Laparoscopic surgery for colon cancer

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Abstract

Colon cancer is a major problem in Western countries and complete surgical resection is the main treatment. Since its introduction the laparoscopic approach has been used to achieve bowel resection with a better postoperative course and better aesthetic outcomes. Initial concerns about the radicality of the resection and the oncologic outcomes have been overcome in the last decade. All over the world large trials have been conducted to compare the laparoscopic approach and the traditional laparotomic one. A review of literature has been conducted to find evidence about this issue, revealing 24 relevant trials. The laparoscopic approach showed short-term benefits without compromising oncological safety. However intraoperative complication rates during laparoscopic colon resections seem to be increased, mainly due to the increased rate of intraoperative bowel injury. This finding confirms a great need for training and a wide learning curve for the surgeon. Our review supports the continued use of laparoscopic surgery in patients with colon cancer.

Keywords Colon cancer, mini-invasive surgery, laparoscopy, colon resection

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Introduction

Colon cancer is a major problem in Western countries and surgery is the main treatment [1]. Laparoscopic colon resection was first reported in the early 1990’s [2] but while the development of laparoscopic surgery over the last two decades was amazingly fast, its adoption in colon surgery was neither uniform nor universal. Initial concerns on the radicality of the resection and the oncologic outcomes as well as the early reports on high incidence of wound recurrence [3-5] limited the wide application of laparoscopic colectomy for malignancy.

However, favorable postoperative results in terms of less pain, reduced surgical-site infections, less consumption of pain-killers, early return of bowel function, and shorter hospital stay in patients who underwent laparoscopic colon surgery have been widely reported, both in series and, more recently, in large trials [6-9]. Therefore, meta-analyses and guidelines confirmed this short-term advantage [10-12].

Hospital statistics report that only a small percentage of resection are performed with this approach, showing that laparoscopy is still far from being widely accepted [13,14].

Long-term results are reported only in few trials comparing laparoscopic and open surgery [15,16].

Nevertheless, results of the recent Australasian Laparoscopic Colon Cancer Study (ALCCaS) [17,18] have demonstrated a significantly higher intraoperative complication rate in laparoscopic surgery, seemingly as a result of higher rates of intraoperative bleeding and bowel injury.

The aim of this review is to evaluate results of studies comparing laparoscopic and open colon resections. Short-term results and complications, intraoperative findings, survival and oncological outcomes were mainly studied.

Methods

A database search was conducted to identify relevant literature using MEDLINE and Cochrane Central Register of Controlled Trials from 1991 to January 2012. Abstracts from society meetings were handsearched too.

Two independent researchers (CR and PM) browsed all the abstracts potentially relevant for this review and full-text was retrieved for relevant papers. Inclusion criteria were: non-urgent resection of colonic malignancies in adult patients and comparison between “laparoscopic” and “open” techniques. Studies about colon and rectal resections were included as
well if data about colon resections could be extracted. Exclusion criteria were: hand-assisted surgery and multiorgan resections. The results of the studies included are reported for each outcome giving main importance to results of systematic reviews (SR) or randomized control trials (RCTs) and (in case of no RCT available) large retrospective studies.

**Results**

The search strategy revealed 172 potentially eligible reports. 89 were excluded according to title or abstract. Full-text was sought for the remaining 83. Finally, we included 18 trials for our review (Table 1). The results are reported as intraoperative, postoperative short-term and postoperative long-term outcomes.

**Intraoperative outcomes**

**Duration of the operation**

Most of the trials reported a longer operative time for laparoscopic procedures compared to open approach (Table 2) and none of the trials showed duration of surgery to be significantly shorter in the laparoscopic group.

However, operative time widely varied among different trials reflecting different operative techniques and methods of data collecting (time in the operating room, skin to skin time, etc.).

**Intraoperative complications**

Since its introduction, the laparoscopic approach gave rise to controversies about intraoperative complications and their management. Seven trials [8-9,17,20,22-27,31,35,36] reported data about complication rates of colon resections (Table 3). Only one trial (ALCCaS) reported a significantly higher risk of intraoperative complications, and a meta-analysis [38] pooling all results together revealed a total intraoperative complication rate of 7.9% for laparoscopic resections compared to 5.4% for conventional ones (OR 1.37; 95% CI 1.06-1.76). The most frequently reported intraoperative complication was bowel injury.

**Conversion to open technique**

Conversion to the open technique is universally defined as the need for a skin incision bigger than the one necessary for specimen extraction to complete the procedure.

Conversion rate is one of the most reported outcomes and ranged from 3 to 46.4% [15,30].

The most common causes for conversion were (ordered by frequency): excessive tumor fixity, uncertainty of tumor clearance and obesity [8].

**Postoperative short-term outcomes**

**Postoperative pain**

The laparoscopic approach causes significantly less post-

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**Table 1 Studies considered for the review**

| Study ID | Year of last publication | Number of patients | Kind of study | Reference |
|----------|--------------------------|--------------------|---------------|-----------|
| ALCCaS   | 2008                     | 593                | Multicenter   | [18]      |
| Barcelona| 2008                     | 219                | Single center | [7,21]    |
| Basse    | 2005                     | 60                 | Single center | [22]      |
| Braga    | 2010                     | 268                | Single center | [17,23]   |
| CLASICCC | 2010                     | 794                | Multicenter   | [9,24-26] |
| COLOR    | 2009                     | 1076               | Multicenter   | [27,28]   |
| COST     | 2007                     | 863                | Multicenter   | [10,30,41]|
| Curet    | 2000                     | 73                 | Single center | [31]      |
| Hasegawa | 2003                     | 50                 | Single center | [6]       |
| Hewitt   | 1998                     | 15                 | Single center | [32]      |
| Kaiser   | 2004                     | 48                 | Single center | [33]      |
| King     | 2006                     | 60                 | Single center | [34]      |
| Liang    | 2006                     | 269                | Single center | [16]      |
| Milsom   | 1998                     | 109                | Single center | [36]      |
| Mirza    | 2008                     | 233                | Single center | [37]      |
| Stage    | 1997                     | 29                 | Single center | [39]      |
| Tang     | 2001                     | 232                | Single center | [40]      |
| Winslow  | 2002                     | 89                 | Single center | [42]      |
P. Millo et al reported data on complication rates in patients undergoing colon resections. The incidence of postoperative complications is lower in patients undergoing laparoscopic resection of colon cancer (18.2% vs. 23%; RR 0.72; P=0.02) [12]. This difference varies widely among studies depending on which outcomes are considered. Wound infection rate is reported lower in patients operated laparoscopically even in high-risk subgroup.

All the major studies assessing gastrointestinal recovery (as time to first flatus, time to first bowel movement or time to first liquid intake) reported faster or similar recovery rates for laparoscopic resections with great heterogeneity.

Intra-abdominal abscess formation and anastomotic leak are reported as single outcomes only in few trials (Braga, COLOR, Lacy, Tang) showing no differences in laparoscopic or open techniques.

Postoperative long-term outcomes

Recurrence

Local recurrence may be divided into port-site or wound recurrence, peritoneal recurrences and recurrences at the site of the primary tumor.

All the trials (Barcelona, Braga, CLASICC, COLOR, COST, Curet, Liang, Kaiser, Mirza) considering these outcomes failed to find any difference between open and laparoscopic surgery (Table 5). Recent meta-analyses confirmed these results, for rectal cancer subgroups as well [12].

Overall mortality and distant metastases

No significant difference in overall mortality and development of distant metastases was found in the included trials, when comparing laparoscopic and open surgery. The follow-up period was longer than 5 years in all except Kaiser. This finding is confirmed also by a meta-analysis [40].

Discussion

The laparoscopic technique has been applied to the resection of colon cancer for more than 20 years. Currently, many surgeons believe that the laparoscopic approach minimizes the trauma of access, reduces pain, and accelerates postoperative return of bowel function and general mobility, achieving quicker functional recovery with comparable oncological results for the treatment of patients with colon cancer [40]. Other potential benefits could include reduced formation of adhesions and lower rates of incisional hernia.

In the short-term, laparoscopic surgery for colon cancer is associated with a significantly longer operative time, but significantly less tissue trauma compared with conventional open surgery [7,8,26]. Potential explanations for...
the abovementioned results include meticulous dissection facilitated by instruments for laparoscopic surgery and camera magnification. However, significant heterogeneity was observed for these outcomes in the short-term, mainly linked to variations in the skill of the surgeon and the condition of the tumor.

However, intraoperative complication rates during laparoscopic colon surgery are increased, mainly due to the higher rates of intraoperative bowel injury. There is no evidence about the postoperative impact of each intraoperative complication recorded, as the rate of postoperative complications is mainly influenced by perioperative care practices which are not directly related to the intraoperative course [41,42]. Reported conversion rates range widely (from 3 to 46.4%), with an association between conversion from laparoscopic to open surgery and a worst postoperative course [44].

Conversion from laparoscopic to open technique is often associated to inability to visualize critical structures to achieve an oncological resection (inferior mesenteric artery and vein, correct plane of dissection or tumor margins) or inability to mobilize the colon (adhesions, tumor fixation) and finally intraoperative complications.

This issue is a matter of debate in the literature and most of the authors agree that the main factors leading to this great variability are: case selection criteria and surgeon's learning curve. The CLASICC trial reported that tumor infiltration/fixation and obesity were the most common reasons for conversion [8].

Large trials (CLASICC or COST) required the operating surgeon to have performed more than 20 laparoscopic resections before submitting patients into the trial. But recently it has been suggested that the learning curve may be bimodal, with improvement continuing to more than 100 cases [43].

Patients undergoing laparoscopic colon resections resumed oral intake significantly earlier and have significantly shorter hospital stays than patients undergoing open resections; this finding suggests that laparoscopy leads to faster recovery. However, some authors reported a shorter hospital stay with the enhanced recovery programmes (ERAS) in open colon surgery, compared to laparoscopy followed by a traditional postoperative course [45]. Laparoscopic resection of colon cancer within an enhanced recovery programme may provide the best short-term clinical outcomes for patients with resectable colon cancer [31].

### Table 4 Postoperative (<30 days) morbidity rate

| Study ID | Number of patients | LAP Morbidity rate (%) | Open Morbidity rate (%) |
|----------|--------------------|------------------------|-------------------------|
| Barcelona | 219               | 11                     | 29                      |
| Braga    | 268               | 12                     | 20                      |
| CLASICC  | 794               | 39                     | 42                      |
| COLOR    | 1076              | 21                     | 20                      |
| COST     | 863               | 21                     | 20                      |
| Curet    | 73                | 4                      | 17                      |
| Hasegawa | 50                | 4                      | 19                      |
| Hewitt   | 15                | 0                      | 0                       |
| Kaiser   | 48                | 18                     | 20                      |
| Liang    | 269               | 15                     | 22                      |
| Milsom   | 109               | 15                     | 15                      |

### Table 5 Overall recurrence Odds Ratio

| Study     | Odds Ratio | 95% CI     | Number of patients |
|-----------|------------|------------|--------------------|
| Barcelona | 0.55       | 0.29–1.06  | 219                |
| Braga     | 0.8        | 0.42–1.54  | 268                |
| CLASICC   | 1.06       | 0.62–1.79  | 794                |
| COLOR     | 1.2        | 0.88–1.63  | 1076               |
| COST      | 0.86       | 0.62–1.20  | 863                |
| Curet     | 1          | 0.06–17.33 | 73                 |
| Kaiser    | 2.28       | 0.22–23.68 | 58                 |
| Liang     | 0.74       | 0.40–1.37  | 269                |
| Mirza     | 1.55       | 0.66–3.64  | 233                |
The equivalence of oncological outcomes such as circumferential, proximal, and distal resection margins and the number of harvested lymph nodes between the laparoscopic and open approach indicate identical oncological safety of both operative techniques. Moreover some authors suggest that laparoscopic magnified vision may improve the sharp dissection of the mesocolon and mesorectum resulting in a higher rate of nodes harvested [46].

The rate of postoperative complications is significantly lower in laparoscopic procedures than in open resections. Many trials report data on complication rates pooled together, misleading about which specific complication rates are affected by laparoscopy. Wound infection rates are significantly lower for laparoscopic resections. Intra-abdominal abscess formation and anastomotic leak after laparoscopic procedures are comparable to those after open resections. This could be probably linked to the different pathogenesis of the complications: the surgical site infection deriving from superficial skin contamination (reduced by laparoscopic procedures) and the deep infection deriving from failure of the anastomosis (often fashioned in the same way in both techniques).

Gutt et al [47] describe that laparoscopic surgery reduces adhesion formation compared with open surgery. Because laparoscopic procedures reduce the overall degree of trauma to the abdominal wall, intraabdominal operative sites and distant intra-abdominal organs, they potentially have an advantage in reducing the formation of postoperative adhesions.

The laparoscopic approach causes significantly less postoperative pain than open surgery. Even if postoperative pain can be successfully controlled by drugs or epidural analgesia, medication side-effects and procedure complication should always be taken into account dealing with such an important outcome. However these results are affected by great heterogeneity due to differences in perioperative pain control protocols and use of epidural analgesia.

In the long-term, no trial found any significant difference in overall recurrence, local recurrence and distant metastasis between laparoscopic and open colorectal resections. There was also no significant difference in wound-site recurrence between the two approaches.

The first reports [48,49] of wound-site recurrence were probably associated to lack of experience in the specimen retrieval method and inappropriate localization choice of the mini-laparotomy. No significant difference was found in overall mortality. Most of the trials suggest that laparoscopic colonic resection is comparable to open resection with respect to long-term oncological results.

Laparoscopic surgery has been defined as a high-technological and a high-cost activity. However a cost analyses would have only a regional value, due to big differences among different countries about health policies and management of costs. There is a suggestion that the short-term benefits of laparoscopic surgery in terms of a shorter recovery may make laparoscopic surgery appear less costly. However, the measurement and inclusion of such costs (indirect costs) in an economic evaluation is contentious [13].

In conclusion, our review of the literature showed that laparoscopic surgery for colon cancer is associated with an earlier resumption of oral intake, shorter duration of hospital stay, less postoperative pain and rate of postoperative complications over the short-term and it is associated with similar long-term oncological outcomes compared to conventional open surgery. However, one potential pitfall of the laparoscopic approach could be the higher risk of intraoperative lesions, such as bowel perforation and the conversion to the open approach, usually associated to a worst postoperative course. This finding confirms a great need for training and a wide learning curve for the surgeon to achieve the abovementioned superiority of the laparoscopic approach. Therefore, successful laparoscopic colon resection for colon cancer is as effective as open surgery in terms of oncological outcomes, and these results support the continued use of laparoscopic surgery in patients with colon cancer.

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