

## Laparoscopic surgery for colon cancer

Paolo Millo<sup>a</sup>, Corrado Rispoli<sup>b</sup>, Nicola Rocco<sup>c</sup>, Riccardo Brachet Contul<sup>a</sup>, Massimiliano Fabozzi<sup>a</sup>, Manuela Grivon<sup>a</sup>, Mario Junior Nardi<sup>a</sup>, Rosaldo Allieta<sup>a</sup>

Aosta Valley Regional Hospital Umberto Parini, Aosta; ASL Napoli 1, PO "Cardinale Ascalesi", Naples; University "Federico II" of Naples, Italy

### 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

*Ann Gastroenterol 2013; 26 (3): 198-203*

### 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

Departments of General Surgery <sup>a</sup>Aosta Valley Regional Hospital Umberto Parini, Aosta (Paolo Millo, Riccardo Brachet Contul, Massimiliano Fabozzi, Manuela Grivon, Mario Junior Nardi<sup>a</sup>, Rosaldo Allieta); <sup>b</sup>ASL Napoli 1, PO "Cardinale Ascalesi", Naples (Corrado Rispoli); <sup>c</sup>University "Federico II" of Naples (Nicola Rocco), Italy

Conflict of Interest: None

Correspondence to: Paolo Millo, Department of General Surgery, Aosta Valley Regional Hospital Umberto Parini, Aosta, Italy, Tel.: +39 01 65543285, Fax: +39 01 653401, e-mail: paolomillo@yahoo.com

Received 31 August 2012; accepted 29 October 2012

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-

**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]
CLASICC	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]

**Table 2** Operative times' weighted mean differences (WMD) among laparoscopic and open resections

Study ID	WMD (min)	95% CI
Braga	39	22.78 – 55.22
COST	55	38.28 – 71.72
COLOR	30	10.93 – 49.06
CLASICC	45	21.46 – 68.53
Curet	72	-44.09 – 188.09
Hasegawa	87	-44.63 – 218.63
Hewitt	57.5	-78.96 – 193.86
Barcelona	24	11.13 – 36.87
Liang	40	31.24 – 49.56
Milsom	75	57.77 – 92.23
Stage	55	- 35.77 – 145.77
Tang	18	-2.29 – 38.29
Winslow	47	24.62 – 69.38

**Table 3** Trials on intraoperative complication

Study ID	OR (CI)	N
ALCCaS	2.65 (1.49-4.73)*	593
Basse	0.5 (0.05-5.02)	60
CLASICC	1.2 (0.76-1.88)	794
COLOR	1.08 (0.60-1.97)	1076
COST	1.95 (0.87-4.39)	863
King	4.23 (0.06-296.85)	60
Tang	1.17 (0.57-2.43)	232

\* $P < 0.05$ 

OR, odds ratio; CI, confidence interval

operative pain than open surgery. Five studies [8,16,26,34,36] reported significantly less pain after laparoscopic colectomy than the open procedure, as evidenced by a reduction in a variety of pain scores. There was also a reduction in the use of narcotic analgesia.

#### Duration of hospital stay after operation

Nine RCTs (Curet, Barcelona, Milsom, Stage, Tang, Hewitt, Braga, COST, COLOR) reported comparisons of length of hospital stay after surgery in the two treatment groups in more than 800 patients [7,9,19,21,26-29,32,34-36]. All of the studies reported a shorter length of stay after laparoscopic resection with one trial reporting a difference of five days in favor of the laparoscopic technique.

#### Postoperative complications

Several trials (Table 4) and two SR with meta-analyses

[12,39] 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 [7,8,19,25,26,32] (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

**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

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 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.

## References

1. Jessup JM, McGinnis LS, Steele GD Jr, et al. The National Cancer Data Base, report on colon cancer. *Cancer* 1996;**78**:918-926.
2. Jacobs M, Verdeja JC, Goldstein HS. Minimally invasive colon resection (laparoscopic colectomy). *Surg Laparosc Endosc* 1991;**1**:144-150.
3. Berends FJ, Kazemier G, Bonjer HJ, et al. Subcutaneous metastases after laparoscopic colectomy. *Lancet* 1994;**344**:358.
4. Wexner SD, Cohen SM. Port site metastases after laparoscopic colonic surgery for cure of malignancy. *Br J Surg* 1995;**82**:295-298.
5. Nduka CC, Monson JR, Menzies-Gow N. Abdominal wall metastases following laparoscopy. *Br J Surg* 1994;**81**:648-652.
6. Hasegawa H, Kabeshima Y, Watanabe M, et al. Randomized controlled trial of laparoscopic versus open colectomy for advanced colonic cancer. *Surg Endosc* 2003;**17**:636-640.
7. Lacy AM, Garcia-Valdecasas JC, Delgado S, et al. Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a randomised trial. *Lancet* 2002;**359**:2224-2229.
8. Guillou PJ, Quirke P, Thorpe H, et al, MRC CLASICC Trial Group. Short-term endpoints of conventional versus laparoscopic assisted surgery in patients with colonic cancer (MRC CLASICC trial): multicentre, randomized controlled study. *Lancet* 2005;**365**:1718-1726.
9. The Clinical Outcomes of Surgical Therapy Study Group. A comparison of laparoscopically assisted and open colectomy for colon cancer. *N Engl J Med* 2004;**350**:2050-2059.
10. Sartori CA, D'Annibale A, Cutini G, et al. Laparoscopic surgery for colonic cancer: clinical practice guidelines of Italian Society of Colonic Surgery. *Tech Coloproctol* 2007;**11**:97-104.
11. Jackson TD, Kaplan GG, Arena G, et al. Laparoscopic versus open resection for colonic cancer: a metaanalysis of oncological outcomes. *J Am Coll Surg* 2007;**204**:439-446.
12. Schwenk W, Haase O, Neudecker J, Müller JM. Short term benefits for laparoscopic colorectal resection. *Cochrane Database Syst Rev* 2005;**3**:CD003145.
13. Murray A, Lourenco T, de Verteuil R, et al. Clinical effectiveness and cost-effectiveness of laparoscopic surgery for colonic cancer: systematic reviews and economic evaluation. *Health Technol Assess* 2006;**10**:1-141, iii-iv.
14. Kehlet H. Surgical stress response: does endoscopic surgery confirm an advantage? *World J Surg* 1999;**23**:801-807.
15. Liang JT, Huang KC, Lai HS, et al. Oncologic results of laparoscopic

- versus conventional open surgery for stage II or III left-sided colon cancers: a randomized controlled trial. *Ann Surg* 2007;**14**:109-117.
16. Braga M, Frasson M, Vignali A, et al. Laparoscopic versus open colectomy in cancer patients: long-term complications, quality of life, and survival. *Dis Colon Rectum* 2005;**48**:2217-2223.
  17. Hewett PJ, Allardyce RA, Bagshaw PF, et al. Short-term outcomes of the Australasian randomized clinical study comparing laparoscopic and conventional open surgical treatments for colon cancer: the ALCCaS trial. *Ann Surg* 2008;**248**:728-738.
  18. Allardyce RA, Bagshaw PF, Frampton CM, et al. Australian and New Zealand study comparing laparoscopic and open surgeries for colon cancer in adults: organization and conduct. *ANZ J Surg* 2008;**78**:840-847.
  19. Lacy AM, Delgado S, Castells A, et al. The long-term results of a randomized clinical trial of laparoscopy-assisted versus open surgery for colon cancer. *Ann Surg* 2008;**248**:1-7.
  20. Basse L, Jakobsen DH, Bardram L, et al. Functional recovery after open versus laparoscopic colonic resection: a randomized, blinded study. *Ann Surg* 2005;**241**:416-423.
  21. Braga M, Frasson M, Zuliani W, et al. Randomized clinical trial of laparoscopic versus open left colonic resection. *Br J Surg* 2010;**97**:1180-1186.
  22. Jayne DG, Thorpe HC, Copeland J, et al. Five-year follow-up of the Medical Research Council CLASICC trial of laparoscopically assisted versus open surgery for colonic cancer. *Br J Surg* 2010;**97**:1638-1645.
  23. Jayne DG, Guillou PJ, Thorpe H, et al; UK MRC CLASICC Trial Group. Randomized trial of laparoscopic-assisted resection of colonic carcinoma: 3-year results of the UK MRC CLASICC Trial Group. *J Clin Oncol* 2007;**25**:3061-3068.
  24. Franks PJ, Bosanquet N, Thorpe H, et al. CLASICC trial participants. Short-term costs of conventional vs laparoscopic assisted surgery in patients with colonic cancer (MRC CLASICC trial). *Br J Cancer* 2006;**95**:6-12.
  25. Buunen M, Veldkamp R, Hop WC, et al. Colon Cancer Laparoscopic or Open Resection Study Group. Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. *Lancet Oncol* 2009;**10**:44-52.
  26. Veldkamp R, Kuhry E, Hop WC, et al; COlon cancer Laparoscopic or Open Resection Study Group (COLOR). Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. *Lancet Oncol* 2005;**6**:477-484.
  27. Fleshman J, Sargent DJ, Green E, et al; for The Clinical Outcomes of Surgical Therapy Study Group. Laparoscopic colectomy for cancer is not inferior to open surgery based on 5-year data from the COST Study Group trial. *Ann Surg* 2007;**246**:655-664.
  28. Curet MJ, Putrakul K, Pitcher DE, et al. Laparoscopically assisted colon resection for colon carcinoma: perioperative results and long-term outcome. *Surg Endosc* 2000;**14**:1062-1066.
  29. Hewitt PM, Ip SM, Kwok SPY, et al. Laparoscopic-assisted vs open surgery for colonic cancer. *Dis Colon Rectum* 1998;**41**:901-909.
  30. Kaiser AM, Kang JC, Chan LS, et al. Laparoscopic-assisted vs open colectomy for colon cancer: a prospective randomized trial. *J Laparoendosc Adv Surg Tech* 2004;**14**:329-334.
  31. King PM, Blazeby JM, Ewings P, et al. Randomized clinical trial comparing laparoscopic and open surgery for colonic cancer within an enhanced recovery programme. *Br J Surg* 2006;**93**:300-308.
  32. Milsom JW, Böhm B, Hammerhofer KA, et al. A prospective, randomized trial comparing laparoscopic versus conventional techniques in colonic cancer surgery: a preliminary report. *J Am Coll Surg* 1998;**187**:46-57.
  33. Mirza MS, Longman RJ, Farrokhyar F, et al. Long-term outcomes for laparoscopic versus open resection of nonmetastatic colonic cancer. *J Laparoendosc Adv Surg Tech* 2008;**18**:679-685.
  34. Stage JG, Schulze S, Moller P, et al. Prospective randomized study of laparoscopic vs open colonic resection for adenocarcinoma. *Br J Surg* 1997;**84**:391-396.
  35. Tang CL, Eu KW, Tai BC, et al. Randomized clinical trial of the effect of open versus laparoscopically assisted colectomy on systemic immunity in patients with colonic cancer. *Br J Surg* 2001;**88**:801-807.
  36. Weeks JC, Nelson H, Gelber S, et al. Short-term quality-of-life outcomes following laparoscopic- assisted colectomy vs open colectomy for colon cancer. *JAMA* 2002;**287**:321-328.
  37. Winslow ER, Fleshman JW, Birnbaum EH, Brunt LM. Wound complications of laparoscopic vs open colectomy. *Surg Endosc* 2002;**16**:1420-1425.
  38. Sammour T, Kahokehr A, Srinivasa S, et al. Laparoscopic colonic surgery is associated with a higher intraoperative complication rate than open surgery. *Ann Surg* 2011;**253**:35-43.
  39. Tjandra JJ, Chan MKY. Systematic review on the short-term outcome of laparoscopic resection for colon and rectosigmoid cancer. *Colorect Dis* 2006;**8**:375-388.
  40. Kuhry E, Schwenk WF, Gaupset R, Romild U, Bonjer HJ. Long-term results of laparoscopic colorectal cancer resection. *Cochrane Database Syst Rev* 2008;**2**:CD003432.
  41. Arriaga AF, Lancaster RT, Berry WR, et al. The better colectomy project: association of evidence-based best-practice adherence rates to outcomes in colonic surgery. *Ann Surg* 2009;**250**:507-513.
  42. Kahokehr A, Sammour T, Zargar-Shoshtari K, et al. Implementation of ERAS and how to overcome the barriers. *Int J Surg* 2009;**7**:16-19.
  43. Tekkis PP, Senagore AJ, Delaney CP, et al. Evaluation of the learning curve in laparoscopic colonic surgery: comparison of right-sided and left-sided resections. *Ann Surg* 2005;**242**:83-91.
  44. Jayne DG, Thorpe HC, Copeland J, et al. Five-year follow-up of the Medical Research Council CLASICC trial of laparoscopically assisted versus open surgery for colonic cancer. *Br J Surg* 2010;**97**:1638-1645.
  45. Basse L, Thorbol JE, Lossl K, Kehlet H. Colonic surgery with accelerated rehabilitation or conventional care. *Dis Colon Rectum* 2004;**47**:271-277.
  46. Gouvas N, Tsiaoussis J, Pechlivanides G, et al. Quality of surgery for rectal carcinoma: comparison between open and laparoscopic approaches. *Am J Surg* 2009;**198**:702-708.
  47. Gutt CN, Oniu T, Schemmer P, et al. Fewer adhesions induced by laparoscopic surgery? *Surg Endosc* 2004;**18**:898-906.
  48. Alexander RJ, Jaques BC, Mitchell KG. Laparoscopically assisted colectomy and wound recurrence. *Lancet* 1993;**341**:249-250.
  49. O'Rourke N, Price PM, Kelley S, Sikora K. Tumour inoculation during laparoscopy. *Lancet* 1993;**342**:368.