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A Cost Overview of Minimally Invasive Total Mesorectal Excision in Rectal Cancer Patients: A Population-based Cohort in Experienced Centres

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Background: Total mesorectal excision has been the gold standard for the operative management of rectal cancer. The most frequently used minimally invasive techniques for surgical resection of rectal cancer are laparoscopic, robot-assisted, and transanal total mesorectal excision. As studies comparing the costs of the techniques are lacking, this study aims to provide a cost overview.

Method: This retrospective cohort study included patients who underwent total mesorectal resection between 2015 and 2017 at 11 dedicated centers, which completed the learning curve of the specific technique. The primary outcome was total in-hospital costs of each technique up to 30 days after surgery including all major surgical cost drivers, while taking into account different team approaches in the transanal approach. Secondary outcomes were hospitalization and complication rates. Statistical analysis was performed using multivariable linear regression analysis.

Results: In total, 949 patients were included, consisting of 446 laparoscopic (47%), 306 (32%) robot-assisted, and 197 (21%) transanal total mesorectal excisions. Total costs were significantly higher for transanal and robot-assisted techniques compared to the laparoscopic technique, with median (interquartile range) for laparoscopic, robot-assisted, and transanal at €10,556 (8,642;13,829), €12,918 (11,196;16,223), and € 13,052 (11,330;16,358), respectively ($P < 0.001$). Also, the one-team transanal approach showed significant higher operation time and higher costs compared to the two-team approach. Length of stay and postoperative complications did not differ between groups.

Conclusion: Transanal and robot-assisted approaches show higher costs during 30-day follow-up compared to laparoscopy with comparable short-term clinical outcomes. Two-team transanal approach is associated with lower total costs compared to the transanal one-team approach.

Keywords: cost overview, laparoscopy, rectal cancer, rectal surgery, robotic, robotic surgery, transanal total mesorectal excision

INTRODUCTION

Total mesorectal excision (TME) is considered the gold standard for the operative treatment of rectal cancer.[1] Laparoscopic total mesorectal excision (L-TME) is associated with a shorter length of stay and operative time as compared with conventional open surgery, without jeopardizing oncologic outcomes.[2–4] However, L-TME does come with technical restrains

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for surgeons and assisting personnel, such as predominantly two-dimensional view, limited range of motion, and poor ergonomic positioning.[5–7]

The combination of these technical difficulties and the challenging anatomy of the patient, especially low rectal tumors in male obese patients, results in demanding procedures. To overcome these challenges, robot-assisted total mesorectal excision (R-TME) and transanal total mesorectal excision (TaTME) have been introduced. Despite the theoretical technical advantages of R-TME and TaTME,[8–10] so far no clear benefits in short and long-term clinical outcomes between these techniques have been shown. Nevertheless, TaTME and R-TME seem to be associated with a significantly higher rate of primary anastomoses.[11]

It is unknown how costs differ between these 3 minimally invasive techniques, as studies assessing costs of new techniques (R-TME and TaTME) are limited in number and lack major surgical cost drivers. R-TME is suggested to come with high costs, which are seemingly caused by high initial purchase costs and increased operating times.[9,12] However, most studies do not take into account the learning curve of the participating surgeons, while operating times tend to decrease significantly after the learning curve has been completed.[13] Therefore, the effect of the learning curve might introduce bias during the comparison of costs between techniques. In addition, recently robotic surgical equipment is priced more economically enabling broader implementation. Although some studies compare the costs of L-TME and R-TME, there is only one study that assessed cost differences between L-TME and TaTME, which took into account a learning curve of only 20 cases. In this study, the difference between a two-team approach or a one-team approach was not analyzed.[14] An one-team approach begins with an abdominal phase, followed by a transanal phase, whereas abdominal and transanal phases are performed simultaneously in a two-team approach.[15] As a result of the two-team approach, operation time is suggested to decrease,[16] but personnel and equipment costs may be higher.

This multicentre cohort study aims to give an overview of the costs of L-TME, R-TME, and TaTME (one- and two-team approaches) in dedicated centers performed by surgeons beyond the learning curve.

METHODS

This is a multicentre retrospective cohort of rectal cancer patients, who underwent L-TME, R-TME, or TaTME from January 1st, 2015, to December 31st, 2017 in the Netherlands. Colorectal surgeons of the 5 dedicated L-TME centers (St. Antonius Hospital Nieuwegein, Tergooi Hospital Hilversum, Jeroen Bosch Hospital den Bosch, Laurentius Hospital Roermond, and Diakonessenhuis Utrecht) all had over 10 years of experience. The 3 dedicated R-TME centers (Amphia Hospital Breda, Meander Medical Center Amersfoort, and Canisius Wilhelmina Hospital Nijmegen) started in 2011, 2011, and 2014, respectively. The three dedicated TaTME centers (Gelderse vallei Ede, VUMC Amsterdam, AMC Amsterdam) started in 2012, 2012, and 2014 respectively. The learning curve of L-TME is considered approximately 90 cases for colorectal surgery.[17] The learning curve in R-TME and TaTME centers was defined as having performed 40 procedures for R-TME or TaTME.[16,18,19] To ensure all surgeons were beyond their learning curve, patients were only included from January 1st, 2016 onwards from centers that started with either the R-TME or TaTME technique in 2014 or before.

Inclusion and Exclusion Criteria

Patients diagnosed with rectal cancer according to the new definition by d'Souza et al[20] using the sigmoidal take-off on magnetic resonance imaging (MRI) or computed tomography were included. Patients were considered eligible if they were >18 years of age, registered in the prospective Dutch Colorectal Audit (DCRA), and received TME in curative and elective settings for rectal cancer in dedicated centers between January 1st, 2015, and December 31st, 2017. Additionally, patients underwent resection in one of the dedicated centers, after the learning curve had been completed. Patients that underwent emergency surgery, underwent TME with palliative intent, required en bloc multi-visceral resection, had a tumor above the sigmoid take-off, and underwent surgery before the learning curve was fulfilled for the dedicated technique in the treating center were excluded. Patients were also excluded if they underwent another technique than the preferred technique of the dedicated center, for instance, an L-TME procedure for a patient in an R-TME center.

Outcomes

The primary outcome was total in-hospital costs during the first 30 days postoperatively between L-TME, R-TME, and TaTME. This study was conducted from a hospital perspective, therefore only direct in-hospital costs were included. Costs for hospitalization and complications requiring intervention were calculated with reference pricing from national cost data published by the Dutch National Health Institute.[21] Patient resource and operation utilization were translated into costs using cost data from 2018, which was used for all years to prevent differences due to inflation.[22] Secondary outcomes were the length of stay and major postoperative complication rates (e.g., bleeding, anastomotic leakage, and bowel perforation).

Baseline characteristics considered were age, sex, body mass index (BMI), American Society of Anaesthesiologists (ASA) classification, history of previous abdominal surgery, the distance of the tumor from the anorectal junction (ARJ) on MRI, tumor diameter, administration of neoadjuvant (chemo) radiation therapy, preoperative clinical tumor classification (TNM), and type of procedure (Hartmann procedure, LAR with primary anastomosis or abdominoperineal resection). Pathologic TNM classification, histologic tumor type, tumor differentiation, procedure length, conversion rate, length of stay, length of stay in the intensive care unit (ICU), 30-day surgical complications, and anastomotic leakage rate according to the definition of the International Study Group of Rectal Cancer,[23] were registered. Length of stay was defined as the number of days between the date of surgery and the date of discharge. Postoperative complications were defined as any deviation from the normal postoperative course occurring within 30 days of surgery. Complications were graded according to the Clavien Dindo classification.[24]

Operative Costs

The costs per surgical technique were calculated using all major surgical cost drivers identified in the current literature.[25] Operative costs included variable and nonvariable costs of the operating room, personnel costs, costs of disposables, and costs for system purchase, maintenance, and updates (Table 1). Operative costs were calculated, using nonvariable costs, variable costs of the operating room, standardized costs of disposable sets, and hourly fees for the surgeon, anaesthesiologist, and assistant salaries. The use of standardized disposable sets was identified according to the sampling of operation reports which were checked for use of specific disposables. Also, initial system purchase, maintenance, disposable sets, and update costs were retrieved from tariffs in local financial administration in a centre of each specific technique and were extrapolated to other dedicated centers. The costs of the system purchase, maintenance, and updates were divided by the ratio, among all surgical specialisms which used the system. Centers in this study all had optimal usage of surgical devices between different surgical specialties and had a similar depreciation period of 10 years. Total

TABLE 1.

Operative Cost Definitions

	Standard Costs for Each Pprocedure	L-TME	R-TME	TaTME 1-team Approach	TaTME 2-team Approach
OR non variable costs	€280 per procedure				
OR variable costs	€542 per hour				
Surgeon	1 surgeon €208 per hour				1 additional surgeon €208 per hour
Anaesthesiologist	1 anaesthesiologist €176 per hour				
Supportive employees	1 nurse anaesthetist €94 per hour 2 surgery assistants €94 per hour				
Surgical necessities and disposables (incl. anastomosis)		Disposables €1605 per procedure	Disposables € 2316 per procedure	Disposables €2197 per procedure	Disposables €2246 per procedure
Initial purchase, system maintenance/updates		1 laparoscopic tower €16 per procedure	Da Vinci Si €1000 per procedure	1 laparoscopic tower €16 per procedure	2 laparoscopic towers €32 per procedure

L-TME indicates laparoscopic total mesorectal excision; OR, operating room; R-TME, robot-assisted total mesorectal excision; TaTME, transanal total mesorectal excision.

variable operating room costs and personnel costs were calculated according to operation time, defined as "cut-close" minutes. As TaTME may be performed using a 1-team and 2-team approach, costs of additional personnel and disposables were taken into account for the 2-team TaTME approach.

Hospitalization Costs

Hospitalization costs included standardized costs of hospital ward admission including costs of therapy, prescribed medicine, laboratory tests, consumables, housing (initial admission and readmission), and personnel costs (both medical and nonmedical) based on reference pricing from national cost data published by the Dutch National Health Institute.[21] Additional costs in hospitalization for ICU stay were also based on national cost data[21] and included ICU-specific diagnostic costs, personnel, housing, consumables, laboratory tests, prescribed medicine and equipment, and general overhead.

Complication Costs

Complication costs were calculated using standardized complication costs which required intervention or readmission, based on reference pricing from national cost data published by the Dutch National Health Institute.[21] Use of resources due to additional interventions was extracted from electronic patients' files from each participating hospital. This was carried out by defining (re)operation type, (re)operation time, and all complications which required surgical re-interventions.

Data Collection

Data per hospital was based on the local DCRA data.[26] Missing data or data unavailable in the DCRA database was subtracted from the electronic medical record (EMR) of participating hospitals and added to the study database. This included data regarding the use of resources due to additional interventions such as reoperation type, reoperation time, length of hospitalization, and readmission. All preoperative MRI data were reviewed by trained researchers to assess the definition of rectal carcinoma according to sigmoidal take-off.[20] All data were stored in the data management system CASTOR. Obtaining informed consent was not required according to the Dutch Medical Treatment Agreement Act. Approval for the study was provided by the regional medical ethical committee and local ethical committees of all the hospitals (MEC-U, AW19.023 W18.100).

Statistical Analysis

Descriptive statistics were computed for patient characteristics, postoperative outcomes, and cost outcomes. For normally distributed data, continuous variables are presented as mean and standard deviation (SD), and Student's *t*-test was used for between-group comparisons. For non-normally distributed data, continuous variables were presented as the median and interquartile range (IQR) (25th percentile to 75th percentile) and the Mann-Whitney U test was used for between-group comparisons. Categorical data are presented as numbers and percentages and the chi-square test was used for comparison. Subgroup analysis was performed to assess primary and secondary outcomes within 1-team and 2-team TaTME. Univariable and multivariable linear regression analyses were used to assess for confounding factors. Costs and outcomes were compared between the different techniques using median and IQR to prevent the influence of extreme outliers. A P value of <0.05 was considered statistically significant. All analyses were performed using R studio version 3.1 2022.

RESULTS

Patient's Characteristics

A total of 1834 patients were identified as eligible between January 1st, 2015 and December 31st, 2017. The study flowchart is shown in Supplemental Figure 1, http://links.lww.com/AOSO/A216. A total of 949 patients were included in the analysis, consisting of 446 (47%) L-TME, 306 (32%) R-TME, and 197 (21%) TaTME procedures. Baseline characteristics are described in Table 2. Baseline characteristics between the 1-team and 2-team TaTME approach are described in Supplemental Table 2, http://links.lww.com/AOSO/A217.

Intra-operative Results

Regarding intraoperative outcomes, operation time was significantly increased in R-TME and TaTME compared to L-TME, with median (IQR) for L-TME, R-TME, and TaTME 149 min (126; 184) vs. 189 min (146; 238) vs. 203 min (146; 255), respectively, $P < 0.05$. Within the TaTME group, sub-group analysis showed that the 2-team approach was associated with a shorter operation time compared to the 1-team approach, with median (IQR) for 1-team TaTME 236 minutes (198; 284) vs. 2-team TaTME 170 minutes (137; 226), respectively, $P < 0.001$. However, operation time remained significantly higher compared to L-TME (Supplemental Table 2, http://links.lww.com/AOSO/A217). Intra-operative complications did not significantly differ between groups (Table 3). The R-TME and TaTME groups were associated with a significantly higher rate of primary anastomoses compared to the L-TME group (L-TME 42.9% vs. R-TME 62.8% vs. TaTME 72.1%, $P \leq 0.001$).

TABLE 2.

Baseline Characteristics

		L-TME	R-TME	TaTME	*P* value
N		446	306	197	
Age, years		67.9 (9.5)	67.1 (10.4)	65.3 (10.5)	0.010
Sex	Male	289 (65)	198 (65)	136 (69)	0.599
	Female	154 (35)	106 (35)	61 (31)	
BMI		26.2 (4.2)	26.0 (3.9)	26.1 (4.3)	0.925
ASA classification 3–4		92 (21)	66 (22)	35 (18)	0.550
Tumour distance from ARJ, cm		5.0 [3; 8]	6.0 [3; 8]	4.2 [2; 6]	<0.001
Procedure	APR	173 (39)	93 (31)	24 (12)	<0.001
	Hartmann	80 (18)	20 (7)	31 (16)	
	LAR + anastomosis	190 (43)	191 (63)	142 (72)	
Neoadjuvant therapy		264 (59)	191 (62)	124 (63)	0.553
	Radiotherapy	135 (31)	59 (30)	113 (37)	0.182
	Chemoradiation	125 (28)	77 (25)	65 (33)	0.182
Tumor diameter mm		30 [20; 40]	30 [20; 40]	25 [12; 35]	0.005
pT-stage	T1	45 (10)	29 (10)	25 (13)	0.883
	T2	162 (37)	110 (36)	70 (36)	
	T3	201 (45)	133 (44)	80 (41)	
	T4	3 (1)	5 (2)	2 (1)	
	Tx	1 (0.2)	1 (0.3)	1 (1)	
	T0	31 (7)	24 (8)	19 (10)	
pM0-stage		418 (97)	286 (95)	176 (93)	0.170
Adenocarcinoma		422 (96)	292 (96)	188 (96)	0.909
Well/moderate differentiated		403 (97)	270 (96)	177 (96)	0.494

All variables are in mean (SD), median [IQR] or number (%).

APR indicates abdominoperineal resection; ARJ, anorectal junction; ASA, American Society of Anaesthesiologists; IQR, interquartile range; L-TME, laparoscopic total mesorectal excision; LAR, low anterior resection; pM-stage, pathological M-stage; pT-stage, pathological T-stage; R-TME, robot-assisted total mesorectal excision; SD, standard deviation; TaTME, transanal total mesorectal excision.

Postoperative Outcomes

For postoperative outcomes, comparable results were observed (Table 3). Length of stay was comparable with median (IQR) for L-TME, R-TME, and TaTME 6 days[5,9] vs. 6 days[4,10] vs. 6 days,[4,9] respectively, $P = 0.781$. Postoperative complications, including anastomotic leakage, did not differ between groups. Intensive care admission did not differ between groups (L-TME 7% vs. R-TME 7% vs. TaTME 4%, $P = 0.236$).

Cost Overview

Operative costs significantly differed between all 3 techniques, with median (IQR) for L-TME, R-TME, and TaTME €6,592 (5,887;7,598) vs. €9,324 (8,109;10,711) vs. €9,486 (7,806;11,125), $P < 0.001$. Hospitalization costs did not differ between groups, with median (IQR) for L-TME, R-TME, and TaTME €2,929 (2.092;5,320) vs. €2,929 (2,092;5,440) vs. €2,929 (2,090;5,021), $P = 0.336$. R-TME and TaTME were associated with higher total costs compared to L-TME, with median (IQR) for L-TME, R-TME, and TaTME €10,556 (8,642; 13,829) vs. €12,995 (11,048; 15,589) vs. €13,052 (11,330; 16,358), $P < 0.001$. Costs between R-TME and TaTME did not differ significantly. Possible confounding was assessed by multivariable analysis after log transformation of total costs to correct for right skew distribution, which is shown in Supplemental Table 1, http://links.lww.com/AOSO/A217.

Between the 1-team and 2-team approach a significant difference was found in operative costs with median (IQR) for 1-team €10,170 (8,935;11,280) vs. 2-team €8,867 (7,479;10,402), $P = 0.002$. Also, total costs were significantly lower in the 2-team approach with median (IQR) 1-team €13,328 (12,169; 16,587) vs. 2-team €12,620 (10,702; 15,994), $P = 0.044$ (Supplemental Table 2, http://links.lww.com/AOSO/A217). However both operative and total costs remained significantly higher when the 2-team approach was compared with L-TME and R-TME. The incidence of complications that required re-intervention did not differ between groups (L-TME 18% vs. R-TME 16% vs. TaTME 21%, $P = 0.337$). Median complication costs (based on re-interventions) when complications occurred, were significantly lower in TaTME compared to L-TME, but costs between TaTME and R-TME did not differ significantly (Supplemental Table 2, http://links.lww.com/AOSO/A217).

In patients who experienced a complication after the procedure, the length of stay was longer with median (IQR) for L-TME 9 days[6,21] vs. R-TME 14 days[6,26] vs. TaTME 13 days,[7,21] $P = 0.514$. Despite the longer length of stay, the total costs (based on re-interventions, length of stay, and operation costs) did not significantly differ between approaches with median (IQR) L-TME €17,427 (13,171; 22,406) vs. R-TME €21,081 (15,995; 27,912) vs. TaTME €18,305 (16,344; 24,171), $P = 0.061$. Table 3 summarizes the cost overview between all 3 techniques.

DISCUSSION

This cost overview study on minimally invasive techniques in dedicated centers, suggests an additional €2,400 in-hospital costs in the first 30 days after surgery for TaTME and R-TME compared to L-TME. No clear benefit in postoperative outcomes or reduced complication rates were found during the first 30 days postoperatively, except for significantly higher anastomosis rates in R-TME and TaTME which may have a substantial effect on long-term associated costs. This study shows that a 2-team approach in TaTME may be associated with lower total costs compared to the 1-team TaTME approach.

Several studies have been published regarding cost comparisons of L-TME and R-TME.[27–29] Most of these studies are in line with the results of the present study: R-TME is associated with higher costs compared to L-TME. Although some previous studies[30–32] suggest that costs between these 2 techniques seem equal, these cost calculations did not include the maintenance cost of the robotic device and direct employee costs of the surgical staff and did not account for the R-TME learning curve.[33]

In contrast to R-TME, the costs of the TaTME approach are scarcely described.[34] Results of our study challenge outcomes of Candido,[14] which showed comparable costs between TaTME and L-TME. Despite both studies included operative and hospitalization costs, our study included additional employee costs (in 2-team TaTME), re-intervention costs, and general operation room costs in contrast to Candido et al.[14] Even though the observed costs of surgical supplies of Candido are comparable to costs in the Netherlands, we expect to have given a more adequate insight by accounting for all major surgical cost drivers.[25] Also our study considered a number of 40 patients for the TaTME learning curve instead of 20 patients, which may have influenced operation time and clinical outcomes.

A striking observation of this study is the difference in operation time and costs between the 1-team and 2-team approaches in the TaTME technique. The influence of the 1- and 2-team TaTME approach on costs has, to the best of our knowledge, never been studied before. However, our results suggest a decrease in operation time with the use of a two-team approach, which is in line with earlier studies.[16] Despite the additional costs of a second surgeon, the decrease in operation time seems to lead to a decrease in operative and total costs in our study. No differences were seen in terms of hospital stay, mortality, readmission, or reoperation between the 1- and 2-team approach in TaTME. This is in line with previous research.[16] However, since operation time is longer and disposables and personnel costs are more expensive compared with L-TME, total costs after R-TME

TABLE 3.

Postoperative Outcomes

		Cohort				Post hoc Testing		
		L-TME	R-TME	TaTME	*P* value	L-TME Versus R-TME	L-TME Versus TaTME	R-TME Versus TaTME
N		446	306	197				
Operation time, minutes		149 [126;184]	189 [146;238]	203 [146;255]	<0.001	<0.001	<0.001	0.080
Conversion		17 (4)	5 (3)	7 (2)	0.435			
Construction of anastomosis		190 (43)	191 (63)	143 (73)	<0.001	<0.001	<0.001	0.024
Construction of stoma	No stoma	91 (21)	68 (22)	60 (31)	<0.001	<0.001	<0.001	0.068
	Deviating ileostomy	89 (20)	126 (41)	85 (43)				
	Deviating colostomy	17 (4)	2 (1)	1 (1)				
	Permanent stoma	249 (56)	110 (36)	51 (26)				
Complication		213 (48)	144 (47)	93 (47)	0.971			
Surgical complication		149 (34)	105 (34)	61 (31)	0.700			
Clavien Dindo ≥3		92 (21)	60 (20)	49 (25)	0.364			
Anastomotic leakage		35 (18)	34 (18)	27 (19)	0.968			
Re-intervention		81 (18)	49 (16)	42 (21)	0.337			
Readmission		63 (14)	54 (18)	31 (16)	0.432			
ICU admission		31 (7)	20 (7)	7 (4)	0.236			
ICU stay*, days		3 [2; 8]	3 [2; 5]	5 [4; 24]	0.099			
Length of stay, days		6 [5; 9]	6 [4; 10]	6 [4; 9]	0.781			
Operative costs, €		6,592 [5,887; 7,598]	9,324 [8,109; 10,711]	9,486 [7,806; 11,125]	<0.001	<0.001	<0.001	0.728
Hospitalization costs, €		2,929 [2,092; 5,320]	2,929 [2,092; 5,440]	2,929 [2,090; 5,021]	0.336			
Complication costs*, €		2,887 [2,849; 3,264]	2,887 [912; 2,887]	2,849 [481; 2,887]	0.005	0.343	0.011	0.243
Total costs, €		10,556 [8,642; 13,829]	12,995 [11,048; 15,589]	13,052 [11,330; 16,358]	<0.001	<0.001	<0.001	0.737

All variables are in mean (SD), median [IQR] or number.

* = if occurred.

ICU indicates intensive care unit; IQR, interquartile range; L-TME, laparoscopic total mesorectal excision; R-TME, robot-assisted total mesorectal excision; TaTME, transanal total mesorectal excision.

and TaTME were significantly higher compared with L-TME. Length of stay and complications are also similar between all 3 different surgical techniques. Our results confirm data of previous studies which show comparable postoperative outcomes between L-TME, R-TME, and TaTME.[11,30,35]

Previous studies reporting on the costs of new techniques are often early experience reports.[27,30,34,36] Therefore, a strength of the current study is reporting on different techniques in rectal cancer surgery while considering the learning curve and therefore reporting only on the performance of the techniques in dedicated centers. Another strength of this study is the sub-analysis of the 2-team and 1-team approaches in TaTME. Significant shorter operative time is observed in a 2-team approach, leading to lower costs despite the presence of an additional surgeon during surgery. In terms of cost analysis, assigning costs based on interventions in this study is a limitation, because out-of-hospital costs and indirect costs are not included in the analysis. Since not all costs are included in the study, the total costs of each technique remain an estimation. Nevertheless, all major cost drivers were included in this study, so we expect to have given adequate insight on costs between different surgical techniques. This study is based on dedicated centers in the Netherlands with optimal usage of surgical devices and tariffs of materials and personnel, public funding, and clinical outcomes that differ between hospitals and countries worldwide. Because of this, results may not be replicable in all healthcare institutes, but the set-up of this cost analysis could be extrapolated to international settings.

Due to the retrospective nature of this study, some degree of bias may be present in the study data and definition of cost data in this cohort. In terms of study data, the retrospective nature of this study led to some differences in baseline between groups (age and tumor location). Although we tried to adjust for confounding factors through univariable and multivariable linear regression analysis, residual confounding might still be present. More importantly, as reported in this study, R-TME and TaTME were associated with a higher rate of primary anastomoses compared with L-TME. This may result in lower permanent stoma rates in R-TME and TaTME, which in turn may significantly influence long-term costs resulting from daily stoma care, stoma nurse follow-up, and stoma-related complications and re-interventions.[37,38] Since this study only assessed outcomes during the first 30 days after rectal cancer surgery, further research is necessary to evaluate the cost and clinical outcomes during long-term follow-up. Long-term costs include costs associated with deviating and permanent stoma's which consist of costs of stoma care, reversal, revision, and complications. Additionally, we could not perform cost-utility analyses, although the quality of life and patient outcomes are important to consider when comparing surgical techniques.[39]

Providing cost insights on these innovative surgical techniques has become a topic of interest over the last years and could contribute to a better understanding as to what is the best technique for both individual patients, as well as society as a whole. With this in mind, it would be interesting for future research to compare long-term cost differences (e.g., 1 year) between these techniques and to assess the quality of life outcomes by cost-effectiveness analysis.

The results of the current study indicate that TaTME and R-TME result in higher in-hospital costs in 30-day outcomes compared to L-TME. No clear benefit in outcomes is shown during the first 30 days postoperatively except for significantly higher anastomosis rates in R-TME and TaTME approach which have a substantial effect on long-term associated costs.

The results also suggest lower total costs in the 2-team TaTME approach compared to the 1-team approach, because of the shorter operation time. For future research, it would be interesting to assess long-term clinical outcomes, quality of life, and costs for these techniques using a cost-utility analysis, for which our current cost analysis can serve as the base.

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