Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2022 May 20; 10(B):1788-1794.
https://doi.org/10.3889/oamjms.2022.9367
eISSN: 1857-9655
Category: *B - Clinical Sciences*
Section: *Surgery*

Robotic Transanal Total Mesorectal Excision Compared to Laparoscopic Transanal Total Mesorectal Excision: Oncologic Results of the Past 5 Years

Danilo Coco[1]*, Silvana Leanza[2]

[1]*Department of General Surgery, Ospedali Riuniti Marche Nord, Pesaro, Italy;* [2]*Department of General Surgery, Carlo Urbani Hospital, Ancona, Italy*

Edited by: Ksenija Bogoeva-Kostovska
Citation: Coco D, Leanza S. Robotic Transanal Total Mesorectal Excision Compared to Laparoscopic Transanal Total Mesorectal Excision: Oncologic Results of the Past 5 Years. Open-Access Maced J Med Sci. 2022 May 20; 10(B):1788-1794. https://doi.org/10.3889/oamjms.2022.9367
Keywords: Midrectal cancer; Rectal cancer; Total mesorectal excision; Low rectal cancer; Robotic transanal total mesorectal excision; Laparoscopic transanal total mesorectal excision; Circumferential resection margin; Distal rectal margin; Recurrence rate; Quality of specimen; Advantages; Disadvantages
***Correspondence:** Dr. Danilo Coco, Ospedali Riuniti Marche Nord, Pesaro, Italy. E-mail: webcostruction@msn.com
Received: 13-Mar-2022
Revised: 09-May-2022
Accepted: 12-May-2022

Funding: This research did not receive any financial support
Competing Interest: The authors have declared that no competing interest exists

Abstract

Colorectal cancer is one of the deadliest diseases on the planet. Rectal cancer (RC) is the 8th most common type of cancer disease worldwide, accounting for over 300,000 fatalities in 2018. Total mesorectal excision (TME) is considered as the gold standard approach for surgical RC management. To alleviate technical problems associated with dissection of distal rectal, transanal procedure to mesorectum was developed. The robotic operating platforms' development has brought about the most significant change. The robotic method, which was described first in the year 2001, is gaining popularity in colorectal surgery. A stable camera platform with three-dimensional imaging and tremor filtering, motion scaling, instruments with numerous degrees of freedom, 3rd arm for fixed retraction, ambidextrous capability, superior ergonomics, and less fatigue, all these advantages have all influenced robotics implementation. However, there are certain disadvantages to robotic surgery, such as high expenses, lengthy time of operation, a bulky cart, and absence of haptic sense. Robotic transanal TME (R-TA TME) is unique method that integrates potential advantages of perineal dissection with precise control of distal margins, along with all robotic technology advantages with respect to dexterity and greater precision. This review goal is to evaluate the available literature critically regarding R-TA TME in comparison to laparoscopic TA TME (L-TA TME) using the most prevalent histopathological metrics, which are the circumferential resection margin, the distal rectal margin, recurrence rate, specimen quality, advantages, and disadvantages. Oncological results for the past 5 years were used. The resources were obtained from electronic sources such as Google Scholar and PubMed. The conclusion of this review revealed that R-TA TME is as safe as well as feasible as L-TA TME, is technically possible, and has comparable oncological results and short-term post-operative outcomes. However, further investigation is required to evaluate long-term oncological or functional results.

Introduction

Colorectal cancer (CRC) is a chief death cause and accounts for approximately 25% of all cancer cases. CRC represents a global health problem and in particular rectal cancer (RC) is the 8th most common cancer type with probable 300,000 deaths in 2018 [1]. Heald *et al*. in 1982 proposed concept of total mesorectal excision (TME), and it is now accepted widely as the gold standard treatment for resection of RC [2]. TME is currently widely regarded as the best and the most effective surgery for treating RC when performed [3]. Rectal resection for distal cancers can be incredibly challenging, even in surgeon's hands who are experts. This is especially true in subjects with lesions that are anterior-located, male sex, obesity, narrow pelvis, bulky tumors, or those who received neoadjuvant chemoradiotherapy, where a complicated distal rectal dissection might raise incomplete mesorectal excision risk [4], [5]. For these reasons, numerous novel procedures have fundamentally transformed the visceral surgery landscape in recent years. Sylla *et al*. [6], in 2010, reported a new procedure on the basis of the natural orifice transanal endoscopic surgery, using transanal endoscopic microsurgery with laparoscopic assistance. This new technique involved total mesorectal resection by transanal route and for this reason, it was called transanal TME (TA TME) or "down-to-up" or "bottom to up" proctectomy. The robotic operation platforms' development has brought about the most significant change. The robotic method, first proposed by Makin *et al*. [7], in the year 2001 is gaining popularity in colorectal surgery. Numerous benefits of robotics have influenced its implementation: Especially in, a stable camera platform with 3D imaging and tremor filtering, motion scaling, instruments with numerous degrees of freedom, 3rd arm for fixed retraction, ambidextrous capability, superior ergonomics, as well as less fatigue [8], [9], [10], [11]. Pigazzi *et al*. completed the first R-TME (up-to-down) procedure in 2006 [10]. Robotics has gained popularity with promising expectations and was applied to perform TA TME, as technique called R-TA TME (R-TA TME). Transanal minimally invasive surgery (TAMIS) was first published by Atallah *et al*. in the year 2010 [11]. Fifty participants were involved, in which the use of TAMIS was done for tumor local excision. The same authors [12] in 2013 published 1st robotic-assisted transanal surgery for TME (RATS-TME) case report, to treat a cT3N1 distal rectum cancer, which was found 4 cm proximal to anal verge. On examining pathologically, the specimen margins were free of tumor, the circumferential resection margin (CRM) was clear, as well as TME was of Quirke Grade 2 classification. Numerous benefits of robotics have influenced its implementation: Especially in, a stable camera platform with 3D imaging and tremor filtering, motion scaling, instruments with numerous degrees of freedom, 3rd arm for fixed retraction, ambidextrous capability, superior ergonomics, as well as less fatigue [8], [9], [10], [11]. R-TA TME seems to show short-term oncological results similar to the laparoscopic technique with the advantage of fewer conversions rate and easier TME dissection. Despite its confirmed feasibility and safety, RTA TME is a difficult procedure with a steep learning curve, as per earlier studies. However, there are certain disadvantages to RS, such as higher expenses, a lengthier time of operation, a bulky cart, as well as loss of haptic sense [13]. Moreover, investigations have revealed urethral injury occurrence which is a significant problem linked directly to transanal phase of surgery as well as current proof of greater distal resection margin (DRM) involvement [14], [15], [16]. Although there have been few publications concentrating on these new techniques to date, few reports have showed promising oncological as well as clinical outcomes. The main aim of this review is to provide a comprehensive picture of present R-TA TME status.

Materials and Methods

A systematic search on literature was done including EMBASE, PubMed, Medline, Cochrane, and Google Scholar databases to identify articles by applying several subject-related combination terms. The identification of search terms with medical subject heading was "low RC, mid-RC, RC, TME, R-TA TME, laparoscopic TA TME (L-TA TME), CRM, DRM, recurrence rate, specimen quality, advantages, and disadvantages." The published literature was gathered via database up till the year 2016, the past 5 years. Reports which involved the following were considered for inclusion: "R-TA TME, L-TA TME." The following were the criteria for exclusion: Letters, case reports, abstracts, and comments. Non-cancer subjects involved in research and duplicate findings were also omitted. The search approach did not include any restrictions of language. The review was done by two independent researchers (SL and DC). After eliminating repeated reports, with the use of PRISMA criteria, 11 publications were chosen that included relevant literature for the study of this review.

Results

In this light, the robotic technology introduction with stable three-dimensional vision might possibly allow highly difficult tasks to be performed with ambidextrous movements, improving dexterity, and reducing tremor, leading to better dissection, specifically in constrained surgical settings [17]. When compared to traditional laparoscopic TME, R-TME might reduce the rate of conversion to open surgery, though no confirmed conversions to open surgery from R-TA TME were documented in reported series or cases. Two conversions to 5-port laparoscopy were described by Kuo *et al*. [18]. The operation took between 132 min and 530 min. The R-TA TME series seems to have a longer operational period, possibly because both phases, abdominal and transanal, were not operated at the same time. In most cases, loss of blood was <100 mL. Although no evidence of distal margin involvement was seen in literature, Hu *et al*. stated three cases of positive CRM. In four studies, the TME quality was described as near complete. This corresponds to 17.1% of non-optimal TME quality rate that might seem to be greater than predicted. The lymph nodes removed varied from 12 to 33 in numbers. Neither the long-term nor mid-term oncological results were fully addressed in any of reported studies. The lengthiest median follow-up ranged 15 months (range 11–18 months). After 1.5 years, Hu *et al*. [19] observed a local recurrence. Atallah *et al*. [12] stated four cases (three males) where an R-TA TME and hybrid abdominal laparoscopic was carried out. An average height of tumor was 3.3 (1–5) cm from anal verge. The mean operation time was 376 min, with 200 (50–300) mL estimated mean loss of blood. No intraoperative morbidity was seen, and 4.3 days were mean post-operative stay length. In every case, the mesorectal quality was described as nearly complete or complete. Each case had negative resection margins. After 8-month follow-up, distant or no local recurrences were noted. Authors concluded that R- TA TME could help with rectum dissection, particularly in the distal two-thirds. A robotic transabdominal and R-TA TME was performed on five patients by Gómez Ruiz *et al*. [20] that demonstrated 100% complete TME, with none DRM and non-CRM+. Huscher *et al*. [21] reported an editorial outlining the outcomes of an R-TA TME and hybrid laparoscopic transabdominal on seven RC subjects (four females). None of patients had undergone neoadjuvant treatment but all were in clinical Stage II or I. 165.7 (85–120) min was the mean operative time. There were no anastomotic leaks in any of subjects. 4.8 (4–6) days were the mean stay in hospital. In every case, the histopathologic examination indicated a nearly complete or complete mesorectum. The mean lymph node numbers extracted were 14 (10–20), and all cases achieved resection of R0. They came to conclusion that coupling transanal access as well as robotics in RC surgery is feasible and might facilitate better outcomes. In a series of 15 subjects, a combined sequential single-port (plus an auxiliary port) robotic transabdominal technique associated to R-TA TME was revealed by Kuo *et al*. [18]. A 473 (335–569) min was median operative time and 33 (30–50) mL was the calculated loss of blood. Because of a left ureteric transection and bleeding at the time of transanal phase, two subjects needed conversion to conventional laparoscopy. 12.2 (10–14) days were mean length of stay in hospital. Every specimen was noted of having a complete mesorectum with clear DRM as well as clear CRM. The researchers found that using technology of robotics in a combined transabdominal and transanal approach for low rectal lesions is viable and might provide advantages in comparison to traditional laparoscopy. R-TATME was published by Monsellato *et al*. [22] on three subjects (two males) who underwent combined method. Location of tumors was at 4 (3–6) cm mean distance from anal verge, cancers of Stage III treated with upfront chemoradiation. Five hundred and fifty (440–600) min was the mean operative time and 10 (7–15) days were the stay length. All specimens had negative margins and were complete TMEs. RATS-TME was found to be both safe and feasible in conclusion. Hu *et al*. [23] published R-TA TME on 20 patients using simultaneous laparoscopic transabdominal approach through a single port (through ileostomy site) and R-TA TME with da Vinci Xi System with a GelPoint Path in a two-team approach. 6.0 (2–10) was mean distance between the tumor and the anal verge. Subjects with Stage III malignancies accounted for 50% of the total, with 60% undergoing neoadjuvant therapy. Eighty-eight (30–500) mL was the mean intraoperative loss of blood. All the patients were reported of having nearly complete or complete mesorectal resections, and three of them seemed to have positive CRM (15%). It was later concluded by them that R-TA TME aided by laparoscopy is feasible and safe. The oncological results of the main studies found in the literature are reported below:

Quality TME C (complete)/NC (near complete)/I (incomplete), %

Verheijen *et al.* [24], 100/0/0; Gómez Ruiz *et al.* [20], 100/0/0; Atallah *et al.* [11], 25/75/0; Atallah *et al*. [12], 100/0/0; Huscher *et al.* [21], 85.7/14.3/0; Kuo *et al*. [18], 100/0/0; Hu *et al*. [23], 90/10/0; Monsellato *et al.* [22], 100/0/0; Suhardja *et al.* [25], 100/0/0; and Ye *et al.* [26], 61.5/38.5/0.

CRM+

None of the studies declared CRM+ except for Hu *et al*. 3/15 patients [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Distal margin+

No studies demonstrated positive distal margin [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Harvested nodes

From 14 to 33 harvested nodes [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

CRM, cm

From 0.88 to 3.2 cm [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Local recurrence

Hu *et al*. demonstrated only one local recurrence. All of the other studies demonstrated none local recurrence [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Blood loss

From 50 cc to 200 cc [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Conversion rate

No conversion to laparoscopic or open surgery. Only one study by Kuo *et al*. demonstrated 2/15 patients conversion rate [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

LOS (days)

3–10 days [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Operative time

165–550 min [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Transanal platform

All studies stated the use of GelPoint Path (daVinci® Si) [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Two-team approach

Only three studies demonstrated the use of double team. Hu *et al*. used two teams in 20/20 patients [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Abdominal approach

Only three studies used robotic approach during abdominal stage [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

Complications

One peristomal dermatitis/dehydration, one pulmonary embolism, two anastomotic leak, one anastomotic bleeding, one wound infection, one mechanical bowel obstruction, one acute renal failure, one post-operative ileus, 7/20 studies (no anastomotic leaks noted), and one duodenal hemorrhage [11], [12], [18], [20], [21], [22], [23], [24], [25], [26].

The results are summarized in Table 1.

Discussion

Treatment of RC remains a difficult frontier in general surgery, as there is no consensus on the optimal surgical method for its management. Indeed, a recent meta-analysis assessed the positive circumferential margins rate and the mesorectal excision quality in 14 different randomized control trials, indicating that the risk of attaining a non-complete mesorectal excision is still considerably higher in laparoscopic surgery [27]. Due to the fact that it has been found to improve local, regional clearance while also decreasing the likelihood of recurrence in mid-low RCs, TME is considered the standard gold treatment for this type of tumor (LR). R-TME and laparoscopy for RC therapy represent a substantial advance, with doubtful short-term and comparable long-term results [28]. In regard of abdominal approach, in the ROLARR investigation it has been determined that R-TME had no statistical considerable clinical or oncological benefit compared to L-TME. R-TME has no statistically significant benefit to L-TME when comparing CRM rates of 5.1 and 6.3%. For what concern the transanal approach, few studies such as case series and comparative studies that compare L-TA TME to R-TA TME failed to found short-term oncologic result in favor of R-TA TME. This technique seems to have advantages and disadvantages. Robotic technology allows for a more accurate dissection that follows oncological planes while evading damage to surrounding structures. To carry out purse-string suture or improve possibilities of managing unpredicted bleeding, 3D HD image with a stable camera viewing, or enhanced freedom of movement with tremor control, will be beneficial [23]. A subjective experience of performing a higher TME quality was noted at the time of robotic dissection, in addition to these benefits [21]. The transanal route provides for higher distal margin control at the procedural beginning. Furthermore, when compared to traditional procedures, the robotic system provides added benefits such as improved ambidexterity during lateral dissection and more stable surgical fields [23]. The autonomic function as well as preservation of pelvic nerves is also facilitated by reducing angular restriction in the space of narrow pelvic [12]. However, use of robotic platform has many disadvantages. A limited access and an increased cost for most of surgeons all around the world are constraints associated with the robotic surgery (RS) usage, which have become greatest anchor for technology dissemination. According to research with respect to cost analysis, RS for CRC is very costly compared to laparoscopic as well as open surgery [29], [30]. Through ROLARR trial, it was discovered that the expenditures of robotic rectal surgery were higher in group who underwent robotic-assisted laparoscopy (13,668 dollars or 11,853 pounds) in comparison to group who underwent conventional laparoscopy (12,556 dollars or 10,874 pounds) [28]. Atallah *et al*. [12] observed a rise in expense of 1500 dollars per case for robotic transanal surgery, which included the GelPOINT® Platform. Operative time can be expected high because lack the possibility to use simultaneous two-field interventions. In addition, the daVinci® Si needed a minimum intertrocar distance more than 8 cm can be cause harms conflict, external clashes, and collisions. The use of robotic platform can cause the loss of force feedback. The arms of robot are intrusive as well as large, which makes the work very challenging in transanal surgery or single-port setting. Finally, for what concern learning curve, RS

Table 1: Pathologic, oncological, and functional outcomes

Ref.	Tumor size, cm	Quality TME (I/II/III), %	CRM +	Distal margin +	Harvested nodes	DAV, cm	CRM, cm	Follow-up, mo	Local recurrence	Distant progression, m	Functional (urinary/sexual)
Verheijen et al [26], 2014		100/0/0	No	No		2					
Gómez Ruiz et al [29], 2015		100/0/0	No	No	14 ± 91	1.8 (1-2.5)[2]		3 (3)[2]	No		
Atallah et al [30], 2015	2.7 (1.5-3.5)[2]	25/75/0	No	No	27 (15-39)[3]	3.3 (1-5) 3		8 (6-12)[3]	No	No	
Atallah et al [31], 2015	3	100/0/0	No	No	33	0.4					
Huscher et al [32], 2015		85.7/14.3/0	No	No	14 ± 31	2.7 ± 21	3.2 ± 1.8[1]	2.5 (2-3.5)[2]			
Kuo et al [33], 2017		100/0/0	No	No	12 (8-18)[3]	1.4 (0.4-3.5)[3]	0.7 (0.2-2.6)[3]				
Hu et al [34], 2020	3.3 ± 1.5[1]	90/10/0	3 (15)	No	18.7 ± 6.31	2.9 ± 1.31	0.88 ± 0.78[1]		1 (5) 18 m	1 (5) 7	
Monsellato et al [35], 2019		100/0/0	No	No				12 (12)	No	No	
Tan et al [36], 2020								7	No	No	
Suhardja et al [37], 2020		100/0/0	No	No	24			12	No	No	No
Ye et al [38], 2021	3 (2-4) [4]	61.5/38.5/0	No	No	15 (13-16)[4]	2 (1.5-2.5)[4]		15 (11-18)[4]	No	No	

[1]mean ± SD.
[2]Mean value (range).
[3]Median (range).
[4]Median (interquartile range).
CRM: Circumferential resection margin, DAV: Distance from anal verge, TME: Total mesorectal excision

requires special training. To gain expertise in robotic TME, at least 20–23 cases are required [31]. On the other hand, R-TA TME is complex as well as technically demanding procedure. The learning curve for R-TA TME has not yet been fully determined, however, it has been estimated in approximately 40 cases. The cost of operation for robotic TME may be lowered after a learning curve, but the overall expenses, comprising fixed expenses, will be still high because of pricey robotic system purchase charge (robotic platform's average cost is $1to $2.3million) [32], [33], [34]. TA TME was coined in the year 2010 by Sylla *et al*. [6] to overcome challenges and difficulties of resecting a low RC. Ta TME acceptance increased swiftly. Because of the improved exposition and ergonomics of rectal anatomy and surrounding structures, this technique was predicted to provide significant benefits. These enhancements were anticipated to result in lower conversion rates, less post-operative difficulties, and a greater probability of performing a successful oncologic resection. However, substantial anastomotic failure rates, carbon dioxide embolisms, and urethral injuries were seen in outcomes of most prominent international TA TME registry. Furthermore, when compared to standard laparoscopic TME, the TA TME failed to demonstrate any substantial increase in functional results in a recent meta-analysis. Indeed, Norwegian TA TME Collaborative Group recently stated higher anastomotic leak rate in TA TME subjects in comparison to those in NoRGast study ($p = 0.047$, 8.4 vs. 4.5) and increased local recurrence rates (7.6%), with few of them presenting with an atypical multifocal pattern. The use of TA TME for RC in Norway has been suspended as a result of these findings. In this consequence, we also concur with recommendation to await for more randomized control trails which shall offer sufficient evidences either to reject or support definitively TA TME and even more R-TA TME [35], [36], [37], [38].

Conclusion

Despite the literature on R-TA TME has few manuscripts, this interesting new technique is gaining traction, and pre-clinical or pilot reports' outcomes in terms of resection margins, mesorectal integrity, number of lymph nodes extracted intraoperatively, and rate of conversion are all promising. R-TA TME was proposed as a revolutionary technique that combines the advantages of TA TME and robotic technology. This combination might be able to overcome limits of traditional laparoscopic TME while simultaneously addressing few issues associated with traditional TA TME. R-TA TME, on the other hand, has a limited amount of experience and lack of RCTS studies. This procedure has only been performed on a small number of people so far. Furthermore, no data on long-term follow-up have been disclosed by any team. Preliminary findings ought to be taken with utmost care, and well-designed comparison studies are required before this potential strategy can be approved. In the coming days, developing robotic capabilities will create significant competition, resulting in cost reductions, while the advent of tiny surgical instruments will shape the future of endoluminal operations. Together with technological refinements and established training programs, these developments may pave the way for robot-assisted operations to become the benchmark for TA TME.

Authors' Contribution

All authors made the same contribution to this article.

Acknowledgment

My special wife, Silvana Leanza MD, Department of General Surgery, Carlo Urbani Hospital, Jesi (AN), Italy.

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