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REVIEW

Transanal total mesorectal excision: a systematic review of the experimental and clinical evidence

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Abstract Achieving a clear distal or circumferential resection margins with laparoscopic total mesorectal excision (TME) may be laborious, especially in obese males and when operating on advanced distal rectal tumors with a poor response to neoadjuvant treatment. Transanal (TaTME) is a new natural orifice translumenal endoscopic surgery modality in which the rectum is mobilized transanally using endoscopic techniques with or without laparoscopic assistance. We conducted a comprehensive systematic review of publications on this new technique in PubMed and Embase databases from January, 2008, to July, 2014. Experimental and clinical studies written in English were included. Experimental research with TaTME was done on pigs with and without survival models and on human cadavers. In these studies, laparoscopic or transgastric assistance was frequently used resulting in an easier upper rectal dissection and in a longer rectal specimen. To date, 150 patients in 16 clinical studies have undergone TaTME. In all but 15 cases, transabdominal assistance was used. A rigid transanal endoscopic operations/transanal endoscopic microsurgery (TEO/TEM) platform was used in 37 patients. Rectal adenocarcinoma was the indication in all except for nine cases of benign diseases. Operative times ranged from 90 to 460 min. TME quality was deemed intact, satisfactory, or complete. Involvement in circumferential resection margins was detected in 16 (11.8 %) patients. The mean lymph node harvest was equal or greater than 12 in all studies. Regarding morbidity, pneumoretroperitoneum, damage to the urethra, and air embolism were reported intraoperatively. Mean hospital stay varied from 4 to 14 days. Postoperative complications occurred in 34 (22.7 %) patients. TaTME with TEM is feasible in selected cases. Oncologic safety parameters seem to be adequate although the evidence relies on small retrospective series conducted by highly trained surgeons. Further studies are expected.

Keywords Transanal TME · TAMIS · Transanal proctectomy · NOTES TME · TEM

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Introduction

In 1982, Heald et al. [1] introduced the technique of total mesorectal excision (TME) as the leading surgical principle to be addressed during rectal cancer surgery.

Properly conducted TME may reduce the recurrence rate to <10 % and increase overall 5-year survival to over 80 % [1].

Laparoscopic rectal surgery has also improved resection quality due to better visualization of the operative field. However, laparoscopic dissection may occasionally be a challenging procedure due to patient and tumor variables [2]. Pelvic exposure during laparoscopic TME is especially restricted in the obese male [3]. Moreover, tumors located

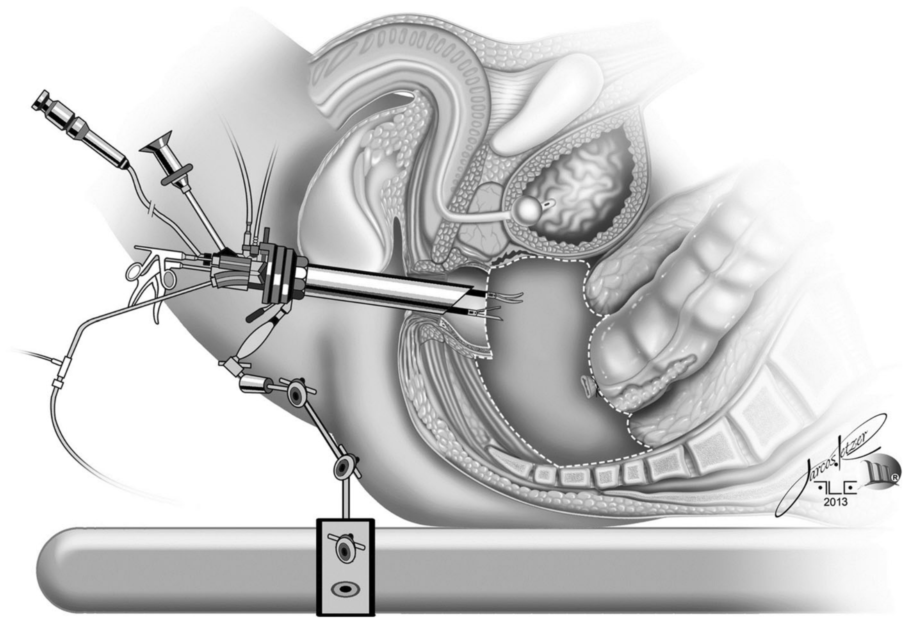

Fig. 1 Schematic drawing of transanal total mesorectal excision using a TEM/TEO platform

on the anterior rectal wall may increase the risk of noncurative surgery [4]. The need to overcome these challenges has motivated surgeons to develop alternative techniques to successfully accomplish oncologic rectal dissection.

Transanal endoscopic microsurgery (TEM) was introduced in 1983 by Buess et al. [5] as a technique for resection of rectal adenomas and early carcinomas. TEM requires a large rigid proctoscope, and setup time may be prolonged. As an alternative to the TEM/transanal endoscopic operations (TEO) platforms, Atallah et al. [6] demonstrated the feasibility of using a single-incision laparoscopic port to gain endoscopic access to the rectal vault using laparoscopic instruments, termed transanal minimally invasive surgery (TAMIS).

The feasibility of a radical proctectomy with TME using TEM/TEO or TAMIS in a retrograde or bottom-up fashion could allow safe radial and longitudinal margins for selected patients [4, 7] for whom a laparoscopic pelvic dissection might be considered technically demanding, such as patients with bulky tumors or in male patients with distal rectal tumors [3] (Fig. 1).

Several acronyms have been proposed for this approach to TME: transanal total mesorectal excision (TaTME), transanal endoscopic proctectomy, and transanal minimal invasive surgery (TAMIS)–TME [8]. It represents a technique that allows the rectum to be mobilized transanally from distal to proximal using a variety of flexible or rigid transanal platforms. We will refer to these innovative operations, collectively, as TaTME operations, although this approach may be also exceptionally used for benign rectal conditions [9, 10]. TaTMEs may be performed in conjunction with transabdominal assistance through multiport laparoscopy, mini-laparoscopy, or a single-port access.

As stated by Hompes et al. [8], TaTME may not be a completely new concept. Moreover, it should be analyzed as a combination of important surgical concepts: the TEM operation [5], the concept of TME [1], the transabdominal transanal (TATA) approach [11], and the introduction of TAMIS [12, 13].

In an editorial, Heald [14] stated that an endoscopic transanal platform for low rectal dissection would revolutionize the approach to the most difficult area of the ‘holy plane’ dissection within the lower pelvis. In the present study, a review of the current evidence was performed for techniques and results of TaTMEs available in the literature.

Materials and methods

A comprehensive systematic review of published work was conducted in PubMed and Embase electronic databases. The search period was from January, 2008, to August, 2014.

The search strategy included the terms and keywords “transanal” and “proctectomy”; “transanal endoscopic proctectomy”; “TAMIS” or “transanal minimally invasive surgery” and “total mesorectal excision”; “NOTES” and “proctectomy”; and “transanal endoscopic microsurgery” and “total mesorectal excision.” The search results were supplemented with hand searching of all retrieved papers (Fig. 2).

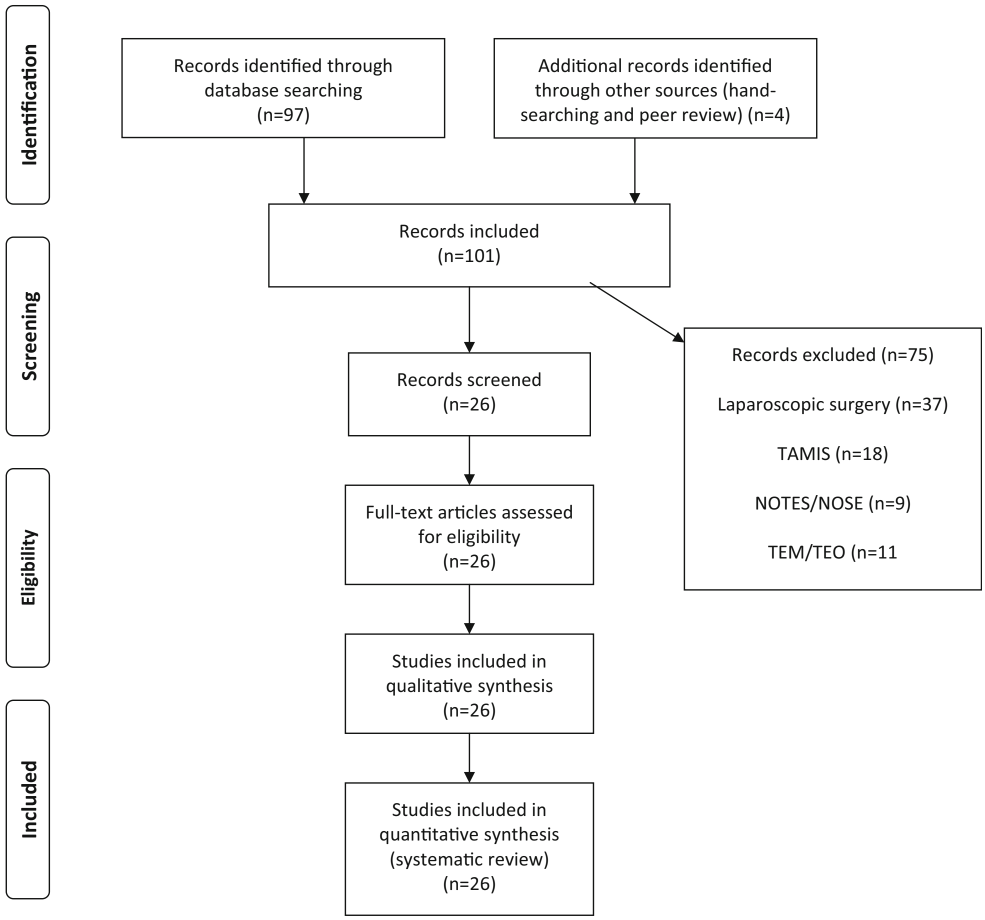

Fig. 2 Preferred reporting items for systematic reviews and meta-analyses (PRISMA) diagram

Inclusion criteria were experimental and clinical studies (case reports, case series, or comparative trials) about TaTME written in the English language. Papers not written in English were excluded. All studies reporting outcomes on clinical and experimental TaTMEs were included in the review process. Studies on transanal extraction of other large bowel segments such as the sigmoid or the entire colon were excluded. The articles reference lists were hand-searched for additional studies missed by the search strategy. Cross-referencing was continued until no further relevant publications were identified. Articles pointed out during the peer review were also added.

Results

Experimental (animal and cadaver) models

The transanal access for colon and rectal resections was initially proven feasible and safe using animal and human cadaver models [15–19].

One of the initial experiences with TaTMEs was undertaken by Sylla et al. [16]. In this pilot study, rectosigmoid resection was performed in two alive pigs and seven pig cadavers using the TEM platform. After placement of a purse-string suture in the distal rectum, a full-thickness circumferential incision was performed. Next, entry into the presacral space was accomplished. En bloc resection of the rectum and the sigmoid colon with mesorectum and mesocolon were endoscopically performed. Proximal colonic dissection was continued as far as anatomic and instrument limitations would allow. The colon was then pulled out through the anus, and after transection of the specimen, a single-stapled coloanal anastomosis was constructed. The authors found that the narrow porcine pelvis and the sharp angle of the sacral promontory precluded proximal dissection. Moreover, they stated that performing additional transgastric endoscopic dissection resulted in an average gain of nearly 6 cm in specimen length. All resected specimens were intact as regards the colon wall and attached mesentery.

Trunzo and Delaney [20] reported on a TaTME performed in a porcine model using a pure transanal approach with the TEM platform and flexible endoscopic assistance. In a 3-h surgical procedure, complete rectal sleeve resection and stapled anastomosis was accomplished. The 10-cm-long specimen was exteriorized with no injuries to the specimen's vascular pedicle or to deep pelvic organs as confirmed during necropsy.

The same pure transanal approach using the TEO platform without flexible endoscopic assistance in the swine model was conducted by Araujo et al. [19]. After insertion of the single-incision laparoscopic surgery (SILS)™ port (Covidien, Mansfield, MA, USA) in the rectum, a low-pressure pneumorectum was created. A 10-mm 30°-angled scope was used with the SILS articulating hand instruments. The distal rectum was occluded circumferentially with a 2/0 cotton purse-string suture placed 3–4 cm from the anal verge. Circumferential rectal mobilization was started posteriorly by incising the rectal wall in a full-thickness fashion until entry into the presacral plane. The posterior rectal dissection was accomplished using the LigaSure™ device (Covidien, Mansfielld, MA, USA). The dissection plane was then accomplished laterally and anteriorly until entry into the peritoneal cavity through the peritoneal cul-de-sac. The entire rectum and distal colon were then pulled out through the anus, and after transection of the specimen, a single-stapled coloanal anastomosis was constructed using the 28-mm CEEA™ circular stapler (Covidien, Mansfield, MA, USA). In this feasibility non-survival study, operative time was 190 min, the specimen length was 12 cm, and it was intact regarding rectal wall and attached mesorectum.

In a porcine survival study undertaken by Sylla et al. [17], the outcomes after a pure transanal endoscopic access versus a transanal endoscopic access combined with an endoscopic transgastric approach were compared in 20 pigs. Although the use of transgastric assistance allowed for a significant increase in specimen length, it also significantly increased operative time. The authors concluded that a transanal approach was feasible as all specimens were retrieved intact and no postoperative events or mortality were observed over the 2-week time period of the study.

Five important studies in human cadaver models were conducted [15, 18, 21–23]. In 2007, Whiteford et al. [15] operated on three male human cadavers. All subjects underwent transanal sigmoid colon mobilization, high vascular ligation, en bloc lymphadenectomy, and stapled end-to-end anastomosis performed through a TEM platform without abdominal assistance. All procedures were successfully completed. Moreover, the authors performed a laparotomy at the end of the procedure to demonstrate that an adequate resection and lymphadenectomy without damage to surrounding anatomy were properly accomplished.

In 2013, Telem and coworkers [21] conducted transanal endoscopic rectosigmoid resections with TME using the TEO® platform (Karl Storz, Tuttlingen, Germany) in the largest TaTME cadaver study to date. The authors operated on 32 fresh human cadavers using transanal endoscopic access alone ($n = 19$), transgastric assistance ($n = 5$), or with conventional laparoscopic assistance ($n = 8$). The mesorectum was sharply dissected with electrocautery or a bipolar device. The shorter (7.5 cm) TEO surgical proctoscope was replaced with the 15 cm one to improve exposure. The peritoneal reflection was divided anteriorly after careful separation of the vagina/prostate from the anterior rectal wall. The specimen was exteriorized and transected, and a handsewn coloanal anastomosis was constructed. Mean operative time was 306 min (range 3–8 180–480 min). Mean specimen length was 53 (15–91) cm. Laparoscopic assistance resulted in a significantly longer specimen (67.7 cm) than transgastric assistance (45.4 cm) or transanal dissection alone (49.2 cm) ($p = 0.013$). Nine cases were complicated by organ perforations. Laparoscopic assistance resulted in a lower, although not significant, occurrence of these complications. The authors concluded that transitioning to clinical application would require laparoscopic assistance.

McLemore et al. [22] conducted the first cadaver model trial of TaTME using the TAMIS platform. Transanal low anterior resection with TME was performed in five fresh human cadavers using the GelPOINT® Path TAMIS platform (Applied Medical, Rancho Santa Margarita, CA, USA) through a transanal route. The transanal operation was further assisted by single-port laparoscopy using the mini-GelPOINT platform placed in the right lower quadrant (usual location for diverting ileostomy), and with an additional 5-mm port placed in the left lower quadrant (usual location of a pelvic drain). TME was successfully accomplished transanally. The rest of the operation was performed laparoscopically using a medial-to-lateral dissection. The inferior mesenteric artery (IMA) was divided and sealed using ENSEAL® (Ethicon Endo-Surgery, Cincinnati, OH, USA) placed via the transanal route. After splenic flexure mobilization, the TAMIS platform was removed from the anus, and the specimen was exteriorized and transected extracorporeally. A coloanal anastomosis was then constructed using both stapled and handsewn techniques. The mean operative time was 200 ± 55 min (range 128–249 min). TME was complete on pathologic analysis with intact mesorectum in all five cases.

Rieder et al. [23] simulated sigmoid lesions created 25 cm from the anal verge in six human male cadavers, which were resected via a pure transanal approach using standard TEM instruments ($n = 4$, TaTME group) or through conventional laparoscopic rectosigmoidectomy ($n = 2$, LAP group). The results of this study were quite disappointing. Although lymph node yield in the TaTME group was similar to that in the LAP group, neither achieved the recommended number of at least 12 (median 5 vs. 4.5, respectively) nodes. The mean length of the TaTME specimens was significantly shorter than those achieved by LAP (16 ± 4 vs. 31 ± 9 cm) ($p < 0.01$). Moreover, in one TaTME case, the lesion was not resected. Operative time was significantly longer (247 ± 15 vs. 110 ± 14 min) after the pure transanal route ($p < 0.01$). The authors observed that their main limitation was the length of currently available TEM instruments. They concluded that a pure transanal approach is likely feasible for low rectal cancers, but that laparoscopic assistance is still mandatory.

TaTME is not devoid of technical difficulty. It is a single-port operation. Therefore, the movement of laparoscopic instruments into the rectal lumen lacks triangulation. On the other hand, robotic TAMIS surgery has already been reported with success in preclinical cadaver models [24, 25] and in clinical practice [26]. The key advantage associated with robotic TAMIS is the movement of an EndoWrist® instrument, the possibility of crossing arms, left-/right-hand control reassignment in the robotic console, and three-dimensional (3D) high-definition images. Gomez-Ruiz et al. [18] have successfully demonstrated the feasibility of TaTME and laparoscopic assistance in 4 human cadavers. A specially designed anal port to be used with robotic docking was used. After TaTME completion, colon mobilization was accomplished using a multiport laparoscopic robot-assisted approach in two cadavers and with a single-incision laparoscopic technique using the GelPOINT Platform in the others. After purse-string closure of the rectum, the specially designed proctoscope was placed in the anal canal and held in place using a static holder. A GelPOINT platform was assembled into the external opening of the proctoscope to maintain the pneumorectum. A 12-mm trocar was used as optic port. Two 8-mm robotic trocars and one 5-mm trocar were also used. A robotic fenestrated bipolar forceps and monopolar scissors (Intuitive Surgical) were used. Transanal nerve-sparing TME was accomplished in all cadavers and was deemed complete in all cases. Crossing and reassignment of robotic arms was not necessary. In one case, there was a violation of the presacral venous plexus. Mean operating time was 82 min (range 60–94 min). Mean specimen size was 22 cm.

Clinical trials

The available published data on TaTME operations comprise non-randomized retrospective comparative series, case series, and case reports. Therefore, studies included in this review were subject to significant bias. Bias comes from selection criteria for the study participants and also the method of reporting data results. Studies differed regarding surgical technique, surgical instrumentation, frequency and method of laparoscopic assistance, and data reporting. Due to significant heterogeneity between reporting on patient outcomes, a meta-analytic assessment was not undertaken.

Knowledge and experience gained from animal and cadaver studies led to worldwide human clinical trials. The first hybrid TaTME was reported in 2010 by Sylla et al. [7]. In this report, a 76-year-old female with a T2N2 rectal cancer after neoadjuvant treatment underwent TaTME. Two abdominal ports were used, one 5-mm port that became the stoma site, and two 2-mm needle ports, one of which was used as a drain site. The TME was performed transanally using the TEO platform. Splenic flexure mobilization was performed laparoscopically. After transanal delivery and division of the specimen, a handsewn coloanal anastomosis was constructed followed by a loop ileostomy. Operative time was 4.5 h, there were no postoperative complications, and the patient was discharged on the 4th day. Final pathology revealed a pT1N0 with negative margins. Twenty-three negative lymph nodes were dissected.

In a report published by Tuech et al. [27], a 45-year-old woman underwent surgery for rectal adenocarcinoma 3 cm above the dentate line using a transanal port and laparoscopic assistance. After initial mucosectomy and a full-thickness circumferential rectal incision, the Endorec® (Aspide Médical, La Talaudière, France) trocar was inserted transanally. After entering the peritoneal cavity, a second Endorec® trocar was positioned in the planned ileostomy site. The left colon and the splenic flexure were mobilized. The IMA was divided laparoscopically. The rectosigmoid colon was exteriorized transanally, and a latero-terminal handsewn anastomosis was fashioned, followed by loop ileostomy. Operative time was 5 h. The 20-cm specimen included 15 lymph nodes, mesorectal excision was considered complete, and the mesorectum was declared intact.

Case reports continued to be the most important evidence regarding feasibility and safety of TaTME. Zorron et al. [28] published 2 cases of hybrid NOTES TME for rectal cancer patients. In the first case, a 54-year-old male with an obstructive non-irradiated adenocarcinoma 8 cm from the anal verge underwent TaTME using a colonoscope inserted into the extraperitoneal peri-rectal space through a 2.5-cm posterior distal rectal incision. TaTME dissection was performed using CO_2 insufflation and endoscopic monopolar scissors. Upon entry into the peritoneal cavity, dissection was completed using a 3-port laparoscopic approach. After dissection completion, the specimen was exteriorized transanally. A stapled anastomosis and a transverse colostomy were constructed.

Operative time was 350 min. Pathology revealed a pT3N1 tumor (3 out of 12 positive). The second case was a 73-year-old female with a rectal adenocarcinoma 6 cm from the anal verge treated with neoadjuvant chemoradiation. TaTME was accomplished using a SILS port. Three-port laparoscopic assistance was used. In this case, pathology revealed a pT3N1 (2 positive lymph nodes out of 11). Patients recovered uneventfully and were discharged on day 6.

Zhang et al. [29] reported the first case of pure TaTME. In this case, in an attempt to decrease the risk of tumor cell implantation, an adhesive was sprayed over the tumor surface before the purse-string suture application. The procedure for prolapse and hemorrhoids (PPH) anoscope (Ethicon Endosurgery, Cincinnati, OH, USA) was used transanally in association with a 3-port cannula to prevent pneumorectum deflation. In this report, a redundant sigmoid colon defined by computed tomography (CT) evaluation was used as a criterion for accomplishment of a pure TaTME. Moreover, CT was also used to define the distance between the IMA root and the anus to evaluate feasibility of transanal vascular control.

Leroy et al. [43] reported the second clinical case of TaTME accomplished exclusively transanally. A 56-year-old female patient with a mid-rectal neoplasia underwent TEO-assisted TME. After TME completion, the sigmoid colon was mobilized by a posterior, retroperitoneal approach. The colon was divided intraperitoneally, and a handsewn side-to-end coloanal anastomosis was constructed with no protective stoma.

Atallah et al. [30] have reported the video standardization of the surgical procedure for TaTME using TAMIS. They have defined well suited to TaTME, the obese male with an advanced distal rectal cancer. By using an hybrid approach (abdominal and transanal), the abdominal portion of the operation is completed before the transanal TME.

To the best of our knowledge, according to epub date, Dumont et al. [31] published the first clinical series of TaTMEs on September 2012. The operations were accomplished with no conversions in 4 male patients. All patients underwent neoadjuvant therapy. Selection risk factors were defined as a narrow pelvis, a voluminous prostate, or obesity. A narrow pelvis was defined as a distance of less than 10 cm between the lower border of the pubic symphysis and the coccyx. Obesity was defined as a body mass index (BMI) over 30 kg/m^2 although in this series, mean BMI was 23.4 kg/m^2 (range 22.4–24.5 kg/m^2). The operation started with the transanal phase. After a circumferential rectal transection using the Lone Star Retractor system^{TM} (CooperSurgical, Trumbull, CT, USA), the GelPOINT Path TAMIS platform was used. Laparoscopic assistance was accomplished through a single-port approach (GelPOINT). Mean operative time was 360 min (range 270–460 min). There were no intraoperative complications. The plane of TME was considered “mesorectal” in all cases. The median lymph node harvest was 16 nodes (range 8–22 nodes). A case of anastomotic fistula occurred. In this study, Wexner [32] scores indicated that no severe incontinence was observed after the operations.

Velthuis et al. [33] have published a clinical series 5 TaTMEs. In this study, patients with mid-rectal T2 or T3 adenocarcinomas underwent neoadjuvant radiation or chemoradiation, followed by TaTME after 1 or 6 weeks, respectively, according to the Dutch guidelines. Full-thickness circumferential access to the distal rectum comprised the Scott ring retractor (Lone Star Medical Products, Stafford, TX, USA). The rectal stump was then closed with a purse-string suture, and a SILS port was introduced in the anal orifice. After circumferential mesorectal dissection, the peritoneal reflection was opened. Next, a second SILS port was placed at the future ileostomy site. The left colon was mobilized using a medial-to-lateral approach. The inferior mesenteric vessels were divided using LigaSure. The colon was exteriorized transanally using the Alexis® wound protector (Applied Medical, Rancho Santa Margarita, California, USA) under direct laparoscopic monitoring. A transverse coloplasty and a handsewn or stapled coloanal anastomosis were undertaken. A loop ileostomy was created in all cases. Due to a bulky mesocolon, two extra laparoscopic ports were required in one case. Median operative time was 175 min (range 160–194 min). One patient had severe intraoperative pneumoretroperitoneum, leading to prolonged ileus, and also developed pneumonia. Laparoscopic drainage of a presacral abscess was needed in one patient.

Another small clinical series of three patients was published by Lacy et al. [34] with the same previously published feature of mini-laparoscopic assistance [7, 35]. In this series, a 10-mm umbilical port, a 5-mm one (stoma site), and a 2-mm one (drain site) were used for laparoscopic assistance, and a GelPOINT Path TAMIS platform was placed transanally. Transrectal endoscopic mesorectal dissection was accomplished to the level of the peritoneal reflection, and in all three cases, coloanal anastomosis was mechanical. Mean operative time was 143 min. Mesorectal resection was reported as satisfactory in all cases. Dehydration due to severe ileostomy output led to readmission of one patient.

Sylla et al. [36] have also reported another small series of five patients with node-negative rectal cancers located 4–12 cm from the anal verge. In all cases, multiport (four or five ports) assistance was used and the transanal platform was the TEO (Storz) equipment. Complete mesorectal excision was achieved in all cases. There were three early complications: 1 case of ileus and 2 cases of urinary dysfunction.

Lacy et al. [37] reported the short-term outcomes of 20 patients who underwent TaTME. Contraindications in this series were BMI over 35 kg/m^2, cT4 staging, recurrence, and contraindications to pneumoperitoneum. Fourteen patients underwent neoadjuvant chemoradiation therapy. Mean BMI was 25.3 kg/m^2. The operations began with laparoscopic evaluation, with one 12-mm trocar in the umbilicus, one 5-mm trocar in the right lower quadrant (planned ileostomy), and another 2-mm in the left lower quadrant (planned drain site). Laparoscopic staging was followed by placement of a GelPOINT path transanal access platform and initiation of pneumorectum. Combined laparoscopic and transanal dissection was conducted in all cases. For low-lying rectal lesions, initial transanal access was performed using the Lone Star Retractor. Inferior mesenteric vessels were transected using vascular clips. Proximal colonic transection was accomplished extracorporeally. A handsewn coloanal anastomosis or a lateral/end-to-end stapled anastomosis was constructed. The mean number of lymph nodes harvested was 15.9.

To date, the largest series (30 TaTME operations) also reporting oncologic outcomes, with a median follow-up of 21 months, was published by Rouanet et al. [4]. Indications included a combination of narrow pelvis (defined as inter-tuberosity distance under 10 cm and inter-ischiatic under 12 cm), fatty mesorectum, unfavorable tumor features (large and anterior), and a weak prediction of clear anterior radial margin on magnetic resonance imaging (MRI). The operation was initiated transanally via a full-thickness circumferential rectal transection at the pectinate line using the TEO platform or after conventional exposure of the anal canal. TME was accomplished transanally using the 15-cm TEO rectoscope and harmonic shears. After entering the peritoneal cavity, the TEO equipment was removed. TME dissection was finished using abdominal laparoscopy. The specimen was removed either through a suprapubic incision or transanally. A coloanal anastomosis with or without a J-pouch and a covering ileostomy were constructed. Preoperative neoadjuvant therapy was performed in 26 (86.7 %) patients. Conversion to open surgery was necessary in 2 (7 %) patients, though the reasons were not reported. Mesorectal resection was graded “good” (grade 3 according to Quirke’s [38] classification) in all cases. Median lymph node yield was 13 nodes (range 8–32 nodes). Four (13 %) patients had positive CRM. There were three intraoperative complications: 1 air embolism and 2 urethral injuries. There were ten postoperative complications including four cases of sepsis (overall 30-day postoperative morbidity rate of 30 %). However, there was no mortality. Disease-free survival after 21 months was 43.3 %. After this interval, the local recurrence rate was 13.3 % (4 patients) and the overall recurrence rate was 40 % (12 patients). Overall survival rates after 12 and 24 months were 96.6 and 80.5 %, respectively.

In the series reported by Atallah et al. [9], transanal proctectomies were indicated for a benign rectal condition (Crohn’s disease) for the first time in the literature. However, these cases were excluded from the results. As previously described by this group [30], the preferred approach for TaTME initiates in the abdomen. In this series, the abdominal phase of the operation was accomplished through a laparotomy in 3 patients, through multiport laparoscopy in 11, and using robotic-assisted laparoscopy in 6. The primary indication was distal, locally advanced rectal cancer. Mean BMI was 24 kg/m^2 (range 18–41 kg/m^2), and mean operating time was 243 min (range 140–495 min). Postoperative surgical complications were wound infection ($n = 2$), pelvic abscess ($n = 4$), and prolonged ileus ($n = 4$). The resection margins were negative in 18 out of 20 cases. The mean lymph node harvest was 22.5 nodes (range 9–51 nodes). The authors concluded that TaTME represents a feasible approach for oncologic surgery of mid/distal rectal cancers and is especially suitable for obese male patients.

A clinical series of TaTMEs without abdominal assistance was first published by Chouillard et al. [39]. This approach was attempted in 16 patients and successfully completed in 10 (62.5 %). A single-port laparoscopic assistance was necessary in 6 (37.5 %) patients. In 2 patients, TaTME resulted in abdominoperineal rectal resection. Postoperative complications requiring a reoperation occurred in three patients. Intestinal obstruction occurred in two patients and a pelvic abscess occurred in one patient. Mesorectal excision was considered complete in all cases. The median number of lymph nodes retrieved was 17 (range 12–81 nodes). In this series, for the patients operated on without abdominal assistance, a protective ileostomy was not used. The authors used an umbilical incision for single-port location and also for the diverting ileostomy.

In the series of 14 patients published by Wolthuis et al. [10], patients with benign rectal diseases were included in the analysis. The benign conditions were fistulas ($n = 2$), fecal incontinence ($n = 1$), rectal stenosis after stapled hemorrhoidopexy ($n = 2$), Crohn’s disease ($n = 1$), ulcerative colitis ($n = 1$), and adenoma ($n = 2$). Five patients with rectal adenocarcinomas were also included. Neoadjuvant treatment was an exclusion criterion. As preferred by other surgeons [31, 33, 37], first, a Lone Star Retractor was inserted, and a circumferential sleeve mucosectomy was accomplished. Next, a GelPOINT path was placed to proceed with the proctectomy. If no adequate length could be obtained after completion of transanal proctectomy, or in patients requiring proctectomy and end colostomy, a medial-to-lateral mobilization was performed laparoscopically by using a 3-port technique to divide the inferior mesenteric vessels and to mobilize the splenic flexure. TaTME was associated with a handsewn coloanal anastomosis in seven patients, with and end colostomy in six, and with a total proctocolectomy with end ileostomy in one patient. In this series, the peritoneal cavity could be entered after opening the pouch of Douglas from below in only 8 (57 %) of the patients. According to the authors, this result may reflect the learning curve actually linked to a new technique. In 3 out of the 14 patients, the procedure could be completed using only a transanal approach. Laparoscopy-assisted TaTME was necessary in 11 (79 %) patients. Intraoperative difficulties hindering dissection occurred in five patients. The authors concluded that transanal mobilization of the rectum above the anal sphincter is feasible.

Velthuis et al. [33] published the first comparative study on TaTMEs. In this study, the pathological quality of TaTME specimens was compared to the ones obtained from matched patients who underwent conventional laparoscopic TME. Twenty-five patients with distal (0–5 cm from the dentate line) or mid-rectal (5–10 cm from the dentate line) cancers underwent transanal TME. These patients were matched for gender with a cohort of patients undergoing laparoscopic TME with or without abdomino-perineal resection. TaTME was performed as previously described by Velthuis et al. [3]. According to the authors, in the first five cases, the procedure was started transanally after placing the Scott retractor for rectal incision. Next, a SILS port was placed to perform transanal TME. Single-port laparoscopic assistance was provided through a second SILS port placed at the future ileostomy site on the right lower quadrant. The authors stated that because of retroperitoneal pneumatosis during the transabdominal phase after the transanal operation, the sequence of steps was reversed after five procedures. Currently, the technique starts with the abdominal phase as described by Atallah [30]. Pathologic evaluation was carried out according to the criteria of Quirke et al. [40]. No differences were observed between the groups in length of specimen, CRM positivity, or distal margin. However, a significant difference ($p < 0.05$) was detected in TME quality. In the transanal group, the mesorectum of all specimens was classified as complete (94 %) except for one (6 %) case, assessed as nearly complete. In the laparoscopic group, 18 (72 %) specimens were classified as complete, 2 (8 %) as nearly complete, and 5 (20 %) as incomplete ($p < 0.05$). Therefore, for the first time, TaTME improved the quality of mesorectal excision.

Zorrón et al. [49] recently published an update on their series of TaTMEs. They operated on nine patients form November 2009 to June 2010. It was not possible to analyze the t2 previously reported cases [17] from this series. Moreover, on their first report on TaTME [17], the authors have reported the use of a SILS port. However, in the last publication [49], the authors stated that seven patients were operated on using the Triport® transanal platform (Olympus, Tokyo, Japan), and two patients were operated on using a flexible Olympus 130 single channel colonoscope for the transanal rectal dissection after placement of an anoscope and direct suture closure of the rectum. Transabdominal assistance was accomplished through a 3-port laparoscopic approach. Mean operative time was 311 min. There were no reported intraoperative complications. Conversion to laparotomy was necessary in 2 cases. There was one anastomotic leak. The mean number of lymph nodes retrieved was 13. The quality of mesorectal dissection was deemed “adequate” in six cases. The authors concluded that a retrograde mesorectal dissection is feasible.

Robotic-assisted transanal endoscopic proctectomy

TaTMEs are essentially a particular type of single-port surgery. Therefore, limited maneuverability is the most important technical difficulty to be considered especially for surgeons not familiar with TEM and TAMIS [41]. A robotic approach to a transanal operation was originally described for local excision of rectal neoplasia [24–26]. The main advantage of robotic systems is the movement of an EndoWrist instrument in the rectal lumen. Other advantage is the possibility of crossing arms, reassigning left-/right-hand control in the console, and three-dimensional high-definition images [18]. Therefore, the next logical step would include to evaluate the role of the Da Vinci® surgical system (Intuitive Surgical, Sunnyvale, CA, USA) for TaTME. This step has already been taken in the experimental cadaver model setting [18] and also in the clinical setting [41, 42, 50].

Atallah et al. [41] have described the first human case of a robotic approach to TaTME—the RATS-TME (Robotic-assisted transanal surgery for TME) operation. The patient was a 51-year-old female with a BMI of 35.3 kg/m^2 who had familial adenomatous polyposis complicated by a rectal cancer 4 cm from the anal verge and a synchronous hepatic flexure tumor. A total proctocolectomy with terminal end ileostomy was indicated after neoadjuvant chemoradiation therapy for the rectal lesion. RATS-TME was initiated by the abdominal phase. First, the entire colon was mobilized laparoscopically and the distal ileum was transected. The colon was also transected at the level of the sigmoid, and the specimen was removed through the ileostomy incision. A Lone Star Retractor was used to circumferentially transect the distal rectum. Next, a GelPOINT platform was installed. The robotic cart was docked at the patient’s right side. Three cannulas were used in the transanal port. One 8-mm robotic monopolar hook and one 8-mm robotic Maryland forceps were used in association with a 30° telescope. The dissection of the distal rectum was considered difficult due to reduction in working space. A completely intact mesorectal envelope was obtained. Due to the bulky mesentery, a Pfannenstiel incision was performed to avoid transanal specimen extraction. Total operative time was 381 min. All margins were free and mesorectal excision was considered near complete due to a 1.5-cm defect in the posterior envelope. The patient was discharged on day 3.

Verheijen et al. [42] have reported their experience with a first case of robotic-assisted TaTME. The patient was 48-year-old female with a cT3N1M0 rectal adenocarcinoma 8 cm form the anal verge. She underwent preoperative chemoradiation therapy and was operated after 6 weeks. Conventional multiport laparoscopy was used for vascular sealing, splenic flexure, and left colon mobilization. The GelPOINT advanced transanal platform was then installed. After docking the robotic cart over the patient's left hip, 3 robotic ports and one 5-mm laparoscopic port were used for transanal robotic-assisted TME. After TME completion, the full specimen was extracted transanally and a circular stapled anastomosis was fashioned and protected by a diverting ileostomy. Total operative time was 250 min. Total robotic-assisted time was 65 min. The patient was discharged on day 3 after an uneventful postoperative course. The pathologist's evaluation of the specimen revealed a complete pathologic response to neoadjuvant chemoradiation therapy (pT0N0). The authors stated that robotic-assisted TaTMEs are promising.

To the best of our knowledge, Atallah et al. [50] were the first to report a clinical series of robotic-assisted TaTMEs for distal rectal cancer. All 3 procedures were performed by a single-attending colorectal surgeon during a 11-month period. The step-by-step description detailing the surgical approach has been previously reported by this group [41]. The mean BMI was 32 kg/m^2 (range 21–38.5 kg/m^2). In all cases, distal and circumferential margins were tumor free. There was no major morbidity or mortality during short-term follow-up. The authors concluded that RATS-TME is feasible.

In this review, due to the early and descriptive nature of the reports, it was decided to summarize the current experience on TaTME in the next section without including the published cases of robotic-assisted TaTME.

Summary of the current clinical evidence on TaTME

Table 1 summarizes the current clinical experience with TaTME. As of this review, data on 150 cases of TaTME were found in the literature (five cases initially reported on by Velthuis et al. in 2012 [3] were reassessed in the 2014 publication [33]; and two cases reported by Zorrón et al. [28] were possibly included in the 2014 paper [49]).

Rectal adenocarcinoma was the indication for TaTME in all cases, except for 9 cases included in the series of Wolthuis et al. [10]. Colorectal surgeons experienced in minimally invasive surgery, many with extensive experimental practice in animal or cadaver models, and with proficiency in TEM/TEO and TAMIS, performed all reported operations.

Operative times ranged from 90 to 460 min. However, mean times were mostly between 143 and 300 min. Transabdominal multiport or single-port laparoscopy, robotic, or open assistance decreased the time required for the procedure and was used in all 150, except for 5 patients [10, 29, 39, 43].

Methods for transabdominal assistance during TaTMEs varied and included conventional laparoscopy [4, 9, 10, 36, 49], mini-laparoscopic access [7, 34, 37], and single-port access [3, 27, 31, 33, 39]. Transanal access was accomplished using a rigid TEO/TEM platform in 37 patients. A TAMIS flexible device was used in 111 cases. A flexible colonoscope was used in two cases.

Except in the study of Wolthuis et al. [10], the macroscopic quality of TME was assessed in all cases and was deemed "intact" [15], "adequate" [17, 31], "satisfactory" [34, 37], or "complete" [3, 4, 7, 9, 29, 36, 39, 43]. CRM involvement was reported in 16 (11.8 %) out of 136 patients, in 4 publications [4, 9, 33, 49]. The mean lymph node harvest was not reported in 2 studies [10, 34]. However, the mean number retrieved was equal to or greater than 12 in all studies for which it was available.

The information on intraoperative complications was available for 118 patients. Only 1 case of pneumoretroperitoneum [33] and 2 cases of urethral lesion and air embolism [4] have been reported.

The information on length of hospital stay was available for 116 patients and ranged from 3 to 29 days. The mean length of stay ranged from four to 14 days. In the 3 largest series [4, 9, 37], it ranged from 4.5 to 14 days.

A report on postoperative complications was available for 117 patients. Postoperative complications occurred in 34 (22.7 %) patients. Infectious complications were the most frequently reported. A pelvic abscess has occurred in 6 cases, wound infection in 2, fever in 2, anastomotic fistula in 2, pneumonia in 1, and sepsis in 1. Infectious complications were followed by urinary tract complications. Urinary retention or dysfunction ($n = 4$) was the most frequent complication followed by urinary tract infection ($n = 3$). Prolonged ileus occurred in 6 cases and intestinal obstruction in 3. Dehydration occurred in 2 cases and a pelvic hematoma in 1. There were no reported deaths for the series included in this review.

Table 1 Summary of the current clinical experience with transanal endoscopic proctectomy

Study	Sylla et al. [7]	Tuech et al. [27]	Zorron et al. [28]	Zhang et al. [29]	Dumont et al. [31]	Leroy et al. [43]	Velthuis et al. [3]	Lacy et al. [34]
Gender (M:F)	F	F	1:1	F	4:0	F	3:2	1:2
Publication date	Jan 2010	Jan 2011 (epub)	Dec 2011 (epub)	Aug 2012 (epub)	Sep 2012	Nov 2012 (epub)	Feb 2013 (epub)	Jul 2012 (epub)
Body mass index (kg/m^2)	20	20	NS	20	23.4 (22.4–24.5)	NS	NS	21.7 (16–25)
Clinical staging	III	T1 (sm3)	III (2)	III	T3N0 (3) T3N1(1)	T2	I (1) II (3) III (1)	I (1) II (2)
Mean/median operative time (min)	270	300	340	300	360 (270–460)	190	175 (160–194)	143
Transabdominal laparoscopic assistance	Mini-laparoscopy	Single-port endorec	Multiport	None	Single-port GelPOINT	None	Single-port (SILS)	Multiport with mini
Transanal platform	TEO (Storz)	Endorec (Aspide)	Colonoscope (1) SILS (Covidien) (1)	PPH (Ethicon) anoscope and a 3-port cannula	GelPOINT (Applied)	TEO (Storz)	SILS (Covidien)	GelPOINT (Applied)
TME grade	Complete	Intact	Adequate	Complete	Intact	Intact	Intact	Satisfactory
(Mean) specimen length (cm)	NS	20	NS	NS	NS	20	NS	NS
Mean LN harvest	23	15	12 and 11	12	16 (8–22)	16	13.4 (11–17)	NS
Pathologic staging	T1N0	T1N0	T3N1 and yT3N1	T3N1	NS	Adenoma	y0 (1) y1 (2) y2 (1) y3 (1)	y1 (1) y2 (2)
Free margins	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intraoperative complications	No	No	No	No	No	No	Pneumoretroperitoneum (1)	No
(Mean) hospital stay (days)	5	NS	7	4	13 (10–21)	NS	NS	4.7 (4–5)
Postoperative complications	No	NS	No	No	Anastomotic fistula (1)	No	Pneumonia (1), Presacral abscess (1)	Dehydration (1)

Study	Sylla et al. [36]	Lacy et al. [37]	Rouanet et al. [4]	Atallah et al. [9]	Chouillard et al. [39]	Wolthuis et al. [10]	Velthuis et al. [33]	Zorron et al. [49]
Gender (M:F)	3:2	11:9	30:0	14:6	6:10	5:9	18:7	9
Publication date	Apr 2013 (epub)	Mar 2013 (epub)	Apr 2013	Nov 2013 (epub)	May 2014 (epub)	Jan 2014	Jun 2014 (epub)	Jul 2014
Body mass index (kg/m^2)	25.7 (23–28)	25.3 (19–33)	26 (21–32)	24 (18–41)	27.9 (21–38)	25 (17–32)	25 (20–36)	NS
Clinical staging	I (3) II (2)	NS	T1 (1) T2 (1) T3 (21) T4 (7)	I (2) II (3) III (15)	NS	NS	T1 (1) T2 (11) T3 (13)	NS

Table 1 continued

Study	Sylla et al. [36]	Lacy et al. [37]	Rouanet et al. [4]	Atallah et al. [9]	Chouillard et al. [39]	Wolthuis et al. [10]	Velthuis et al. [33]	Zorron et al. [49]
Mean/median operative time (min)	274.6 (189–360)	234 (150–325)	304 (170–432)	243 (140–495)	265 (155–440)	148 (90–250)	NS	311
Transabdominal laparoscopic assistance	Multiport	Multiport with mini	Multiport (3)	Open (3) Multiport (11) Robotic (6)	None (10) Single-port (6)	Multiport in 11/14	Single-port (SILS)	Multiport
Transanal platform	TEO (Storz)	GelPOINT (Applied)	TEO (Storz)	GelPOINT (Applied) or SILS (Covidien)	GelPOINT (Applied) or SILS (Covidien)	GelPOINT (Applied)	SILS (Covidien)	Triport (Olympus, Japan)
TME grade	Complete	Satisfactory	Complete	Complete in 17/19	Complete	NS	Complete in 24/25	Adequate in 6
(Mean) specimen length (cm)	NS	NS	NS	NS	34.6 (15–101)	NS	18 (12–28)	NS
Mean LN harvest	33 ± 15	15.9 ± 4.3	13 (8–32)	22.5 (9–51)	17 (12–81)	NS	14 (7–24)	13
Pathologic staging	y0 (1) y1 (2) y3 (1)	Adenoma (2) y1 (4) y2 (7) y3 (6) y4 (1)	T1 (1) T2 (8) T3 (18) T4 (3)	0 (5) I (3) II (6) III (5) IV (1)	Y0 (1) I (5) II (5) III (5)	NS	NS	NS
Free margins	Yes	Yes	22/26	18/20	Yes	NS	24/25	6/9
Intraoperative complications	No	No	Urethral lesion (2) air embolism (1)	No	No	No	NS	No
(Mean) hospital stay (days)	5.2 ± 2.6	6.5 ± 3.1	14 (9–25)	4.5 (3–24)	10 (4–29)	8.7 (3–14)	NS	7.5
Postoperative complications	Ileus (1), Urinary dysfunction (2)	Urinary retention (2), Ileus (1), Dehydration (1)	Intestinal obstruction (1), Sepsis (1)	Wound infection (2), Abscess (4), Ileus (4)	Intestinal obstruction (2), Pelvic abscess (1)	Fever (2), Urinary infection (3), Pelvic hematoma (1)	NS	Anastomotic leak (1)

TME total mesorectal excision, *TaTME* transanal total mesorectal excision, *NS* not stated, *LN* lymph node, *TEO* transanal endoscopic operations, *SILS* single-incision laparoscopic surgery, *PPH* procedure for prolapse and hemorrhoids

Discussion

TaTME is a technique that was developed to overcome technical difficulties associated with laparoscopic TME. Evidence suggests that TaTME with TME is feasible and safe as demonstrated in experimental and clinical practice. The clinical series presented in this review indicate that an adequate oncologic transanal TME operation is reproducible, with negative circumferential and distal margins, comparable quality and extent of mesorectal excision, and extent of lymphadenectomy. Although more research is necessary to confirm these findings, the comparative results published by Velthuis et al. [33] indicated that a significant higher rate of completeness of mesorectal excision may be associated with the transanal approach when compared to laparoscopic TME. However, long-term oncologic outcomes need to be evaluated. The general consensus is that curative TaTMEs should be performed only when a board-approved protocol is available and only by colorectal surgeons with extensive experience in minimally invasive and transanal endoscopic surgery. Many advocate animal and/or cadaver training prior to attempting the procedure.

Although laparoscopic TME is a standardized and reproducible procedure [44], it can be a technically difficult operation [2]. In the UK MRC CLASICC trial [45], a high incidence of positive CRMs after laparoscopic anterior resection was observed. Tumor location in the mid and distal rectum may be considered per se an important risk factor for compromised CRM [4, 9]. Obesity and male gender may be other risk factors for inadequate oncologic clearance. For this selected group of patients, a pure or hybrid TaTME may be an interesting alternative to increase the chance of a full oncologic resection. Furthermore, TaTME is an approach that avoids an abdominal incision and its potential complications.

As in other NOTES techniques, inadequacy of current instrumentation limits the ability to achieve a pure transanal endoscopic approach [29, 39, 43]. Therefore, laparoscopic assistance (conventional, mini, or single access) helps providing control of inferior mesenteric vessels, splenic flexure mobilization, and monitoring of transanal specimen extraction. Lacy and colleagues [37] have observed in swine and human cadaver models that laparoscopic assistance reduces operative time [3, 37].

Published reports and clinical series have demonstrated that a rigid TEM/TEO platform or a flexible transanal access system (TAMIS) may be used. In the TEM/TEO rigid platform, two 4-cm-width different lengths surgical rectoscopes are available for use (TEM: 12 and 20 cm; TEO: 7.5 and 15 cm). Therefore, surgeons may exchange scopes to improve exposure [21]. TEM/TEO is a reusable and stable platform. However, the initial cost associated with equipment acquisition should be considered. In contrast, use of "soft" single-port devices such as the SILS port and the GelPOINT transanal access platform may result in a less negative impact on anorectal function, although this remains to be determined [37, 46]. Moreover, maneuverability and triangulation are improved within TAMIS platforms. Ultimately, a flexible scope and conventional laparoscopic instruments may be used with TAMIS [44].

Regarding morbidity, it may be important to acknowledge that most rectal cancer cases in the reviewed clinical series are associated with some degree of technical complexity. Although it is well accepted that patients may be put at some risk when new techniques are adopted [47], the occurrence of urethral injuries must be noted with concern and may be classified as an intraoperative complication closely related to the technique itself [4].

Care must be taken as TaTME becomes more widely used. It was demonstrated that intraoperative and early postoperative complications may occur. All complications may be underestimated in a retrospective study. Furthermore, the majority of published data refers to immediate morbidity. There remains little information regarding the ileostomy closure rate and the occurrence of late anastomotic strictures.

The oncologic safety associated with TaTME needs to be validated in a larger number of cases preferably in prospective randomized multicenter trials. In the present review, the good quality of TEM and lymph node yield appears reasonable, albeit with small numbers of examined specimens obtained by highly specialized surgeons. Randomized trials will face implementation challenges since TaTME is indicated when an obstacle to conventional laparoscopic TME is expected. Precise indications and contraindications for the operation have yet to be agreed upon.

A final issue must be addressed. Most surgeons performing TaTMEs are experienced in TEM/TAMIS techniques. Therefore, TaTMEs may be more difficult for general and colorectal surgeons not used to performing transanal procedures.

Although the technique may hold promise for the future [48], it is probably best to recommend that TaTMEs should not be performed without an IRB approval until more diligent development through larger series be reported.

Conflict of interest None.

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