



# Principles of Minimally Invasive Surgery for Colorectal Cancer, A Mini Review Article

Jaime Ruiz-Tovar<sup>1,\*</sup>

<sup>1</sup>Department of Surgery, Universidad Alfonso X el Sabio, Madrid, Spain

\*Corresponding author: Department of Surgery, Universidad Alfonso X el Sabio, Madrid, Spain. Tel: +34-630534808, Email: jruiztovar@gmail.com

Received 2019 February 22; Accepted 2019 June 16.

## Abstract

For most patients with colorectal cancer, laparoscopic surgery is considered the gold-standard approach as it features the advantages of minimally invasive surgery and is as oncologically safe as the conventional approach. However, during the past decades, there has been major controversy about the indications and feasibility of the laparoscopic approach for patients with colorectal neoplasm. In this paper, we review the evolution of laparoscopy in the treatment of colorectal cancer.

**Keywords:** Colorectal Cancer, Laparoscopy, Minimally Invasive Approach

## 1. Introduction

The laparoscopic approach to colorectal disease surgery has generated immense controversy since 1991 when Jacobs described the first laparoscopic colectomy. Colorectal laparoscopic surgery features various advantages and disadvantages when compared with conventional surgery. The advantages are all the widely known advantages of laparoscopic approaches (less postoperative pain, less abdominal wall complications, less surgical site infections, less postoperative ileus, shorter hospital stay, faster recovery, etc.). On the other hand, the main disadvantage is a longer postoperative time, though this disadvantage is directly related to the experience and laparoscopic skills of the surgeon (1).

Colorectal surgery differs from other intra-abdominal laparoscopic approaches in the following ways:

- Multiple abdominal quadrants are involved in the surgery

- Colon and bowel have a complex blood supply that is often difficult to identify in fatty and inflamed mesenteria.

These features imply that the laparoscopic approach to colorectal disease surgery requires extensive laparoscopic training as well as the use of advanced laparoscopic devices to guarantee favorable outcomes. To safely perform such surgery, the surgeon must have widespread experience in colorectal surgery besides advanced laparoscopic skills (1, 2).

Despite the higher operative cost related to laparoscopy, the reduction in hospital stay leads to an

overall economic advantage in comparison with conventional surgery (1).

Currently, the laparoscopic approach is used for the surgical treatment of benign and malignant colorectal diseases. However, the acceptance of laparoscopic surgery for colorectal cancer has been slower compared with other pathologies, and several aspects still remain controversial for several groups despite the fact that actual evidence supports its use as a safe approach with greater advantages and less disadvantages compared with conventional surgery. Several prospective randomized studies have shown that laparoscopic surgery for colorectal cancer is technically possible, safe, and offers the advantages of a laparoscopic approach. Initially, there was great optimism about this technique, which later diminished with the publication of an important number of metastatic implants in the port sites, even in early stage tumors. Consequently, many surgeons abandoned the laparoscopic approach for malignant disease surgery, and several surgical societies temporarily recommended its limitation to controlled trials including a prolonged follow-up to obtain exact knowledge of the influence of laparoscopy on recurrence and long-term survival (3, 4).

## 2. Indications of Laparoscopic Surgery in Colorectal Cancer

The indications for laparoscopic surgery have changed as the technology and laparoscopic experience of surgi-

cal groups have advanced. Although laparoscopic surgery for colorectal cancer is performed in most hospitals of developed countries, several surgeons still believe that these surgeries should be limited to centers with wide experience. Nowadays, young surgeons acquire immense laparoscopic skills during their training and, given that colorectal cancer is a very frequent entity, it is easy to establish a fast learning curve, especially when junior surgeons are supervised by a senior laparoscopic colorectal surgeon. These factors have facilitated the development of laparoscopic surgery for colorectal cancer, leading to its use in many hospitals in developed countries with advanced technological devices (1, 5).

Probably, there is still some controversy with low rectal tumors. These tumors are less frequent and the surgery is technically more difficult; these cases might benefit from referral to a center with greater experience (2).

Initially, the patient with an advanced tumor was considered the ideal candidate for a laparoscopic approach as the technique would not influence survival. In reality, the concept is completely inverse; early stage tumors are the ones that benefit most from laparoscopic surgery, as a correct technique with oncologic criteria provides the same neoplastic outcome but involves less impact on the life of the patient (5, 6).

Advanced tumors that might require multi-visceral resections are probably more complex and less amenable to a laparoscopic approach. However, the advances in neoadjuvant treatment actually allow safe laparoscopic resections with oncologic criteria and similar prognosis. Classically, tumors staged T4 or those larger than 8 cm were considered an absolute contraindication to laparoscopic surgery because there would be a greater risk of neoplastic cell release and spread by the CO. However, this concept is currently abolished, and the contraindications ultimately depend on the experience and skills of the surgeon as well as perhaps the location of the tumor and the involvement of adjacent structures (2).

### 3. Oncologic Resection

In laparoscopic surgery, the base of an oncologic resection must be strictly followed. Similar to conventional surgery, laparoscopic surgery should involve the en bloc resection of the colon segment as well as the corresponding lymph node territory, while avoiding handling with the tumor, maintaining sufficient free margins, and ligating the vessels at its origin (7).

Initially, there were certain doubts regarding the oncologic quality of the laparoscopic resection, but this controversy soon was overcome with widespread evidence becoming available in favor of the laparoscopic approach as

a careful and safe method of resection. Most of the studies analyzing this issue have focused on evaluating the anatomicopathological features of the resected specimen, including the length of the resected segment, free margins, and number of lymph nodes isolated. These studies demonstrated that all these parameters were similar after laparoscopic or conventional resections (8, 9).

### 4. General Concepts of Laparoscopic Colorectal Surgery

The laparoscopic approach reproduces the technique, concepts and operative steps of conventional surgery:

#### 4.1. Intraoperative Identification of the Tumor

The first surgical step for confirming the diagnosis is to identify the lesion and the degree of locoregional involvement, apart from the relation with other organs, such as the ureter. The preoperative extension study might have not detected peritoneal implants or small liver metastases. The identification of the lesion and its relation with other organs permits us to establish the ideal surgical strategy or even to convert to conventional surgery if necessary. One of the main problems of intraoperative diagnosis is the detection of small lesions or resected polyps with neoplastic infiltration due to the impossibility of colon palpation. In these cases, it is mandatory that the margins of the tumors or the location of the resected polyp are tattooed endoscopically prior to surgery (1, 3, 4).

#### 4.2. Dissection, Mobilization and Management of the Vascular Pedicles

The dissection of the mesenteric vascular pedicles is the first step. The dissection plane must preserve the Gerota fascia, avoiding the invasion of the retroperitoneum. The right and left colons are retroperitoneal organs that are often difficult to mobilize. They have to be separated from the retroperitoneum by dividing the parietocolic coalescence. This maneuver must be carefully performed to preserve the anatomic structures and avoid the mobilization of the ureter. In right hemocolectomies, the hepatic flexure of the colon is usually included in the resected segment, while in sigmoidectomies and rectal resections, the splenic flexure is not included. This segment of the colon must however be freed from adhesions to the spleen and stomach in order to allow the descent of a longer segment of the colon, making possible a tension-free anastomosis (1, 3, 4).

#### 4.3. Resection of Mesocolon and Bowel

Depending on the location of the lesion, the resection of the affected segment of the colon may be performed intra- or extra-corporeally. In right hemicolectomies, once the aforementioned steps are completed, the colon can be entirely exteriorized to the outside of the abdomen, and the resection of the colon and small bowel as well as the anastomosis can be performed extracorporeally. In sigmoidectomies and rectal resections, the distal resection of the colon is performed intracorporeally with a linear endostapler, after which the rest of the colon proximal to the section point is exteriorized (usually through a Pfannenstiel incision or a small incision in left flank) to resect the affected part of the colon and to prepare the bowel for the anastomosis. Some expert laparoscopic surgeons prefer to perform the dissection, bowel preparation and anastomosis intracorporeally, and only exteriorize the specimen through a small incision at the close of the surgery. This procedure is obviously technically more complicated, but these surgeons defend it based on the use of a smaller Pfannenstiel incision. However, diverse studies have demonstrated that this option is as safe as extracorporeal anastomosis (similar anastomotic leaks) and is not associated with lower surgical site infection rates, lower ventral hernia rates or lower global complication rates. Some surgeons also support the extraction of the specimen through the anus, avoiding the need for accessory incisions in the abdominal wall. This has been accepted for benign colorectal pathologies, but remains controversial for malignant ones as it can cause the spread of neoplastic cells to the distal colon and rectum (1, 3, 4).

### 5. Short-Term Results of Laparoscopic Colectomies

In the conventional surgery, the abdominal wall incision represents only one part of the total surgical aggression, which also includes the mobilization of the small bowel, the dissection of lymph nodes, the division of peritocolic coalescence, and the performance of anastomosis. Thus, the laparoscopic approach reduces only the damage to the abdominal wall, while the rest of the aggression is similar in both techniques. However, the reduction of the abdominal wall damage alone results in a shorter recovery from the surgery and a reduction in medical complications associated with lower postoperative pain, such as lung complications (atelectasis and pneumonia), thromboembolic events, and postoperative ileus (as postoperative pain prevents early deambulation in the postoperative course). Moreover, a smaller skin incision is less prone to the development of an incisional surgical site infection,

which is the most frequent postoperative complication after colorectal surgery and is the major cause of prolonged hospital stay (9-11).

The laparoscopic approach has some significant differences with other intra-abdominal laparoscopic techniques, which makes it technically more complex and means that a longer learning curve is required. Several studies attempted to determine the duration of the learning curve, but the results ranged between 11 and 70 colonic resections. This wide range is probably due to multiple factors, with most surgeons agreeing that the learning curve depends on parameters such as the surgeon's laparoscopic skills, surgeon's past experience with other advanced laparoscopic procedures, surgeon's age, and hospital volume (10, 11).

The conversion rates published in literature are also highly variable, ranging between 14% and 40%. The most frequent causes of conversion are adhesions from previous abdominal surgeries, intraoperative bleeding, and large tumors with or without local infiltration; such cases cannot be handled laparoscopically (11).

As expected, operative time is significantly longer in laparoscopic techniques, varying between 160 and 350 minutes depending on the resection performed (11).

Comparative studies also demonstrate an earlier oral intake after laparoscopic colectomies secondary to a reduction in postoperative ileus. This is probably due to less bowel handling, better maintenance of intra-abdominal conditions of humidity and temperature, reduced neurohormonal response to surgical damage, less need of opioid analgesia, and earlier deambulation. The lower incidence of infectious complications, which often provoke postoperative ileus, can also be a cause involved (12).

In comparison with conventional surgery, the main disadvantage of laparoscopic colorectal surgery is its superior economic cost secondary to the prolonged operative time and the use of disposable and expensive laparoscopic material. However, the shorter hospital stay after laparoscopic surgery balances its greater intraoperative costs. Recent economic studies even suggest that laparoscopic surgery is associated with lower economic costs associated with the total treatment of a specific pathology. Moreover, it has to be considered that most patients with colorectal cancer are at advanced ages, and suspension of labor activity is not an economic burden associated with the surgery for such subjects, though this factor must be taken into consideration in young patients (12).

### 6. Oncologic Outcome After Laparoscopic Surgery

Colorectal cancer can be surgically cured in around 50% of cases. Consequently, the immediate benefits must

be counterbalanced with the possibility of reducing the survival curves or the curability indices (9).

One of the main points of controversy in the past was the appearance of metastatic implants in the port sites. This was not exclusive to advanced-stage tumors and was also seen in early-stage ones. These port-site metastases have been associated with the free extraction of the pneumoperitoneum through unprotected abdominal holes (port-sites), which can facilitate the spread of neoplastic cells to the abdominal wall. Thus, it has been proposed that at the end of the surgery, the pneumoperitoneum should be extracted through the port valves without extracting the whole device from the abdominal wall. This proposal has been widely accepted and, in recent reports, the incidence of port-site metastasis ranges from 0.6% to 1%, which is similar to that obtained after conventional surgery (9, 13, 14).

Several studies and meta-analyses involving a significant number of patients and long-term follow-ups have compared laparoscopy with conventional resections, demonstrating that recurrence rates and global survival are similar in both approaches. Several authors even state that the oncologic outcome can even be better after laparoscopic surgery, especially in locally advanced tumors without distant metastases. The surgeon is a relevant factor in the survival of patients with colorectal cancer. Surgeons dedicated exclusively to colorectal pathology and performing an elevated number of surgeries obtain better oncologic results. Such experience-related improvements in outcomes are even more relevant in laparoscopic techniques requiring specific training (13, 14).

Another possible factor that may influence survival in patients undergoing laparoscopic surgery is the lower postoperative immunosuppression induced by the laparoscopic approach (14).

## Footnotes

**Authors' Contribution:** Jaime Ruiz-Tovar, MD, PhD is the only author and has performed alone all the work regarding this paper.

**Conflict of Interests:** The author declares no potential conflict of interest in the publication of this manuscript in relation to the following statements:

**Ethical Considerations:** The manuscript was prepared according the Declaration of Helsinki normative.

**Financial Disclosure:** There is no financial disclosure.

**Funding/Support:** There is no funding.

## References

- Pedziwiatr M, Malczak P, Mizera M, Witowski J, Torbicz G, Major P, et al. There is no difference in outcome between laparoscopic and open surgery for rectal cancer: A systematic review and meta-analysis on short- and long-term oncologic outcomes. *Tech Colo-proctol.* 2017;**21**(8):595-604. doi: [10.1007/s10151-017-1662-4](https://doi.org/10.1007/s10151-017-1662-4). [PubMed: [28795243](https://pubmed.ncbi.nlm.nih.gov/28795243/)]. [PubMed Central: [PMC5602007](https://pubmed.ncbi.nlm.nih.gov/PMC5602007/)].
- Bretagnol F, Leroy J. Laparoscopic resection for T4 colon cancer: Perioperative and long-term outcomes. *Updates Surg.* 2016;**68**(1):59-62. doi: [10.1007/s13304-016-0354-3](https://doi.org/10.1007/s13304-016-0354-3). [PubMed: [27048295](https://pubmed.ncbi.nlm.nih.gov/27048295/)].
- Keller DS, Ibarra S, Haas EM. Minimally invasive colorectal surgery: Status and technical specifications. *Minerva Chir.* 2015;**70**(5):373-80. [PubMed: [26149521](https://pubmed.ncbi.nlm.nih.gov/26149521/)].
- Zeng WG, Zhou ZX. Mini-invasive surgery for colorectal cancer. *Chin J Cancer.* 2014;**33**(6):277-84. doi: [10.5732/cjc.013.10182](https://doi.org/10.5732/cjc.013.10182). [PubMed: [24589210](https://pubmed.ncbi.nlm.nih.gov/24589210/)]. [PubMed Central: [PMC4059865](https://pubmed.ncbi.nlm.nih.gov/PMC4059865/)].
- Morneau M, Boulanger J, Charlebois P, Latulippe JF, Lougnarath R, Thibault C, et al. Laparoscopic versus open surgery for the treatment of colorectal cancer: A literature review and recommendations from the Comité de l'évolution des pratiques en oncologie. *Can J Surg.* 2013;**56**(5):297-310. doi: [10.1503/cjs.005512](https://doi.org/10.1503/cjs.005512). [PubMed: [24067514](https://pubmed.ncbi.nlm.nih.gov/24067514/)]. [PubMed Central: [PMC3788008](https://pubmed.ncbi.nlm.nih.gov/PMC3788008/)].
- Martel G, Crawford A, Barkun JS, Boushey RP, Ramsay CR, Ferguson DA. Expert opinion on laparoscopic surgery for colorectal cancer parallels evidence from a cumulative meta-analysis of randomized controlled trials. *PLoS One.* 2012;**7**(4). e35292. doi: [10.1371/journal.pone.0035292](https://doi.org/10.1371/journal.pone.0035292). [PubMed: [22532846](https://pubmed.ncbi.nlm.nih.gov/22532846/)]. [PubMed Central: [PMC3332109](https://pubmed.ncbi.nlm.nih.gov/PMC3332109/)].
- Hiranyakas A, Ho YH. Surgical treatment for colorectal cancer. *Int Surg.* 2011;**96**(2):120-6. doi: [10.9738/CC18.1](https://doi.org/10.9738/CC18.1). [PubMed: [22026302](https://pubmed.ncbi.nlm.nih.gov/22026302/)].
- Wasserberg N. Laparoscopic colectomy for colorectal cancer. *Isr Med Assoc J.* 2010;**12**(9):572-6. [PubMed: [21287804](https://pubmed.ncbi.nlm.nih.gov/21287804/)].
- Sharma B, Baxter N, Grantcharov T. Outcomes after laparoscopic techniques in major gastrointestinal surgery. *Curr Opin Crit Care.* 2010;**16**(4):371-6. doi: [10.1097/MCC.0b013e32833b0480](https://doi.org/10.1097/MCC.0b013e32833b0480). [PubMed: [20613501](https://pubmed.ncbi.nlm.nih.gov/20613501/)].
- Rosin D, Khaikin M, Zmora O. Minimally invasive approach to colorectal surgery. *Minerva Chir.* 2008;**63**(2):127-49. [PubMed: [18427445](https://pubmed.ncbi.nlm.nih.gov/18427445/)].
- Bruch HP, Esnaashari H, Schwandner O. Current status of laparoscopic therapy of colorectal cancer. *Dig Dis.* 2005;**23**(2):127-34. doi: [10.1159/000088594](https://doi.org/10.1159/000088594). [PubMed: [16352892](https://pubmed.ncbi.nlm.nih.gov/16352892/)].
- Lacy AM, Garcia-Valdecasas JC, Delgado S, Castells A, Taura P, Pique JM, et al. Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: A randomised trial. *Lancet.* 2002;**359**(9325):2224-9. doi: [10.1016/S0140-6736\(02\)09290-5](https://doi.org/10.1016/S0140-6736(02)09290-5). [PubMed: [12103285](https://pubmed.ncbi.nlm.nih.gov/12103285/)].
- Whelan RL. Laparotomy, laparoscopy, cancer, and beyond. *Surg Endosc.* 2001;**15**(2):110-5. doi: [10.1007/s004640000393](https://doi.org/10.1007/s004640000393). [PubMed: [11285949](https://pubmed.ncbi.nlm.nih.gov/11285949/)].
- Lee SW, Gleason NR, Whelan RL. Laparoscopic resection for colorectal cancer: is it justified? *Surg Oncol Clin N Am.* 2000;**9**(4):763-81. discussion 783-4. doi: [10.1016/S1055-3207\(18\)30114-5](https://doi.org/10.1016/S1055-3207(18)30114-5). [PubMed: [11008243](https://pubmed.ncbi.nlm.nih.gov/11008243/)].