Global value dossier for minimally invasive surgery

Colorectal surgery
Jayne Smith-Palmer
Ossian Health Economics and Communications, Bäumleingasse 20, 4051 Basel, Switzerland
Phone: +41 61 271 6214
E-mail: smith-palmer@ossianconsulting.com

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The original document was completed in March 2016, with a literature review conducted up to 2015. During the data check in 2021, all originally included references were cross checked for accuracy and any claims supported only by publications pre-2010 were further examined for accuracy against more recent literature. No exhaustive literature review was performed during the update.
Contents

1. Colorectal surgery (right, left and sigmoid colectomy, rectal resection) ..................4

   1.1. Overview of procedure ..................................................................................................4

   1.1.1. Colorectal surgery ..................................................................................................4

   1.1.2. Minimally invasive colorectal surgery ....................................................................4

   1.2. Common colorectal surgical procedures ....................................................................5

   1.3. Clinical and economic outcomes with laparoscopic versus open colorectal surgery ................................................................................................................14

   1.3.1. Clinical and economic evidence tables ..................................................................22

   1.4. References ................................................................................................................57

List of Tables

Table 1-1 Summary of meta-analyses comparing laparoscopic versus open colorectal surgery ........................................................................................................................23

Table 1-2 Summary of key clinical studies comparing laparoscopic versus open colorectal surgery ................................................................................................................30

Table 1-3 Summary of key studies comparing economic outcomes of laparoscopic versus open colorectal surgery ..................................................................................47

List of Figures

Figure 1-1 Indications for colectomy in US patients 2005−2010 ........................................5

Figure 1-2 Stages of colectomy showcasing instruments to assist in each phase ..........6

Figure 1-3 Right hemicolecction with ileocolic anastomosis ............................................7

Figure 1-4 Left hemicolecction with transverse and sigmoid colon anastomosis ............8
Figure 1-5  Sigmoid colectomy with anastomosis of descending colon and upper rectum.................................................................9

Figure 1-6  Low anterior resection .................................................................10

Figure 1-7  Abdominoperineal resection with colostomy ................................10

Figure 1-8  Reported rates of SSI with laparoscopic versus open colorectal surgery 17

Figure 1-9  Length of stay with laparoscopic versus open colorectal surgery ..........18

Figure 1-10  Blood loss with laparoscopic versus open colorectal surgery ............19

Figure 1-11  Operating time with laparoscopic versus open colorectal surgery ........20

Figure 1-12  Total hospital costs for laparoscopic versus open colorectal surgery in US-based studies .................................................................21

Figure 1-13  Total hospital costs for laparoscopic versus open colorectal surgery in the UK ..................................................................................................22
1 Colorectal surgery (right, left and sigmoid colectomy, rectal resection)

1.1 Overview of procedure

1.1.1 Colorectal surgery

An estimated 149,500 new cases of colorectal cancer are expected for 2021 in the United States, which represents 8% of all new cancer cases in the US, making it the fourth most common cancer. Surgery is the only curative treatment for colorectal cancer and encompasses complete resection of the primary tumor with negative margins in addition to a complete oncologic lymphadenectomy.

1.1.2 Minimally invasive colorectal surgery

Laparoscopic colorectal resection was first performed in 1991. Initially, when used for removal of tumors in patients with colorectal cancer there was concern over the high incidence of port-site metastases. This has now largely been negated due to improved technique isolation of diseased tissue prior to extraction and rates of port-site metastases with laparoscopic colectomy are now similar to rates of metastases around the edge of the wound site reported with open colectomy. US data show that 37% of laparoscopic colectomies are performed in patients with primary malignant neoplasm, 29% for diverticular disease and 19% for benign neoplasms (Figure 1-1).

Laparoscopic colectomy has several benefits compared with open colectomy (see Section 1.3) and is becoming increasingly widely used across both developed and emerging markets. However, as operating time is typically longer with laparoscopic colectomy versus open there is demand in some settings to demonstrate tangible clinical benefit and cost-effectiveness of the use of laparoscopic techniques.
1.2 Common colorectal surgical procedures

There are four stages of surgery common to almost all colorectal surgical procedures, these are access to the target site: dissection of target tissue, resection of the target tissue and repair of impacted vasculature, and closure of the access channels (Figure 1-2). During each stage, the surgical instruments required may vary depending on whether access is via the open or laparoscopic route.

Source: Wilson et al. 2014 (n=37,249 patients from the National Surgical Quality Improvement Program database)
**Right hemicolecctomy:** the removal of the cecum, ascending colon, hepatic flexure, initial third of the transverse colon and part of the terminal ileum (in addition to removal of fat and lymph nodes). Laparoscopic right colectomy involves a total of four surgical incisions and insufflation of the abdomen with carbon dioxide. Prior to any mobilization the surrounded area is examined for the presence of metastases, after which the colon is divided from its posterior and lateral attachments and ileocolic vessels ligated (Figure 1-3). The ascending colon is then transected from the ileum and transverse colon and removed after deflating the abdomen. Finally, an anastomosis is created between the ileum and transverse colon.
Left hemicolecetomy: the removal of the left (descending) colon. The laparoscopic procedures require approximately five small incisions. The renocolic, splenocolic and pancreaticolic ligaments are first cut to remove the descending colon from its attachments. The mesentery and the major vessels it contains must be ligated and divided. The omentum is divided from the transverse colon, splenic flexure mobilized and the necessary length of diseased bowel removed (Figure 1-4). An anastomosis is then created between the transverse and sigmoid colon.
Figure 1-4  Left hemicolecotomy with transverse and sigmoid colon anastomosis

Proctosigmoidectomy, sigmoidectomy and protectomy: the removal of the rectum and sigmoid colon, removal of the sigmoid colon (from the splenic fixture to the rectosigmoid junction) and removal of the rectum, respectively. The laparoscopic procedure involves three to five incisions and the colon transected 5–10 cm on either side of the tumor (or at the rectosigmoid junction); in proctosigmoidectomy the upper section of the rectum is also removed (Figure 1-5). After which, in cases of colorectal carcinoma, the excised tissue can be placed in a specimen bag and removed through the excisions or removed through a wound protector at the wound site to prevent contact of malignant cells with healthy tissue. An anastomosis is then created.
Low anterior resection: the removal of a segment of the rectum (subtype of proctectomy), as well as associated lymph nodes in the case of surgery for colorectal cancer (Figure 1-6). The procedure is less extensive than abdominal perineal resection and a colostomy is not required; an anastomosis is created between the remaining part of the colon and rectum.
**Abdominal perineal resection:** (also known as the Miles operation) the removal of the anus, rectum and part of the sigmoid colon (in addition to lymph nodes), used in cases of rectal carcinoma in the distal third of the rectum (Figure 1-7). A colostomy is created by pulling the end of the sigmoid colon through the abdominal wall. The creation of a colostomy involves creating an opening (stoma) for the large intestine in the abdomen wall through which stool can exit into an external bag (colostomy bag).

**Figure 1-6** Low anterior resection

**Figure 1-7** Abdominoperineal resection with colostomy
Guidelines on the use of laparoscopic colorectal resection

Society of American Gastrointestinal and Endoscopic Surgeons (SAGES)
Guidelines for laparoscopic resection of curable colon and rectal cancer

- We recommend that laparoscopic resection follow standard oncologic principles: proximal ligation of the primary arterial supply to the segment harboring the cancer, appropriate proximal and distal margins, and adequate lymphadenectomy. (+++, strong)

- We recommend that laparoscopic resection for rectal cancer follow standard oncologic principles: Adequate distal margin, ligation at the origin of the arterial supply for the involved rectal segment, and mesorectal excision. (++O, strong)

- For locally advanced adherent colon and rectal tumors, an en bloc resection is recommended. We suggest an open approach if a laparoscopic en bloc resection cannot be performed adequately. (++OO, weak)

- We recommend that patients with an obstructing right or transverse colon cancer undergo a right or extended right colectomy. The open approach is required if the laparoscopic approach will not result in an oncologically sound resection. (++OO, strong)

- We suggest that for patients with an obstructing left-sided colon cancer, the procedure be individualized according to clinical factors. Colonic stenting may increase the likelihood of completing a one-stage procedure and may decrease the likelihood of an end colostomy. (++O, weak)

- The use of a wound protector at the extraction site and the irrigation of port sites and extraction site incisions may reduce abdominal wall cancer recurrences. (++OO, strong)

- Before surgeons apply the laparoscopic approach for the resection of curable colon and rectal cancer, they must have adequate knowledge, training, and experience in laparoscopic techniques and oncologic principles. (++O, strong)
• While robotic surgery for colon and rectal cancer appears feasible and safe, in the absence of long-term oncologic outcome studies, no clear recommendation can be made. (++OO, weak)

United Kingdom National Institute for Health and Care Excellence (NICE) technology appraisal guidance (TA105) on the use of laparoscopic surgery for colorectal cancer

• Laparoscopic (including laparoscopically assisted) resection is recommended as an alternative to open resection for individuals with colorectal cancer in whom both laparoscopic and open surgery are considered suitable.

• Laparoscopic colorectal surgery should be performed only by surgeons who have completed appropriate training in the technique and who perform this procedure often enough to maintain competence.

• The decision about which of the procedures (open or laparoscopic) is undertaken should be made after informed discussion between the patient and the surgeon. In particular, they should consider:
  o The suitability of the lesion for laparoscopic resection
  o The risks and benefits of the two procedures
  o The experience of the surgeon in both procedures

The American Society of Colon and Rectal Surgeons Clinical Practice Guidelines for the laparoscopic treatment of colon cancer

• When expertise is available, a minimally invasive approach to elective colectomy for colon cancer is preferred. Grade of Recommendation: Strong recommendation based on high-quality evidence, 1A.

• Hand-assisted laparoscopic and robotic surgical techniques for right colon cancer result in oncologic outcomes that are equivalent to open or straight laparoscopic techniques. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.
• For patients with obstructing left-sided colon cancer and curable disease, initial colectomy or initial endoscopic stent decompression and interval colectomy may be performed. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

• For patients with obstructing right or transverse colon cancer and curable disease, initial colectomy or initial endoscopic stent decompression and interval colectomy may be performed. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.
1.3 Clinical and economic outcomes with laparoscopic versus open colorectal surgery

Key findings

**Clinical outcomes**

- **Oncologic equivalence/disease-free survival:** Laparoscopic surgery for colorectal cancer is now associated with similar outcomes to open surgery in terms of disease-free survival and port-site metastases. Some studies even found laparoscopic surgery to have better survival outcomes regarding disease-free and/or recurrence-free survival than open surgery.

- **Survival:** There is no significant difference between laparoscopic and open colorectal surgery for colorectal cancer in terms of overall survival rates. Recent studies even reported increased overall survival after laparoscopic surgery.

- **Surgical Site Infection:** Rates of surgical site infection are consistently lower (often significantly) with laparoscopic colorectal surgery than open colorectal surgery.

- **Length of Stay:** Length of hospital stay is significantly shorter following laparoscopic colorectal surgery than with open colorectal surgery.

- **Blood loss:** Blood loss during surgery is significantly lower with laparoscopic versus open colorectal surgery.

- **Blood transfusion:** The proportion of patients requiring blood transfusion is lower with laparoscopic colorectal resection than with open colorectal resection.

- **Incision size:** Laparoscopic colorectal surgery requires a significantly shorter incision, leading to less scarring, than open colorectal surgery.

- **Bowel function:** Return of bowel function occurs significantly sooner in patients who have undergone laparoscopic colorectal surgery than in those who have undergone open colorectal surgery.
• **Operating time**: Studies show that the operating time associated with laparoscopic colorectal surgery is consistently and significantly longer than with open surgery\textsuperscript{14,19,21,25,32-34,38-41,44,45} (Figure 1-11)

**Economic outcomes**

• **Operating time**: Longer operating time is not associated with significantly higher costs\textsuperscript{46}

• **Total costs**: Findings from cost studies are inconsistent, in instances where total costs were lower with laparoscopic versus open colorectal surgery the cost savings were primarily driven by lower complication rates
  
  o **United States**: In US-based studies, total hospital costs for laparoscopic colorectal resection were generally lower than for open colorectal resection\textsuperscript{26,37,42,47-50} (Figure 1-12)
  
  o **Europe**: In the UK, there was no significant difference in total hospital costs for open versus laparoscopic colorectal resection.\textsuperscript{51} However, a retrospective study of the whole population of patients undergoing an elective surgery in NHS hospitals found costs of laparoscopy to be significantly less than for open surgery.\textsuperscript{52} (Figure 1-13)
  
  o **Canada**: In Canada, total costs were lower for laparoscopic colectomy than for open colectomy\textsuperscript{32,53}, in one study this achieved statistical significance\textsuperscript{32}
  
  o **China**: In one study conducted in China total hospital costs were significantly higher with laparoscopic colectomy than open colectomy\textsuperscript{40}
  
  o **Australia**: Findings from Australia were inconsistent; in one study total costs were significantly lower with laparoscopic colectomy than open colectomy\textsuperscript{31} and in another study they were non-significantly higher\textsuperscript{54}
  
  o **Brazil**: Total costs for laparoscopic colorectal surgery were found to be significantly lower than for open surgery\textsuperscript{43}

• **Savings due to clinical benefits**: Clinical benefits of laparoscopic colectomy, including shorter LoS and lower rates of postoperative
complications translate into economic benefits, which are important from the payer perspective.

**Other findings**

- **Surgeon volume**: Higher surgeon volume is associated with better outcomes and lower costs compared with low volume surgeons.\(^9\)

- **Readmission rates**: Readmission rates are typically lower in patients undergoing laparoscopic colorectal resection than in those undergoing open colorectal resection. The difference was found to be not significant in older studies.\(^{32,33}\) More recent studies, however, found the difference in readmission rates to be significant.\(^{42,52}\)
  
  - Rates of readmission are influenced by several factors including BMI, surgeon volume, operating time and presence of SSI\(^{55,56}\); increased BMI is also associated with an increased surgical difficulty\(^{57}\) and significantly increased risk for SSI.\(^{57,58}\)

- **Pulmonary complications**: Laparoscopic surgery is associated with lower absolute risk of pulmonary complications versus open surgery.\(^{59}\)

- **Quality of life**: Evidence from quality of life studies is inconsistent; with a recent systematic review reporting that some studies suggest no significant difference, while others suggest a significant QoL benefit with the laparoscopic approach.\(^{60}\)

- **Emerging markets**: Clinical outcomes reported in studies of laparoscopic versus open colectomy in emerging markets such as India and Brazil are similar to outcomes reported in Europe and North America.\(^{7,39,43}\)

- **Trends in cost studies**: In published cost studies the percentage difference between laparoscopic and open colectomy varies widely, but for studies conducted in Western settings there is a trend toward a decline in the cost of laparoscopic colectomy over time.\(^{52,61}\)
Figure 1-8  Reported rates of SSI with laparoscopic versus open colorectal surgery

<table>
<thead>
<tr>
<th>Study Year</th>
<th>Patients with SSI, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veldkamp 2005</td>
<td>3 (ns) 4</td>
</tr>
<tr>
<td>Bilimoria 2008</td>
<td>11.8 *</td>
</tr>
<tr>
<td>Kiran 2010</td>
<td>9.1</td>
</tr>
<tr>
<td>Wilson 2014</td>
<td>6.6 ***</td>
</tr>
<tr>
<td>Orcutt 2011</td>
<td>9 **</td>
</tr>
<tr>
<td>Odermatt 2013</td>
<td>10 ns</td>
</tr>
<tr>
<td>Moreira 2010</td>
<td>4.5</td>
</tr>
<tr>
<td>Santacruz 2017</td>
<td>15.3 ***</td>
</tr>
</tbody>
</table>

*p<0.05; **p<0.01; ***p<0.001; NR, not reported; ns, not significant; SSI surgical site infection
Figure 1-9  Length of stay with laparoscopic versus open colorectal surgery

* * * p<0.05; ** * p<0.01; *** * p<0.001; NR, not reported; ns, not significant
**Figure 1-10  Blood loss with laparoscopic versus open colorectal surgery**

Estimated blood loss, mL

- Open
- Laparoscopic

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Blood Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veldkamp</td>
<td>2005</td>
<td>175</td>
</tr>
<tr>
<td>Orcutt</td>
<td>2011</td>
<td>150</td>
</tr>
<tr>
<td>Braga</td>
<td>2010</td>
<td>127</td>
</tr>
<tr>
<td>Prakash</td>
<td>2010</td>
<td>ns</td>
</tr>
<tr>
<td>Chen</td>
<td>2014</td>
<td>221</td>
</tr>
<tr>
<td>Moreira</td>
<td>2010</td>
<td>250</td>
</tr>
<tr>
<td>Li</td>
<td>2015</td>
<td>90</td>
</tr>
<tr>
<td>Yang</td>
<td>2018</td>
<td>235</td>
</tr>
<tr>
<td>Shah</td>
<td>2021</td>
<td>100</td>
</tr>
</tbody>
</table>

* * * : p < 0.001; ** : p < 0.01; *** : p < 0.05; NR, not reported; ns, not significant
Figure 1-11  Operating time with laparoscopic versus open colorectal surgery

*\(p<0.05\); **\(p<0.01\); ***\(p<0.001\); NR, not reported; ns, not significant
Figure 1-12  Total hospital costs for laparoscopic versus open colorectal surgery in US-based studies

* * *<p><sup>0.05</sup>; **<sup>p<0.01</sup>; ***<sup>p<0.001</sup>; NR, not reported; ns, not significant
1.1.1. Clinical and economic evidence tables

A summary of clinical evidence on laparoscopic versus open colorectal surgery from published meta-analyses and published studies is shown in Table 1-1 and Table 1-2, respectively. A summary of economic evidence from published cost studies is shown in Table 1-3.

In the following tables outcomes where p<0.05 are underlined.
## Table 1-1  Summary of meta-analyses comparing laparoscopic versus open colorectal surgery

<table>
<thead>
<tr>
<th>Authors</th>
<th>Details</th>
<th>Procedures</th>
<th>Outcome</th>
<th>Effect (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang et al. 2014</td>
<td>15 RCTs, n=6,557 patients</td>
<td>Open versus laparoscopic surgery for colorectal cancer</td>
<td>Peri-operative</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blood loss, mL (WMD)</td>
<td>−91.06 (−179.66, −2.46)*</td>
<td>0.044</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Operating time, minutes (WMD)</td>
<td>49.34 (29.57, 69.12)*</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Length of incision, cm (WMD)</td>
<td>−9.23 (−13.77, −4.68)*</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Postoperative</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time to first bowel movement,</td>
<td>−0.95 (−1.18, −0.73)*</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>days (WMD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fluid intake (WMD)</td>
<td>−0.70 (−1.11, −0.29)*</td>
<td>0.042</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Complication rate (OR)</td>
<td>0.86 (0.77, 0.97)</td>
<td>0.067</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blood transfusion (OR)</td>
<td>0.46 (0.32, 0.65)</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30-day mortality (OR)</td>
<td>0.58 (0.38, 0.88)</td>
<td>0.996</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Anastomotic leak (OR)</td>
<td>0.99 (0.72, 1.34)</td>
<td>0.543</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Length of hospital stay, days</td>
<td>−2.64 (−4.41, −0.87)</td>
<td>0.000</td>
</tr>
<tr>
<td>Post-discharge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-year overall survival (OR)</td>
<td>1.03 (0.97, 1.10)</td>
<td></td>
<td></td>
<td></td>
<td>0.856</td>
</tr>
<tr>
<td>3-year disease-free survival (OR)</td>
<td>1.03 (0.95, 1.10)</td>
<td></td>
<td></td>
<td></td>
<td>0.014</td>
</tr>
<tr>
<td>3-year local recurrence (OR)</td>
<td>1.30 (0.82, 2.07)</td>
<td></td>
<td></td>
<td></td>
<td>0.356</td>
</tr>
<tr>
<td>5-year overall survival (OR)</td>
<td>1.00 (0.95, 1.05)</td>
<td></td>
<td></td>
<td></td>
<td>0.595</td>
</tr>
<tr>
<td>5-year disease-free survival (OR)</td>
<td>0.97 (0.90, 1.04)</td>
<td></td>
<td></td>
<td></td>
<td>0.649</td>
</tr>
<tr>
<td>5-year local recurrence (OR)</td>
<td>1.09 (0.76, 1.57)</td>
<td></td>
<td></td>
<td></td>
<td>0.119</td>
</tr>
</tbody>
</table>
### Ma et al. 2011

<table>
<thead>
<tr>
<th>Open versus laparoscopic resection for colorectal cancer</th>
<th>Post-discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 RCTs, n=4,207 patients</td>
<td></td>
</tr>
<tr>
<td>Overall recurrence (OR)</td>
<td>0.92 (0.77, 1.11)</td>
</tr>
<tr>
<td>Local recurrence (OR)</td>
<td>0.81 (0.59, 1.12)</td>
</tr>
<tr>
<td>Distant metastases (OR)</td>
<td>1.01 (0.78, 1.30)</td>
</tr>
<tr>
<td>Wound-site recurrence</td>
<td>1.97 (0.77, 5.02)</td>
</tr>
<tr>
<td>Cancer-related mortality at max follow up (OR)</td>
<td>0.82 (0.66, 1.02)</td>
</tr>
<tr>
<td>Overall mortality at max follow up (OR)</td>
<td>0.87 (0.73, 1.03)</td>
</tr>
<tr>
<td>Overall complications (OR)</td>
<td>0.71 (0.58, 0.87)</td>
</tr>
</tbody>
</table>

### Ohtani et al. 2011

<table>
<thead>
<tr>
<th>Open versus laparoscopic surgery for colorectal cancer</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 RCTs, n=4,458 patients</td>
<td></td>
</tr>
<tr>
<td>Operating time, minutes (WMD)</td>
<td>39.32 (30.72, 47.91)</td>
</tr>
<tr>
<td>Estimated blood loss, mL (WMD)</td>
<td>−133.05 (−201.30, −64.81)</td>
</tr>
<tr>
<td>Number of transfused patients (OR)</td>
<td>0.45 (0.19, 1.05)</td>
</tr>
<tr>
<td>LoS, days (WMD)</td>
<td>−2.80 (−4.78, −0.81)</td>
</tr>
<tr>
<td>Incision length, cm (WMD)</td>
<td>−10.97 (−14.37, −7.57)</td>
</tr>
<tr>
<td>Time to oral intake, days (WMD)</td>
<td>−1.08 (−1.36, −0.80)</td>
</tr>
<tr>
<td>Overall complication (OR)</td>
<td>0.83 (0.66, 1.05)</td>
</tr>
<tr>
<td>Anastomotic leakage (OR)</td>
<td>1.07 (0.74, 1.54)</td>
</tr>
<tr>
<td>Peri-operative mortality (OR)</td>
<td>0.69 (0.36, 1.31)</td>
</tr>
</tbody>
</table>
### Post-discharge

<table>
<thead>
<tr>
<th>Event</th>
<th>Odds Ratio (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall recurrence (OR)</td>
<td>0.98 (0.84, 1.14)</td>
<td>0.81</td>
</tr>
<tr>
<td>Local recurrence (OR)</td>
<td>0.86 (0.62, 1.19)</td>
<td>0.36</td>
</tr>
<tr>
<td>Distant metastasis (OR)</td>
<td>1.02 (0.84, 1.25)</td>
<td>0.81</td>
</tr>
<tr>
<td>Wound-site recurrence (OR)</td>
<td>2.87 (1.08, 7.68)</td>
<td>0.04</td>
</tr>
<tr>
<td>Cancer-related mortality (OR)</td>
<td>0.83 (0.65, 1.07)</td>
<td>0.14</td>
</tr>
<tr>
<td>Overall mortality (OR)</td>
<td>0.93 (0.79, 1.08)</td>
<td>0.33</td>
</tr>
</tbody>
</table>

### Postoperative

<table>
<thead>
<tr>
<th>Event</th>
<th>Odds Ratio (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recurrence in operation area, colorectal (OR)</td>
<td>0.81 (0.54, 1.22)</td>
<td>0.31</td>
</tr>
<tr>
<td>Port-site recurrence, colorectal (OR)</td>
<td>1.97 (0.77, 5.02)</td>
<td>0.16</td>
</tr>
<tr>
<td>Distant metastases, colorectal (OR)</td>
<td>1.01 (0.76, 1.34)</td>
<td>0.93</td>
</tr>
<tr>
<td>Cancer-related mortality at maximum follow up, colorectal (OR)</td>
<td>0.84 (0.67, 1.06)</td>
<td>0.15</td>
</tr>
<tr>
<td>Overall mortality at maximum follow up, colorectal (OR)</td>
<td>0.84 (0.70, 1.00)</td>
<td>0.050</td>
</tr>
</tbody>
</table>

### Kuhry et al. 2008

- **Subjects**: 12 RCTs, n=3,346 patients
- **Procedure**: Open versus laparoscopic surgery for non-metastasized colorectal cancer

### Di et al. 2013

- **Subjects**: 5 RCTs, n=2,695 patients
- **Procedure**: Open versus laparoscopic surgery for colon cancer

### Additional Details

- **5-year tumor-free survival (RR)**: 1.00 [0.94, 1.06] *p* = 0.87
- **5-year survival rate (RR)**: 1.02 [0.97, 1.07] *p* = 0.54

---

25 | Minimally Invasive Surgery Global Value Dossier: Colorectal surgery
<table>
<thead>
<tr>
<th>Study</th>
<th>Study Design</th>
<th>No. of Studies/Participants</th>
<th>Procedure Comparison</th>
<th>Peri-operative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ding et al. 2013(^\text{63})</td>
<td>12 studies (RCTs and non-randomized), n=1,362 patients</td>
<td>12 studies (RCTs and non-randomized), n=1,362 patients</td>
<td>Open versus hand-assisted laparoscopic surgery for colorectal disease</td>
<td>Operating time, minutes (WMD) 3.51 (−16.47, 23.50)(^a) 0.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blood loss, mL (WMD) −108.20 (−141.52, −74.87)(^a)  &lt;0.00001</td>
<td>Postoperative</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time to first flatus, days (WMD) −0.94 (−1.22, −0.65)(^a)  &lt;0.00001</td>
<td>LoS, days (WMD) −3.22 (−3.88, −2.57)(^a)  &lt;0.00001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urinary tract infection (OR) 0.58 (0.15, 2.20) 0.43</td>
<td>Pneumonia (OR) 0.46 (0.16, 1.35) 0.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Anastomotic leak (OR) 0.95 (0.40, 2.27) 0.91</td>
<td>Wound infection (OR) 0.45 (0.23, 0.87) 0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ileus (OR) 0.35 (0.16, 0.74) 0.006</td>
<td>Mortality (OR) 0.68 (0.19, 2.36) 0.54</td>
</tr>
<tr>
<td>Athanasiou et al. 2017(^\text{41})</td>
<td>11 case control trials, n=1,415 patients</td>
<td>11 case control trials, n=1,415 patients</td>
<td>Open versus laparoscopic resection of transverse colon cancer</td>
<td>Operating time, min (WMD) 45.0 (29.5, 60.5)  &lt;0.00001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Anastomotic leaks (OR) 0.72 (0.33, 1.53) 0.39</td>
<td>Surgical site infection (OR) 1.15 (0.50, 2.64) 0.74</td>
</tr>
<tr>
<td></td>
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<td>Time to oral intake, days (WMD) −1.68 (−1.84, −1.53)  &lt;0.00001</td>
<td>Time to oral intake, days (WMD) −2.94 (−4.27, −1.62)  0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mortality (OR) 1.36 (0.22, 8.44) 0.74</td>
<td>Overall survival (HR) 0.83 (0.56, 1.22) 0.34</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Disease-free survival (HR) 0.82 (0.60, 1.11) 0.20</td>
<td>Local recurrence (OR) 1.13 (0.42, 3.07) 0.81</td>
</tr>
<tr>
<td>Study</td>
<td>Study Details</td>
<td>Comparative Groups</td>
<td>Postoperative Outcomes</td>
<td>Peri-operative Outcomes</td>
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<td>-------</td>
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<tr>
<td><strong>Wu et al. 2017</strong>&lt;sup&gt;64&lt;/sup&gt;</td>
<td>28 studies (RCT and non-randomized), n=140,640 patients</td>
<td>Open versus laparoscopic surgery for treatment of diverticulitis</td>
<td>Overall mortality (OR)</td>
<td>0.40 (0.25, 0.63)</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Overall morbidity (OR)</td>
<td>0.65 (0.51, 0.82)</td>
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<td>LoS, days (pooled mean difference)</td>
<td>-4.05 (-4.64, -3.47)</td>
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<td></td>
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<td>Ileus (OR)</td>
<td>0.80 (0.76, 0.84)</td>
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<td>Anastomotic leak (OR)</td>
<td>0.69 (0.62, 0.75)</td>
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<td>Surgical site infection (OR)</td>
<td>0.53 (0.49, 0.57)</td>
</tr>
<tr>
<td><strong>Tong et al. 2017</strong>&lt;sup&gt;65&lt;/sup&gt;</td>
<td>9 studies (RCT and non-randomized), n=4,747 patients</td>
<td>Open versus laparoscopic colorectal cancer surgery</td>
<td>Operating time, minutes (WMD)</td>
<td>0.46 (-55.56, 56.60)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blood loss, mL (WMD)</td>
<td>-64.66 (-87.31, -42.01)</td>
</tr>
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<td></td>
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<td>Time to first flatus, days (WMD)</td>
<td>-1.22 (-1.53, -0.91)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Postoperative complications (OR)</td>
<td>0.62 (0.52, 0.72)</td>
</tr>
<tr>
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<td></td>
<td>LoS, days (WMD)</td>
<td>-2.38 (-3.30, -1.46)</td>
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<tr>
<td><strong>Rausa et al. 2019</strong>&lt;sup&gt;66&lt;/sup&gt;</td>
<td>48 studies (RCT and controlled clinical trials), n=5,652 patients</td>
<td>Total laparoscopic versus open right hemicolectomy&lt;sup&gt;*&lt;/sup&gt;</td>
<td>Operating time (RR)</td>
<td>20.0 (-29.0, 70.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blood loss (RR)</td>
<td>41.0 (11.0, 72.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Overall complications (RR)</td>
<td>1.9 (1.3, 2.7)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Anastomotic leak (RR)</td>
<td>1.3 (0.7, 2.6)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Surgical site infection (RR)</td>
<td>2.1 (1.2, 3.6)</td>
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<td></td>
<td></td>
<td></td>
<td>Reoperation (RR)</td>
<td>3.3 (1.3, 8.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30-day mortality (RR)</td>
<td>1.5 (0.7, 3.2)</td>
</tr>
<tr>
<td>Study</td>
<td>Design Description</td>
<td>Procedure Comparison</td>
<td></td>
<td></td>
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<td>-------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Baloyiannis et al. 2020</td>
<td>21 studies (prospective and retrospective trials), n=2,498 patients</td>
<td>Open versus laparoscopic transverse colon cancer colectomy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 60-day readmission (RR)
- Baloyiannis et al. 2020: 1.2 (0.4, 3.8)  
- NR

### LoS (RR)
- Baloyiannis et al. 2020: 3.8 (0.5, 7.0)  
- NR

### Peri-operative

#### Intraoperative complications (OR)
- Baloyiannis et al. 2020: 2.45 (0.59, 10.19)  
- 0.22

#### Operative time, min (WMD)
- Baloyiannis et al. 2020: 42.47 (28.81, 56.14)  
- <0.00001

#### Blood loss, mL (WMD)
- Baloyiannis et al. 2020: -86.84 (-108.29, -65.39)  
- <0.00001

### Postoperative

#### Overall postoperative complications (OR)
- Baloyiannis et al. 2020: 0.64 (0.51, 0.82)  
- 0.0003

#### Ileus (OR)
- Baloyiannis et al. 2020: 0.83 (0.49, 1.40)  
- 0.49

#### Anastomotic leak (OR)
- Baloyiannis et al. 2020: 0.64 (0.37, 1.11)  
- 0.11

#### Surgical site infection (OR)
- Baloyiannis et al. 2020: 0.62 (0.39, 0.98)  
- 0.04

#### Reoperation (OR)
- Baloyiannis et al. 2020: 0.59 (0.26, 1.32)  
- 0.2

#### Time to first flatus, days (WMD)
- Baloyiannis et al. 2020: -0.94 (-1.30, -0.57)  
- <0.00001

#### Time to oral intake, days (WMD)
- Baloyiannis et al. 2020: -1.25 (-1.87, -0.64)  
- <0.0001

#### LoS, days (WMD)
- Baloyiannis et al. 2020: -2.39 (-3.23, -1.56)  
- <0.00001

### Post-discharge

#### Mortality (OR)
- Baloyiannis et al. 2020: 0.35 (0.12, 1.01)  
- 0.05

#### Recurrence (OR)
- Baloyiannis et al. 2020: 0.65 (0.43, 0.97)  
- 0.04

#### Overall survival (HR)
- Baloyiannis et al. 2020: 0.83 (0.68, 1.02)  
- 0.08

#### Disease-free survival (HR)
- Baloyiannis et al. 2020: 0.81 (0.65, 1.02)  
- 0.07

---

A meta-analysis also included comparison versus robot-assisted and laparoscopic-assisted right hemicolectomy; only the findings of total laparoscopic right hemicolectomy are presented here. Laparoscopic-assisted right hemicolectomy was only compared to robotic-assisted right hemicolectomy, therefore the findings regarding laparoscopic-assisted right hemicolectomy were not reported here. The comparison is inverted, so that RR values above 1.00 favor
laparoscopic surgery and values below 1.00 favor open surgery.

WMD = Weighted mean difference (95% CI); negative values favor laparoscopic surgery, positive values favor open surgery

RR = Relative Risk (95% CI); HR = Hazard Ratio (95% CI); OR = Odds Ratio (95% CI); for HRs, ORs and RRs, values below 1.00 normally favor laparoscopic surgery, values above 1.00 normally favor open surgery with the exception of Rausa et al. 2019 where the comparison is inverted.
<table>
<thead>
<tr>
<th>Study</th>
<th>Setting</th>
<th>Study details</th>
<th>Procedure (year performed)</th>
<th>Summary of clinical findings</th>
<th>Open</th>
<th>Laparoscopic</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Median time in theater, minutes</td>
<td>170</td>
<td>202</td>
<td>&lt;0.0001</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Median blood loss, mL</td>
<td>175</td>
<td>100</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Postoperative</td>
<td>3.8</td>
<td>2.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean fluid intake &lt;1L, days</td>
<td>4.6</td>
<td>3.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean time to first bowel movement, days</td>
<td>4.6</td>
<td>3.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean LoS, days</td>
<td>9.3</td>
<td>8.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>All complications</td>
<td>20%</td>
<td>21%</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Wound infection</td>
<td>3%</td>
<td>4%</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Anastomotic failure</td>
<td>2%</td>
<td>3%</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bowel obstruction &gt;3 days</td>
<td>3%</td>
<td>2%</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Re-intervention</td>
<td>5%</td>
<td>7%</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Death</td>
<td>2%</td>
<td>1%</td>
<td>0.45</td>
</tr>
<tr>
<td>Jayne et al. 2010</td>
<td>United Kingdom</td>
<td>MRC CLASSICC RCT 5-year follow up n=268 open; n=526 laparoscopic</td>
<td>Open versus laparoscopic colectomy for colorectal cancer (1996-2002)</td>
<td>Post-discharge (5 years)</td>
<td>58.1%</td>
<td>57.9%</td>
<td>0.848</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5-year overall survival</td>
<td>58.6%</td>
<td>55.3%</td>
<td>0.483</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>5-year disease-free survival</td>
<td>8.7%</td>
<td>10.8%</td>
<td>0.594</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 year local recurrence</td>
<td>20.6%</td>
<td>21.0%</td>
<td>0.820</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 year distant recurrence</td>
<td>20.6%</td>
<td>21.0%</td>
<td>0.820</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Methodology</td>
<td>Procedure Comparison</td>
<td>Post-discharge (5 years)</td>
<td>In- Hospital mortality</td>
<td>Complication rate</td>
<td>Ostomy rate</td>
</tr>
<tr>
<td>-------------------</td>
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<tr>
<td><strong>Fleshman et al.</strong> 2007&lt;sup&gt;16&lt;/sup&gt;</td>
<td>United States and Canada</td>
<td>5 year follow up of the COST RCT, n=428 open; n=435 laparoscopic</td>
<td>Open versus laparoscopic colectomy for colon cancer&lt;sup&gt;1&lt;/sup&gt; (1994–2001)</td>
<td>5 year overall survival: 74.6% 76.4% 0.93 5 year disease-free survival: 68.4% 69.2% 0.94 5 year local recurrence rate: 2.6% 2.3% 0.79 5 year overall recurrence rate: 21.8% 19.4% 0.25</td>
<td></td>
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</tr>
<tr>
<td><strong>Juo et al.</strong> 2014&lt;sup&gt;29&lt;/sup&gt;</td>
<td>United States</td>
<td>US Nationwide Inpatient sample n=116,261 open; n=115,694 laparoscopic; propensity matched</td>
<td>Elective open versus laparoscopic colectomy&lt;sup&gt;2&lt;/sup&gt; (2008–2010)</td>
<td>Postoperative</td>
<td>In-hospital mortality: 2.0% 0.4% &lt;0.001 Complication rate: 33.2% 19.8% &lt;0.001 Ostomy rate: 13.0% 3.5% &lt;0.001 Median LoS, days: 6 4 &lt;0.001 Discharge disposition: Routine: 68.4% 86.1% &lt;0.001 Transfer to other healthcare facility: 12.1% 4.6% &lt;0.001</td>
<td></td>
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<tr>
<td><strong>Kang et al.</strong> 2012&lt;sup&gt;49&lt;/sup&gt;</td>
<td>United States</td>
<td>Retrospective analysis using the National Inpatient Sample, n=71,200 open, n=43,165 laparoscopic and n=7,545 converted</td>
<td>Elective open versus laparoscopic colorectal resection for colon cancer, rectal cancer or diverticulitis (2009)</td>
<td>Postoperative</td>
<td>In-hospital mortality: 1.17% 0.49% NR Mean LoS (days): 8 5 NR Wound complication: 5.8% 2.6% NR Anastomotic leak: 13.5% 9.4% NR Pneumonia: 2.7% 1.3% NR Ileus or bowel obstruction: 18.7% 14.1% NR Urinary retention: 2.7% 1.9% NR Respiratory failure: 2.5% 1.0% NR</td>
<td></td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Procedure</td>
<td>Postoperative</td>
<td>Peri-operative</td>
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<tr>
<td>Wilson et al. 2014</td>
<td>United States</td>
<td>Retrospective study using National Surgical Quality Improvement Program data, n=21,606 open; n=15,643 laparoscopic</td>
<td>Open versus laparoscopic partial colectomy (2005-2010)</td>
<td><strong>Acute renal failure</strong></td>
<td><strong>Mean operating time, minutes</strong></td>
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<td>7.1%</td>
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<td>3.9%</td>
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<td>NR</td>
<td>0.001</td>
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<td>2.3%</td>
<td>1.6%</td>
<td>0.001</td>
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<td>NR</td>
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<td>Steele et al. 2008</td>
<td>United States</td>
<td>Retrospective analysis of the Nationwide Inpatient Sample, n=95,627 open, n=3,296 laparoscopic</td>
<td>Elective open versus laparoscopic resection for colon cancer (2003-2004)</td>
<td><strong>Postoperative</strong></td>
<td><strong>Mean LoS, days</strong></td>
<td></td>
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<tr>
<td></td>
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<td><strong>In-hospital complication</strong></td>
<td>22%</td>
<td>18%</td>
<td>&lt;0.001</td>
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<td><strong>In-hospital mortality</strong></td>
<td>1.4%</td>
<td>0.6%</td>
<td>&lt;0.001</td>
</tr>
<tr>
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<td><strong>Mean LoS, days</strong></td>
<td>7.6</td>
<td>6.0</td>
<td>0.006</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Deep vein thrombosis</strong></td>
<td>1.2%</td>
<td>0.3%</td>
<td>0.001</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Urinary tract infection</strong></td>
<td>3.7%</td>
<td>0.122</td>
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<tr>
<td>Kiran et al. 2010</td>
<td>United States</td>
<td>Retrospective analysis of the National Surgical Quality Improvement Program</td>
<td>Open versus laparoscopic colorectal surgery (2006-2007)</td>
<td><strong>Postoperative</strong></td>
<td><strong>Operating time &gt;180 minutes</strong></td>
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<td><strong>Superficial infection</strong></td>
<td>10.3%</td>
<td>6.6%</td>
<td>0.001</td>
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<td><strong>Deep infection</strong></td>
<td>2.4%</td>
<td>1.0%</td>
<td>0.001</td>
</tr>
<tr>
<td>Study</td>
<td>Location</td>
<td>Study Design</td>
<td>Comparison</td>
<td>Outcomes</td>
<td>United States</td>
<td>Australia</td>
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<td>Bilimoria et al. 2008&lt;sup&gt;27&lt;/sup&gt;</td>
<td>United States</td>
<td>Retrospective analysis of the American College of Surgeons - National Surgical Quality Improvement Program data; 121 hospitals n=2,222, open, n=837, laparoscopic</td>
<td>Elective open versus laparoscopic colectomy for cancer (2005-2006)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Organ space infection</td>
<td>4.3%</td>
<td>2.4%</td>
<td>0.001</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Wound dehiscence</td>
<td>2.7%</td>
<td>0.85%</td>
<td>0.001</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Postoperative</td>
<td>Any adverse event</td>
<td>21.7%</td>
<td>14.6%</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SSI</td>
<td>11.8%</td>
<td>9.1%</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Wound disruption/dehiscence</td>
<td>1.5%</td>
<td>0.5%</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pneumonia</td>
<td>3.4%</td>
<td>1.8%</td>
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<td></td>
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<td></td>
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<td></td>
<td>Pulmonary embolism</td>
<td>0.8%</td>
<td>0.5%</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Unplanned intubation</td>
<td>2.5%</td>
<td>1.6%</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Renal failure</td>
<td>2.0%</td>
<td>1.3%</td>
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<td></td>
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<td></td>
<td>Urinary tract infection</td>
<td>3.2%</td>
<td>1.9%</td>
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<td></td>
<td></td>
<td></td>
<td>Bleeding requiring transfusion</td>
<td>0.5%</td>
<td>0.7%</td>
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<td></td>
<td></td>
<td></td>
<td>Deep venous thrombosis</td>
<td>1.3%</td>
<td>0.6%</td>
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<td></td>
<td></td>
<td></td>
<td>Sepsis</td>
<td>6.5%</td>
<td>4.7%</td>
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<td></td>
<td></td>
<td>Return to OR</td>
<td>5.8%</td>
<td>5.5%</td>
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<td></td>
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<td></td>
<td></td>
<td>Postoperative LoS &gt;6 days</td>
<td>49.7%</td>
<td>26.3%</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Mortality</td>
<td>1.8%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Thompson et al. 2014&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Australia</td>
<td>Retrospective analysis, n=647, open, n=744, laparoscopic</td>
<td>Elective open versus laparoscopic resection for colorectal cancer&lt;sup&gt;3&lt;/sup&gt; (2009-2011)</td>
<td>Peri-operative</td>
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<td></td>
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<td></td>
<td></td>
<td>Mean (95% CI) operating time, minutes</td>
<td>214 (204-224)</td>
<td>216 (209-224)</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td>Postoperative</td>
<td>Mean (95% CI) anesthesia duration, minutes</td>
<td>261 (251-272)</td>
</tr>
<tr>
<td>Causey et al. 2012</td>
<td>United States</td>
<td>Retrospective database analysis of the American College of Surgeons - National Surgical Quality Improvement Program data, n=735 open; n=342 laparoscopic</td>
<td>Postoperative</td>
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<td>Open versus laparoscopic colectomy for ulcerative colitis (2005-2008)</td>
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<tr>
<td>Mean (95% CI) LoS, days</td>
<td>10.3 (9.7-11.0)</td>
<td>9.2 (8.7-9.7)</td>
<td>0.008</td>
<td></td>
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<tr>
<td>Mean (95% CI) ICU admission, hours</td>
<td>14.7 (10.8-18.7)</td>
<td>7.4 (4.8-10.0)</td>
<td>0.002</td>
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<tr>
<td>Causey et al. 2012</td>
<td>United States</td>
<td>Retrospective database analysis of the American College of Surgeons - National Surgical Quality Improvement Program data, n=735 open; n=342 laparoscopic</td>
<td>Postoperative</td>
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<td>Open versus laparoscopic colectomy for ulcerative colitis (2005-2008)</td>
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<td>Causey et al. 2012</td>
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<td>Open versus laparoscopic colectomy for ulcerative colitis (2005-2008)</td>
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<td>Causey et al. 2012</td>
<td>United States</td>
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<td>Open versus laparoscopic colectomy for ulcerative colitis (2005-2008)</td>
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<tr>
<td>Causey et al. 2012</td>
<td>United States</td>
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<td>Postoperative</td>
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<td>Open versus laparoscopic colectomy for ulcerative colitis (2005-2008)</td>
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<td>Causey et al. 2012</td>
<td>United States</td>
<td>Retrospective database analysis of the American College of Surgeons - National Surgical Quality Improvement Program data, n=735 open; n=342 laparoscopic</td>
<td>Postoperative</td>
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<td>Open versus laparoscopic colectomy for ulcerative colitis (2005-2008)</td>
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<td>Causey et al. 2012</td>
<td>United States</td>
<td>Retrospective database analysis of the American College of Surgeons - National Surgical Quality Improvement Program data, n=735 open; n=342 laparoscopic</td>
<td>Postoperative</td>
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<td>Open versus laparoscopic colectomy for ulcerative colitis (2005-2008)</td>
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<td>9.2 (8.7-9.7)</td>
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<tr>
<td>Mean (95% CI) ICU admission, hours</td>
<td>14.7 (10.8-18.7)</td>
<td>7.4 (4.8-10.0)</td>
<td>0.002</td>
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<tr>
<td>Causey et al. 2012</td>
<td>United States</td>
<td>Retrospective database analysis of the American College of Surgeons - National Surgical Quality Improvement Program data, n=735 open; n=342 laparoscopic</td>
<td>Postoperative</td>
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<td>Open versus laparoscopic colectomy for ulcerative colitis (2005-2008)</td>
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<tr>
<td>Mean (95% CI) LoS, days</td>
<td>10.3 (9.7-11.0)</td>
<td>9.2 (8.7-9.7)</td>
<td>0.008</td>
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<tr>
<td>Mean (95% CI) ICU admission, hours</td>
<td>14.7 (10.8-18.7)</td>
<td>7.4 (4.8-10.0)</td>
<td>0.002</td>
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<tr>
<td>Causey et al. 2012</td>
<td>United States</td>
<td>Retrospective database analysis of the American College of Surgeons - National Surgical Quality Improvement Program data, n=735 open; n=342 laparoscopic</td>
<td>Postoperative</td>
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<td>Open versus laparoscopic colectomy for ulcerative colitis (2005-2008)</td>
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<tr>
<td>Mean (95% CI) LoS, days</td>
<td>10.3 (9.7-11.0)</td>
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<td>0.008</td>
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<tr>
<td>Mean (95% CI) ICU admission, hours</td>
<td>14.7 (10.8-18.7)</td>
<td>7.4 (4.8-10.0)</td>
<td>0.002</td>
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<td></td>
<td>United States</td>
<td>Retrospective analysis of a prospectively maintained database, n=231 open and n=231 matched laparoscopic patients with ASA classification 3 or 4 (2002-2007)</td>
<td>Open versus laparoscopic colectomy in patients with ASA classification 3 or 4</td>
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<tr>
<td>Mortality</td>
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<td></td>
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</tr>
<tr>
<td>Partial colectomy</td>
<td>0%</td>
<td>1.37%</td>
<td>0.419</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Total abdominal colectomy</td>
<td>0.89%</td>
<td>6.66%</td>
<td>0.023</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>End ileostomy</td>
<td>0%</td>
<td>2.02%</td>
<td>0.397</td>
<td></td>
<td></td>
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<tr>
<td>Complication</td>
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<tr>
<td>Partial colectomy</td>
<td>27.6%</td>
<td>28.4%</td>
<td>0.914</td>
<td></td>
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<tr>
<td>Total abdominal colectomy</td>
<td>18.7%</td>
<td>41.6%</td>
<td>&lt;0.001</td>
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<tr>
<td>End ileostomy</td>
<td>34.2%</td>
<td>34.3%</td>
<td>0.995</td>
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<tr>
<td>Pouch</td>
<td>18.2%</td>
<td>29.8%</td>
<td>0.008</td>
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<tr>
<td>Moreira et al. 2010$^{26}$</td>
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<tr>
<td>Peri-operative</td>
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<tr>
<td>Median (range) estimated blood loss, mL</td>
<td>250 (20-2000)</td>
<td>150 (20-1500)</td>
<td>&lt;0.001</td>
<td></td>
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<tr>
<td>Median (range) operating time, minutes</td>
<td>150 (60-400)</td>
<td>160 (40-500)</td>
<td>0.09</td>
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<tr>
<td>Postoperative</td>
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<tr>
<td>Median (range) time to first flatus, days</td>
<td>4 (1-35)</td>
<td>3 (1-13)</td>
<td>&lt;0.001</td>
<td></td>
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<tr>
<td>Median (range) time to first bowel movement, days</td>
<td>5 (1-35)</td>
<td>3 (1-13)</td>
<td>&lt;0.001</td>
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<tr>
<td>Median (range) LoS, days</td>
<td>7 (3-97)</td>
<td>5 (2-67)</td>
<td>&lt;0.001</td>
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<tr>
<td>30-day mortality</td>
<td>2.5%</td>
<td>1%</td>
<td>0.3</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative complication</td>
<td>28%</td>
<td>19%</td>
<td>0.02</td>
<td></td>
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<tr>
<td>Anastomotic leak</td>
<td>4%</td>
<td>5%</td>
<td>0.6</td>
<td></td>
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<tr>
<td>Wound infection</td>
<td>10%</td>
<td>4.5%</td>
<td>0.02</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Study Details</td>
<td>Procedure Comparison</td>
<td>Peri-operative</td>
<td>Postoperative</td>
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<tr>
<td>Braga et al. 2010⁴⁴</td>
<td>Italy</td>
<td>RCT</td>
<td>n=134 open, n=134 laparoscopic</td>
<td>Open versus laparoscopic left colonic resection (2000-2004)</td>
<td>Mean (SD) operating time, minutes 174 (77) 213 (57) &lt;0.001</td>
<td>Mean (SD) operative blood loss, mL 127 (265) 46 (130) 0.002</td>
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<td>Transfused patients 14.9% 8.2% 0.136</td>
<td>Conversion to open – 5.2% –</td>
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<td></td>
<td>30-day morbidity 20.1% 11.9% 0.094</td>
<td>Reoperation 6.7% 5.2% 0.881</td>
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<tr>
<td>Day et al. 2013²⁴</td>
<td>United Kingdom</td>
<td>Retrospective single center data, n=208 open; n=457 laparoscopic</td>
<td>Elective resection for colorectal cancer (2003-2010)</td>
<td>Postoperative</td>
<td>Median (range) LoS, days 7 (2-43) 4 (1-59) &lt;0.0005</td>
<td>Post-discharge (5 years) 5 year overall survival 72.5% 75.8% 0.12</td>
<td></td>
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<tr>
<td>Vallribera et al. 2014⁶⁹</td>
<td>Spain</td>
<td>Retrospective single center chart review, n=268 open, n=277 laparoscopic</td>
<td>Open versus laparoscopic colectomy for colonic adenocarcinoma (2005-2009)</td>
<td>Postoperative</td>
<td>All complications 37.3% 21.6% 0.001</td>
<td>Medical complications 16.4% 10.5% 0.033</td>
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<td></td>
<td>Wound complications 4.8% 4.7% 0.924</td>
<td>Surgical complications 23.5% 15.5% 0.034</td>
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<td>Mortality 6.7% 3.2% 0.034</td>
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<td>Study</td>
<td>Country</td>
<td>Design</td>
<td>Procedure</td>
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</tbody>
</table>
| **White et al.** | United Kingdom | Retrospective analysis | Open versus laparoscopic restorative portectomy and proctocolectomy (2006–2011) | 30-day readmission: 12.2% vs 17% (NR)  
30-day reoperation: 7.6% vs 13% (NR)  
Ileostomy closure at 6 months: 63% vs 66% (0.772)  
Ileostomy closure at 1 year: 86.6% vs 93% (0.173)  
Pouch problems: 13.2% vs 11% (0.198)  
Pouch failure: 11.3% vs 3% (0.172)  
Anastomotic leakage: 9.2% vs 11% (NR)  
Median (IQR) LoS, days: 6 (4-8) vs 8 (7-12) (<0.001) |
| **Hardy et al.** | Canada      | Retrospective cohort analysis | Elective open versus laparoscopic colon surgery for all indications (2004–2009) | Median (IQR) operating time, minutes: 196 (152–251) vs 224 (185–259) (0.001)  
Median (IQR) incision to closure time, minutes: 133 (95–187) vs 170 (133–200) (0.001)  
Median (IQR) LoS, days: 7.0 (6.0–11.0) vs 5.0 (4.0–7.0) (0.000)  
In-hospital complication: 22.5% vs 21.6% (0.900)  
Admission to ICU: 6.0% vs 5.8% (0.966)  
Received blood transfusion: 9.7% vs 5.4% (0.116)  
Reoperation: 6.5% vs 5.8% (0.833)  
30-day readmission: 12.5% vs 7.6% (0.122) |
<table>
<thead>
<tr>
<th>Study</th>
<th>Location</th>
<th>Study Design</th>
<th>Comparison</th>
<th>Peri-operative</th>
</tr>
</thead>
</table>
| Orcutt et al. 2011   | United States | Retrospective database analysis of prospectively collected data, n=243 open, n=75 hand-assisted laparoscopic and n=35 laparoscopic-assisted | Open versus MIS (laparoscopic-assisted [LA] and hand-assisted laparoscopic [HAL]) for colorectal cancer (2002-2010) | Peri-operative:  
  - Median blood loss, mL: 150 (LA=229; HAL=179)  
  - Median surgical time, minutes: 168 (LA=229; HAL=179)  

Postoperative:  
  - Complication rate: 49% (LA) vs. 36% (HAL) (p=0.03)  
  - Wound infection rate: 20% (LA) vs. 16% (HAL) (p=0.38)  
  - Anastomotic leak: 5% (LA) vs. 2% (HAL) (p=0.24)  
  - Median days to return of flatus: 4 (LA) vs. 3 (HAL) (p<0.01)  
  - Median days to return of BM: 5 (LA) vs. 4 (HAL) (p<0.01)  
  - Median LoS, days: 8 (LA) vs. 6 (HAL) (p<0.01)  
  - Median length of ICU stay, days: 1 (LA) vs. 0 (HAL) (p<0.01)  
  - 90-day readmission rate: 22% (LA) vs. 13% (HAL) (p=0.08) |
| Gervaz et al. 2010   | Switzerland | RCT, n=54 open, n=59 laparoscopic | Elective open versus laparoscopic sigmoidectomy for diverticulitis (2005-2009) | Peri-operative:  
  - Mean (SD) duration of surgery, minutes: 118 (28) vs. 168 (37) (p<0.001)  

Postoperative:  
  - Mean (SD) maximal pain, VAS: 4.5 (1.9) vs. 3.9 (1.8) (p=0.055)  
  - Mean (SD) duration of ileus (flatus), hours: 53.6 (18) vs. 35.9 (14.2) (p<0.001)  
  - Mean (SD) duration of ileus (bowel movement), hours: 106.6 (24) vs. 81.4 (31) (p<0.001)  
  - Mean (SD) LoS, days: 7.9 (2.6) vs. 7.7 (9.7) (p<0.001) |
<table>
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<tr>
<th>Study</th>
<th>Country</th>
<th>Design</th>
<th>Setting</th>
<th>Comparison</th>
<th>Postoperative</th>
<th>Peri-operative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agarwal et al. 2015(^{17})</td>
<td>United States</td>
<td>Retrospective, single center case-matched review, n=123 open; n=41 laparoscopic</td>
<td>Open versus laparoscopic colectomy (extended right, extended left and total abdominal) for stage I-III adenocarcinoma of the transverse colon (1996-2009)</td>
<td><strong>Postoperative</strong></td>
<td><strong>Mean (SD) LoS, days</strong></td>
<td><strong>Complication rate</strong></td>
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<td>9.4 (6.3)</td>
<td>6.8 (2.9)</td>
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<tr>
<td>Chen et al. 2014(^{40})</td>
<td>China</td>
<td>Retrospective non-randomized analysis, n=80 open, n=80 laparoscopic-assisted</td>
<td>Open versus laparoscopic surgery for colorectal cancer (2009-2013)</td>
<td><strong>Peri-operative</strong></td>
<td><strong>Conversion to open</strong></td>
<td><strong>Mean (SD) surgical time, minutes</strong></td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Comparison</td>
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<tr>
<td>Prakash et al. 2010&lt;sup&gt;39&lt;/sup&gt;</td>
<td>India</td>
<td>Retrospective analysis n=62 open and n=62 matched laparoscopic patients</td>
<td>Open versus laparoscopic colorectal resection for cancer in the rectosigmoid region (2006-2008 for laparoscopic; 2003-2005 for open)</td>
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<tr>
<td>Odermatt et al. 2013&lt;sup&gt;35&lt;/sup&gt;</td>
<td>United Kingdom</td>
<td>Retrospective analysis of a prospective database, patients propensity matched, n=181 open, n=36 laparoscopic</td>
<td>Open versus laparoscopic emergency resection for colon cancer (2006-2011)</td>
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</tbody>
</table>

### Peri-operative
- **Conversion to open surgery**
  - Mean (SD) operation time, minutes: 180 (58.3) vs 296.7 (57.5) days, ns
  - Mean (SD) blood loss, mL: 380 (108) vs 116 (108) mL, p=0.23
  - Blood transfusion: 38.7% vs 6.4%, <0.001

### Postoperative
- **30-day mortality**
  - Mean (SD) LoS, days: 11.0 vs 7.5 days, p=0.019
- **3 year overall survival**
  - Mean (SD) LoS, days: 36.6% vs 34.9%, p=0.528
- **3 year recurrence-free survival**
  - Mean (SD) LoS, days: 43.2% vs 51.1%, p=0.239

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<table>
<thead>
<tr>
<th>Study</th>
<th>Location</th>
<th>Study Design</th>
<th>Procedure Comparison</th>
<th>Time Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kapritsou et al. 2013 36</td>
<td>Greece</td>
<td>Retrospective study, n= 40 open, n=48 laparoscopic</td>
<td>Open versus laparoscopic colectomy for colorectal cancer (2009-2011)</td>
<td>Postoperative</td>
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<td>Mean (SD) LoS, days</td>
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<td>Complications</td>
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<td>Median operation time, minutes</td>
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<td>Median LoS, days</td>
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<td>Median ICU stay, days</td>
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<tr>
<td>Li et al. 2015 45</td>
<td>China</td>
<td>Retrospective single center study of n=25 open and n=10 laparoscopic matched patients</td>
<td>Open versus hand-assisted laparoscopic right hemicolectomy for obstructive right-sided colon cancer (2013)</td>
<td>Peri-operative</td>
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<td>Mean (SD) length of incision, cm</td>
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<td>Mean (SD) operating time, minutes</td>
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<td>Mean (SD) blood loss, mL</td>
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<td>Postoperative</td>
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<td>Mean (SD) LoS, days</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Cohort Description</td>
<td>Postoperative</td>
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<tr>
<td>Liao et al. 2017</td>
<td>Taiwan</td>
<td>Retrospective</td>
<td>Nationwide population-based cohort with n=5,658 open and n=1,738 laparoscopic</td>
<td>Mean (SD) LoS, days 15.6 (10.4)</td>
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<td>for colon cancer (2009-2011)</td>
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<td>Mean (SD) overall survival, days</td>
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<td>Mean (SD) recurrence-free survival, days</td>
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<td>Mean (SD) disease-free survival, days</td>
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<tr>
<td>Fitch et al. 2017</td>
<td>USA</td>
<td>Retrospective</td>
<td>Healthcare claims database with n=558 open and n=741 laparoscopic</td>
<td>Mean (SD) LoS, days 3.4%</td>
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<td>for colon cancer (2013)</td>
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<td>Mean (SD) ICU stay 5.94 (4.32)</td>
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<td>Readmissions 10.93% 6.61% 0.0165</td>
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<td>Total complications 47.0% 26.9% &lt; 0.001</td>
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<td>Colorectal-specific complications 24.6%</td>
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<tr>
<td>Santacruz et al. 2017</td>
<td>Spain</td>
<td>Prospective multi-center study with n=1,655 open and n=1,313 laparoscopic</td>
<td>Mean (SD) LoS, days 339 (20.5)</td>
<td>160 (12.2) 0.001</td>
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<td>for colon cancer (2011-2012)</td>
<td>Peri-operative complications (%) 60 (3.6)</td>
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<td>Surgical site infection (%) 254 (15.3)</td>
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<td>Postoperative complications (%) 500 (30.2)</td>
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<td>Anastomotic leak (%) 138 (8.3)</td>
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<td>Mortality (%) 54 (3.3) 24 (1.8)</td>
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<td>Median (IQR) LoS, days 9 (7-13)</td>
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<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Intervention Comparison</td>
<td>Peri-operative</td>
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<tr>
<td>Yang et al., 201819</td>
<td>China</td>
<td>Single center retrospective study, n=111 open and n=101 laparoscopic</td>
<td>Open versus laparoscopic surgery for colorectal cancer (2006-2015)</td>
<td>Mean (SD) operative time: 173.5 (72.7)</td>
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<td>210.8 (88.9)</td>
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<td>0.028</td>
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<td>30-day total (%) complications: 35 (31.8)</td>
<td>12 (12.9)</td>
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<td>30-day morbidity: 1</td>
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<td>Median (range) time to flatus, days: 4 (3-15)</td>
<td>2 (1-9)</td>
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<td>Median (range) time to diet, days: 7 (5-27)</td>
<td>3 (2-18)</td>
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<td>Median (range) time to ambulation, days: 5 (3-9)</td>
<td>2 (1-5)</td>
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<td>Median (range) LoS, days: 15 (7-31)</td>
<td>7 (5-21)</td>
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<td>90-day mortality (%): 11 (12.4)</td>
<td>2 (1.4)</td>
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<tr>
<td>Shah et al., 202121</td>
<td>Pakistan</td>
<td>Single center retrospective analysis of prospectively maintained database, n=89</td>
<td>Open versus laparoscopic surgical resection of right colon adenocarcinoma (2010-2018)</td>
<td>Median (IQR) operative time: 170 (130-204)</td>
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<td>195 (168)</td>
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<td>&lt;0.001</td>
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<td>5-year overall survival: 46.5%</td>
<td>60.5%</td>
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<td>5-year disease-free survival: 39.8%</td>
<td>57.3%</td>
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<td>Recurrence during follow up: 22.7%</td>
<td>21.8%</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Cohort Description</td>
<td>Complications (%)</td>
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<td>Open and n=141 laparoscopic</td>
<td>15 (16.9)</td>
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<td>1 (1.1)</td>
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<td>0.123</td>
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<td>&gt;0.999</td>
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<td>administrative database with</td>
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<td>propensity score matching, n=55,358</td>
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<td>patients in total</td>
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<td>Nationwide Inpatient Sample, n=348,645</td>
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<td>open and n=174,748 laparoscopic</td>
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</table>
### Ribeiro et al. 2020[^1]

Brazil  
Retrospective database analysis, n=164 open and n=116 laparoscopic  
Elective laparoscopic versus open colorectal surgery (2012-2013)  

<table>
<thead>
<tr>
<th>Postoperative</th>
<th>Mean (SD) LoS, days</th>
<th>Blood transfusion</th>
<th>ICU admission</th>
<th>Mortality</th>
<th>Use of antibiotics</th>
<th>Anastomotic leak</th>
<th>Readmission</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LoS</strong></td>
<td>9.86 (16.27)</td>
<td>20.1%</td>
<td>56.1%</td>
<td>3.0%</td>
<td>47.0%</td>
<td>5.5%</td>
<td>10.4%</td>
</tr>
<tr>
<td><strong>LoS</strong></td>
<td>6.02 (3.86)</td>
<td>9.5%</td>
<td>37.1%</td>
<td>0.9%</td>
<td>43.1%</td>
<td>4.3%</td>
<td>10.3%</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>&lt;0.001</td>
<td>0.019</td>
<td>0.002</td>
<td>0.406</td>
<td>0.54</td>
<td>0.784</td>
<td>1.000</td>
</tr>
</tbody>
</table>

[^1]: Excluded rectal resection and patients with distant metastases; study also included comparison versus robot-assisted colectomy; only the findings of open versus laparoscopic colectomy are presented here

[^2]: Excluding previous colonic resection, multiple previous surgeries, severe co-morbid conditions, coagulopathy and metastatic disease

[^3]: Including anterior resection, high anterior resection, right hemicoectomy, left colonic resection, APER, subtotal colectomy, Hartmann’s, right hemicoectomy and anterior resection, and panproctocolectomy

[^4]: Excluded patients with advanced or systemic cancer

[^5]: Includes partial colectomy, ileocolic resection, low pelvic anastomosis, Hartmann’s procedure, total abdominal colectomy, colectomy/coloproctostomy, TPC/EI

[^6]: Includes right colectomy, left colectomy, subtotal colectomy and sigmoid colectomy

[^7]: Includes right hemicoectomy, left hemicoectomy, sigmoid resection and other

[^8]: Excluded patients undergoing total abdominal colectomy or a procedure involving the rectum

[^9]: Includes right hemicoectomy, left hemicoectomy, sigmoid colectomy, low anterior resection, abdominoperineal resection and total colectomy
Includes right hemicolecotomy, extended right hemicolecotomy, ileocecal resection, transverse colectomy, left colectomy, sigmoid colectomy, subtotal colectomy, Hartmann’s

Includes right hemicolecotomy, transcolectomy, extended right hemicolecotomy/total colectomy, left hemicolecotomy, sigmoidectomy, high anterior resection, abdominoperineal resection, anterior resection of the rectum, ultralow anterior resection

Including right colectomy/ileocecectomy, left colectomy/sigmoidectomy, anterior resection, total abdominal colectomy, abdominoperineal resection, and ileo-pouch anal anastomosis

Including anterior resection (TME), high anterior resection, right hemicolecotomy, left colonic resection, APER, subtotal colectomy, Hartmann’s, right hemicolecotomy and anterior resection, panprotocolectomy

In addition to colectomy, this study also compared the open and minimally invasive approach to bariatric, cholecystectomy, hysterectomy, inguinal hernia, thoracic, and ventral hernia procedures

Includes right colectomy, extended right colectomy, transverse colon resection, left colectomy, sigmoidectomy, subtotal colectomy and total colectomy

Neither the absolute number nor the overall percentage of patients with laparoscopic and open approaches were stated in the study.

Also includes data regarding robotic approach, only the findings regarding laparoscopic versus open surgery are reported here

ASA, American Society of Anaesthesiology; BM, bowel movement; DFS, disease-free survival; HAL; hand-assisted laparoscopic; LA, laparoscopic-assisted; LoS, length of stay; NR, not reported; NS, not significant; OS, overall survival; RCT, randomized controlled trial; SSI, surgical site infection

OR = Odds Ratio (95% CI); for ORs, values below 1.00 normally favor laparoscopic surgery, values above 1.00 normally favor open surgery with the exception of Chiu et al. 2019\(^{71}\) where the comparison is inverted.
<table>
<thead>
<tr>
<th>Study</th>
<th>Setting</th>
<th>Study details</th>
<th>Procedures</th>
<th>Currency (Cost year)</th>
<th>Cost Outcome</th>
<th>Open Median (IQR) OR cost</th>
<th>Laparoscopic Median (IQR) OR cost</th>
<th>P value</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td></td>
<td>Median (IQR) PACU cost 505 (0-767)</td>
<td>438 (269-602)</td>
<td>0.022</td>
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<td>Median (IQR) ward cost 5,592 (3,972-8,478)</td>
<td>3,224 (2,141-5,391)</td>
<td>0.001</td>
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<td>Median (IQR) total hospital cost 12,721 (9,621-18,790)</td>
<td>9,600 (7,666-13,518)</td>
<td>0.001</td>
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<tr>
<td>Thompson et al. 2014</td>
<td>Australia</td>
<td>Retrospective analysis, n=647 open, n=744 laparoscopic</td>
<td>Elective open versus laparoscopic resection for colorectal cancer (2009-2011)</td>
<td>EUR (2012)</td>
<td>Mean (95% CI) total cost 22,442 (21,125-23,719)</td>
<td>20,396 (19,451-21,286)</td>
<td>0.010</td>
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<td>Mean (95% CI) anesthesia cost 2,155 (2,028-2,273)</td>
<td>2,424 (2,323-2,525)</td>
<td>0.001</td>
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<td>Mean (95% CI) imaging cost 134 (108, 161)</td>
<td>168 (130, 208)</td>
<td>0.174</td>
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<td>Mean (95% CI) pathology cost 818 (768, 867)</td>
<td>789 (748, 830)</td>
<td>0.389</td>
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<td>Mean (95% CI) pharmacy cost 229 (164, 295)</td>
<td>154 (122, 187)</td>
<td>0.058</td>
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<td>Study</td>
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<td>Study Design</td>
<td>Comparison</td>
<td>Procedure</td>
<td>CAD (year not stated)</td>
<td>outcomes</td>
<td>Cost (USD or CAD)</td>
<td>p-value</td>
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<tr>
<td>Alkhamesi et al. 2011</td>
<td>Canada</td>
<td>Retrospective analysis, n=503 open, n=233 laparoscopic</td>
<td>Elective open versus laparoscopic segmental colectomies (right and left-sided colectomies) (2005-2010)</td>
<td>Right colectomy</td>
<td>Bed cost: 6,632.8 OR cost: 3,811.9 Total cost: 10,444.7</td>
<td></td>
<td>Mean (95% CI) theater cost: 5,584 (5,386, 5,783)</td>
<td>0.757</td>
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<td></td>
<td>Left colectomy</td>
<td>Bed cost: 5,949.1 OR cost: 5,197.5 Total cost: 11,146.6</td>
<td></td>
<td>Mean (95% CI) theater cost: 5,628 (5,445, 5,810)</td>
<td></td>
</tr>
<tr>
<td>Norwood et al. 2011</td>
<td>Australia</td>
<td>Analysis of RCT data, n=44 open, n=41 laparoscopic</td>
<td>Open versus laparoscopic surgery for colon cancer (1998-2005)</td>
<td></td>
<td>Median (range) total cost: 9,948 (5,395-90,398)</td>
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<td>0.65</td>
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<tr>
<td>Eisenberg et al. 2010</td>
<td>United States</td>
<td>Retrospective analysis, n=162 open, n=76 laparoscopic</td>
<td>Elective open versus laparoscopic colon resection (2004-2006)</td>
<td></td>
<td>Total cost with complication: 18,296 Total cost with no complication: 17,686</td>
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<td>0.0003</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Study Type</td>
<td>Procedure Description</td>
<td>Cost Measure</td>
<td>Median (USD 2008)</td>
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<td>p-value</td>
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<td>Vaid et al. 2012</td>
<td>United States</td>
<td>Retrospective cost study</td>
<td>Elective open versus laparoscopic colectomy for cancer (right, left or sigmoid)</td>
<td>Median total cost</td>
<td>43,459</td>
<td>41,971</td>
<td>&lt;0.001</td>
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<tr>
<td></td>
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<td>using the National Inpatient</td>
<td></td>
<td>Median total cost, complicated</td>
<td>62,221</td>
<td>58,388</td>
<td>0.407</td>
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<tr>
<td></td>
<td></td>
<td>Sample, n=58,802 open, n=5,147 laparoscopic</td>
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<td>Median total cost, not complicated</td>
<td>39,152</td>
<td>39,017</td>
<td>0.532</td>
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<tr>
<td>Marshall et al. 2010</td>
<td>United States</td>
<td>Single center retrospective</td>
<td>Open versus laparoscopic surgery for colon cancer (2008-2009)</td>
<td>Median overall inpatient cost</td>
<td>18,564</td>
<td>12,500</td>
<td>&lt;0.01</td>
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<td>database analysis, n=17 open, n=33 laparoscopic</td>
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<td>Median surgical cost</td>
<td>8,709</td>
<td>5,842</td>
<td>&lt;0.05</td>
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<td>Median nursing cost</td>
<td>10,095</td>
<td>5,328</td>
<td>&lt;0.05</td>
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<td>Median laboratory cost</td>
<td>1,703</td>
<td>805</td>
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<td>Median radiology cost</td>
<td>504</td>
<td>0</td>
<td>&lt;0.05</td>
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<td>Median cost, other</td>
<td>2,509</td>
<td>1,459</td>
<td>&lt;0.05</td>
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<tr>
<td>Dowson et al. 2012</td>
<td>United Kingdom</td>
<td>Prospective cost study</td>
<td>Elective open versus laparoscopic colorectal surgery (2006-2007)</td>
<td>Mean (GBP 2006/7) hospital costs (all)</td>
<td>3468 (3805)</td>
<td>1807 (1801)</td>
<td>0.001</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>in consecutive patients, n=70 open,</td>
<td></td>
<td>Mean (GBP 2006/7) total costs (all)</td>
<td>4,383 (2,953)</td>
<td>3,875 (2,008)</td>
<td>0.308</td>
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<td></td>
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<td>Mean (GBP 2006/7) operative cost right resection</td>
<td>3,602 (1,070)</td>
<td>3,153 (1,246)</td>
<td>0.350</td>
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</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Patient Characteristics</td>
<td>Cost Components</td>
<td>Cost Summary</td>
<td>p-Value</td>
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<td>Moreira et al. 2010&lt;sup&gt;26&lt;/sup&gt;</td>
<td>United States</td>
<td>Retrospective analysis of a prospectively maintained database, n=231 open and n=231 matched laparoscopic patients with ASA classification 3 or 4 (2002–2007)</td>
<td>Open versus laparoscopic colectomy in patients with ASA classification 3 or 4 (2002–2007)</td>
<td>USD (year not stated)</td>
<td>Mean anesthesia cost: 1,328</td>
<td>Mean pharmacy cost: 886</td>
<td>Mean medicine therapy cost: 643</td>
<td>Mean nursing floors cost: 2,445</td>
</tr>
<tr>
<td>Crawshaw et al. 2015&lt;sup&gt;72&lt;/sup&gt;</td>
<td>United States</td>
<td>Retrospective analysis of a national claims</td>
<td>Elective open versus laparoscopic</td>
<td>USD (year not stated)</td>
<td>Mean (SD) net payment to hospital: 25,470 (19,957)</td>
<td>Mean (SD) net payment to physician: 2,141 (2,160)</td>
<td>&lt;0.001</td>
<td>0.49</td>
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<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Procedure Comparison</td>
<td>Year</td>
<td>Mean Surgical Cost</td>
<td>Total Cost</td>
<td>Significance</td>
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<tr>
<td>Kapritsou et al. 2013</td>
<td>Greece</td>
<td>Retrospective study, n=40</td>
<td>Open versus laparoscopic colectomy for colorectal cancer (2009-2011)</td>
<td>2009-2011</td>
<td>$3,617</td>
<td>$5,750</td>
<td>&lt;0.000</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Design</td>
<td>Sample Size</td>
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<td>Year</td>
<td>Mean Hospital Cost</td>
<td>Mean Surgery Expenditure</td>
<td>Mean Post-Surgery Costs</td>
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<tr>
<td>Kang et al. 2012</td>
<td>United States</td>
<td>Retrospective analysis using the National Inpatient Sample, n=71,200 open, n=43,165 laparoscopic and n=7,545 converted</td>
<td>Elective open versus laparoscopic colorectal resection for colon cancer, rectal cancer or diverticulitis (2009)</td>
<td>USD (year not stated)</td>
<td>56,977</td>
<td>46,624</td>
<td>NR</td>
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<tr>
<td>Chen et al. 2014</td>
<td>China</td>
<td>Retrospective non-randomized analysis, n=80 open, n=80 laparoscopic-assisted</td>
<td>Open versus laparoscopic surgery for colorectal cancer (2009-2013)</td>
<td>RMB (year not stated)</td>
<td>3.9 (1.1)</td>
<td>8.1 (3.1)</td>
<td>0.003</td>
<td>10.8 (6.5)</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Procedure Description</td>
<td>Year</td>
<td>Total Hospital Charges (USD)</td>
<td>Mean (SD) Costs (EUR)</td>
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<tr>
<td><strong>Steele et al. 2008</strong></td>
<td>United States</td>
<td>Retrospective database analysis using the Nationwide Inpatient Sample, n=95,627 open, n=3,296 laparoscopic</td>
<td>Elective open versus laparoscopic resection for colon cancer (2003-2004)</td>
<td>30</td>
<td>34,178</td>
<td>15,468 (9,429)</td>
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<tr>
<td><strong>Mar et al. 2018</strong></td>
<td>Spain</td>
<td>Retrospective analysis of prospective multi-center observational study, n=628 open and n=963 laparoscopic</td>
<td>Open versus laparoscopic colorectal cancer surgery (2010-2012)</td>
<td>NR</td>
<td>12,824 (6,538)</td>
<td>420 (1,594)</td>
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</table>

Mean (SD) costs:
- 30 days: 950 (2,885) NR
- 1 year: 1,505 (3,509) NR
- 2 years: 1,693 (3,925) NR
- Mean (SD) costs: 23,023 (12,089) NR
<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Study Design</th>
<th>Comparison</th>
<th>Year</th>
<th>Mean (SD) costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liao et al. 2017</td>
<td>Taiwan</td>
<td>Retrospective study of nationwide population-based cohort with n=5,658 open and n=1,738 laparoscopic</td>
<td>Open versus laparoscopic colectomy for colon cancer (2009-2011)</td>
<td>USD (year not stated)</td>
<td>Mean (SD) hospital costs</td>
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<td></td>
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<td>4,735 (3,922)</td>
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<tr>
<td>Fitch et al. 2017</td>
<td>United States</td>
<td>Retrospective analysis of healthcare claims database with n=558 open and n=741 laparoscopic</td>
<td>Open versus laparoscopic colectomy for colon cancer (2013)</td>
<td>USD (2013)</td>
<td>Mean cost of anchor hospitalization</td>
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<td>37,105</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Study Design</td>
<td>Population</td>
<td>Procedure</td>
<td>Year Range</td>
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<tr>
<td>Laudicella et al. 2016&lt;sup&gt;52&lt;/sup&gt;</td>
<td>England</td>
<td>Retrospective cost study of hospital administrative database with propensity score matching, n=55,358 patients in total</td>
<td>Open versus laparoscopic colectomy for colon cancer (2006-2013)</td>
<td>GBP (2012)</td>
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<td>Including 30-day readmission</td>
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<td></td>
<td>Including 90-day readmission</td>
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<tr>
<td>Sheetz et al. 2017&lt;sup&gt;50&lt;/sup&gt;</td>
<td>USA</td>
<td>Retrospective population-based study of Medicare claims database, n=295,271 open and n=133,528 laparoscopic</td>
<td>Open versus laparoscopic colectomy (2010-2012)</td>
<td>USD (year not stated)</td>
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<td>Multiple linear regression</td>
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<td>Total episode payments</td>
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<td>Index hospitalization payments</td>
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<td>Readmission payments</td>
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### Instrumental variable analysis

<table>
<thead>
<tr>
<th>Total episode payments</th>
<th>24,573</th>
<th>20,452</th>
<th>&lt;0.01</th>
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<tbody>
<tr>
<td>Index hospitalization payments</td>
<td>17,570</td>
<td>15,077</td>
<td>0.38</td>
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<tr>
<td>Physician payments</td>
<td>2,694</td>
<td>2,249</td>
<td>&lt;0.01</td>
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<tr>
<td>Readmission payments</td>
<td>10,292</td>
<td>9,791</td>
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<tr>
<td>Post-acute care payments</td>
<td>2,737</td>
<td>1,850</td>
<td>&lt;0.01</td>
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</table>

<table>
<thead>
<tr>
<th>Ribeiro et al. 2020</th>
<th>Brazil</th>
<th>Retrospective database analysis, n=164 open and n=116 laparoscopic</th>
<th>Elective laparoscopic versus open colorectal surgery (2012-2013)</th>
<th>BRL (year not stated)</th>
<th>Mean (SD) costs of index admission</th>
<th>41,652 (95,127)</th>
<th>32,915 (16,314)</th>
<th>0.024</th>
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</thead>
<tbody>
<tr>
<td>Mean (SD) costs of readmissions</td>
<td>2,808 (13,679)</td>
<td>2,508 (7,511)</td>
<td>0.650</td>
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<tr>
<td>Mean (SD) total costs</td>
<td>44,461 (95,789)</td>
<td>35,424 (18,350)</td>
<td>0.026</td>
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</table>

**a**Includes right hemicolectomy, transcolectomy, extended right hemicolectomy/total colectomy, left hemicolectomy, sigmoidectomy, high anterior resection, abdominoperineal resection, anterior resection of the rectum, ultralow anterior resection

**b** Neither the absolute number nor the overall percentage of patients with laparoscopic and open approaches was stated in the study.

**c** The instrumental variable analysis addresses selection bias that was not accounted for in the conventional multivariable analysis. In this study, regional use of the laparoscopic approach was used as the instrumental variable.

ICU; intensive care unit; IQR, inter-quartile range; OR, operating room; PACU, post-anesthesia care unit; SD, standard deviation
1.4 References


https://europepmc.org/article/med/1669400


