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Transanal minimally invasive surgery: a giant leap forward

Sam Atallah · Matthew Albert · Sergio Larach

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Abstract
Background Our novel approach is a hybrid between transanal endoscopic microsurgery (TEM) and single-port laparoscopy that we have termed TransAnal Minimally Invasive Surgery (TAMIS). We report the clinical application of this technique and present preliminary data that show TAMIS to be an effective tool for resection of both malignant and benign lesions of the rectum.
Methods Over a 3-month period (May–July 2009) all patients with rectal lesions who were candidates for conventional transanal excision were offered the option to undergo TAMIS resection. Patients with biopsy-proven malignant lesions were required to undergo endorectal ultrasound preoperatively to determine tumor stage. To perform TAMIS, a single-incision laparoscopic surgery port (SILS Port, Covidien) is introduced into the anal canal by applying steady manual pressure. Once seated in position, endoscopic access to the rectal vault is gained and pneumorectum is established. With this access, ordinary laparoscopic instruments, including graspers, thermal energy devices, and needle drives, are used to perform the transanal excisions.
Results Six patients, aged 43–85 years old (mean = 59.8), underwent TAMIS resection of rectal lesions. The average distance from the anal verge was 9.3 cm and the mean tumor diameter confirmed by pathology measured 2.93 cm. There were no conversions from TAMIS to conventional transanal excision. While the average operating time was 86 min, four of the six TAMIS resections (67%) were completed in less than 1 h. The mean set-up time was only 1.9 min and this may be one reason that the mean operative time was considerably less than the average operative time for TEM surgery (120–140 min). In short-term follow-up, there was no morbidity or mortality observed.
Conclusions TAMIS is a feasible alternative to TEM, providing its benefits at a fraction of the cost.

Keywords Transanal resection · Rectal cancer · TAMIS · Single-incision port

Compared to conventional transanal excision, transanal endoscopic microsurgery (TEM) provides superior quality of resection, decreased local recurrence, and improved survival, particularly among patients with histologically favorable stage I rectal cancer [1–5]. In long-term follow-up, the modality of TEM excision of rectal tumors has proven to be safe and effective, with morbidity and mortality similar to that of conventional transanal excision [6–10]. However, although TEM has been in use for more than 20 years, it has been slow to become universally adopted by colorectal surgeons, in part because of a steep learning curve, but also because of the significant cost of the highly specialized instrumentation [11, 12].

Technology continues to undergo rapid evolution. In parallel, the surgeon's minimally invasive surgery skill has matched this advancement. Crossover exists by which instrumentation designed for a single application can be used for a different task. Such is the case for natural orifice surgery (NOTES) whereby endoscopes and even TEM instrumentation has been used to perform NOTES [13–16].

S. Atallah, M. Albert, and S. Larach contributed equally to this work.

S. Atallah (✉) · M. Albert · S. Larach
Center for Colon and Rectal Surgery, Florida Hospital Orlando, 601 East Rollins St, Orlando, FL 32803, USA
e-mail: atallah@post.harvard.edu

Most recently, technology-driven minimally invasive surgery has led to single-incision, multiport devices that have facilitated a wide spectrum of abdominal procedures [14, 16–21]. Today, even single-access laparoscopic colectomies have been performed safely and successfully [22–24]. The working angles in single-access laparoscopy are essentially identical to those used in TEM. Therefore, crossover exists between the skill set necessary to perform single-port laparoscopy and TEM. The considerable upfront cost of TEM instrumentation, however, remains a significant barrier to its widespread use.

Our novel approach is a hybrid between TEM and single-port laparoscopy that we have termed TransAnal Minimally Invasive Surgery (TAMIS). We report the clinical application of this technique and present preliminary data that show TAMIS to be an effective tool for resection of both malignant and benign lesions of the rectum.

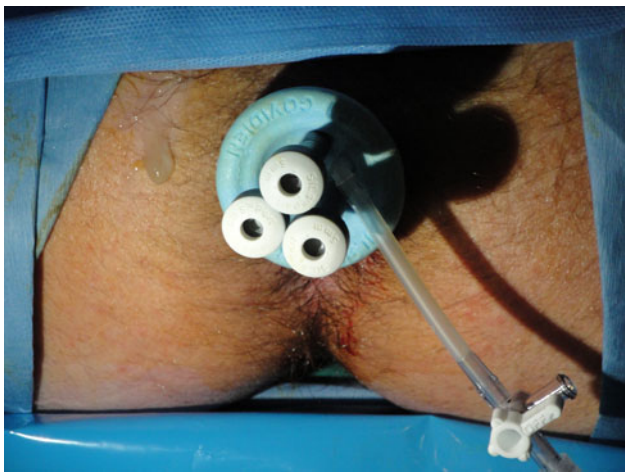

Fig. 1 Made of a specialized thermoplastic elastomer, the SILS™ Port, originally designed to facilitate single-incision laparoscopy, is well-suited as an anorectal access port for TAMIS. Three centimeters in diameter at its neck, it contains three 5-mm cannulas for single-port minimally invasive surgery and a separate insufflation-dedicated access. The option to substitute one of the 5-mm cannulas with a 12-mm cannula (not shown) is invaluable

Methods

Over a 3-month period (May–July 2009), all patients with rectal lesions who were candidates for conventional transanal excision were offered the option to undergo TAMIS resection. Informed consent was obtained from each patient, and each was given the option to undergo conventional transanal excision or TAMIS. Patients with locally advanced rectal cancer were not considered candidates for conventional local excision or TAMIS. Patients with biopsy-proven malignant lesions were required to undergo endorectal ultrasound preoperatively to determine tumor stage. Only patients with uT1uN0 lesions were considered candidates for TAMIS. Postoperatively, patients were followed for a mean of 6.2 weeks (range = 4–8 weeks).

To perform TAMIS, a single-incision laparoscopic surgery port (SILS™ Port, Covidien, Mansfield, MA) is first lubricated and then gently introduced into the anal canal by applying steady manual pressure. Once seated in position, endoscopic access to the rectal vault is gained and pneumorectum is established (Fig. 1).

The SILS Port is 3 cm in diameter at its neck and contains three 5-mm cannulas for single-port surgery and a separate insufflation-dedicated access (Fig. 2A, B). The port is also designed so that one of the 5-mm cannulas can be exchanged for a 12-mm cannula. Made of a flexible, sponge-like material, the SILS port is ideal for placement into the anal canal and in our experience has provided a conforming fit, usually without leakage of insufflated CO_2 at 18 mm H_2O. The port's upper rim allows it to anchor just above the anorectal ring. With this access, ordinary laparoscopic instruments, including graspers, thermal energy devices, and needle drives, can be used to perform the transanal excision. Where applicable, specialized articulating laparoscopic instruments (Novare Surgical, Cupertino, CA) are employed.

Patient positioning in the operating room was dependent on the anatomic location of the tumor. For posterior lesions, patients were positioned dorsal lithotomy, while anterior lesions required the patient to be positioned prone jack-knife. Prior to TAMIS resection, patients underwent rigid proctosigmoidoscopy to confirm tumor orientation and distance from the anal verge. Each patient had undergone a mechanical bowel prep and received 1 g of ertapenem sodium (Invanz®, Merck, Whitehouse Station, NJ) intravenously as a single dose prior to incision.

Results

Six patients, aged 43–85 years old (mean = 59.8), underwent TAMIS resection of rectal lesions (Table 1). The average distance from the anal verge was 9.3 cm and the mean tumor diameter confirmed by pathology measured 2.93 cm. Two of the six TAMIS resections contained early-stage adenocarcinoma (Tis and T1 lesions). For the patient whose 6.0-cm villous adenoma contained focal Tis adenocarcinoma, six benign lymph nodes were retrieved from the mesorectum of the surgical specimen (case A). All margins were negative except for one (case F), in which a small focus of villous adenoma was identified at the resection margin. This patient underwent subsequent fulguration of the minute focus of adenoma and continues to undergo careful surveillance.

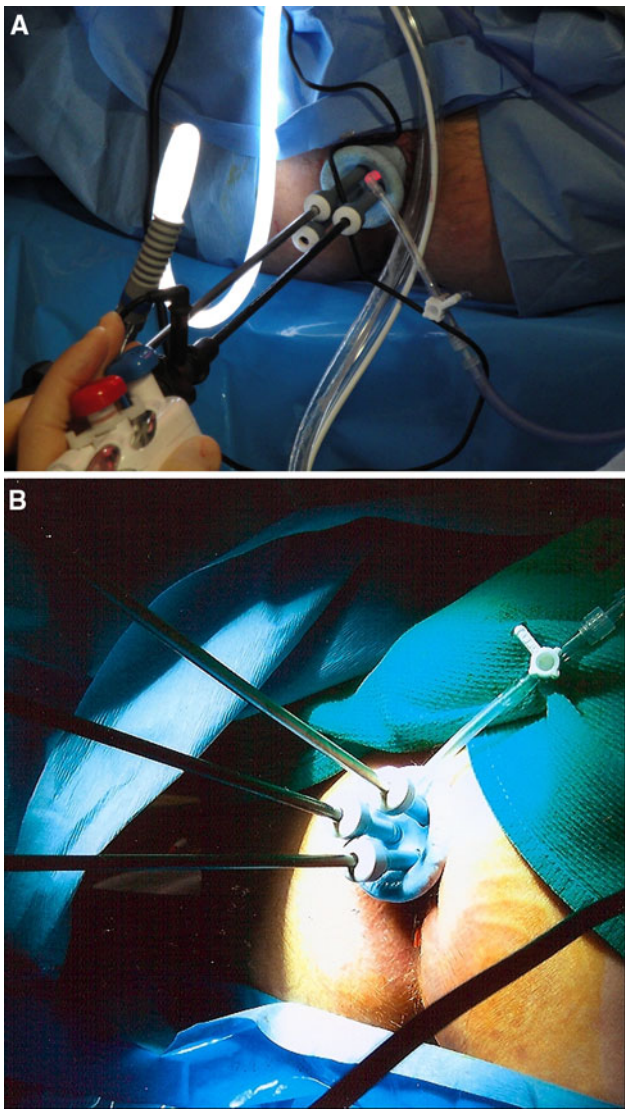

Fig. 2 **A** TAMIS: Single-port access is used to facilitate minimally invasive surgery so that transanal excision of rectal lesions can be performed. TAMIS is a novel approach that is a hybrid between single-port laparoscopy and transanal endoscopic microsurgery. Shown here is the SILS™ Port in position within the anal canal. Insufflation of the rectum is established with a dedicated port. Through the remaining three cannulas, two are used for laparoscopic instrumentation while one is used for a 5-mm 30° lens. For posterior lesions, the camera lens is positioned in the anterior port, as shown. **B** Resection of a posterior lesion using TAMIS (patient positioned dorsal lithotomy). Note the narrow working angles. Flexible, articulating instruments (Novare) allow improved triangulation and greatly facilitate ease of resection

Once the resections were completed, intraluminal suturing was performed to reapproximate the excision defect. This was done in all cases except one, whereby a 10-mm endo-GIA stapler was introduced into the rectum via a 12-mm SILS port cannula to allow for intraluminal division along the broad stock of a well-pedunculated polyp (case F). There were no conversions from TAMIS to conventional transanal excision.

As noted in Table 2, most patients were discharged on the day of surgery or on the first postoperative day. One patient underwent a concomitant cecectomy and was discharged on the second postoperative day. Another patient (case D) underwent resection of an anterior lesion in the intraperitoneal rectum which proved to be technically difficult. Also, during full-thickness excision, the peritoneum was violated. The defect was closed with interrupted absorbable sutures using TAMIS. This patient was observed for 48 h and subsequently discharged without incident. Of the six patients who underwent TAMIS resection, no short-term adverse sequelae were observed (average of 6.2 weeks follow-up).

While the average operating time was 86 min, four of the six TAMIS resections (67%) were completed in less than 1 h. In case D, the operative time was 3.2 h because of the lesion's anterior position in the intraperitoneal rectum. Furthermore, it was the first anterior lesion resected using TAMIS and our surgical protocols for this resection were still being established. In case A, the operating time was 121 min because of the tumor's size, which measured 6.0 cm in diameter and occupied three-fourths the circumference of the rectal lumen (Fig. 3). Despite two cases requiring well over an hour to complete, the mean set-up time was only 1.85 min; this may be one reason that the mean operative time was considerably less than the average operative time for TEM surgery (120–140 min).

As noted, in case A there was difficulty maintaining insufflation and the rectal vault would repeatedly collapse. This problem was solved by deepening the patient's general anesthetic and adding muscle paralysis. In our initial experience, there was minimal bleeding, perhaps secondary to the tamponading effect of the pneumorectum which was kept at a level greater than venous pressure (18 mm H_2O). Furthermore, each case demonstrated excellent operative field visibility without fogging of the camera lens (Fig. 4). Interestingly, pneumorectum establishes a natural, pneumatic dissection of the investing rectal fascia, significantly improving operative visibility and more exactly defining the plane of dissection (Fig. 5).

There was no difficulty with the SILS device molding to the anal canal and maintaining pneumorectum, except as noted for patient A. However, the integrity of the seal was slightly compromised when moderate torque was used to achieve proper working angles during resection. Because less torque is required with articulating laparoscopic instruments (Novare Surgical), this problem was greatly minimized when such instruments were used. Furthermore, placement of temporary sutures to secure the SILS Port to the perianal skin proved to be helpful in keeping the device properly seated.

Table 1 Tumor characteristics

Case, age/sex	Tumor location[a] (cm)	Tumor position	Tumor diameter (cm)	Resection margin	Final tumor pathology
A, 43/M	9	Posterior	6.0	Negative[b]	Tis well-differentiated 0.4-cm adenocarcinoma within villous adenoma
B, 68/F	6.5	Posterior	0.6	Negative	pT1 moderately differentiated adenocarcinoma
C, 85/M	10	Posterior	2.0	Negative	Villous adenoma
D, 56/M	13	Anterior	3.5	Negative	Tubulovillous adenoma
E, 49/F	6	Posterior	1.5	Negative	Carcinoid
F, 58/M	11.5	Anterior	4.0	Focal only	Villous adenoma

[a] Distance from anal verge

[b] The specimen also contained six nodes that were benign

Table 2 Clinical and operative results with TAMIS

Case	TAMIS setup time[a] (min)	Operative time (min)	Intraoperative difficulty	Hospital stay (days)	Morbidity and mortality
A	2.20	121	Difficulty maintaining insufflation	1	None
B	2.50	59	None	0	None
C	2.25	56	None	0	None
D	1.90	192	None	2	None
E	1.00	45	None	2[b]	None
F	1.25	43	None	0	None

[a] Time required to position SILS™ Port and establish pneumorectum

[b] Patient had concomitant laparoscopic cecectomy

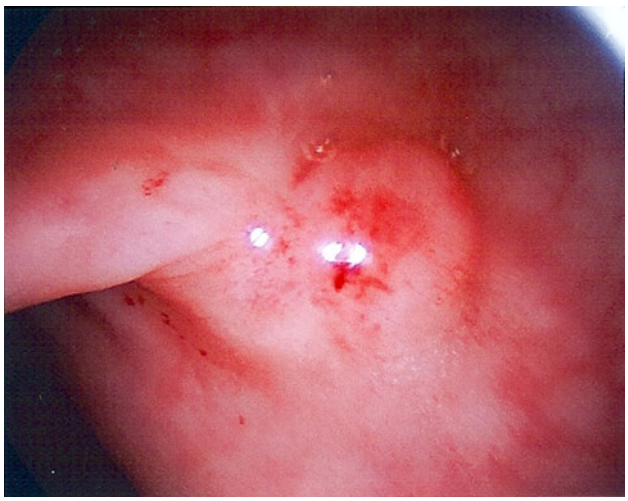

Fig. 3 Endoscopic view of uT1uN0/pT1 adenocarcinoma of the subperitoneal rectum prior to TAMIS resection

Fig. 4 Full-thickness resection of a 0.6-cm uT1uN0/pTI adenocarcinoma with pathologically negative margins. Note how the pneumodissection of the perirectal fascia improves visibility of the operative field. This rectal wall defect was reapproximated via intraluminal suturing using transanal minimally invasive surgery (TAMIS)

Discussion

Transanal endorectal microscopic surgery was first pioneered by Buess in 1985 [25] and predates widespread use of modern laparoscopy by general and colorectal surgeons. That this unique, natural orifice surgical approach was developed prior to the first laparoscopic cholecystectomy is testament that TEM was well ahead of its time. However, during the past 20 years there have been significant advancements in laparoscopic technology but TEM has

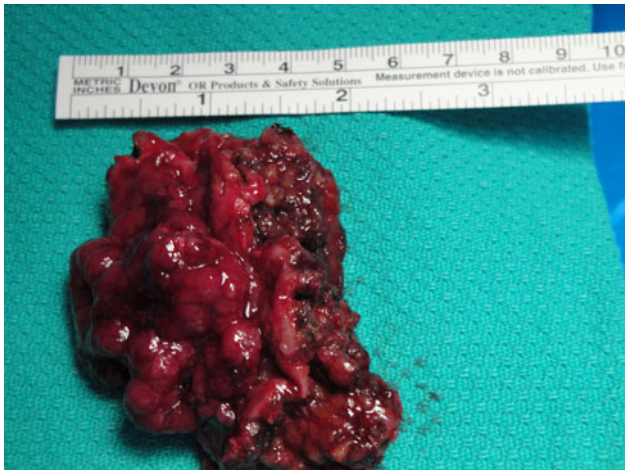

Fig. 5 Specimen after TAMIS resection. Histologic margins were 0.5 cm circumferentially on this 6.0-cm villous adenoma which contained a focal 0.4-cm invasive adenocarcinoma. Six benign nodes were also retrieved in the mesorectum of the specimen

essentially remained the same. We appear to have finally arrived at the crossroads between minimally invasive single-incision laparoscopy and transanal endoscopic microsurgery, thereby allowing for the introduction of this low-cost, hybrid technique: TAMIS.

Until now, TEM had been the only way to perform endoscopic transanal resection of rectal tumors [26]. TAMIS provides a cost-effective alternative to this approach. Furthermore, the SILS Port used to facilitate TAMIS is readily available at most major hospitals and surgical centers. With minimal setup time, low equipment cost, and particularly the adaptation of existing laparoscopic instruments, TAMIS may provide a platform for the next generation in peranal resection. Furthermore, while our preliminary data demonstrate that TAMIS can be used for the resection of neoplastic lesions, it may also be adapted for the surgical treatment of benign anorectal disease, including high fistulas and rectal procidentia.

One advantage of TAMIS over TEM lies is in the access design. Made from thermoplastic elastomer, the SILS Port is pliable and allows for a conformed fit within the anal canal. Its pliable design and relatively small, 30-mm diameter allows for safe and atraumatic transanal access. This may translate into less adverse effect on anorectal function compared to TEM (which utilizes a 40-mm rigid rectoscope). In prospective studies, TEM has been associated with short-term anal dysfunction, including a reduction in anal sphincter tone and a significant decrease in maximal resting and contraction pressures for up to 6 weeks postoperatively [27, 28].

Another advantage of TAMIS is that the SILS access port can be removed quickly and reintroduced as needed. For example, the device can be removed during specimen extraction after transanal excision and reintroduced with a secure fit within about 1 min to complete closure of the resection defect. Furthermore, the ability to introduce conventional laparoscopic instruments through an optional 12-mm port is a feature exclusive to TAMIS and cannot be accomplished by TEM. With only a small series, we found this feature quite useful as it allowed successful endostapling across the stock on a well-pedunculated 4.0-cm polyp (case F).

In a recent study by Maslekar et al. [12], TEM was shown to be significantly more cost-effective compared to standard surgical resection (low anterior resection), suggesting that TEM is a low-cost alternative to an abdominal approach. However, this applies only to lesions that cannot be resected by conventional transanal means. Thus, TEM may be more cost-effective for a rectal tumor encountered in the upper or middle third of the rectum but not when the lesion is low enough to be excised with conventional methods or TAMIS. One must also consider the prohibitive up-front cost of TEM instrumentation. In comparison, the hospital cost of a disposable SILS Port device is approximately $525 per application. Hence, TAMIS provides a reasonable low-cost option to TEM without compromising the clear advantage of microsurgery [29].

TAMIS is a new technique still in its infancy and much remains to be learned. More data will be required and experience needed before concluding its superiority over TEM. As the number of cases performed grows and long-term follow-up is achieved, our group is optimistic that TAMIS will rival TEM, providing its benefits at a fraction of the cost.

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Disclosure Drs. Sam B. Atallah, Matthew R. Albert, and Sergio W. Larach have no conflicts of interest or financial ties to disclose.

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