Original article

Robotic-assisted Surgery Versus Conventional Laparoscopic Surgery in Treatment of T2 and T3 Rectal Cancer

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Abstract

Background: Several randomized trials have demonstrated that robotic and laparoscopic surgery for rectal cancer is safe and can accelerate recovery without compromising the oncological outcomes. The goal of the study is to compare short- and long-term outcomes of robotic-assisted surgery versus conventional laparoscopic surgery for rectal cancer patients. **Patients & Methods**: From January 2014 to October 2018 at Klinikum Magdeburg, Germany, 46 patients with rectal cancer were operated using the robotic approach (RRR). Another 28 patients were operated using the laparoscopic approach (LRR) and matched to patients in the robotic group by sex, age, BMI, Tumor-stage and procedure. The patients in (RRR group) were further subdivided into five subgroups and compared according to the sequential order of their procedures per year to assess the effect of learning curve. **Results:** The operative times were longer with robotic resections *(P=.001).* The time to resumption of a soft diet was approximately 1 day prolonged and length of stay was 2 to 3 days longer in LRR group, although these results were not significant. No significant differences were observed in the complication rates, short- and long-term outcomes between both groups. **Conclusion** The robotic surgery for rectal cancer patients is safe and feasible. Furthermore, the results indicated that the perioperative outcomes of robotic surgery may be comparable to those of laparoscopic surgery. Although the robotic approach may offer potential advantages for rectal surgery, comparable short- and long-term outcomes may be achieved when laparoscopic surgery is performed by experienced surgeons.

Keywords: Robotic rectal surgery, Outcomes, learning curve.

Introduction:

The robot was first introduced to the surgical arena in the 1980s in the form of telesurgery [1]. Through several modifications and advancements since then, robotic surgery has established itself as a valid option for patients undergoing certain surgical procedures [2-4].

A large breadth of literature has been published comparing the benefits of robotic and laparoscopic surgery for colorectal cancers and the data thus far suggests that robotic rectal surgery is safe and feasible. Laparoscopic rectal surgery offers an advantage over the robotic ones when looking at operative time, the steep learning curve, and operative costs [5, 6]. However, the laparoscopic surgery for rectal cancer have also been highlighted, with being the limited range of motion with only four degrees of freedom, loss of dexterity, and two-dimensional visualization [2, 7–10].

In addition, robotic surgeries may offer an advantage in dissection in the deep pelvis especially in patients who have undergone neoadjuvant therapy [2, 9]. While each surgical method offers some advantages over the other, several studies have demonstrated comparable outcomes between robotic and laparoscopic rectal surgery for intraoperative morbidity, complication rates, and postoperative recovery [1, 9, 11, 12].

It's known that the quality of the surgical specimen and the long-term oncological outcomes of laparoscopic surgery are equivalent to those of open surgery. However, the recovery, the physiological functions, and other short-term outcome measures improve obviously after laparoscopic surgery [13–16]. The laparoscopic surgery for rectal cancer is technically demanding, limiting its application in nonspecialized centers. The restricted movement of the rigid instruments, anatomical confinement of the pelvis, amplification of the tremor from the fulcrum effect, and unstable image provided by the hand-held camera contribute to the difficulty of this procedure [17]. The influence of these factors is more pronounced for mid and low rectal cancer. This observation is reflected by a conversion rate as high as 8% for laparoscopic surgery for rectal cancer [18–20].

Neoadjuvant chemoradiation therapy (nCRT) for rectal cancer has been shown to reduce the local recurrence rate and increase the sphincter preservation rate [21-23]. Performing nCRT in patients with ≥T3 or N-positive rectal cancer has become a clinical routine in most institutions [24].

However, its post-treatment effects, such as tissue fibrosis and edema, further contribute to the difficulty of the laparoscopic procedure. Several studies have demonstrated equivalent outcomes and potential benefits of the robotic approach for pelvic diseases [17, 26 & ,27]. Other studies have specified that robotic surgery for rectal cancer results in more favorable outcomes in patients with unfavorable clinical characteristics, such as obesity, male sex, receiving nCRT, and tumors in the lower two-thirds of the rectum [25 & 28]. However, no solid evidence demonstrating the superiority of the robotic procedure over the conventional laparoscopic procedure is available to support its general adoption for rectal surgery, particularly considering its high cost [29 & 31].

Methods and patients:

Our type of study is a comparative study. The legalization was approved by of Benha ethical committee. Between January 2014 and October 2018, at Klinikum Magdeburg, Germany and Benha University hospital, 46 patients were operated on by using the DaVinci Si HD Robotic System (Intuitive Surgical Inc., Sunnyvale, CA) at our institution. These patients were included in the robotic (RRR) group.

For further comparison and for assessing the effect of the learning curve on the Outcome measures for the robotic approach, the patients in the robotic group were further subdivided into the first (RRR1: 2014), second (RRR2: 2015), third (RRR3: 2016), fourth(RRR4: 2017) and fifth (RRR5: 2018) groups according to the sequential order of their procedures per year. During the same period, another 28 patients were operated on by using the conventional laparoscopic approach (LRR group) without or after receiving nCRT and were matched to patients in the robotic group by age, sex, the body mass index, Tumor-stage and procedure. Moreover, in order to improve objectivity and approximate a randomized controlled study, we used the propensity score matching method. The matching was successful because the ROC analysis showed a well-balanced curve ($C = 0.427$). Nevertheless, the inclusion and exclusion criteria remained constant throughout the study for both groups. The robotic and laparoscopic operations were performed by a single surgical team. The oncological outcomes such as lymph node (LN) extraction, circumferential resection margin (CRM), and distal resection margin (DRM), overall survival (OS) and disease-free survival (DFS) for the two methods have been reviewed in our study.

Patient selection:

Inclusion criteria:

- Patients with T2 and T3 rectal carcinoma, with tumor-margin between (2-15) cm from anal verge.
- Adequate preoperative sphincter function and continence.
- Absence of local spread and distant metastasis.

Exclusion Criteria:

- Contraindications to major surgery and (ASA) Physical Status scoring 4.
- Those in Dukes stage D ´´locally advanced´´ (T4 lesion).
- Tumor located less than 2 cm above the anal verge.
- Evidence of preoperative fecal incontinence.
- Patients unwilling to take part in the study.
- Patients with undifferentiated tumors.
- Patients with intestinal obstruction.
- Metastatic rectal cancer.

Operative steps of robotic surgery for rectal cancer

Patients were placed in a flat modified lithotomy position with the head down at 30° and the right side down at 20°. We used 5 ports for the procedure. A 12-mm umbilical trocar was inserted to create a port for the camera. Three 8-mm da Vinci trocars were inserted at the right lower, right upper and left upper abdomen. A 12-mm port was inserted at the right lateral abdomen to create a port to be used by the assistant surgeon. After lymph node dissection, the inferior mesenteric artery was divided at its root. The inferior mesenteric vein was divided at approximately the same level. The splenic flexure was mobilized to facilitate a tension-free anastomosis, as required. Pelvic dissection was performed according to the principles of total mesorectal excision (TME). The tumor-bearing bowel segment was eventually resected through endoscopic stapling or intersphincteric resection, and bowel continuity was restored using the intracorporeal double stapling technique or transanal hand-sewn suture.

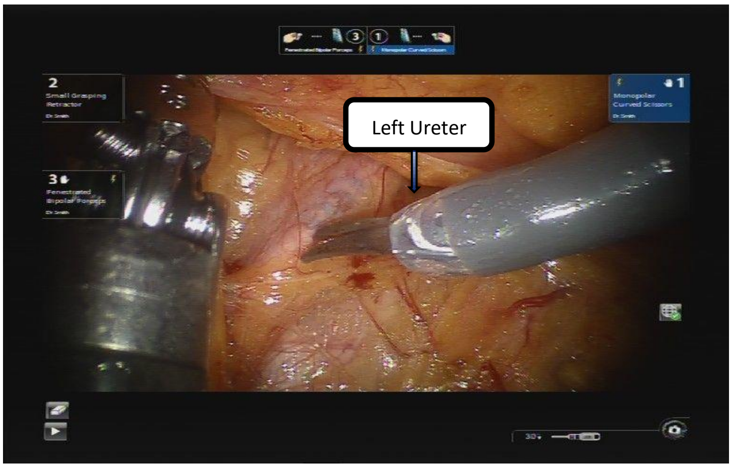

Figure 1: showing medial to lateral dissection with left ureter representation

The outcome measures:

The operation time and intraoperative blood loss were recorded. Conversion was defined as the unintended extension of laparotomy beyond the routine incision length (5 cm) necessary for specimen retrieval. A diverting stoma was created at the level marked by the Stoma therapist. Bowel continuity was restored after the completion of adjuvant chemotherapy. For 44 patients, the adjuvant chemotherapy and for 5 Patients the adjuvants CRT were administered. This was 4 to 6 weeks after rectal resection.

The histopathological parameters of the surgical specimens, including proximal and distal resection margin, circumferential resection margin (CRM), and the number of lymph nodes harvested, were recorded to assess the quality of surgery. The CRM was considered positive (R1) if cancer cells were observed microscopically within 1 mm of the CRM

[15]. The response to nCRT was classified using the tumor regression grade scale proposed by *Dworak et al* [32]. Morbidity and mortality events that occurred 30 days postoperatively were recorded. For specificity, anastomotic leakage was defined as the clinical or radiological evidence of a defect of the integrity of the anastomotic site [33].

Statistical analysis:

Analysis of data was performed using Statistical Package for Scientific Studies (SPSS) version 23 for Windows (IBM SPSS, Inc., Chicago, IL). The description of quantitative variables was in the form of mean, standard deviation (SD) and range for parametric data, and median and interquartile range for non- parametric data. The Kolmogrov-Simrnov test for detection of normality distribution was used. The description of qualitative variables was in the form of numbers (No.) and percent (%). Chi-square test was used to compare categorical variables while independent samples t-student test was used to compare the continuous variables between the two groups. The significance of the results was assessed in the form of P-value that was differentiated into: Non-significant when P-value > 0.05,

Results

Patient characters

The mean age of the study population was 69.5 ± 11 years (range: 33–90 years). A 63% of the patients were male patients with a mean body mass index (BMI) of 29.0 ± 3.8, and about 29.5% had a history of previous abdominal surgery as shown in Table 1.

Table 1: Showing patients' characters of study population in both groups

Patient characters	Subgroups	LRR	RRR	P value
Age (years)	(Mean±SD)	74±11	65±11	0.164
	(Range)	(51 to 90)	(33 to 88)	
BMI (kg/m2)	(Mean±SD)	30± 4	28± 3.6	0.398
	(Range)	(24 to 44)	(19.5 to 36)	
Female	Number& percentage	11 from 28 (39.3%)	16 from 46 (34.8%)	0.427
Male	Number& percentage	17 from 28 (60.7%)	30 from 46 (65.2%)	
History of previous Surgery	Number& percentage	8 from 28(28.5%)	14 from 46 (30.5%)	0.682

Pathological characteristics (Tumor stage)

The two groups were similar with regard to the tumor size and the effect of the treatment with nCRT. A total of 48.64% (36/74) of patients showed a certain degree of response to nCRT, but none of the patients experienced complete regression in our study. The proximal and distal resection margins did not differ significantly between the groups. In our study we have found a total of 2 patients (one patient in each group) showed CRM involvement, the difference was also nonsignificant (P=0.535). The size of pathological tumor was statistically similar between the two groups (*P <0.001**). However the mean numbers of lymph nodes harvested were 13.9 in the RRR group (range: 4–25) and 16 (range: 4–37) in the LRR group, which was statistically different in both groups (*P <0.001**) as shown in Table 2.

Table 2: Showing the pathological parameters in the surgical specimen in both groups

	Group	LRR	RRR	p value
Proximal margin, cm	(Mean±SD)	11.36 ± 3.68	9.76±3.59	*(P <0.001*)*
Distal margin, cm	(Mean±SD)	9.25±4.12	7.41±7.41	*(P <0.001*)*
Circumferencial margin	involved	0	2(4.4%)	*(P <0.001*)*
	uninvolved	28	44(95.6)	
Tumor size, cm	Mean±SD	2.11±0.74	2.35±0.74	*(P <0.001*)*
Treatment effect	Grade 0	0	0	*(P=0.238)*
	Grade 1	2	10	
	Grade 2	5	19	
	Grade 3	0	0	
Pathological T stage	ypT0	0	0	*(P=0.238)*
	ypT1	0	0	
	ypT2	4	16	
	ypT3	3	13	
Pathological N stage	ypN+	7	29	*(P=0.157)*
	ypN-	0	0	
Number of harvested LNs	Mean±SD	16±7	14±5	*(P <0.001*)*
	Range	4–37	4–25	
Distance of Anastmosis,cm	(Mean±SD)	6±3	4.7±3	*(P=0.894)*

The Robotic Surgical procedure

The most frequently performed procedure was low anterior resection (69.6% and 89.4% in the RRR and LRR groups, respectively). The anastomoses of all low and ultra-low anterior resections were performed using the double stapling technique, whereas anastomoses of all intersphincteric resections (2 patients in RRR group) were performed using the trans-anal hand-sewn suture. The diverting stoma creation rate did not significantly vary between the two groups (30.5% and 35.8% in the RRR and LRR groups, respectively, *P=0.253*).

The operation time was significantly longer (approximately 26 minutes longer) in the RRR group than in the LRR group (*P*=0.003*). The estimated blood loss (EBL) did not vary significantly between both groups. It was also noted that the operation time in males was longer than females (i.e., approximately 15 to 20 minutes) although these results were not significantly different in both groups. (*P=0.497*). In the RRR subgroups the operation time was not significantly shorter (approximately 15 minutes shorter in RRR subgroup 5 (2018) in comparison to RRR subgroup 1 (2014) as shown in Figure 2.

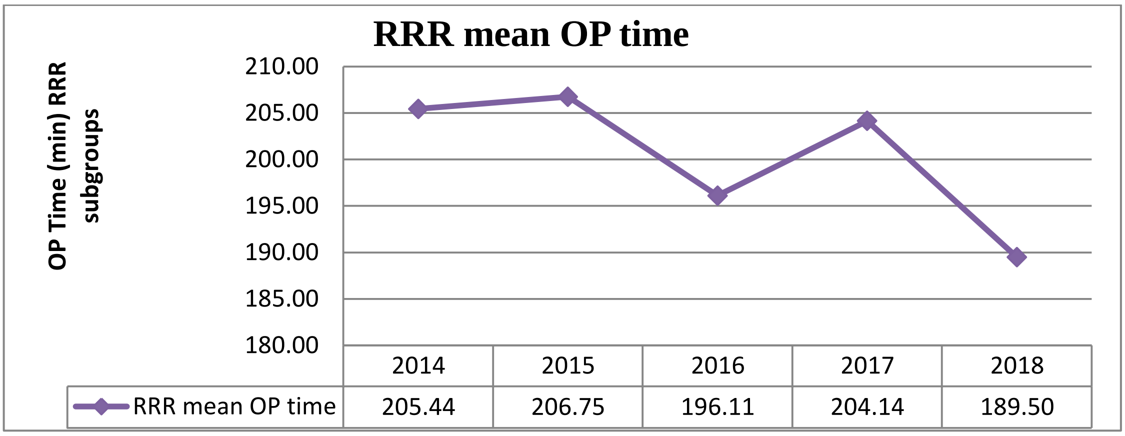

Figure 2: Showing the mean OP time in the RRR subgroups

The conversion rate to open surgery was statistically similar in both groups (8.7% and 7.1% in the RRR and LRR groups, respectively) (*P*<0.001*). As shown in Figure 3.

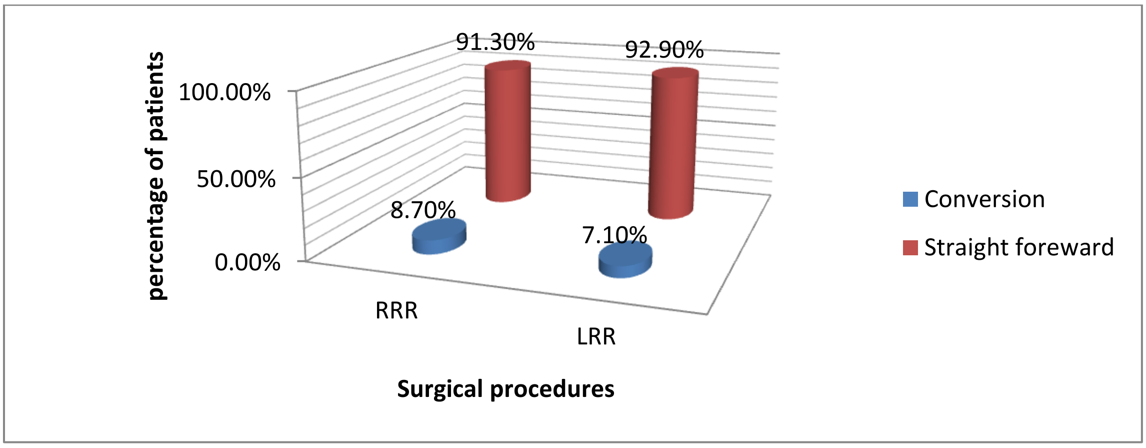

Figure 3: Showing the rate of conversion to open surgery in minutes in both groups

It was also noted that the conversion rate in the RRR subgroup was significantly lower (0%) in the fourth and fifth subgroups robotic surgery (3 patients from 18 patients in 2014 and 1 patient from 9patients in 2016) which may be due to the increased learning curve. (*P <0.001)** as shown in Figure 4

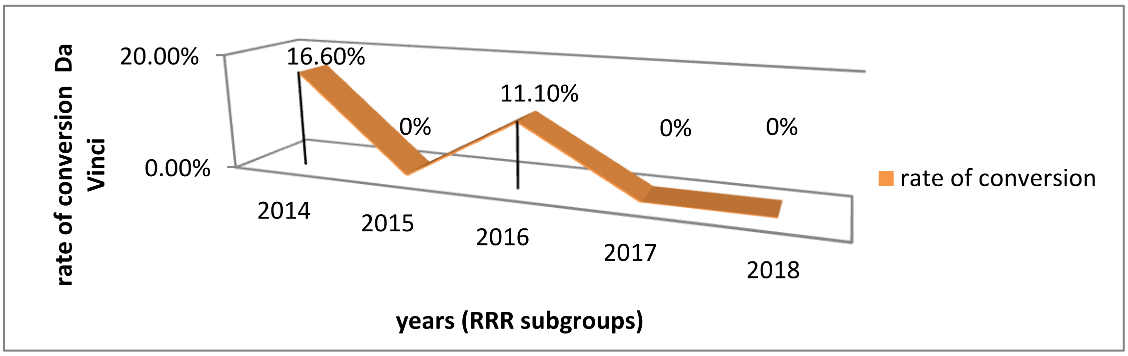

Figure 4: Showing the rate of conversion in RRR subgroups

The Postoperative complications:

Of the study population, about 31% of the patients had complications related to the operation. The common procedure-related complications included anastomotic leakage, pelvic abscess, ileus, and urinary tract problems (*Table 3*). Moreover, the affected proportion of patients was similar in both groups (28% and 35% in the robotic and conventional laparoscopy groups, respectively) (*P = 0.775*). The time to passage of flatus was also similar between the groups. However, the time to resumption of a soft diet was delayed by approximately 1 day in the laparoscopic group (*P=0.309*). The postoperative hospital stay was also longer (delayed by 2 to 3 days) in the laparoscopic group, although this finding was not statistically significant. (*P=0.205*)

One of the most important postoperative complications is the rate of anastomotic leakage. The affected proportion of patients was not statistically different in both groups (10.9% and 10.7% in the robotic and conventional laparoscopy groups, respectively) (*P=0.775*) as shown in (*Figure 5*). We noticed that all the patients who had anastomotic leakage were men (5 from 46 patients and 3 from 28 in the robotic and conventional laparoscopy groups, respectively).

Table 3: Showing the postoperative complications, time to first Flatus, time to resumption of soft diet and postoperative hospital stay, etc. in both groups

	Groups	RRR group	LRR group	P value
Postoperative complications	No	33 Patients	18 Patients	0.775
	yes	13 Patients(28%)	10 Patients(35%)	
	Anastomtic leakage	10.9% (5 Patients from 46 patients)	10.7% (3 Patients from 28 patients)	0.983
	Relaparotomy	6.5% (3 Patients from above 5 patients)	7.1% (2 Patients from above 3 patients)	0.586
	Ileus	8.7% (4 Patients from 46 patients)	7.1% (2 Patients from 28 patients)	0.812
	Pelvic abscess	4.4% (2 Patients from 46 patients)	7.1% (2 Patients from 28 patients)	0.34
	SSI	10.9% (5 Patients from 46 patients)	3.6% (1 Patient from 28 patients)	0.188
	Intra/postoperative Bleeding	4.4% (2 Patients from 46 patients)	14.4% (4 Patients from 28 patients)	0.336
	Rate of blood transfusion	6.5% (3 Patients from 46 patients)	17.9% (5 Patients from 28 patients)	0.128
	Incisional Hernia	No	3.6% (1 Patient from 28 patients)	0.197
	Urinary complications	6.5% (3 Patients from 46 patients)	21.6% (6 Patients from 28 patients)	0.719
	Stoma complications	4.4% (2 Patients from 46 patients)	3.6% (1 Patient from 28 patients)	0.414
	DVT and PE	2.2% (1 Patients from 46 patients) died	No	0.535
	Cerebral infarction	2.2% (1 Patients from 46 patients) died	No	0.535
	Rate of conversion	8.7% (4 Patients from 46 patients)	7.1% (2 Pateints from 28)	<0.001*
Time to 1st flatus passage(day)	(Mean±SD)	2.7±1.2	3.3±1.3	0.774
Time to resumptionof soft diet(day)	(Mean±SD)	3.8±1.3	4.35±1.2	0.309
Postoperative Hospital stay(day)	(Mean±SD)	13±7.46	16±8.96	0.205

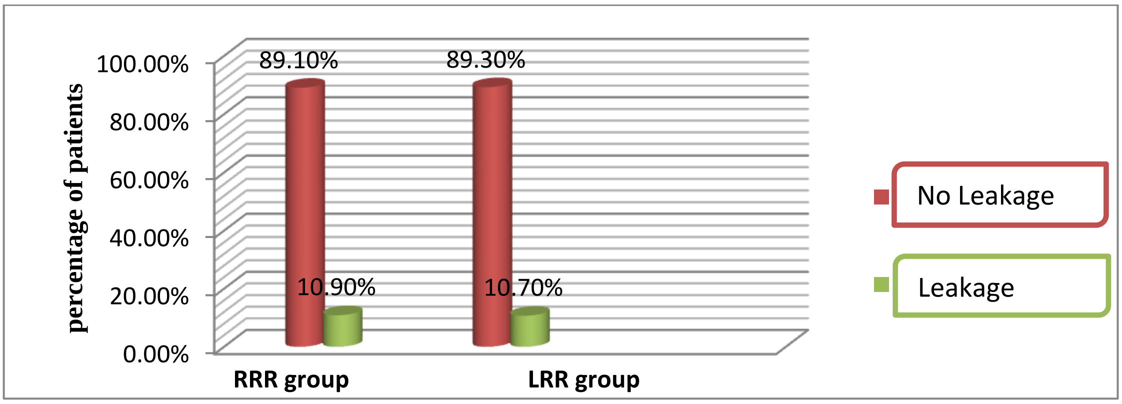

Figure 5: Showing the rate of anastomotic insufficiency (Anastomotic leakage) in both groups

The mean Hospital stay was longer in males than females (17 days and 15 days in male and female in the LRR respectively) and also was (15 days and 11 days in male and female in the RRR group respectively), although this finding was also not statistically significantly (*P=0.413*). The rate of paralytic ileus was also noted in both groups and the affected proportion of patients was not statistically different in both groups (8.7% and 7.1% in the robotic and conventional laparoscopy groups, respectively) (*P=0.812*).

Discussion:

A robot-assisted procedure could potentially overcome some of the limitations of conventional laparoscopic rectal surgery. The robotic system enables the surgeon to control a three dimensional, high-definition, 10-fold magnification vision steady camera. It provides wrist motion for the endoscopic instruments with (7 degrees of freedom, 180 degrees of articulation and 540 degrees of rotation). The motion scaling feature reduces physiological tremors, provides superior dexterity, and increases ergonomic comfort. Therefore, robotic systems can overcome several of the technical difficulties associated with traditional laparoscopic surgery and allow high-quality procedures to be performed in narrow spaces such as the pelvic cavity [34].

However, robotic surgery has the disadvantage of providing less tactile sensation and tensile feedback to the surgeon compared with conventional laparoscopy, important drawback when manipulating tissue during an operation. In addition, the docking procedures of robotic carts are time consuming and require more assistants. Also, the robotic cart may be difficult to remove quickly if open conversion is needed because of urgent intraoperative bleeding. Collisions between robotic arms present another difficulty in using this technology to perform rectal cancer surgery [35]. Another important drawback regarding robotic surgery is its cost, which has limited its use universally [36, 37 & 38]. We did not analyze cost in our study, but prior publications showed a greater expense of thousands of Euros when using the robotic approach compared with traditional laparoscopy [36].

The total mean age of rectal cancer patients was (69.5 ± 11 years) years, ranged (between 33 and 90 years; a finding was comparable to the same patient criteria reported by many studies done previously [39 & 40] (which was 56.6 and 66 years respectively). A higher incidence of rectal cancer was observed in male gender (63%), which is similar to the previously reported incidence (65%) [41]. The mean BMI of the patients in our study (29.0 ± 3.8) is comparable to that of the other clinical trials by other researchers, [42]. The ratio of patients with history of previous abdominal surgery (29.5%) ranged (between 28.5% and 30.5%) which is similar to the previously reported incidence (35.35%) ranged between (26.7% and 44%) [43].

In our study the robotic (RRR) and laparoscopic (LRR) groups were comparable with regard to baseline demographics and clinical parameters. All patients in both groups were comparable with regard to distance of the lesion from the anal verge and number of clinical T stages. No distant metastasis was detected in RRR group; however one patient in the LRR group got oligometastasis in segment 6 in the liver after 18 months and it was resected with an open surgery procedure.

Pathologic Outcomes

One operative factor that is known to have a significant effect on the oncologic outcomes is lymph node extraction. Complete mesocolic excision along with lymphadenopathy has been shown to be associated with better oncologic outcomes *Yang Y. et al.* [7 & 45]. The recommendation by the College of American Pathologists was a minimum of 12 lymph nodes for colorectal resection. This has been accepted by the American Joint Commission on Cancer and the National Cancer Institute and has been used as a standard to guide therapy (*National Cancer Institute, Rectal cancer treatment overview 2014*) [46].

There are many meta-analyses, which had compared the differences in the number of nodes harvested robotically versus laparoscopically. One of these looked at lymph node excision for colorectal cancer [7]. Another two studies looked specifically at resection for rectal cancer [29 & 47]. None of them found a statistically significant difference in the number of nodes extracted by the robot as compared to laparoscopic resection.

In the LRR group, more patients exhibited N-positive cancer (19.6% and 25% in the RRR and LRR groups, respectively and consequently clinical stage III cancer, P=.104), which were comparable to the reported incidence (75% and 50 % in the robotic and laparoscopic groups respectively, P= 0.02) [44].

It was noted that, the mean harvested LNs (13.9± 4.9 LNs and 16± 7 LNs in the RRR and LRR groups, respectively) which were significantly different in both groups (P <0.001*) which were similar to the reported incidence 12.3± 4.2 LNs and 14± 6.5 LNs in RRR and LRR groups, respectively, P=0.6) [43].

Considering that the number of lymph nodes may decrease after nCRT, the present findings were even more favorably comparable with previous findings in patients undergoing nCRT [26 & 28]. However, our result indicated that a similar number of lymph nodes were harvested in the robotic and LRR groups, consistent with previous reports [19, 25, 28, 30, 31, 48 & 49]. This difference in the number of retrieved LNs may be due to the high rate of neoadjuvant therapy in the RRR group. The rate of neoadjuvant therapy was statistically significant (63.0% and 28.6% in the RRR and LRR groups, respectively, P= 0.016*). It is worthy to state that the low number of dissected LNs and also the tumor-free dissected LNs were markedly noticed in the patients with nCRT.

In 2008, it was reported that preoperative therapy, either short course radiotherapy or chemo-radiotherapy, is essentially used to increase respectability, and to enhance sphincter preservation, local control and possibly, Disease free survival rates in Stage III rectal cancer [50]. According to Mandard tumor regression grade (TRG), 24 patients (65%) showed good response while 13 (35%) showed poor response to neoadjuvant chemo-radiotherapy. Moreover it was reported that 30.2% patients had good response (TRG I and II) [51].We performed the operation 4 to 6 weeks after neoadjuvant therapy. This is consistent with the reported interval time for surgery to obtain the maximal tumor response reported [39].

When looking at the percentage of positive CRM in the recently published literature there is a range of 0–7.5 % with LRR and 5–7.3 % with RRR which were significantly not different. One meta-analysis by looking at RRR versus LRR performing TME for rectal cancer, found that robotic TME was associated with lower rates of positive CRM as compared to laparoscopic TME (p = 0.04) [52]. In our study we have found that a total of (2 patient) one patient in each group showed CRM involvement; although the difference was nonsignificant. (2.2% and 3.6% in the RRR and LRR groups, respectively, P=0.535

Effect of learning curve on perioperative outcomes

A previous study suggested that the learning curve for laparoscopic rectal resection is steep, and that 30 to 70 cases are required to overcome the learning phase. [53] An even higher number of 50 to 80 cases were reported [24]. By contrast, the learning curve for robotic rectal resection has been reported to be shorter. It is generally agreed that 15 to 35 cases are required for surgeons to be proficient in robotic rectal resection [20, 54 & 55].The shorter learning curve is mainly attributable to the aforementioned advantageous operational features of the robotic system [26, 27 & 56].

Our results revealed that both approaches were feasible and equally effective. The operation time for robotic surgery was initially longer. However, after a relatively short learning curve, the short-term outcomes of robotic surgery for rectal cancer were comparable to those of laparoscopic surgery performed by experienced surgeons which was similar to the results reported before [44]. The operation time was significantly longer (201 minutes and 175 minutes in the RRR and LRR groups, respectively,) (i.e., approximately 26 minutes longer in in the RRR group than in the LRR group (P=.003*). These results were comparable to the reported incidence (274 min and 235 min in the RRR and LRR groups, respectively, P=0.27) [26]. The estimated blood loss did not vary significantly between both groups. It was also noted that the operation time in males was longer than females (i.e., approximately 15 to 20 minutes) although these results were not significantly different in both groups. (P=0.497). This may be due to narrow pelvis of men. The conversion rate to open surgery was statistically similar in both groups (8.7% and 7.1% in the RRR and LRR groups, respectively) (P<0.001*).

Although nCRT is an established risk factor for the complications, the complication rate in our study was comparable to the previously reported rates of 10.7% to 41.3% and 12.2% to 32.8% for robotic and laparoscopic rectal resections, respectively [18, 20, 23, 25, 30 & 48]. Moreover, in the present study, no significant difference was observed between the 2 groups. Furthermore, the complication rate tended to be lower in the RRR-5 subgroup, indicating the potential of the robotic procedure to further reduce the complication rate. However, this finding is not supported by previous studies [53] which reported that the complication rate did not differ significantly between 2 robotic TME consecutive groups of patients. Of our study population, about (28% and 35% in RRR and LRR groups respectively, P = 0.775) of the patients had complications related to the operation. The common procedure-related complications included anastomotic leakage, pelvic abscess, ileus, and urinary tract problems.

The time to passage of flatus was also similar between the 2 groups. However, the time to resumption of a soft diet was delayed by approximately 1 day in the laparoscopic group (P=0.309). The postoperative hospital stay was also longer (delayed by 2 to 3 days) in the laparoscopic group, although this finding was not statistically significantly. (P=0.205). Moreover, we've noticed that the mean Hospital stay was longer in males than females (17 days and 15 days in male and female in the LRR respectively) and also was (15 days and 11 days in male and female in the RRR group respectively), although this finding was also not statistically significantly. (P=0.413). It was noted that in all patients of our study the erectile-, sexual function and general sexual satisfaction were restored completely. The urinary function and defecation remained unchanged after surgery in both groups.

The most relevant data resulting from these studies was that robotic surgery had reduced conversion to open surgery compared to the laparoscopic group. Additionally, the short-term clinical and oncologic outcomes were not significantly different between groups. The recently published 5-year results demonstrate that there are similar rates for overall survival, disease-free survival, and local recurrence between robotic and laparoscopic surgical procedures [35].

Comparative studies have reported equivalent performance for laparoscopic and robotic rectal resections [30 & 31]. Our results provided further evidence that although the robotic procedure offers potential advantages to overcome the limitations of the laparoscopic procedure, comparable outcomes can still be achieved when technically demanding laparoscopic rectal resection is performed by an experienced team.

Table 4: Showing the effect of the learning curve on perioperative outcomes comparison between the conventional laparoscopic group (LRR) and the first (RRR 1) and the fifth robotic (RRR 5) subgroups.

	Subgroups	LRR group	RRR subgroup 1 (2014)	RRR subgroup 5 (2018)	P value
Type of surgical procedure	Low anterior resection	60.6%(17 Patients from 28 Patients)	39%(7Patients from 18 patients)	75% (6 Patients from 8 Patients)	0.253
	Ultralow anteriot resection	25% (7 Patients from 28 patients)	11% (2 Patients from 18 patients)	No	
	Intersphincteric resection	No	No	No	
	Abdominoperineal resection	14.4% (4 Patients from 28 patients)	50%(9 Patients from 18 patients)	25% (2 Patients from 8 patients)	
Rate of conversion	Open Surgery	7.1%(2 Patients from 28 patients)	6.5%(3 Patients from 18 patients)	No	<0.032*
Operation time (min)	(Mean±SD)	175 ±33	205 ±43	189± 36	0.221
Blood loss (mL)	(Mean±SD)	53 ±23	48 ±28	45.6± 34	0.113
Time to 1st flatus passage(day)	(Mean±SD)	3.3 ±1.3	2.7 ±1.4	3± 1.3	0.269
Time to resumptionof soft diet(day)	(Mean±SD)	4.35 ±1.2	3.7 ±1.4	4.25± 1.6	0.549
Postoperative Hospital stay(day)	(Mean±SD)	16 ±8.96	15.6 ±10.6	15 ± 4.3	0.192
Postoperative complications	No	18 Patients	13 Patients	6 Patients	0.845
	Yes	35% (10 Patients from 28 patients)	27% (5 Patients from 18 patients)	25% (2 Patients from 8 patients)	

In attempt to assess the effect of the learning curve on perioperative outcomes in our study, the LRR, and the first robotic (RRR 1) and the fifth robotic (RRR 5) subgroups were compared as shown in (Table 4). Similar operative procedures were performed in the three surgery groups. Nevertheless, the operation time was longer (approximately 30 minutes longer) in the Robot 1 group than in the LRR group, but it did not reach the statistical difference (P=0.221). Similarly, the operation time was a little bit longer (approximately 16minutes longer) in the Robot 1 subgroup than in the Robot 5 subgroup, although the difference did not reach statistical significance (P=0.243). By contrast, a much smaller difference was observed in the operation time between the LRR and Robot 5 subgroup (approximately 14 minutes, P=.229). The estimated blood loss was less in the Robot 2 subgroup than in the other 2 groups (approximately 53 mL, 48 mL and 45 mL in the LRR, RRR1 and RRR5 respectively, P=0.113). However, the difference did not reach statistical significance. Similarly, although the complication rate did not vary significantly among the 3 groups (35% for LRR, 27% for Robot 1, and 25% for Robot 5, the rate tended to be lower in the Robot 5 group. The time to passage of flatus (P=0.269) and the time to resumption of a soft diet (P=0.549) were also similar among the 3 groups. The postoperative hospital stay was also longer in the LRR group, although this finding was not statistically significant. (P=0.192). These finding may be attributed to the effect of the learning curve.

One of the key steps to pursue a successful robotic program is the surgical volume. It is strictly connected to the learning curve and to the quality of outcomes. Three to five cases per week during the initiation of the program are necessary to obtain continuity in the learning curve. *Palmer et al* [57] reported a significant increase in surgical volume since the introduction of the robotic program, from 40 to 350 cases per year within five years. It is clear that the high volume centers can have an impact in terms of variable costs reduction; hence, the best chance to increase surgical volume and therefore to reduce costs is to share the use of the robotic system with all surgical teams, including urologists, gynecologists, thoracic surgeons, and other specialties [58].

Limitations

One of the major limitations of our study is the retrospective design. The patient number was small, and the patient selection was not randomized, although we obviated the discrepancy by matching patients by age, sex, the body mass index, Tumor stage and procedure.

Notably, none of the previous studies were randomized control trials, thus suggesting that studies were affected by bias. Additional studies may be needed to determine the exact fate of patients at 10 years.

Finally, we could not determine the cost benefit and the long term outcome after robotic surgery. Moreover, this study provides an initial comparison between robotic surgery and laparoscopic surgery for early stage rectal cancer patients, which offers a foundation for larger randomized controlled studies.

Conclusion:

Our early experience indicates that robotic surgery is a feasible and safe procedure in patients with rectal cancer. Although there were no significant benefits regarding the perioperative and oncological results, robotic surgery provides better outcomes, especially in patients undergoing rectal surgery. However, before extending the indications for this procedure, it is necessary to evaluate the perioperative and long-term oncological safety in large randomized controlled trials.

Finally, minimally invasive surgery for rectal cancer is still confined to only few centers, despite the evidence of better short- and long-term outcomes and at least the same oncologic safety of traditional open surgery. The reason for this low diffusion is mainly technical, and robotic surgery seems to overcome some of the limitations of laparoscopy, offering an easy technique with less fatigue for the surgeons and a better possibility of teaching for the beginners.

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Abbreviations

APR: Abdominoperineal resection, nCRT: neoadjuvant Chemotherapy, BMI: Body mass index, CRM: Circumferential resection margin, DRM: distal resection margin, DFS: Disease-free survival, ISR: Intersphincteric resection, OS: Overall survival, TME: Total mesorectal excision, SD: Standard deviation, CR: complete response

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