Tech Coloproctol (2016) 20:483–494
DOI 10.1007/s10151-016-1475-x

HOW I DO IT

Critical concepts and important anatomic landmarks encountered during transanal total mesorectal excision (taTME): toward the mastery of a new operation for rectal cancer surgery

S. Atallah[1] · M. Albert[1] · J. R. T. Monson[1]

Received: 4 April 2016 / Accepted: 27 April 2016 / Published online: 17 May 2016

Abstract Over the past 3 years, colorectal surgeons have begun to adapt the technique of transanal total mesorectal excision. As international experience has been quickly forged, an improved recognition of the pitfalls and the practical details of this disruptive technique have been realized. The purpose of this technical note was to express the various nuances of transanal total mesorectal excision as learned during the course of its clinical application and international teaching, so as to rapidly communicate and share important insights with other surgeons who are in the early adoption phase of this approach. The technical points specific to transanal total mesorectal excision are addressed herein. When correctly applied, these will likely improve the quality of surgery and decrease morbidity attributable to inexperience with the transanal approach to total mesorectal excision.

Keywords Transanal TME · TAMIS · Rectal cancer · Transanal total mesorectal excision (taTME)

Introduction

Transanal total mesorectal excision (taTME) is a disruptive surgical technology that represents an important mode of access to the distal rectum and it thereby offers the ability to perform high-quality rectal cancer resection [1–5]. This is particularly true for patients with difficult pelvic anatomy and in the words of Prof. R. J. Heald, taTME offers a "solution to an old problem" [6]. However, taTME is relatively new and thus unfamiliar to colorectal surgeons. Hence, there are critical anatomic landmarks and concepts that must be appreciated by the operator. Importantly, taTME is not as simple as performing TME in reverse. There are multiple key principles that must be understood, and formal training pathways established [7] so that the technique can be safely implemented [8].

Over the past 4 years, our center has gained considerable experience with taTME using the transanal minimally invasive surgery (TAMIS) platform [9] for curative-intent rectal cancer surgery [10–12]. Furthermore, our center (Florida Hospital, Orlando, FL) is currently the largest training center for taTME in North America having trained over 100 surgeons in the past 14 months during two-day combined didactic modules, live surgery sessions, and cadaveric hands on one-on-one instruction. The following is a culmination of taTME-specific discussion points critical to mastery of the taTME technique that have been learned through the training of surgeons and through our own clinical experience. When correctly applied, these key pearls will likely improve the quality of taTME surgery and decrease morbidity attributable to inexperience with this new and disruptive surgical innovation.

Operative sequencing: above or below first?

It is frequently debated whether to start taTME from above (abdomen) or below (transanal) first in the sequence of the operation. Proponents of beginning the taTME dissection from above first, argue that (a) it begins with familiar planes, (b) respects the no-touch principle of vessel-ligation prior to organ manipulation [13], (c) and prevents the pneumo-dissection along the retroperitoneum that can distort native planes. Furthermore, by starting in known planes from above

✉ S. Atallah
atallah@post.harvard.edu

[1] Florida Hospital, Winter Park, FL, USA

to perform the TME, it is possible that the lesion is discovered to be approachable from a standard, 'all-above' TME and thereby obviating the need to add the complexity of taTME in such instances. Meanwhile, proponents of starting from below first suggest that (a) the operation can be completed with less time [14], (b) that there is no data to support the 'no-touch' technique [15], and that it (c) early on focuses the attention of the surgeon on the most critical part of the dissection, which is the portion of the operation that involves dissection in the vicinity of the tumor, and thus demands the most preparedness.

It remains surgeon preference as to whether to start from above or below first with taTME. However, if a 'below-first' approach is chosen, then—from an oncologic standpoint—it is mandatory that the abdomen and pelvis be at least visualized prior to starting the dissection from below. Hence, diagnostic laparoscopy should be performed to exclude undiagnosed pathology (such as carcinomatosis) or other findings that could render the tumor unresectable prior to beginning the taTME/transanal steps of the operation [16]. Thus, proper exploration of the abdomen and pelvis remains a compulsory first step for all abdomino-pelvic cancer operations, including taTME, and cannot be omitted.

Case selection

The benefit of taTME lies in the inline vantage point obtained with the horizontal rectum (Fig. 1). This improved access could potentially translate into an improvement in resection quality for select patients. Locally advanced, distal one-third rectal cancers are most appropriate for taTME while proximal one-third rectal cancers are least appropriate. Typically, upper rectal cancers that lie above the peritoneal reflection are not resected using the taTME approach except in special circumstances, such as in patients with a long horizontal segment and deep anterior reflection where the ability to proceed from above is restricted. Thus, application of taTME to distal, locally advanced rectal tumors with a long horizontal segment and the well-known triad of the difficult pelvis—android male pelvis, visceral obesity, and post-radiation changes—seems best.

Performing taTME for mid-rectal (middle third) tumors on a routine basis is probably not of value as most of the advantages of taTME are lost. Securing the purse-string distal to the tumor in the mid-rectum is difficult as it must be sutured using laparoscopic instruments (using TAMIS/TEM techniques), for both the initial purse-string and for the anastomosis. Furthermore, the dissection is typically more challenging as the surgeon must proceed in a direct vertical plane at this level to partially transect the widest portion of the mesorectal envelope and enter the plane between the mesorectal envelope and endopelvic fascia (Fig. 2). This 'partial mesorectal excision' is difficult to perform transanally, and the evidence for taTME and the theorectical advantage and rationale for taTME in this setting is insufficient. However, it can be considered in special circumstances, especially when the surgeon begins from above and is no longer able to proceed beneath the level of the tumor due to difficult pelvic anatomy. Hence, failure to progress from the abdominal approach with

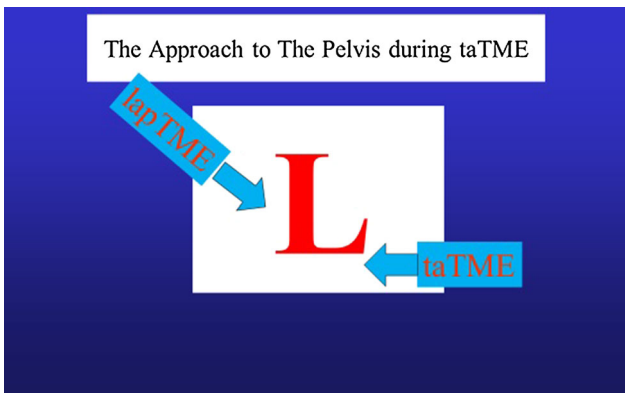

Fig. 1 General approach to taTME is shown. The rectum can be simplified into the shape of as a capital letter "L". As such, the *horizontal portion* of the rectum is best approach from the in-line vantage point of transanal access. The longer this segment and the lower the tumor, the longer the TME dissection from below. Upper rectal dissection is best approached abdominally, while the mid-rectum is a '*grey area*' were the advantages of taTME and the advantages of laparoscopy become neutral

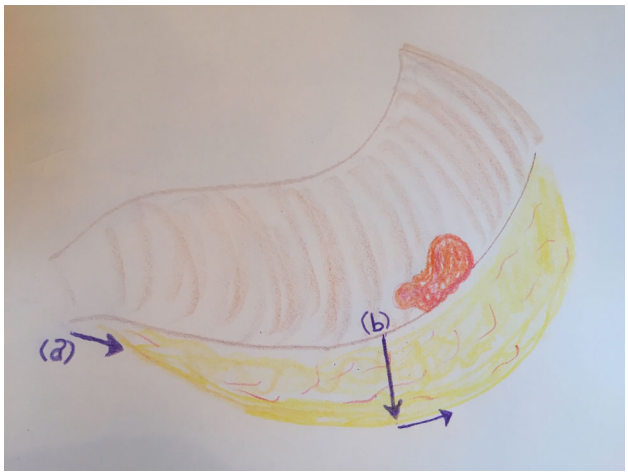

Fig. 2 Schematic diagram illustrates the difference in the approach to distal rectal cancer (*a*), and middle rectal cancer, (*b*). When the latter is performed, a 'partial' mesorectal excision is carried out. Note that unlike the gentle slope of the tapered tail of the mesorectal envelope encountered for distal resection with taTME, the surgeon must traverse a *vertical plane* through the widest portion of the mesenteric envelope, and then 'turn 90°' into the correct plane as the dissection proceeds cephalad

minimally invasive techniques is an indication to 'convert to' taTME.

Case preparation: pelvic geometry

Typically, rectal protocol magnetic resonance imaging (MRI) is performed for the purpose of staging, and in some instances, MRI is repeated after completion of neoadjuvant therapy to assess tumor response and to revaluate the circumferential resection margin (CRM). The focus of image interpretation has traditionally been related to tumor location and height from the anal verge, stage, and CRM. With taTME, however, it is crucial that the geometry itself—such as the shape, volume, and 'slope' of the mesentery and pelvis—be appreciated, which is best achieved by interpreting the T2-weighted MRI images in midline sagittal section (Fig. 3a, b). This give the taTME surgeon a mind's eye view of the relevant anatomy and a better understanding of the bony pelvis (e.g., degree of sacral and coccygeal curvature) as well as the geometry of the mesorectal envelope (e.g., its width and slope) which varies from patient to patient. Furthermore, the operating surgeon will be able to appreciate the relative length of the horizontal rectum, which is the segment for which taTME is best suited. The longer the horizontal segment, the more of the operation will be completed from below (using taTME) rather than from above because the access and view point is optimized. The concept of using the pelvic anatomy and the geometry of the pelvis as a guide for planning surgery is a departure from traditional thinking and how MRI is applied for rectal cancer, and it is an important step in planning the operation of taTME.

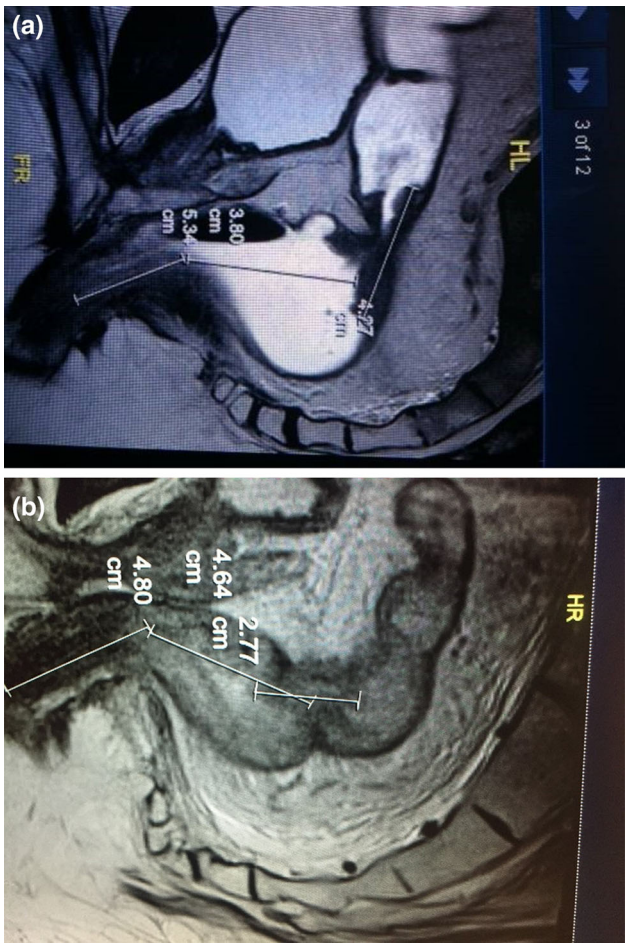

Fig. 3 **a**, **b** Understanding the geometry of the pelvis, including the bony pelvis and the mesentery, is important in the planning phase of taTME. The surgeon must have a mind's eye view of the pelvic and mesenteric shapes, which are patient-specfic. Shown here are two different T2 weighted magnetic resonance images (mid-sagittal section) of patients with rectal carcinoma. Note the difference in the mesenteric contour and the curvature of the bony sacrum and coccyx. Examining these non-tumor related factors is important for the taTME surgeon in particular

Platform and insufflation

Until 2009, only one modality for advanced transanal surgery was available—the Transanal Endoscopic Microsurgery (TEM) platform [17]. Transanal Minimally Invasive Surgery (TAMIS) was introduced in 2009 as a hybrid between TEM and multichannel single port laparoscopy [9, 18, 19]. It allows for high-quality local excision of rectal neoplasia, and a short access channel allows for improved angulation within the pelvis making TAMIS particularly well-suited for taTME [10, 20] (Fig. 4a, b). Today, based on data from the Lorec taTME database and published analysis most reported taTME operations (approximately 75 %) are performed utilizing the TAMIS platform [1, 21]. The most common TAMIS port used is the GelPOINT Path Transanal Access Platform (Applied Medical, Inc., Rancho Santa Margarita, CA, USA)—based on a recent assessment of the taTME European (Lorec) taTME Registry [1].

The adaption of a valveless trocar and insufflation system (AirSeal, ConMed, Inc, Utica, NY, USA) resolves the nuisance problem of billowing or "breathing" of the pelvis which results from fluctuations in insufflation pressure [22, 23]. It also optimizes the optical view because a separate smoke evacuation system continuously vents plumes of smoke that otherwise obscure the surgical field. An 8-mm AirSeal trocar is preferred, and it should be assembled to the TAMIS port lid superiorly and equidistant to the two TAMIS cannulas (Fig. 5). While TAMIS is the most common platform used in published series and in the Lorec taTME registry [1], it is not the only approach and some authors have advocated the rigid, short shaft length TEO platform. Surgeons that support use of the TEO scope for taTME prefer the shorter, 7.5-cm shaft length. An

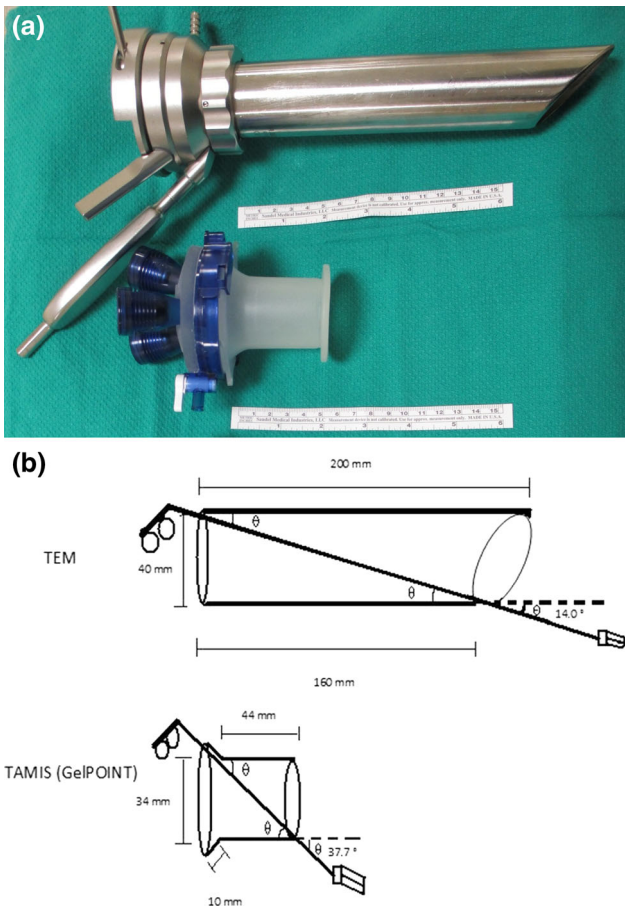

Fig. 4 **a** Advanced transanal platforms for taTME include TEM and TAMIS. **b** The improved angulation of laparoscopic instruments is inversely proportional to platform shaft length, thus the relatively shorter shaft of the TAMIS port results in an increase ability to achieve wider angles for taTME dissection

advantage to using a more traditional transanal platform such as this is that the surgeon does not need to depend on another surgeon (or experienced assistant) to perform taTME—as is the case with TAMIS [24].

Antiseptic and tumoricidal rinse of the rectum prior to initiating taTME

Currently, most data related to the utility of antiseptic rinse within the rectum are derived from urologic studies related to infection after prostate biopsy and the results are mixed. Thus, a conclusive benefit to antiseptic washout has not been established [25–27]. There are, however, limited clinical series suggesting antiseptic irrigation of the rectal stump is beneficial [28, 29]. In 2015, Velthius et al. [30] studied intra-abdominal infection with 'TAMIS-TME' (synonymous with taTME). In this study, providone iodine (polyvinylpyrrolidone, PVP-I) rinse of the rectal lumen

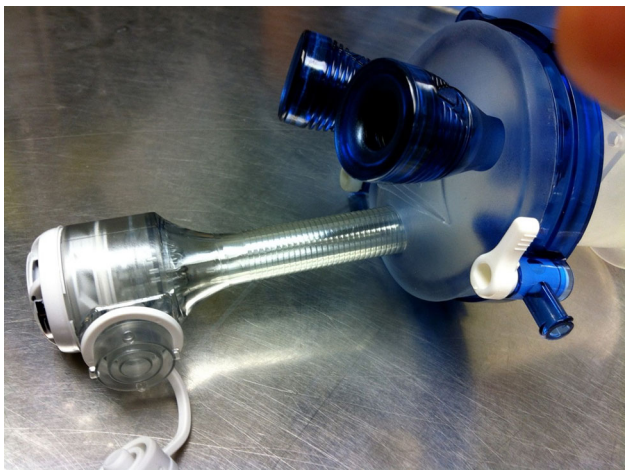

Fig. 5 Valveless 8-mm trocar has been applied to the gelatinous membrane of the TAMIS port equidistant to two TAMIS cannulas. The device is connected to special insufflator via triple lumen tubing (not shown) which allows for the optimization of the CO_2 insufflation within a very small working field, thus minimizing so-called pelvic breathing and smoke accumulation

was conducted before and after purse-string formation on 23 patients undergoing TAMIS-TME. Cultures were taken from four quadrants of the pelvis via the abdominal laparoscopic ports and this revealed that 9/23 (39.1 %) had positive cultures for enteric species (especially *Escherichia coli*), and 4/23 (17.4 %) had localized infections treated with systemic antibiotics and/or percutaneous drainage procedures. These findings suggest a high rate of bacterial seeding and minor pelvic infection and the utility of PVP-I remains unknown because there are no randomized trials or case–control trials with taTME that address whether or not there is a difference in the rate of local sepsis with and without the application of topical antiseptic washout. Thus, antiseptic rinse remains surgeon preference but is recommended by the authors.

Available antisepsis includes aqueous solutions such as (a) PVP-I and (b) bacitracin. PVP-I is an aqueous iodophor solution that denatures microbial proteins and is considered safe on mucous membranes. However, iodine is inactivated by the presence of blood. It is typically supplied as a 10 % solution and is often diluted with sterile water in a 50:50 ratio. PVP-I is effective against most gram-negative rods, fungi, endospores, and Mycobacteria species. Bacitracin is supplied as a powder and is often reconstituted in sterile water for the tumoricidal effect and is safe for application on mucus membranes. Bacitracin is especially effective against Group A and B Sreptococcus, *Staphalococus aureus*, *S. epidermidis* and *S. pyogenes*, and although it has a broad spectrum, many gram-negative rods are resistant or exhibit poor susceptibility to aqueous bacitracin. Alcohol-based antisepsis has also been described, including diluted,

4 % isopropyl alcohol and 4 % chlorhexidine gluconate. However, alcohol-based preparations, even when diluted, are considered off-label use as they should not be typically applied to mucus membranes as clinical studies in this area are lacking.

More important than the antiseptic value of topical rinsing of the rectal vault is the potential to perform the washout for the tumoricidal benefit. There is compelling data to support that cancer cells within the large intestine are exfoliated [31–34] and can therefore seed the operative bed and site of anastomosis in restorative procedures [35–37]. This can result in local recurrence [38–41], however, it has been demonstrated that tumoricidal washout of the rectum can significantly reduce the incidence of local recurrence [42–44]. Interestingly, tumoricidal washout of the rectum was an important detail of the initial description of TME by RJ. Heald and was an integral part of his technique in which local recurrence for curable rectal cancer after surgery was low and local failure rates were observed to be 2 % at 5 year follow-up [45, 46]. Based on these data, and despite the lack of randomized prospective trials, the authors recommend irrigation with a tumoricidal agent before and after application of the purse-string during taTME.

Purse-string and marking of the rectal wall

In addition to antimicrobial and/or tumoricidal irrigation, it is important to insure that the purse-string is airtight and watertight so that bacteria—and potentially exfoliated live tumor cells—do not seed the operative bed. While not yet studied with taTME, the potential for tumor cell seeding from a defect in the purse-string could theoretically exist. Best practice and experience suggest that the purse-string should be created with an even distribution of suture bites so that the center point of the purse-string does not become skewed from the center of the lumen, insuring a tight seal (Fig. 6a, b). Typically the suturing of the purse-string is carried out using a monofilament suture such as 2-0 or 0 Prolene on a swaged and tapered Small-Half Circle (SH) needle, and it is recommended by some experts (Roel Hompes, MD) that the monofilament purse-string be effectively 'hand-braided' by adding multiple (30) knots which allows for better traction and manipulation during taTME as it serves as a grasper 'joystick' for manipulating the rectum. New instruments and concepts for intraluminal suturing are under development so that surgeons are able to have improved reach and facility to perform this step by using transparent anoscopes and devices that create unity between a hand-held needle driver and anoscope for improved functionality [47].

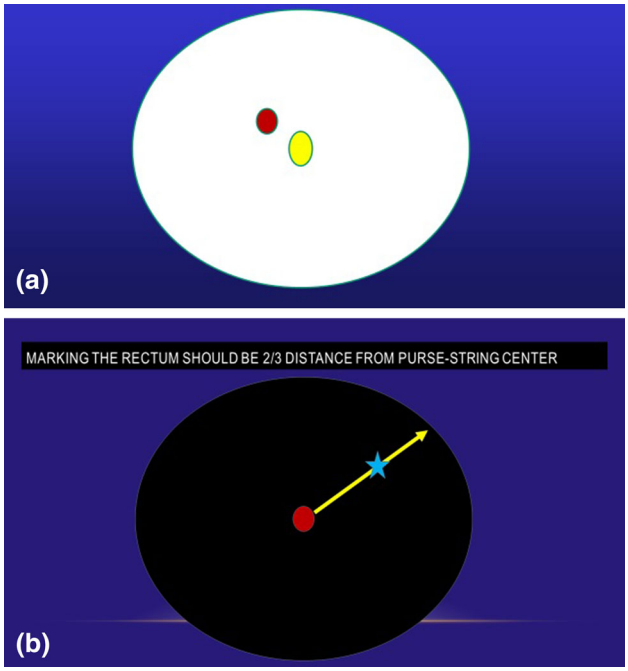

Fig. 6 **a** *Yellow circle* represents the rectal center point and when a purse-string is applied evenly, the purse-string should be at the center. The *red circle* represents a skewed center point that can occur when the stitches are not evenly placed. **b** Once the purse-string has been placed, rectal wall division is best performed circumferentially two-thirds the distance from the center point of the purse-string to the outer edge of the rectum

Vessel sealer use

While the use of a vessel sealer is possible with the transanal portion of taTME, it is generally not recommended, because during taTME bleeding should be controlled with simple monopolar electrocautery, and occasionally bipolar cautery. Hemorrhage that requires a vessel sealer to achieve hemostasis indicates an incorrect operative plane and should alert the surgeon to reassess the plane of dissection. Of course, if bleeding is encountered, a vessel sealer and other methods (e.g., endoscopic vascular clips) can be used to achieve control using TAMIS/TEM techniques, but the critical point is that plane reassessment is mandatory.

Segmental and stepwise approach to dissection

The approach to taTME should be systematic and the dissection divided into quadrants (Fig. 7). After full thickness incision through the rectal wall, the dissection should proceed in the posterior quadrants first (3–6 o'clock and 9–6 o'clock), and then communicating at the midline raphe (6 o'clock) which is usually more dense and thus more difficult to establish with taTME. The dissection

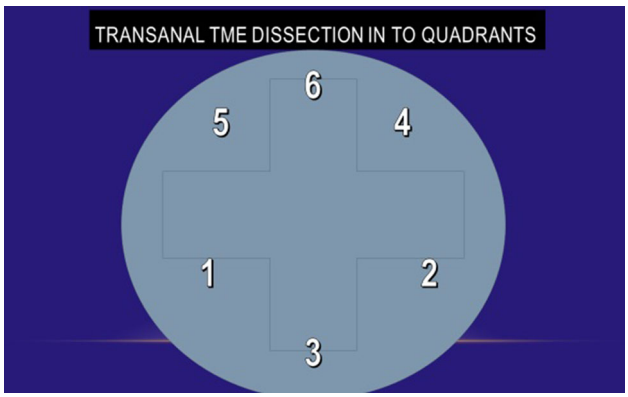

Fig. 7 Step-wise approach to rectal dissection is demonstrated whereby the dissection progresses in a standardized approach following the numerical order shown. In this fashion, the posterior lateral segments are first completed, then the dense raphe, and finally the anterior dissection is carried out with the 12 O'clock portion of the taTME approached last

should then progress caudad to cephalad, and once the posterior planes are established, the right and left anteriolateral planes are created. In this approach, the midline anterior is last to be dissected. The posterior-first approach allows the anterior wall to act as a retractor. With the patient in dorsal lithotomy, once the anterior plane is dissected, it will be drawn downward by gravity obscuring the view for the remainder of the posterior dissection, and thus a posterior-first approach is preferred.

As the dissection extends toward the anterior peritoneal reflection, most taTME experts recommend not communicating through to the peritoneal cavity until as much of the taTME portion of the resection has been completed as the pneumopelvis, even when using a valveless trocar system, can become unstable.

Avoiding urethral injury

Urethral injury has emerged as the most significant procedure-specific morbidity with taTME [2]. In our own taTME cadaveric training sessions, approximately one in five surgeon teams were observed to inadvertently mobilize the prostate and as many as 18 documented urethral injuries have occurred during the clinical adoption of this new technique (personal communication by Pat Sylla, MD). But importantly, the anatomy can be recognized and with proper teaching and training urethral injury can be avoided.

Urethral injury occurs to the membranous (pre-prostatic) urethra during very distal anterior dissection, and is probably more likely to occur with locally advanced distal lesions after neoadjuvant radiation (Fig. 8a, b). This occurs because surgeons are (a) not aware of the complex anatomy of the neurovascular bundle of Walsh [48], which is part of

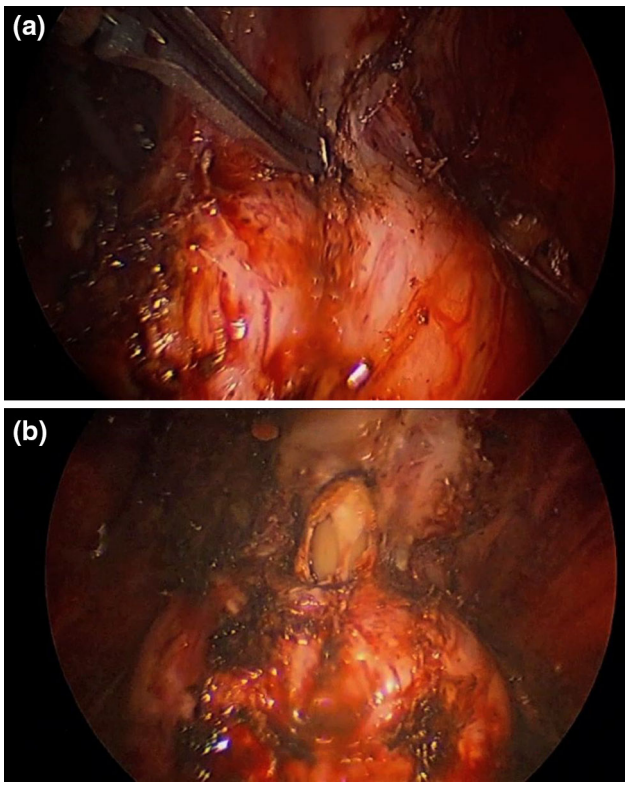

Fig. 8 **a** Lower lobe of the prostate and exposed, pre-prostatic urethra moments before inadvertent transection of the posterior wall of the urethra with a vessel sealing device. Vessel sealing with taTME is strongly discouraged because it can lead to wrong-plane surgery. **b** The appearance of the transected urethra after injury during taTME with foley catheter visible. The spherical and symmetric shape of the prostate, as shown, is prototypical of the exposed prostate during taTME

the prostatic blood supply (Fig. 9a, b), and (b) because the appearance of the lower lobe of the prostate from the taTME vantage point is still unfamiliar.

The neurovascular bundle of Walsh consists of multiple nerves, but importantly contains paired arterial vessels (approximately 3–4 mm in diameter) that are often easily recognized during the anteriolateral dissection. The correct plane is superficial—never deep to—these paired vessels which are prostatic arterial branches (the capsular branches) derived from the inferior vesical artery (a branch from the internal iliac artery).

It appears that the capsular arterial branches are not encountered by surgeons except during taTME. They are often encountered as pulsatile arteries at approximately the 10 and 2 O'clock position (Fig. 10). The most important step is to recognize these paired vessels and to maintain a plane superficial to them [49]. Usually the vessels are encountered before the prostate is visible (that is, they lie in a plane superficial to the inferior lobe of the prostate and membranous urethra). Bleeding that cannot be controlled at this level with monopolar cautery suggests injury to the

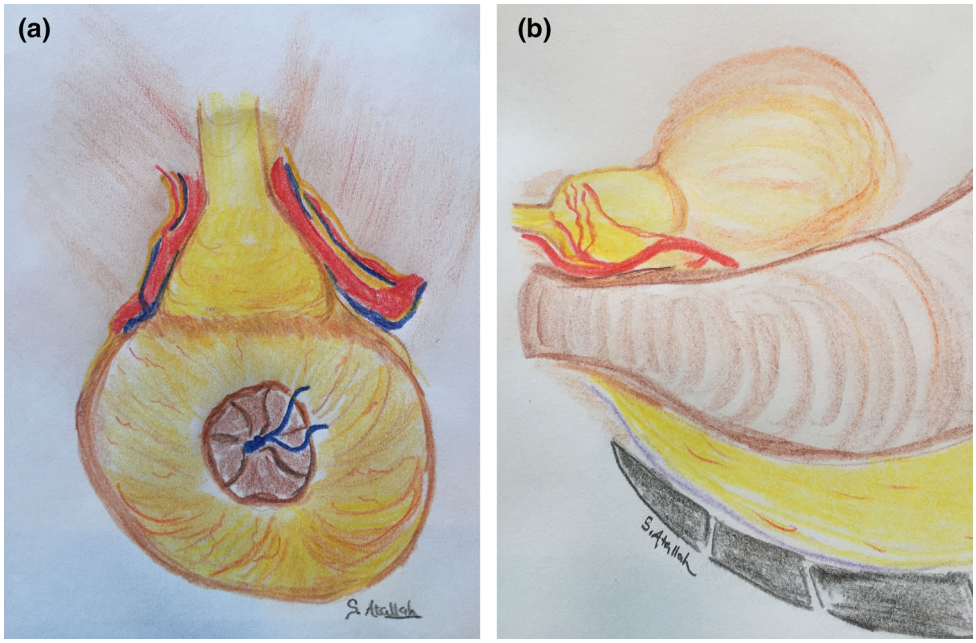

Fig. 9 **a** Surgeon's view of the vessels of the neurovsacular bundle of Walsh and the lower lobe of the prostate. Importantly, the vessels are superficial to the prostate and membranous urethra. Two paired vessels seen anteriolaterally are often exposed during taTME and they must be recognized and reflected away from the plane of dissection **b** sagittal view of the neurovascular bundle of Walsh and prostate with its relationship to the rectum

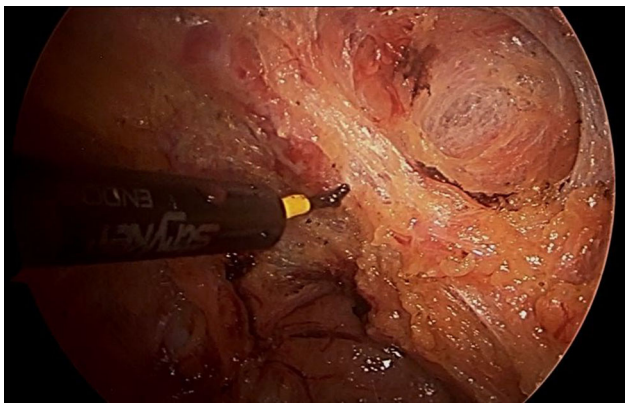

Fig. 10 At the 10 O'clock position, a visible ~4-mm vessel is seen. This is part of the neurovascular bundle of Walsh and supplies the inferior lobe of the prostate. Derived from the inferior vesicle artery, this capsular branch is a crucial landmark that taTME surgeons must learn to recognize

branches of the neurovascular bundle of Walsh and thus a plane that is too deep anteriorly. Failure to recognize these vessels and continuing the plane of dissection 'through' those vascular branches will then deflect the posterior lobe of the prostate downward, drawing it into the plane of dissection. At this point, the prostate and rectum will appear as a single fused structure creating a visual heuristic that could impair surgeon judgment. With taTME, it appears that the posterior aspect of the membranous urethra is the most likely section to be injured during the distal anterior dissection. Appropriate training and education about the appearance of the inferior lobe of the prostate and an understanding of its neurovascular complex are essential in preventing injury to the urinary system.

The authors believe that formal training of taTME surgeons is vital so that prostatic anatomy is relearned from the perineal perspective such that surgeon cognition of these structures is improved—the appearance of these structures is quite specific to the taTME viewpoint. From this vantage point, the inferior lobe of the prostate appears smooth and symmetric with a pale yellow white capsule. The spherical nature of the prostate is quite characteristic and training programs often emphasis its shape so that it can be recognized and avoided during taTME (Fig. 8a, b).

Study is underway to investigate new modes of identifying the urethra during taTME, and these include the use of a lighted stent in the urethra [50] and the application of fluorescence with a lighted urethral stent—the latter of which is currently being investigated by Vincent Obias, MD (personal communication). Furthermore, augmented reality with real-time stereotactic navigation for taTME has also been explored as a method to improve the quality of plane dissection and thereby decrease the risk of injury to vital structures [51–54], including the male urethra. There are new modalities to real-time imaging currently under study which could change the surgeon's ability to confirm the plane of dissection and avoid inadvertent injury to anatomic structures [55].

Avoiding vaginal wall injury

Although less critical than urethral injury, in females the posterior wall of the vagina can be inadvertently injured during anterior dissection, particularly when the recto-vaginal septum is fused or fibrotic due to the desmoplastic effects of neoadjuvant radiation and tumor related factors. When the plane of dissection does not separate naturally during taTME, it is recommended that the vagina be digitized and palpated so that haptic feedback can help guide the surgeon during this portion of the injury.

Pelvic autonomic nerves

Kneist et al. [56] have published an exemplary clinical study in which patients underwent intraoperative EMG to map the pelvic nerves during TAMIS-TME. They identified five key zones in which surgeons encounter branches of the inferior hypogastric plexus (IHP) during the taTME dissection. While the detailed information in this study is enriching, from a practical standpoint, there are important concepts that taTME surgeons should become familiar with.

First, the portion of taTME (representing the start of plane dissection in the posterior zones, and distal 1/3 of the rectum) is devoid of autonomic nerves. In this 'bare area,' entry into a plane deep to the endopelvic fascia can expose the levator ani musculature, but no significant anatomic structure or nerve is at risk for injury in this section which includes the posterior hemisphere of the distal one-third of the rectum and mesorectal envelope extending cephalad to approximately 4–5 cm from the anal verge.

Second, the most prominent branches of the IHP will appear at approximately 6–8 cm from the anal verge posteriorly and represent the S2 and S3 IHP routes and they will appear as a 'bow' shape. Third, pneumodissection with taTME can occur deep to the nerve plexus (Fig. 11). This can result in wrong-plane surgery if the surgeon is not alerted to this anatomy.

Lateral dissection, pneumodissection, and the adipose pillars

At the approximate 3 and 9 O'clock position at the level of the mid-rectum, the taTME dissection will often expose bilateral pillars of adipose tissue (approximately 2–3 cm in diameter) that are avascular and these are seldom apparent when TME is performed from above. The natural, pneumatic dissection that occurs tends to create a false plane lateral to these pillars, resulting in what appears to be an angel hair plane. This can be misleading, even for the experienced taTME surgeon and a continued dissection lateral to the exposed pillars results in untoward pelvic bleeding as the plane leads the surgeon into the pelvic sidewall and its vascular plexus (Fig. 12a–c).

Fig. 11 Inferior hypogastric plexus (IHP) often appears in the shape of a bow, as shown. The bow shaped S2/S3 IHP routes are clearly exposed posterior to the mesorectum. Note that a false 'pneumodisseciton' plane is created deep to the nerve plexus. It is imparative that the taTME surgeon be alerted to this possibility which could lead to dissection in a plane deep to the endopelvic fascia resulting in inadvertent pelvic nerve injury and the potential for operative bleeding from sacral veins

Posterior dissection: the vacant zone, midline raphe, and the retrorectal fascia

The initial 5 cm of posterior dissection during taTME is performed along the conical levetor ani muscle of the posterior pelvic compartment. During the caudal most portion of the posterior dissection (as is necessary for resection of tumors within the distal 3 cm of the rectum), the mesenteric envelope is extremely tapered. The endopelvic fascia is quite thin and sometimes not well appreciated as it is often embryologically fused to the mesorectal envelope. As the posterior dissection commences, the muscle fibers of the levator ani are often visible. This slightly too deep plane is quite easily corrected and there is essentially no risk of nerve or presacral vessel injury as this 'zone' contains no significant structures. Thus, it is a safe starting point in the taTME dissection. Because of the 'barren area' and ease of exposure of the levator ani muscles, a safe plane is established that ensures the dissection is not intra-mesenteric. As the plane of dissection progresses cephalad, the plane between the endopelvic fascia and mesorectal envelope is more easily appreciated and adipose tissue deep to the endopelvic fascia is often observed during taTME (Fig. 13a, b).

Also evident posteriorly and extending laterally commencing at the level of the mid-rectum is a third layer of fascia that is critical in taTME surgery. Namely, this "Y"-shaped fascia is the retrorectal fascia, and it tends to lead the surgeon in a plane that is deep to rather than superficial

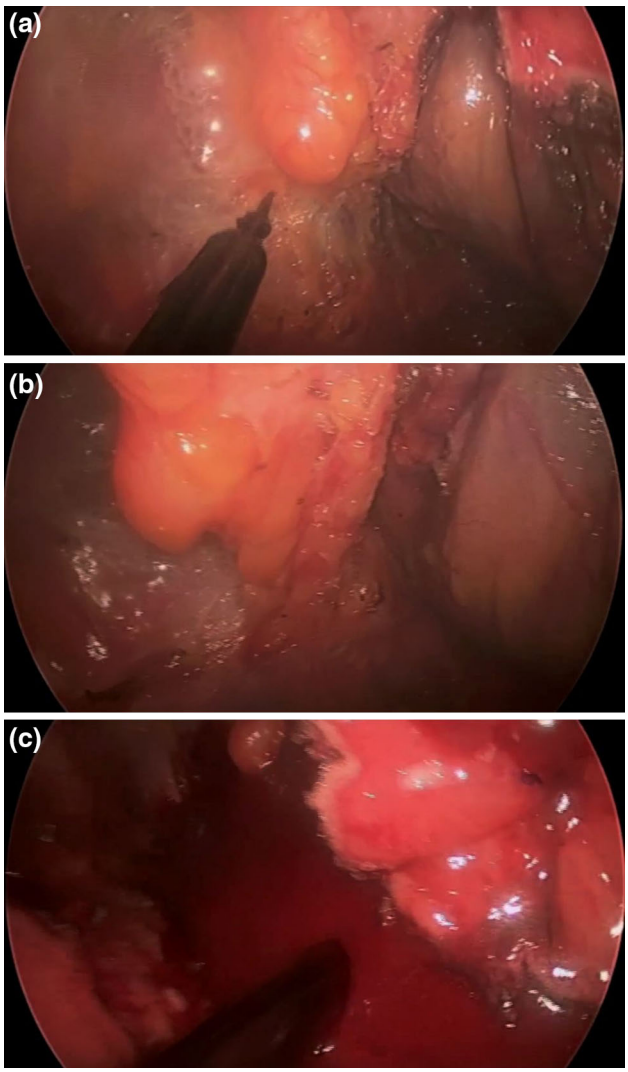

Fig. 12 **a** Laterally, at approximately 5–8 cm from the anal verge, paired 2- to 3-cm-diameter adipose 'tonsils' can be observed. These are not part of the mesorectal envelope. Lateral to the tonsillar adipose tissue is an areolar plane, but this should not be dissected. **b** The tonsillar, pillar of fat is clearly visible, and as dissection has (incorrectly) occured in this far lateral plane **c** untoward bleeding results as pelvic sidewall vessels are encountered

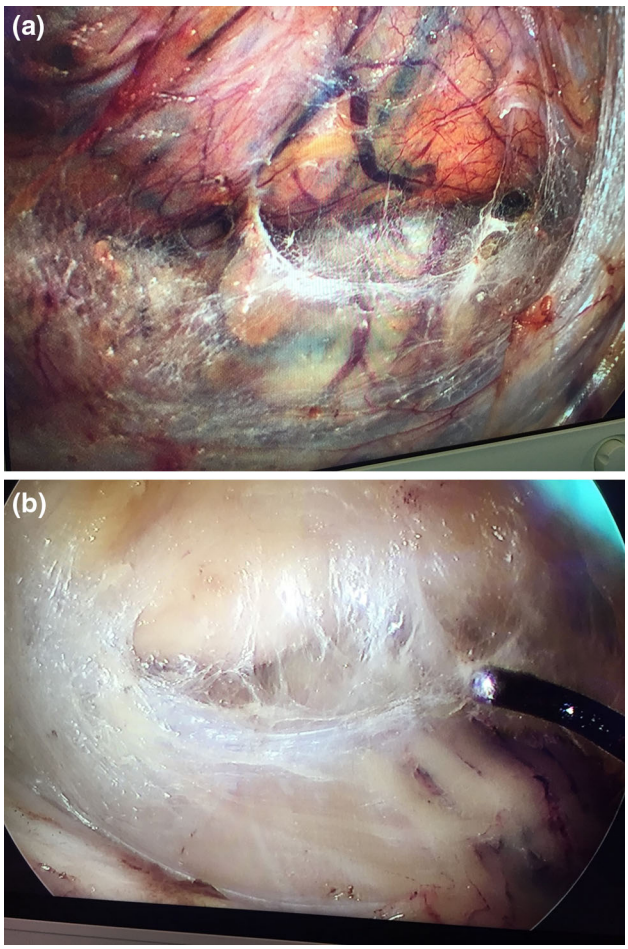

Fig. 13 **a** The appearance of the posterior segment of the taTME dissection (about 7 cm from the anal verge) with sacral vessels clearly seen deep to the thin, areolar endopelvic fascia, which is embryonically fused to the mesorectal envelope. **b** Another example with adipose tissue deep to the endopelvic fascia, as there is often adipose tissue that is not part of the mesorectal envelope, and sacral veins often are seen running vertically, as shown

to the endopelvic fascia (Fig. 14). Most (but not all) pelvic autonomic nerve branches course deep to the endopelvic fascia, and it is particularly important that taTME surgeons understand how it is possible to inadvertently enter this plane, due to the "Y" shape of the retrorectal fascia.

Specimen extraction

Transanal extraction limits abdominal access trauma, but is not always prudent to perform during taTME. For patients with a narrow pelvis, visceral obesity, and a long anal canal, transanal extraction could result in untoward shearing of the mesentery with the potential to seed exfoliated tumor cells. Furthermore, it can result in shear stress on the more proximal arterial inflow—in particular, the marginal artery. If the marginal artery is avulsed due to shear stress at a point more proximal than that selected for division, conduit ischemia could result compromising the anastomosis and the restoration of GI continuity. To minimize marginal artery injuring during transanal specimen extraction, the mesentery at the level chosen for proximal division should be performed intracorporeally with division of the marginal artery so that shearing of the artery (more proximal than the intended site of bowel transection) does not occur. This is a critical step to perform when taTME includes transanal extraction. Alternate options for specimen extraction include

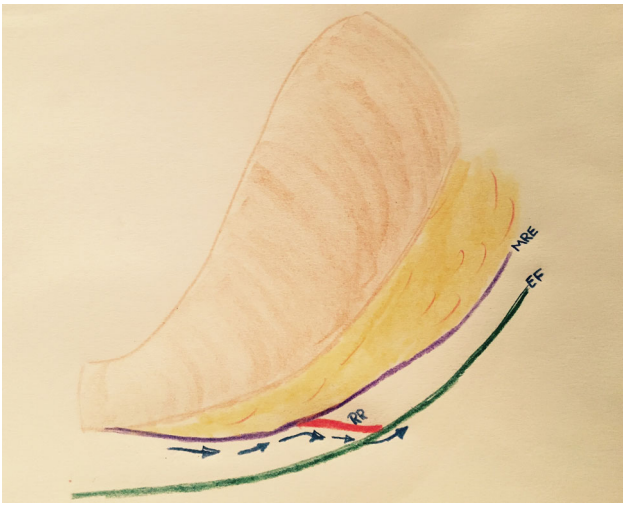

Fig. 14 Schematic diagram depicts the retrorectal fasica (RR, *red*) and its relationship to the mesorectal envelope (MRE, *purple*) and endopelvic fascia (EF, *green*). The "Y" configuration is significant, because the taTME surgeon will tend to follow a plane that is too deep (*arrows*) leading to a plane beneath the endopelvic fascia. For surgeons performing TME from above, the retrorectal fascia, instead, leads the surgeon toward the mesorectal envelope

a Pfannenstiel incision or via the site of a planned diverting ileostomy.

Anastomotic techniques

A recent in-depth discussion of the anastomotic approaches used for taTME has been previously published by Penna et al. and Bracey et al. and readers are referred to these articles for further discussion [57, 58]. Use of circular staplers intended for hemorrhoidal procedures (Covidien EEA Hemorrhoidal and Prolapse Stapler with DST Series Technology) with either the 3.5 mm staple height or the 4.8 mm height can be used to complete the anastomosis. A transparent disposable anoscopic with markings enables accurate purse-string application and a transparent winged 'port' allows for introduction of the 33 mm stapler once the sleeve portion of the TAMIS port has been removed. These devices are supplied with the single-use stapler by the manufacturer (Covidien, Plymouth, MN, USA), and thus it is commonly used with taTME for constructing either a double-purse-string end-to-end or end-to-side low rectal anastomosis. The long anvil of such a device is especially useful for constructing the anastomosis. From a technical standpoint, it is not necessary to perform retro-cuff dissection. That is, to construct the anastomosis and apply the distal purse-string, the anorectal cuff does not need to be dissected as the tissue of the anorectal cuff is often quite compliant and the lower purse-string tends to form well with a secure seal.

Two-team approach

While there has been much recent discussion about performing taTME with two surgical teams to conserve operative time, this approach is not at all new to colorectal surgeons as abdomino-pelvic resection (APR) has been performed in this fashion for decades [59]. From a practical standpoint, there are some limitations to performing simultaneous two-team taTME during the entirety of the operation. For example, during mobilization of the splenic flexure, with the patient positioned right-side down and moderate reverse Trendelenburg, it is difficult for the perineal and abdominal surgeons to operate simultaneously. The greatest advantage of the two-team taTME is realized at the point of entry into the peritoneal cavity from below. Once entry is made, working from above and below simultaneously greatly facilitates completion of the TME (Fig. 15a, b). After the TME dissection has been completed, specimen delivery and conduit preparation with anastomosis is also best performed with two surgeon teams as, at this point, abdominal to pelvic field communication necessitates a cooperative approach to construction of the anastomosis.

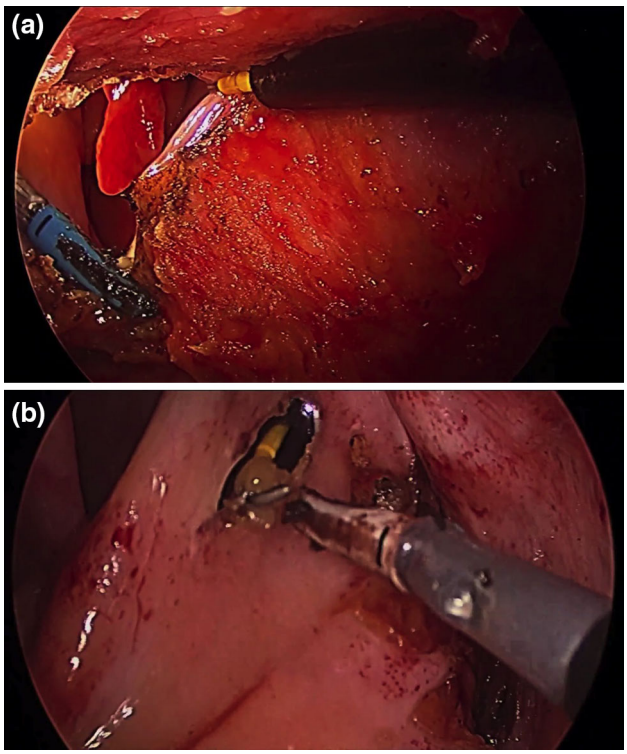

Fig. 15 **a** Upon peritoneal entry, a two-team approach to completing the taTME operation is used. Here shown is the taTME surgeon's perspective were the right peritoneal reflection is being divided with both surgeons working in concert. **b** The abdominal surgeon's perspective during this same portion of the taTME dissection is demonstrated

Special problems—intersphincteric dissection and pelvic exenteration

Performing taTME with intersphincteric (ISR) dissection for extremely low-lying rectal cancer is feasible, but this necessitates a modification to the technique. To perform ISR with taTME, a self-retaining retractor (such as a Lone Star Retractor, Houston, TX, USA) is placed near the dentate line. An ISR is then carried out under direct vision. As the dissection progresses cephalad, it is possible to then create a purse-string, and subsequently introduce an advanced transanal platform such that taTME can be completed in the usual fashion. Such a hybrid technique has been previously described in video format utilizing a robotic transanal technique as well [60].

Some aspects of pelvic exenteration can be managed using taTME. For example, the entire posteriolateral dissection of the TME can be performed from below and the anterior compartments then removed en bloc with the rectum. With the taTME technique, sphincter preservation is feasible as GI continuity can be restored if the sphincter mechanism is not involved with tumor. As previously described, an APR can also be performed using modifications of the taTME technique [10].

Conclusions

The disruptive technique of taTME is an innovation which represents an important step toward improving pelvic access and, in turn, resection specimen quality. Numerous technical and anatomic pearls, when recognized, can help insure the safe adoption of this operation. Procedure-specific anatomic landmarks and critical concepts of taTME can be learned. Formal training is strongly encouraged to insure early mastery of taTME and to diminish the probability of morbidity that would otherwise be attributable to inexperience.

Compliance with ethical standards

Conflict of interest The authors received no funding for this study, and the research was not supported by any grants or other funding. Dr. S. Atallah and M. Albert are paid consultants for ConMed, Inc. and Applied Medical, Inc. Dr. J. R. T. Monson is an advisor for Twistle.com and received teaching honoraria from Applied Medical, Inc., and Covidien.

Ethical approval This study involved no human participants. This research was performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was not applicable in this study.

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