RESEARCH ARTICLE JSLS

Experience With Transitioning From Laparoscopic to Robotic Right Colectomy

Florent Gerbaud, Alain Valverde, MD, Divya Danoussou, Nicolas Goasguen, MD,
Olivier Oberlin, MD, Renato Micelli Lupinacci, MD, PhD

ABSTRACT

Background and Objectives: The number of robotic colorectal procedures performed has rapidly increased, but there are only sparse data available about the robotic learning curve of expert laparoscopic colorectal surgeons.

Methods: In this retrospective study, we reviewed 101 minimally invasive right colectomies consecutively performed by a single surgeon with 20 years of clinical practice fully dedicated to laparoscopic surgery. Thus, the last 59 laparoscopic resections were compared with the first 42 robotic resections.

Results: The duration of the procedure was longer in the robotic group, but the conversion rate was the same in both groups. There was no difference between groups in rates of overall and severe postoperative complications, reoperation, hospital length of stay, and readmission. Number of harvested lymph nodes and oncological quality of resection defined by the pathologist were the same.

Conclusions: This study suggests that the transition from the right laparoscopic colectomy with extracorporeal anastomosis to the robot-assisted right colectomy with intracorporeal anastomosis when performed by a surgeon with experience in laparoscopic colorectal surgery may not entail any increase on the morbidity rate or reduce the oncologic quality of the resection.

Key Words: Colon cancer, Laparoscopy, Robotics.

Service de Chirurgie Digestive, GH Diaconesses Croix Saint Simon (Drs Gerbaud, Valverde, Danoussou, Goasguen, Oberlin, Lupinacci).

Disclosure: none.

Funding/Financial Support: none.

Conflicts of Interest: The authors have no conflicts of interest directly relevant to the content of this article.

Informed consent: Dr. Lupinacci declares that written informed consent was obtained from the patient/s for publication of this study/report and any accompanying images.

Address correspondence to: Renato Micelli Lupinacci, MD, PhD, Service de Chirurgie Digestive, GH Diaconesses Croix Saint Simon, 125 rue d'Avron, 75020 Paris, France. Tel: +33 1 44 64 16 66; Fax: +33 1 44 64 33 17; E-mail: rlupinacci@hopital-dcss.org

DOI: 10.4293/JSLS.2019.00044

INTRODUCTION

The robotic system is used in various fields of surgery, and its application to different indications continues to expand in parallel with the development of technology.[1] Since the first descriptions of robotic-assisted colectomy in 2001,[2] the number of robotic colorectal procedures performed worldwide has rapidly increased.[3] The introduction of new technologies in surgery is not free of risks and poses questions concerning surgeon training and how to ensure patient safety.

There are only sparse data available about the learning curve of expert laparoscopic colorectal surgeons, which might be different from that for a colorectal surgeon primarily starting with robotics without prior laparoscopic experience, especially as the robotic system theoretically should simplify the operative procedure, which may result in a fast learning curve.

We reviewed the first 42 robotic-assisted right colectomies performed by a single surgeon with 20 years of clinical practice fully dedicated to general surgery. The surgeon had an appropriate training in laparoscopic techniques during residency and then performed predominantly minimally invasive surgery for both minor (gallbladder and inguinal hernia) and major surgeries (colorectal, bariatric, upper gastrointestinal).[4,5] Thus, the aim of this study was to evaluate if the transition from the right laparoscopic colectomy to the robot-assisted technique when performed by an experienced surgeon entails any increase in the complication rate or decrease in oncologic quality of the resection.

PATIENTS AND METHODS

All consecutive patients who underwent minimally invasive right colectomy (MIRC) for adenoma/adenocarcinoma at the Groupe Hospitalier Diaconesses Croix Saint Simon (GHDCSS) hospital between June 2013 and March 2019 were identified from our institutional database. One single surgeon (A.V.) performed 101 consecutive MIRCs during this period, which constitutes the subject of the present study. The first 59 patients underwent laparoscopic right colectomy (LRC) with an extracorporeal anastomosis (ECA), whereas the last 42 patients underwent robot-assisted right colectomy (RARC) with either ECA, which was performed in the first 19 procedures, or intra-

Table 1.
Patient Demographics and Preoperative Characteristics

Variable	Robot-assisted (n = 42)	Laparoscopic (n = 59)	*P*-value
Age (years), mean ± SD	67 ± 8.6	72 ± 8.6	**.028**
Sex, n			.782
Female	21 (50%)	28 (47.5%)	
Male	21 (50%)	31 (52.5%)	
BMI (kg/m^2), mean ± SD	26 ± 4.7	24 ± 4.3	.129
BMI ≥ 30 kg/m^2, n	14 (33.3%)	12 (20.3%)	.104
ASA group, n			.221
1 or 2	25 (59.5%)	43 (72.8%)	
3 or 4	17 (40.5%)	16 (27.2%)	
Preoperative diagnosis, n			.348
Benign neoplasm	12 (28.5%)	22 (37.2%)	
Malignant neoplasm	30 (71.5%)	37 (62.8%)	
Localization of the neoplasm, n			.448
Cecum/ascending colon	31 (73.8%)	40 (67.7%)	
Right flexure/proximal transverse	11 (26.1%)	19 (22.3%)	

ASA, American Society of Anesthesiologists; BMI, body mass index.

corporeal anastomosis (ICA) for the last 23 procedures. There were no planned selection criteria for each surgery. The choice between the different approaches was simply chronological and dependent on the availability of the robotic operating theater.

Data were collected retrospectively and included demographic, clinical, and pathological data: sex, age, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status score, tumor size, localization of the lesion (cecum/ascending colon versus right colonic flexure/proximal transverse), presence of an invasive component (adenoma versus adenocarcinoma), conversion to open surgery,[6] estimated blood loss (EBL), drainage, presence of intraoperative complications, oncological quality of resection (graded by the pathologist), number of harvested lymph nodes (HLNs), duration of operation, and postoperative hospital length of stay (LOS). The pathologist was blinded to the mode of surgery. Patients were assessed

Table 2.
Intraoperative Outcomes

Variable	Robot-assisted (n = 42)	Laparoscopic (n = 59)	*P*-value
Conversion to open surgery, n	0	1 (1.69%)	1
Estimated blood loss (mL)			.730
Mean ± SD	27 ± 26	31 ± 29	
Median, range	10 (5–200)	20 (0–400)	
Surgery duration (min)			**<.0001**
Mean ± SD	197 ± 25.3	137 ± 19	
Median, range	204 (140–270)	135 (94–245)	
Drainage, n	0	2 (3.38%)	.509
Intraoperative complications, n	2 (4.76%)	1 (1.69%)	.569

for complications at discharge from the hospital and at 30 days postoperatively. Complications were classified by the Clavien–Dindo method.[7] Postoperative ileus was defined as previously published.[8] All patients who had a complication grade 1 or higher were included in the complication rate. Evidence of distant metastases was not an exclusion criterion.

Surgical procedure

The surgical procedure was equal whether robotic or laparoscopic. Briefly, a standard right colectomy was performed. Patient was placed in the Trendelenburg position and titled to the left. The procedure started by the section of right colon feeding vessels at their root. Right ileocolonic artery was systematically sectioned, whereas the superior right colic artery was sectioned only for right colonic flexure/proximal transverse tumors. ECA was performed through a transverse right subcostal incision or small midline incision and consisted of a standard lateral-to-lateral mechanic anastomosis. ICA was performed manually using a lateral-to-lateral absorbable barbed running suture (V-Loc™ 90 Absorbable Wound Closure Device; Covidien).

Statistical analysis

Normally distributed continuous variables were reported as mean ± standard deviation, and categorical variables

Table 3.
Morbidity and Postoperative Outcomes

Variable	Robot-assisted (n = 42)	Laparoscopic (n = 59)	*P*-value
Postoperative complications, n			
Overall	9 (21.4%)	17 (28.8%)	.393
Clavien ≥ 3	4 (9.5%)	6 (10.1%)	1
Postoperative complications before discharge (type), n			
Cardiovascular complications	0	2	
Pulmonary complications	1	1	
Genitourinary	1	0	
Gastrointestinal	0	2	
Venous infarction	0	1	
Acute cholecystitis	0	1	
Abdominal wall	1	0	
Postoperative bleeding	1	3	
Anastomotic	1	3	
Intracavitary	0	0	
Surgical site infection	2	3	
Superficial	0	2	
Deep	2	1	
Anastomotic leakage	2	1	
Fever of unknown origin*	0	2	
Paralytic ileus	1	1	
Reoperation, n	4 (9.5%)	4 (6.7%)	.715
Hospital LOS (days)			.294
Mean ± SD	6 ± 2.3	7 ± 3.1	
Median, range	5 (2–16)	5 (3–29)	
Readmission, n	3 (7.1%)	2 (3.3%)	.646

LOS, length of stay.
*Antibiotherapy >48 hours.

were reported as counts and percentages. We compared groups using Student's t test for continuous variables and χ^2 or Fisher's exact test for categorical data. Reported P values were 2-sided and were considered significant at the 5% level. Statistical analysis was performed using IBM SPSS® version 20.0 software.

RESULTS

Patient's baseline characteristics were similar in both groups; only age was significantly different (P = .028). Demographics are summarized in **Table 1**.

Concerning intraoperative data, the duration of the procedure was longer in the RARC (197 min vs 137 min, $P <$ .0001). Conversion rate and EBL were the same in the 2 groups. In the LRC group, 1 patient had torsion of the anastomosis, demanding take down of the anastomosis and confection of a new one. In the RARC group, 2 patients had intraoperative complications. One patient had intraoperative bleeding requiring transfusion, and for 1 patient anastomosis was considered ischemic and the surgeon preferred to resect the bowel segments and redo the ileocolic anastomosis. Intraoperative outcomes are presented in **Table 2**.

Morbidity and postoperative outcomes are presented in **Table 3**. There was no difference between groups in rates of overall and severe postoperative complications, reoperation, hospital LOS, and readmission.

Tumor stage, tumor size, number of HLNs, and oncological quality of resection were the same. Recurrence rate and survival also did not differ between groups. Pathological and survival outcomes are summarized in **Table 4**.

In the RARC group, any difference was observed between ECA and ICA groups. Noteworthy, duration of the procedure was 20 min shorter in the ICA group although it didn't reach statistical significance. Data on ECA versus ICA are presented in **Table 5**.

DISCUSSION

A laparoscopic procedure is currently performed in about 50% of patients in the United States undergoing elective right colectomy.[9] When performed laparoscopically, it is usually a hybrid procedure with exteriorization of the bowel through a mini-laparotomy and ECA. Considering ICA, upholders' principal arguments are better short-term outcomes likely related to less surgical trauma to the bowel. ICA would avoid unnecessary transverse colon mobilization and mesenteric traction required to exteriorize the bowel and to perform the anastomosis. This should allow a quicker recovery of bowel function, an alternative

Table 4.
Pathological Characteristics and Oncologic Outcomes

Variable	Robot-assisted (n = 42)	Laparoscopic (n = 59)	*P*-value
Tumor T stage, n			.458
T0–2	25 (59.5%)	31 (52.5%)	
T3–4	17 (40.5%)	28 (47.5%)	
Tumor size (mm), mean ± SD	38 ± 20	42 ± 19	.395
N stage, n			.276
N+	8 (19%)	9 (15.2%)	
Lymph node harvested (n), mean ± SD	26 ± 11	23 ± 7	.370
Resection, n			.569
R0	40 (%)	58 (%)	
R1	2 (%)	1 (%)	
Adjuvant chemotherapy, n	8 (19%)	10 (16.9%)	.791
Recurrence, n			
Local	0	3 (5%)	.263
Distant	1 (2.3%)	2 (3.3%)	1
Overall*	1 (2.3%)	4 (6.7%)	.397

*One patient had local and distant recurrence.

Table 5.
Patient Demographics, Preoperative Characteristics, and Outcomes of 42 Robotic-Assisted Right Colectomy in Comparison Between Intracorporeal (IA) and Extracorporeal (EA) Anastomosis

Variable	EA (n = 19)	IA (n = 23)	*P*-value
Age (years), mean ± SD	68 ± 5.9	65 ± 11.9	.521
Sex, n			.976
Female	10 (52.6%)	12 (52.1%)	
Male	9 (47.4%)	11 (47.9%)	
BMI (kg/m^2), mean ± SD	27 ± 5.1	25 ± 4.4	.367
BMI ≥ 30 kg/m^2, n	5 (26.3%)	7 (30.4%)	
ASA group, n			
1 or 2	12 (63.1%)	12 (52.1%)	.474
3 or 4	7 (36.9%)	11 (47.9%)	
Preoperative diagnosis, n			
Benign neoplasm	2 (10.5%)	8 (34.7%)	.083
Malignant neoplasm	17 (89.5%)	15 (65.3%)	
Localization of the neoplasm, n			.143
Cecum/ascending colon	12 (63.1%)	20 (86.9%)	
Right flexure/proximal transverse, n	7 (36.9%)	3 (13.1%)	
Conversion to open surgery, n	0	0	
EBL (mL), mean ± SD	41 ± 30	11 ± 9	**.007**
Surgery duration (min), mean ± SD	201 ± 23	192 ± 27.4	.377
Intraoperative complications, n	0	2 (8.6%)	.492
Postoperative complications, n			
Overall	4 (21%)	5 (21.7%)	1
Clavien ≥ 3	3 (15.7%)	1 (4.3%)	.313
Reoperation, n	3 (15.7%)	1 (4.3%)	.313
Hospital LOS (days)			.529
Mean ± SD	5.5 ± 3	6.2 ± 2.9	
Median, range	5 (2–16)	5 (3–16)	
Readmission, n	1 (5.2%)	2 (8.6%)	1
Tumor T stage, n			.146
T0–2	10 (52.6%)	15 (65.2%)	
T3–4	9 (47.4%)	8 (34.8%)	
Tumor size (mm), mean ± SD	39 ± 19	35 ± 20	.639
N stage			.188
N+, n	5 (26.3%)	4 (17.3%)	
Lymph node harvested (n), mean ± SD	27 ± 13	24 ± 9	.694

ASA, American Society of Anesthesiologists; IA, intracorporeal anastomosis; EA, extracorporeal anastomosis; EBL, estimated blood loss; LOS, length of stay.

incision site for specimen extraction, and a lesser consumption of analgesic drugs.[10–13] Another theoretical advantage of ICA derives from the direct vision of the mesentery, which theoretically prevents anastomotic and mesentery twist.[10] Many surgeons, however, are uncomfortable performing laparoscopic ICA due to technical difficulties,[11] and some believe that the robotic platform can help surgeons to overcome them.[12,13]

New technologies are constantly being introduced into the surgical marketplace with the promise of improved patient outcomes. They are not, however, lacking risks, and they spark several questions, including how to evaluate specific skill acquisitions, as well as legal and ethical aspects. The introduction of new technologies should provide a judicious balance between the time need for the collection of sufficient data to support its use and the health care needs of patients while data are being collected.[14] This said, one may think that the late introduction of a new modality may bereave the patients of better care.[14,15]

Our study has potential drawbacks principally associated with its retrospective nature and the small number of patients. It is certainly underpowered to allow a generalizing conclusion. However, this study suggests that the transition from the right laparoscopic colectomy with ECA to the RARC with ICA when performed by a surgeon with both experience in laparoscopic colorectal surgery and robot-assisted surgery may not entail any increase on the morbidity rate or reduce the oncologic quality of the resection. It has been shown that a board-certified surgeon is able to acquire new skills without any apparent learning curve.[16] Indeed, Odermatt et al. have shown that experienced laparoscopic colorectal surgeons may have a shorter learning curve when changing from laparoscopic to robotic total mesorectum excision and concluded that the introduction of a robotic system into a specialist colorectal unit may only have some minor effect on outcomes.[17]

Although decreased incidence of postoperative surgical site infection, shorter LOS, earlier return to work, and lower postoperative hernia rates have been documented with minimally invasive colectomy, there is still debate whether using ICA contributes to significant improvements in patient outcomes.[18–21] Moreover, a recent analysis of 509,029 patients who underwent elective colectomy in the United States from 2009 to 2012 showed that the rate of iatrogenic complications was higher for robotic surgery.[9]

In conclusion, the use of new technologies in surgery is related to an increasing complexity in various aspects, including awkward ethical challenges concerning how to ensure the safety of a technology and which criteria should be used before giving permission to surgeons. Thus, the principal message of this study is not the comparison between 2 techniques but the suggestion that skills attained during laparoscopic surgery are possibly transferable to robotic surgery. Larger studies on this topic are needed to confirm our results before it gives rise to discussions whether previous laparoscopic experience should be taken into consideration during credentialing and evaluation of knowledge and skills for robotic surgery, rather than merely counting the numbers of procedures performed.

References:

1. Shah J, Vyas A, Vyas D. The history of robotics in surgical specialties. *Am J Robot Surg*. 2014;1:12–20.

2. Weber PA, Merola S, Wasielewski A, Ballantyne GH. Telerobotic-assisted laparoscopic right and sigmoid colectomies for benign disease. *Dis Colon Rectum*. 2002;45:1689–1694, discussion 1695–1696.

3. Matsuyama T, Kinugasa Y, Nakajima Y, Kojima K. Robotic-assisted surgery for rectal cancer: Current state and future perspective. *Ann Gastroenterol Surg*. 2018;2:406–412.

4. Valverde A, Goasguen N, Oberlin O, et al. Robotic versus laparoscopic rectal resection for sphincter-saving surgery: Pathological and short-term outcomes in a single-center analysis of 130 consecutive patients. *Surg Endosc*. 2017;31:4085–4091.

5. Hauters P, Auvray S, Cardin JL, et al. Comparison between single-incision and conventional laparoscopic cholecystectomy: A prospective trial of the Club Coelio. *Surg Endosc*. 2013;27: 1689–1694.

6. Shawki S, Bashankaev B, Denoya P, Seo C, Weiss EG, Wexner SD. What is the definition of "conversion" in laparoscopic colorectal surgery? *Surg Endosc*. 2009;23:2321–2326.

7. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240: 205–213.

8. Harnsberger CR, Maykel JA, Alavi K. Postoperative ileus. *Clin Colon Rectal Surg*. 2019;32:166–170.

9. Yeo HL, Isaacs AJ, Abelson JS, Milsom JW, Sedrakyan A. Comparison of open, laparoscopic, and robotic colectomies using a large national database: Outcomes and trends related to surgery center volume. *Dis Colon Rectum*. 2016;59:535–542.

10. Morpurgo E, Contardo T, Molaro R, Zerbinati A, Orsini C, D'Annibale A. Robotic-assisted intracorporeal anastomosis ver-

sus extracorporeal anastomosis in laparoscopic right hemicolectomy for cancer: A case control study. *J Laparoendosc Adv Surg Tech A*. 2013;23:414–417.

11. Jamali FR, Soweid AM, Dimassi H, Bailey C, Leroy J, Marescaux J. Evaluating the degree of difficulty of laparoscopic colorectal surgery. *Arch Surg Chic Ill 1960*. 2008;143:762–767.

12. Scotton G, Contardo T, Zerbinati A, Tosato SM, Orsini C, Morpurgo E. From laparoscopic right colectomy with extracorporeal anastomosis to robot-assisted intracorporeal anastomosis to totally robotic right colectomy for cancer: The evolution of robotic multiquadrant abdominal surgery. *J Laparoendosc Adv Surg Tech A*. 2018;28:1216–222.

13. Reitz ACW, Lin E, Rosen SA. A single surgeon's experience transitioning to robotic-assisted right colectomy with intracorporeal anastomosis. *Surg Endosc*. 2018;32:3525–3532.

14. Sachdeva AK, Russell TR. Safe introduction of new procedures and emerging technologies in surgery: Education, credentialing, and privileging. *Surg Clin North Am*. 2007;87:853–866, vi–vii.

15. Strong VE, Forde KA, MacFadyen BV, et al. Ethical considerations regarding the implementation of new technologies and techniques in surgery. *Surg Endosc*. 2014;28(8):2272–6.

16. Colquhoun PH. CUSUM analysis of J-pouch surgery reflects no learning curve after board certification. *Can J Surg*. 2008;51:296–299.

17. Odermatt M, Ahmed J, Panteleimonitis S, Khan J, Parvaiz A. Prior experience in laparoscopic rectal surgery can minimise the learning curve for robotic rectal resections: A cumulative sum analysis. *Surg Endosc*. 2017;31:4067–4076.

18. Wu Q, Jin C, Hu T, Wei M, Wang Z. Intracorporeal versus extracorporeal anastomosis in laparoscopic right colectomy: A systematic review and meta-analysis. *J Laparoendosc Adv Surg Tech A*. 2017;27:348–357.

19. Miller PE, Dao H, Paluvoi N, et al. Comparison of 30-day postoperative outcomes after laparoscopic vs robotic colectomy. *J Am Coll Surg*. 2016;223:369–373.

20. Fabozzi M, Cirillo P, Corcione F. Surgical approach to right colon cancer: From open technique to robot. State of art. *World J Gastrointest Surg*. 2016;8:564–573.

21. Fabozzi M, Allieta R, Brachet Contul R, et al. Comparison of short- and medium-term results between laparoscopically assisted and totally laparoscopic right hemicolectomy: A case-control study. *Surg Endosc*. 2010;24:2085–2091.