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Robotic Versus Laparoscopic Right Hemicolectomy For Cancer

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Abstract

Background: Laparoscopic right colectomy is regarded technically difficult especially with intracorporeal anastomosis, and in obese patients. Robotic surgery may offer a solution to these limitations. Our aim is to evaluate the results of robotic right hemicolectomy for cancer compared to traditional laparoscopy.

Methods: Retrospective study including all patients who underwent elective laparoscopic or robotic right hemicolectomy for cancer from January 2009 till August 2011.We analyzed the preoperative, operative and pathological criteria, postoperative outcomes and follow up.

Results: We had 48 patients (M: F of 1.3:1), 34 laparoscopic, 14 robotic comparable as regards ASA grade BMI and co-morbid conditions. The site of lesions were; cecum=18, ascending colon=24, hepatic flexure=7 (one patient had 2 synchronous tumors). There were no statistically significant differences in the total operative time or amount of blood loss or hospital stay between both groups. No open conversion in the robotic group compared to 2 in the laparoscopic group. There was a statistically significant difference in the number of lymph nodes retrieved; 21.1±10 in the robotic group compared to 16.4±4.8 in the laparoscopic group (P value=0.0320). In the laparoscopic group we performed extracorporeal mechanical anastomosis in 24 cases (70%) and in the robotic group intracorporeal manual anastomosis in 9(64%). In the laparoscopic group there were 3 anastomosis related complications: 2 bleedings and one major leak, none in the robotic group. We had a single mortality in the laparoscopic group from advanced disease. Short term follow up revealed no relapses in neither groups.

Conclusion: Robotic hemicolectomy for right colon cancer appears as a safe and effective technique with less anastomosis related complications and better patient outcome with comparable oncological results.

Introduction

Minimally invasive techniques have revolutionized general surgical practice, above all impacting surgery of the gastrointestinal (GI) tract and reports of its short term benefits were observed in all other surgical subspecialties [1]. The first successful laparoscopic colectomy by Jacobs et al was reported in 1991 [2]. In the US and UK, several encouraging trials supported the use of laparoscopic resection for curable colorectal cancer in selected patients by experienced surgeons [1]. Advantages included reduced requirements for analgesics, a lower incidence of wound infection, earlier resumption of a regular diet, faster return of bowel function and normal daily activities, and a shorter hospital stay [2]. Early reservations over port-site metastases and adequacy of oncological resection have been addressed through several large scale trials and laparoscopic colorectal surgery is considered safe, oncologically equivalent to open surgery, and the new standard in colorectal practice [1,3]. When compared with left sided colon resection, laparoscopic right colectomy is usually regarded as a laparoscopic-assisted procedure with extracorporeal resection and anastomosis. Thus, laparoscopic right colectomy has a slower pace of development compared with surgery for left-sided colon [2]. Furthermore, laparoscopic right colectomy is sometimes regarded technically difficult due to anatomical vascular variations, and the difficulty encountered in obese patients in externalizing the colon for anastomosis, especially with a thickened shortened mesentery, thus limiting the extension of resection and risking mesenteric thrombosis by excessive traction, resulting into shift to a more challenging intracorporeal anastomosis or open conversion. Laparoscopic right colectomy with extracorporeal anastomosis is considered technically more challenging

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than sigmoid colectomy, and laparoscopic right colectomy with intracorporeal anastomosis is considered as one of the most difficult laparoscopic procedures [4,5]. On the other hand, an intracorporeal anastomosis whether mechanical or hand sewn is associated with a shorter incision for specimen extraction and decreases wound related complications [6].

Other difficulties encountered in laparoscopic colorectal surgery include bidimentional view, awkward instrumentation with amplificated hand tremors due to physical fatigue, diminished manual dexterity with only 4 degrees of motion and assistant-dependant camera manipulation. Instrument movement can be counterproductive due to the fulcrum effect of the abdominal wall and there is a significant learning curve. Theoretically, Robotic surgical systems offer a solution to overcoming the above mentioned limitations. A number of platforms have been reported notably the da Vinci Robotic system (Intuitive Surgical Inc., Sunnyvale, California, USA), the only one with FDA approval [1]. Specialities as cardiac surgery and urology have seen an explosion in the use of this system to augment minimally invasive approaches [7].

The first Robotic assisted colectomy was published by Ballatyne group of University of Hackensak, NJ, USA in 2002 [8]. Later, D'Annibale group from Italy published a retrospective series of 53 cases of benign and malignant cases in different locations and concluded that the skill and flexibility that the robot provided could be useful in certain procedures [9]. The aim of this study is to evaluate the results of Robotic right hemicolectomy for cancer compared to traditional laparoscopic right hemicolectomy that were performed in the period from January 2009 till August 2011 in the department of general and specialized surgery at Nuovo Ospedale Civile S. Agostino-Estense (NOCSAE), Modena, Italy.

Methods

This is a single institution non-randomized retrospective study including all patients who underwent minimally invasive Right hemicolectomy for cancer (laparoscopic and Robotic) from 1st of January 2009 till 1st of August 2011 at Nuovo Ospedale Civile S. Agostino-Estense (NOCSAE), Modena, Italy. Only elective patients with malignant lesions were considered for this study. Accordingly emergency colectomy or patients with benign pathology were excluded. The decision of whether the procedure was laparoscopic or Robotic was according to discussions between the surgical team and the patients with full informed consent and all interventions were done with an intention to treat basis. We analyzed the preoperative variables, operative interventions, pathological criteria, early postoperative outcomes, morbidity and follow up. Data which were recorded prospectively, are retrospectively reviewed and analyzed with SPSS for windows (version 17.0, SPSS inc., Chicago,IL). We calculated percentage, the Mean ± standard deviation (SD), for appropriate variables using the Chi Square test and the t-test and P value of < 0.05 as significant.

Preoperative hospital protocol

All elective patients receive antibiotic, antithrombotic and antiulcer prophylaxis according to a uniform protocol. As regards antibiotic prophylaxis, all patients receive 2.2gms of Amoxicillin-Clavulonic acid, by slow IV over 30 min before induction of anesthesia. If a procedure is prolonged >3hours, another 1.2 gm is given, or if the patient is ASA≥3, 2.2gms is given every 8 hours for 24 hours. Antithrombotic prophylaxis is in the form of low molecular weight Heparin according to patient body weight and associated medical conditions. All patients have low residue diet one week before surgery and receive full bowel preparation in the form of 4 liters of oral osmotic laxative the day before the operation (SELG®-ESSE 1000, Promefarm, Italy). Diagnosis is made by history and clinical examination and confirmed by full colonoscopy with biopsy and histopathological examination with tattoing of the site of the lesion. Preoperative workup is done routinely for all patients and includes full blood picture, renal and liver function profiles, coagulation profile and ECG. Chest CT as well as multidetector pelviabdominal CT is done for staging. Preoperative anesthetic consultations done for all patients and the American Society of Anesthesiologists (ASA) grades recorded with all necessary precautions addressed for each patient.

Interventions

In the laparoscopic group: we performed laparoscopic right hemicolectomy with medial to lateral approach and extracorporeal stapled anastomosis in most of the cases. In this technique, the patient is positioned supine with arms tucked to his side. Pneumoperitoneum is achieved by Veress needle in the left upper quadrant. Insertion of the first optic port by 5-11 optical trocar (Visiport™ Plus. Tyco Healthcare, Norwalk, Connecticut, USA), 3 cm to the left of the umbilicus, starting by visual abdominal exploration. Three other trocars are inserted under vision, one 12mm in Lt upper quadrant for Rt surgeon's hand , one trocars of 5mm in Lt lower quadrant for his Lt hand and a third 5mm trocar in Rt lower quadrant for the second assistant to hold up the Rt colon, all near mid-clavicular line. Patient is moved to Trendelenburg position with right side upward tilt to shift the omentum and small intestine to the left upper quadrant. Identification of the lesion over the right colon by the tattoo mark. Identification, dissection and division

Figure 1. *End-to-side anastomosis by EEA 25*

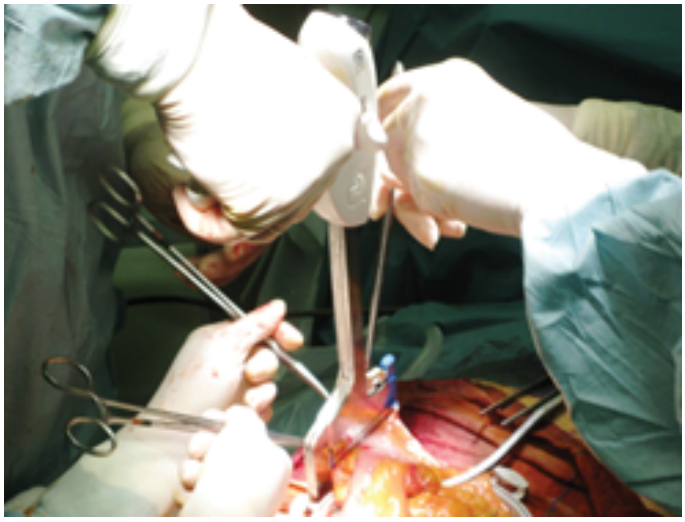

Figure 2. *Closing the colostomy with TA 60*

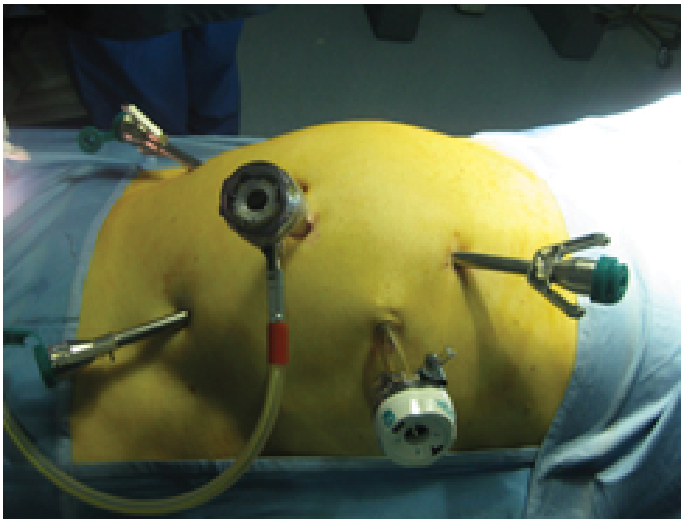

Figure 4. *Trocar position for Robotic Rt Hemicolectomy*

Figure 3. *Anastomosis completed*

Figure 5. *Robot docked on the patient in Rt hemicolectomy*

of ileocolic trunk, right colic and right branch of middle colic is done between clips. Division of parietal adhesions of the right colon from the cecum is done till the hepatic flexure. Identification and the gonadal vessels right ureter and third part of the duodenum are done during this procedure. Sectioning of the hepatico-colic ligament and liberation of the hepatic flexure is done. An upper midline minilaparotomy of 5-6cm is done and wound protector inserted and the liberated right colon and terminal ileum are delivered through the wound for an extracorporeal anastomosis. Section of the terminal ileim and transverse colon is done extracorporeally and an isoperistaltic end-to-side ileo-transverse anastomosis is done using circular stapler and linear cutter (EEA 25+ TA 60) (Figure 1-3).

The anastomosed bowel is reinserted into the abdomen. The mini-laparotomy wound closed. Re-insufflation is done and the mesenteric defect closed laparoscopically and a para-anastomotic (penrose) drain is inserted. The procedure is concluded and ports withdrawn under vision and wounds sutured.

In the Robotic group: we did robotic right hemicolectomy with intracorporeal anastomosis in most cases, using the da Vinci Robotic System (Intuitive Surgical Inc., Sunnyvale, California, USA). In this approach, the patient is positioned supine with arms tucked to his side. Pneumoperitoneum is achieved by Veress needle in the left upper quadrant. Insertion of the first optic port by 5-12 trocar, 3 cm to the left of the umbilicus, starting by visual abdominal exploration. Insertion under vision of 3 Robotic trocars 7mm, 2 in both lower quadrants and one in left upper quadrant according to patient body habitus, and one accessory trocar 12mm few centimeters lateral to the optic trocar (Figure 4)

Patient is moved to Trendelenburg position with right side upward tilt to shift the omentum and small intestine to the left upper quadrant. Identification of the lesion over the right colon by the tattoo mark. Robotic procedure begins at the consol after docking of the robot from the right side of the patient's and insertion of robotic instruments into the slave arms (Figure 5).

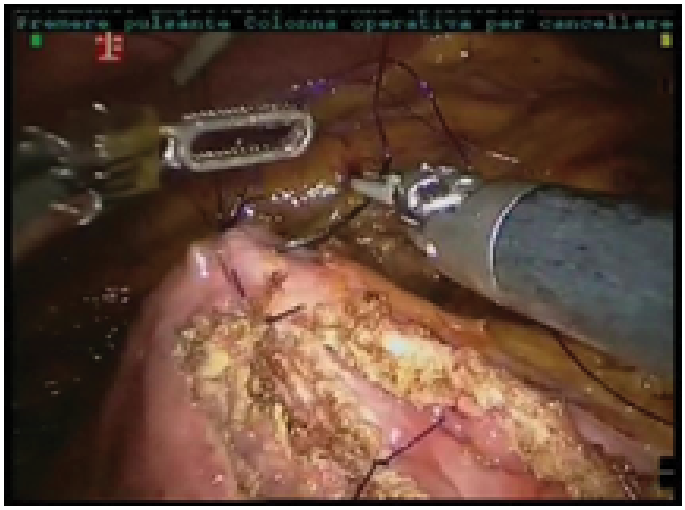

Figure 6. *Robotic hand-sewn ileo-colic anastomosis*

The approach is a medial to lateral approach and starts by identification of the Ileocolic vascular trunk by holding the ascending colon up by the third robotic arm. The other 2 working arms dissect then ligate the vessels by clips. The ileocolic artery and vein, the right colic as well as the right branch of the middle colic artery are sectioned, after clipping, by robotic ultrasonic shears, and the dissection continues in an avascular plane till the white line of Toldt is observed. Division of parietal adhesions of the right colon from the cecum is done till the hepatic flexure. Identification and the gonadal vessels right ureter and third part of the duodenum are done during this procedure. Sectioning of the hepatico-colic ligament and liberation of the hepatic flexure is done. Division of the terminal ileum and transverse colon with endo-staplers (Echelon®, Ethicon Endosurgery, USA) using blue cartridges. Construction of the anastomosis is done usually manually using robotic intracorporeal isoperistaltic side to side suturing (double posterior layers with single anterior extramucosal suturing). In few cases intracorporeal stapled anastomosis is used (Figure 6).

Suturing of the mesenteric defect, then reinforcement of the sutures by fibrin glue. Insertion of para-anastomotic (penrose) laminar drain. Mini-Pfanestiel incision is done to extract the specimen through a wound protector. Closure of the wound in layers and port sites.

Intraoperatively

Procedure type and time was recorded, and for the Robotic group this included the robot docking time. Intraoperative complications were recorded, and an estimate of the amount of blood loss was made.

Postoperative protocol

All patients started oral fluids postoperatively as tolerated and gradually shifted to semisolid then solid food. Antibiotic prophylaxis was continued as needed as well as the antithrombotic and antiulcer measures until the patient was fully ambulant. Patients were usually discharged within one week, unless postoperative condition dictated otherwise and a follow up visit was scheduled before discharge. Postoperative complications were recorded as well as histopathological examination of the resected colon.

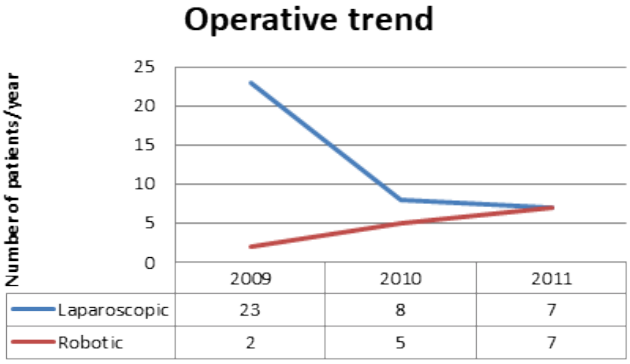

Figure 7. *Operative trend in minimally invasive Right hemicolectomy in NOCSAE (n=53)*

Results

From January 2009 till August 2011, there was a total of 53 minimally invasive right hemicolectomy (both laparoscopic & robotic) at Nuovo Ospedale Civile S. Agostino-Estense (NOCSAE), Modena, Italy. Out of this number, 48 patients had elective Rt hemicolectomies for cancer; 14 Robotic and 34 laparoscopic. Five cases were excluded from the study: one patient with benign ileo-ceco-colic intussusseption, another with large benign hepatic flexure submucous lipoma presenting with an ulcerated lesion on endoscopy and 3 emergency colectomies (two patients had colonic perforation during endoscopic polypectomy for carcinomatous polyp and one emergency colectomy for uncontrollable bleeding due to carcinoma of the ascending colon).

Operative trend

There is a steady increase in the number of robotic right hemicolectomies compared to a decline in the number of laparoscopic right hemicolectomies in the same studied period (Figure 7).

Patient criteria

Total number of studied patients was 48; 27 Males = and 21 Females (P value=0.5272) with M: F=1.3:1. The demographic and patient criteria are shown below (Table 1). There was no statistically significant differences between either groups as regards demography, ASA grade BMI or co-morbid conditions, (mean age for robotic group= 66.14±7.1 compared to 67.8±8.6, with P value equals 0.5272, statistically insignificant). Most of the cases were referred from the screening program with positive FOB (fecal occult blood detection) and confirmed histological diagnosis of carcinoma by endoscopy. All patients were preoperatively staged by thoraco-abdominal CT.

Operative criteria

There was no open conversion in the robotic group compared to 2 open conversions in the laparoscopic group. One patient in the robotic group was converted from robotic to laparoscopy after complete mobilization of the colon due to a technical problem in the robotic light source with image failure. Otherwise there were no statistically significant differences in the total operative time (P value equals 0.3599) or amount of blood loss between both groups

Table 1. *Patient demographics and clinical criteria*

Variable	Robotic N=14	Laparoscopic N=34
Age	66.14±7.1	67.8±8.6
M/F	5-Sep	18/16
Obese (BMI≥30)	2(14%)	5(16%)
ASA I	1(7%)	4(12%)
II	12(86%)	24(70%)
III	1(7%)	6(18%)
Clinical presentation:		
FOB +	10(72%)	26(76%)
Bleeding	2(14%)	1(3%)
Anemia	1(7%)	4(12%)
Other	1(7%)	3(9%)
Other concomitant procedures	-	Cholecystectomy=3
		Hernioplasty=2
		Meckel's resection=1

Table 2. *Operative criteria*

Variable	Robotic N=14	Laparoscopic N=34
OR duration (min)	212.57±39	199.5±46.5
Blood loss (ml)	125±123	146.76±135.9
Anastomosis		
Extracorporeal (Mechanical)	2(14%)	24(70%)
Extracorporeal (Manual)	0	9(27%)
Intracorporeal (Mechanical)	3(22%)	1(3%)
Intracorporeal (Manual)	9(64%)	0
Anesthesia		
G/A	14(100%)	34(100%)
Conversion		
Robotic-lap	1(7%)	-
Robotic-open	0	-
Lap-Open	0	2(5.8%)
Intra-operative complications	0	0

(P value equals 0.607). On the other hand, 70% of the laparoscopic group had extracorporeal stapled (mechanical) anastomosis compared to 64% of manual intracorporeal anastomosis in the robotic group (Table 2).

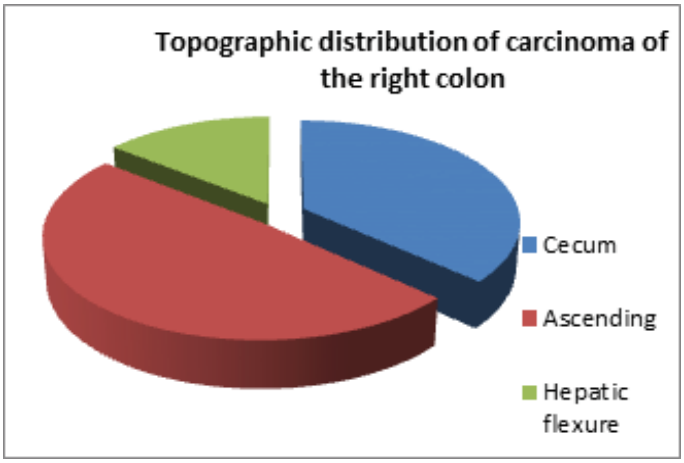

Figure 8. *Topography of carcinoma in the operated patient*

Pathological criteria

The main site of predilection of carcinoma of the right colon was the ascending colon followed by the cecum then the hepatic flexure (Table 3). The total number was 49 and the distribution of malignant lesions was as follows (figure 8); Cecum=18, Ascending colon=24, Hepatic flexure=7. There was a statistically significant difference between the 2 groups regarding the number of lymph nodes retrieved in favor of the robotic group with an average of 21.1±10 lymph nodes in the robotic group compared to 16.4±4.8, with P value=0.0320 and 95% confidence interval (Table 4). Most of the lesions were moderately differentiated adenocarcinoma. In 2 (14%) patients of the robotic group it was a mucinous adenocarcinoma and one patient in this group had another malignancy in the right kidney which was removed in the same operation (clear cell renal cell carcinoma).

Postoperative outcome

There were statistically significant differences between both groups regarding postoperative canalization, and tolerance to liquid diet (Table 5). No differences however were noted in the hospital stay or time of removal of drains.

As regards postoperative morbidities and mortalities (Table 6), there were 2 early mild postoperative surgical complications in the robotic group in the form of post operative fever in one patient and melena in the other patient that resolved by medical treatment. In contrast to the laparoscopic group in which there were 3 anastomosis related complications 2 bleeding from the anastomotic line, one treated conservatively and the other was managed by endoscopic clipping. The third patient had anastomotic leak with peritonitis which necessitated reoperation on the 3rd postoperative day. This leak was due to suture disruption at the enterotomy site in a patient who had laparoscopic intracorporeal mechanical anastomosis. In the same group there was one pulmonary atelectasis and 3 patients developed diarrhea on the 3rd postoperative day, 2 of which were due to clostridium difficile and all resolved by medical treatment. There was a single mortality in the laparoscopy group in a patient with advanced carcinoma of the hepatic flexure and diffuse hepatic metastases which was converted to open and died postoperatively from hepatic coma.

Table 3. *Site of malignant lesions*

Variable	Robotic N=14	Laparoscopic N=34	Total
Site of lesion			
· Cecum	5	13	18
· Ascending	7	17	24
· Hepatic flexure	3	4	7
Number of lesions/patient			
· Single	13	34	47
· Multiple*	2	0	2

*One patient in Robotic group had 2 synchronous malignant tumors; one in the Cecum and another one in the ascending colon).

Table 4. *Pathological criteria*

Variable	Robotic N=14	Laparoscopic N=34	Total
Preoperative pathology	Adenocarcinoma	Adenocarcinoma	-
Postoperative pathology Grade			
GX (could not be assessed) G1 (well differentiated) G2 (Moderately differentiated) G3 (Poorly differentiated)	- 4 7 3	2 9 16 8	2 13 23 11
Length of specimen (cm) °	24.9±6.89	27.58±6.59	P= 0.2126
Distal margin (cm) §	7.67±5	6.6±4	P= 0.4379
Number of LNs retrieved‡	21.1±10	16.4±4.8	P=0.0320
LN invasion	3	8	11
Vascular invasion	1	10	11
Neuronal invasion	1	4	5
TNM classification* TX T1 T2 T3 T4 N0 N1 N2 Mx M0 M1	 0 3 3 8 0 11 2 1 14 - 0	 2 7 5 19 1 24 5 3 31 - 1	 2 10 8 27 1 35 7 4 45 - 1

°P value non significant. §P value non significant. ‡P value statistically significant, 95% confidence interval of this difference: From 0.422 to 8.97

*In 2 patients of the laparoscopic group, the TNM could not be assessed postoperatively as there was no residual tumor in the resected colon and after endoscopic removal which was complete, but nevertheless, due concerns about the radicality of the procedure, the operation was carried out and the polypectomy site tattooed to ensure complete removal.

Table 5. *Postoperative criteria*

Variables (days)	Open (gas)	Open (stool)	Liquid diet	Solid diet	NGT	Drain	Hosp stay
Robotic N=14 (mean)	3.21±0.8	4.21±0.8	4±0.8	5.71±1.8	2.28±0.7	6.42±1.2	8.71±2.7
Laparoscopic N=34 (mean)	4.05±1.5	5.05±1.4	4.9±1.3	6.05±1.3	2.9±1.5	6.7±2.7	9.52±4
P value	0.05	0.04*	0.018*	0.46	0.11	0.71	0.49

*Statistically significant values

Table 6. *Postoperative morbidity & mortality*

Number of patients with complications/mortality		
	Robotic	Laparoscopic
Early postop	2(14%)	7(21%)
Late postop	0	0
Medical compl	1(7%)	4(12%)
Mortality	0	1(3%)

Discussion

Specialties like urology and cardiac surgery have seen an explosion in the use of da Vinci robotics to augment minimally invasive approaches. The likely rationale for this is the added dexterity provided by Intuitive Surgical's Endowrist technology, which improves ease in performing complex tasks such as suturing. In general surgery, advanced robotics will likely find its place in the most complex laparoscopic procedures where the enhanced dexterity and superior visualization will extend the feasibility of the minimally invasive approach [8].

Laparoscopic techniques introduced in colorectal surgery are designed to improve operative and oncologic outcomes, providing lower morbidity, faster recovery, and less postoperative pain. Those outcomes have been addressed by randomized trials, which demonstrated equal or superior short-term results for laparoscopic colorectal surgery compared with open procedures and were validated in the long-term. On the other hand, regarding robotic colorectal surgery, published literature shows several studies, many of them reflected fragmentary experience with the robotic system, rather than focused on the results of robotic colon surgery [10].

The da Vinci surgical robot was acquired at Nuovo Ospedale Civile S. Agostino-Estense (NOCSAE), Modena, Italy since 2006. Since then several general surgical procedures were done with the robotic approach such as robotic Nissen for gastro-oesophageal reflux disease, Heller's myotomy for oesophageal achalasia, distal pancreatectomy for mucinous adenomas. In November 2009 the first robotic Rt colectomy for cancer was attempted with success. Following this, robotic adrenalectomy and trans-axillary robotic thyroidectomy was also introduced. Following this we observed an increased trend towards performing elective robotic right hemicolectomy for cancer (nearly doubled in 2010) compared to traditional laparoscopic approach in the studied period till now (which was reduced to 1/3 in 2010). This may be due to improvement in the learning curve, and patient's acceptance. Stavros et al (11) identified thirty-nine case series or comparative nonrandomized studies published in the period from 2002 to 2009, in a systematic review with a total of 1023 cases since the first case was published in 2002 [7] and an overall increase in the number of cases. Publications have focused on robotic surgery in rectal resections since 2008 with a steep increase in number. Indeed, the key advantages of robotics appears to be in pelvic surgery; this is in part the reason for the wide dissemination of robotic technology in urologic and gynecologic surgery. We believe that the learning curve of the robotic approach in right hemicolectomy is important before attempting robotic rectal surgery.

In 2008, the MIRA (Minimally Invasive Robotic Association) and the SAGES (Society of American Gastrointestinal and Endoscopic Surgeons) published an International Consensus for robotic surgery stating that simpler procedures should be attempted in the learning curve but has also emphasized the role of research. According to MIRA & SAGES, robotic surgery has a special application in the following general surgical procedures [7]:

- Heller myotomy.
- Paraoesophageal hernia repair.
- Transhiatal oesophagectomy.
- Transthoracic oesophageal surgery.
- Gastric bypass.
- Gastrectomy from neoplasia.
- Reconstructive biliary surgery.
- Distal pancreatectomy with spleen preservation.
- Selected colorectal surgery procedures.
- Lymphadenectomies from neoplasia.

The male to female ratio in our studied patients was 1.3:1 which corresponds to the international ratio stated in the literature [12]. On the other hand we did not find obesity as a determining risk factor for development of colorectal cancer in our studied population. In fact the majority of our cases were referrals (72% of the robotic group and 76% of the laparoscopic group) from the gastroenterology and endoscopy unit which is part of a regional surveillance program, and the FOB test screening which reflects the importance of an interdisciplinary approach to tackle this disease effectively. We did not find statistically significant differences in the total operative time between robotic and laparoscopic right hemicolectomies (212.57±39 in the robotic and 199±46 in the laparoscopic group, with $p = 0.03599$) in contrast to Rawling et al who published in 2007 a series of 57 cases, of which 17 were robotic and 15 laparoscopic right hemicolectomies [13]. This may be attributed to the previous experience in robotic procedures by the operating team in our facility, as the robotic setup time in right hemicolectomy (from insufflations and port placement till the surgeon sits on the consol) was around 7 minutes. In the mentioned study, the total time was 218.9 min for the robotic and 169.2 min for the laparoscopic procedures ($p = 0.002$). The longer operative time was attributed to robotic setup time (median=27.9 min), and the robotic intracorporeal anastomosis. In fact, the intracorporeal anastomosis in our study was easy to perform using the da Vinci surgical system without additional stress to the surgeon or added operative time. Only 2 patients in the robotic group had an extracorporeal anastomosis, one was in the beginning of our series and the other patient had a right subcostal incision due to a concomitant nephrectomy for renal cell carcinoma. These results match the results obtained from the D'Annibale group in [14], which used intracorporeal anastomosis (IA) in 50 consecutive robotic right hemicolectomies with no anastomosis related complications.

In contrast, we had 3 anastomosis related complications in the laparoscopic group, 2 extracorporeal with postoperative bleeding one was controlled by endoscopic clips and the other was managed conservatively. The only patient who had a stapled intracorporeal anastomosis in this group suffered indeed of a major leak which appeared to be from disruption of the suture line used to close the enterotomy site of the stapler. From our results and from D'Annibale's study, we believe that the daVinci surgical system is highly suitable for performance

of micro sutures and anastomosis and that the intracorporeal approach avoids the risk of tension and twisting of the mesentery which may occur in the extracorporeal approach. Another point worth noting is that the intracorporeal technique has the potential advantage of allowing the surgeon to choose the optimal abdominal location for extracting the specimen and consequently to perform a smaller skin incision. We used a mini Pfannestiel incision to extraxt 13 out of 14 robotic specimens and a midline mini laparotomy to extract the specimen in 32 patients of the laparoscopic group (excluding the 2 open conversions). Although we did not experience in the follow up of our patients the development of incisional hernias, other studies reported the rate of incisional hernia after midline laparotomy, ranging between 2% and 20%, while others reported a 2% rate after a Pfannenstiel incision [13] We had two open conversions in the laparoscopic group, one due to intraoperative difficulties with a large mass and the other due to adherence to the liver and diffuse hepatic carcinomatosis. On the other hand we had no open conversions in the robotic group, but one patient was converted to conventional laparoscopy for safety owing to image failure as a result of inadvertent switching of electronic connections. There was no difference in average blood loss in either group, which again corresponds to the recent studies in the literature, nor did this have an effect on the length of hospital stay. We would like however to emphasize the fact that, in effect, an inherent limitation of the robotic system is that it does not allow a surgical intervention in more than one abdominal region at a time because the robotic arms are steadily fixed on the patient. To change a surgical field, the entire system must be reinstalled. As a consequence, many surgeons prefer to use the robot only for certain stages of the operation [15].

The main site of right colon cancer was in the ascending colon followed by the Cecum then the hepatic flexure in both groups and concomitant benign polyps with various degrees of dysplasia elsewhere in the colon and rectum were endoscopically removed. All were adenocarcinoma and 2 patients in the robotic group had mucinous variant adenocarcinoma. The tumors were moderately differentiated in about 50% of all cases (Grade 2). However, in 2 patients of the laparoscopic group, tumor grade and the postoperative TNM could not be assessed postoperatively as there was no residual cancer in the resected colon after endoscopic removal of the neoplastic polyps which was complete, but nevertheless, due concerns about the radicality of the endoscopic procedure, the operation was carried out after the polypectomy site was tattooed. There were no statistically significant differences between both groups regarding the length of the resected specimen or safety margin; however the difference was significant regarding the number of lymph nodes extracted. Recent reports highlighted the significance of the number of retrieved lymph nodes in the resected colon as a measure of radicality and prognosis in term of disease-free and long term survival [13]. The American Joint Commission on Cancer (AJCC) and the American College of Pathologists (CAP) recommend evaluation of a minimum of 12 lymph nodes. Moreover, it has recently been demonstrated that the lymph node ratio (LNR) rather than the number of harvested lymph nodes is a significant prognostic factor for both disease recurrence and overall survival in specimens with more than ten harvested lymph nodes, and that the length of the specimen is a strong and independent predictor of the number of harvested lymph nodes. In our experience the average number of lymph nodes retrieved in the robotic group was 21.1±10 compared to 16.4±4.8 with LNR of 3/21 and 8/16 respectively, which strongly suggest the superiority of the robotic approach in terms of oncological radicality. This will have its implications in the future as we embark on more difficult cases of rectal cancer. As regards the postoperative outcome, not surprisingly, the difference was statistically significant in favor of the robotic approach in terms of passage of stool and resumption of oral intake. However the total hospital stay was not different and indeed slightly prolonged than average rates in the reported literature [11], which may be due to the fact that we do not implement the fast-track policy in our practice for colorectal cancer. Issues of cost were not a part of this study; however the pressing economical situations worldwide may have to be taken into consideration as its effect transcends to affect the whole health care system. The only limitations of this study is that it did not include a cost analysis, and the short duration of the follow up of some patients although some had 26 month follow up. The total cost of the robotic procedures is expected to be lower in the future as the new generations of surgical robots of other brands become available, and as the technique becomes widespread with standardized approaches and universal consensuses as regards the gold standards of care.

Conclusion

Robotic right colectomy for cancer is a safe and effective technique with less anastomosis related complications and better patient outcome with comparable oncological results to the laparoscopic approach. This is due to the superior vision and precision provided by the robotic surgical system and better control of the operative field due to camera control and enhanced dexterity provided by the wristed instruments. All this is provided with reduced surgeon's fatigue. On the other hand, the limitations of this approach are currently the higher total cost, the inability to work in 2 body regions simultaneously, and slightly different port site orientation to avoid robotic arm collision as well as a steep learning curve.

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