Laparoscopic Colorectomy for Colorectal Cancer: Retrospective Analysis of 889 Patients in a Single Center

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Laparoscopic colectomy has been reported as an alternative for treatment of colorectal cancer. However, its long-term efficacy and safety remain obscure. The purpose here was to review our experience with laparoscopic colectomy in 899 patients between June 2001 and December 2008. Of them, 43 patients were converted to open surgery and 846 accepted laparoscopic colorectomy successfully. Among these 846 patients, 790 patients underwent radical resection and 56 patients underwent palliative resection. Only 1 patient died from perioperative pulmonary infection; thus the mortality was 0.12% (1/846). The morbidity of perioperative complications was 18.20% (154/846); intraoperative complication rate was 4.49% (38/846) and the most common intraoperative complication was subcutaneous emphysema and hypercapnia (1.65%, 14/846); postoperative complication rate was 13.71% (116/846) and the most common postoperative complication was ileus (4.37%, 37/846). The overall followed-up rate was 86.41% (731/846, 680 for radical operations and 51 palliative operations). Postoperative deaths happened to 139 patients, including 112 after radical operation and 27 after palliative resection. Of these 112 patients, 97 deaths were cancer-related (14.26%, 97/680) and 15 deaths were non-cancer-related. There were 10 patients encountered local recurrence (1.47%, 10/680) and 105 for metastasis (15.44%, 105/680) after radical operation. Forty-two patients are still alive with tumor. Overall survival rate was 80.98% (592/731), 3-year disease-free survival (DFS) rate after radical operation was 78.0%, and 3-year DFS rate after radical operation for stage I, stage II, and stage III was 89.0%, 85.0%, and 65.0%, respectively. In conclusion, laparoscopic colorectal resection is a feasible and safe technology for colorectal cancer.

Keywords: colectomy; colorectal cancer; laparoscopy; metastasis; postoperative morbidity

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points move in the opposite direction to the surgeon’s hands due to the pivot point, making laparoscopic surgery a non-intuitive motor skill that is difficult to learn (Fleshman et al. 1996; Nelson et al. 2001). In addition, although early reports on laparoscopy-assisted colectomy in patients with colon cancer have suggested that it reduces perioperative morbidity, its influence on long-term results is unknown (Lacy et al. 2002).

Hence laparoscopic colectomy is currently in its infancy, and will inevitably undergo many evolutionary stages. Each of these stages, however, will serve to improve results of treatment and strive to decrease patient morbidity. The purpose of this study is to review our nine-year experience with laparoscopic colon resection, from June 2001 to December 2008 and to evaluate the reliability and safety of laparoscopic colectomy in colorectal cancer through a retrospective analysis of 899 patients, giving a clinical appraisal.

**Materials and Methods**

**Clinic data**

This report aimed at 889 colorectal cancer patients (472 males, 417 females), and their age ranges from 18 to 96 years (median 62.5). Symptoms manifested mucous blood stool, sense of defecation, abdominal pain and abdominal bump. All of these patients were diagnosed by colonoscopy, barium enema, abdominal computed tomography (CT) or magnetic resonance imaging (MRI). Thereinto, 115 patients had ascending colonic cancer (procedure is right hemicolectomy), 29 had transverse colonic cancer (transverse colon resection), 73 had descending colonic cancer (left hemicolectomy), 123 had sigmoid colonic cancer (sigmoid colectomy), 536 had rectal cancer (417 anterior resection of rectum, 106 Mile’s operation (abdomino-perineal resection), and 13 Hartmann’s operation (resection of the anastomosis with proximal colostomy and closure or exteriorization of the distal stump)) and 10 had multiple colonic cancer (total colectomy). In this study, 2-cm distal margins were used for criterion of rectal cancer resections. Anterior resection was performed in patients with rectal section distal to the tumor > 2 cm. If the rectal section distal to the tumor < 2 cm or tumor residual in distal margin, Mile’s was performed. Staging according to tumor-node-metastasis (TNM) system was listed as follows: 7 patients with stage 0, 151 patients with stage I, 330 with stage II, 316 with stage III, and 85 with stage IV. Pathologic types were summarized as 165 of poorly differentiated adenocarcinoma, 581 of moderately differentiated adenocarcinoma, 77 of highly differentiated adenocarcinoma, 47 of signet ring cell carcinoma and 19 of mucous cell carcinoma. In some patients, the third stop lymph nodes were excised. The patients in stage IV were performed for palliative resection, but the others were curative resection.

**Surgical procedure**

Preoperative preparation is the same as that of traditional open surgery. All the patients were anesthetized generally with trachea intubation and laid sprawled on the back or lithotomy position; the positions were variable for different operations. Tilt direction of the patient and position of the surgeon were also variable according to the location of the tumor. The pneumoperitoneum pressure was maintained at the level of 11 to 15 mm Hg. Positions and numbers of trocars are variable, and four or five ports are usually selected during operation (Fig. 1). The details of surgical procedures are the same with previous descriptions (Ahad and Figueredo 2007; Fleshman et al. 2007).

**Results**

**Perioperative outcome**

Of the 889 colorectal cancer patients, 846 of them accepted laparoscopic colorectomy successfully: 314 patients of colectomy and 532 patients of rectectomy. Of the 846 patients, 790 patients underwent radical operation and 56 patients underwent palliative operations (Tables 1 and 2). The other 43 patients were converted to open surgery (conversion rate was 4.84%, 43/889), in which 39 of them were converted initially and the other 4 were passively. The reasons for initiative conversion were invading other organs (27), mesentery contracture (2), big tumor bulk (3), ileus (3), and wide small intestine conglutination resulting from previous operations (4). The reasons for passive conversions were operative complications that are difficult to deal under laparoscopy (1 hypercapnia, 1 massive hemorrhage, 1 spleen damage, and 1 bowel damage). As shown in Table 3, the conversion rate of laparoscopic colorectal resection was very low in 2001 and 2002, while it was higher than before after 2003.
Outcome measures included operation time, blood loss, numbers of lymph nodes harvested, length of assisted incision and postoperative hospital stay. Mean operation time was 201.66 ± 81.81 minutes, mean blood loss was 100 ml (median), mean numbers of harvested lymph nodes were 12.27 ± 9.02, mean exhaust time after operation was 1.95 ± 1.06 days, and mean postoperative hospital stay was 9.88 ± 5.93 days. Detailed information is shown in Tables 4 and 5, in which the data were analyzed using SPSS for Windows 10.0. Blood loss did not follow normal distribution, and so we adopted median instead of mean as average value.

Complications of different operations are shown in Tables 6 and 7. The total number of intraoperative complications was 38 (bottom line in Table 6); the morbidity of intraoperative complication was 4.49% (38/846). Among them, the most important intraoperative complication was subcutaneous emphysema and hypercapnia (1.65%, 14/846), and the second one was massive hemorrhage (1.18%, 10/846). The total number of postoperative complications was 116 (bottom line in Table 7); the morbidity of postoperative complications was 13.71% (116/846). The most common postoperative complication was ileus (4.37%, 37/846) and the second one was wound infection (2.72%, 23/846) (Table 7). The overall morbidity of complications was 18.20% [(38 + 116)/846]. One patient died from lung infection at 17th day postoperative; so the perioperative mortality was 0.12% (1/846). The others were cured by anti-infection, enhanced nutrition and changing dressing. Eleven patients needed further surgical therapy, including 5 patients with anastomotic leakage, 2 patients with ileus, 1 patient with bleeding from left middle rectal artery, 1 patient with anastomotic bleeding, 1 patient with stoma necrosis, and 1 patient with stoma prolapse. Among 846 patients, 464 patients, including staged II (179), III (244) and IV (41), accepted chemotherapy postoperatively for 3 to 6 months or more.
Follow-up results

Table 8 shows the detailed clinical data of follow-up for different stages, from 0 to IV (Survival and free survival were counted by abridged life table). The median follow-up time was 29 months (range from 1 to 93 months), while 115 patients were lost (110 radical operations and 5 palliative operations). Therefore, the overall followed-up rate was 86.41% (731/846, 680 for radical operations and 51 palliative operations). Postoperative death happened to 139 patients (Died patient in Table 8), including 112 deaths after radical operation and 27 deaths after palliative resection. Of these 112 deaths after radical operation, 97 patients died a cancer-related death (97/680, 14.26%) and 15 of them were not because of cancer. There were 10 patients encountered local recurrence (10/680, 1.47%) and 105 patients encountered metastasis (105/680, 15.44%) after radical operation. Forty-two patients are still alive with tumor (18 patients with recurrences or metastasis after radical operation.
Laparoscopic Colorectomy for 889 Colorectal Cancer Patients

Overall survival rate was 80.98% (592/731), 3-year disease-free survival (DFS) rate after radical operation was 78.0%, and the 3-year DFS rate after radical operation for stage I, stage II, and stage III was 89.0%, 85.0%, and 65.0%, respectively.

Pairwise comparison indicated the stage II patients had a significantly better survival curve than that of stage III and IV patients. The stage IV patients had the worst survival rate. There was no statistically significant difference between survival rate of stage I and II.

**Discussion**

**Learn curve of laparoscopic colorectal surgery**

Laparoscopic colorectal surgery is complex as traditional open surgery. As a result, open colorectal surgery experience is required for laparoscopic surgeons. Learn curve of laparoscopic surgery is often evaluated in terms of operation time, blood loss, conversion rate, time to oral intake, and postoperative hospital stay (Bennett et al. 1997; Schlachta et al. 2001; Dinçler et al. 2003; Tekkis et al. 2005). As shown in Tables 3 and 4, our conversion rate was lower in 2001 and 2002, and operation time was shorter. This may be due to the reason that the surgeon selected early staged patients to laparoscopic surgery and operated without aggressive attempt. Therefore, surgeons would get through the learn curve smoothly. However, after 2003, our conversion rate was higher than before, and they were 4.59%, 4.70%, 5.79%, 6.25%, 3.94% and 6.62% for each year. This reason may be that surgeon’s operative technique was improved, and so the indication was broadened,

<table>
<thead>
<tr>
<th>Stage</th>
<th>Patient</th>
<th>Lost patient</th>
<th>Median (month)</th>
<th>Follow-up rate (%)</th>
<th>Died patient</th>
<th>Cases alive with tumor</th>
<th>5y survival Rate (%)</th>
<th>3y free survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7</td>
<td>0</td>
<td>26</td>
<td>7 (100%)</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>I</td>
<td>150</td>
<td>21</td>
<td>34</td>
<td>129 (86.00%)</td>
<td>9</td>
<td>4</td>
<td>87.0</td>
<td>89.0</td>
</tr>
<tr>
<td>II</td>
<td>325</td>
<td>46</td>
<td>36</td>
<td>279 (85.85%)</td>
<td>32</td>
<td>7</td>
<td>80.0</td>
<td>85.0</td>
</tr>
<tr>
<td>III</td>
<td>308</td>
<td>43</td>
<td>28</td>
<td>265 (86.04%)</td>
<td>71</td>
<td>7</td>
<td>56.0</td>
<td>65.0</td>
</tr>
<tr>
<td>IV</td>
<td>56</td>
<td>5</td>
<td>14</td>
<td>51 (91.07%)</td>
<td>27</td>
<td>24</td>
<td>10.0</td>
<td>/</td>
</tr>
<tr>
<td>Sum</td>
<td>846</td>
<td>115</td>
<td>29</td>
<td>731 (86.41%)</td>
<td>139</td>
<td>42</td>
<td>69.0</td>
<td>78.0</td>
</tr>
</tbody>
</table>

Fig. 2. Kaplan-Meier curve comparing survival for various stage patients. The stage II patients had a significantly better survival curve than that of stage III and IV patients. The stage IV patients had the worst survival rate. There was no statistically significant difference between survival rate of stage I and II. Cum: cumulative.
which resulted in more challenges in operation.

Locations of trocars and assisted incision

It is crucial to choose the suitable positions of trocars, which provide with flexibility of laparoscopic procedures (Jones et al. 1995; Bemelman et al. 1996; Darzi 2000; Marcello et al. 2008). With correct positions that ensure smooth operation performances, we can shorten operation time, reduce complications, and lighten operative trauma. Chinese Cancer Society (CCS) had established <Operation Guideline for Laparoscopic Colorectal Surgery> in 2006, in which the positions of trocars were well described. But position and amount are not fixed; they can be changed according to operators’ habit. The authors are trying to find the appropriate position of trocars in laparoscopic colorectal surgery from lots of operations in recent years (see Fig. 1). We suppose these positions will bring convenience to the operators.

In right hemicolectomy or transverse colon resection, a middle-line assistant incision in upper abdomen is suggested. Thus, it is convenient to uncover the proximal part of mesenteric vessels, achieve skeletonization of the vessels and excise lymph nodes completely. The port at the upper margin of the umbilicus will constitute a part of the incision, which will reduce the ports. Single suture of the linea alba will shorten the closing time with little tissue damage. In left hemicolectomy or anterior resection of rectum, a transverse assistant incision superior of pubic symphysis is suggested. But muscle and peritoneum are slit vertically. This incision is low, through which we can repair tissue damage under direct version when it is necessary. With skin and muscle at different directions, subcutaneous infection could affect muscle layer little. As a result, the infection is easily localized and that incision hernia can be avoided. The scar will be covered by underwear, which looks comfortable. In Mile’s surgery, the specimen is removed through perineal incision. Another point, it is proposed to cut off the near or distal bowel but draw the two parts out of the abdomen before the specimen is removed, which will bring convenience to following procedures with smaller incision.

Intra-operative complications and postoperative complications

Intra-operative complication can be divided to two categories according to the reasons. One is the result of the laparoscopy technique, including subcutaneous emphysema and hypercapnia (1.65%, 14/846). These complications can be resolved by reducing abdominal pressure or stopping pneumoperitoneum without sequela. We can reduce the morbidity by fixing trocars or setting low pneumoperitoneum pressure for high risk patients, who are old, thin or with slack abdomen. The other category is the result of the procedure, including injuries of vessel, ureter, spleen and bowel. A prospective nonrandomized controlled trial favored that these complications were similar to open surgery. Laparoscopic colorectal surgery is technique depended, so complication is associated with operators' skill and their cooperation. In addition, using appropriate instrument is also of importance.

The most common postoperative complication is ileus (4.37%, 37/846) and the second one is wound infection (2.72%, 23/846), which is similar to the earlier reports (Senagore et al. 2002; Senagore 2005). In this group, the total complication rate was 13.71% (116/846). According to these reports, the total morbidity of postoperative complications of laparoscopic colorectal surgery is 1-38%, which is lower than that of equivalent open surgery. Low morbidity may result from smaller incision, less infection and adhesion.

Radical efficacy of laparoscopic colorectal surgery

Like open surgery, the main factors effecting radical efficacy of laparoscopic colorectal operation are excision bound and excision of lymph nodes. In this group, our procedures followed non-tumor principle. Length of removed bowel, cutting place of mesenteric vessel and excision of lymph tissue were all equivalent to open surgery. Amount of lymph nodes harvested ranged from 0 to 68, with average 12.27 ± 9.02, which had met the criteria of conventional open radical operation. In the study of Buchanan et al. (2008), the number of lymph nodes harvested ranged from 0 to 24, with average 9, in which 135 patients had accepted conventional open surgery. The radical efficacy of laparoscopic colorectal operation is evaluated in terms of local recurrence, metastasis, wound plantation and long-term survival. Along with the progress of laparoscopic technique and improvement of procedure, incidence of port plantation has been reduced from 21% to 0.5%-1%. Local recurrence rate after radical operation was 16.91% (115/680), 5 years survival was 72%, and 3-year DFS after radical operation was 78%. According to the report stated by Sample et al. (2006), local recurrence rate after radical operation was 22.1%, 5-year overall survival rate was 65.3%, and 5-year DFS rate after radical operation was 58%. In recent years, several international prospective clinical randomized controlled trials showed no significant difference in terms of recurrence rate, total survival and free survival between laparoscopic and open colorectal operation.

Indication and contraindication

Having surgical experience by more than 700 patients, the authors think that tumors at any position could be removed by laparoscopic surgery. Tumors staged I - III can be resected radically, and staged IV can be resected palliatively. Some experts think T4, especially invading adjacent organs is excluded, but we think it can be resected as long as tumor is movable and invaded tissue could be removed together with an awareness of conversion to open surgery when necessary.

Absolute contraindications include inability to tolerate general anesthesia or laparoscopic surgery (with severe
heart, lung, liver, kidney diseases), sepsis, coagulation dis-
function, pregnancy, distributed peritoneum plantation or
lymph metastasis, bigger than 8 cm in diameter, invading
several organs and needing combined multiple organs
resection, serious abdominal distension, perforation causing
peritonitis, invading small intestine and causing fistula.
Relative contraindications include bleeding tendency,
extreme obesity, severe conglutination (result from previous
surgical history), diaphragmatic or abdominal hernia,
abnormal colon anatomy. With improvements of skills and
instruments, some contraindications will be excluded.

Compared to open surgery, laparoscopic colorectal
surgery has several advantages, including faster recovery of
bowel function, earlier oral intake, less pain and shorter
hospital stay. In conclusion, laparoscopic colorectal sur-
gery is feasible and safe, short-term outcome is favorable,
and long-term outcome has been approved.

Conflict of Interest

The authors had no conflicts of interest to declare in rela-
tion to this article.

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