



# Right colectomy: consecutive 100 patients treated with laparoscopic and robotic technique for malignancy. Cumulative experience in a single centre

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## Abstract

Robotic-assisted resections prove beneficial in overcoming potential limitation of laparoscopy, but clear evidences on patient's benefits are still lacking. We report our experience on 100 consecutive patients who underwent right colectomy with either robotic or laparoscopic approaches. Data were prospectively collected on a dedicated database (ASA score, age, operative time, conversion rate, re-operation rate, early complications, length of stay, and pathological results). Median total operative time was 160 min in LS group (IQR = 140–180) and 204 min for RS group (IQR = 180–230). Median time to first flatus was 2.5 days for LS group (IQR = 2–3) and 2 days for RS group (IQR = 1–2). Length of stay (median) was 8 days in LS group (IQR = 6–10) and 5 days in RS group (IQR = 5–7). No statistically significant difference was found between the 2 groups when the number of harvested nodes, the anastomotic leakage and the postoperative bleeding were analyzed. The 30-day mortality was 0% in LS and RS groups. Conversion rate for LS group was 14% (7/50 pts) and for RS group was 0% (0/50). Minimally invasive surgery is a feasible and safe technique. The RS may overcome some technical limitations of laparoscopic surgery and it achieves the same oncological results compared to LS but with higher costs. The lower conversion rate allows to expect better clinical outcomes and lower complication rate.

**Keywords** Robotic surgery · Right colectomy · Laparoscopy · Colorectal cancer · Intracorporeal anastomosis · Learning curve

## Introduction

Minimally invasive techniques are a reality in modern colorectal surgery. The first laparoscopic hemicolectomy was performed in 1990 and, despite of an early skepticism, laparoscopic surgery for malignancy has gradually spread. Since 2002, a series of randomized clinical trials comparing laparoscopic and open colectomies resulted in evidence concerning the oncological adequacy of laparoscopic technique [1–6].

The advantages of minimally invasive approach in colorectal cancer surgery have been demonstrated in

both pathophysiological and oncological aspects, with a decreased inflammatory response leading to an enhanced immune response and reduced postoperative morbidity, with comparative results in terms of survival and outcome [3–9].

Many advantages over traditional techniques have been reported including less pain, quicker return to daily activities, minimal scarring, reduced length of stay and less tissue injury. Oncological minimally invasive surgery is feasible with at least the same long-term efficacy as the traditional open approach [10].

Laparoscopy, however, has both technical and “anatomical” disadvantages in colorectal surgery: long learning curve, a large surgical field that requires a skilled camera assistant surgeon, constant dialog between the operator and the assistant, loss of three dimensional vision, reduced ergonomics during specific phases of the procedure (with the need of uncomfortable positions), poor dexterity of the laparoscopic instruments, decreased range of movement due to the rigidity of the insertion of the trocars site, amplification of physiological tremor, and the fulcrum effect [11–14].

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Compared with laparoscopy, surgery assisted by robotic systems is known to have several advantages, including a more ergonomic position, a stable camera platform, a stereoscopic view under the surgeon's direct control, elimination of tremors, improved dexterity given by the instrument's seven degrees of freedom that mimic hand movements. Robotic arms follow the slightest movement of the surgeon's hands; it also can scale down hand movements when the tiniest dissections are needed and it eliminates hand tremors, which further enhances technology's precision and control during surgical procedures [12, 15, 16].

Currently, there are only few comparative studies between RS and LS, whereas many papers have been published regarding open and laparoscopic surgery [17, 18]. We aim to contribute to the discussion on the new trends in surgery comparing feasibility and safety of laparoscopic and robotic right colectomy for colon cancer.

## Materials and methods

We report a retrospective study based on prospectively recorded data of 100 consecutive patients with right colon cancer who underwent right colectomy from 2010 to 2015 either with LS and RS with the DaVinci® System (Intuitive Surgical Inc., Sunnyvale, CA).

Patients data included ASA score (American Society of Anesthesiologists), age, operative time, conversion rate, re-operation rate, early complications, length of stay, and pathological results, with the primary aim to evaluate the feasibility and the safety of both techniques, postoperative complications, and clinical outcomes.

The Da Vinci® Robotic System was introduced in our Hospital in 2012 with the purpose of a multidisciplinary adoption (General Surgery, Urology, ORL, Gynecology).

After an appropriate training with the DaVinci® simulator, a learning curve was drawn through a series of increasingly difficult operations, all the patients submitted to colorectal surgery were consecutively recruited for robot-assisted colectomy, instead of a traditional laparoscopic colectomy, treated by the same surgeon; an informed consent was obtained.

All patients underwent standard right colectomy; CME was not performed in this study.

There were no exclusion criteria for robotic surgery. All the patients underwent "fast-track surgery" protocol adopted in our Institution since 2009. Goals of the protocol included the following: preoperative oral intake of fluids and no bowel preparation, postoperative early mobilization, no routine use of nasogastric tubing, the use of prokinetics such as metoclopramide, enforced introduction of clear liquid diet postoperative day 1, and early removal of bladder catheter. Before induction of general anesthesia urinary catheter were

positioned in all patients. An epidural catheter for postoperative analgesia was positioned in all patients except in those with oral anticoagulant therapy or APTT ratio abnormalities. Only in 5 cases positioning was not possible for anatomical reasons (3 in RS and 2 in LS group). Standard DVT with Enoxaparine and short-term antimicrobial with Cefazoline and Metronidazole prophylaxis were adopted.

## Statistical analysis

Numeric variables were summarized by their median and Inter Quartile Range (IQR = 1st quartile–3rd quartile); categorical variables were summarized by absolute frequencies and percentages. Differences among means were evaluated by non-parametric ANOVA or Mann–Whitney test. The Odds Ratios between groups were fitted by logistic regressions. *P* values were computed by permutation methods, to avoid any asymptotic approximation or distributional assumption, and adjusted for False Discovery Rate (p-adj), when appropriate. *P* values < 0.05 were considered significant. All analyses were computed in R environment (ver. 3.2.2).

## Surgery technique

Surgery starts with induction of pneumoperitoneum by Veress needle and introduction of a trocar for the camera about 3 cm left and 2 cm above the umbilicus.

In Laparoscopy three more trocars are put in place. Two 12 mm trocars in epigastrium and in left lower abdominal quadrant and one 5 mm trocar 1–2 cm left from the right anterior superior iliac spine.

In Robotic four trocars in addition to the camera are put in place. The 8 mm robotic trocar for arm 1 (monopolar scissors) is placed in epigastrium, about 3 cm left from the midline, the robotic trocar for arm 2 (bipolar forceps) is placed suprapubic, and the robotic trocar for the arm 3 (Prograsp or Cadière forceps) is placed 1–2 cm left from the right anterior superior iliac spine. The 12 mm trocar for the assistant is placed in the left lumbar region.

Previous laparotomies do not exclude by rule minimally invasive surgery because adhesions can be treated laparoscopically, even before robotic assistance. The abdomen is inspected to determine the feasibility of minimally invasive resection and to identify the extent of disease.

The patient is tilted in Trendelenburg position (almost 10°–15°) and turned to the left so that the ileus is displaced from the right abdominal quadrants and the right mesentery is completely exposed.

Dissection in laparoscopy is performed with ultrasonic dissector, while in robotic is performed only with mono and bipolar energy.

It starts from ileocolic vessels to the distal ileum and then from the duodenum, with the dissection of the mesocolon from the prerenal fascia, to the pancreas and the transverse mesocolon.

Afterwards, dissection continues to the coloepiploic ligament and with the mobilization of the hepatic flexure and the complete detachment of the ascending colon.

Finally the transection of the ileus and the transverse colon is performed.

A latero-lateral, isoperistaltic, intracorporeal ileocolic anastomosis is performed with a linear stapler and the enterotomy is closed with a double layer running suture. The extraction site of the specimen was always suprapubic.

### Results

We analyzed a series of 100 consecutive patients, 50 treated with LS (28 M, 22 F) and 50 with RS (24 M, 26 F). The mean age for each group was 70.3 yy (LS) and 69.6 yy (RS). All patients underwent right colectomy for malignancy.

Distribution according the ASA Score (American Society of Anesthesiologists) was as follow:

- LS group: ASA1 14% (7/50), ASA2 68% (34/50), ASA3 18% (9/50).
- RS group: ASA1 12% (6/50), ASA2 74% (37/50), ASA3 14% (7/50) (Table 1).

In LS group, intracorporeal anastomosis was performed in 18 (36%) patients. In RS group, intracorporeal

anastomosis was performed in all the patients; only in one case an extracorporeal anastomosis was performed due to hypercapnia that did not allow to continue the operation with the minimally invasive technique.

The conversion rate to open surgery due to technical issues for LS group was 14% (7/50 pts) and for RS group was 0% (0/50); the extracorporeal anastomosis procedure is not intended as a conversion.

In LS group perioperative complications were: 5 anastomotic leakage (10%, 4 surgical and 1 conservative treatment), 3 anastomotic bleeding (6%, 1 endoscopic, 1 surgical and 1 conservative treatment), 4 postoperative ileus (8%), 1 small bowel occlusion (2%, surgical treatment), 3 respiratory complications (6%). We performed 6 reoperations (12%), and the 30 days mortality rate was 0%.

In RS group perioperative complications were: 2 anastomotic leakages, requiring revisional surgery (4%), 2 anastomotic bleeding (4%, 1 endoscopic and 1 conservative treatment), 1 perihepatic abscess (2%) treated with percutaneous drainage US guided, 4 patients had postoperative ileus (8%), 2 respiratory complications (4%). We performed 2 reoperations (4%) and the 30 days mortality rate was 0%.

Median total operative time was 160 min in LS group (IQR = 140–180) and 204 min for RS group (IQR = 180–230).

We observed that the total operative time in Robotic surgery decreases significantly during the learning curve of the surgeon and the team (Fig. 1).

Median time to first flatus was 2.5 days for LS group (IQR = 2–3) and 2 days for RS group (IQR = 1–2). Time to bowel movement (median) was 5 days for LS group (IQR = 3–6) and 4 days for RS group (IQR = 3–4).

Length of stay (median) was 8 days in LS group (IQR = 6–10) and 5 days in RS group (IQR = 5–7).

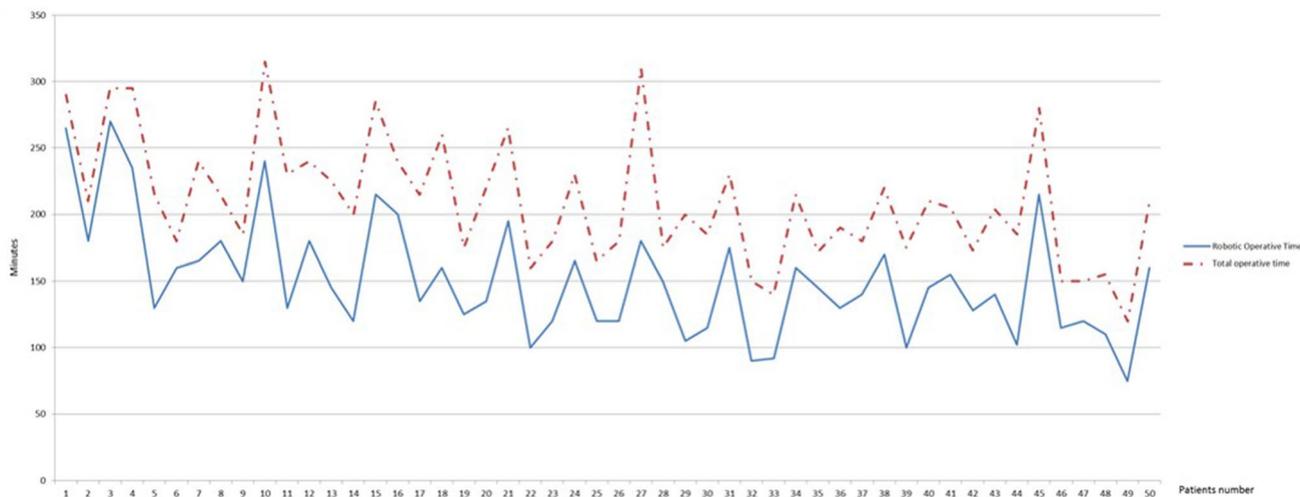
No differences as regard histology were found with a median number of harvested nodes of 23 in LS group (IQR = 15–33) and 20.5 in RS group (IQR = 16–22) (Table 2).

### Discussion

The first robotic colectomies were reported by Weber et al. in 2001 [11]. Since then, a wide range of colorectal operations have been performed, including right and left colectomies, sigmoid resections, rectal anterior resections, abdominoperineal resections, and total colectomies. Initially, these operations were performed mainly for benign diseases [19, 20] and gradually adopted for cancer. Colorectal robotic surgery also seems to be feasible for malignant disease [15–21] with comparable results to standard laparoscopy in terms of oncological radicality, surgical accuracy, and in terms of short-term outcomes.

**Table 1** Preoperative parameters and UICC classification

Preoperative parameters	RS (n = 50)	LS (n = 50)
Age (year) median	70.3	69.6
Gender		
Male number	28	24
Female number	22	26
Body mass index (kg/m <sup>2</sup> ) median	26.2	25.25
Comorbidity %	66%	54%
Previous abdominal surgery %	40	48
ASA score		
ASA 1	7	6
ASA 2	34	37
ASA 3	9	7
UICC		
0	9	15
I	10	7
II	16	9
III	12	16
IV	3	3



**Fig. 1** Learning curve (LS and RS groups)

**Table 2** Postoperative parameters

Postoperative parameters	LS (n = 50)	RS (n = 50)	P value
Day to oral feeding (median)	1	1	ns
Day to first flatus (median)	2.5	2	< 0.001
Day to first evacuation (median)	5	4	< 0.001
Day to discharge (median)	8	5	< 0.001
Harvested nodes (median)	23	20.5	ns
Mortality at 30 days	0	0	ns
Readmission rate at 30 days	0	0	ns
Operation time (min) (median)	160	204	< 0.001
Conversion rate (%)	14%	0%	< 0.001

The experience of our Department of Surgery is reported in this study. The aim was to evaluate the feasibility and the safety of robotic right colectomy for cancer.

The layout for trocars placement, previously described by authors skilled in robotic surgery [15–17], was applied with some adjustments due to patient conformation to avoid arms collisions.

We analyzed the series of 100 consecutive patients treated either with LS (50 pts) or RS (50 pts) to evaluate whether the robotic right colectomy was as successful as laparoscopic surgery. The LS and RS groups of patients were similar in terms of demographic and clinical characteristics. All patients suffered from colon cancer and were submitted to standard right colectomy. No statistically significant differences ( $p=0.681$ ,  $p\text{-adj}=0.778$ ) were found between the two groups in the number of harvested nodes.

The growing interest in Complete Mesocolic Excision (CME), introduced by Hoenberger [22], and its impact on long-term survival could arise interest in RS for right colonic cancer. RS could help during the extended and careful nodal

dissection that is one of the most challenging times during LS [23–25].

Operative time was shorter in LS group (160 min) than RS group (204 min).

Robotic surgery has a high variable total operative time in different series (range 143–342 min [17, 26, 27]) and the median operative time, in a recent meta-analysis [17], was found to be longer by almost 54 min than LS time. Our data are comparable with the most recent papers [17, 26, 27].

Bowel function recovery is significantly reduced in RS than in LS groups ( $p < 0.001$ ,  $p\text{-adj} = 0.001$ ).

Again the median time to first flatus was reduced to 2 days for RS group and 2.5 days for LS group ( $p < 0.001$ ,  $p\text{-adj} < 0.001$ ), and this agree with the results found in literature [23, 25–28].

Length of stay was lower in RS group than in LS. The higher number of complication in LS group can partially explain the longer median length of stay.

The increased operative time is justified either in terms of clinical benefit to the patient and costs of hospitalization. The early resumption of intestinal function can be attributed to a less trauma with the robotic instruments, that act on a fulcrum located in the context of the abdominal wall, by the lower mesocolon traction, which is guaranteed by the presence of a fixed and stable field, and by the availability of instruments able to perform the most delicate and fragmented traction during surgery.

A substantial difference was observed in the conversion rate between the two groups.

In literature we found a significant variability in conversion rate. Recent papers [28, 29] attest this value between 9 and 12.9%. The conversion rate in LS group was 14% (7/50) compared to 0% (0/50) in the RS group ( $p < 0.001$ ,  $p\text{-adj} = 0.001$ ); in our experience we have observed that the

management of any intraoperative complication was easiest in robotic surgery.

In all cases treated with robotics the procedures were performed totally robotically, only in a single case we performed an extracorporeal anastomosis due to anesthetic problems.

In the RS group it was never necessary to place additional laparoscopic or robotic trocars to overcome conflicts of instruments or robotic arms. The best result in favor of RS group in terms of conversion was statistically significant ( $p < 0.001$ ,  $p\text{-adj} = 0.001$ ).

In a recent paper [29] 776007 colectomies were analyzed, of which nearly 300,000 underwent right colectomy; compared with patients who had mini-invasive operations, patients who had conversion to open surgery had a higher mortality, higher overall morbidity, longer length of hospitalization, and increased hospital charges.

This result emphasizes the importance of the low conversion rate which is allowed by the robotic surgery and means reduced need for medical and surgical short- and long-term cares, with an earlier resumption of normal social and work activities.

The 30 days mortality was 0% for LS and RS groups.

The statistical analysis did not show significant differences between the groups in terms of anastomotic bleeding and anastomotic leakage.

Our results are confirmed by a recent meta-analysis published in 2018 about 8257 patients treated with robotic versus laparoscopic right colectomy; it concluded that there are no significant differences in mortality and postoperative complications while the conversion rate and postoperative bowel recovery is better for robotic surgery; instead laparoscopy is better in terms of operative time and costs [30].

## Conclusions

In our experience, minimally invasive surgery was a safe, feasible and effective option in patients with right-sided colon cancer, allowing comparable oncological radicality with either LS or RS.

RS group obtained best results in terms of postoperative outcomes, such as faster recovery of the intestinal function. The RS group had a 0% conversion rate and this fact is of considerable importance since patients with conversion to open surgery had a higher mortality, higher overall morbidity, longer length of hospitalization, and increased hospital charges.

Robotic surgery may exceed the technical limitation of traditional laparoscopic surgery. In our experience it is a feasible and safe technique, it achieves better clinical outcomes and obtains the same oncological specimen features compared to LS, although with higher costs. Robotic surgery

permits to perform difficult dissections with greater precision and safety with all the advantages guaranteed by the minimally invasive access.

## Compliance with ethical standards

**Conflict of interest** The Authors have no conflicts of interest or financial ties to disclose.

**Research involving human participants and/or animals** We declare that the study has been conducted according to GCP and ethical standards with no adoption of human or animal source of experimental investigation. This is a retrospective study.

**Informed consent** Informed consent was obtained by all patients as per local protocol.

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