanal minimally invasive surgery (TAMIS) platform [30] is used, it permits a clear and magnified filed to access to the confined distal rectum (once called "no man's land") from below. In that sense, TaTME represents the amalgamation of quintessence of TME, NOTES, ISR, TEM/TAMIS and single-port laparoscopy. Expectedly, it is technically demanding and requires training before it is applied to patients [16]. Therefore, although our surgical team had extensive experience and expertise in laparoscopic, ISR and TEM surgery for rectal cancer, we did not enroll our first patient before accomplishing preclinical experiments of swine and cadavers.

In about half a year, we had performed 20 cases, including two cases of live demonstrations of surgery in conferences. For a new surgical technique, safety is of great importance. With respect to comorbidity, there was one accidental urethral injury as a result of dissecting too anteriorly into an enlarged prostate and two urinary retentions, which might be resulted by dissecting too anterolaterally to cause minor injury to the autonomic nerves. Therefore, as anatomical landmarks from below remain lacking [31], attentions must be paid to avoid getting lost into improper plane.

In the present study, we accomplished 11 pTaTME cases, which is the largest report as far as we know. As previously mentioned, the most challenging part of pTaTME is to ligate IMV and mobilize proximal colon and MSF. Moreover, methods adopted to prevent disastrous anastomotic leak (AL) such as protective stoma [32] and air leak test [33] are inconvenient to perform. Consequently, it raises concerns about increased Als in pTaTME cases. Nevertheless, the routine construction of stoma and MSF in conventional rectal surgery have not gained universal acceptance [32, 34]. As summarized in Table 6,

Table 6 Comparison of the 11 pTaTME cases with previous reports

Author	Zhang et al. [21]	Leroy et al. [5]	Chouillard et al. [22]	Our study
Published time	2012.8	2012.11	2014.7	
Country	China	France	France	China
Case	1	1	10	11
Gender (M/F)	0/1	0/1	2/8	5/6
Age (years)	48	56	58.2 (34–74)[a]	57.9 (40–84)[c]
BMI (kg/m^2)	20	NR	27.9 (21–38)[b]	21.2 (16–24)[c]
Location of tumor	7 cm from anal verge	Mid-third of rectum	Mid- or low rectal tumors	7.1 (3.6–12) cm[c]
NeoT	No	No	No	No
Transanal platform	Custom-made	TEO device	GelPoint, SILS Port	SILS Port
Anastomosis	End-to-end stapler	Side-to-end, handsewn CAA	End-to-end, handsewn CAA	End-to-end stapler
MSF	None	None	Most	None
Stoma	None	None	None	None
OT (min)	300	190	272.5 (200–400)[a]	180.6 (70–300)[c]
EBL (ml)	50	Minimal	225 (50–600)[b]	99.1 (20–400)[c]
Complication	No	Pelvic hematoma	Bowel obstruction (1), pelvic abscess (1)	Anastomotic hemorrhage(1), mild anastomotic leak (1)
Return to flow diet (days)	2	1	NR	2 (2–5)[c]
Length of stay (days)	7	NR	10.4 (4–29)[b]	12.5 (9–27)[c]
Pathologic stage	T3N1M0	Tubulovillous adenoma with low-grade dysplasia	T1-3N0-1	TIS-3N0-1
Specimen length (cm)	17	20	29.2 (21–41)[a]	9.9 (5–15)[c]
Retrieved number of LN	12	16	15.2 (11–22)[a]	12.0 (1–20)[c]
DRM distance	NR	NR	4.05 (1.5–7.5)[a]	1.3 (0.8–2.5)[c]
Positive CRM	No	No	No	No

NR not reported, *M/F* male/female, *BMI* body mass index, *MSF* mobilization of splenic flexure, *OT* operative time, *EBL* estimated blood loss, *CAA* coloanal anastomosis, *LN* lymph node, *DRM* distal resection margin, *CRM* circumferential resection margin

[a] Data are extracted from the ten pTaTME patients, expressed as mean (range)

[b] Overall data from the 20 patients because detailed data from the ten pTaTME patients not available, expressed as mean (range)

[c] Data from the 11 pTaTME patients, expressed as mean (range)

none of the three (Zhang et al. [21], Leroy et al. [5] and us) had performed MSF or constructed stomas except that Chouillard et al. [22] had "always" performed MSF. Unexpectedly, there was only one mild anastomotic leak in the present study and one pelvic abscess in the study of Chouillard et al. [22]. As a matter of fact, anastomosis was tension free if specimen was transected after pulling through the anus, because there was still 1–2 cm length of proximal colon left extracorporeally, which exerted no tension after it was returned for anastomosis. Furthermore, another concern of pTaTME is inadequate obtaining of specimen and LNs. As data in Table 6 show that all studies are qualified, this concern seems unnecessary, either. However, it is noted that LN yield in our study was relatively unsatisfactory to fulfill the NCCN guidelines, and particularly, in one early case whose biopsied result was tubulovillous adenoma, only one LN was retrieved, which might be attributed to shorter specimen length due to early learning curve. Moreover, five patients who undertook neoadjuvant therapy also had LN harvest $\leq$12, which is considered acceptable without worrisome of inadequate treatment [35]. Nevertheless, retrieval of LN was a less important pathologic variable when compared with quality of mesorectum [24] and CRM [35]. With regard to these two variables, our results of all patients were favorable: No mesorectum was incomplete with any positive CRMs and DRMs, as compared with a large hTaTME study ($n = 56$) which showed 84 % of intact mesorectum and 5.4 % of positive CRM [7]. As a matter of fact, TaTME has been acclaimed because of its advantages of guaranteeing a safer DRM and CRM, and avoiding multiple firings of staplers from above [9, 10].

As mentioned previously, the number of hTaTME cases far exceeds that of pTaTME because of less operative difficulty. However, as compared with pTaTME and standard laparoscopic surgery, hTaTME does not have obvious advantage of mini-invasiveness as abdominal incisions and scars would still remain; moreover, operative cost is increased since two groups of operative equipment and/or staffs are required [10], i.e., the average operative cost of hTaTME in our patients was theoretically about $1600 more than that of pTaTME. In the present study, we tested the hypothesis that it would be rational of not introducing laparoscopic assistance unless it was required while performing the planned pTaTME. However, it might be criticized that such a "salvage" strategy to the unsuccessfully going pTaTME would put surgeon in a dilemma and place the patient in a difficult situation. In the 15 patients who were preoperatively scheduled to undertake pTaTME, totally four cases (26 %) were converted to laparoscopic assistance. Moreover, as shown in Table 5, except for the patient who suffered from a urethra injury, the results and postoperative recovery of the remaining three patients did not seem compromised. Therefore, we preliminarily show that such a strategy is feasible. As a matter of fact, the logic of this strategy is similar to that of converting laparoscopic surgery to salvage open surgery in the early days when organ injury and complications in laparoscopic surgery were somehow unacceptable [36]. Even so, we are fully aware of the following problems: Firstly, economic and cosmetic effect should never be the limitations of a promising technique. Nevertheless, the total expense of a pTaTME with severe complication may far exceed that of a successful hTaTME. Secondly, hTaTME is perhaps not necessary a transitional step toward pTaTME, since it has demonstrated significant advantages in reducing operative time [8], particularly when two-team approach [13] was adopted. Furthermore, it potentially solved the surgical difficulty of the mid- and low rectal cancer, especially in the situations of obesity, male patients, narrow pelvis [7, 17].

There were some limitations of our study. First, although this study was prospectively designed, it was single institutional with limited sample size, that's why comparative study with conventional surgery as Fernandez et al. [8] and Velthuis et al. [6]. was not conducted; second, although the results of the comparative analysis favor female patients as we attempted to demonstrate the technical superiority of pTaTME in them, bias such as age ($p < 0.05$) and statistics with extreme values prevent us to draw a powerful and reliable conclusion; third, although the resection quality in our cases as well as many other similar studies were favorable, whether it could translate into at least non-inferior local control and survival requires a long-term follow-up. However, like most studies, due to the limited follow-up, we could only provide a very short-term survival outcome. Moreover, no results of objective function and quality of life were provided; fourth, although we intended to enroll curable patients except those staged as T4b, the included patients were in relative early stage due to selection bias.

Conclusion

In conclusion, this preliminary study demonstrates that TaTME is safe and feasible in selected patient with rectal cancer. At the present stage, in spite of some of its inherent disadvantages, hTaTME has gain more popularity because it is much easier to perform than pTaTME; however, despite limitation of instrumentation, it is not impossible to accomplish pTaTME with favorable outcomes. Thus, the strategy of not introducing laparoscopic assistance unless it is required while performing the planned pTaTME seemed rational and feasible but should be interpreted with caution. However, regardless of whether pTaTME or hTaTME is used, studies with larger sample size and longer follow-up that focus on the oncologic and functional outcomes of TaTME and prospectively compare TaTME with conventional surgery are warranted in future.

Compliance with ethical standards

Disclosures Prof. Dr. Liang Kang, Dr. Wen-Hao Chen, Dr. Shuang-Ling Luo, Dr. Zhi-Hua Liu, Dr.Yan-Xin Luo, Prof. Dr. Mei-Jin Huang and Prof. Dr. Jian-Ping Wang have no conflicts of interest or financial ties to disclose.

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