Lower Gastrointestinal Surgery: Robotic Surgery versus Laparoscopic Procedures

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Keywords

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Summary

Introduction: For a long time, the comprehensive application of minimally invasive techniques in lower gastrointestinal (GI) surgery was substantially impaired by inherent anatomical and technical complexities. Recently, several new techniques such as robotic operating platforms and transanal total mesorectal excision (taTME) have revolutionized the minimally invasive approach. This review aims to depict the current state of the art and evaluates the advantages and drawbacks in regard to perioperative outcome and quality of oncological resection. **Methods:** A systematic literature search was performed using the search terms ‘colorectal cancer’, ‘rectal cancer’, ‘minimally invasive surgery’, ‘laparoscopic surgery’, and ‘robotic’ to identify relevant studies reporting on robotic surgery (RS) either alone or in comparison to laparoscopic surgery (LS). Publications on taTME were analyzed separately. **Results:** 69 studies reporting on RS with a total of 20,872 patients, and 17 articles on taTME including 881 patients, were identified. **Conclusion:** Both RS and taTME can facilitate a minimally invasive approach for lower GI surgery in an increasing number of patients. Furthermore, combining both techniques might become an auspicious approach in selected patients; further prospective and randomized trials are needed to verify its benefits over conventional taTME.

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Introduction

In recent years, several innovative techniques have fundamentally changed the landscape of visceral surgery. The laparoscopic approach, which found widespread acceptance after 1987 following the evolution of video technology [1], became a crucial milestone and formed the basis for the development of various minimally invasive surgical techniques. Conventional open procedures were gradually superseded by laparoscopic surgery (LS). Pivotal benefits of LS include decreased postoperative pain, improved cosmetic results, reduced length of hospital stay (LOS), faster recovery back to normal diet and bowel function, along with comparable oncological outcome [2–7].

In lower gastrointestinal surgery, the broad implementation of minimally invasive procedures has been substantially hampered by the demanding anatomical and technical complexities of colorectal surgery such as the narrow male pelvis, obesity, locally advanced disease, low rectal masses, or the necessity of intracorporeal ileocolic anastomosis [8, 9]. Moreover, certain pitfalls of the laparoscopic approach, such as 2-dimensional vision, tremor, and limitations in triangulation and motility, potentially impede the procedure. Resulting in overall conversion rates of up to 30% [2, 5, 10–14], which is associated with poor oncological outcome and higher morbidity [2, 15], these drawbacks crucially impair surgical outcome [8, 9, 16]. Bridging this gap, several advancements now serve to facilitate minimally invasive surgery in challenging surgical situations.

The most profound change has resulted from the development of robotic operating platforms. First described in 2001 [17], the robotic approach has found increasing acceptance in colorectal surgery. Its implementation has been driven by several advantages of robotics: In particular, a stable camera platform with 3-dimensional imaging and tremor filtering, instruments with multiple degrees of freedom, motion scaling, ambidextrous capability, a third arm for fixed retraction, better ergonomics, and less fatigue [18–21]. Nevertheless, downsides of robotic surgery (RS) need to be borne in mind, such as high costs, bulky cart, longer operating time, and lack of haptic sense [22]. Colorectal LS and RS have been

Table 1. Characteristics of publications on transanal total mesorectal excision (taTME)

Author [ref.]	Journal	Year	Country	Study design	Overall (n = 881)	laTME (n = 257)	taTME (n = 187)	Sex, male/female, n		BMI, mean $\pm$ SD/median (range)		Tumor location	
								laTME	taTME	laTME	taTME	p	p
Dumont [61]	Dis Colon Rectum	2012	France	CS	4	4	4	4/0	23.3 $\pm$ 1.7			mid/low	
Rouanet [62]	Dis Colon Rectum	2013	France	CS	30	30	30	30/0	26.0 (21.0–32.4)			mid/low	
Sylla [63]	Surg Endosc	2013	Korea	CS	5	5	5	3/2	26.4 (24.0–27.1)			mid/low	
Lacy [64]	Surg Endosc	2013	Spain	CS	3	3	3	1/2	24.0 (16.0–25.0)			mid	
Velthuis [65]	Surg Endosc	2014	Netherlands	MCC	50	25	25	18/7	28 (21–34)			low/mid	0.07
Atallah [66]	Tech Coloproctol	2014	USA	CS	20	20	20	14/6	25.0 (20.0–36.0)			mid/low	
Chouillard [51]	Surg Endosc	2014	France	CCS	33	15	18	7/8	24.0 (18.0–41.0)	29.0 $\pm$ 4.2	27.1 $\pm$ 4.5	NR	0.22
Zorzon [67]	J Minim Access Surg	2014	Brazil	CS	9	9	9	5/4	NR			mid/low	
Atallah [68]	Tech Coloproctol	2014	USA	CS	3	3	3	2/1	36.0 (31.0–38.5)			low	
Fernandez-Hevia [69]	Ann Surg	2015	Spain	MCC	74	37	37	22/15	25.1 $\pm$ 4.0			low/mid	0.11
D'Angelis [70]	Langenbecks Arch Surg	2015	France	MCC	64	32	32	21/11	24.5 $\pm$ 3.2			low/mid	0.438
Lacy [71]	J Am Coll Surg	2015	UK	CS	140	140	140	89/51	25.2 $\pm$ 3.9			up/mid/low	
Tuech [72]	Ann Surg	2015	France	CS	56	56	56	41/15	27.0 (20.0–42.0)			low	
Gomez Ruiz [73]	Dis Colon Rectum	2015	Spain	CS	5	5	5	4/1	26.0 (23.5–28.5)			low	
Perdwood [74]	Colorectal Dis	2016	Denmark	MCC	50	25	25	19/6	26 (19–38)			low/mid	0.070
Chen [75]	Ann Surg Oncol	2016	Taiwan	MCC	150	100	50	76/24	24.6 $\pm$ 3.1			low/mid	0.572
Rasulov [76]	Tech Coloproctol	2016	Russia	CCS	45	23	22	14/9	26.0	26.0	26.0	mid/low	0.47

laTME = Laparoscopic total mesorectal excision; NR = not reported; BMI = body mass index in kg/m²; SD = standard deviation; CS = case series; CCS = comparative case series; MCC = matched case control trial.

shown to provide equal perioperative and oncological outcome even in patients presenting with complicated anatomical situations such as narrow male pelvis or obesity [22–28].

This review aims to provide an up-to-date literature review on studies reporting on minimally invasive techniques for colorectal malignancies. 69 publications on RS and LS as well as 17 studies on transanal total mesorectal excision (taTME) and laparoscopic TME (laTME) were evaluated. In particular, this review assesses perioperative outcome and oncological quality of resection.

Methods

A systematic literature search (PubMed, Science Direct, and Google Scholar) was conducted according to the PRISMA guidelines [29] using the search terms ‘colorectal cancer’, ‘rectal cancer’, ‘minimally invasive surgery’, ‘laparoscopic surgery’, and ‘robotic’. Publications on case series of RS either alone or in comparison to LS were eligible. The resulting reference list was complemented with additional hand-searched studies missed by this search strategy. Studies including non-malignant cases were excluded. Due to the large number of eligible robotic TME (roTME) publications, we considered only comparative case series published after 2010 with a minimum of 100 patients for closer analysis. A complete listing of all articles is provided in supplementary tables 1–4 (available at <http://www.karger.com/ProdukteDB/produkte.asp?doi=486008>). Publications on taTME were treated separately; articles on taTME case series were eligible as well. Duplicates were excluded in a first screening. After this, eligibility was proven based on the title, and the abstracts of all remaining articles were revised according to inclusion and exclusion criteria. Finally, full-text checks ensured that the articles met the inclusion criteria. Characteristics of the publications are depicted in supplementary table 1 (available at <http://www.karger.com/ProdukteDB/produkte.asp?doi=486008>) and table 1.

Robotic-Assisted Colorectal Surgery

Operative Time

One drawback of RS for colorectal cancer is the increased operative time leading to longer anesthesia, as shown by significant results of 25 publications (supplementary table 2; available at <http://www.karger.com/ProdukteDB/produkte.asp?doi=486008>). Compared to only 9 studies with comparable operative time, this clearly illustrates the current situation of RS.

In our experience, especially for roTME, the initial period including the learning curve is quite laborious. However, operating times comparable to laTME are achieved after 20–30 cases. It is noteworthy that the majority of current publications represent or at least include the learning curve of the respective surgical study group.

Another important aspect are multiquadrant operations: In cases of required simultaneous splenic flexure mobilization and rectal resection, robotic platforms are of limited use. To avoid a time-consuming second docking and additional trocars, some surgeons prefer to use a hybrid technique and perform splenic flexure mobilization laparoscopically.

Hospital Stay and Readmission

LOS was comparatively investigated by 32 studies; the majority found equal time to discharge following RS and LS (supplementary

table 2; available at <http://www.karger.com/ProdukteDB/produkte.asp?doi=486008>), although 8 publications revealed a significantly shorter LOS for RS. Out of 24 studies with equal results for LOS, statistical significance was barely missed in 2 series with a p value of 0.05, potentially due to an underpowered analysis.

Readmission was reported in 7 series; 6 presented equal results for RS and LS, whereas the most comprehensive multicenter matched case control study (MCC) revealed a significant difference with a slightly higher readmission rate for RS (9.1 vs. 9.4%; $p = 0.049$).

Morbidity

While LS in comparison with a conventional open approach convinces with reduced intraoperative complications and perioperative morbidity, shorter immobilization, less pain, and faster recovery [4, 6, 11, 30], it is questionable whether RS is capable of further improving perioperative convalescence.

This is endorsed by studies included in this review (supplementary table 3; available at <http://www.karger.com/ProdukteDB/produkte.asp?doi=486008>): Major and minor complication rates reveal equal perioperative morbidity for LS and RS. Merely 1 publication shows significantly less major complications for RS [31]. Several publications presented a reduced need of analgesics and shorter time to liquid or soft diet, others revealed equivalent results for postoperative diet.

In summary, while LS already reduces postoperative major morbidity to a low level of 0–20%, RS is capable of providing equal postoperative morbidity.

Conversion Rate

Several complexities of colorectal surgery can limit the technical feasibility of conventional LS leading to conversion rates of up to 5–30% [32]. However, conversion to an open approach, while providing technical feasibility, is also associated with increased morbidity, higher rates of metachronous metastasis and local recurrence, as well as poor disease-free survival, in-hospital mortality, and transfusion requirements [2, 33–37].

Out of 69 evaluated publications, 32 reported comparatively on conversion rates (supplementary table 3; available at <http://www.karger.com/ProdukteDB/produkte.asp?doi=486008>). 4 studies showed significantly lower conversion rates for RS, and 28 revealed non-significant results: 7 publications showed higher conversion rates for RS, whereas 16 reported on lower and 5 on equivalent rates. 1 huge MCC trial demonstrated significantly higher conversion rates for RS. In all cases, several aspects of study design seem to affect the results. On the one hand, despite huge differences in conversion rates (e.g., LS vs. RS, 11.1:0%; 20:5%; 10.5:5.2%), plenty of studies did not reach statistical significance. The vast majority of included publications are retrospective analyses and represent the surgical learning curve. As the evidence grade is currently low for RS, further publications are needed to clarify whether this is the result of underpowered analysis. Furthermore, upcoming studies with exclusion of initial cases might potentially reveal different conversion rates. Overall, the current literature demonstrates equal to lower conversion rates for RS.

Nerve-Sparing Procedure

Improved functional outcome has been reported following RS due to nerve-sparing surgical techniques. Significantly more voiding dysfunction following LS compared to RS was found by Cho et al. [38]. Furthermore, this study reported on equal rates of sexual dysfunction, whereas RS, in a prospective case series by Kim et al. [39], was associated with faster recovery of bladder voiding and sexual function.

Quality of Mesorectal Excision

Several pathological details serve as surrogate parameter for locoregional tumor clearance. Among them, completeness of TME is a main parameter for quality of oncological resection [40]. Especially in circumferential resection margin(CRM)-negative patients, substantial damage to the mesorectal specimen is a main risk factor for local recurrence [41]. Poor quality of mesorectal resection has been shown to be associated with low rectal tumors [40, 42].

Comparable results for the quality of TME with RS and LS are reported by 12 out of 14 comparative publications. Baik et al. [22] demonstrated significantly higher TME quality following LS in a randomized trial of 18 RS patients, whereas Allemann et al. [43] showed higher TME quality for RS (95 vs. 55%; $p = 0.0003$).

Oncological Outcome and Efficiency

Besides TME quality, a positive CRM provides high predictive value for local recurrence and worse disease-specific survival [40, 44, 45]. Similar to poor TME quality, a significant association of positive CRM with low tumors has been demonstrated [40, 42].

RS provided an equal proportion of positive CRM in 23 studies. D'Annibale et al. [46] showed a significantly smaller proportion of positive CRM for RS compared to LS (LS vs. RS, 12 vs. 0%; $p = 0.022$).

A total of 33 publications reported comparatively on harvested lymph nodes. 26 studies found equal results, whereas 4 studies showed significantly more retrieved lymph nodes for RS and 3 studies found more lymph nodes following LS (supplementary table 4; available at <http://www.karger.com/ProdukteDB/produkte.asp?doi=486008>).

As already mentioned, data with higher evidence on RS in colorectal malignancies is scarce. 2 randomized trials and 10 MCC studies are included in this analysis.

Cho et al. [38], in an MCC, revealed for RS and LS not only no differences in oncological surrogate parameters such as CRM or TME quality but also equal results for disease-specific survival, overall survival, and 5-year disease-free survival.

In 2018, the publication of the first randomized controlled trial (RCT) comparing robotic and laparoscopic rectal resection is expected. The ROLARR trial is a superiority trial observing resection margins, 3-year local recurrence, and disease-specific survival [47]. First presentations at international conferences (ASCO 2016 and ACS 2016) revealed similar surgical quality and safety. Additionally, a subgroup analysis showed lower conversion rates in demanding cases such as obese male patients with bulky and low tumors.

Table 2. Operation time, hospital stay, and readmission in publications on transanal total mesorectal excision (taTME)

Author [ref.]	Year	Study design	Operation time			Hospital stay			Readmission		
			laTME, min	taTME, min	p	laTME, days	taTME, days	p	laTME, %	taTME, %	p
Dumont [61]	2012	CS		360 (270–460)			13 (3–8)			NR	
Rouanet [62]	2013	CS		304 (120–432)			14 (9–25)			NR	
Sylla [63]	2013	CS		274.6 ± 85.4			5.2 ± 2.6			20	
Lacy [64]	2013	CS		143			5 (4–5)			33.3	
Velthuis [65]	2014	MCC	NR	NR		NR	NR		NR	NR	
Atallah [66]	2014	CS		243 (140–495)			4.5 (3–24)			NR	
Chouillard [51]	2014	CCS	275 ± 58	245 ± 66	0.18	9.4 (6–19)	10.4 (4–29)	>0.05	NR	NR	
Zoron [67]	2014	CS		311			7.56			NR	
Atallah [68]	2014	CS		380 (339–409)			4 (4–5)			66.6	
Fernandez-Hevia [69]	2015	MCC	252 ± 50	215 ± 60	< 0.01	6.8 ± 3	9 ± 7.6	0.1	22	6	0.03
D'Angelis [70]	2015	MCC	225 ± 51.7	195 ± 43.6	0.017	9.8 ± 4	7.8 ± 2.1	0.018	9.4	6.2	1.0
Lacy [71]	2015	CS		166 ± 57			6 (5–9)			NR	
Tuech [72]	2015	CS		270 (150–495)			10 (6–21)			NR	
Gomez Ruiz [73]	2015	CS		370 (256–445)			6 (5–7)			NR	
Perdawood [74]	2016	MCC	351 (220–480)	300 (235–420)	0.002	14 (4–50)	5 (2–43)	0.020	16	16	1.0
Chen [75]	2016	MCC	178.7 ± 34.8	182.1 ± 55.4	0.632	7.1 ± 3.8	7.4 ± 2.5	0.425	110	6	0.415
Rasulov [76]	2016	CCS	305 (210–455)	320 (265–495)	0.624	8 (4–17)	8 (6–18)	0.606	NR	NR	

laTME = Laparoscopic total mesorectal excision; NR = not reported; CS = case series; CCS = comparative case series; MCC = matched case control trial.

Transanal TME

The technique of taTME was retrospectively compared to open surgery and conventional LS in various trials proposing taTME to be safe and feasible [48, 49]. Furthermore, studies suggest that taTME has certain advantages in low rectal resection compared to LS or open surgery such as lower conversion rates, especially in obese patients, and better preservation of autonomic function, while oncological results are similar [50]. So far, little data exists on comparative or matched-pair analyses regarding laTME and taTME, not to mention roTME. Table 1 demonstrates patient characteristics with most studies including cancers in both the mid and the low rectal third; however, none of them preformed subgroup analyses, which would have been interesting especially with regard to location-dependent differences in oncological outcome (e.g., COLOR II trial) [32].

Operation time in the taTME group was significantly shorter in 3 studies where 2-team approaches for taTME were feasible, with significantly shorter LOS in 2 of the studies and a significantly lower readmission rate in 1 study (table 2). Minor and major complications rates as far as reported were similar in the laTME and the taTME group with conversion rates from 0% in most studies to 44% in 1 small series of 33 patients undergoing taTME [51] (table 3). Regarding pathological surrogate parameters, completeness of TME (complete or nearly complete) was achieved in >90% of the taTME specimens in most of the studies with one showing a significant difference compared to laTME (table 4). No significant difference was observed with regard to CRM and number of harvested lymph nodes.

In a comparative study of our own data, robotic low anterior resection (RLAR) and taTME for rectal cancer were equal with regard to oncological surrogate parameters, suggesting that both pro-

cedures are equally applicable for resection of low rectal cancer especially in patients with anatomical limitations such as male gender and bulky tumors (unpublished data). No differences were found between intraoperative complication and conversion rates.

Conclusion

The multicenter randomized trials COLOR II and COREAN showed equal disease-free survival and local recurrence for laTME and conventional open resection [3, 32]. Conversely, non-inferiority could not be demonstrated for laTME in comparison to open surgery in the latest published multicenter randomized trials ALaCaRT and ACOSOG-Z6051 [52, 53]. However, ALaCaRT and ACOSOG-Z6051 based their analysis on pathological surrogate parameters for oncological outcome only, such as negative distal and circumferential margins and quality of TME, whereas follow-up parameters are not provided [52, 53].

A comparison to COLOR II, which revealed a significantly higher percentage of CRM-positive resections in the subgroup of lower rectal cancer following open resection [30] and showed equivalent disease-free survival and local recurrence in a 3-year follow-up [32], sheds a different light on these findings.

The CLASICC trial as the first RCT comparing laparoscopic versus open resection for colorectal cancer in 2005 provided comparable outcomes for the laparoscopic and the open approach [2]; nevertheless, conversion to open surgery was associated with a higher chance for positive CRM along with an increased risk for local recurrence. Later RCTs such as COLOR II and COREAN could not reproduce an association of conversion with positive

Table 3. Major and minor complication and conversion rates in publications on transanal total mesorectal excision (taTME)

Author [ref.]	Year	Study design	Major complication rate, CD III–V			Minor complication rate, CD I–II			Conversion rate		
			laTME, %	taTME, %	p	laTME, %	taTME, %	p	laTME, %	taTME, %	p
Dumont [61]	2012	CS	NR	NR		NR	NR			0	
Rouanet [62]	2013	CS		NR			NR			6.7	
Sylla [63]	2013	CS		0			60			0	
Lacy [64]	2013	CS		0			33.3			NR	
Velthuis [65]	2014	MCC	NR	NR		NR	NR		NR	NR	
Atallah [66]	2014	CS		NR			NR			NR	
Chouillard [51]	2014	CCS	NR	NR		NR	NR		26.7	44.4	0.47
Zoron [67]	2014	CS		11.1			NR			11.1	
Atallah [68]	2014	CS		0			33.3			0	
Fernandez-Hevia [69]	2015	MCC	14	8	0.17	38	25	0.17	0	0	–
D’Angelis [70]	2015	MCC	15.6	6.2	0.663	21.9	18.8	0.663	3.1	3.1	1.0
Lacy [71]	2015	CS		10			23.6			0	
Tuech [72]	2015	CS		NR			NR			4.3	
Gomez Ruiz [73]	2015	CS		0			20			0	
Perdawood [74]	2016	MCC	NR	NR		NR	NR		16	0	0.055
Chen [75]	2016	MCC	4	2	–	0.13	0.12	–	5	2	0.380
Rasulov [76]	2016	CCS	8.6	0	0.661	17.3	27	0.661	4.3	4.5	0.368

laTME = Laparoscopic total mesorectal excision; NR = not reported; CS = case series; CCS = comparative case series; MCC = matched case control trial; CD = Clavien-Dindo classification for postoperative complications: I – any deviation from normal postoperative course without the need for pharmacological treatment or surgical, endoscopic and radiological interventions; allowed therapeutic regimens are: drugs such as antiemetics, antipyretics, analgesics, diuretics, and electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside. II – requiring pharmacological treatment with drugs other than such allowed for grade I complications. Blood transfusions and total parenteral nutrition are also included. III – requiring surgical, endoscopic, or radiological intervention. IV – life-threatening complication (including central nervous system) requiring intensive care. V – death of a patient.

Table 4. Pathological outcome in publications on transanal total mesorectal excision (taTME)

Author	Year	Study design	Completeness of TME			Positive circumferential margin			Harvested lymph nodes	
			laTME, %	taTME, %	p	laTME, %	taTME, %	p	taTME/roTME : laTME	p
Dumont [61]	2012	CS		100			0		16 (8–22)	
Rouanet [62]	2013	CS		100			6.7		3 (8–32)	
Sylla [63]	2013	CS		100			0		33 ± 15	
Lacy [64]	2013	CS		100			0		NR	
Velthuis [65]	2014	MCC	72	96	<0.05	8	4	–	14 (7–24) : 13 (1–36)	0.42
Atallah [66]	2014	CS		55			5		22.5 (9–51)	
Chouillard [51]	2014	CCS	77.8	53.3	0.41	NR	NR		10.8 ± 4.3 : 12.3 ± 9.9	0.61
Zoron [67]	2014	CS		66.7			11.1		13	
Atallah [68]	2014	CS		33.3			0		35 (18–39)	
Fernandez-Hevia [69]	2015	MCC	94.6	91.9	0.6	0	0	–	14.3 ± 6 : 14.7 ± 6	0.94
D’Angelis [70]	2015	MCC	75	84.4	0.611	9.4	3.1	0.342	17.06 : 18.63	0.697
Lacy [71]	2015	CS		97.1			6.4		14.7 ± 6.8	
Tuech [72]	2015	CS		84			5.7		12 (7–29)	
Gomez Ruiz [73]	2015	CS		100			0		14 ± 9	
Perdawood [74]	2016	MCC	68	80	0.113	16	4	0.349	21 (9–42) : 22 (7–45)	0.778
Chen [75]	2016	MCC	NR	NR	<0.05	NR	NR		16.7 ± 7.8 : 17.4 ± 8.9	0.553
Rasulov [76]	2016	CCS	74	68	0.859	0	4.5	0.31	17 (0–54) : 20 (8–56)	0.144

laTME = Laparoscopic total mesorectal excision; NR = not reported; CS = case series; CCS = comparative case series; MCC = matched case control trial.

CRM [3, 30]. As the CLASICC trial represents the learning curve of LS, this might explain the differences in the findings.

However, LS continues to be challenging, especially for rectal cancer. A striking coefficient is the patient-specific individual anatomy

and tumor manifestation: A narrow male pelvis, obesity, and bulky and low tumors can substantially hamper LS [8, 9, 16, 28]. Hence, RS was proposed and has already demonstrated ability to address the problem of anatomical limitations in low anterior resection.

Shorter LOS, less pain, and lower demand for analgesics result in faster convalescence after roTME. Several authors consider less tissue trauma in RS due to subtle retraction by robotic arms and fine dissection as a main reason for less pain and shorter LOS [22, 54]. Overall, this underlines the safety and feasibility of colorectal RS.

Feasibility is also reflected in a shorter learning curve: Especially in roTME, fewer cases are needed for surgeons to adapt to the robotic technique in comparison to its laparoscopic counterpart. Jimenez-Rodriguez et al. [55] suggested 21–23 cases, which is in line with the 20 cases recommended by Kim et al. [56]. Bokhari et al. [57] suggested 15–25 cases. All are less compared to 35–50 cases recommended by Wishner et al. [58] for laTME.

As evidence level 1 publications on RS for rectal malignancies are still rare, this analysis is mainly based on retrospective analyses and a non-controlled randomized trial. 2 RCTs, 1 reporting on 36 cases of right colectomy and the other on 162 cases of rectal cancer,

are the only available evidence level publications. Even though this data reveals the safety and feasibility of RS, no high-evidence trials are available to support this finding. TaTME is a promising alternative to conventional laTME addressing anatomical limitations like male, narrow, obese pelvis, with similar oncological outcomes and a tendency towards shorter operation times and LOS.

In conclusion, RS is a promising tool for the implementation of minimally invasive surgery in an increasing number of patients. A combination of both taTME and RS will likely become a promising strategy in selected patients [59], while prospective randomized trials are needed to prove the advantages of this approach over conventional laTME [60].

Disclosure Statement

There are no personal conflicts of interest of any of the authors.

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