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Review Article

Colorectal robotic surgery: overview and personal experience

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Abstract

In the last two decades, there has been an increased interest in minimally invasive surgical techniques, especially in robotics which has become a new technological trend in colorectal surgery. However, the potential advantages of robotic over laparoscopic approach for colorectal resection is still under discussion. The aim of this review is to give a general overview of the current studies of robotic colorectal surgery presenting also the experience of our center.

Keywords: rectal resection; cost; robotic surgery

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Introduction

Colorectal resections by mean of minimally invasive techniques, including laparoscopic and robotic approaches, have rapidly evolved in the last decade [1].They provide the patients with better short-term outcomes, including smaller incisions, shorter hospital stay and less blood loss [2]. However, some research centers have demonstrated also some disadvantages inherit in the laparoscopic surgery [3]. These include loss of 3-dimensional vision, the need to use longer instruments, thus increasing surgeon hand tremors, and loss of human wrist's

movement because it only allows for 4 degrees of freedom and the lack of intuitive movement due to the levering effect that the trocars have on the instruments. Thus, robotic colectomy was developed to overcome these limitations of laparoscopic surgery which have been claimed to be particularly useful for more challenging procedure like colorectal resection.

However, experience is still limited and outcomes of colorectal malignancy remain controversial, especially for oncological prognosis [4]. But, in the last decade robotics have done important advances [new generation of robot, new devices and instrumentation]. Herein, we collected and analyzed the main published data about robotic colorectal surgery divided in right, left and rectal resection. Furthermore, we present the experience with colorectal surgery of our center.

Right colectomy

Longer operating time is still one of the major issue of robotic surgery, which has been studied in the only randomized clinical study comparing robotic and conventional laparoscopic right colectomy [5]. But, on the other hand, as depicted in table 1, a study comparing the first 30 laparoscopic and robotic right colectomies of the same surgeon and institute suggested statistically comparable operating times for both the groups [6].

General opinion is that docking time, surgeons' experience (place on the learning curve), and intracorporeal creation of anastomosis are all 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, as expected, that as the surgeon and surgical team gain experience, operating time shortens [7,8].

Older studies showed similar blood loss during robotic and laparoscopic right colectomy for cancer [6, 9] and significantly lower than the open approach [5].

Different laparoscopic procedures have been described for the resection of right colon tumors including the intracorporeal ileo-colic anastomosis, which is challenging to perform with nonarticulated rigid instruments. For this reason, most of the surgeon prefers an extracorporeal anastomosis. The enhanced dexterity in using the instruments and the vision of the robotic approach make this challenging step easier by the adoption of a minimally invasive approach.

In several series it has been showed that conversion rates as well as length of hospital stay were similar for robotic and laparoscopic procedures [6, 9] confirming the safety of the robotic approach for right colon resection [5, 6, 9] (see Table 1).

In addition, robotic right colectomy provides similar overall morbidity and mortality rates with open [5] and conventional laparoscopic right colectomy [6, 9].

The latest generation of DaVinci and devices have reduced the number of necessary ports improving the single-port colorectal surgery which has been recently introduced with right colectomy [10].

Both pathological and oncological aspects of robotic right colectomy are not compromised [5, 6, 9] with a

disease-free survival rate of 90% and an overall survival rate of 92% at a median follow-up time of 36 months (6–96 months) [7].

Table 1 Robotic right colectomy series

	No of patients	Operative time (min)	Blood loss (ml)	Conversion	Length of stay (days)
Park 2012 [9]	35	195	35.8	0	7.9
Shin 2012 [6]	6	342.5	185	0	10.7
Luca 2011 [5]	33	191.7	6.1	NA	5
D'Annibale 2010 [7]	50	223.5	20	0	7

Left colectomy

Similarly to the right colectomy, robotic left colectomy is also associated to longer operative time, as showed in table 2. The study from Lim et al. which compared laparoscopic and robotic anterior resection for sigmoid colon cancer found that the robotic procedure was associated with a significantly longer operative time [11]. Also Shin [6] reported comparable operative times for robotic and laparoscopic resection of left-sided colon cancer. On the other hand, comparable operating times were reported in the series of Helvind et al. for patients who underwent laparoscopic or robotic colectomy for colon cancer [12].

Blood loss and conversion rates during robotic cases were comparable with those of laparoscopic left colectomy [6, 11].

On the other hand, either a comparable or shorter length of hospital stay was reported for robotic left colectomy for cancer [6, 11]. Similarly, outcomes in terms of blood loss and length of hospital stay were comparable between robotic and laparoscopic left colectomy for benign and malignant disease of the colon [13].

Postoperative morbidity and mortality rates were similar to those of the laparoscopy group [11]. Similarly, a 92% overall and an 89% disease-free 3-year survival rate were reported after robotic sigmoid colectomy, which were comparable to those in the laparoscopy group [11].

Table 2 Robotic left colectomy series

	No of patients	Operative time (min)	Blood loss (ml)	Conversion	Length of stay(days)
Lim 2013 [11]	34	252.5	60.3	0	5.5
Helvind 2013 [12]	101	243	NA	5	6.4
Shin 2012 [6]	7	337.1	105.7	0	9.1
Luca 2011 [5]	55	290	68	0	7.5

Rectal resection

It has been argued that robotic approach might have more benefits in more challenging procedures, like rectal resection, because of the reduced anatomical space of the pelvis, especially in low rectal cancers that require a complete total mesorectal excision.

For this reason, our opinion is that in the last decade, the number of publications about robotic rectal surgery has been constantly increasing [1].

The operating time still represents a disadvantage in robotic surgery; however, as reported in our previous study [4] and consistent with other authors' work [14] after a learning curve of almost 40 robotic rectal resections, there exists a remarkable decrease in the operative time. Thus, it is obvious that experience gained in the operative procedures decreases the time taken for robotic rectal resection surgery. The latest version of the da Vinci Xi may also contribute to a decrease in the operative time thanks to narrower arms and a more straightforward docking manoeuver.

The rates of conversion for the rectal resection with laparoscopic and robotic processes in the literature are reported to be between 7-34% and 0-10%, respectively [2, 15].

Randomized clinical ROLARR trial is currently ongoing. However, initial results have been presented in the clinical american college conference of surgery showing a slight lower conversion rate in the robotic arm.

In our previous published study, the difference in overall conversion rate was not statistically significant [4]. However, when data were analyzed according to the tumor location [upper, mid, lower rectum], the conversion rates between robotic and laparoscopic procedures for lower rectal cancers were respectively 1.8% and 9.2% [P = 0.04].

Estimated blood loose was studied in several series resulting to be similar to the laparoscopic approach. Only Kang et al [16] and Erguner et al [17] reported a significantly lower blood loose with the robotic approach when compared to the laparoscopic one.

Length of hospital stay was reported to be similar to the laparoscopic approach in most of the studies. However, 5 of them reported a shorter stay for the robotic group [2]. Furthermore, no statistically significant differences in the overall 30 days mortality between the robotic and laparoscopic approach was found [2].

None of the comparative studies found differences regarding pathological and oncological characteristics between robotic and laparoscopic rectal resection [2].

In the literature, only a few studies report data on oncologic outcomes which have been found to be comparable [18-21].

Cost analysis

To the best of our knowledge, there are only few studies in the literature reporting the cost of robotic compared with conventional laparoscopic colorectal resection. Initial studies reported that robotic colorectal surgery is associated with an additional $350 direct equipment cost per case [22]. Despite the increasing clinical implementation of robotic colectomy, it is still more expensive than conventional laparoscopic procedures [9] as well as

open surgery [24]

Expected improvements in technology and potential competitions may reduce the cost of robotic surgery in the future.

The real cost difference of robotic vs laparoscopic and open colorectal resections should also be evaluated to include different factors such as the cost to the quality of life, sexual and defecation functions, return to normal activity, etc. However, it is extremely difficult to place a value on these factors, and only prospective scientific studies have the means to take them into account. Furthermore, there are some factors that are almost impossible to value and are extremely difficult to compare with the laparoscopy itself, such as the training efficacy that only the double robotic console can offer or the easier instrument control and more ergonomic position of the surgeon, which are all especially useful for complex procedures.

Table 3 Robotic vs laparoscopy rectal resection (preoperative data)

	Robot-assisted *n*= 86	Laparoscopy *n*= 112	*P* value
Age (mean)	63.9 ± 9.5	61.6 ± 11.9	0.14
Male/Female (*n*)	48/38	67/45	0.66
BMI (Kg/m^2)	26.1 ± 4.1	25.67 ± 3.36	0.45
ASA (*n*)			0.06
I-II	68	98	
III-IV	18	14	
Mean distance from anal verge to the tumor (cm)	6.9	7.5	0.8
Tumor location (*n*)			
Upper rectum	31	41	
Mid rectum	30	39	
Lower rectum	25	32	
Neoadjuvant treatment	65	87	0.7

BMI: body mass index

Table 4 Robotic vs laparoscopy rectal resection (operative data)

	Robot-assisted *n*= 86	Laparoscopy *n*= 112	*P* value
Operative procedures *n*			0.73
LAR	62	73	
APR	20	32	
Colo-anal	4	7	
Mean operative time (min)	336 ± 16	283 ± 84	0.001
Mean blood transfusion (ml)	43.2 ± 117.6	30 ± 68.4	0.08
Conversion to open (*n*)	4	13	0.091

LAR: low anterior resection

APR: abdominalperitoneal resection

Table 5 Robotic vs laparoscopy rectal resection (postoperative data)

	Robot-assisted *n*= 86	Laparoscopy *n*= 112	*P* value
Mean hospital stay (days)	12.2 ± 7.91	12.7 ± 8.3	0.72
Clavien III/IV *n*	7	12	0.64
Overall Complications (*n*)	20	25	0.73
Anastomotic leakage	8	9	0.49
Intraabdominal abscess	3	7	0.03
Blood transfusion (ml)	221 ± 456	246 ± 480	0.42
Reoperation rate	3	4	0.72
Readmission rate *n*	5	13	0.001
Mean number of retrieved nodes	9.2 ± 4.5	9.7 ± 6.8	0.49
CRM ≤1 *n*	3	4	0.83
R1 *n*	2	3	0.81

Learning curve of robotic colorectal resection

In several studies, it has been showed that the learning curve for performing robotic colorectal operations is shorter than for laparoscopy and is achieved after almost 15 cases [25]. The period of highest skill has been identified after 25 cases. Although initially slower than laparoscopy, operative times for robotic surgery improved rapidly and after 41 cases became faster than laparoscopy [25].

Our experience with robotic colorectal surgery

A total of 120 robotic colorectal resections were performed in our department between October 2010 and May 2017. Comparing robotic vs laparoscopic rectal resection, operative time in the robotic group was longer than in the laparoscopy group (336 min vs 283 min; P = 0.001) (Table 3, 4).

The mean length of hospital stay was 12.2 days in the RRR group and 12.7 in the LLL group (P =0.72), however, readmission was significantly higher in the LLL group (11.6% vs 5.8%; P = 0.001) (Table 5). The mean reason for readmission was because of fever related to intraabdominal abscesses, and was, in fact, higher in the LLL group (6.2 vs 3.4; P =0.03). Nevertheless, all of these complications were minor as they were treated conservatively with antibiotics, except for two which required radiological drainages.

Our data are consistent with the current literature that reveals overall complication rates from robotic operations to range from 5.4% to 43.2% [2].

As expected from previous data reported in the literature, results for reoperation rates, anastomotic leakages and blood loss were found to be similar in both groups [2].

Similarly to our previous study [4] no differences between groups have been found regarding the mean number of harvested nodes, the number of affected circumferential margins and the mean length of distal resection margins

At our center, we are performing a cost analysis of rectal vs laparoscopic

resection and according to our results, we found that rectal resection costs were only slightly higher for the robotic group than for the laparoscopy group (7279.3€ vs 6879.8€, P = 0.44).

Conclusions

This review confirms the excellence of per-operative and oncological outcomes of patients following robotic colorectal resection. However, for many procedures, no conclusive evidence has been able to prove any superiority of robotic surgery over laparoscopic approaches. But this does not mean that the future of robotic surgery is hopeless, the technology will continue to grow and develop and the research outcomes will likely reflect these advances.

Conflict of interest

The authors have no potential conflicts of interest to disclose.

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