Short- and Medium-Term Outcome of Robot-Assisted and Traditional Laparoscopic Rectal Resection

Alberto Patriti, MD, PhD, Graziano Ceccarelli, MD, Alberto Bartoli, MD, Alessandro Spaziani, MD, Alessia Biancafarina, MD, Luciano Casciola, MD

ABSTRACT

Background: Traditional laparoscopic anterior rectal resection (TLAR) has recently been used for rectal cancer, offering good functional results compared with open anterior resection and resulting in a better postoperative early outcome. However, laparoscopic rectal resection can be technically demanding, especially when a total mesorectal excision is required. The aim of this study was to verify whether robot-assisted anterior rectal resection (RLAR) could overcome limitations of the laparoscopic approach.

Methods: Sixty-six patients with rectal cancer were enrolled in the study. Twenty-nine patients underwent RLAR and 37 TLAR. Groups were matched for age, BMI, sex ratio, ASA status, and TNM stage, and were followed up for a mean time of 12 months.

Results: Robot-assisted laparoscopic rectal resection results in shorter operative time when a total mesorectal excision is performed (165.9 ± 100.6 vs 210 ± 137 minutes; P < 0.05). The conversion rate is significantly lower for RLAR (P < 0.05). Postoperative morbidity was comparable between groups. Overall survival and disease-free survival were comparable between groups, even though a trend towards better disease-free survival in the RLAR group was observed.

Conclusion: RLAR is a safe and feasible procedure that facilitates laparoscopic total mesorectal excision. Randomized clinical trials and longer follow-ups are needed to evaluate a possible influence of RLAR on patient survival.

Key Words: Traditional laparoscopic anterior rectal resection, Robot-assisted laparoscopic anterior rectal resection, Rectal cancer, da Vinci Surgical System.

INTRODUCTION

Current rectal cancer treatment is based on a multidisciplinary approach entailing surgery, chemotherapy, and radiotherapy. The aim of surgery is to remove the rectum and the mesorectum contained within the intact fascia of the rectum. This technique reduces pelvic recurrence, prolongs survival, and preserves postoperative erectile and urinary function by avoiding nerve injury.1,2 Laparoscopic anterior resection with total mesorectal excision (TME) has been recently introduced as a treatment option for rectal cancer.3

Oncologic outcomes of laparoscopic TME are comparable to those of the open counterpart, and the postoperative course showed improvement in several retrospective and randomized controlled studies.3,4

Robot-assisted surgery is considered an evolution of traditional laparoscopy, but little data support any real benefits of this technology.5

Robotic attributes improve surgeon dexterity where fine manipulation of tissues in a close, fixed operating field or when hand-sewn sutures and knot tying are required.6 Therefore, we believe that a robotic approach could be relevant for laparoscopic anterior rectal resection.

To evaluate the role of robotics in rectal surgery, we compared intra- and postoperative outcomes of anterior resection using a traditional laparoscopic approach (traditional laparoscopic anterior resection; TLR) and a robot-assisted procedure with the 3-arm da Vinci Surgical System (Intuitive Surgical Inc., Sunny-valle, CA) (robot-assisted laparoscopic anterior resection; RLAR).

MATERIALS AND METHODS

Between March 2004 and October 2008, a minimally invasive approach was proposed to all patients with a histologically proved rectal adenocarcinoma irrespective to the stage of disease. Preoperative workup included physical examination, colonoscopy, total-body computed tomography, and blood count. Pelvic magnetic resonance imaging was used to evaluate local infiltration, when needed.
Patients preoperatively staged as T3 or T4 without distant metastases were treated by preoperative radiochemotherapy (45 Gy for 4 weeks together with systemic 5-fluouracil intravenous infusion) and were reevaluated with a clinical examination and computed tomography 20 days after treatment. Resectable synchronous liver metastases were not considered a contraindication for a minimally invasive approach and were treated at the same time of the primary tumor (one-stage resection). Liver resections were always carried out with the aid of the robotic system.

The day before surgery, patients were randomly scheduled for 1 of the 2 procedures. Data were collected prospectively.

Clinical parameters analyzed included patient characteristics, operative variables, pathologic examination, short-term and medium-term outcomes.

Perioperative data included operative time, blood loss, conversion rate, perioperative complications, and length of hospital stay. Operative time was calculated as the time between pneumoperitoneum induction and port-site closure. Intraoperative blood loss was measured by subtraction of aspirated and instilled fluids.

Pathologic examination included type, stage of disease (TNM), number of lymph nodes harvested, and longitudinal and radial margins of excision.

Patients underwent a weekly clinical examination during the 30 days after discharge and then were followed up every 6 months with a physical examination, tumor markers, liver ultrasound, computed tomography, chest x-ray, and colonoscopy.

The impact of surgery on pelvic nerve preservation was investigated by interview. Sexual function impairment was defined as the impossibility of achieving an erection or ejaculation after surgery. Patients with pre-existing poor genital function were excluded from the statistical analysis.

**Operative Technique**

During the study period, we performed total mesorectal excision (TME), with transection of the rectum at the level of the pelvic floor and removal of intact mesorectum, for patients with mid and distal rectal cancer. For tumors of the upper rectum or recto-sigmoid junction, transection of the rectum and mesorectum 4 cm below the lower border of the tumor was performed following sharp perimesorectal dissection (partial mesorectal excision: PME).

This approach has been demonstrated to be effective as routine TME for all rectal cancers. In cases of very low tumors, an intersphincteric resection with specimen extraction through the anus and hand sewn coloanal anastomosis was performed. Abdominoperineal resections (APR) were proposed to patients with sphincter-invading lesions or with very low tumors and poor fecal continence.

**Laparoscopic Technique**

One camera port and 3 working trocars are positioned after CO₂ pneumoperitoneum at 12 mm Hg is induced using a Veress needle. The position of the trocars is shown in **Figure 1**. The patient is kept in a steep Trendelenburg position during the whole procedure to remove the small bowel from the pelvis. The left colon is fully mobilized by
using the Harmonic scalpel along the posterior plane covered by Toldt’s fascia, after which the left ureter and gonadal vessels are identified. Splenic flexure is not routinely mobilized. Peritoneal serosa is incised starting at the sacral promontory. Dissection then proceeds cranially to the origin of the inferior mesenteric artery (IMA) and inferior mesenteric vein (IMV). IMA is divided between clips at its origin and IMV at the level of the duodenojejunal flexure. The cleavage plane between the presacral fascia and the visceral layer that underlines the mesorectum is then identified at the level of the sacral promontory.

Mesorectal dissection is carried out circumferentially using the Harmonic scalpel. Measurement of distance between the tumor and the cutting line is performed by digital exploration or endoscopy.

Division of the rectum is carried out with a linear endoscopic stapler inserted through the right iliac fossa trocar. Proximal section of the vascular arcade and colon is performed laparoscopically, and the specimen is extracted through a left lower quadrant minilaparotomy. The anastomosis is created with a mechanical circular stapler inserted transanally, according to the double-stapled technique. Ileostomy is not routinely performed.

Robotic Technique

We perform a hybrid technique with laparoscopic mobilization of the colon and robotic-assisted mesorectal excision, as described by Pigazzi.8,9 The scrub nurse and one on-table assistant dress the robot while pneumoperitoneum is being established. Therefore, time for abdominal insufflation with the Veress needle and robot docking are superimposed.

A 12-mm camera port, two 8-mm robotic working ports, and 2 additional laparoscopic trocars are placed as shown in Figure 1. The patient is kept in a steep Trendelenburg position during the whole procedure. A medial-to-lateral dissection with high ligation of the inferior mesenteric vein and artery near its origin is carried out laparoscopically followed by laparoscopic mobilization of descending and sigmoid colon and of the splenic flexure, if necessary. Thereafter the da Vinci robotic system is docked in between the patient’s legs. The 2 working arms usually carry a Cadier forceps on the left and a hook cautery on the right. The on-table assistant uses 2 ports for suctioning and retraction. The dissection is continued in the fashion of a total mesorectal excision.

Once the TME is completed, the assistant divides the distal rectum by using a 30-mm linear stapler through the 12-mm laparoscopic port. The specimen is extracted through a minilaparotomy on the left lower quadrant, and the anastomosis is created as described above.

Statistical Analysis

Parametric variables are given as means ± SD and were analyzed with the Student t test.

Frequencies were analyzed with the χ² test, and the Mann-Whitney test was used for nonparametric data.

Survival curve analysis was carried out with the Kaplan-Meier method, and the evaluation of differences between the groups was performed with the log-rank test. Statistical significance was set at P<0.05. Statistical analysis was carried out using Prism 4.0.3 data analysis software for Windows (GraphPad Software, San Diego, CA, USA).

RESULTS

Seventy-six consecutive patients were treated for rectal cancer between March 2004 and October 2008.

A minimally invasive approach was proposed to all patients. In 7 cases, however, conversion to laparotomy was necessary, 3 patients preferred an open approach, so they were all excluded from the study. Patient characteristics are summarized in Table 1. The 2 groups are matched for age, BMI, ASA status, and TNM stage. A greater number of low rectal cancers were deliberately treated by a robotic approach, because after the first cases we felt a subjective improvement in low mesorectal dissection using the da Vinci system and randomization abandoned because TLAR was considered disadvantageous. Moreover, the RLAR group differs from the TLAR also for the greater number of patients who underwent neoadjuvant chemo-radiotherapy and patients with a history of previous abdominal surgery.

Intraoperative Data

Intraoperative and pathologic data are summarized in Table 2. As mentioned above, in the RLAR group more patients underwent TME than in the TLAR group.

Robot-assisted operations comprising a TME (total proctectomy and abdomino-perineal resection) were significantly faster than the laparoscopic counterparts. On the other hand, robot-assisted PME was more time consuming. In the TLAR group, a conversion rate of 19% was recorded. In the RLAR group, there were not conversions to open surgery, but in 2 patients the planned robotic approach was abandoned in favor of traditional laparos-
copy because the rectal cancer was higher than expected at the preoperative workup. Blood losses were small, and transfusions were not required in the 2 groups. A diverting stoma was never performed. In all cases, adequate tumor-free resection and radial margins were obtained, and the number of lymph nodes harvested was comparable between groups (Table 2).

In both groups, concomitant procedures were carried out but time for their execution and respective blood-loss were not considered for statistical analysis. Stage IV patients with resectable liver metastases underwent 1-stage resection of the primary and liver metastasis, a 1.5-cm nodule in segment 8 and a 1.5 nodule in segment 7 in the RLAR and TLAR groups, respectively.

### RESULTS

The 30-day mortality was null, and no significant differences occurred in terms of specific complications between the 2 groups of patients (Table 3).

Two patients in the TLAR group required postoperative transfusion for trocar and rectal bleeding, respectively. Both cases were treated conservatively, but the patient with the rectal hemorrhage developed an anastomotic fistula requiring a diverting loop-ileostomy, prolonged antibiotic therapy, and total parenteral nutrition. Patients in both groups scheduled for adjuvant chemoradiation or chemotherapy alone underwent treatment one month after surgery (TLAR 7 patients, 33±11 days; RLAR 9 patients, 31±6 days).

During the follow-up period, we did not identify differences between groups in the incidence of erectile dysfunction and fecal incontinence. Postoperative erectile dysfunction does not seem to be correlated with the extent of mesorectal dissection. In fact, all 5 cases observed were patients with tumors in the higher third of the rectum. However, it is more likely that it is correlated with other factors, such as the learning curve and the complexity of mesorectal excision. Erectile dysfunction was reported by the first 2 patients in the RLAR group and by a patient with a bulky tumor in the TLAR group.

Concerning oncologic results, we evaluated all the 66 patients with a mean follow-up of 18.7 and 29.2 months in the TLAR and RLAR groups, respectively.

During this period, 2 patients (3% of total patients) died of cancer: 1 in the TLAR and 1 in the RLAR group. The local

### Table 1.

Demographic Data

|                  | TLAR* | RLAR* | P Value |
|------------------|-------|-------|---------|
| Patients         | 37    | 29    |         |
| Age (years)      | 69 ± 10 | 68 ± 10 | >0.05   |
| Sex (M:F)        | 1:2   | 1:1.6 |         |
| BMI*             | 25.4 ± 6.44 | 24 ± 6.2 | >0.05   |
| ASA Status       |       |       | >0.05   |
| I                | 2     | 2     |         |
| II               | 14    | 13    | <0.01   |
| III              | 21    | 14    | <0.05   |
| Previous Surgery | 11    | 18    | <0.01   |
| Neoadjuvant Chemoradiotherapy | 2 | 7 | <0.05 |
| Tumor Location (cm from anal verge) | 11 ± 4.5 | 5.9 ± 4.2 | <0.01 |
| TNM Stage        |       |       | >0.05   |
| I                | 17    | 11    |         |
| II               | 8     | 9     |         |
| III              | 10    | 7     |         |
| IV               | 2     | 2     |         |

*BMI = Body Mass Index; TLAR = Traditional laparoscopic anterior rectal resection; RLAR = robot-assisted anterior rectal resection.
recurrence rate was 5.4% and 0% in the TLAR and RLAR, respectively.

A total of 4 patients in the TLAR group (6% of the total patients) are alive with metastatic disease and/or local recurrence. One patient at 47 months after surgery was palliated with bowel stenting and radiotherapy for local recurrence and carcinosis. One patient has brain and adrenal metastases, and in the third the CT scan showed local recurrence and multiple liver and lung metastases in rapid progression under chemotherapy. The fourth patient underwent robot-assisted TME for local recurrence 8 months after a traditional laparoscopic PME.

No differences were observed in overall and disease-free survival, but we found a trend towards a better disease-free survival in the RLAR group (Figure 2).

**DISCUSSION**

Application of robotics to the treatment of rectal cancer has been demonstrated to be feasible in recent studies highlighting technical advantages brought about by the da Vinci System in TME.  

The general advantages of this robotic system are a 3-dimensional view, hand-tremor filtering, fine dexterity, and motion scaling, providing an absolute benefit when the operative field is narrow and fixed and sharp dissection is necessary. Despite the subjective experience of the surgeon at the console being impressive, to date there are no comparative studies demonstrating a real impact of this technology on patient outcome.  

To the best of our knowledge, this is the first study comparing RLAR and TLAR. We are well aware of the intrinsic limitations of the study. After a few cases, we
preferred to treat all patients with low rectal cancer with a robotic approach mismatching the 2 groups, the mean follow-up time is not appropriate to give definitive results on oncologic outcome, and the series is small for a powerful statistical analysis. Nevertheless, because the short-term results were surprising with respect to operative time and conversion rate, it was decided that publication of these results would be of interest. On the other hand, what from a statistical point of view is a bias can be considered a point of strength of the study. In fact, outcome results have to be weighted on the major complexity of the procedures performed in a robot-assisted approach. The majority of patients in the RLAR group had previous abdominal surgery and low rectal cancer requiring a TME. In addition, in the RLAR group, more patients underwent neo-adjuvant chemoradiation in respect to the TLAR and OAR groups. Our study indicates for the first time that robot-assisted TME can be performed in a significantly shorter operative time compared with TLAR and with a lower conversion rate. Distal and radial margins were tumor-free in all cases as obtained in the TLAR group. The mean number of harvested nodes was comparable as well. These data demonstrate that RLAR respects oncological criteria for mesorectal excision and improve surgical maneuvers, reducing operating times.

On the contrary, no advantages in terms of subjective and objective results were obtained in PME. In cases of high rectal tumors, RLAR results in longer operating times. These data rely on the easy execution of PME during

Table 3.

| Outcomes                          | TLAR       | RLAR       | P Value |
|----------------------------------|------------|------------|---------|
| Hospital Stay (days)             | 9.6 ± 6.9 (5-37) | 11.9 ± 7.5 (6-29) | >0.05   |
| 30 Days Morbidity                |            |            |         |
| Anastomotic leak                 | 1 (2.7%)   | 2 (6.8%)   | >0.05   |
| Wound infection                  | 2 (5.4%)   | 1 (3.4%)   | >0.05   |
| Hemorrhage                       | 2 (5.4%)   | 1 (3.4%)   | >0.05   |
| Prolonged ileus                  | 1 (2.7%)   | 2 (6.8%)   | >0.05   |
| Urinary retention                | 1 (2.7%)   | 1 (3.4%)   | >0.05   |
| Enteritis                        | 0          | 2 (6.8%)   | >0.05   |
| Overall                          | 18.9%      | 30.6%      | >0.05   |
| Follow-up Time (months)          | 18.7 ± 13.8| 29.2 ± 14  | >0.05   |
| Long-term Morbidity              |            |            |         |
| Erectile dysfunction†            | 3 (16.6%)  | 1 (5.5%)   | >0.05   |
| Faecal incontinence              | 1 (2.7%)   | 2 (6.8%)   | >0.05   |
| Constipation                     | 3 (8.1%)   | 4 (13.7%)  | >0.05   |
| Incisional hernia                | 2 (5.4%)   | 0          | >0.05   |
| Overall                          | 32.8%      | 26%        | >0.05   |

†In male population.
*TLAR = traditional laparoscopic anterior rectal resection; RLAR = robot-assisted anterior rectal resection.

Figure 2. Disease-free survival curves. Robot-assisted anterior rectal resection: continuous line. Traditional laparoscopic anterior rectal resection: interrupted line.
laparoscopic left colon mobilization by simply prolonging the plane of dissection above the inferior mesenteric artery over the sacral promontory. This maneuver is greatly facilitated in laparoscopy by pneumodissection, and we do not believe that robotics could further improve it. Perhaps, studies comparing a totally robot-assisted and totally laparoscopic PME are needed to validate this impression. Regarding complications and postoperative outcome, both minimally invasive approaches resulted in a comparable early postoperative course. No differences were reported between groups in the incidence of sexual dysfunction, even if its expected frequency in the RLAR group is higher than that observed due to the larger amount of low rectal tumors.12,13

Survival curve analysis revealed no differences between the 2 groups, but a trend towards a better disease-free survival was highlighted in the RLAR group. Notably, in the RLAR group, there are not local recurrences during the follow-up period. This result can be explained by a different tumor response to adjuvant chemotherapy or to an increasing number of neoadjuvant therapies in the RLAR group, but possible improvement in local disease control by robotic dissection is also a reasonable possibility. Image magnification and 3-dimensional vision could be responsible for this result as a consequence of the fine dissection and the easier identification of the cleavage planes also in a narrow pelvis.

This observation, if confirmed in randomized controlled trials, could dramatically change the standard approach to rectal cancer.14 Coupled with better local control, a minimally invasive procedure could accelerate the beginning of adjuvant treatments by reducing complications and patient discomfort. As a matter of fact, laparoscopic colorectal resection is associated with a better early outcome than that of traditional open surgery.15,16

It is convincing that a better postoperative course could itself be a factor in improving survival of patients with advanced disease requiring early postoperative chemotherapy.17–19

In our series, both RLAR and TLAR patients underwent planned postoperative chemoradiation without delay. Therefore, robot-assisted TME could allow an increasing number of patients with low rectal cancer to benefit from the intrinsic advantages of minimally invasive surgery.

Unfortunately, in our study the length of stay cannot be used as a discriminating factor of a better early outcome. Indeed, in Italy the healthcare delivery system does not give patients any financial incentives to be discharged early. The general attitude is to discharge patients in relation to the absence of complications, tolerance of a normal diet, and patient preference.

CONCLUSION

Despite the fact that the limitations of the study do not permit definitive results, robotics is likely to improve laparoscopic TME but not PME. Future prospective controlled studies should be aimed at verifying whether robotic TME might increase local control of rectal cancer, disease-free patient survival, and postoperative sexual function in male patients. If confirmed, our data suggest the possibility for a tailored approach to rectal cancer with a predominant role for robotics for lower cancer treatment and a restricted use of traditional laparoscopy to cancers requiring PME.

References:

1. Heald RJ, Husband EM, Ryall RD. The mesorectum in rectal cancer surgery—the clue to pelvic recurrence? Br J Surg. 1982; 69(10):613–616.

2. Junginger T, Kneist W, Heintz A. Influence of identification and preservation of pelvic autonomic nerves in rectal cancer surgery on bladder dysfunction after total mesorectal excision. Dis Colon Rectum. 2003;46(5):621–628.

3. Morino M, Parini U, Giraudo G, et al. Laparoscopic total mesorectal excision: a consecutive series of 100 patients. Ann Surg. 2003;237(3):335–342.

4. Leroy J, Jamali F, Forbes L, et al. Laparoscopic total mesorectal excision (TME) for rectal cancer surgery: long-term outcomes. Surg Endosc. 2004;18(2):281–289.

5. Gutt CN, Oniu T, Mehrabi A, et al. Robot-assisted abdominal surgery. Br J Surg. 2004;91(11):1390–1397.

6. Giuliani PC, Coratti A, Angelini M, et al. Robotics in general surgery: personal experience in a large community hospital. Arch Surg. 2003;138(7):777–784.

7. Leong AF. Selective total mesorectal excision for rectal cancer. Dis Colon Rectum. 2000;43(9):1237–1240.

8. Hellan M, Anderson C, Ellenhour JD, et al. Short-term outcomes after robotic-assisted total mesorectal excision for rectal cancer. Ann Surg Oncol. 2007;14(11):3168–3173.

9. Pigazzi A, Ellenhour JD, Ballantyne GH, Paz IB. Robotic-assisted laparoscopic low anterior resection with total mesorectal excision for rectal cancer. Surg Endosc. 2006;20(10):1521–1525.

10. Baik SH, Ko YT, Kang CM, et al. Robotic tumor-specific
mesorectal excision of rectal cancer: short-term outcome of a pilot randomized trial. *Surg Endosc.* 2008;22(7):1601–1608.

11. D’Annibale A, Morpurgo E, Fiscon V, et al. Robotic and laparoscopic surgery for treatment of colorectal diseases. *Dis Colon Rectum.* 2004;47(12):2162–2168.

12. Kneist W, Junginger T. Male urogenital function after confirmed nerve-sparing total mesorectal excision with dissection in front of Denonvilliers’ fascia. *World J Surg.* 2007;31(6):1321–1328.

13. Quah HM, Jayne DG, Eu KW, Seow-Choen F. Bladder and sexual dysfunction following laparoscopically assisted and conventional open mesorectal resection for cancer. *Br J Surg.* 2002;89(12):1551–1556.

14. Ziogas D, Roukos D. Robotic surgery for rectal cancer: may it improve also survival? *Surg Endosc.* 2008;22:1405–1406.

15. Veldkamp R, Kuhry E, Hop WC, et al. Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. *Lancet Oncol.* 2005;6(7):477–484.

16. Strohlein MA, Grutzner KU, Jauch KW, Heiss MM. Comparison of laparoscopic vs. open access surgery in patients with rectal cancer: a prospective analysis. *Dis Colon Rectum.* 2008;51(4):385–391.

17. Pugliese R, Di Lernia S, Sansonna F, et al. Results of laparoscopic anterior resection for rectal adenocarcinoma: retrospective analysis of 157 cases. *Am J Surg.* 2008;195(2):233–238.

18. Capussotti L, Massucco P, Muratore A, et al. Laparoscopy as a prognostic factor in curative resection for node positive colorectal cancer: results for a single-institution nonrandomized prospective trial. *Surg Endosc.* 2004;18(7):1130–1135.

19. Lacy AM, Delgado S, Castells A, et al. The long-term results of a randomized clinical trial of laparoscopy-assisted versus open surgery for colon cancer. *Ann Surg.* 2008;248(1):1–7.