Right hemicolectomy: laparoscopic versus robotic approach

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BACKGROUND: *Minimally invasive surgery for colorectal cancer has been demonstrated to have the same oncological results as open surgery, with better clinical outcomes. Robotic surgery is an evolution of minimally invasive technique. This study aims to evaluate surgical and oncological short-term outcomes of robotic right colon resection in comparison with the laparoscopic approach.*
METHODS: *Between January 2014 and May 2017, fifteen laparoscopic right hemicolectomies were compared to seven robotic ones. The primary data points included operation time, length of hospital stay, extraction site incision length, complications, and conversions. When malignancy was the indication for surgery, additional data points have been added.*
RESULTS: *The study showed no difference in parameters between the two groups, but estimated blood loss was significantly smaller for Robotic arm. We found a prolonged total operative room time in the robotic arm, while the surgical time is similar in two groups. The data collected about specimen length and number of lymph nodes suggest that robotic procedure is oncologically similar to laparoscopic one.*
CONCLUSIONS: *Robotic approach allows performance of adequate dissection of the right colon with radical lymphadenectomy as in laparoscopic surgery, confirming the safety and oncological efficacy of this technique, with acceptable results and short-term outcomes.*

KEY WORDS: Da Vinci surgery, XI, Laparoscopic colorectal surgery, Right hemicolectomy, Robot

Introduction

The aim of surgical treatment of colorectal cancer is to remove the primary tumor, including lymphatic drainage, with clear surgical margins [1]. Over the last two decades colorectal surgery has dramatically changed due to the widespread implementation of laparoscopic surgery [2]. Results of the Clinical Outcomes of Surgical Therapy Study Group (COST) trial in 2004 showed that laparoscopy has comparable long-term oncological outcomes to open colectomy in the treatment of colon cancer [3.4] but with improved post-operative recovery and morbidity [5,6].

However, laparoscopy has important drawbacks, including lack of three-dimensional visualization, limited maneuverability because of rigid instrumentation, poor ergonomics, amplified impact of physiological tremors, and assistant-dependent camera movements and retraction. Robotic surgery was developed to overcome the technical difficulties and the limitations of conventional laparoscopy [7,8].
Robotic surgery for colorectal cancer has several advantages over conventional surgery in performing precise dissection. It provides the surgeon with a three-dimensional surgical view, eliminates instrument tremor, and reduces movement of the robotic interface, and the surgeon can perform the operation while seated. Pigazzi et al. [9] reported that this ergonomic design might result in less fatigue for the surgeon compared with conventional laparoscopic surgery.
Moreover, the tips of the robotic arms are ergonomically designed with an EndoWrist, which has seven

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degrees of freedom with 180° articulation, which allow meticulous dissection and aid in intraperitoneal suturing. The improved visual systems of robotic surgery are useful in pelvic autonomic nerve preservation [10] in rectal surgery and in performing intracorporeal anastomosis in right hemicolectomy [11].

However, much of the controversy surrounding the robot pertains to the longer operative time but also the high cost associated with robotic procedures, which has limited its use universally.

The benefits of robotic over laparoscopic colonic surgery are less well established and no benefit of has been demonstrated when comparing laparoscopic to robotic right hemicolectomy [12]. The purpose of study was to demonstrate our experience in a standardized procedure of colon surgery, as the right hemicolectomy, comparing the laparoscopic approach with robotic approach.

Methods

Data Collection and Statistical Analysis

We performed a retrospective review of 22 patients who underwent either standard laparoscopic or robotic colon surgery with the *da Vinci Xi Robot* (Intuitive Surgical) at Department of General Surgery, OspedaliRiuniti, Foggia, between January 2014 and May2017.

All procedures in this study were performed by two surgeons, a board-certified colon and rectal surgeons with extensive experience in minimally invasive surgery.

From January 2014 and May 2017, 30 right hemicolectomy were performed. All patients in need of an elective right colectomy, regardless of the etiology, were included in the study. A total of 30 consecutive patients underwent 15 laparoscopic right colectomies (LRC) and 7 robotic right colectomies (RRC).All open right-colon surgery (ORC) cases were excluded.

Robotic technique was introduced in the practice in May 2016.All patients after May 2016 were offered robotic right colectomy. Two patients who refused robotic colectomy were included in the laparoscopic arm. One patient was concerned that robotic surgery may still be "experimental". The other patient had concerns about our limited experience with the robot and the length of time of the operation. Informed consent was obtained from all patients. Fifteen LRCs were compared to 7 RRCs.

Parameters studied were prospectively recorded in a database and were retrospectively reviewed.

The primary data points included operation time, estimated blood loss, length of in-hospital stay (LOS), extraction site incision length, complications, and whether the procedure was converted to open.When malignancy was the indication for surgery, additional data points including histologic diagnosis, clinical stage, specimen length and number of nodes collected were noted.

Total operating room time (TORT) was defined as time from patient in the room to patient out of the room, including the anesthesia time and the time needed to clear the operating room after the completion of the procedure.

Operative time (OT) was defined as start of incision to completion of skin closure.

Surgical time (ST) was defined as start of surgical procedure to completion of skin closure, without the phase of trocars positioning, docking and instruments positioning.

Estimated blood loss (EBL) was determined by the anesthesiologist and nurses.

We measured the extraction site incision length immediately after closure, as well as the length of the specimen.Cases were performed by 1 of 2 authors (or both). An extracorporeal anastomosis was performed in all cases because this was our customary practice.

Mortality was considered as death occurring during the first 30 postoperative days regardless of the cause. Early complications were defined as those occurring during the first 30 postoperative days.

There was no standard protocol in place for advancement of the patients' diet postoperatively. The discharge criteria were identical for both groups. Patients were discharged when they were tolerating a softdiet and, at least, passing flatus or after having a bowel movement. Follow-up was accomplished by office visits, chart review, and telephone interviews when necessary. Cancer patients were followed at 4-month intervals after their initial postoperative visits.

A two-tailed Student's t-test was used for those random variables that are demographics (age and BMI). For the random variables that represent operative parameters, a one-sided non-parametric method—the Mann–Whitney test—was used. The results are reported as mean, median, standard deviation, and range. A p-value less than 0.05 was considered significant.

Results

Both groups were similar in demographics, BMI, indications for surgery, and comorbidities (Table I). The LRC group had a mean age of 75 + 3,0 years (Median 75, Range 69 - 80), and the RRC group had a mean age of 75,7 + 2,56 years (Median 76, Range 74 – 79; *p value = 0,593*). The mean BMI for the LRC group was 26,53 + 5,50 kg/m^2 (Median 25, Range 19 - 41) and for the RRC group was 27,14 + 5,90 kg/m^2 (Median 26, Range 21 – 38; *p value = 0.025*). The indications for surgery in all case were cancer, except one case of caecum angiodysplasia.

Table II summarize our findings regarding the perioperative outcomes.The LRC group had a mean OT of 104,20 + 12,03 min (Median 99, Range 89–123), and

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TABLE I - *Patients' demographic and pathological data.*

Variable studied	LRCn. 15	RRC n. 7	p
Age (years) Mean ± SD Median Range	75 + 3,0 75 69 - 80	75,7 + 2,56 76 74 - 79	0,593
BMI (Kg/m^2) Mean ± SD Median Range	26,53 + 5,50 25 19 - 41	27,14 + 5,90 26 21 - 38	0,815
Gender Male Female	7 8	3 4	-
Indication Cancer Caecum angiodysplasia	14 1	7 0	-

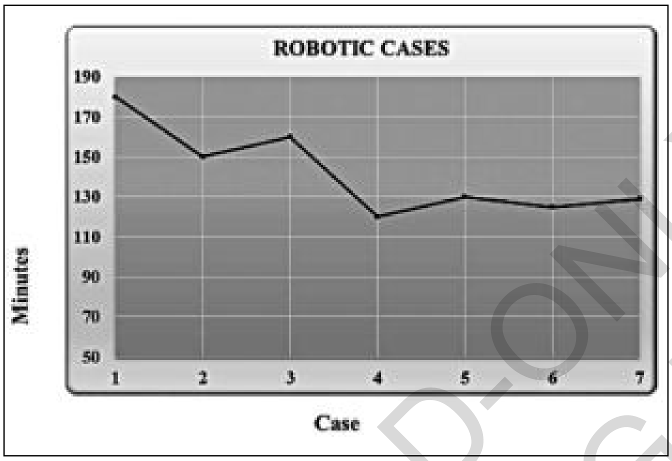

Fig. 1: Operative time of robotic procedures (Department of General Surgery, Ospedali Riuniti, Foggia)

the RRC group had a mean OT of 142,22 + 22,05 min (Median 130, Range 120–180; *p-value<0,05*). TORT for the LRC group was 155,26 + 29,24min (median 150, range 120 – 210) and for the RRC group was 251,57 + 41,58 min (median 265, range190–300; *p-value<0,05*). The LRC group had a mean ST of 80,33 + 11,56 min (Median 80, Range 65–100), and the RRC group had a mean ST of 93,57 + 17,25 min (Median 90, Range 75–120; *p-value=0.083*).So, only the results of TORT and OT were statistically significant, instead of the ST that was similar in two groups.

To evaluate the presence of a learning curve with robotic right colectomy (Fig. 1), we compared the mean duration of surgery for the first 3 patients in the robotic arm with that of the last 3 patients in the robotic arm, with a result statistically significant (*p-value* = 0,009).

We obtained the same statistical result compared the mean duration of total operative time between the first 3 robotic procedures and the last 3 ones (*p-value* 0.033). There was no statistic difference in term of EBL, LOS and extraction site length (respectly *p-value*= 0,275; *p-value*= 0,857; *p-value*=0.764).

In the robotic arm, there were no transitions to laparoscopy, nor were there any conversions to open surgery.No anastomotic leaks occurred and we did not reinforce any anastomoses with fibrin glue or use bioabsorbable staple line reinforcement. One patient in the robotic group presented surgical wound infection and one complication in the laparoscopic group was ileus.There was no mortality.

The oncologic characteristics of our study were also noted (Table III). There was no significant difference in tumor stage (*p-value*= 0,512) or histologic grade (*p-value* = 0.512) between the 2 groups. In addition, there was no significant difference in specimen length (*p-value*= 0,711) and in the number of lymph nodes harvested between the laparoscopic group (Median 18, Range 7 - 27) and the robotic group (Median 19, Range 8 – 22; *p-value*=0,764). No resections performed for malignancy yielded positive margins in either group.

Mean follow-up for the LRC group was 366 days (median 351, range 27 –735) and for the RRC group was 133 days (median 120, range 29 – 272). No patients were lost to follow-up, and no patients had cancer recurrence or metastases.

Discussion

Since 2000, robotic-assisted surgery has been increasing in popularity, especially for cardiac, gynecologic and urologic procedures [13,14]. The first *robotic colorectal surgery* was performed in 2002 by Weber et al. [15] for benign disease and by Hashizume et al. 1[6] for malignant disease. D'Annibale et al. [17] performed 53 colorectal surgeries in 2003, andPigazzi et al. [18] reported robotic TMEs for rectal cancer in 2006.

Robotic right colon resection with intracorporeal anastomosis was reported by Trastulli and coworkers [19], with feasible and safe results [20].

Based on the short- and long-term outcomes of robotic surgery for colorectal cancer, this technique has a good feasibility and safety profile. Because of these developments in robotic surgery, it now is regarded as one of the treatment options for colorectal cancer [21].

Most of the interest has been in robotic total mesorectal excision. In contrast, robotics for colon resection has met with little enthusiasm. In studies comparing laparoscopic to robotic techniques such as this one, authors are comparing their "early" experience with robotics to their "late" experience with laparoscopic techniques. This is unfair to robotics and is why we believe there may still be a role for robotic colectomy. Nevertheless, the role of robotic surgery has not yet been established for colorectal surgery.

Laparoscopic colectomy has been shown to have signifi-

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TABLE II - *Perioperative outcomes.*

Variable studied	LRC n. 15	RRC n. 7	p
Total Operating Room Time (TORT)			
Mean ± SD	155,26 + 29,24	251,57 + 41,58	P < 0,05
Median	150	265	
Range	120 - 210	190 - 300	
Operative Time (OT)			
Mean ± SD	104,20 + 12,03	142,22 + 22,05	P<0,05
Median	99	130	
Range	89-123	120-180	
Surgical Time (ST)			
Mean ± SD	80,33 + 11,56	93,57 + 17,25	0,083
Median	80	90	
Range	65 - 100	75 - 120	
Estimated blood loss EBL (ml)			
Mean ± SD	87,33 + 32,83	71,42 + 39,76	0,275
Median	90	70	
Range	30-140	20-150	
Length of stay LOS (days)			
Mean ± SD	7,67 + 1,23	7,71 + 1,79	0,857
Median	8	7	
Range	6 - 10	6 - 11	
Extraction site length (cm)			
Mean ± SD	4,86 + 1,35	5,42 + 2,16	0,764
Median	4,5	4,5	
Range	3,5 - 9	4-10	
Conversion to open surgery	0	0	–
Mortality	0	0	–
Complications			
Wound infection (n)	0	1	–
Ileus	1	0	

TABLE III - *Oncological outcomes.*

Variable studied	LRC n. 14	RRC n. 7	p
Histology (n)			
Well differentiated	3	2	0,378
Moderately differentiated	9	4	
Poorly differentiated	2	1	
Tumor stage (n)			
I	1	1	
II	10	5	0,512
III	3	1	
IV	0	0	
Number of lymph nodes			
Mean ± SD	17,6 + 6,79	17,42+ 4,54	0,764
Median	18	19	
Range	7 - 27	8- 22	
Specimen length (cm)			
Mean ± SD	23,07+ 8,46	23,71 + 8,13	0,711
Median	22	20	
Range	15 - 45	16 - 40	

cant advantages over open colectomy [22], such as other laparoscopic procedure [23], and is even considered the gold standard by some authors [24,25]. After first being described by Jacobs et al. [26], laparoscopic colectomy took longer and was more expensive than conventional open colectomy [27,28]. However, with time it proved to offer significant advantages to the patient, including quicker return of bowel function, less postoperative pain, shorter hospital stay, and lower postoperative morbidity and mortality [29]. In addition, laparoscopic procedures have a minor impact on the change in post-operative laboratory test results [30].

Robotic colorectal surgery today may be in the same position that laparoscopic surgery was 20 years ago. Robotic surgery purportedly offers advantages to overcome the limitations of laparoscopic surgery (Table IV). Prolonged operating time is one of the major disadvantages of robotic surgery. The only randomized clinical study comparing robotic and conventional laparoscopic right colectomy in colon cancer showed that the operative time was significantly longer in the former group. Similarly, robotic right colectomy was associated with a

TABLE IV - *Advantages and disadvantages of robotic surgery versus conventional laparoscopic surgery.*

	Laparoscopic Surgery	Robotic Surgery
Advantages	Proven efficacy	3D high-definition video imaging
	Ubiquitous and affordable	Image magnification
	Well-developed technology	Filtration of physiological tremor
		Better ergonomics
		Articulating robotic instruments
		Intracorporeal anastomosis
		Tele-surgery
Disadvantages	Loss of touch sensation	Absence of touch sensation
	Limited degree of motion	Prolonged operating time
	Fulcrum effect	Increased cost
	Amplification of physiological tremor	Learning curve and need for specialized surgical team
	Bad ergonomics	

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longer operating time than open right colectomy for colon cancer [31]. However, the study comparing he first 30 laparoscopic and robotic right colectomies of the same surgeon and institute suggested statistically comparable operating times for both the groups [32]. Previous studies, including patients with both benign and malign disease, reported either prolonged [33] or comparable [34] operating times for robotic right colectomy. D'Annibale et al reported docking time, surgeons' experience (place on the learning curve), and intracorporeal creation of anastomos is as factors influencing the prolonged operating time for robotic right colectomy. In addition, operating time gradually decreased as the number of robotic right colectomy cases increased suggesting that as the surgeon and surgical team gain experience, operating time shortens [35].

In our study, we found a prolonged total operative room time in the robotic arm in comparison with laparoscopic one due to both specific robotic procedures, particularly docking, and to anesthesia time andthe time needed to clear the operating room after surgery (*p-value*< 0.05). The docking phase, a specific phase of the robotic surgeries, was on average 20-25 minutes.

However, the surgical time is similar in two groups (*p-value* = 0,083), demonstratingthat the time of the surgical procedure of robotic right colon mobilization and of the consequent anastomosis extracorporeal is comparable. So, the amount of the total operative time required for robotic procedures was significantly greater than in laparoscopic ones because of specific factors lie to the surgical approach including especially docking.

We adopted a four-arm robotic colectomy technique and a 12-mm left lateral additional port, which allows the assistant to quickly do the necessary exchanges of graspers, suction, harmonic scalpel, suture transfer, and laparoscopic staplers. The assistant is kept actively involved which makes the operation more efficient

In fact, by only utilizing the robotic arms, the set-up is simplified and this is especially useful during the initial experience. We prefer the use of the additional port and we think that there were no significant advantages to using the fourth robotic arm in right colectomies with extracorporeal anastomosis. We believe that this three-armtechnique with the additional portcould decrease the arm collisions, the cumbersome and time-consuming exchanges of instruments and so the total operative time. The learning curve is a graphic representation of the temporal relationship between the surgeon's mastery of a specifically assigned task and the chronological number of cases performed [22]. Learning curve is also defined as the number of procedures needed for a surgeon to maintain a steady operative time and acceptable complication rate; or the point at which repetition of the procedure will not yield any additional improvement in surgical skills [36]. We know that for laparoscopic colectomies the learning curve is estimated to be between 55 and 70 cases [37].

In our study, to evaluate the presence of a learning curve we compared the mean duration of operative time and the total operative room time for the first 3 cases in the robotic arm with that of the last 3 patients in the robotic arm, with a result statistically significant (*p-value* = 0,009; *p-value* = 0,033).

These findings confirm the learning curve of surgeons and of the group of nurses, dedicated toset-up the operating room for da Vinci system.

Some authors suggest that the robot may facilitate difficult or complex tasks during a procedure such as splenic flexure mobilization, pelvic dissection, or construction of an anastomosis [38]. We believe that the intuitive nature of the robot and the improved surgical dexterity makes the transition to an intracorporeal anastomosis easier. In our series, the anastomosis was constructed extracorporeally in all cases, as the routine practice for all LRCs in the authors' previous experience. There may be advantages to the construction of an intracorporeal

TABLE V - *Outcomes of robotic right colectomy for colon cancer*

	N. of patients	Operative time (min)	Conversion	N. of harvested lymph nodes	Blood loss (mL)	Length of stay (days)	Anastomosis leakage
D'Annibale et al 2010	50	223,5	0	18,8	20	7	0
Luca et al 2011	33	191,7	–	26,6	6,1	5	0
Park et al 2012	35	195	0	29,9	35,8	7,9	1
Park et al 2012	15	201,4	0	24,2	41,7	7	0
Shin 2012	6	342,5	0	25,8	185	10,7	0

anastomosis. In fact, some studies have suggested that intracorporeal anastomosis results in superior postoperative outcomes and possibly lower extraction site morbidity such as hernia and wound infection [39]. For example, there is probably less traction and tension applied to the colon and the mesentery during an intracorporeal anastomosis. Furthermore, the extent of the dissection and injury to tissues is likely less. These factors may translate into less postoperative ileus and fewer complications. This, in turn, may result in shorter hospital stays. There may even be an impact on leak rates. Another advantage of the intracorporeal anastomosis is that it allows one to choose where to make the incision for the extraction. Intracorporeally, the terminal ileum and transverse colon always reach without tension, and, since the specimen is completely detached, it can be brought out through any extraction site. One final advantage of the intracorporeal anastomosis is that bowel orientation is not lost, as can occur with the extracorporeal approach, and "twisting" of the mesentery is avoided. These findings could favorite the transition to intracorporeal anastomosis also in our Department.

The average specimen length and the average number of lymph nodes harvested were similar for both groups, suggesting that RRC is oncologically similar to LRC. More study is needed to assess the long-term outcomes of robotic colorectal surgery for cancer.

Our study also showed no difference in LOS between the two groups, but EBL was significantly smaller for RRC. Although we would like to attribute the lower blood loss to a more precise dissection achieved with the robot, EBL is a subjective parameter, and this difference may not have any clinical significance.

Our perioperative and oncological outcomes compare favorably with results reported in the lit erature (Table V).

A weakness of our study is the relatively small number of patients. This study was not randomized, but the demographics of both the RRC and LRC groups were similar.

Finally, this study did not include a cost comparison.

The cost of a robotic system, including its yearly maintenance fees and disposables, can represent a significant cost to hospitals and health systems. This is compounded by the lack of reimbursements by payers. Expected improvements in technology and potential competitions may reduce the cost of robotic surgery in the future.

We share the opinion that the dissection with the robot is more precise. Superior visualization, a stable platform, and articulating instruments all contribute to this advantage. This could have clinical relevance if we think of how laparoscopic colorectal surgery proved to be less traumatic than open surgery. We believe that minimally invasive techniques are less immunosuppressive, are associated with less ileus, and result in quicker recovery. This same advantage may apply to robotic surgery if proved in the future. Our EBL, average BMI, conversion rate, and LOS were very similar to those published in the literature. There were no anastomotic leaks or mortality in either group. As others have shown, RRC is safe and feasible. The true advantage of robotics may be in its ability to simplify complex tasks. To validate robotic colorectal surgery further, however, the results of a multicenter, randomized clinical trial are required. Therefore, a need exists to assess its cost-effectiveness compared with functional and oncologic outcomes.

Conclusion

For right colectomy, robotic surgery appears to be at least as safe as laparoscopic surgery. No major complications, leaks, conversions, or mortality were registered in our series. Prolonged operating time, increased costs, and learning curve are the major drawbacks. In addition, robotic colectomy can be performed without compromising oncological principles, but data for long-term outcomes are still limited.

Riassunto

Le tecniche chirurgiche mininvasive, per il trattamento delle patologie del colon retto hanno dimostrato di essere caratterizzate dagli stessi risultati delle tecniche tradizionali in merito agli scopi oncologici, ma sono contraddistinte da migliori risultati clinici. La chirurgia robotica, grazie all'impiego del robot DaVinci Xi, rappresenta un'evoluzione del classico approccio mininvasivo laparoscopico.

In questo studio si ha come scopo quello di individua-

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re risultati chirurgici e oncologici a breve termine, dell'emicolectomia destra robotica e compararli a quelli ottenuti nella corrispettiva procedura laparoscopica.
Sono stati analizzati un numero complessivo di 22 casi, di cui 15 sottoposti a procedura laparoscopica e 7 a quella robotica. I principali dati presi in considerazione in questo studio, sono stati, la durata dell'intervento chirurgico, i giorni di degenza postoperatoria, la lunghezza del sito d'estrazione del pezzo operatorio, la presenza di complicanze e il tasso di conversione. Solo nei casi in cui il trattamento era eseguito per patologia maligna sono stati introdotti ulteriori dati.
I risultati di questo studio dimostrano come non ci siano particolari differenze tra i due gruppi analizzati, sebbene si sia osservato una significativa minore perdita stimata di sangue nei pazienti sottoposti a procedura robotica. È stato inoltre osservato un tempo operatorio più lungo nelle procedure robotiche, mentre la durata della procedura chirurgica è risultata essere simile nei due gruppi. I dati raccolti sulla lunghezza del campione e sul numero di linfonodi suggeriscono che la procedura robotica è oncologicamente simile a quella laparoscopica.
L'approccio robotico consente l'esecuzione di un'adeguata dissezione del colon destro con linfoadenectomia radicale come nella chirurgia laparoscopica, confermando la sicurezza e l'efficacia oncologica di questa tecnica.

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