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ORIGINAL ARTICLE

Short-term outcomes in patients with colon cancer treated with robotic right colectomy

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Summary

Purpose: *To report a single surgeon series of consecutive robotic right colectomies (RRC) performed for non-metastatic right colon cancer.*

Methods: *A retrospective review of a prospectively maintained database of patients who underwent elective robotic right colectomy for right colon adenocarcinoma was conducted. Patients with stage 0-III disease were included in the study. Outcomes evaluated included operative time, number of lymph nodes harvested, estimated blood loss, time to return of bowel function, length of hospital stay, complications and a minimum of 6-month follow up.*

Results: *Forty-five consecutive patients were included in this study. The mean operative time was 175 min, the mean lymph nodes harvested were 22 and the mean length of hospital stay was 5 days. The mean time to normal bowel function restoration and to discontinuation of patient-controlled analgesia was 2 days. The hospital post-operative courses were complicated in two patients by ileus and fever due to pulmonary atelectasia, respectively. No conversions to laparotomy, reoperations or 90-day deaths were recorded.*

Conclusions: *Robotic colorectal surgery has gained a lot of supporters through the years although a debate still exists concerning the outcomes. The present study is one of the largest evaluating short-term results of RRCs performed by a single surgeon. We believe we demonstrated the safety and efficacy of RRC in the treatment of right colon non-metastatic adenocarcinoma.*

Key words: *colorectal, right colectomy, robot-assisted colectomy, robotic colectomy*

Introduction

Since the first report of robotic-assisted laparoscopic right hemicolectomy for benign disease, the use of robotic technology has gained increasing interest among colorectal surgeons [1]. From 2002 until October 2010, a total of 39 research articles reporting the results from 1,031 patients who had undergone robot-assisted colorectal procedures have been published [2]. In the following 4-year period, 12 papers comparing the outcomes of robotic vs laparoscopic colorectal resection in 786 patients were published [3]. According to the National Inpatient Sample (NIS) database between October 2008 and December 2010, 1,584 robot-assisted colectomies were performed, that represented 0.6% of the total number of elective colectomies performed in the US in that period (244,129) [4]. The majority of robotic resections reported in that study were sigmoidectomies (n=874) followed by

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right hemicolectomies (n=536). These numbers are expected to increase significantly in the years to come following the trends that characterized the wide adoption of laparoscopic operations in the beginning of the 21st century.

Following the merger of Computer Motion, Inc. (Santa Barbara, CA, USA) with Intuitive Surgical, Inc., (Mountain View, CA, USA) in 2003 and the discontinuation of its product ZEUS®, the only available surgical robot in the market is the "da Vinci® Robotic System" [5]. This technology has been launched in order to increase the dexterity and facility with which complex dissections are performed [6] and additionaly incorporates all the advantages of laparoscopy compared to open colorectal operations (fewer wound-related complications, reduced pain, no compromise of oncologic safety and similar overall survival rates) with an additional increased image stability, three-dimensional imaging with adjustable magnification, ambidextrous capabilities, unparalleled comfort for the surgeon and wide range of instruments with an ability to move with 7 degrees of freedom, resembling the movement of the human wrist during operation [5,7,8]. On the other hand, the learning curve of robotic surgery is steeper than that of laparoscopy and is estimated to be in the range of 15-30 cases for the former and 5-310 cases for the latter [9].

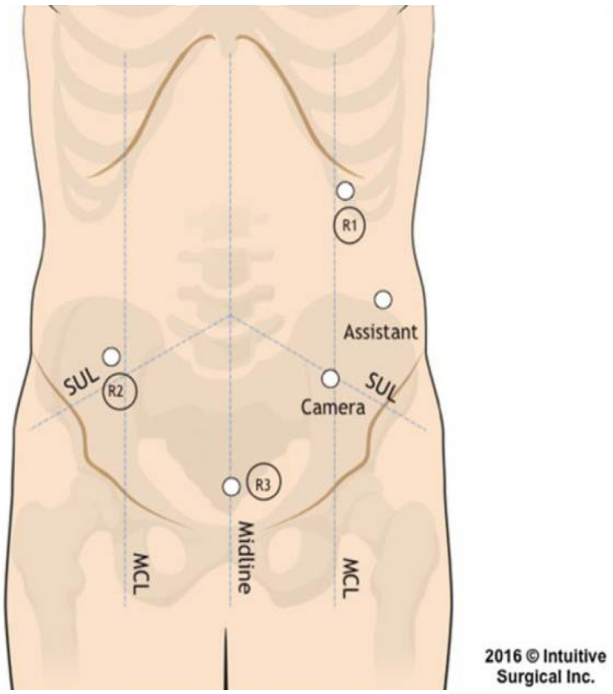

Figure 1. The proposition of Intuitive Surgical Inc. for robotic right colectomy. We slightly modified the placement of the camera port in our technique. SUL: spinal umbilical line, MCL: midclavicular line, R 1,2,3: robotic arm ports

The main drawbacks of the da Vinci® Robotic System are its high cost of acquisition ($1.25 million as of 2004 [5]), maintenance and consumables, as well as its size which renders its use in small operating rooms impossible [8]. Furthermore, due to lack of tensile feedback, increased awareness is required from the surgeon in order to estimate the applied forces to the tissues [8]. Last but not least, according to the available literature, robotic–assisted operations have considerably longer operative times when compared to laparoscopic, either because of the lack of adequate experience or because of the need to replace the robotic arms, so as to access more than one abdominal quadrants [10,11]. To this end, the increased docking time needed should be also considered. However, it has been shown that both the time needed for the preparation of the equipment and the operative time, demonstrate a remarkable decline within the 50 first operations [12].

In the present study, we report our technique for RRC with an assessment of feasibility, safety, as well as the short-term results in a cohort of 45 patients treated in one center by a single surgeon.

Methods

After Scientific and Ethics Committee approval, we conducted a retrospective review of a prospectively maintained database of 45 consecutive patients who underwent RRC for right colon cancer. Written informed consent was acquired from all patients. Stage 0-III patients were included in the present study. All operations were carried out by a single American Board of Surgery (ABS)-certified surgeon (Konstantinidis K), who has an experience of more than 1850 robotic and 15000 laparoscopic abdominal operations. The following patient characteristics were analyzed: age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, tumor staging and past medical history. Perioperative outcomes included operative time, estimated blood loss, time of return to normal bowel function, postoperative pain management, lymph nodes harvested, length of hospital stay and any complications within the follow-up period.

Operative technique

Under general anesthesia, the patient is placed in supine position with the bed on left tilt and reverse Trendelenbourg position. The chest and legs are secured to the table. The robot is set to come and dock from the right shoulder of the patient. We place the trocars by slightly modifying the original Intuitive Surgical Inc. proposition as shown in Figure 1. A 10mm incision is initially performed below and to the left of the umbilicus in order to facilitate the Hasson trocar insertion. After establishing the pneumoperitoneum an initial detailed exploration of the abdominal cavity is performed. Under direct vision, we usually insert three 8mm ro-

botic trocars. The first in the right lower quadrant (R2), the second in the left upper quadrant (R1) and the last in the left lower quadrant (R3) (Figure 1). Then, a 12mm air seal trocar is inserted in the left lower quadrant and later used for inserting endo-stapler into the abdominal cavity. Finally, a laparoscopic 5mm trocar is inserted in the left lower quadrant for the bedside-assistant surgeon to use. After the setup is completed, the da Vinci robotic system is docked and connected.

The mass, which has been marked through colonoscopy prior to surgery is recognized and the planned point for transverse mesocolic division is marked based on the location of the right branch of the middle colic artery. The table is tilted to the left to allow the small intestine to fall away from the point of interest. From the 5mm laparoscopic port in the left lower quadrant the first assistant grasps the ileocecal valve to put the ileocolic vascular pedicle on tension. After meticulous dissection, the ileocecal artery and vein are ligated with clips. The pedicle is divided close to the origin of the ileocecal artery. Then, the right mesocolon is mobilized from the Gerota's fascia, the duodenum and the right ureter are identified and protected and the ileal mesentery is divided with the robotic vessel sealer out to a point of 10 cm centrally from the ileocecal valve. The mesocolic mobilization is then carried up to the duodenum and the transverse mesocolon. After that we mobilize the transverse colon by dividing the gastrocolic ligament from the level of the middle colic artery and towards the hepatic flexure (medial to lateral mobilization). After completing this step, the ascending colon is mobilized by dividing the peritoneal attachments in the white line of Toldt across the right paracolic gutter. The transverse mesocolon is divided with the vessel sealer. The transverse colon and ileum are then divided with the use of linear staplers from the air-seal port. An isoperistaltic side-to-side anastomosis is performed between the ileum and the transverse colon; Vicryl 3/0 stitches are preferred to join the distal transverse colon to the ileum 6 cm from the cut end. Then, an ileotomy and colotomy are performed and a linear cutting stapler from the left-sided 12 mm air seal port is inserted through these openings to create the common channel. The remaining ileocolotomy is then sewn closed with running 2-0 barbed Vicryl suture and a layer with interrupted 2/0 polydioxanone suture (PDS). A drainage tube is inserted through a 5 mm robotic trocar incision and is placed near the anastomosis. The mesenteric defect is not routinely closed. The Hasson port site is expanded to a 4 cm muscle-splitting incision and the specimen is extracted in a shielded fashion using a wound protector. After extraction of the specimen the fascia is closed using two running looped PDS No1 starting from each side of the wound. In the other port sites only the skin is sutured.

Results

The demographic data of our patients are shown in Table 1. The perioperative and the postoperative outcomes and complications are shown in Table 2. The mean age of patients was 62 years and mean BMI was 27 kg/m^2. The majority of the patients had an ASA score of 2 (n=23, 51%), followed by those with an ASA score of 3 (n=16, 36%). Only 1 patient (2% of all participants) was assessed as having a life-threatening condition (ASA score 4), while 5 patients (11%) had no comorbidities. Operation duration was slightly increased in patients with previous abdominal procedures. An extra laparoscopic trocar was inserted in order to facilitate the operation in 2 overweight patients. No conversions to open surgery were required in the present cohort. Mean operative time was 175 min

Table 1. Patient characteristics

Characteristics	*Patients, n=45*
Age, years, mean (range)	62 (42-78)
Sex, n (%)	
Female	21 (47)
Male	24 (53)
BMI (kg/m^2), mean	27
Previous abdominal operation, n (%)	21 (46)
TNM tumor staging, n (%)	
Stage 0	4 (9)
Stage I	18 (40)
Stage II	15 (33)
Stage III	8 (18)
ASA class, n (%)	
1. No disturbance	5 (11)
2. Mild disturbance	23 (51)
3. Severe disturbance	16 (36)
4. Life threatening	1 (2)

Table 2. Perioperative outcomes and postoperative complications

Perioperative outcomes	
Conversion rate, n	0
Mean operative time, min, (range)	175 (135-220)
Mean estimated blood loss, ml (range)	80 (30-350)
Mean time to return of bowel function, days (range)	2 (1-7)
Mean time to PCA discontinuance, days (range)	2 (1-4)
Mean length of stay, days (range)	5 (4-9)
Mean lymph nodes harvested, n (range)	22 (18-31)
Postoperative complications, n (%)	2 (4)
Ileus	1
Atelectasia	1

with a range of 135 to 220 min and mean length of stay was 5 days with a range of 4 to 9 days. Mean number of lymph nodes harvested was 22. None of our patients needed the patient-controlled analgesia pump after the 4th postoperative day. Early postoperative complications were observed in 2 out of 45 patients: the first patient developed postoperative ileus and the second fever due to pulmonary atelectasia. Both of them were treated conservatively and the rest of their hospital stay was uneventful. At 1 year, one patient presented with port-side hernia.

Discussion

In the present study we report on the initial and mid-term results in a cohort of 45 patients with right colon cancer who were treated with robotic right colectomy. All the patients were operated in a single center, by the same surgeon and all the anastomoses were performed intra-corporeally. Our initial results suggest that performance of an entirely RRC is safe and feasible in the hands of experienced colorectal surgeons.

As far as the perioperative outcomes are concerned, our data align with those of other authors, not only in the duration, but also in terms of the oncological outcomes. In our series the mean operative time of 175 min is comparable to the mean operation time of other recent similar series. In one of the largest series of cases performed by a single surgeon, a mean robot operating time of 145.2 min is reported in a sample of 59 patients [13], moreover in the review published by Antoniou et al. a mean operative time of 167 min is reported [2]. However, this value is highly variable ranging from 152 to 317.5 min and has been associated not only with the prior experience of the surgeon but also with the underlying pathology (benign vs. malignant disease) and the history of previous abdominal operations.

The present study evaluates short-term results in a mildly overweight population (mean BMI=27 kg/m^2), while 46% of the total population also had previous abdominal operations. Moreover, according to our results, RRC is feasible in a highly morbid population, as 38% of our patients had an ASA score ≥3. Park et al. demonstrated similar results in a series of 35 RRCs for malignancy in a population with similar demographic characteristics as ours [7].

Nowadays there is continuous debate concerning the two minimally invasive approaches, and in particular on the supremacy of the robotic over the laparoscopic method. Authors that support laparoscopy question whether robotic platform fulfills its promise and justifies the increased cost. A previous meta-analysis indicates that RRCs compared to laparoscopic operations has increased operative times, decreased blood loss and a more favorable postoperative outcome [14]. No difference was identified in the conversion rate to open surgery. Furthermore, the laparoscopic approach appears to be superior in terms of the number of lymph nodes harvested in patients with malignancy [10]. Yet, a satisfactory oncologic outcome can be acquired through robotic right colectomy, as we demonstrate that more than the minimally required (n=12) lymph nodes can be harvested [15]. Another advantage of laparoscopic surgery is, not surprisingly, the reduced total hospital cost per patient [7]. While robotic colectomies have an increased cost per day, this was compensated by a decreased hospital stay and reduced complication rate, yielding an overall cost comparable to that of the open method [4].

Robotic colorectal surgery is in its initial stages. Further well-designed prospective multicenter studies are required to compare laparoscopic and robotic colorectal surgery and to identify the possible indications, restrictions, advantages and limitations. During the past few years the need to further minimize postoperative morbidity and improve cosmetic result has emerged. This issue has been effectively addressed through the single-incision approach in which the same site, usually the umbilicus, functions as a multi-channel port to the abdominal cavity, specimen-extracting orifice and drain insertion site [16]. In this technique, a natural body orifice is used as an access point to reach all intra-abdominal organs. It is supported [17] that right colectomy is a candidate for the single-site approach due to the small incision required for specimen extraction. So far, a small number of studies have demonstrated the feasibility of single-site robotic right colectomy, but with longer operating times and increased incidence of incisional hernias and infections compared to the standard multiport approach [17-19]. These limitations are expected to be overcome, as appropriate instrumentation is widely available. Our team with its experience in robotic single-site abdominal operations, including the world's first single-site robotic right colectomy with omentectomy and a series of single-site robotic cholecystectomies, works on developing new modifications and improving these limitations these [20,21].

Taking into consideration the demographics of our participants, the zero conversion rate and the remarkably low postoperative complications' rate, we suggest that robotic colectomy is a safe procedure with comparable or even superior re-

sults compared to other alternative approaches. It is without doubt that in the years to come the issues that have risen and particularly the increased cost and the relatively limited range of instruments available for the da Vinci Surgical System will be addressed, allowing a wider application of this promising technology. In our opinion, the ergonomics that the robotic platform offers should also be addressed accordingly in all studies to be published in the future.

Author contributions

All authors contributed significantly to this study and meet all the criteria according to the guidelines of the International Committee of Medical Journal Editors (ICMJE).

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Conflict of interests

Konstantinos Konstantinidis, MD, PhD, is a teaching proctor for Intuitive Surgical Inc.

All other authors declare no conflicts of interests.

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