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TECHNICAL NOTE

Single-port robotic transanal minimally invasive surgery (SPR-TAMIS) approach to local excision of rectal tumors

S. Liu[1] · S. R. Kelley[1] · K. T. Behm[1]

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Abstract

Background Trans-anal excision is the surgical treatment of choice for endoscopically unresectable rectal polyps, early rectal cancers, small carcinoid tumors, and other low-risk tumors. The single-port robotic (SPR) platform is the newest development in robotic surgery capable of performing trans-anal minimally invasive surgery (TAMIS). In theory, the single incision design would naturally lend itself to the size limitation of the anal canal, but in practice, this method has not been tested. Herein we describe the techniques and first reports of performing TAMIS using the SPR platform.

Technique We describe in detail how to perform the SPR-TAMIS technique using lessons and experience gained from performing this on five patients who had endoscopically unresectable rectal polyps or T1 rectal cancers. Each patient was followed for a minimum of 30 days and was seen in clinic post-operatively. A retrospective chart review was performed to obtain information on technical success, anatomic measurements, and reported complications.

Results The SPR TAMIS was successfully performed on all five patients without any reported complications. All underwent a non-piecemeal excision and had return of regular bowel function at 30-day follow-up. All patients were discharged from the hospital the same day as their operation.

Conclusions SPR-TAMIS is a novel, safe, and feasible procedure capable of achieving non-piecemeal resections of low-risk rectal tumors. Further study needs to be conducted to determine complication rates, functional and oncologic outcomes, and ensure the long-term safety profile.

Keywords Robotic surgery · TAMIS · Single port robotic surgery

Introduction

Modern approaches to management of low-risk rectal polyps include local excision via a transanal approach. These lesions include polyps not amenable to endoscopic resection, T1 rectal cancers with low-risk histological characteristics, small carcinoid tumors, and low-grade gastrointestinal stromal tumors (GIST) [1, 2]. The benefit of this approach is to avoid the surgical morbidity associated with low anterior resection (LAR) and abdominal perineal resection (APR) [3].

Transanal endoscopic microsurgery (TEM), as it was initially termed, was demonstrated to be a safe method for treating early stage rectal tumors with favorable oncologic outcomes [4, 5]. Transanal minimally invasive surgery (TAMIS) was introduced in 2009 as a way to achieve the same surgical outcome using widely available laparoscopic instruments [6]. Robotic TAMIS (R-TAMIS) was introduced in 2010 when surgeons began performing the procedure using the DaVinci™ Robotic Surgical System (Intuitive Surgical, Sunnyvale, CA,USA) [7]. Although there is scarce long-term follow-up data for R-TAMIS, short-term results in selective centers have been promising in terms of safety profile, technical learning curve, and oncologic outcome [8, 9].

In 2019, the single-port robotic surgical platform DaVinci SP™ (Intuitive Surgical Inc., Sunnyvale, USA) was cleared for clinical use in the operating room. This system utilizes a single 25-mm rigid robotic cannula to introduce up to one camera and three robotic working arms to perform an operation. Given that the anal canal can easily accommodate a port this size, the next progression of technique is to attempt transanal surgery with this platform. In 2017, investigators explored this possibility in cadaveric models with some

✉ K. T. Behm
Behm.Kevin@mayo.edu

[1] Division of Colon and Rectal Surgery, Mayo Clinic, 200 First Street SW, Gonda Bldg, Rochester, MN 55905, USA

success, but have not yet translated over to live patients [10]. In theory, the physical boundary of the rigid robotic port would prevent over-stretching of the anal sphincter since the deployment of the instruments occurs in the more distensible rectal vault. Additionally, the elbow joints of the single-port instruments splay out after they have passed the anal canal, allowing better instrument maneuverability compared to prior platforms. This allows access to more proximal lesions in the rectum without risk of additional sphincter muscle strain. This is the premise from which we have developed the single-port robotic TAMIS (SPR-TAMIS) technique in our practice.

To our knowledge, there has been no description of this technique or its outcomes in the literature. In this paper, we present our technique for the SPR-TAMIS as well as report a case series with short-term (30 days) follow-up.

Materials and methods

Patients

We performed SPR-TAMIS on five patients who had endoscopically unresectable rectal polyps or T1 rectal cancers. Each patient was followed for a minimum of 30 days and was seen in clinic postoperatively. A retrospective chart review was performed to obtain information on technical success, anatomic measurements, and reported complications. Local Internal Review Board (IRB) approval was obtained for this retrospective analysis and was deemed to be minimal risk. No informed consent was required.

Technique

Preoperative workup

The ideal patients for SPR-TAMIS resemble those for R-TAMIS. These include rectal polyps not amendable to endoscopic resection and without evidence of local invasion on imaging early stage rectal neoplasms (uTis or uT1N0M0) without high-risk features, T1 carcinoid tumors, GISTS, or selective palliative cases.

Patients have colonoscopy for biopsy and to rule out synchronous lesions. If malignancy is identified, a computed tomography (CT) scan of the chest and abdomen is obtained to rule out distant disease. Dedicated rectal cancer protocol pelvic magnetic resonance imaging (MRI) (± endoscopic ultrasound) is obtained to evaluate for local invasion.

Operative setup

Patients undergo mechanical bowel preparation with a 238 g of MiraLAX™ (Bayer, Boca Raton, FL, USA) in 64 oz of clear liquid, four bisacodyl tablets, and oral antibiotics (neomycin and metronidazole) the evening prior to the operation. General endotracheal anesthesia and paralysis are performed. Patients are positioned in a combined dorsal lithotomy position with Yellofin® stirrups (Allen Medical, Acton, MA, USA). This position is utilized for all cases as the robotic platform can rotate 360 degrees.

A digital rectal examination is performed to confirm tumor location. A GelPOINT® Path Transanal Access Platform (Applied Medical, Rancho Santa Margarita, CA,USA) is placed into the anal canal and suture anchored to the surrounding skin. The robot is docked from either side of the patient (Fig. 1). The robotic trocar is introduced directly into the center of the GelPOINT® platform into the anus. An 8-mm AirSeal® (ConMed, Utica, NY, USA) trocar is introduced on the lateral aspect of the GelPOINT® to provide continuous CO_2 insufflation. The AirSeal® port is introduced only far enough to allow for gas entry and not into the anal canal (Fig. 2).

The camera is placed in the designated docking location, which is set in the superior position at baseline. This is the standard positioning utilized for posterior and posterolateral lesions. For anterior lesions, the entire platform may

Fig. 1 Docking of the robot and patient positioning. The boom can be placed on either side of the patient's feet. However, we prefer to place it on the patient's right to allow right handed surgical assistants easier access

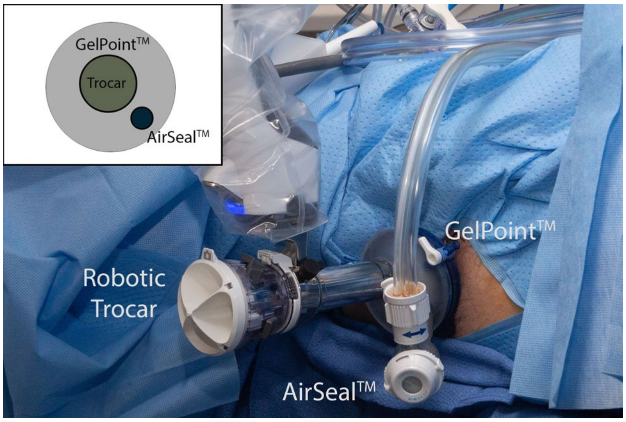


Fig. 2 Location for placement of GelPoint® device with the robotic trocar and AirSeal® trocar. The AirSeal® can be placed on either side of the GelPoint® device

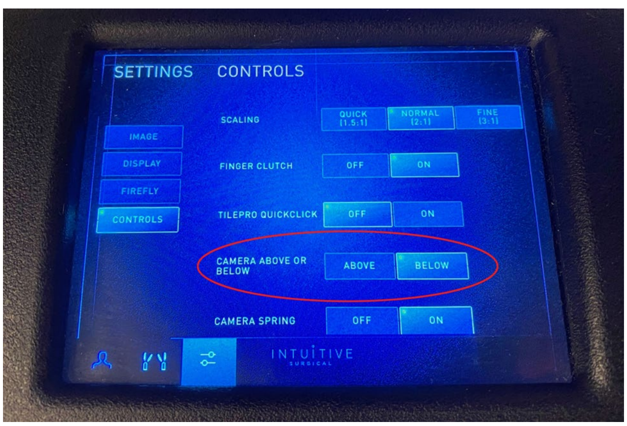


Fig. 3 Robotic console image of switching camera views

be rotated 180 degrees so that the camera is in the inferior position of the trocar. At this state, the robotic console will have the option to switch to a bottom up view, very similar to the camera angle switch in the DaVinci Xi™ (Fig. 3). This allows the surgeon to view the lesion in a more traditional downward setup. Our preferred instruments for dissection are the bipolar Cadiere forceps and the monopolar curved scissors. These two instruments are placed interchangeably between the left and right ports to optimize dissection. This maneuver mainly comes into play for low lesions in the anal canal, as the elbows of the robotic arms are unable to fully deploy. Swapping the instrument between left and right positions helps to avoid unnecessary tissue trauma. This will be explained more in the troubleshooting section.

Once the instruments are introduced into view of the robotic camera, the surgeon will take control and deploy them into the rectal vault. To avoid undue tension on the rectal wall, maximum deployment of the arms is performed under direct visualization, as well with the guidance animation available on the robotic console (Fig. 4).

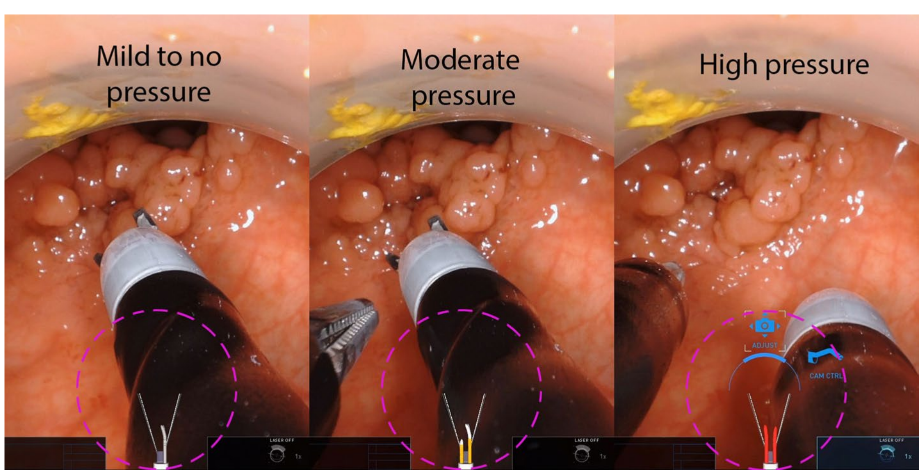
Operative dissection

The dissection begins by marking an approximately 1 cm parameter from the margin of the lesion to be excised using the monopolar scissors. The robotic camera is able to move in a serpiginous fashions over the lesion allowing additional degrees of freedom to clearly visualize the proximal margin (Fig. 5).

Excision of the lesion can be performed in a variety of ways. We advocate a distal to proximal approach to allow for clear visualization (Fig. 6a). It is easy to undermine this dissection beyond the necessary proximal margin, thus the surgeon must intermittently check the boundaries of dissection (Fig. 6b).

After the last band of tissue is disconnected from the specimen, an assistant can place a laparoscopic grasper on the distal margin through the robotic instrument port. The trocar valve can be removed from the metal cannula without undocking the robot or removing the Gelpoint™ platform.

Fig. 4 Device deployment with the animation guidance. The pressure experienced by the robotic arms goes from white, to yellow, to orange, and to red. Red signifies undue tension and should be avoided



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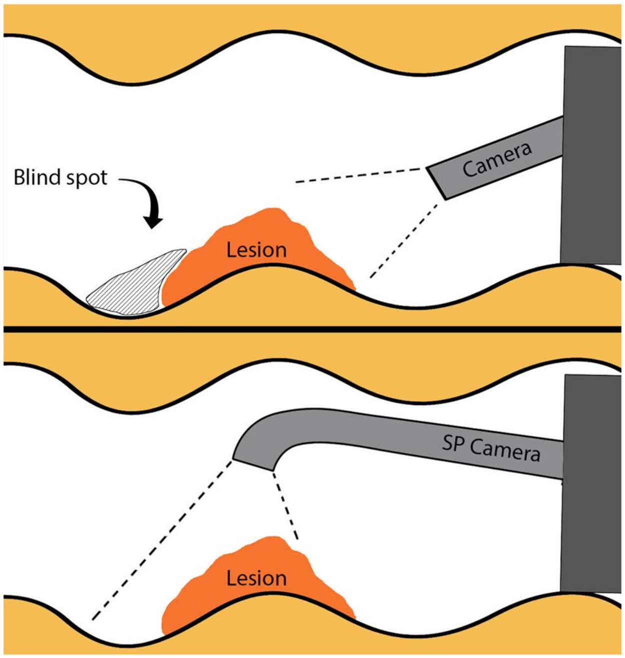

Fig. 5 A conventional rigid camera will always have difficulty looking past the lesion creating an area of blind spot. However, the new robotic camera allows viewing behind the lesion to eliminate this obscurity

This will allow the surgeon to maintain orientation of the specimen during extraction for pathologic evaluation and it allows for an efficient transition to closure of the defect.

Closure of the defect

After confirmation of negative margins by frozen section, it is our preference to close all defects to decrease complications of bleeding and minimize bowel symptoms postoperatively. This is performed robotically utilizing a barbed absorbable 2-0 suture (V-Loc™, Medtronic, Minneapolis, MN, USA). The defect is closed in a running fashion from two ends in a transverse fashion with overlapping of 2–3 stitches in the middle of the wound (Fig. 7). After final visual examination, the single-port robotic platform is undocked and the surgery is concluded.

Troubleshooting

Patient anatomy plays a large role in the success of SPR-TAMIS. One consideration is the distance of the rectal lesion from the anal canal. The working arms of the single-port robotic platform need 10 cm to fully deploy. If the lesion is very close to the anal canal, the robotic arms

Fig. 6 Full thickness distal to proximal dissection down to the perirectal fat. The defect can be examined after extraction of specimen

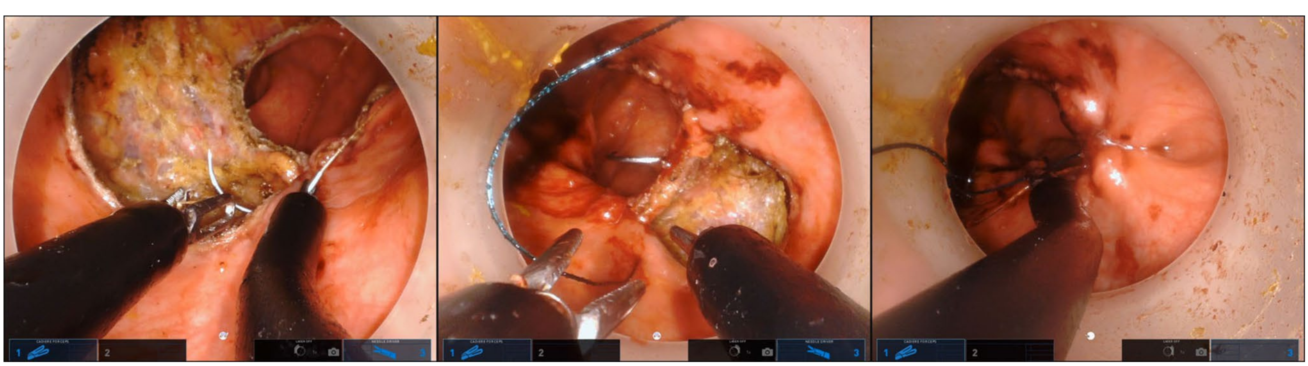

Fig. 7 Two rows of sutures to close the defect transversely

may not be able to fully deploy as the "elbows" of the arms are restricted from lateral motion within the GelPoint port. While the instrument tips will still function in this state, their degree of freedom is significantly limited. This is not an absolute contraindication for surgery. However, frequent adjustment of the docked robotic port may be necessary. Often the working instruments need to be swapped from left to right or vice versa to obtain a more favorable working angle.

Another area of technical difficulty with the SPR-TAMIS technique is the docking process. Because the single-port boom encompasses four separate motor units in one, it is considerably larger and heavier than the conventional robotic arms. This makes fine adjustments during docking very difficult. We recommend always having two people holding the robotic arm while making these adjustments to prevent sudden lateral movement. Because the operating table is not coupled to the robotic platform, sudden lateral displacement of the robotic trocar while being docked within the anal canal may theoretically cause sphincter injury.

Results

To date, we have successfully performed the SPR-TAMIS in five patients. The technical specifications and patient demographics of each case are listed in Table 1. The average area of lesion removed was 8.8 ± 7.9 cm^2, with the largest tumor encompassing an area of 22.6 cm^2. The largest lesion removed was 5.4 cm in longest dimension. The lowest lesion removed was 3 cm from the top of the anorectal ring while the highest lesion was 16 cm away. All lesions were tubulovillous adenomas with low-grade dysplasia except for one T1 invasive moderately differentiated adenocarcinoma. There was one readmission for rectal bleeding on post-operative day 9 that was self-limited and the patient was discharged the next day. All patients had a 2-week follow-up visit, and all reported normal bowel habits at that time.

Discussion

The SPR-TAMIS is the newest iteration of the TAMIS technique for low-risk rectal lesions. This paper helps to describe our experience and operative approach on the newest single-port robotic platform. While this platform has been tried in a variety of procedures in urology and otolaryngology, it has not been described for transanal surgery. To our knowledge, this is the first description of using this platform to perform the SPR-TAMIS.

The technical design of the single-port platform makes it a natural choice when working in the small confines of the rectum, especially for more proximal lesions. The robotic arms on the single-port platform gain full range of motion when fully deployed once inside the more capacious space inside the rectum. This is in contrast to previous robotic platforms where the more rigid arms have the most range of motion in the mid to distal rectum, as they are closer to the fulcrum of the trocar. The difference in design effectively expands the use of SPR-TAMIS to include lesions in the middle and proximal rectum.

Lesions located in the distal rectum may not be best suited for the single-port robotic platform when compared to standard R-TAMIS or laparoscopic TAMIS. As we described, 10 cm is needed to allow full deployment of the elbows. If lesions are low, there may not be enough working space for the single-port platform arms to deploy to their full extent. Although it is possible to perform the operation with the arms in straight configuration without elbow deployment, it can be very challenging and more time consuming compared to the conventional R-TAMIS.

The single-port trocar has the added benefit of protecting the anal sphincters from over-stretching. Conventional robotic arms have theoretical risks of creating excessive stretch on the anus if they perform too much lateral motion. But the stainless steel single-port robotic trocar inserts directly through the anal canal, and is fixed in size. This theoretically prevents the single-port robotic arms from exerting lateral forces on the anal sphincter muscles. The risk for sphincter injury is instead during the docking

Table 1 Patient demographics and measurements of rectal lesions

Patient	Age, years	Sex	Maximum length, cm	Area of specimen, cm^2	Distance from AR, cm	Final pathology	Surgical margins
#1	63	F	2.5	6.3	Mid rectal	TVA with LGD	Negative
#2	50	M	1.9	2.5	10	TVA with LGD	Negative
#3	66	M	2.5	5.3	3	T1	Negative
#4	51	F	5.4	22.7	Mid rectal	TVA with LGD	Negative
#5	59	M	2.8	7.6	16	TVA with LGD	Negative

AR anorectal ring, *TVA* tubulovillous adenoma, *LGD* low-grade dysplasia process at the beginning of the case, where it is important to ensure the trocar does not compress unevenly in the anal canal. We would also caution the surgeon to carefully observe the robotic arms animation on the console screen throughout the case. This is because the single-port robotic arms flare out when deployed and may apply undesired force on the rectum.

Conclusions

In our experience, the SPR-TAMIS is a safe and effective way of performing transanal excision or low-risk rectal lesions. It may be best suited for lesions located in the mid and proximal rectum, whereas the conventional R-TAMIS may be better suited for the low rectum. The SPR-TAMIS may also mitigate risk of sphincter injury due to the protective location of its single trocar. Although we view this technique favorably, general adoption will need future research to evaluate its long-term outcomes.

Author contributions SL: data analysis and interpretation; critical revision for intellectual content; final approval of the manuscript. SRK and KTB: study conception and design; critical revision for intellectual content; final approval of the manuscript.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval Local Internal Review Board (IRB) approval was obtained for this retrospective analysis and was deemed to be minimal risk.

Informed consent No informed consent was required.

References

1. Nash GM, Weiser MR, Guillem JG et al (2009) Long-term survival after transanal excision of T1 rectal cancer. Dis Colon Rectum 52(4):577–582. https://doi.org/10.1007/DCR.0b013e3181a0adbd
2. Anthony LB, Strosberg JR, Klimstra DS et al (2010) The NANETS consensus guidelines for the diagnosis and management of gastrointestinal neuroendocrine tumors (nets): well-differentiated nets of the distal colon and rectum. Pancreas 39(6):767–774. https://doi.org/10.1097/MPA.0b013e3181ec1261
3. Peeters KCMJ, van de Velde CJH, Leer JWH et al (2005) Late side effects of short-course preoperative radiotherapy combined with total mesorectal excision for rectal cancer: increased bowel dysfunction in irradiated patients-a Dutch colorectal cancer group study. J Clin Oncol Off J Am Soc Clin Oncol 23(25):6199–6206. https://doi.org/10.1200/JCO.2005.14.779
4. Buess G, Kipfmuller K, Hack D et al (1988) Technique of transanal endoscopic microsurgery. Surg Endosc 2:71–75
5. Allaix ME, Arezzo A, Caldart M et al (2009) Transanal endoscopic microsurgery for rectal neoplasms: experience of 300 consecutive cases. Dis Colon Rectum 52:1831–1836
6. Lim SB, Seo SI, Lee JL et al (2012) Feasibility of transanal minimally invasive surgery for mid-rectal lesions. Surg Endosc 26(11):3127–3132
7. Barendse RM, Doornebosch PG, Bemelman WA et al (2012) Transanal employment of single access ports is feasible for rectal surgery. Ann Surg 256(6):1030–1033
8. Tomassi MJ, Taller J, Yuhan R, Ruan JH, Klaristenfeld DD (2019) Robotic transanal minimally invasive surgery for the excision of rectal neoplasia: clinical experience with 58 consecutive patients. Dis Colon Rectum 62(3):279–285. https://doi.org/10.1097/DCR.0000000000001223
9. Liu S, Suzuki T, Murray BW et al (2019) Robotic transanal minimally invasive surgery (TAMIS) with the newest robotic surgical platform: a multi-institutional North American experience. Surg Endosc 33(2):543–548. https://doi.org/10.1007/s00464-018-6329-3
10. Marks J, Ng S, Mak T (2017) Robotic transanal surgery (RTAS) with utilization of a next-generation single-port system: a cadaveric feasibility study. Tech Coloproctol 21(7):541–545. https://doi.org/10.1007/s10151-017-1655-3