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Comparison of early experience of robotic and transanal total mesorectal excision using propensity score matching

Wai Lun Law[1] · **Dominic C. C. Foo**[1]

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Abstract

Background Robotic surgery and transanal minimally invasive surgery are the two recently developed techniques, which can overcome the difficult pelvic dissection in conventional laparoscopy. This study aimed to compare the early cases of robotic and transanal total mesorectal excision (taTME) using propensity score matching.

Methods The first 40 cases of taTME and the first 80 sphincter-saving robotic total mesorectal resection for rectal cancer were selected from the prospectively collected database. Using propensity score matching, the outcomes of 40 matched cases of robotic TME were compared with the 40 cases of taTME.

Results Before matching, patients in the taTME group were significantly younger. The tumors were smaller but more distally located. Significantly more patients in the taTME group received preoperative chemoradiation. After matching, the two groups did not show any differences in gender, age, comorbidity, the level of tumors, and incidences of preoperative chemoradiation. The operating time was significantly shorter (254 vs. 170 min, $p < 0.05$) and the blood loss was less (50 vs. 150 ml, $p = 0.002$) in the taTME group. Conversion rate was 5% in both groups. There was no difference in the hospital stay, overall morbidity, the anastomotic leakage rate, and the urinary complication rate between the two groups. More patients in the taTME group did not require a separate abdominal incision. The distal margin, the number of lymph nodes examined, and the rate positive circumferential margin (0 vs. 5%, $p = 0.494$) were also similar between the two groups.

Conclusions Both taTME and robotic surgery can achieve favorable outcomes in the rectal cancer resection. Comparison of the early experience of the two procedures with propensity score matching showed the taTME was associated with a shorter operating time, less blood loss, and a higher rate of transanal extraction of the specimen. Further evaluation by randomized trials is warranted.

Keywords Robotic · Transanal · Total mesorectal excision

Since Heald published and advocated total mesorectal excision (TME) [1, 2] in the 1980s, the technique has become the gold standard surgical treatment for rectal cancer. In the era of minimally invasive surgery, laparoscopic rectal resection has been demonstrated to result in better short-term outcomes [3–5]. Nevertheless, there are limitations in conventional laparoscopic rectal surgery. The pelvic dissection, which is the most crucial part of rectal cancer surgery, is difficult particularly in an obese male patient with a bulky distal cancer. The results from two recently published randomized trials could not demonstrate that laparoscopic rectal surgery was not inferior to open surgery when the oncologic parameters including the circumferential and distal resection margins and TME completeness were considered [6, 7].

Robotic surgery and transanal surgery have been developed to overcome some of the limitations of conventional laparoscopic surgery for rectal cancer. The robotic system provides a stable platform with 3-dimension and magnified view as well as versatile instruments for dissection. These features are particularly useful in surgery in the deep pelvis, and robotic TME has demonstrated to yield favorable short-term results and oncologic outcomes [8–10]. The low conversion rate and better preservation of the bladder and sexual functions are also advantages of robotic rectal resection [8, 11].

✉ Wai Lun Law
lawwl@hku.hk

[1] Department of Surgery, Queen Mary Hospital, The University of Hong Kong, 102 Pokfulam Road, Pok Fu Lam, Hong Kong

Transanal TME (taTME) has been developed with the advent of transanal minimally invasive surgery [12]. It addresses the difficult distal pelvic dissection by approaching it from the anal side using a transanal platform. It provides better visualization and enables precise distal TME dissection, which is the most crucial part of the operation for a distal rectal cancer. Better delineation of the distal margin is also an advantage of taTME. Comparison of short-term outcomes with conventional laparoscopic resection showed encouraging results [13, 14]. However, there is only one comparison of taTME with robotic TME in the literature to date [15]. This study aimed to examine the outcomes of early cases of taTME with early cases of robotic rectal resection. To avoid bias in patient selection, we compared the two groups before and after propensity score matching.

Methods

In our center, minimally invasive surgery has become widely applied in rectal operation since 2000 and is currently the preferred surgical option for rectal cancer. Our robotic program started in 2008 after a prior experience of over 250 laparoscopic rectal resections. We began to perform transanal TME in 2014 in selected patients after participation in workshops and extensive experiments on cadavers.

From October 2014 to June 2017, 41 taTME operations were performed. One patient who underwent proctocolectomy and ileostomy for a mid-rectal cancer with long-standing colonic Crohn's disease was excluded in the analysis. In the controlled group, the first eighty patients who underwent robotic rectal resection with sphincter preservation were selected from the prospective database. Data on the patients' demographics, tumor characteristics, preoperative treatment, operating details, postoperative outcomes, and histology were analyzed. Comparisons between the two groups were made before and after propensity score matching.

Perioperative management

During the study period from 2008 to 2017, the perioperative management of patients with rectal cancer was similar and was described in our previous publications [5, 10, 16]. The majority of patients underwent preoperative staging with pelvic MRI and CT scans of the abdomen, pelvis, and thorax. PET CT scans were used selectively for those with obstructing cancer and in those with distant metastasis. All the patients were discussed in the multidisciplinary treatment meeting with the presence of radiologists and clinical oncologists to decide on the application of neoadjuvant therapy. Neoadjuvant chemoradiation was offered to patients when the mesorectal margin was at risk, which was defined as less than 1 mm by MRI. The chemoradiation regimen consisted of long-course radiation with 4500–5400 cGy in 5–6 weeks with synchronous chemotherapy. Neoadjuvant chemoradiation was also recommended for patients who were destined to have an abdominoperineal resection or ultralow cancer requiring hand-sewn coloanal anastomosis, with or without intersphincteric resection. An enhanced recovery pathway, aiming at early mobilization, early feeding, and good pain control, was used in the postoperative period.

Operating techniques

The operating details of robotic resection for rectal cancer were described in our previous publications [10, 17]. The surgery was performed with the Da Vinci S robotic system (Intuitive Surgical, USA). A hybrid approach with left colon mobilization and division of inferior mesenteric vessels was adopted in most of the cases. The Da Vinci robot was docked beside the left lower limb, and rectal dissection was performed with the four robotic arms down to the pelvic floor. The rectum was transected with the endoscopic staplers, which were inserted through the right lower quadrant port. In case of distal cancer, transanal transection, with intersphincteric resection if necessary, and coloanal anastomosis were performed.

The techniques of the transanal TME were also described in our previous publication [18]. The method evolved during the learning period. A two-team approach was used throughout the study period. After the first 10 cases using single-incision surgery in the abdominal part, a conventional multi-port approach was used in the subsequent patients as we did not find significant benefit in single-incision surgery. Regarding the taTME, after the initial few cases, a GelPoint Path (Applied Medical, USA) was used as the preferred transanal access platform. The AirSeal (SurgiQuest, USA) was used when it was available. The purse-string was applied either transanally in case of a low tumor or through the transanal platform when the tumor was more than 2 cm from the dentate line. The dissection was performed mostly with monopolar coagulation following the mesorectal plane until the peritoneal cavity was entered. The specimen was retrieved through the anus in most cases. However, an abdominal incision was made if the specimen was too bulky for transanal extraction. A single-stapling anastomosis was constructed whenever possible with the application of a purse-string suture over the transected rectal stump. Otherwise, a hand-sewn anastomosis was performed for those with a very distal transection with or without intersphincteric resection.

Data collection and statistics

All data were prospectively collected in a database for rectal cancer, which was started in 1993 in our department. The demographic data, operative findings, postoperative outcome, and pathology details were collected prospectively. Operative mortality was defined as death that occurred within 30 days following the primary operation. Postoperative morbidities were defined as complications that contributed to a prolonged hospital stay or led to additional surgical procedures or radiological inventions.

To reduce the bias due to non-randomization nature of patient selection, we conducted a propensity score matching model. A logistic regression model was performed to estimate the propensity score of each patient using the covariates including the sex, age, level of the tumor, American Society of Anesthesiology (ASA) status, and preoperative chemoradiation. A nearest neighboring matching method was used to identify the best robotic patient for each individual taTME patient. A one-to-one matching was performed to select a matched group of 40 patients with robotic surgery. Comparisons of the variables were performed before and after propensity score matching.

The comparison of categorical variables was made with Chi-square test or Fisher's exact test when appropriate. Non-parametric variables are presented as median values and ranges. These variables were compared using the Mann–Whitney U test. *p* values less than 0.05 were considered statistically significant. All the analysis was performed with IBM SPSS Statistic version 24 (IBM, Endicott, New York, USA).

The study was approved by the Institution Review Board of The University of Hong Kong/Hospital Authority Hong Kong West Cluster. (IRB reference no: UW-17-529).

Results

Forty consecutive patients who underwent taTME with sphincter preservation from August 2014 to Jun 2017 were included in this study. The initial consecutive 80 cases of low anterior resection performed by the robotic system were included for comparison so that the early experience of the two procedures could be compared. All the patients had histologically proven adenocarcinoma of the rectum and the management strategy was decided at the multidisciplinary treatment meeting. The comparison of the two groups before propensity score matching is shown in Table 1.

When the early consecutive cases were compared before propensity score matching, in the transanal TME group the patients were significantly younger, the level of tumor was lower, and more patients (67.5%) underwent neoadjuvant chemoradiation.

Table 1 Comparison of robotic and taTME before propensity score matching

	taTME $N=40$	Robotic TME $N=80$	*p* values
Gender (male:female)	29:11	50:30	0.276
Median age[a]	64.5 (40–79)	69.5 (45–88)	0.013
ASA status (I:II:III)	11:52:17	6:27:7	0.886
Comorbid medical conditions	20	42	0.796
Conversion	2	2	1.000
Previous abdominal surgery	10	16	0.531
Operating time (min)[a]	254 (177–462)	269 (170–564)	0.136
Blood loss (ml)[a]	50 (10-1000)	100 (10-2500)	0.004
Complications	5	17	0.243
Reoperation	0	4	0.150
Median hospital stay (days)[a]	6 (4–22)	6 (3–64)	0.476
Preoperative chemoradiation	27	22	<0.005
Stage of disease			0.067
0	3	2	
1	18	19	
2	8	24	
3	8	29	
4	3	6	
Complications	5	17	0.320
Anastomotic leak	2	4	1.000
Postoperative mortality	0	1	0.478
Urinary complication	1	5	0.374
Stapled anastomosis	31	74	0.037
No abdominal incision	33	15	<0.005
Level of anastomosis (mm)[a]	30 (10–60)	40 (10–80)	<0.005
Level of tumor (mm)[a]	50 (20–100)	70 (20–150)	<0.005
Size of tumor (mm)[a]	25 (0–60)	35 (0–90)	<0.005
Distal margin (mm)[a]	20 (5–50)	35 (5–80)	<0.005
Number of LN examined	13 (3–26)	14.5 (5–62)	0.290
Positive circumferential margin	0	5	0.168

taTME transanal total mesorectal excision, *ASA* American Society of Anesthesiologists physical status score, *LN* lymph nodes

[a]Values are in median (range)

Regarding the operative findings, there was no difference in the operating time between the two groups, but the blood loss was significantly lower in the taTME group. Two patients required conversion in each group. In the taTME group, one conversion was because of significant adhesions in the peritoneal cavity, and the other was due to inadequate perfusion to the descending colon, and a total colectomy with ascending colon rectal anastomosis was performed subsequently. The transanal dissection was successful in

both cases. In the robotic group, one conversion was due to pelvic bleeding, and the other was due to the inability to insert the transverse stapler to transect the rectum. The level of anastomosis was lower in the taTME group (3 cm from the anal verge), and more patients underwent a hand-sewn anastomosis (22.5 vs. 7.5%, $p = 0.037$).

There was no difference between the complication rate, reoperation rate, and length of hospital stay between the two groups. The distal margin was significantly shorter in the transanal group; however, no patient had a positive distal margin. There was no difference in the stage of the disease, the number of lymph node harvested between the two groups. There was no positive circumferential margin in the transanal group, while the rate of positive CRM in the robotic group was 6.5%; however, this did not show any statistical difference.

Comparison of the patients after propensity score matching is shown in Table 2. The demographic data including the age, gender, premorbid medical conditions, and the incidence of previous surgery were similar in the two groups after matching. The tumor level and the rate of neoadjuvant chemoradiation did not show any difference.

Regarding the operative findings, the operating time was significantly shorter (254 vs. 270 min, $p = 0.05$) and the blood loss was also significantly less in the taTME group (50 vs. 150 ml, $p = 0.002$). The level of anastomosis was similar in the two groups at 3 cm from the anal verge ($p = 0.107$). Stapled anastomosis was performed in similar incidences in the two groups, although the majority of stapled anastomoses in the transanal group were fashioned with single-stapling technique, while in the robotic group the anastomoses were mostly fashioned with the double-stapling method. Moreover, more patients in the taTME group had transanal extraction of specimen and did not require an abdominal incision (82.5 vs. 30%, $p < 0.05$).

There were no differences in the postoperative complications, hospital stay, and reoperation rate between the two groups. The incidences of anastomotic leak and urinary complication were also similar in the two groups.

Regarding the oncologic findings, there was no difference in the stage of the diseases. The number of lymph node harvest, the incidence of positive circumferential margin, and the distal margin were similar between the two groups. The quality of TME specimens did not show any difference between the two groups.

Table 2 Comparison of robotic and transanal TME after propensity score matching

	TaTME $N = 40$	Robotic $N = 40$	p values
Gender (male:female)	29:11	26:14	0.630
Median age[a]	64.5 (40–79)	61.5 (45–84)	0.817
ASA status (I:II:III)	11:52:17	8:26:6	0.828
Comorbid medical conditions	20	17	0.654
Conversion	2	2	1.000
Previous abdominal surgery	10	6	0.402
Operating time (min)[a]	254 (177–462)	270 (199–564)	0.050
Blood loss (ml)[a]	50 (10–1000)	150 (10–2500)	0.002
Complications	5	7	0.757
Reoperation	0	2	0.494
Median hospital stay (days)[a]	6 (4–22)	6 (3–47)	0.228
Preoperative chemoradiation	27	22	0.360
Stage of disease			0.777
0	3	2	
1	18	16	
2	8	7	
3	8	13	
4	3	2	
Complications (total)	5	7	0.755
Clavien I and II	4	5	
Clavien III and IV	1	2	
Anastomotic leak	2	2	1.000
Postoperative mortality	0	1	0.478
Urinary complication	1	1	1.000
Stapled anastomosis	31	34	0.568
No abdominal incision	33	12	< 0.005
Level of anastomosis (mm)[a]	30 (10–60)	30 (10–50)	0.107
Level of tumor (mm)[a]	50 (20–100)	60 (20–100)	0.221
Size of tumor (mm)[a]	25 (0–60)	30 (0–60)	0.031
Distal margin (mm)[a]	20 (5–50)	20 (5–60)	0.116
Number of LN examined	13 (3–26)	13 (5–21)	0.918
Positive circumferential margin	0	2	0.494

taTME transanal total mesorectal excision, *ASA* American Society of Anesthesiologists physical status score, *LN* lymph nodes

[a]Values are in median (range)

Discussion

Robotic surgery and taTME are the two approaches developed to overcome some of the limitations of conventional laparoscopic rectal resection. There have been studies comparing robotic and laparoscopic TME [8–10, 19, 20] as well comparing transanal and laparoscopic TME [14]. However, to our knowledge, there is only one study comparing robotic and transanal TME [15].

The current study attempted to compare the early experience of the two approaches for rectal cancer. In our center, robotic rectal resection was initially performed in 2008 after over 250 cases of laparoscopic resections. Transanal TME

was developed recently, and the first case was performed in 2014 after over 500 laparoscopic resections and after 180 robotic resections for rectal cancer. Thus, both procedures were started after an adequate experience of conventional laparoscopic resection. The perioperative management strategies regarding the preoperative imaging, multidisciplinary meeting, and postoperative management by enhanced recovery pathway were similar in the patients in the two groups.

The comparison of the two groups before the propensity score matching showed the difference in selection of patients for the two procedures in the early experience. Patients in the taTME group had more distal cancer and more likely had neoadjuvant chemoradiation. Because of the more distally located cancer, more patients in the taTME group required hand-sewn anastomosis. The conversion rate was 5% in the transanal group, while that in the robotic group was 2.5%. These findings showed that the conversion rates of both procedures were low even in the learning phase of the two approaches. Conversion due to difficult pelvic dissection occurred only in one patient with robotic dissection. In the other three conversions, the pelvic dissection could be successfully performed. We reported a conversion rate of 15% in our first 100 laparoscopic rectal resection [21] and most randomized trials reported conversion rates of over 10% [6, 22, 23]. The difficulty in pelvic dissection, especially for distal cancer, is the usual reason for conversion. This study has demonstrated that both transanal TME and robotic TME could facilitate the pelvic dissection and reduce the conversion rate. The advantage of robotic surgery in reducing conversion has been widely reported in case series and meta-analysis. In the reports on transanal TME, the conversion rate is also very low. In the recently published registry of 720 patients with transanal TME, the perineal conversion rate was only 2.8% [24]. Thus, both procedures can overcome the difficulty of conventional laparoscopy in pelvic dissection and reduce the conversion due to operation in the deep narrow pelvis.

Regarding the operating details, there were no differences in the operating time in the consecutive series. However, after propensity score matching, the operating time for transanal TME was significantly shorter than robotic surgery. In the initial learning phase of robotic surgery, the placement of the ports and docking of the Da Vinci robot require a learning period to achieve a smooth procedure. In taTME, the two-team approach has been reported to shorten the operative time. In some comparative studies, the reported operating time in taTME was shorter than that of conventional laparoscopy [14].

Robotic surgery uses a similar approach as conventional laparoscopy regarding rectal transection and anastomosis. In most cases, the transection of the rectum is performed using endoscopic staplers, and a double-stapled anastomosis is created. The accurate identification of the distal margin and the application of the endoscopically at a right angle to the rectum can be challenging in a narrow pelvis. Moreover, more than one staple firing is usually needed. It has been demonstrated that more than two staple firings were associated with a higher leakage rate [25]. In taTME, the distal transection margin can be accurately defined, and a single-stapled anastomosis can be performed. This can avoid transecting the rectum with multiple staple firings. Further studies are required to show whether this can reduce the anastomotic leakage rate. Moreover, in most cases of taTME, the specimen can be extracted transanally, which is an example of natural orifice specimen extraction (NOSE). In our series, transanal extraction of the specimen was possible in 78% of patients in the taTME group and 30% of patients in the robotic group after matching. NOSE has been reported to be a feasible and promising technique in minimally invasive colorectal surgery and was shown to be associated with less pain, analgesic requirement, and other incision-associated morbidities [26–28].

The most important parameters to assess the quality of rectal cancer surgery are the TME quality and the circumferential margin. In the current study, there was no positive circumferential margin in the taTME group, while the CRM positive rate was 6.3 and 5.0% in the robotic group before and after matching, respectively. There was no statistical difference between the two groups. The positive CRM in the robotic group was similar to other studies [9, 19, 29]. In most of the studies, no difference in positive CRM could be demonstrated when compared to conventional laparoscopic rectal resection. In taTME, the difficult part of the dissection in the distal rectum is aided by the better optics and pneumodissection to allow precise dissection of the presacral plane and the rectoprostatic plane or rectovaginal plane to ensure good a TME specimen. In the International Registry, the positive circumferential margin rate was only 2.4% [24].

Admittedly, there are limitations in this study. This was not a randomized trial and bias in the selection of patients for each minimally invasive procedure was unavoidable. This is shown in the differences in the patient and tumor characteristics before matching. With the use of the propensity score matching, we attempted to eliminate the bias in patient selection. The patients selected were in the early cases in the learning curve, and the surgical techniques might not be standardized. However, it is our objective to comparing the early cases of the two approaches. In fact, with the experience in conventional laparoscopy, the two approaches were picked up quickly, without any significant morbidities.

Conclusion

This study showed that both robotic and taTME could achieve a safe rectal resection.

Successful precise pelvic dissection following the principle of TME with a low conversion rate is possible with the two approaches. In the matched patients in the early experience, there were no differences in the complications, hospital stay, and the rates of positive circumferential margin between the approaches. With the two-team approach, taTME was associated with a shorter operating time and less blood loss. Our results showed that similar outcomes could be achieved without the use of the expensive robotic system. Further studies, preferably with randomized controlled trials, to compare these two procedures for rectal cancer are certainly warranted.

Compliance with ethical standards

Disclosure Professor Wai Lun Law and Dr. Dominic C. C. Foo have no conflicts of interest or financial ties to disclose.

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