Abstract
Since its introduction in 1983, transanal endoscopic microsurgery (TEM) has emerged as a safe and effective method to treat rectal lesions including benign tumors, early rectal cancer, and rectal fistulas and strictures. This minimally invasive technique offers the advantages of superior visualization of the lesion and greater access to proximal lesions with lower margin positivity and specimen fragmentation and lower long-term recurrence rates over traditional transanal excision. In addition, over two decades of scientific data support the use of TEM as a viable alternative to radical excision of the rectum with less morbid-ity, faster recovery, and greater potential cost savings when performed at specialized centers.

Introduction
Cancer of the rectum is the fifth most common form of cancer in adults worldwide. In 2012, an estimated 40,300 new rectal cancers will be diagnosed in the US with a median age 69 years.5 Five-year survival rates for rectal cancer are high for early stage disease (90% for Stage I disease) but drop significantly with worsening stage (7% for metastatic Stage IV disease). Recently, advances in neoadjuvant and adjuvant therapy have decreased the rate of local recurrence and improved long-term survival for some patients. Although the treatment for rectal cancer has become increasingly multimodal, surgical excision of the primary tumor remains essential for eradication of disease.

For a long time there has been a debate about the best surgical approach to early stage rectal cancer, whether treatment should involve radical excision (excision of the rectum) or local excision (tumor alone). Proponents of radical surgery argue that excision of the rectum with its surrounding lymphatic drainage offers the best chance for cure. On the other hand, advocates of local excision feel that a less-aggressive approach can avoid the potential ramifications of major pelvic surgery such as sepsis, poor anorectal function, sexual dysfunction, and difficulty with urination and can eliminate the potential need for a permanent stoma. Although the debate has gone back and forth on the adequacy of local excision, there is a growing body of scientific data that suggests that local excision can be sufficient in patients with early rectal cancer of the mid and distal rectum with good histologic features and preoperative imaging (computed tomography, magnetic resonance imaging, and endorectal ultrasound) that shows no evidence of lymph node involvement. Traditionally, transanal excision has been performed with the conventional technique using traditional equipment. Although this conventional technique can give surgeons operative access to most distal rectal lesions, it can be difficult to conduct on mid-rectal tumors or in large patients with a deep but-toc k cleft. The technical difficulties experienced under such circumstances can lead to poor visualization, inadequate margins, or specimen fragmentation.

In response to the technical limitations of conventional transanal excision, in the 1980s Professor Gehard Buess from Tubingen, Germany, began to develop the technique of transanal endoscopic microsurgery (TEM). In collaboration with the Richard Wolf Company in Germany, Dr Buess developed the specialized instruments necessary to perform endoscopic surgery transanally. TEM was introduced into...
Transanal Endoscopic Microsurgery for Rectal Tumors: A Review

Clinical practice in 1983, and was gradually implemented in several European countries and eventually introduced in North America and Asia. The last decade has witnessed international growth in the application of TEM yielding a significant amount of scientific data to support its clinical merits and advantages and also shedding some light on its limitations.

Indications for TEM
TEM was initially used exclusively for benign lesions and for invasive lesions in patients who were considered to be too high risk for radical surgery. However, as experience with TEM has grown, TEM has become recognized as an effective and safe option for rectal tumors such as adenomas, carcinoid, and gastrointestinal stromal tumors (GIST). TEM has been selectively used in the treatment of fistulous disease such as high anorectal fistulas (suprasphincteric or extrasphincteric), rectourethral, and rectovaginal fistulas. Limited application of TEM has also been reported in the treatment of anastomotic strictures (stricturoplasty) or the correction of rectal prolapse (fixation of the posterior wall of the rectum to the presacral tissue).

Current indications for TEM have expanded to include the treatment of early stage rectal cancer in addition to palliation in cases of advanced rectal cancer in patients who refuse radical excision or in those who are poor surgical candidates. Patients with incidental carcinoma following polypectomy are suitable candidates for TEM especially in the setting of a sessile polyp or when there is concern about margin positivity. For potentially curative resection of malignant lesions, preoperative staging is of the utmost importance so that only those lesions with the lowest likelihood of nodal metastases are selected for TEM. Both endorectal ultrasound or MRI can be used to determine the lesion depth of penetration and to evaluate the mesorectum for metastatic disease.

TEM Equipment
TEM equipment can be divided into 2 major components: 1) operating instruments and 2) the endosurgical unit (Figure 1). The operating instruments, which are handled by the surgeon during the procedure, include: the operating rectoscope (Figure 2), the stereoscope (Figure 3), and the long-handled instruments for dissection, excision, and suturing (Figure 4). The endosurgical unit provides carbon dioxide (CO₂) insufflation, suction, irrigation, and continuous monitoring of intrarectal pressure. The operating rectoscope is approximately 4 cm in diameter and either 12 cm or 20 cm in length with a beveled or straight-faced end. The surgeon’s end has an airtight faceplate with 4 ports sealed by capped rubber sleeves through which the optical stereoscope, suction, and 2 long-shafted operating instruments are inserted (Figure 5). The surgeon visualizes the field through the binocular stereoscopic eyepiece, which provides a precise 3-dimensional view of the operative area with up to 6-fold magnification of the operative field. The stereoscopic eyepiece itself includes dual lenses, an insufflation channel, and lens irrigator operated by foot pedal. An accessory monocular scope is connected to a video screen to allow the surgical team to view the procedure. All operating instruments are 5 mm in diameter and include graspers, scissors, a high-frequency knife, needle driver and clip applier. Most instruments angle downward at the tip. Graspers are made both with a right or left curve. The rectoscope and its attachments are secured to the operating room table using a multifunctional clamp, the Martin’s Arm.

The endosurgical unit provides the light source, irrigation, and suction, and is equipped with a pressure-controlled insufflator that measures pressure constantly via a separate channel so that interruption of the gas insufflation for pressure...
measurement is not necessary. Simultaneously, an integrated roller pump provides constant suction at the same rate as the gas insufflation to allow for stable gas pressure in order to maintain visualization of the distended rectum without insufflation of the more proximal colon.

**Operative Technique**

Rectal cleansing is critical for adequate visualization of the rectal lumen and lesion. It can be achieved with either a mechanical bowel preparation or, alternatively, 2 rectal enemas depending on the patient’s regular bowel habits. Intravenous antibiotics are used selectively. TEM procedures are usually performed under general anesthesia and a Foley catheter is used to decompress the bladder. Preoperative localization of the tumor is performed with rigid sigmoidoscopy in the clinic setting to determine the quadrant location of the lesion and to plan for operative positioning of the patient to allow the lesion of interest to sit at the 6-o’clock position. Patients with an anterior-based lesion are positioned in the prone jackknife position (legs spread apart and secured to arm boards) while those with a posterior lesion are positioned in lithotomy. Laterally located lesions are best approached with patients in the appropriate lateral decubitus position.

The operation starts with gentle dilation of the anus with two fingers and insertion of the rectoscope, inspection of the rectum under manual air insufflation and positioning of the rectoscope for optimal visualization of the lesion. The rectoscope is then attached to the operating table using the Martin’s arm. During the resection, frequent repositioning of the scope is often necessary to keep the operative field in optimal view. Optics and operative instruments are introduced and the endosurgical unit is activated providing insufflation, suction, irrigation and pressure monitoring. Using cautery, the surgeon first makes the desired margin of clearance. This margin should be 5 mm from the macroscopic tumor edge for benign lesions and 10 mm in cases of invasive carcinoma. For adenomas located within the intraperitoneal portion of the rectum, a careful mucosectomy is performed to prevent entry into the peritoneum with the ensuing loss of rectal distention. For extraperitoneally located adenomas and for all invasive carcinomas, full thickness resection is standard. Circumferential adenomas in the lower and middle rectum can be resected as complete full thickness segments followed by an end-to-end anastomosis. Invasive carcinoma in the posterior or lateral position may be resected with some perirectal fat, which can often yield 1 or 2 adjacent lymph nodes, which can be examined for metastatic spread.

The resection bed for lesions below the peritoneal reflection may be left open or closed using a running suture with 3-0 polydioxanone suture (PDS) on a small-half (SH) needle. Knot tying using TEM equipment is very difficult and is instead achieved using silver clips, which are secured onto the suture. Closure of all intraperitoneal defects is mandatory and should be performed in 2 layers with separate closure of the peritoneum if entered.

**Outcomes**

**Complications**

The overall complication rate for TEM for benign and for malignant lesions has been reported to range from 6% to 31%. Perioperative complications include hemorrhage and peritoneal entry, which may require conversion to laparotomy. The intraperitoneal perforation rate varies from 0% to 9%. However, perforation into the peritoneal cavity does not always necessitate conversion to open laparotomy. In a series of 144 patients by Ganai and colleagues, 9 patients (6%) had peritoneal entry but all were managed by primary closure of the defect avoiding conversion to open anterior resection. Moreover, in a retrospective review of 34 patients, Gavagan and colleagues reported no increase in major or minor complications and no significant increase in the hospital length of stay for those with peritoneal perforation compared with those without. Postoperative hemorrhage has been reported in 1% to 13% of patients. Most resolve spontaneously or are managed conservatively with blood transfusion. Very few patients require surgical intervention. Suture line dehiscence, perirectal abscess, and rectal stenoses have also been described. In most instances, suture line dehiscence is managed nonoperatively and treated with local therapy and antibiotics.

Early and late complications in TEM patients were similar or lower than for patients undergoing open resection in several randomized trials comparing TEM with radical excision. Lezoche and colleagues found no significant difference in complication rates between patients randomized to either TEM (n = 35) or laparoscopic total mesorectal excision (n = 35) for T2N0 rectal cancer following neoadjuvant treatment. Winsde and col-
leagues randomized 50 patients with T1 rectal cancer to TEM (n = 24) and anterior resection (AR) (n = 26). Patients were not statistically different in age or tumor location. However, early morbidity was 21% in the TEM group compared with 35% in AR group. TEM patients also had significantly shorter average operating times (103 min vs 149 min, p < 0.05), lower blood loss (p < 0.001), shorter length of stay (5.7 days [standard deviation [SD]] 1.8 days vs 15.4 days [SD 1.5 days], p < 0.0001) and a lower postoperative analgesia requirement.31

Recurrence
The adenoma recurrence rate following TEM ranges from 0% to 6%,16,18,26,29,34,35 McCloud and colleagues reviewed their experience with 75 patients who underwent TEM for rectal adenomas to determine predictors of early recurrence. Although recurrence at 6 months was not found to be significantly associated with age, gender, type, or position of the adenoma, distance from the anal verge or degree of dysplasia, there was a significant association between incomplete adenoma excision and risk of recurrence. Recurrence rates at 6 months were 0% for completely excised adenomas and 21% for those incompletely excised as determined by histologic evaluation.36 Comparison of TEM with conventional transanal excision for adenoma resection has also shown lower margin positivity, less specimen fragmentation, and a lower recurrence rate with TEM than conventional excision (3% vs 32%, p = 0.003).37

TE as the definitive and sole curative treatment should be limited to early stage T1N0 cancer (submucosal invasion with negative nodes, preoperative imaging stage). The recurrence rate following TEM for T1 lesions ranges from 0% to 6%.16,18,26,29,34,35 Several studies comparing TEM and radical surgery for T1 cancers demonstrated no statistically significant difference in recurrence rate or survival for TEM compared with radical surgery.30,31 If unfavorable histologic characteristics are found following TEM excision or if the lesion penetrates into the muscularis propria (pT2) or if there is lymphovascular invasion or involved margins, most surgeons advise immediate radical surgery. Borschitz and colleagues studied 105 patients with T1 rectal carcinoma resected by TEM and stratified them into low- and high-recurrence risk by histologic characteristics including tumor differentiation and lymphatic or venous invasion. The local recurrence rate for low-risk carcinomas was 6% and for high-risk tumors was 39% after TEM resection. However immediate reoperation of the high-risk tumors resulted in a reduction of the recurrence rate to 6%, the same rate as for low-risk tumors.39

With recent advances in chemoradiation, local excision can be used selectively for T2 lesions when augmented by neoadjuvant or adjuvant therapy. Overall recurrence rates following TEM excision of T2 lesions (including patients who did and did not have chemoradiation) range from 6% to 18%.15,21-23,41 However, the use of neoadjuvant or adjuvant therapy has been demonstrated to significantly reduce local recurrence rates. Duck and colleagues reviewed their experience of 21 patients with T2 tumors and demonstrated a 0% local recurrence rate in patients who underwent radiotherapy following TEM compared to a 50% recurrence rate in patients who refused adjuvant radiotherapy following TEM.41 Lezoche and colleagues compared TEM and laparoscopic total mesorectal excision in a prospective randomized study of 70 patients with T2 lesions (35 TEM and 35 laparoscopic excision) all of whom had neoadjuvant chemoradiation therapy and found no significant difference in local recurrence or disease-free survival during a minimum 5-year follow-up.35 However, Lee and colleagues demonstrated a significantly higher 5-year local recurrence rate following TEM compared with radical excision for T2 lesions (19.5% vs 9.4%, p = 0.035) but similar disease-free survival (80.5% vs 83.3%, p = 0.12) in patients who did not receive adjuvant chemoradiation.30

Patients with T3 lesions are not suitable candidates for TEM alone because of the high risk of local recurrence and lymph node metastases and limited data is available on the oncologic outcome of such patients. Guerrieri and colleagues reported on 23 patients with T3 rectal cancer treated with TEM following preoperative radiotherapy. Local failure occurred in 2 cases (9%) and disease-free survival was 59% at a mean follow-up of 46 months.39 Similarly, Lezoche and colleagues showed a local recurrence rate of 4% with an 85% rectal cancer specific survival rate at 90 months in T3 patients following radiotherapy.35

Functional Outcomes
The physiologic effect of TEM on postoperative anal sphincter function has been investigated and demonstrates diminished anorectal manometric resting pressures following TEM.12-21 Kennedy and colleagues performed anorectal physiologic studies preoperatively and at 6 weeks postoperatively in 18 consecutive patients undergoing TEM. A significant decrease in maximum anal resting pressure was noted which correlated with duration of the procedure. However, no significant change in continence level was noted and pudendal nerve terminal motor latency, mucosal electrosensitivity and rectal compliance were not significantly changed.42 Impairment in continence was seen in 37% of patients following TEM in a study conducted by Dafnis and colleagues and was again correlated with prolonged operative time but not associated with patient age or gender.42

Cataldo and colleagues assessed baseline and postoperative anorectal function in 37 patients undergoing TEM using validated functional assessment tools (Fecal Incontinence Severity Index [FISI] and Fecal Incontinence Quality of Life [FIQL]) and found no significant difference between baseline and postoperative FISI and FIQL scores.43 Similarly, a study comparing quality of life between patients undergoing TEM and patients undergoing total mesorectal excision (TME) found that general quality of life was similar between the 2 groups postoperatively but TEM patients had fewer problems with defecation than the TME patients.44

Early and late complications in TEM patients were similar or lower than for patients undergoing open resection in several randomized trials comparing TEM with radical excision.
Cost
TEM benefits include decreased morbidity, shorter hospital length of stay, and faster recovery. However, the initial cost of the specialized TEM equipment is perceived by some surgeons as a limiting factor in the widespread adoption of this technique. Nevertheless, TEM can be cost effective if offered at high-volume centers. In a case-controlled study, Maslekhar and colleagues compared 52 patients undergoing TEM with 52 patients undergoing open procedures at a single institution between 1997 to 2003. TEM costs were $3500 to $5800 lower per patient compared with patients who had an anterior resection when taking into consideration the hospital stay, equipment and instruments, and stoma closure when applicable. An even larger cost saving was seen in the retrospective review by Cocilovo and colleagues who reported an average cost for TEM of $7775 compared with $34,018 for a low-anterior resection at their institution.

Conclusion
Since 1983, TEM has been used effectively to treat benign rectal lesions and early rectal cancer. TEM allows the surgeon to tackle lesions too difficult to approach with conventional transanal excision with improved immediate endpoints (margin positivity and specimen fragmentation) and lower long-term recurrence rates. Over two decades of scientific data support the use of TEM as a viable alternative to radical excision of the rectum with less morbidity, faster recovery, and potential cost savings when performed at specialized centers. Functional disturbance of continence occurs in a minority of patients.

The role of TEM in patients with T2N0 and T3N0 is still being debated and warrants further investigation. Currently TEM should be limited in these cases to patients who refuse or are too high risk for transabdominal radical excision. Under such circumstances serious consideration should be given to adjuvant or neoadjuvant chemoradiation to reduce the risk of local recurrence.

Disclosure Statement
The author(s) have no conflicts of interest to disclose.

References
32. Lezoche E, Guerini M, Paganini AM, et al. Transanal endoscopic versus total mesorectal laparoscopic resections of T2-N0 low rectal cancers

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**Life!**

Surgeons must be very careful
When they take the knife!
Underneath their fine incisions
Stirs the Culprit - Life!

— Emily Dickinson, 1830-1886, American poet