PO Box 2345, Beijing 100023, China
www.wjgnet.com
wjg@wjgnet.com

World J Gastroenterol 2006 December 21; 12(47): 7676-7683
World Journal of Gastroenterology ISSN 1007-9327


RAPID COMMUNICATION

# Meta-analysis of short-term outcomes after laparoscopy-assisted distal gastrectomy

Shunsuke Hosono, Yuichi Arimoto, Hiroshi Ohtani, Yoshitetsu Kanamiya

Shunsuke Hosono, Yuichi Arimoto, Hiroshi Ohtani, Yoshitetsu Kanamiya, Department of Surgery, Osaka City Sumiyoshi Hospital, 1-2-16, Higashi-Kagaya, Suminoe-ku, Osaka 559-0012, Japan

Correspondence to: Dr. Shunsuke Hosono, Department of Surgery, Osaka City Sumiyoshi Hospital, 1-2-16, Higashi-Kagaya, Suminoe-ku, Osaka 559-0012, Japan. oceanus0222@yahoo.co.jp
Telephone: +81-6-66811000 Fax: +81-6-66861547
Received: 2006-10-08 Accepted: 2006-11-20

## Abstract

**AIM:** To elucidate the current status of laparoscopy-assisted distal gastrectomy (LADG) with regard to its short-term outcomes by comparing it with conventional open distal gastrectomy (CODG).

**METHODS:** Original articles published from January 1991 to August 2006 were searched in the MEDLINE, EMBASE, and Cochrane Controlled Trials Register. Clinical appraisal and data extraction were conducted independently by 2 reviewers. A meta-analysis was performed using a random effects model.

**RESULTS:** Outcomes of 1611 procedures from 4 randomized controlled trials and 12 retrospective studies were analyzed. Compared to CODG, LADG was a longer procedure (weighted mean difference [WMD] 54.3; 95% confidence interval [CI] 38.8 to 69.8; $P$ < 0.001), but was associated with a lower associated morbidity (odds ratio [OR] 0.54; 95% CI 0.37 to 0.77; $P$ < 0.001); this was most significant for postoperative ileus (OR 0.27; 95% CI 0.09 to 0.84; $P$ = 0.02). There was no significant difference between the two groups in anastomotic, pulmonary, and wound complications and mortality. Duration from surgery to first passage of flatus was faster (WMD -0.68; 95% CI -0.85 to -0.50; $P$ < 0.001) and the frequency of additional analgesic requirement (WMD -1.36; 95% CI -2.44 to -0.28; $P$ = 0.01), and duration of hospital stay (WMD -5.51; 95% CI -7.61 to -3.42; $P$ < 0.001) were significantly lower after LADG. However, a significantly higher number of lymph nodes were dissected by CODG (WMD -4.35; 95% CI -5.73 to -2.98; $P$ < 0.001).

**CONCLUSION:** LADG for early gastric cancer is associated with a lower morbidity, less pain, faster bowel function recovery, and shorter hospital stay.



**Key words:** Laparoscopic gastrectomy; Gastric cancer; Postoperative complications; Mortality; Lymphadenectomy; Meta-analysis

Hosono S, Arimoto Y, Ohtani H, Kanamiya Y. Meta-analysis of short-term outcomes after laparoscopy-assisted distal gastrectomy. *World J Gastroenterol* 2006; 12(47): 7676-7683

http://www.wjgnet.com/1007-9327/12/7676.asp

## INTRODUCTION

Many surgeons are interested in laparoscopic surgery for gastric cancer because it has been proved that laparoscopic surgery has several advantages over conventional open surgery[1-3]. Since 1991, laparoscopy-assisted distal gastrectomy (LADG) has been adopted by Kitano[4] for the treatment of early gastric cancer, and it has been performed worldwide, especially in Japan and Korea. In 1997, Goh *et al*[5] published the early results of 118 LADGs; they sent a questionnaire to 16 surgeons across 12 countries and found that 10 of these surgeons claimed LADG to be superior to conventional open distal gastrectomy (CODG) because of a faster recovery, reduced pain, and better cosmesis[5]. Many studies comparing LADG with CODG with respect to their short-term outcomes have been performed. However, the feasibility and advantages of LADG have not been thoroughly evaluated thus far. Therefore, we performed a meta-analysis by comparing LADG with CODG with regard to their short-term outcomes to elucidate the current status of LADG. Unfortunately, only 4 prospective randomized controlled trials (RCTs) have been published[6-9]. Lack of RCTs may be due to the difficulty encountered in conducting a large RCT in Japan, where LADGs are most frequently performed because the Japanese are disinclined toward enrolling in RCTs and show a strong preference for a specific type of treatment[9]. Therefore, performing a reasonable meta-analysis of only RCTs may not be currently justified. Nevertheless, summarizing all the published data is important because it may help surgeons in choosing a better approach for the management of individual patients with gastric cancer. This meta-analysis is not only limited solely to RCTs but also includes retrospective trials that have compared LADG with CODG. We have also analyzed the RCTs separately in addition to analyzing all the included studies.

## MATERIALS AND METHODS

### *Literature search*

From January 1991 to August 2006, a thorough search of the MEDLINE, EMBASE, and Cochrane Controlled Trials Register databases was performed. The following keywords were used: "laparoscopic," "laparoscopy-assisted/laparoscopic-assisted," and "gastrectomy." The search was limited to studies published in English; all titles and abstracts were scanned and appropriate citations were reviewed.

### *Inclusion and exclusion criteria*

Inclusion criteria were as follows: (1) study type-RCTs and non-randomized prospective and retrospective studies; (2) studies that analyzed both LADG and CODG for the treatment of gastric cancer; (3) studies with any sample size; and (4) when we found several studies reporting the same patients, we included only the most recent study; however, if an older study in this category was an RCT, then it was included in our meta-analysis.

### *Methods of review*

Clinical appraisal and data extraction were conducted independently by 2 authors (S.H. and Y.A.). Discrepancies between the authors were resolved by consensus. The primary outcome measures were operative findings, postoperative complications and operation-related mortality, and postoperative clinical course. The following operative findings were analyzed: operating time, blood loss, and total number of dissected lymph nodes. The following postoperative complications were analyzed: overall complications, anastomotic leakage and stenosis, postoperative ileus, pulmonary complications, and wound infection. Overall complications were evaluated based on the total number of postoperative events. Anastomotic leakage included duodenal stump leakage; postoperative ileus included both mechanical and paralytic ileus; and pulmonary complications included pneumonia, pleural effusion, and atelectasis. Postoperative clinical course was analyzed in terms of bowel function recovery, frequency of additional analgesic requirement, number of days with body temperatures more than 37℃, duration of postoperative hospital stay, and WBC counts and C-reactive protein (CRP) levels on postoperative d 1, 3, and 7. Bowel function recovery was assessed by calculating the time interval between surgery and the first passage of flatus. Data were obtained from individual trials using the most reliable data available. Raw data were considered the most reliable, followed by derivation from the graph. It was assumed that all definitions in the included trials were synonymous, unless specified otherwise.

### *Statistical analysis*

Weighted mean differences with 95% confidence intervals were used for analyzing continuous variables that were presented in the same scale (e.g., operating time, blood loss, and postoperative hospital stay). When the trials had reported medians and ranges instead of means and standard deviations, we assumed that the difference in medians is equal to that in means, and the estimated standard deviation was considered equivalent to a quarter of the reported range. If neither a range nor any other measure of dispersion was available, then the standard deviation was estimated by halving the mean or the median. For dichotomous variables, odds ratios with 95% confidence intervals were calculated using a random effects model. If a particular outcome measure was reported in more than 2 RCTs, we conducted data analyses of these RCTs as well as of the overall studies. All statistical calculations were performed using the computer software Review Manager (RevMan) version 4.2.8 provided by Cochrane Collaboration. A value of $P < 0.05$ was considered significant. Heterogeneity was evaluated by using the $\chi^2$ test; $P < 0.1$ was considered significant for heterogeneity.

## RESULTS

Through our database searches, we found 4 RCTs[6-9] and 12 non-randomized retrospective studies[10-21] that compared LADG with CODG. We performed a meta-analysis of all the 16 studies using the data obtained from 1611 patients (837 and 774 patients who underwent LADG and CODG, respectively). The characteristics of the studies included in our meta-analysis are listed in Table 1.

### *Operative findings*

All studies[6-21] had reported the operating time, and 15 studies[6-17,19-21] had reported blood loss. Most studies claimed that CODG was superior to LADG in terms of operating time; however, some[8,10,12,13,16] did not report such an advantage. Pooled data obtained from the weighted mean difference revealed that an additional 54 min was required to perform LADG ($P < 0.001$), and that the blood loss was decreased ($P < 0.001$) when compared with CODG. The number of dissected lymph nodes had been reported in 14 studies[6-9,11,12,14-21], including 4 RCTs[6-9]. There were different levels of lymphadenectomy (Table 1). Analyses of the pooled data of only the RCTs as well as of all the studies revealed that a significantly higher number of lymph nodes were dissected during CODG ($P < 0.001$) (Figure 1). A significant heterogeneity was observed among all the studies; however, heterogeneity was not detected among the 4 RCTs. A summary of the pooled results with regard to the operative findings is presented in Table 2.

### *Morbidity and mortality*

Thirteen studies[6-14,16,18,19,21], which included 1054 patients, provided data regarding the overall postoperative complications. Overall complications after LADG (58/535) were significantly less than that after CODG (97/519; $P < 0.001$; Figure 2). Seven studies[8,9,11,12,16,18,21], which included 750 patients, provided data regarding anastomotic leakage. The incidence of anastomotic leakage was not different between LADG (2/385; 0.5%) and CODG (10/365; 2.7%) ($P = 0.10$). Similarly, the incidence of anastomotic stenosis was also not different between LADG (6/172; 3.5%) and CODG (5/163; 3.1%) ($P = 0.86$) in 5 studies[7,9,11,12,16]. Six studies[7,10,12,13,16,18] reported that postoperative ileus was significantly less frequent after LADG (2/267; 0.75%) than that after CODG (13/264; 4.9%) ($P = 0.02$) (Figure 3). Wound infection was observed in 9 studies[7,8,11,12,14,16,18,19,21], which included 869 patients. There was no difference

**Table 1 Trials included in the meta-analysis**

| Ref. | Yr | Country | *n* LADG | *n* CODG | Level of lymph node dissection | Participants in LADG |
|---|---|---|---|---|---|---|
| Prospective randomized controlled trials | | | | | | |
| 6 | 2002 | Japan | 14 | 14 | D1 + α | Patients with EGC in whom EMR was not indicated |
| 7 | 2005 | Korea | 24 | 23 | D2 | Patients with preoperatively diagnosed mucosal or submucosal cancer |
| 8 | 2005 | Italy | 30 | 29 | D1, D2 | Patients who presented with metastatic tumor or with tumor extension beyond the distal stomach were excluded. |
| 9 | 2005 | Japan | 14 | 14 | D1 + α | Patients with EGC assumed to infiltrate the mucosa or submucosa |
| Retrospective studies | | | | | | |
| 10 | 2000 | Japan | 49 | 53 | D1 + α | Patients with EGC assumed to infiltrate the mucosa or submucosa |
| 11 | 2000 | Japan | 21 | 31 | D1 + α | Patients with EGC assumed to infiltrate the mucosa |
| 12 | 2001 | Japan | 24 | 35 | D1 + α | Patients with preoperatively diagnosed mucosal or submucosal cancer; those with deep submucosal cancer were excluded. |
| 13 | 2003 | Japan | 10 | 17 | D1 + α | Patients with EGC assumed to infiltrate the mucosa or submucosa |
| 14 | 2005 | Japan | 37 | 31 | D2 | Patients with EGC assumed to infiltrate the mucosa or submucosa, and those diagnosed with advanced cancer without lymph node metastasis |
| 15 | 2005 | Japan | 235 | 200 | D2 | Patients with preoperatively diagnosed gastric cancer assumed to be confined to the muscular layer without lymph node metastasis |
| 16 | 2005 | Japan | 89 | 60 | D1 + β | Patients with preoperatively diagnosed EGC assumed to infiltrate the mucosa or submucosa without lymph node metastasis |
| 17 | 2005 | Japan | 20 | 22 | D1 + α, D1 + β | Patients with preoperatively diagnosed EGC assumed to infiltrate the mucosa or submucosa without lymph node metastasis |
| 18 | 2005 | Korea | 71 | 76 | D1 + α, D1 + β, D2 | Patients with mucosal cancer indicated for EMR were excluded. |
| 19 | 2005 | Korea | 16 | 16 | D2 | Patients with EGC assumed to infiltrate the mucosa or submucosa |
| 20 | 2006 | Japan | 47 | 33 | D1 + β | Patients with EGC assumed to infiltrate the mucosa |
| 21 | 2006 | Korea | 136 | 120 | D1 + α, D1 + β, D2 | Patients with preoperatively diagnosed EGC |

LADG: Laparoscopy-assisted distal gastrectomy; CODG: Conventional open distal gastrectomy; EGC: Early gastric cancer; D1: Perigastric lymph nodes; D1 + α: Perigastric lymph nodes and lymph nodes along the left gastric artery; D1 + β: Perigastric lymph nodes and lymph nodes along the left gastric artery and the celiac axis; D2: Perigastric lymph nodes and lymph nodes along the left gastric, common hepatic, proper hepatic, celiac, and splenic arteries; EMR: Endoscopic mucosal resection.

**Table 2 Operative findings**

| Outcome | Type of studies included in the meta-analysis | Trials (*n*) | Patients (*n*) | Pooled results WMD (95% CI) | Interpretation | Test for heterogeneity |
|---|---|---|---|---|---|---|
| Operating time | RCTs | 4 | 162 | 83.1 (40.5, 125.6) $Z = 3.83$, $P < 0.001$ | L > C | $\chi^2 = 91.9$, df = 3 $P < 0.001$, $I^2 = 96.7\%$ |
| | Overall | 16 | 1611 | 54.3 (38.8, 69.8) $Z = 6.88$, $P < 0.001$ | L > C | $\chi^2 = 620.9$, df = 15 $P < 0.001$, $I^2 = 97.6\%$ |
| Blood loss | RCTs | 4 | 162 | -104.3 (-189.0, -19.5) $Z = 2.41$, $P = 0.02$ | L < C | $\chi^2 = 13.6$, df = 3 $P = 0.004$, $I^2 = 77.9\%$ |
| | Overall | 15 | 1464 | -145.6 (-181.4, -109.9) $Z = 7.99$, $P < 0.001$ | L < C | $\chi^2 = 280.4$, df = 14 $P < 0.001$, $I^2 = 95.0\%$ |
| No. of Lymph nodes dissected | RCTs | 4 | 162 | -4.34 (-6.66, -2.02) $Z = 3.66$, $P < 0.001$ | L < C | $\chi^2 = 1.68$, df = 3 $P = 0.64$, $I^2 = 0\%$ |
| | Overall | 14 | 1482 | -4.35 (-5.73, -2.98) $Z = 6.20$, $P < 0.001$ | L < C | $\chi^2 = 34.8$, df = 13 $P = 0.001$, $I^2 = 62.7\%$ |

L: Laparoscopy-assisted distal gastrectomy; C: Conventional open distal gastrectomy; RCTs: Randomized controlled trials; WMD: Weighted mean difference; CI: Confidence intervals; df: Degree of freedom.

in wound infection rate between LADG (9/448; 2.0%) and CODG (13/421; 3.1%). Only 2 of the 16 studies[8,18] reported on mortality; however, there was no difference between LADG and CODG with regard to mortality. A summary of the pooled results for morbidity and mortality is presented in Table 3.

### Postoperative clinical course

Bowel function recovery was evaluated by counting the number of days from surgery to the first passage of flatus in 12 studies[6,7,9-12,14,15,17-19,21], which included 1296 patients. Our analysis showed that bowel function recovery was achieved 0.7 d earlier by the LADG patients than by the CODG patients ($P < 0.001$) (Figure 4). Postoperative pain was assessed by determining the frequency of additional analgesic requirement for postoperative pain in only 6[6,7,9,10,17,18] of the 16 studies. The requirement of additional analgesics after LADG was 3.3 times less frequent

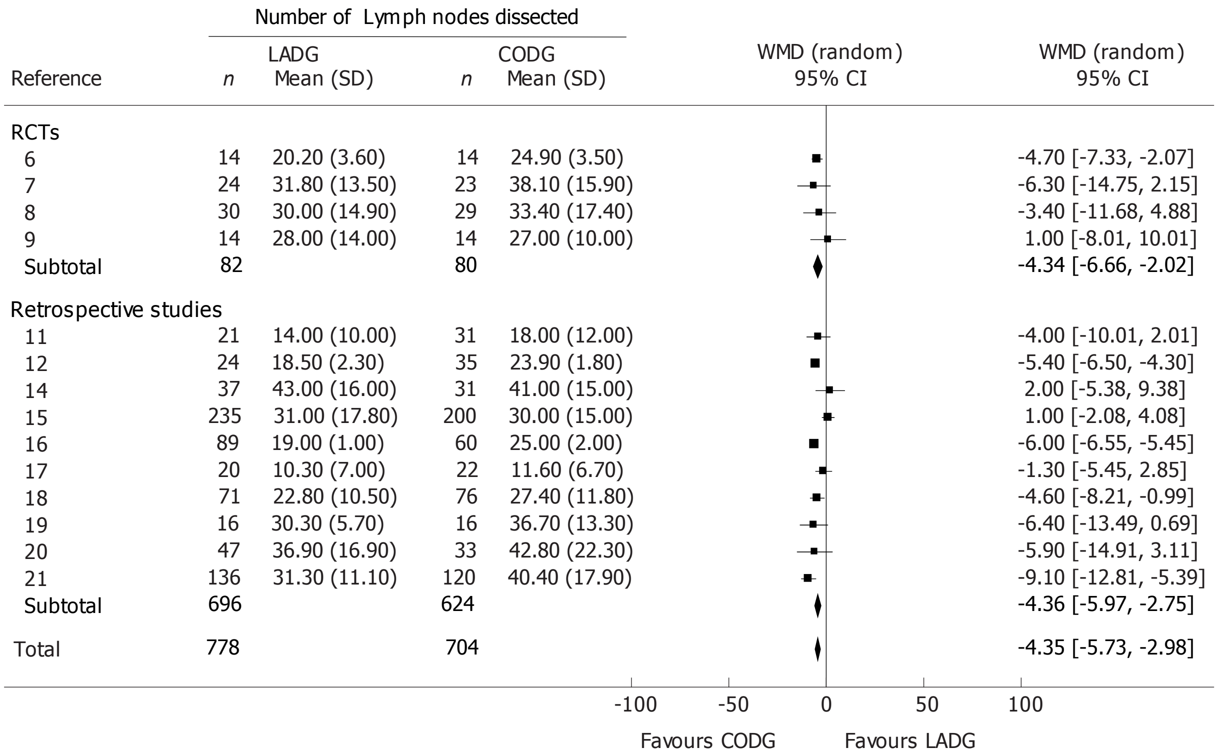


**Figure 1** Analysis of the number of lymph nodes dissected. Weighted mean differences (WMDs) are shown with 95% CI.

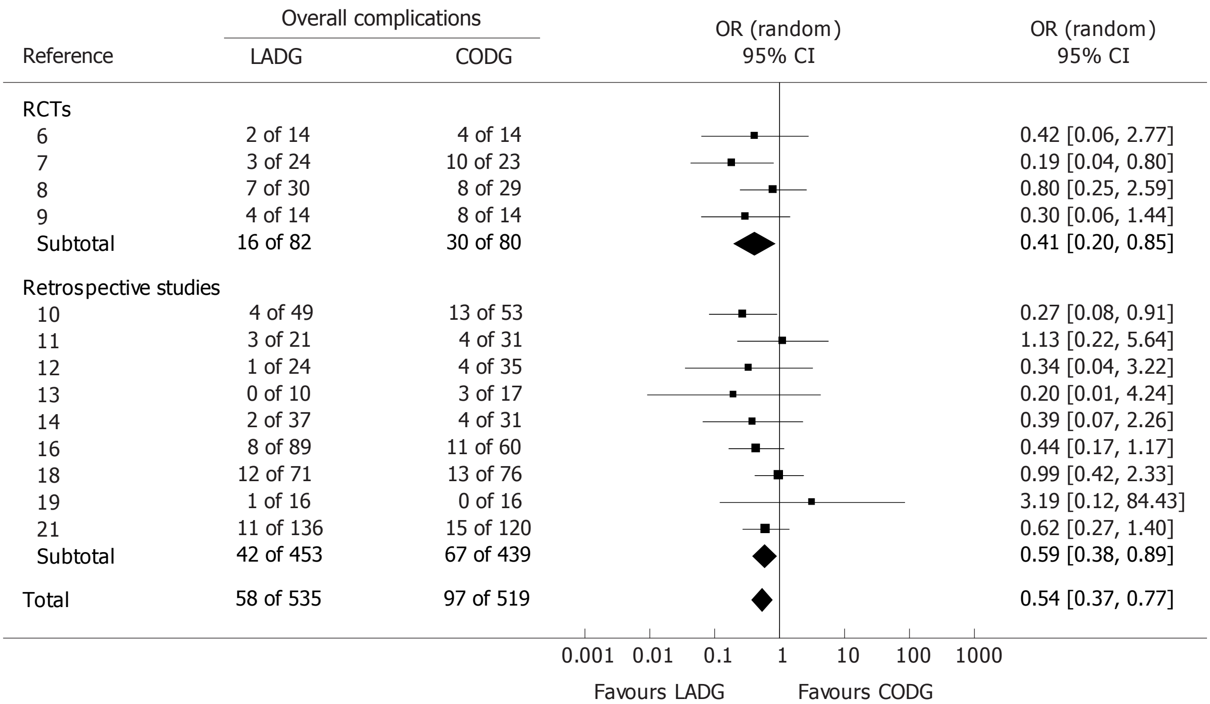


**Figure 2** Analysis of overall complications. Weighted mean differences (WMDs) are shown with 95% CI.

than that after CODG. Data regarding the duration of postoperative hospital stay was provided in 15 studies[6-19,21], which included 1531 patients. From our analysis, this duration was 5.5 d shorter for LADG patients than for CODG patients ($P < 0.001$). Variability of the duration of postoperative hospital stay was extremely high with a mean duration ranging from 7.8 to 29.2 d in LADG and from 11.2 to 40.7 d in CODG. However, most individual studies, except 4 studies[6,7,13,19], reported a significantly shorter hospital stay after LADG than after CODG. The number of days with body temperatures more than 37℃ was reported in 5 studies[9-11,14,17]. Body temperatures normalized 1.3 d earlier in LADG patients than in CODG patients. WBC counts on postoperative d 1, 3, and 7 were

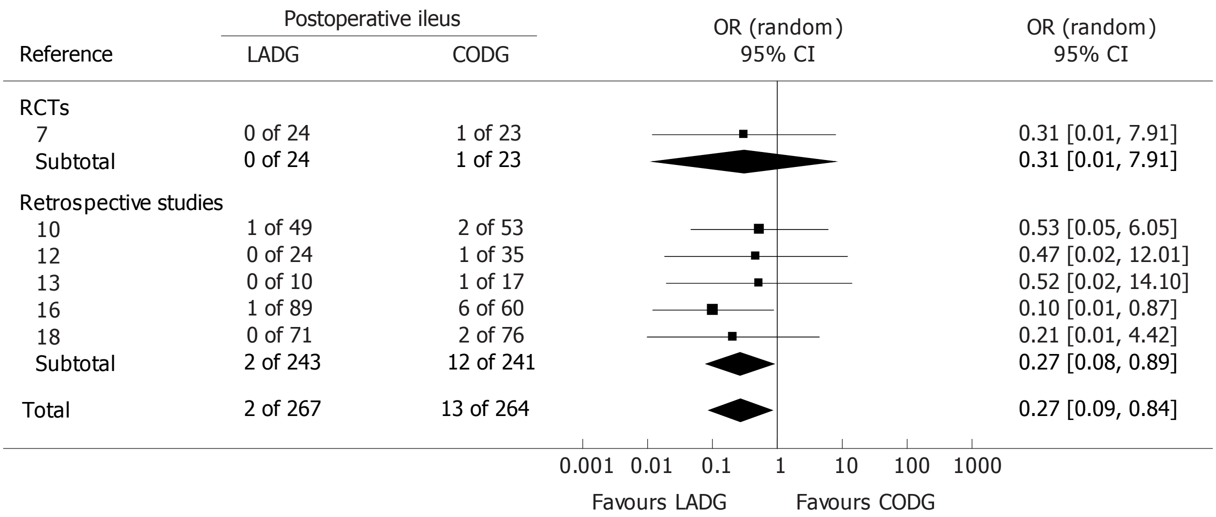


**Figure 3** Analysis of postoperative ileus. Odds ratios (ORs) are shown with 95% CI.

**Table 3 Morbidity and mortality**

| Outcome | Type of studies included in the meta-analysis | Trials ($n$) | LADG | | CODG | | Pooled results OR (95% CI) | Interpretation | Test for heterogeneity |
|---|---|---|---|---|---|---|---|---|---|
| | | | Events | Patients ($n$) | Events | Patients ($n$) | | | |
| Overall complications | RCTs | 4 | 16 | 82 | 30 | 80 | 0.41 (0.20, 0.85) $Z$ = 2.41, $P$ = 0.02 | L < C | $\chi^2$ = 2.52, df = 3 $P$ = 0.47, $I^2$ = 0% |
| | Overall | 13 | 58 | 535 | 97 | 519 | 0.54 (0.37, 0.77) $Z$ = 3.37, $P$ < 0.001 | L < C | $\chi^2$ = 9.11, df = 12 $P$ = 0.69, $I^2$ = 0% |
| Anastomotic leakage | RCTs | 2 | 0 | 44 | 3 | 43 | 0.23 (0.02, 2.18) $Z$ = 1.28, $P$ = 0.20 | L = C | $\chi^2$ = 0.07, df = 1 $P$ = 0.80, $I^2$ = 0% |
| | Overall | 7 | 2 | 385 | 10 | 365 | 0.38 (0.12, 1.18) $Z$ = 1.67, $P$ = 0.10 | L = C | $\chi^2$ = 0.96, df = 6 $P$ = 0.99, $I^2$ = 0% |
| Anastomotic stenosis | RCTs | 2 | 0 | 38 | 2 | 37 | 0.31 (0.03, 3.11) $Z$ = 1.00, $P$ = 0.32 | L = C | $\chi^2$ = 0.00, df = 1 $P$ = 1.00, $I^2$ = 0% |
| | Overall | 5 | 6 | 172 | 5 | 163 | 1.11 (0.35, 3.54) $Z$ = 0.18, $P$ = 0.86 | L = C | $\chi^2$ = 2.01, df = 4 $P$ = 0.73, $I^2$ = 0% |
| Postoperative ileus | Overall | 6 | 2 | 267 | 13 | 264 | 0.27 (0.09, 0.84) $Z$ = 2.26, $P$ = 0.02 | L < C | $\chi^2$ = 1.40, df = 5 $P$ = 0.92, $I^2$ = 0% |
| Pulmonary complications | RCTs | 4 | 10 | 82 | 19 | 80 | 0.47 (0.20, 1.12) $Z$ = 1.70, $P$ = 0.09 | L = C | $\chi^2$ = 1.95, df = 3 $P$ = 0.58, $I^2$ = 0% |
| | Overall | 8 | 12 | 260 | 22 | 271 | 0.54 (0.25, 1.15) $Z$ = 1.59, $P$ = 0.11 | L = C | $\chi^2$ = 3.66, df = 7 $P$ = 0.82, $I^2$ = 0% |
| Wound infection | RCTs | 2 | 3 | 54 | 3 | 52 | 0.96 (0.18, 5.01) $Z$ = 0.05, $P$ = 0.96 | L = C | $\chi^2$ = 0.05, df = 1 $P$ = 1.00, $I^2$ = 0% |
| | Overall | 9 | 9 | 448 | 13 | 421 | 0.69 (0.30, 1.57) $Z$ = 0.89, $P$ = 0.37 | L = C | $\chi^2$ = 3.00, df = 8 $P$ = 0.93, $I^2$ = 0% |
| Mortality | Overall | 2 | 2 | 101 | 3 | 105 | 0.67 (0.11, 4.24) $Z$ = 0.43, $P$ = 0.67 | L = C | $\chi^2$ = 0.19, df = 1 $P$ = 0.66, $I^2$ = 0% |

L: Laparoscopy-assisted distal gastrectomy; C: Conventional open distal gastrectomy; OR: Odds ratio; CI: Confidence intervals; RCTs: Randomized controlled trials; df: Degree of freedom.

reported in 7[9-11,13,14,17,18], 5[9,10,13,17,18], and 4[9,10,17,18] studies, respectively; serum CRP levels on postoperative d 1, 3, and 7 were reported in 5[9,10,13,14,17], 4[9,10,13,17], and 3[9,10,17] studies, respectively. The increase in both WBC counts and CRP levels on postoperative d 1 and 3 was significantly less in LADG patients than in CODG patients; however, there was no significant difference with regard to WBC counts and CRP levels on postoperative d 7 between these two groups. A summary of the pooled results with regard to the postoperative clinical course is presented in Table 4.

## DISCUSSION

In this meta-analysis, we compared the feasibility and advantages of LADG with those of CODG to elucidate the current status of LADG. Although LADG was found to be a significantly longer procedure, its associated morbidity rate was lower than that of CODG. This observation was most significant with regard to postoperative ileus. There was no significant difference between the two groups with regard to anastomotic, pulmonary, and wound complications and mortality.

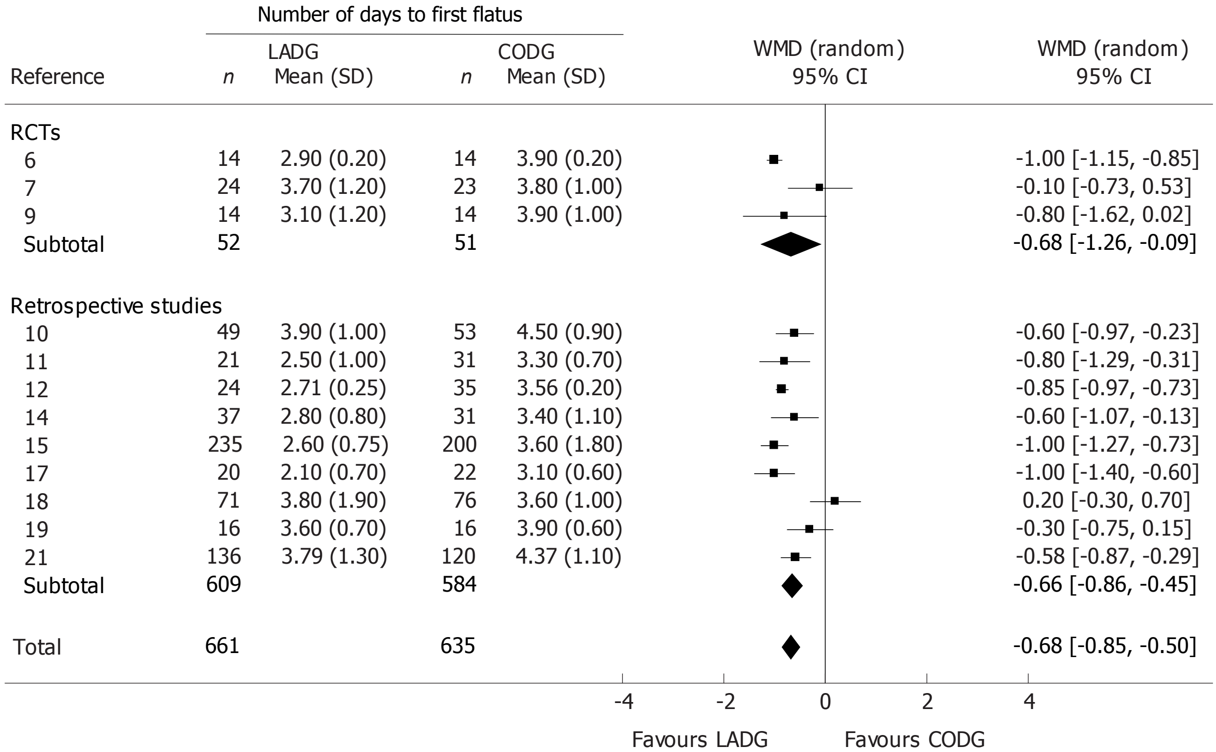


**Figure 4** Analysis of the number of days from surgery to the first passage of flatus. Weighted mean differences (WMDs) are shown with 95% CI.

**Table 4 Clinical course after operation**

| Outcome | Type of studies included in the meta-analysis | Trials ($n$) | Patients ($n$) | Pooled results WMD (95% CI) | Interpretation | Test for heterogeneity |
|---|---|---|---|---|---|---|
| Bowel function recovery | RCTs | 3 | 103 | -0.68 (-1.26, -0.09) $Z$ = 2.27, $P$ = 0.02 | L < C | $\chi^2$ = 7.55, df = 2 $P$ = 0.02, $I^2$ = 73.5% |
| | Overall | 12 | 1296 | -0.68 (-0.85, -0.50) $Z$ = 7.63, $P$ < 0.001 | L < C | $\chi^2$ = 39.6, df = 11 $P$ < 0.001, $I^2$ = 72.2% |
| Frequency of analgesic requirement | RCTs | 3 | 103 | -1.69 (-2.18, -1.21) $Z$ = 6.82, $P$ < 0.001 | L < C | $\chi^2$ = 0.12, df = 2 $P$ = 0.94, $I^2$ = 0% |
| | Overall | 6 | 394 | -1.36 (-2.44, -0.28) $Z$ = 2.48, $P$ = 0.01 | L < C | $\chi^2$ = 40.6, df = 5 $P$ < 0.001, $I^2$ = 87.7% |
| No. of days with temperatures more than 37℃ | Overall | 5 | 292 | -1.25 (-1.69, -0.82) $Z$ = 5.64, $P$ < 0.001 | L < C | $\chi^2$ = 2.05, df = 4 $P$ = 0.73, $I^2$ = 0% |
| Duration of hospital stay | RCTs | 4 | 162 | -3.32 (-7.69, 1.05) $Z$ = 1.49, $P$ = 0.14 | L = C | $\chi^2$ = 33.5, df = 3 $P$ < 0.001, $I^2$ = 91.1% |
| | Overall | 15 | 1531 | -5.51 (-7.61, -3.42) $Z$ = 5.16, $P$ < 0.001 | L < C | $\chi^2$ = 280.7, df = 14 $P$ < 0.001, $I^2$ = 95.0% |
| WBC (POD 1) | Overall | 7 | 466 | -1409.5 (-1934.6, -884.4) $Z$ = 5.26, $P$ < 0.001 | L < C | $\chi^2$ = 5.63 , df = 6 $P$ = 0.47, $I^2$ = 0% |
| WBC (POD 3) | Overall | 5 | 346 | -1028.1 (-1578.7, -477.4) $Z$ = 3.66, $P$ < 0.001 | L < C | $\chi^2$ = 4.18, df = 4 $P$ = 0.38, $I^2$ = 4.2% |
| WBC (POD 7) | Overall | 4 | 319 | -280.1 (-751.7, 191.5) $Z$ = 1.16, $P$ = 0.24 | L = C | $\chi^2$ = 1.73, df = 3 $P$ = 0.63, $I^2$ = 0% |
| CRP (POD 1) | Overall | 5 | 267 | -1.33 (-2.20, -0.46) $Z$ = 3.01, $P$ = 0.003 | L < C | $\chi^2$ = 7.24, df = 4 $P$ = 0.12, $I^2$ = 44.8% |
| CRP (POD 3) | Overall | 4 | 199 | -3.71 (-6.61, -0.80) $Z$ = 2.50, $P$ = 0.01 | L < C | $\chi^2$ = 24.4, df = 3 $P$ < 0.001, $I^2$ = 87.7% |
| CRP (POD 7) | Overall | 3 | 172 | -1.33 (-2.90, 0.25) $Z$ = 1.65, $P$ = 0.10 | L = C | $\chi^2$ = 8.36, df = 2 $P$ = 0.02, $I^2$ = 76.1% |

L: Laparoscopy-assisted distal gastrectomy; C: Conventional open distal gastrectomy; RCTs: Randomized controlled trials; CRP: C-reactive protein; POD: Postoperative day; WMD: Weighted mean difference; CI: Confidence intervals; df: Degree of freedom.

Gastrointestinal recovery was faster after LADG. Furthermore, the frequency of additional analgesic requirement, number of d with temperatures more than 37℃, duration of postoperative hospital stay, and acute inflammatory reaction in terms of WBC counts and CRP levels were significantly lower after LADG. However, the number of lymph nodes dissected in CODG patients was significantly higher than that in LADG patients.

LADG with systematic lymphadenectomy is considered technically more complicated than other laparoscopic procedures such as laparoscopic cholecystectomy and colon resection because in LADG, large vessels have to be identified and extensive lymph node dissection has to be performed. Although the learning curve of LADG has reached a plateau, LADG remains a time-consuming procedure[22]. However, with improvements in instruments and techniques, the operating time for LADG would decrease[10,21]. Furthermore, Kim *et al*[23] claimed that the operating time for LADG is related to the knowledge of and familiarity with the laparoscopic system and instruments and the skill of the operating team. The prevalence of standard techniques and the development of an education and training system would be important in the future.

The Japanese Gastric Cancer Association guideline recommends the following optimal lymph node dissection levels for early gastric cancer: perigastric lymph nodes (D1) and lymph nodes along the left gastric artery for mucosal cancer and for submucosal cancer < 1.5 cm in diameter; D1 and lymph nodes along the left gastric artery and the celiac axis for preoperatively diagnosed submucosal cancer without lymph node metastasis and for early cancer < 2.0 cm in diameter with only perigastric lymph node metastasis; and D2 (D1 and lymph nodes along the left gastric, common hepatic, proper hepatic, celiac, and splenic arteries) for early cancer > 2.0 cm in diameter with lymph node metastasis[24]. On the other hand, many surgeons in the USA and other Western countries rarely perform extensive prophylactic lymphadenectomy because 2 European randomized trials[25,26] showed that there was no survival advantage of D2 over D1 lymphadenectomy, and that operative mortality and morbidity were higher after D2 than after D1 lymphadenectomy. Although there exists some controversy about whether D2 lymphadenectomy is superior to D1 lymphadenectomy in conventional open surgery for gastric cancer, some studies[7,8,14,15,19,27] reported that the mortality and morbidity rates after LADG with D2 lymphadenectomy were acceptable. However, with regard to the number of dissected lymph nodes, which was considered to reflect the quality of lymphadenectomy, our meta-analysis of all the published studies showed that CODG was superior to LADG; meta-analysis of only the RCTs also showed a similar result. Miura *et al*[27] demonstrated that a significantly higher number of lymph nodes were harvested by CODG, and that the difference was significant for the perigastric lymph nodes along the major curvature and the second tier nodes along the celiac and splenic arteries. One of the explainable reasons for these observations is that several studies included in our meta-analysis might have been conducted during the learning phase of LADG. However, Fujiwara *et al*[22] reported that there was no difference between their preliminary study and the study following the learning curve with regard to the number of dissected lymph nodes in LADG. To obtain a definitive answer, a well-designed RCT following the learning curve of LADG would be required. Our meta-analysis may indicate that during the learning phase, LADG should be performed for early gastric cancer with low potential of lymph node metastasis.

The principal advantage of laparoscopic surgery is the reduction in the stress induced by minimal manipulation of the small bowel and the use of a small incision, which accounts for early bowel function recovery and prevention for postoperative ileus. It is noteworthy that all the aforementioned advantages were obtained despite the longer operating time for LADG. Faster bowel function recovery could lead to early resumption of oral intake, and subsequently early hospital discharge. Furthermore, it could result in less postoperative nausea, vomiting, and abdominal discomfort. Mitigating surgical stress reduces the generalized inflammatory reaction; consequently, it might lead to a reduction in the overall complication rate.

The application of LADG for gastric cancer is still controversial because of the lack of clinical evidence regarding its long-term outcomes. Indeed, there is only 1 prospective randomized controlled trial of the long-term outcomes of LADG[8]. Huscher *et al*[8] noted that there was no significant difference in the 5-year overall survival and disease-free survival between LADG and ODG. Several retrospective studies reported comparable results[15,16,28]. However, the lack of statistical significance in the long-term outcomes may be attributable to the small sample size.

Our study demonstrated that all the comparative studies published in the English literature preferred LADG to CODG for the treatment of gastric cancer with regard to short-term outcomes. However, it is uncertain whether there is any need to perform a meta-analysis. The poor methodology of the available trials may be anticipated and their heterogeneity may be statistically proven later although no heterogeneity was observed with regard to the analysis of postoperative complications. The explainable reasons for the heterogeneity were the different levels of laparoscopic expertise; the issue related to the learning curve; different levels of lymphadenectomy; nonblinded assessment of outcomes; lack of randomization, except 4 RCTs; and the assumption regarding the mean and standard deviation. Based on these reasons, we employed the random effects model of DerSimonian and Laird[29] even when statistically significant heterogeneity was not detected. However, in the future, a well-designed RCT with a large sample size would be required to aptly compare the controversial outcome measures, particularly the operating time and quality of lymphadenectomy.

In conclusion, compared to CODG, LADG for early gastric cancer is associated with a lower morbidity, less pain, faster bowel function recovery, and a shorter hospital stay. To establish LADG as the standard treatment for gastric cancer, further studies should be conducted with regard to the following aspects: (1) the prevalence of standard techniques and the development of an education and training system and, (2) well-designed RCTs following the learning curve of LADG to increase the statistical power and elucidate oncological clearance, including the quality of lymphadenectomy and long-term outcomes.

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## COMMENTS

### Background

Nowadays, laparoscopy-assisted distal gastrectomy (LADG) for the treatment of early gastric cancer is a well-established procedure. However, the feasibility and advantages of LADG have not been thoroughly evaluated thus far. Therefore, we attempted a meta-analysis to elucidate the current status of LADG with regard to its short-term outcomes by comparing it with conventional open distal gastrectomy (CODG).

### Research frontiers

The application of LADG for gastric cancer is still controversial because of the lack of clinical evidence regarding its long-term outcomes.

### Innovations and breakthroughs

This paper summarizes all the published data comparing LADG with CODG.

### Peer review

This paper will provide useful information for the readers of the *World Journal of Gastroenterology* regarding the daily management of patients with gastric cancer.

**S- Editor** Liu Y **L- Editor** Zhu LH **E- Editor** Bi L