Obesity and narrow pelvis prolong the operative time in conventional laparoscopic rectal cancer surgery, but not in a two-team transanal total mesorectal excision approach

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Title: Obesity and narrow pelvis prolong the operative time in conventional laparoscopic rectal cancer surgery, but not in a two-team TaTME approach.

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Abstract

Purpose*:* Narrow pelvis, tumor diameter, and obesity have been reported as clinical variables correlated with the difficulty of conventional laparoscopic low anterior resection (Lap-LAR). A two-team transanal total mesorectal excision (TaTME) approach where the transabdominal- and TaTME are performed simultaneously might reduce the difficulty associated with these factors. This study aimed to clarify the factors associated with the longer time required for TME (TME time) in conventional Lap-LAR and a two-team approach for TaTME.

Methods*:* We analyzed 52 patients with rectal carcinoma treated with Lap-LAR and 35 patients treated with TaTME. We performed simple linear regression analysis to assess the association between TME time and bony pelvic size using 3D pelvimetry, longest tumor diameter, and body mass index (BMI).

Results*:* Linear regression analysis demonstrated a highly significant association between TME time and obstetric conjugate (R^2=0.098, P=0.024) and BMI (R^2=0.307, P<0.001) in the Lap-LAR group, while no significant association was observed in the TaTME group. Male patients, who had a narrower bony pelvis and higher BMI than female patients, had longer TME time than female patients in the Lap-LAR group (213 min vs. 172 min, P=0.021), while the TME time of male and female patients did not differ in the TaTME group (122 min vs. 108 min, P=0.451). The TME time in the TaTME group was significantly shorter than that in the Lap-LAR group (121 min vs. 197 min, P<0.001).

***Conclusion**:* A two-team TaTME approach provided a shorter TME time compared to conventional Lap-LAR, regardless of pelvic size and BMI.

Keywords: transanal total mesorectal excision (TaTME), two-team approach, rectal cancer

Statements and Declarations

Drs. Hiroshi Hasegawa, Takeru Matsuda, Kimihiro Yamashita, Ryuichiro Sawada, Hitoshi Harada, Naoki Urakawa, Hironobu Goto, Shingo Kanaji, Taro Oshikiri, and Yoshihiro Kakeji have no conflicts of interest or financial ties to disclose.

Introduction

If an approach can reduce the difficulty of surgery, this approach may not only reduce the operative time but also improve the short-term and long-term postoperative outcomes. In 2008 Targarona et al. reported that narrow pelvis, high body mass index (BMI), male sex, and longer tumor diameter are the clinical variables associated with a difficult laparoscopic rectal resection and incomplete total mesorectal excision (TME) or positive distal and circumferential resection margins [1]. Although laparoscopic resection for rectal cancer is widely accepted in many countries, laparoscopic resection might still have technical difficulties due to limitations of the articulation of laparoscopic devices, surgical instruments, and limited visual field [2-4]. A recent meta-analysis showed that the complete TME rate of the laparoscopic approach was lower than that of the open approach [5]. Recently, a laparoscopic transanal approach was introduced as transanal TME (TaTME), which was proposed as an alternative to overcome the technical difficulties of conventional laparoscopic rectal resection [6].

In a two-team approach, both the abdominal and transanal teams perform rectal resection simultaneously until the sigmoid colon and rectum are completely free [7,8]. It seems reasonable that the two-team approach would shorten the operative time, but it is unclear whether the approach has overcome the various difficulties such as narrow pelvis, high BMI, male, and longer tumor diameter.

In this study, we aimed to clarify factors associated with the longer time required for TME (TME time) in conventional laparoscopic low anterior resection (Lap-LAR) and a two-team approach for

TaTME. Since the operations other than performing TME are almost the same for the two approaches, we considered the TME time to be comparable. We would like to show what kind of patients would benefit from the two-team approach.

Materials and Methods

Patients

This retrospective study analyzed patients with mid- to low rectal cancer who were treated with Lap-LAR or a two-team approach for TaTME at Kobe University Hospital between October 2015 and February 2021. The definition of low anterior resection was that the anastomotic site was below the peritoneal reflection and that the anastomotic technique was a double-stapling technique in conventional Lap-LAR and a single-stapling technique in TaTME. We introduced Lap-LAR to our hospital in March 2001. As described in a previous report [9], we introduced TaTME for laparoscopic abdominoperineal resection (APR) in 2016. A two-team TaTME approach for APR has been employed since 2017. We then introduced TaTME for low anterior resection in a two-team setting in February 2018 and gradually expanded its adaptation. All surgeries were performed by certified surgeons of the Endoscopic Surgical Skill Qualification System (ESSQS) of the Japan Society for Endoscopic Surgery or trainee surgeons under the guidance of certified surgeons. All perineal procedures in the TaTME group were performed by a single surgeon (T.M.), who had the ESSQS certification.

The diagnosis of rectal carcinoma was performed using the eighth edition of the Union for International Cancer Control tumor-node-metastasis classification of malignant tumors [10]. The longest tumor diameter was obtained for the resected specimen. If a tumor was excised by colonoscopy before surgery or was unmeasurable after neoadjuvant therapy, we defined the diameter as 0.

Patients who were treated with concomitant resection of other organs, such as the urinary bladder and uterus were excluded. The Lap-LAR group included 52 consecutive patients with rectal carcinoma treated with Lap-LAR between October 2015 and March 2020. The TaTME group included 35 consecutive patients with rectal carcinoma treated with TaTME in a two-team setting between February 2018 and February 2021. This study was approved by the institutional ethics board of Kobe University Hospital (registry number.: B210035).

3D pelvimetry

All computed tomography (CT) examinations were performed using a 192-slice dual-source CT system (SOMATOM Force; Siemens, Erlangen, Germany). Three-dimensional (3D) CT was produced using the volume-rendering algorithm on a workstation (Ziostation2 version 2.4.2.3; Amin, Tokyo, Japan). The bony structure of the pelvis was 3D modeled to measure the obstetric conjugate and transverse diameter (farthest distance between the iliopectineal lines) (Figure 1).

Surgical technique

Lap-LAR was performed as previously described [11]. The rectum was divided using a linear stapler and a double-stapling technique was used for anastomosis.

TaTME was performed as previously described [12,13]. The transanal part of the procedure was initiated with the identification of the dentate line using a self-retaining anal retractor (Lone Star, CooperSurgical; Trumbull, CT, USA). The transabdominal part of the procedure was started using the same procedure as conventional Lap-LAR with 10 mmHg pneumoperitoneum. Both the abdominal and transanal teams started the procedure at the same time and performed TME simultaneously until the sigmoid colon and rectum were completely free. A single-stapling technique was used for anastomosis.

Lateral pelvic lymph node dissection (LLND) [14], mobilization of the splenic flexure, and construction of the ileostomy were performed as needed by the abdominal team.

Definition of time required for TME

The time required for TME (TME time) was defined as the time between the pneumoperitoneum and transection of the rectum by a linear stapler in Lap-LAR and as the time between the pneumoperitoneum by the abdominal team and the completion of TME in which the rectum and sigmoid were completely free in TaTME. After TME, we performed almost the same procedure, including LLND, mobilization of the splenic flexure, construction of ileostomy, and closure of the abdominal wall, in spite of the different anastomotic techniques, in both Lap-LAR and TaTME.

Statistical analysis

For statistical analysis, we used JMP version 10 (SAS Institute Inc., Cary, NC, USA).

Categorical variables were compared using the chi-square test. Non-parametric variables were compared using the Wilcoxon-Mann–Whitney test. A simple linear regression analysis was used to estimate the relationship between the time required for TME and clinical variables. A P-value less than 0.05 ($P < 0.05$) was considered statistically significant.

Results

Patient characteristics

The patient characteristics are shown in Table 1. Fifty-two patients underwent Lap-LAR and 35 patients underwent TaTME. For four patients in the Lap-LAR group and 12 patients in the TaTME group, neoadjuvant chemoradiotherapy (50.4 Gy/28 fractions and concurrent-oral capecitabine) was introduced. Neoadjuvant chemotherapy (FOLFOXIRI/bevacizumab) was administered to five patients in the TaTME group. For one patient in the TaTME group, conversion surgery was performed after chemotherapy (FOLFOX/bevacizumab). The rate of treatment before surgery was significantly higher in the TaTME group than in the Lap-LAR group (51.4% vs. 7.7%, $P<0.001$).

Patient operative outcomes, postoperative complications, and pathological findings

The patient operative outcomes, postoperative complications, and pathological findings are outlined in Table 2. The rates of LLND, mobilization of the splenic flexure, and construction of diverting ileostomy were significantly higher in the TaTME group than in the Lap-LAR group (31.4% vs. 5.8%, P=0.001, 25.7% vs. 9.6%, P=0.047, and 94.3% vs. 30.8%, P<0.001, respectively). Although the total operative time did not significantly differ between the groups (P=0.101), TME time was significantly shorter in the TaTME group than in the Lap-LAR group (121 min vs. 197 min, P<0.001).

While the rates of anastomotic leakage did not significantly differ between the groups (P=0.718), postoperative bowel obstruction was significantly higher in the TaTME group than in the Lap-LAR group (23.0% vs. 0%, P<0.001).

The circumferential resection margin positive rate was 0% in the TaTME group and 3.8% in the Lap-LAR group, with no statistically significant difference (P=0.148).

Factors associated with longer TME time

The results of the simple linear regression analysis are presented in Figure 2. While TME time was significantly associated with obstetric conjugate (R^2=0.098, P=0.024) and BMI (R^2=0.307, P<0.001) in the Lap-LAR group, there was no significant association in the TaTME group.

Comparison of time required for TME in male and female patients

Male patients had a narrower bony pelvis and higher BMI than female patients (Table 3). We compared TME time between men and women in both the Lap-LAR and TaTME groups. While TME time in male patients in the Lap-LAR group was significantly longer than that in female patients (P=0.021), there was no significant difference between men and women in the TaTME group (Figure 3).

Discussion

As a result of randomized controlled clinical trials that show laparoscopic surgery has comparable long-term outcomes to open surgery in rectal cancer treatment [15], laparoscopic surgery is widely accepted as a standard approach in many countries. The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database showed that the laparoscopic approach for rectal cancer resection gradually increased each year from 9.8% in 2005 to 52.8% in 2016 [2]. Similarly, the Japanese National Clinical Database showed that the laparoscopic approach for low anterior resection also gradually increased each year from 29.5% in 2011 to 62.6% in 2017 [3].

However, laparoscopic resection still has technical difficulties. Narrow pelvis, longer tumor diameter, and higher BMI have been reported as clinical variables correlated with the difficulty of Lap-LAR [1,16]. In this study, the TME time was significantly associated with narrow pelvis and BMI in the Lap-LAR group. In our institute, Lap-LAR was introduced in 2001 and is a well-established procedure in our hospital. All surgeries were performed by certified surgeons of the ESSQS of the Japan Society for Endoscopic Surgery or trainee surgeons under the guidance of certified surgeons [17]. Therefore, surgical difficulties of laparoscopic surgery caused by a narrow pelvis and obesity might persist even in an environment where laparoscopic surgical procedures are mature.

Obstetric conjugate and transverse diameter are well-established parameters of the bony pelvis for predicting dystocia in labor [18] and are sometimes applied to the narrow pelvis in rectal cancer resection [4,16]. We showed that the shorter obstetric conjugate (the distance between the pubic bone and the promontory angle) was significantly associated with longer TME time in Lap-LAR. This result is consistent with the clinical feeling of colorectal surgeons who find anterior rectal wall manipulation most difficult in trans abdominal laparoscopic approach.

To overcome the technical difficulties of Lap-LAR, robotic-assisted surgery and TaTME have been proposed. Both new surgeries still have limited long-term outcome data [15] and require more surgical resources compared to Lap-LAR. In particular, two-team approach for TaTME requires a double surgical team and more laparoscopic devices than conventional Lap-LAR. Therefore, it is necessary to clarify why and how TaTME decreases surgical difficulties in Lap-LAR. In our study, TME time was not associated with obstetric conjugates in the TaTME group. Linear regression analysis showed that the inclination of the approximate straight line of BMI in TaTME was smaller than that in Lap-LAR. These results indicate that a two-team approach for TaTME reduces surgical difficulties caused by a narrow pelvis and obesity. Moreover, this reduction in surgical difficulties may provide a stable TME time.

It is well known that significant differences in the pelvic structure exist in men and women [4]. In this study, male patients had a narrower pelvis and higher BMI than female patients. Consequently, there was no significant difference in the TME time between male and female patients in the TaTME group. This result indicates that TaTME is particularly useful for male patients with rectal cancer.

Compared to the Lap-LAR group, the TME time in the TaTME group was about 70 minutes shorter, but the total operative time was about 20 minutes shorter. This may be due to the higher frequency of lateral pelvic lymph node dissection, mobilization of the splenic flexure, and construction of ileostomy in the TaTME group. The rate of postoperative bowel obstruction was significantly higher in the TaTME group, and the majority of bowel obstructions were due to stoma outlet obstruction. To prevent peritonitis due to anastomotic leakage, almost all patients (94.3%) in the TaTME group underwent ileostomy construction. How to reduce ileostomy and prevent anastomotic leakage in TaTME is an important problem to be overcome.

This study has some limitations. First, this study was not a randomized study and might have included patient selection bias. The rate of neoadjuvant treatment and additional operative procedures was higher in the TaTME group than in the Lap-LAR group. This indicates that more advanced tumor patients were included in the TaTME group, which may have affected the surgical outcomes. However, because the most important aim of this study was to clarify factors associated with longer TME time in Lap-LAR and TaTME, we selected this study design. Second, we did not analyze the learning curve effects of the TaTME group. While the surgical procedure of Lap-LAR was well matured, that of TaTME in this study might be immature. This indicates that better outcomes of TaTME might be obtained after maturation of the surgical technique of TaTME.

In conclusion, our findings suggest that the two-team approach for TaTME provides a shorter and more stable TME time compared to conventional Lap-LAR, regardless of pelvic size and BMI. Male patients who have narrow pelvis and high BMI would benefit from the two-team approach.

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Figure legends

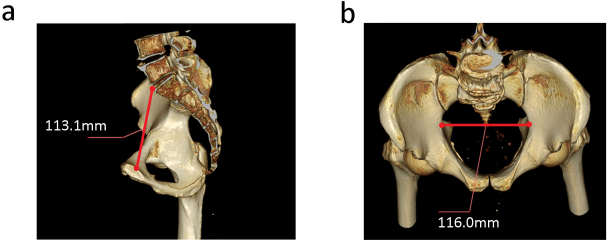
Figure 1. Pelvic inlet measurements. a) Obstetric conjugate. b) Transverse diameter.

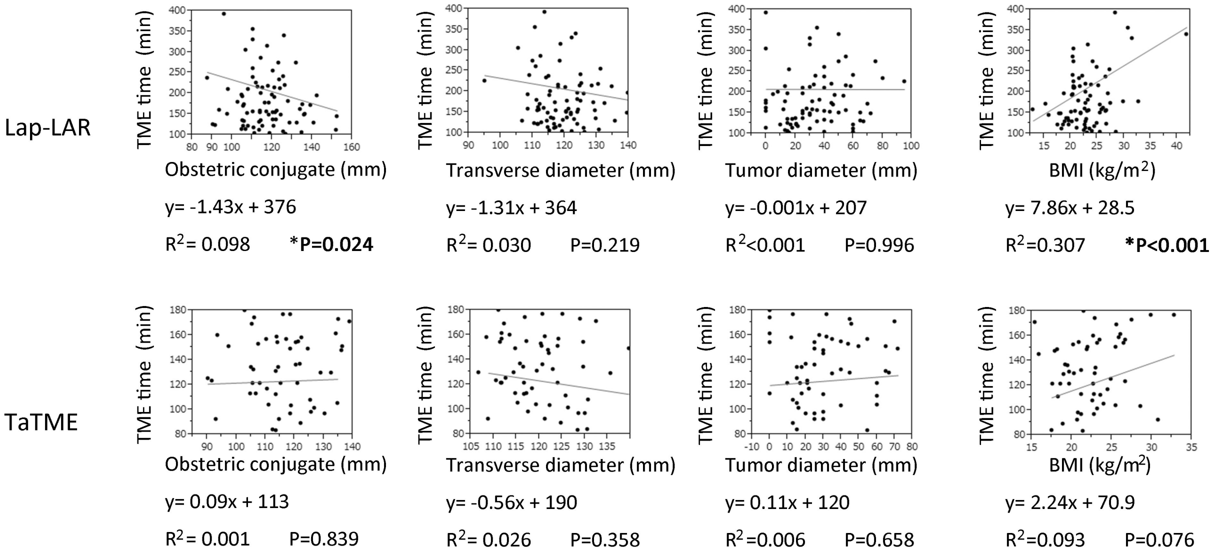
Figure 2. Simple linear regression analyses performed to assess the association between TME time and clinical factors. *P<0.05

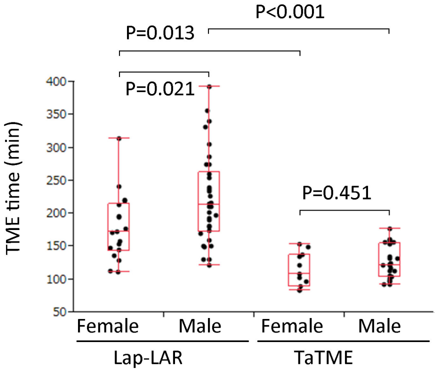
BMI body mass index, *Lap-LAR* laparoscopic low anterior resection, *TaTME* transanal TME, *TME* total mesorectal excision, *TME time* time required for TME

Figure 3. Comparison of TME time between male patients and female patients.

Lap-LAR laparoscopic low anterior resection, *TaTME* transanal TME, *TME time* time required for TME


a
113.1mm
b
116.0mm


Lap-LAR
TaTME
TME time (min)
Obstetric conjugate (mm)
y= -1.43x + 376
R2= 0.098 *P=0.024
Transverse diameter (mm)
y= -1.31x + 364
R2= 0.030 P=0.219
Tumor diameter (mm)
y= -0.001x + 207
R2<0.001 P=0.996
BMI (kg/m2)
y= 7.86x + 28.5
R2=0.307 *P<0.001
Obstetric conjugate (mm)
y= 0.09x + 113
R2= 0.001 P=0.839
Transverse diameter (mm)
y= -0.56x + 190
R2= 0.026 P=0.358
Tumor diameter (mm)
y= 0.11x + 120
R2=0.006 P=0.658
BMI (kg/m2)
y= 2.24x + 70.9
R2=0.093 P=0.076



P<0.001
P=0.013
P=0.021
P=0.451
TME time (min)
400
350
300
250
200
150
100
50
Female
Male
Female
Male
Lap-LAR
TaTME

Table 1. Patients and tumor characteristics

	Lap-LAR (n=52)		TaTME (n=35)		P
Age, median (range)	68	(40-96)	64	(34-85)	0.668
Female sex, n (%)	18	(34.6)	11	(31.4)	0.757
BMI (kg/m^2), median (range)	22	(13-41.8)	23	(17.5-32.8)	0.333
Bony pelvic inlet measurements					
Obstetric conjugate (mm), median (range)	118.6	(87.6-152.4)	114.3	(90.2-134.8)	0.317
Transverse diameter (mm), median (range)	118.6	(95.0-139.7)	119.5	(108.9-139.6)	0.522
Treatment before surgery					<0.001
No, n (%)	48	(92.3)	17	(48.6)	
Chemoradiotherapy, n (%)	4	(7.7)	12	(34.3)	
Chemotherapy, n (%)	0	(0)	6	(17.1)	
The longest diameter of tumor (mm), median (range)	35	(0-95)	25	(0-72)	0.085
cT, n (%)[a]					0.037
0/is/1	12	(23.1)	6	(17.1)	
2	10	(19.2)	10	(28.6)	
3	19	(36.5)	18	(51.4)	
4	11	(21.2)	1	(2.9)	
cN, n (%)[a]					0.155
0	28	(53.8)	22	(62.9)	
1	18	(34.6)	6	(17.1)	
2	6	(11.5)	7	(20.0)	
cM, n (%)[a]					0.359
0	50	(96.2)	32	(91.4)	
1	2	(3.8)	3	(8.6)	

BMI body mass index, *Lap-LAR* laparoscopic low anterior resection, *TaTME* transanal total mesorectal excision

[a]Tumors were classified according to the eighth edition of the Union for International Cancer Control tumor-node-metastasis cancer staging system.

Table 2. Operative outcomes, postoperative complications, and pathological findings

	Lap-LAR (n=52)		TaTME (n=35)		P
Additional operative procedure					
Lateral pelvic lymph node dissection, n (%)	3	(5.8)	11	(31.4)	0.001
Mobilization of splenic flexure, n (%)	5	(9.6)	9	(25.7)	0.047
Construction of diverting ileostomy, n (%)	16	(30.8)	33	(94.3)	<0.001
Conversion to open surgery, n (%)	0	(0)	0	(0)	1
Total operation time (min), median (range)	307	(207-803)	283	(179-531)	0.101
TME time (min), median (range)	197	(111-392)	121	(83-177)	<0.001
Estimated blood loos, g (range)	0	(0-300)	0	(0-175)	0.046
Transfusion, n (%)					1
Yes	0	(0)	0	(0)	
No	52	(100)	35	(100)	
Postoperative complications, Clavient-dindo classification grade≧Ⅱ, n(%)					
Anastomotic leakage	4	(7.7)	2	(6.0)	0.718
Bowel obstruction	0	(0)	8	(23.0)	<0.001
Urinary dysfunction	1	(1.9)	0	(0)	0.309
Hospital days, median (range)	17	(8-49)	19	(11-47)	0.129
Proximal resection margin positive, n (%)	0	(0)	0	(0)	1
Distal resection margin positive, n (%)	0	(0)	0	(0)	1
Circumferential resection margin positive, n (%)	2	(3.8)	0	(0)	0.148

Lap-LAR laparoscopic low anterior resection, *TME* total mesorectal excision, *TaTME* transanal TME

Table 3. Bony pelvic size and BMI of patients treated by Lap-LAR or TaTME

	Lap-LAR				P	TaTME				P
	Female(n=18)		Male (n=34)			Female (n=11)		Male (n=24)		
Obstetric conjugate (mm), median (range)	124.8	(106.7-152.0)	112.3	(87.6-136.3)	0.001	118.8	(105.5-130.5)	113.9	(90.2-134.8)	0.155
Transverse diameter (mm), median (range)	125.2	(108.5-139.7)	115.2	(95.0-131.3)	<0.001	129.6	(111.8-139.6)	117.5	(108.9-128.6)	0.002
BMI (kg/m^2), median (range)	20.3	(13.0-29.9)	22.7	(17.6-41.8)	0.005	21.2	(17.5-28.6)	23.5	(19.7-32.8)	0.014

BMI body mass index*, Lap-LAR* laparoscopic low anterior resection, *TaTME* transanal total mesorectal excision