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Robotic Surgery for Rectal Cancer: A Single Center Experience of 100 Consecutive Cases

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Rezumat

Abordul robotic în cancerul de rect: experiența primelor 100 de cazuri

Introducere: În ultimele decenii apariția tehnicilor de chirurgie minimal invazivă a revoluționat printre altele și chirurgia generală. În pofida avantajelor oferite de aceste tehnici, în procedurile complexe (printre care se numără și chirurgia cancerului de rect) laparoscopia nu a reușit să se impună datorită curbei de învățare lungi și ratei de conversie relativ ridicate. Scopul acestei lucrări este de a prezenta experiența unui singur centru în abordul robotic al cancerului de rect, analizând rezultatele postoperatorii imediate și pe termen mediu.
Material și metodă: În perioada ianuarie 2008-iunie 2012 au fost efectuate 100 de rezecții robotice consecutive la pacienți cu cancer de rect. Au fost analizate retrospectiv datele demografice, de anatomie patologică precum și rezultatele postoperatorii imediate și supraviețuirea pe termen mediu.
Rezultate: Au fost efectuate prin abord robotic 77 de rezecții anterioare și rezecții anterioare joase și 23 de rezecții abdomino-perineale. 4 cazuri au fost convertite la abordul clasic. Timpul operator mediu pentru procedurile cu prezervare de sfincter a fost 180 minute, iar pentru rezecțiile abdomino-perineale de 160 de minute. Marginile de rezecție au fost în medie de 3 cm. Numărul mediu de limfoganglioni recoltați a fost de 14. Spitalizarea postoperatorie medie a fost de 10 zile. Mortalitatea postoperatorie imediată a fost nulă. Morbiditatea a fost de 30%. 4 pacienții au prezentat disfuncții urinare tranzitorii. Disfuncții erectile severe s-au întregistrat la 3 pacienți. Perioada medie de urmărire a fost de 24 de luni. Supraviețuirea la 3 ani a fost de 90%.
Concluzii: Chirurgia robotică aduce avantaje atât chirurgilor (facilitează disecția în pelvisul îngust) cât și pacienților (calitatea bună a vieții datorită prezervării funcției sexuale și urinare la marea majoritate a pacienților, morbiditate scăzută, rezultate oncologice bune). În cancerul de rect abordul robotic este o alternativă promițătoare care tinde să depășească dificultățile tehnice ale abordului laparoscopic, crescând numărul pacienților cu cancer de rect care pot beneficia de abordul minimal-invaziv.

Cuvinte cheie: abord robotic, cancer de rect, disecția totală de mesorect, rezultate oncologice, funcție sexuală

Abstract
Background: Minimally invasive techniques have revolutionized the field of general surgery over the few last decades. Despite its advantages, in complex procedures such as rectal surgery, laparoscopy has not achieved a high penetration rate because of its steep learning curve, its relatively high conversion rate and technical challenges. The aim of this study was to present a single center experience with robotic surgery for rectal cancer focusing mainly on early and mid-term postoperative outcome.
Methods: A series of 100 consecutive patients who underwent robotic rectal surgery between January 2008 and June 2012 was analyzed retrospectively in terms of demographics,

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pathological data, surgical and oncological outcomes.
Results: Seventy-seven patients underwent robotic sphincter-saving resection, and 23 patients underwent robotic abdominoperineal resection. There were 4 conversions. The median operative time for sphincter-saving procedures was 180 min. The median time for robotic abdominoperineal resection was 160 min. The median distal resection margin of the operative specimen was 3 cm. The median number of retrieved lymph nodes was 14. The median hospital stay was 10 days. In-hospital mortality was nil. The overall morbidity was 30%. Four patients presented transitory postoperative urinary dysfunction. Severe erectile dysfunction was reported by 3 patients. The median length of follow-up was 24 months. The 3-year overall survival rate was 90%.
Conclusions: Robotic surgery is advantageous for both surgeons (in that it facilitates dissection in a narrow pelvis) and patients (in that it affords a very good quality of life via the preservation of sexual and urinary function in the vast majority of patients and it has low morbidity and good mid-term oncological outcomes). In rectal cancer surgery, the robotic approach is a promising alternative and is expected to overcome the low penetration rate of laparoscopy in this field.

Key words: robotic approach, rectal cancer, TME, oncological outcomes, sexual function

Introduction

Since 1826, when Jacques Lisfranc performed the first rectal excision (1), the field of rectal surgery has expanded widely, with significant advances including transsphincteric resection and abdominoperineal resection (APR). There are 2 significant landmarks in the surgical approach for rectal cancer: the anterior resection, which was introduced in 1930, and the total mesorectal excision (TME), which was proposed by Heald in 1982.

In the early 1990s, new major technical advances made the minimally invasive approach in rectal cancer surgery possible. The first laparoscopic colon resection was performed in 1991 (2,3). Compared with colon resection, laparoscopic rectal resections require careful consideration as a result of additional concerns regarding an accurate total mesorectal excision and, consequently, the possibility of compromising the oncological outcome in cases of incomplete TME. A laparoscopic procedure should follow the same oncological principles as an open procedure.

Recent studies revealed better short-terms outcomes and similar oncological outcomes compared to open surgery (4,5). Because of the steep learning curve (most authors demonstrated that approximately 50-70 cases are needed to overcome the learning curve) and to the fact that laparoscopic rectal resection is a technically challenging procedure (6) in this particular field, laparoscopic surgery could not achieve the impact that it has in cases of different pathology (e.g., cholecystectomy, splenic surgery, GE junction surgery). The main challenge of laparoscopic surgery is the use of straight rigid instruments in a deep, narrow space.

Robotic surgery was developed in response to the limitations of laparoscopic surgery; it can provide surgeons with a tridimensional view and the ability to control the operative field by manipulating the camera, as well as enhanced dexterity and precision due to the EndoWrist Instruments with 7 degrees of freedom (7). Recent studies reported a lower learning curve compared to laparoscopic surgery (8,9) and highlighted the intraoperative advantages and positive short-term outcomes. The major inconvenience of robotic surgery is related to its high cost, regarding both the equipment and the disposable instruments, so the question that needs to be answered in the near future is whether such an expense is justified in the treatment of rectal cancer.

The aim of this study was to evaluate the morbidity, oncological outcomes and the quality of life in a consecutive series of 100 patients undergoing robotic rectal procedures performed at a single institution.

Materials and Methods

Between January 2008 and June 2012, 100 consecutive patients undergoing robotic rectal resection for cancer were analyzed retrospectively. The study was aproved by the Fundeni Clinical Institute Ethics Committee. Informed written consent was signed by all patients. The procedures were performed by 3 surgeons who were experienced in advanced laparoscopy and robotic surgery. We excluded patients with previous colonic surgery, carcinomatosis, T4 tumors that required a multiorgan resection (2 cases of pelvic exenteration were performed using the robotic approach), older occlusive forms in which Hartmann resection was performed (4 cases) and a contra-indication to prolonged pneumoperitoneum. The presence of liver metastasis was not an exclusion criterion.

The preoperative patient workup included physical examination, complete blood count, electrolytes, liver function test and EKG. Colonoscopy was performed routinely in order to evaluate the entire colon and to obtain a biopsy. Chest, abdominal and pelvic imaging by CT and magnetic resonance of the pelvis were performed. Preoperative clinical data included patient's characteristics and TNM staging. The final treatment plan was decided by a multidisciplinary team that included surgeons, radiologists and oncologists and that followed the NCCN guidelines for rectal cancer. Patients staged as T3/T4 without distant metastasis and stage 4 patients with liver metastasis only were treated with preoperative radio chemotherapy (45-50 Gy in combination with systemic 5 FU). Patients with resectable synchronous liver metastasis were referred to a multimodal approach, robotic rectal resection was performed for rectal cancer, and open liver resection after intraoperative ultrasound was performed for resectable liver metastases in the same procedure.

Perioperative clinical data included general patient characteristics, history of abdominal surgery and tumor location. The intraoperative results consisted of the type of surgical procedure, conversion to open and laparoscopic surgery, operative time for each type of procedures (LAR, APR) and volume of blood loss. The postoperative results included pathological data (tumor diameter, distal resection margins, number of retrieved lymph nodes, status of circumferential resection margin and TNM stage), postoperative complications, hospital stay and follow-up.

Follow-up consisted of a clinical examination within 1 month of surgery, examinations every 3-6 months after discharge with tumor markers, abdominal ultrasound and chest X-ray in the first year and examinations every 6 months in the second year. Colonoscopy was performed at the end of the first year and every 2 years thereafter. In patients with postoperative chemoradiotherapy, an abdominal/pelvic CT or MRI was performed at the end of treatment or at the end of the first year in patients with early-stage rectal cancer.

To investigate sexual and urinary function after robotic rectal resections, patients were investigated using the IPPS (International Prostatic Symptom Score) questionnaire for urinary function and either the IIEF (International Index of Erectile Function) questionnaire, which evaluates men's sexual function (10), or the FSFI (Female Sexual Function Index), which evaluates women's sexual function (11). The information was collected before surgery and during a period between 6 and 12 months after surgery.

Operative technique

In 2008, robotic surgery for rectal cancer was performed using the Da Vinci S Surgical System; since 2009, the Da Vinci Si Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) has been used in robotic rectal resections for a four-arm full robotic procedure.

In cases of upper rectal cancer preoperative colonoscopic tattooing using an injection method with prepackaged sterile India ink for the localization of the inferior margin of the tumor was performed. Mechanical bowel operation was performed the day before surgery. Prophylaxis with antibiotics and treatment for thrombosis were performed in the same way as for open rectal surgery. After the induction of general anesthesia, the patient was placed in a modified lithotomy position with the legs abducted and slightly flexed at the knees, and the patient's left arm was placed alongside the body. The position was secured with a vacuum-mattress device. Peritoneum of 10-12 mm Hg was achieved with a Veress needle inserted 2-3 cm to the right and superior to the umbilicus, and a 12-mm trocar for the camera was placed. A 30 0 down-looking endoscope was used. Four additional trocars were inserted as follows: one in the right iliac fossa 10 cm from the camera port, in the upper abdomen, slightly to the left; one in the left iliac fossa, on the spino-umbilical line, while the robotic ports and a laparoscopic trocar for the side assistant were placed in the right abdominal flank, 8 cm from the camera and right arm ports. The patients were placed in 30-degree Trendelenburg position and tilted right-side down. The Da Vinci system was docked over the patients' left hip. For vascular access, left colon mobilization and splenic flexure mobilization, a 3-arm robotic procedure was performed using the ports placed in the right iliac fossa and in the upper abdomen. At this stage, docking the fourth arm could result in collisions between the robotic arms, that is why we prefer a 4-arm robotic procedure only for TME. The IMV was taken at the inferior border of the pancreas. The IMA was isolated and divided between clips 1 cm from its origin with caution in order to preserve the hypogastric nerves. In some cases, with tall and obese patients, it was not feasible to perform splenic flexure takedown with a single docking procedure. In these cases, splenic flexure takedown was performed laparoscopically at the end of the robotic procedure after undocking the robot. For TME, the fourth robotic arm was docked. The dissection was performed using a monopolar hook and monopolar robotic scissors or a Harmonic scalpel, depending on the surgeon's preference. In low rectal tumors, when a sphincter-saving procedure was intended, especially in a deep male pelvis and in cases with a bulky tumor, the seven degrees of freedom of the Endowrist instruments facilitated the dissection. Care was taken to preserve the hypogastric and pelvic autonomic nerves in the posterior, lateral and anterior dissections of the rectum. The most difficult part of this step was to identify and to preserve the lateral and anterior nerves. In cases of upper rectal tumors, the dissection continued around the rectum 4-5 centimeters below the inferior margin of the tumor that had been marked preoperatively; this procedure was a partial mesorectal excision. In those cases, the surgical procedure that was performed was an anterior resection. For mid and low rectal tumors, the entire rectum was mobilized. The surgical procedure performed for mid rectal tumors was a low anterior resection with an anastomosis below the peritoneal reflection. The rectum was divided by the assistant using an Endo GIA roticulator stapler with a 45-mm blue load. Although 2 or 3 loads were necessary in the majority of cases, in some cases, up to 5 loads were used. After undocking, the specimen was extracted via a 4-5 cm Phannenstiel incision. An Alexiswound retractor (small; AppliedMedical, Rancho Santa Margarita, CA) was used to protect the incision. After dividing the proximal colon, an anvil was placed into the proximal stump, the colon was placed back into the abdomen, and the anastomosis was performed laparoscopically or robotically (with the help of the fourth robotic arm used as a retractor) using a circular EEA stapler (12). In 2 cases, we used transanal specimen extraction after dividing the distal rectum to avoid the Phannenstiel incision. The proximal colon was divided extracorporeally, and after the anvil was secured, the colon was pushed back into the peritoneal cavity. The anastomosis was performed in the same fashion as described above.

Two drains were left in place, and a loop ileostomy was performed. At the beginning of our experience, ileostomies were routinely performed. The current rule is to perform ileostomy only in cases of low and ultra-low anterior resections. In cases of anterior resections, virtual ileostomy is preferred in the same manner as described by Sacchi et al (13).

In selected cases of low rectal cancer, an ultra-low anterior resection with a manual coloanal anastomosis (CA) was performed. In cases of abdominal-perineal resection, the splenic flexure was not mobilized, and the specimen was extracted through the perineal incision after dividing the proximal colon with an Endo GIA linear stapler.

In three cases of stage 4 rectal cancer with synchronous resectable liver metastasis, an open liver resection was performed at the end of the robotic rectal procedure via a subcostal incision after a laparoscopic ultrasound evaluation. The liver resections were as follows: one left hepatectomy extended to segments 8 and 1, multiple wedge resections for metastasis located in segments 2, 3, 5, 6 and 8 and a left lateral sectionectomy combined with radiofrequency destruction of metastasis located in segment 8, which was not suitable for resection because of its central location.

Statistical analysis

Data were expressed as the median (range) for continuous variable and number (percentage) for categorical variables. Overall survival was assessed using Kaplan-Meier method.

Results

The clinical characteristics of patients who underwent robotic rectal resections are listed in *Table 1*. There were 66 males and 34 females. The median age was 62 years. BMI ranged from 16.4 to 38. Almost half of the patients had significant comorbidities (mainly cardiovascular diseases). Previous abdominal surgery was not a contraindication or a reason for conversion to open surgery. Over half of patients (58%) received neoadjuvant chemoradiotherapy (nCRT). The tumor was located in the lower rectum in 31 cases, in the mid rectum in 39 cases and in the upper rectum in 30 cases.

Thirty patients underwent robotic anterior resection for upper rectal cancer, and 39 patients underwent low anterior resection for mid rectal cancer. In cases of low rectal cancer, we performed robotic abdominoperineal resection in 23 cases, and in 8 cases an ultraLAR with hand-sewn coloanal anastomosis was performed (*Table 2*).

There were 7 patients with stage 4 rectal cancer. In three cases of stage 4 rectal cancer with synchronous resectable liver metastasis, an open liver resection was performed. In 4 cases, there were multiple unresectable liver metastases, and the patients underwent robotic rectal resection only. Diverting loop ileostomy was performed in 64 cases of sphincter-saving surgery (83%). In 3 cases, virtual ileostomies were performed. There was no need to open the ileostomy in these cases. The robotic procedure was converted in 4 cases owing to the extension of the disease to adjacent organs, which was not diagnosed preoperatively. There was no conversion for intraoperative bleeding. The median operative time for sphincter-saving procedures was 180 min. The median time for robotic abdominoperineal resection was 160 min. Estimated blood loss ranged between 0 and 250 ml.

The overall morbidity rate was 30%. In 18% of patients, a surgical complication occurred (*Table 3*). In 12 patients, these complications were managed conservatively. The most frequent cause of postoperative morbidity was anastomotic

Table 1. *Patient characteristics, N=100*

	Mean	
Sex		
Male	66	
Female	34	
Age (years) - median, range	62	32-84
BMI- median, range	26	16.4-38
Comorbidity	48	
History of abdominal surgery	19	
Tumor location		
Low <5 cm	31	
Mid 5-10 cm	39	
Upper 10-15 cm	30	
Preoperative CRT	58	

Table 2. *Surgical outcomes, N=100 %*

Type of operation		
APR	23	
AR	30	
LAR	39	
uLAR with coloanal anastomosis	8	
Diverting loop ileostomy	64	83%
Conversion	4	
Operative time –APR - median, range	180	100-330
Operative time –LAR - median, range	160	85-255
Estimated blood loss - median, range	150	0-250
Tumor diameter- median, range	3.75	0.5-12 cm
Distal resection margins - median, range	3	0.2-7 cm
Retrieved lymph nodes - median, range	14	4-32
TNM stage -0	5	
I	24	
II	43	
III	21	
IV	7	
Grading	G1-64, G1-2 -18, G2-8, G2-3 -5	
Postoperative stay - median, range	10	6-38
Follow-up (months) - median, range	24	9-63

Table 3. *Surgical complications*

Surgical complications 18 cases	Treatment
Anastomotic leak 9 cases (colostomy)	1-Open reoperation
	2-Open reoperation – revision surgery for failed colo-anal anastomosis
	6-Conservative treatment
Bowel obstruction 1 case	Open reoperation
Postoperative bleeding 1 case	Open reoperation
Unrecognized intraoperative bowel injury 1 case	Open reoperation (Intestinal suture)
Biliary fistula 1 case	Conservative, ERCP
Pelvic abscess	CT drainage
Wound infection 4 cases	Conservative

leak (9 cases). The leak rate was significantly higher in patients with mid and inferior rectal tumors (8 out of 9 leak cases) and in males (7 cases). Seven of 9 patients underwent preoperative chemoradiotherapy. Three patients with anastomotic leak underwent open reintervention, 2 patients underwent revision surgery for failed colo-anal anastomosis, and in one case, a colostomy was necessary. After revision of the colo-anal anastomosis, the postoperative course was uneventful.

In patients with robotic rectal resections and open liver resections (3 cases), the following complications occurred: one case of prolonged biliary fistula (> 500 ml/ day) requiring endoscopic treatment and one case of pelvic abscess requiring CT drainage.

General complications occurred in 12 patients (*Table 4*). There was no in-hospital mortality.

Pathological outcomes are presented in *Table 2*. The median distal margin of the operative specimen was 3 cm. The median number of harvested lymph nodes was 14. The distal resection margin was negative in all patients. The circumferential resection margin was negative in all cases, except for one patient.

Regarding the investigation of sexual and urinary function, 78 of 100 patients completed the questionnaires (26 women and 52 males). Most patients had minimal urinary symptoms before surgery. Four patients presented transitory postoperative urinary dysfunction, all of whom were medically treated (alpha 1 adrenergic receptor antagonist). Only 2 were discharged with a urinary catheter; the catheter was removed after 25 days following surgery for one patient and after 40 days for the other. On follow-up, there was no significant deterioration in the IPPS score. Twenty-one of 52 males and 13 of 26 women had no sexual activity prior to surgery. At the 6- to 12-month follow-up, there were no significant differences in the IIEF and FSFI scores with the exception of 3 patients with severe erectile dysfunction (among patients with sexual activity prior to surgery).

Regarding oncological outcomes, the median follow-up time was 24 months (range 9-63 months). There were no port-site metastases. The 3-year overall survival rate was 90% (*Fig. 1*). Median overall survival was not reached because of a high number of censored cases.

There were 2 local recurrences during the follow-up period. One patient underwent open emergency surgery for intestinal occlusion as a result of pelvic recurrence 8 months after the initial operation (intraoperatively, pelvic recurrence with ileal invasion and peritoneal carcinomatosis was found, and an ileo-transversoanastomosis was performed). The second patient, with previously positive circumferential resection margin, underwent robotic abdominoperineal resection for a pelvic recurrence 9 months after robotic low anterior resection.

There were 7 deaths during the follow-up period, including 3 patients with stage 4 rectal cancer, 3 patients with stage 3 rectal cancer and one patient with stage 1 rectal cancer.

Table 4. *General complications*

Complications	Number of cases-12
Pneumonia	1
Pleural effusion	2
Acute renal failure	1
Urinary retention	4
Ileus	4

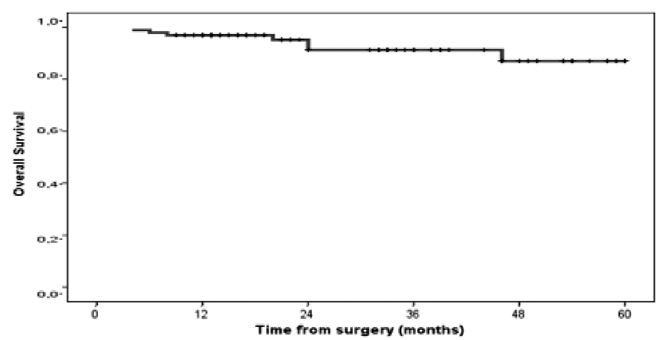

Figure 1. *Overall survival*

Discussion

The Medline electronic database was reviewed using PubMed in order to identify articles focusing on robotic colorectal surgery that were published until June 2012. Because oncological outcomes and short-term outcomes could be affected by the learning curve, we decided to analyze only studies based on 50 patients or more who underwent robotic rectal resection for rectal cancer. We found 7 articles with a total number of 530 patients. All the studies were published in the last few years (2009-2011), indicating an increasing and rapidly growing interest in the field of robotic rectal resection (*Table 5*).

The results of these studies were compared to our findings, and in addition, there are several topics to be discussed regarding the learning curve, cost, quality of life and the robotic approach in patients with stage 4 rectal cancers with liver metastasis.

Surgical technique: hybrid or full robotic procedure?

The totally robotic procedures were categorized as follows:

- Single docking totally robotic procedures (14-17) are feasible mostly in Asian patients because of the ethnic difference of these patients. The "flip-arm" technique (18), which utilizes all three arms throughout the procedure and keeps the patient-side cart docked only once, is included in this category. Another type of single docking procedure is the "reverse-hybrid procedure" (19), which involves a reversal of the operative sequence with lymphovascular and rectal dissection to precede proximal colonic mobilization.

Table 5. *Current status of robotic rectal surgery*

Authors / Year of publication / Journal	No of cases	Procedure type	Surgical technique	Operative time –mean (range)	Conversion	Leak	Morbidity	Length of stay mean (range)	Follow-up (months)
Zimmern et al. / 2010 / World J Surg (20)	58	47 LAR, 11 APR	Hybrid	308.8 APR 324.4-380.7 LAR	1.7%	-	36.6% APR 23.4% LAR	6.3-6.7 LAR 10.3 APR	10.3 APR 12.9-20.7 LAR
NK Kim at al. / 2010 / Journal of the Korean Society of Coloproctology (41)	100	98% sphincter-saving surgery	-	385±102.6	2%	8.2%	20%	11.7±6.7	-
Baik* et al. / 2009 / Ann Surg Oncol (42)	56	56 LAR	Hybrid	178 (120-315)	0	1.7%	10.7%	5.7±1.1, 5 (5-10)	14.3
Pigazzi+ et al. / 2010 / Ann Surg Oncol (24)	143	80 LAR 32 CA 31 APR	Totally robotic, hybrid	297 (90-660)	4.9%	10.5%	41.3%	8.3 (2-33)	17.4
Baek et al. / 2010 / Ann Surg (31)	64	34 LAR 18 CA 12 APR	Hybrid	270 (150-540)[a]	9.4%	7.7%	35.9%	5 (2-33)[a]	20.2
Choi et al. / 2009 / Diseases of the colon & rectum (14)	50	40 LAR 8 ISR 2 APR	Single-stage totally robotic	304.8 (190-485)	0	8.3%	18%	9.2(5-24)	-
Kwak* et al. /2011 / Diseases of the colon & rectum (15)	59	54 LAR 5 ISR	Single-stage totally robotic	270 (241-325)[a]	0	13.6%	32.2%	-	15

+ = multicentric; * = comparative; a = median; ISR= intrasphincteric resection;

- Dual docking procedures, which involve redocking and repositioning of the robotic cart, are more time consuming but are especially useful for surgeons with no previous experience in laparoscopic surgery (9).
- In three docking procedures, the surgical cart is placed in one of three different positions depending on the phase of the procedure, and they consist of splenic flexure takedown, vascular phase and TME (9).

Most authors, especially those with laparoscopic experience, favor the hybrid approach (8,20-23). In the hybrid approach, the surgeon uses a single position of the robotic cart for TME and a laparoscopic part for the mobilization of the splenic flexure. Regarding the vascular approach, different opinions exist. Baik et al. (22) and Pigazzi et al. (24) report division of IMA and vein and mobilization of the left colon using the laparoscopic approach.

In all cases, we attempted a single docking totally robotic procedure, but in some cases, robotic splenic flexure mobilization is unfeasible because the robotic system is unable to reach the left upper abdomen (high splenic flexure). In our series, the feasibility rate of performing a totally robotic procedure was 93%. In such cases, laparoscopic takedown of the splenic flexure is advisable, especially by surgeons who are advanced in laparoscopic techniques (12,16,25). Another solution is to disengage, reposition the robot in the upper left part and redock, which is a time-consuming alternative that is useful for surgeons with no significant experience in laparoscopic surgery.

In order to control the inferior mesenteric vessels and to take full advantage of the robotic system with its 7 degrees of instrumentation, it is possible to divide the vessels between ligatures. A cost-effective alternative to the robotic clips would be to divide the vessels between laparoscopic clips placed by the assistant.

The use of the fourth robotic arm is beneficial in narrow spaces such as the deep pelvis. The fourth arm is used as a retractor and is very helpful in the circumferential dissection of the rectum deep in the pelvis. Its position can be constantly rearranged. Robotic surgery allows a right-handed surgeon to perform surgery as an ambidextrous surgeon.

Learning curve of robotic rectal surgery

Laparoscopic techniques have induced a tremendous revolution in the field of general surgery. Regarding rectal surgery, laparoscopy has a low adoption rate because it is a technically challenging procedure. Robotic surgery overcomes the limitation of laparoscopic surgery, and its benefits (tridimensional view, enhanced dexterity and precision) could decrease the learning curve of laparoscopic surgery. We began performing laparoscopic rectal surgery in 1995, and since then, we have performed a total of 92 laparoscopic rectal cancer procedures, almost half of which have been abdominal perineal resections (12, 26). Since 2008, when we started performing robotic surgery (27), we have surpassed this number (100 cases in 4.5 years), as well as the number of sphincter-saving procedures (12). Since then, all patients with rectal cancer have undergone the robotic approach.

One of the main causes for conversion in laparoscopic surgery is the inability to perform pelvic dissection with complete and accurate mesorectal excision in the deep male pelvis. The advantages of the robotic system have decreased the conversion rate to open surgery (4%) and have allowed us to perform accurate deep pelvic dissection, resulting in an increased number of sphincter-saving procedures with good functional results.

A study published in 2011 by Bokhari et al. (8) suggests that after a learning phase of 15-25 cases, surgeons may achieve a high level of competence. After performing 20 robotic rectal resections, the operative time was significantly decreased even among surgeons with no previous laparoscopic experience (24). In large studies, the operative time for various types of robotic rectal resections ranged from 178 to 304 min, which is in line with the operative times reported in large studies of laparoscopic rectal resections (28-30). After performing a relatively small number of cases, and based on our previous experience in minimally invasive surgery, skin-to skin operative time for robotic surgery became comparable and even shorter than the operative time for laparoscopy. In our opinion, previous laparos-copic experience is required in order to rapidly overcome the learning curve of the procedure and to have a wide range of available alternatives (e.g., the ability to perform a hybrid procedure when needed and the possibility to convert the procedure to laparoscopic surgery in case of system failure).

Regarding morbidity, our results (30%) compare favorably with the data published in the literature (35.9% morbidity reported by Baek et al., 41.3% reported by Pigazzi et al. and between 24.4% and 36.6%, depending on the type on the procedure, reported by Baek et al). (14,24,31). In 14 of 30 patients, the complications were minor (i.e., wound infections, pleural effusion and ileus). We cannot establish any correlation between surgical morbidity and the learning curve. As expected, the leak rate (9%) was found to be higher in males, in mid and low rectal tumors and in patients with neoadjuvant chemo radiotherapy. There was no in-hospital mortality.

Robotic approach in rectal cancer with liver metastases: the impact on overall survival

While most authors excluded patients with stage 4 rectal cancer from their series (24,31), we believe that these patients can also benefit from the robotic approach, and whenever possible, a one-stage resection of rectal cancer and liver metastasis should be performed. In our series, including stage 4 rectal cancer patients influenced the overall survival results when compared to the data published in the literature showing 3-year overall survival of 97% (24) and 96.2% (31). The purpose of the surgery is to improve the early outcome and to minimize the time to chemotherapy. Whenever possible, a combined robotic, laparoscopic or open resection should be performed. Although it is described in the literature (23) and although we performed rectal cancer resection combined with liver resections entirely by the laparoscopic approach, a total minimally invasive approach for these cases was not feasible in our patients because of the number and location of the liver metastases. The hepatic lesions were approached via a left subcostal incision, thus avoiding a traditional large incision used for the open approach of both liver and rectal lesions. This procedure is technically challenging and requires expertise in open and minimally invasive oncologic surgery (32-34). In our experience, this procedure was associated with acceptable morbidity.

Quality of life

To demonstrate the benefits of robotic surgery, one of the main parameters to evaluate, along with oncological outcomes, is the quality of life. The technical benefits of robotic surgery, such as improved tridimensional views, tremor elimination and enhanced dexterity, should result in a better preservation of the pelvic autonomic nerves and better quality of life. There are a few “danger zones” related to nerve preservation. These zones include the origin of the IMA, at the level of sacral promontory; most important, there is a high risk of injuring the nerves during the anterior and lateral dissection. Most frequently, the postoperative urinary and sexual complications result from damage to the parasympathetic nerves, which are located deeper in the pelvis (35). In the laparoscopic approach, the straight, rigid instruments approach the proper dissection plane at an acute angle, which results in increased urinary and sexual complications in these patients as a result of nerve injury at this level. In the robotic approach, the articulated instruments and 3-D view allow us to approach the plane in the same fashion as in open surgery. A balance must be found between preserving the right oncologic plane and preserving the pelvic nerves.

A recent published review on sexual dysfunction and quality of life in patients with colorectal cancer reported a percentage that varied from 5 to 88% regarding sexual dysfunction in men and was approximately 50% in women (36). Regarding urinary and sexual function after laparoscopic TME, a study published recently by Jin-Tung Liang et al. (37) showed poor voiding function after removal of the Foley catheter in 5.4% of cases, and in male patients, poor sexual function (e.g., failure to ejaculate, retrograde ejaculation) was found in 25% of cases. Another study, published in 2011 by Sartori et al., showed severe urinary complication in 3% of cases, impaired sexual function in almost half the cases and poor sexual function in 30% of cases (38).

Jayne et al. reported that in men, overall sexual function and erectile function tended to be worse after laparoscopic compared to open rectal surgery (39).

Only 2 papers have reported sexual and voiding function after robotic TME. Kim et al. reported that robotic total mesorectal excision for rectal cancer is associated with earlier recovery of normal voiding and sexual function when compared to the laparoscopic approach (40). Patriti et al. reported erectile dysfunction in the first 2 of 29 patients undergoing robotic LAR, which may have resulted from the learning curve (23).

In our series, 4 of 100 patients presented transitory postoperative urinary dysfunction, all of whom were medically treated (alpha 1 adrenergic receptor antagonist), and only 2 were discharged with a urinary catheter, which were later removed with no incidents. Severe erectile dysfunction was reported by 3 patients.

Although there are very few reports on this subject, our data confirm that the robotic approach for rectal cancer surgery results in a low incidence of urinary and sexual complications. Of course, large prospective studies are needed in order to confirm the advantages of this approach.

Conclusion

Robotic surgery has advantages for both surgeons (in that it facilitates the dissection in the narrow pelvis and in cases of bulky tumors and it allows the surgeon to perform safe sphincter-saving procedures in a high number of patients) and patients (in that it allows for a good quality of life via the preservation of sexual and urinary function in the vast majority of patients and it has low morbidity and good mid-term oncological outcomes). Robotic surgery for rectal cancer is expected to overcome the low penetration rate of laparoscopy in this field.

Operative time is not impaired by the robotic approach. Currently, the only limitation of the use of the robotic approach on a larger scale is its high cost, but improving the OR time and case volume in dedicated centers can partially compensate for its disadvantages. Our results suggest that in rectal cancer surgery, the robotic approach is a promising alternative.

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