Technical Note/Original Article

Robotic Transanal Surgery

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Key Words
Transanl minmally invasive surgery; Transanal total mesorectal excision; Robotic surgery

Background. Rectal surgery is considered more technically challenging owing to its confinement in the small and narrow pelvis. Transanal surgery has been proposed as a solution to this bottleneck. However, surgical challenges remain when using present laparoscopic instruments. Robotic surgery has been developed to overcome the shortcomings of laparoscopic surgery. This paper presents our first experience in robotic transanal surgery which included transanal minimally invasive surgery (TAMIS) and transanal total mesorectal excision (TaTME).
Methods. Patients eligible for TAMIS included those having early rectal cancer T1 lesion with no evidence of lymphadenopathy and tumor size of less than 3 cm, or benign lesions which are not suitable for conventional transanal excisions. The selection criteria for patients receiving TaTME included low rectal lesions with no evidence of external sphincter or levator ani invasion, and body mass Index (BMI) $\leq$ 25 kg/m^2.
Results. Between March 2015 and October 2016, 27 patients who received robotic transanal surgery were enrolled in the present study. Fifteen patients underwent robotic TaTME for low rectal cancer, and 12 patients received robotic TAMIS for middle to low rectal lesions. For the TAMIS group, the mean operating time was 145 min (range: 60-210) and the mean postoperative hospital stay was 4.4 days (range: 1-10). For the TaTME group, the mean tumor distance between tumor and anal verge was 3.3 cm (range: 2.0-5.0) and the median operating time was 473 min (range: 335-569). Left ureteral transection was encountered in one patient intraoperatively, and another patient required reoperation for postoperative adhesive intestinal obstruction. There was no 30-day mortality.
Conclusions. Transanal approach offered a new concept and technique in rectal surgery for its better tumor radicality. However, this approach is relatively new and unfamiliar to colorectal surgeons. More acquaintance with surgical anatomy and carefully patient selection are keys to improveing the quality of transanal surgery and decreasing morbidity for inexperienced surgeons with this new and innovative operation.
[*J Soc Colon Rectal Surgeon (Taiwan) 2017;28:153-158*]

Rectal lesions located in the low rectum are surgically challenging and the surgical approach of choice remains controversial.[1] For benign neoplasm or early-stage rectal cancer confined within the surgical anal canal, traditional transanal full-thickness local excision (FTLE) under direct vision can be easily performed with satisfactory oncological and functional outcomes. Transanal endoscopic microsurgery (TEM) and transanal minimally invasive surgery (TAMIS), performed using laparoscopic instruments, have been

Received: December 30, 2016. Accepted: March 16, 2017.
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applied on patients unsuitable for transanal FTLE, performed using conventional Parks retractor or flexible endoscope.[2-5] For most malignances of advanced stage, radical surgical resection remains indispensable.[6] However, total mesorectal excision (TME) by conventional open or laparoscopic approach encounters surgical challenges, especially in patients that are male or with narrow pelvis, high body mass index (BMI), and bulky tumors. Thus transanal total mesorectal excision (TaTME) has been proposed as an alternative solution.[7-10] By using present laparoscopic instruments, this approach still suffers the disadvantages of operating through a single-site, and has its limitations in ergonomics and attendant learning curve. Robotic surgery has been developed to overcome the shortcomings of laparoscopic surgery.[11-14] Compared with laparoscopic surgery, the robotic surgical system has three-dimensional visualization, tremor-free movements, stable operating platform, and superior dexterity with greater degrees of freedom. This paper presents our first experience in robotic transanal surgery including both TAMIS and TaTME.

Materials and Methods

All procedures were performed by a single surgeon (KLJ). Written informed consent was obtained from all patients included in the study and all results were recorded in accordance with local data protection regulations. Patients eligible for TAMIS included those (i) with early rectal cancer T1 lesion but no evidence of lymphadenopathy detected by magnetic resonance imaging (MRI), (ii) having tumor fo size less than 3 cm, (iii) benign rectal lesions but unsuitable for transanal FTLE performed using conventional Parks retractor or flexible endoscope, (iv) aged above 75 years with comorbidity, and (v) having no synchronous lesion. The selection criteria for patients receiving TaTME included (i) lesions within 3-5 cm from the anal verge as determined by endoscopy and MRI, (ii) the absence of external sphincter or levator ani invasion, (iii) patients aged between 18 and 75 years, (iv) body mass Index (BMI) ≤ 25 kg/m^2, (v) American Society of Anesthesiology (ASA) class ≤ 2, and (vi) Eastern Cooperative Oncology Group (ECOG) performance score ≤ 2.

Surgical procedure for TAMIS

After general anesthesia, the patient was positioned in modified lithotomy position. The GelPOINT Path Transanal Access Platform (Applied Medical Inc, Rancho Santa Margarita, CA, USA) was inserted as the transanal access platform. Carbon dioxide was insufflated at a setting of 12 mmHg. The da Vinci Si or Xi robotic cart was docked from the left side of the operating table. The two operative trocars were sited at the base; and the endoscope trocar, at the apex of the GelPOINT device. The fenestrated bipolar grasper was introduced through arm 1 on the left; the monopolar curved scissors, through arm 3 on the right; and an upward-looking 30° endoscope, through arm 2. The circumferential margins of dissection were marked with cautery, and after full-thickness resection, the rectal defect was closed with 15 cm 3-0 V-Loc absorbable sutures.

Surgical procedure for TaTME

After general anesthesia, the patient was positioned in a modified lithotomy position. The da Vinci Si robotic cart was docked from the left side of the operating table. The port configuration followed that of TAMIS. Intersphincteric dissection was performed at the level of the dentate. After separating the mucosa and internal sphincter muscles from the external sphincter and puborectalis, the GelPOINT Path Transanal Access Platform was inserted. Carbon dioxide was insufflated at a setting of 12 mmHg. Upon completion of TME, the robotic arms were undocked and repositioned for the abdominal phase of the procedure. A 2.5-cm vertical paraumbilical incision was made and the Single-Site® port was introduced through the anterior abdominal wall. The robotic cart was then docked between the legs of the patient and carbon dioxide was insufflated with an intraabdominal pressure of 12 to 15 mmHg. The fenestrated bipolar forceps was inserted from the right curved cannula and the permanent cautery hook, from the left. An additional 8-mm robotic port was inserted into the right lower quadrant of the abdomen to accommodate another Endowrist® instrument. Steps performed subsequently included: (1) ligation of inferior mesenteric vessels, (2) radical proctectomy with TME to reach the perineal dissection, (3) transanal retrieval of specimen, and (4) straight coloanal hand-sewn anastomosis.

Results

Between March 2015 and October 2016, 27 patients who received robotic transanal surgery were enrolled in the present study. Twelve patients received robotic TAMIS for middle to low rectal lesion. The other 15 patients underwent robotic TaTME for low rectal cancer. The demographic characteristics of the patients are listed in Table 1. In the robotic TAMIS group, 5 patients had biopsy-proved adenocarcinoma, with one patient having T2 lesion but refusing radical surgery, two patients having T1 lesion, and two patients having rectal cancer showing clinical complete remission (cCR) after neoadjuvant chemoradiation therapy (NCRT). Moreover, two patients had neuroendocrine tumor, two patients had villotubular adenoma with wide base, one patient had intestinal endometriosis and another one had rectal ulcer which could not excluded malignancy. The mean age of patients was 57.3 years (range: 33-78). The mean distance between tumor and anal verge was 5.9 cm (range: 2.0-10.0). The mean operating time was 145 min (range: 60-210). The mean volume of blood loss was only 5 ml (range: 0-10). The mean postoperative hospital stay was 4.4 days (range: 1-10). There were no instances of morbidity or mortality.

In the robotic TaTME group, 13 patients had biopsy-proved adenocarcinoma; among them, 11 (84.6%) received NCRT. Two patients had broad-based tubulovillous adenomas measuring more than 3 cm. The patients' characteristics and clinical results are summarized in Table 2. The mean age of patients was 60.3 years (range: 44-75). The mean distance between tumor and anal verge was 3.3 cm (range: 2.0-5.0). The median operating time was 473 min (range: 335-569), and the estimated blood loss was 33 ml (range: 30-50). Left ureteral transection was encountered in one patient intraoperatively, and another patient required reoperation for postoperative adhesive intestinal obstruction. There was no 30-day mortality.

Discussions

With wide application of population screening for cancer, there has been increase in the detection of early-stage colorectal cancer (CRC). In 2013, approximately 40% of CRC detected in the United States was of early stage.[15] Traditionally, radical surgeryl with

Table 1. Demographic characteristics of patients undergoing robotic TAMIS

	Age	Sex	BMI	FAV	ASA	System	Histopathology	Op time	EBL	Hospital stay
Case 1	78	M	22.1	2	II	Si	Adenocarcinoma T2	120 min	min	10
Case 2	68	F	31.3	8	II	Si	Villotubular adenoma 3 cm	210 min	min	1
Case 3	73	F	17.9	3	II	Si	Rectal ulcer	205 min	min	7
Case 4	33	F	24.8	8	II	Si	NET	93 min	min	1
Case 5	45	F	18.0	10	II	Si	Endometriosis	140 min	min	1
Case 6	35	M	20.8	6	II	Si	NET	121 min	min	2
Case 7	50	M	23.5	7	I	Si	Tubular adenoma (high-grade dysplasia)	180 min	min	8
Case 8	65	F	28.3	6	II	Xi	Rectal cancer S/P CRT with cCR	190 min	min	5
Case 9	63	F	26.8	5	II	Xi	Rectal cancer S/P CRT with cCR	210 min	min	5
Case 10	66	M	22.5	6	II	Xi	Adenocarcinoma T1	107 min	min	2
Case 11	54	M	26.2	5	II	Xi	Adenocarcinoma T1	60 min	min	4
Case 12	58	M	30.1	5	II	Xi	Sclerosing lesion	105 min	min	7

BMI: body mass index; FAV: from anal verge; ASA: American Society of Anesthesiologists; EBL: estimated blood loss; NET: neuroendocrine tumor; CRT: chemoradiation therapy; cCR: clinical complete remission.

Table 2. Demographics and clinicopathologic results of patients after robotic TaTME

Characteristic	N = 15
Age (years)	60.3 (44-75)
Gebder (male:female)	7:8
Distance from anal verge (cm)	3.3 (2.0-5.0)
BMI (kg/m^2)	22.0
Histopathology	
Adenocarcinoma	13
Villotubular adenoma	2
Preoperative chemoradiation	
No	2
Yes	11
Estimated blood loss (mL)	33 (30-50)
Operation time (min)	473 (335-569)
Hospital staying (d)	12.2 (10-14)
Complications (%)	20
Distal resection margins (cm)	1.4 (0.4-3.5)
CRM (cm)	0.7 (0.2-2.6)
Number of lymph node retrieved	12 (8-18)

BMI: body mass index; CRM: circumferential resection margin.

TME was the standard treatment for low rectal cancer. However, radical surgery is associated with a high morbidity (30-68%), and the mortality approaches 7%. Significant complications including anastomotic leakage, sepsis, permanent or temporary stoma, perineal wound complications, and urinary, sexual and bowel dysfunction that may undermine quality of life.[16-18] To avoid worsened functional outcomes after radical surgery, FTLE is adopted as a curative option in the treatment of selected rectal cancers. So far, the selection criteria for FTLE include small (< 4 cm), low-lying tumors confined to the muscularis propria. Patients with adverse pathologic features (mucinous/signet-ring histology, or poor differentiation), or tumors occupy more than 40% of the rectum are at high risk for local recurrence, and FTLE is not recommended.[19,20]

In recent years, minimally invasive surgery has brought about great changes. The development of reduced-port, single-incision or even natural orifice transluminal endoscopic surgery revolutionized the concept of minimal incision or even incisionless surgery.[21-25] However, single-incision laparoscopic surgery performed using current laparoscopic instruments has never been widely applied because it violated the basic principle of minimally invasive surgery known as "triangular formation", which results in a collision between the scope and instruments. Robotic surgery has revolutionized the field of minimally invasive surgery. It has been developed to overcome the shortcomings of conventional laparoscopic surgery.[11-14] Today, almost two million robotic surgeries have been performed worldwide. Robot-assisted rectal surgery has become increasingly widespread due to its several advantages. In particular, most of these procedures are performed in the confines of the deep and narrow pelvis. The safety and efficacy of robotic rectal cancer surgery have been established and the intraluminal instrument articulation and dexterity offered by the EndoWrist enabled rectal lo be approached from any angle.

The standard potentially curative treatment of rectal cancer is TME. However, TME performed using conventional open or laparoscopic approach still encounters many surgical challenges, especially in male patients and those with narrow pelvis, high BMI, or bulky tumors.[16-18] Thus, transanal approach was proposed to solve these potential disadvantages.[7-10] The use of single-port laparoscopic platforms has been introduced by Lacy in 2010 for TaTME.[26] TaTME has potential benefits for better specimen quality with enhanced radicality, overcoming the difficulties in rectal transection and anastomosis frequently encountered in transabdominal approach, and higher sphincter-saving rate without compromising oncological outcomes.

In conclusion, rectal surgery is considered more technically challenging for its confinement in the small and narrow pelvis. In particular, for mid and low rectal tumors, it is more difficult to achieve a radical resection because of the limited workspace and visualization. Transanal approach offered a new concept and technique in rectal surgery for its high rate of CRM negativity, longer distal resection margins, and enhanced tumor radicality, which contribute to better oncological outcomes. However, this approach is relatively new and unfamiliar to colorectal surgeons. Better acquaintance with surgical anatomy to avoid injury of nerve and urethra or vagina, and careful patient selection are keys to improving the quality of transanal surgery and decreasing morbidity attributable to inexperience with this new surgical innovation.

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技術說明與原著

經肛門達文西機械手臂手術

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直腸手術由於骨盆腔空間狹小因而增加困難度，採用經肛門的方式可以改善手術難易，但目前現行的腹腔鏡器械行經肛門手術仍有活動限制，所以達文西機械手臂的靈活關節便提供良好的手術操控，進而達到完整切除病灶的目標，本篇的研究是分享單一醫療機構的經肛門達文西機械手臂手術成果。

關鍵詞 經肛門微創手術、經肛門全直腸系膜切除、達文西機械手臂手術。