Meta-analysis of laparoscopic versus open D2 gastrectomy in managing locally advanced gastric cancer: early postoperative course and pathological outcomes

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Background

With a fifth incidence and a third death rate among all malignancies, stomach cancer is a serious worldwide health problem. The best course of treatment is removing all lymph nodes together with the tumor, increasing the likelihood of survival. Laparoscopic gastrectomy has become more common because of its advantages in terms of appearance, decreased discomfort, and shorter hospital stays; this is especially true in Korea and Japan. For locally advanced gastric cancer, it is still unclear if laparoscopic D2 gastrectomy is more feasible and effective than open surgery.

Patients and methods

This study conducted a systematic review and meta-analysis to evaluate the differences between laparoscopic and open D2 gastrectomy in terms of feasibility, radicality, surgical outcomes, and postoperative complications. PRISMA statement guidelines and Cochrane handbook for Systematic Reviews of Interventions were followed. Relevant databases were searched, and studies published between 2017 and September 2022 were included. Key outcome measures included operative time, blood loss, postoperative recovery, pathological outcomes, and lymph node involvement.

Results

The meta-analysis included a total of 22 studies. The operative time was significantly shorter for laparoscopic D2 gastrectomy compared with open surgery. However, laparoscopic D2 gastrectomy was associated with higher blood loss. Postoperative recovery measures, such as the time to first flatus and first oral intake, were significantly shorter for laparoscopic D2 gastrectomy. Pathological outcomes showed no significant differences in terms of resection margins and tumor size. The number of harvested lymph nodes did not significantly differ between laparoscopic and open D2 gastrectomy. Laparoscopic D2 gastrectomy demonstrated a lower rate of positive lymph nodes compared with open surgery.

Conclusion

Based on the findings of this meta-analysis, laparoscopic D2 gastrectomy seems to be a safe and practical procedure for treating patients with locally advanced gastric cancer. It is associated with reduced blood loss, faster postoperative recovery, equivalent postoperative complications, and comparable oncological safety. These results support the use of laparoscopic D2 gastrectomy as an effective alternative to open surgery in the management of advanced gastric cancer.

Keywords:
gastric cancer, laparoscopic, open D2 gastrectomy

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Introduction

Globally, more thanone million new cases of gastric cancer were diagnosed in 2018, making it the fifth most common cancer in the world. Gastric cancer was estimated as responsible for about 783 000 deaths worldwide in 2018, making it the third most lethal cancer type (GLOBOCAN, 2018).

The cornerstone of treatment for possibly curable gastric cancer is gastrectomy combined with proper lymphadenectomy [1].

Open gastrectomy (OG) has remained the mainstay of curative approach for gastric cancer for a long time. In 1994, Kitano first described the efficacy of laparoscopy gastrectomy (LG) in the case of early-stage carcinoma in the antrum of the stomach [2].

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Compared with open surgery, LG offers several benefits, including improved cosmesis, less discomfort, and shorter hospital stays [3–5].

LG has become the usual treatment for early-stage gastric cancer in Korea and Japan due to advancements in laparoscopic technology [6].

Some surgeons are worried about the use of laparoscopic D2 lymphadenectomy in gastric cancer as expertise with LG for early gastric cancer has grown [7]. Furthermore, compared with D1 lymphadenectomy, D2 lymphadenectomy is a more difficult surgery [8].

In a D2 distal gastrectomy, the 8a, 9p, and 12a lymph node groups are removed in addition to D1 lymphadenectomy. In a D2 complete gastrectomy, lymph node stations 1 through 12a are removed. Clinical N+ or clinical T2–T4 cancers should be treated with D2 lymphadenectomy [9].

In cases of stomach cancer, total surgical resection continues to be the sole treatment option. To reduce the possibility of microscopically positive margins, 4 cm gross margins are now advised by NCCN recommendations [10].

A recent study has found that whereas D2 lymphadenectomy was linked to considerably greater disease-specific survival, the removal of the pancreas and spleen also increased the postoperative death rate. The pancreas and spleen are spared during a modified D2 gastrectomy, reducing postoperative mortality. However, if the tumor is linked to the pancreas or spleen, then removal of those organs is required [11].

For the best short-term oncological results, a skilled surgeon can conduct a safe and feasible laparoscopic D2 gastrectomy. To examine long-term results, however, more cases with an adequate follow-up duration are required [12].

Aim

The study aims to review the difference between open and laparoscopic D2 gastrectomy in patients with locally advanced gastric cancer in terms of feasibility and radicality. In addition to evaluate the surgical outcomes and postoperative complications.

Patients and methods

Literature search

This research was performed at the Department of General Surgery, Ain Shams University. Ethical Committee approval and written, informed consent were obtained from all patients. A systematic review of the literature from PubMed, Cochrane, Web of Science, Nature, and Google Scholar from 2017 till September 2022 relevant keywords was performed to identify all relevant publications. Search terms included controlled terms from Medical Subject Headings (MeSH) in PubMed and Embase's thesaurus (Emtree) in Embase.

Search strategy and study selection

We used the following search strategy for searching different databases: ('Gastric cancer' OR 'Stomach neoplasms') AND ('D2 gastrectomy' OR 'D2 lymphadenectomy' OR 'Locally advanced gastric cancer') OR ('Open D2 gastrectomy' AND 'Laparoscopic D2 gastrectomy') AND ('Early postoperative complications' OR 'Surgical margins' OR 'Harvest lymph nodes' OR 'Pathological outcome').

Selection criteria

The search findings were independently evaluated for potential eligibility for the meta-analysis. The inclusion criteria were: (a) study designs that included randomized controlled trials, case–control studies, and cohort studies; (b) having compared the two surgical procedures, LG versus OG for the treatment of advanced gastric cancer; (c) having reported detailed/available data of the surgical results, including short-term/long-term results; and (d) the article had to be written in English.However, our exclusion criteria were as follows: the papers containing any of the following criteria were excluded (a) robot-assisted gastrectomy, (b) no OG as a control group, (c) abstract only, (d) insufficient data, and (e) we excluded the duplicated articles by the same author unless those with longer follow-ups studies.

No restrictions were placed on the screening of search data for any published articles. The two parts of titles and abstract screening were followed by full-text screening. To identify any other acceptable studies that might have been overlooked in the preceding processes, reference lists of the included studies were carefully searched.

Statistical analysis

Utilizing Review Manager (RevMan), version 5.4, all statistical analyses were carried out. Forest plots were used to combine comparable data for the outcomes from the included research. We used funnel plots to identify any publication bias. For dichotomous variables, the risk difference and 95% confidence intervals (CIs) were reported, whereas for continuous variables, the mean difference (MD) and 95% CI were shown. To investigate study heterogeneity, Cochrane's P values and I^2 were examined. A random effect model was used in this meta-analysis to overcome the high degree of heterogeneity that was likely present due to clinical and methodological issues.

Results

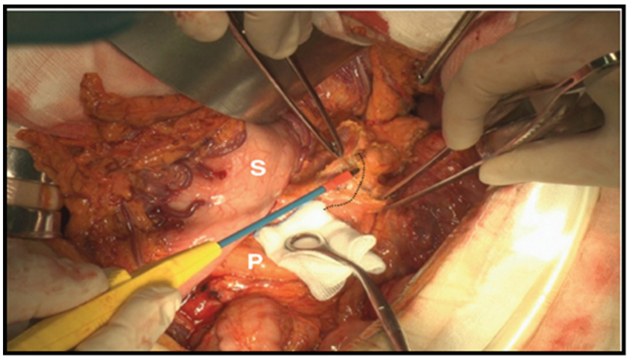
Literature search results

The initial search resulted in 1851 articles from four databases including PubMed, Cochrane, Web of Science, and Nature. Five papers are retrieved from Google Scholar. Of these, 1851 articles we excluded, 710 articles due to duplication. In all, 1141 articles underwent title and abstract screening, and 1103 were excluded because they did not meet the inclusion criteria. The remaining 38 articles underwent full-text screening. A total of studies were finally included for the final qualitative synthesis and the quantitative analysis. We excluded 16 studies after full-text screening. Exclusion from the full-text screening was based on the following reasons: 10 papers did not satisfy the eligible criteria, one paper was meta-analysis, two papers were of insufficient data, and the last two were not found The PRISMA flow diagram show the literature search results. (Fig. 5).

Characteristics of the included studies

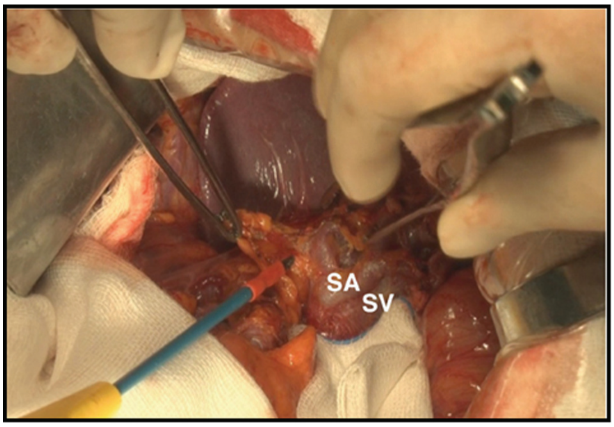
Twenty-two studies were on D2 gastrectomy using a laparoscope and OG. The included studies focused on some baseline characteristics, that is age and BMI. Early postoperative course evaluation included, that is operative time (min), blood loss (ml), hospital stay (day), first flatus (day), and first oral intake (day).

Figure 1



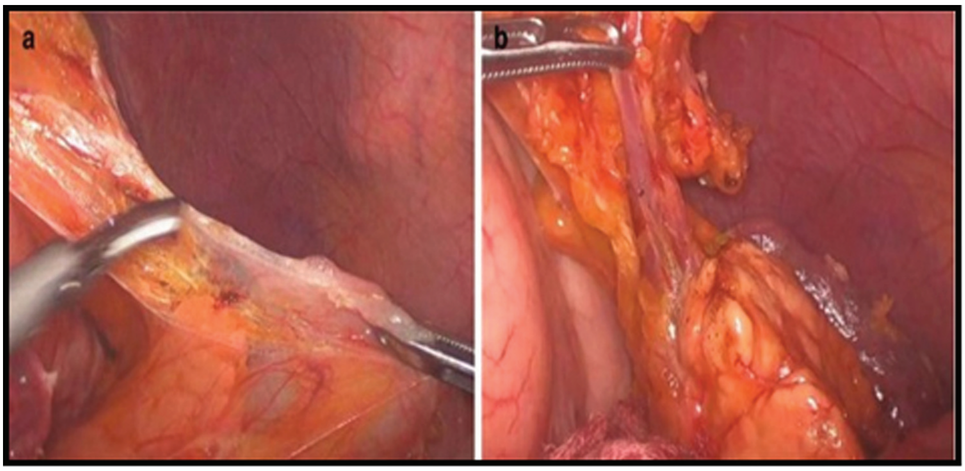
Suprapancratic lymph node dissection between station 11p and station 11d. Dot line upper border of the pancreas: S, stomach and P, pancreas [13].

Figure 2



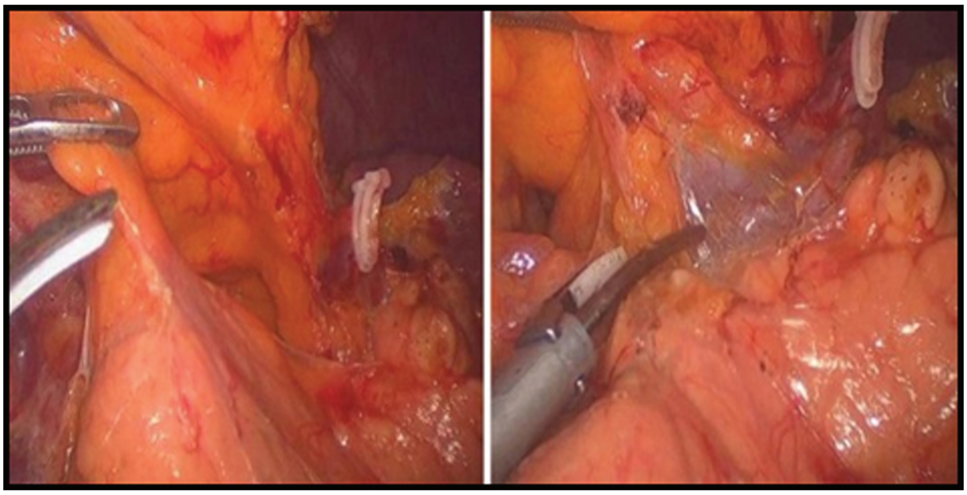
Exposed splenic vessel at the hilum of the spleen for station 10 lymph node dissection. SA, splenic artery and SV, splenic vein [13].

Figure 3



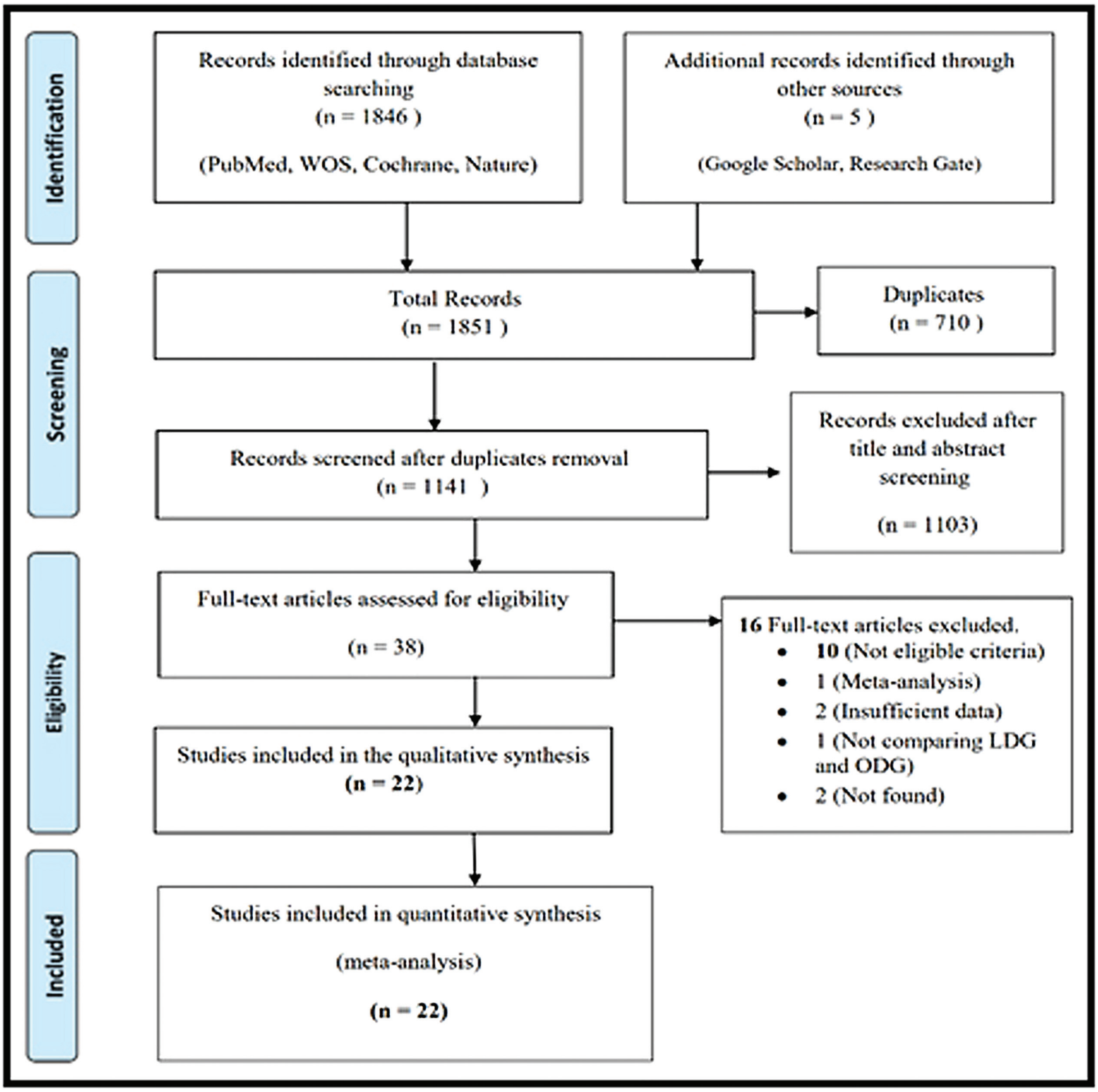
Total omentectomy (a) and isolation of the left gastroepiploic vessels (b) [14].

Figure 4



Splenic vessel exposure at the junction between station 11p and station 11d [14].

Figure 5



PRISMA flow diagram of the literature search results.

Table 1 Summary of the included studies and NOS score for cohort and case–control studies

References	Design	Country	New castle Ottawa scale
Xu *et al.* [15]	Case–control study	China	9
Zhang *et al.* [16]	Case–control study	China	9
Li *et al.* [17]	Cohort study	China	6
Ludwig *et al.* [18]	Cohort study	Germany	8
Shi *et al.* [5]	Randomized controlled trial	China	–
Huang *et al.* [19]	Cohort study	China	7
Shibuya *et al.* [20]	Cohort study	Japan	7
Wang *et al.* [21]	Randomized controlled trial	China	–
Xu *et al.* [22]	Cohort study	China	9
Ammori *et al.* [23]	Cohort study	Jordan	9
Garbarino *et al.* [24]	Cohort study	China	9
Xi *et al.* [25]	Cohort study	China	8
Wang *et al.* [26]	Cohort study	China	9
Feng *et al.* [27]	Cohort study	China	8
Fujisaki *et al.* [28]	Cohort study	Japan	8
Khaled *et al.* [29]	Cohort study	Egypt	8
Long *et al.* [30]	Cohort study	China	9
Trastulli *et al.* [31]	Case study	Italy	8
Wang *et al.* [32]	Cohort study	China	7
Wu *et al.* [33]	Cohort study	Taiwan	7
Caruso *et al.* [34]	Case–control study	Italy	9
Wei *et al.* [35]	Cohort study	Taiwan	9

Pathological outcomes, that is, the number of resected lymph nodes, were analyzed.

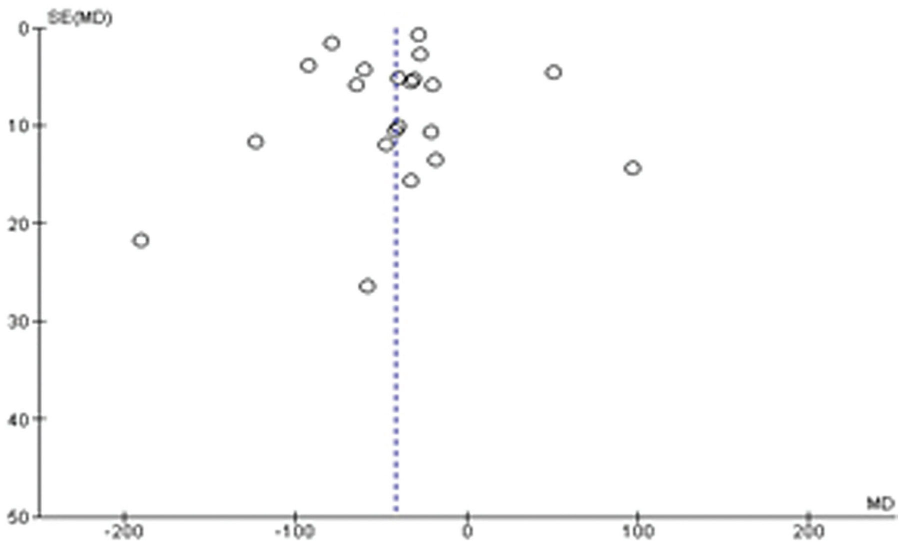
Quality assessment of the included studies by NIH tools was done. Details on the first author, year of publication, study design, country, and NOS score for cohort and case controls were recorded (Table 1).

The procedures used in the included studies were diverse making some sources of heterogeneity between the pooled included studies. The NOS of the included studies ranged from 6 to 9, suggesting that the studies were of acceptable moderate quality.

Publication bias assessment

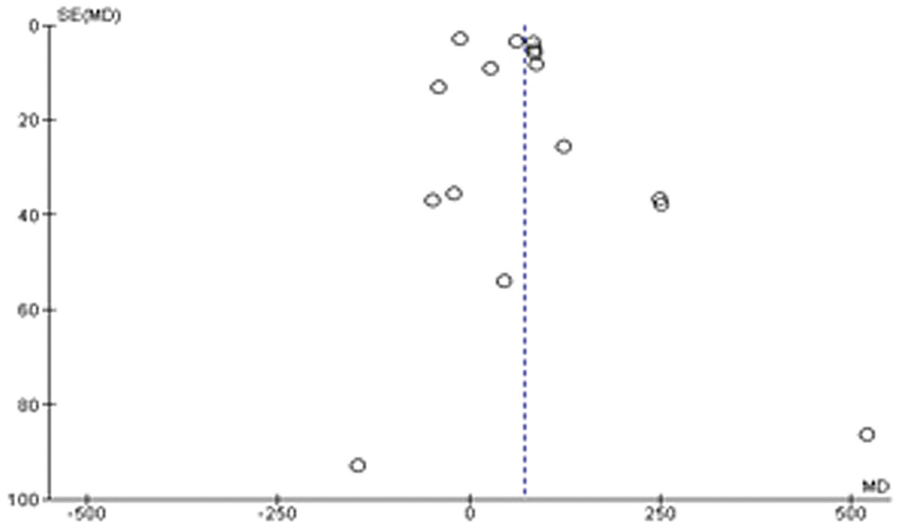
Publication bias in this meta-analysis was presented by the funnel plot Figs 6–9. Funnel plot of operative time, blood loss, and first flutes for laparoscopic versus open D2 gastrectomy. The results were asymmetrically

Figure 6



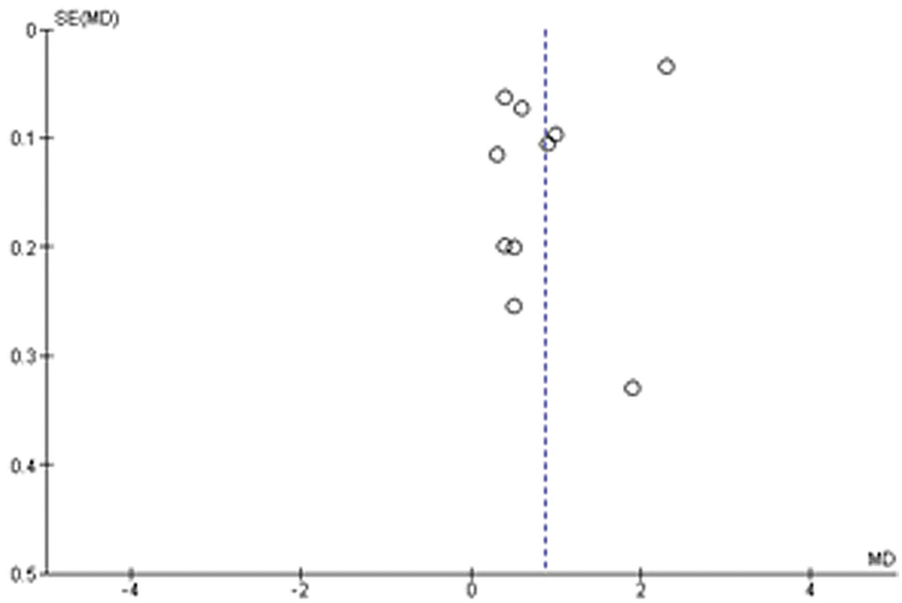
Funnel plot of operative time for laparoscopic versus open D2 gastrectomy.

Figure 7



Funnel plot of blood loss for laparoscopic versus open D2 gastrectomy.

Figure 8



Funnel plot of first flatus for laparoscopic versus open D2 gastrectomy.

distributed, indicating some publication bias in the analysis (Figs 6–8).

Also, the funnel plot of the number of harvest lymph nodes showed asymmetric distribution, meaning the presence of some publication bias in the analysis (Fig. 9).

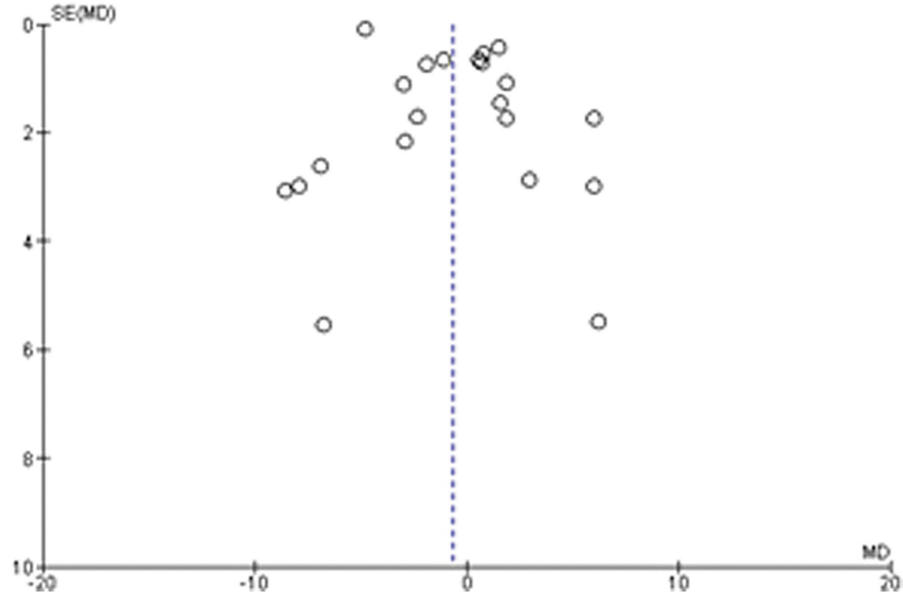
However, the funnel plots do not conduce for other outcomes because the number of studies for each outcome was less than 10 studies to assess the publication bias.

Outcomes

Early postoperative course

Operative time (min): 21 studies reported the operative time (min) for laparoscopic versus open D2 gastrectomy. The overall duration was significantly shorter for OD2G compared with LD2G [MD=−41.34; 95% CI: (−56.50, −26.17), P<0.001]. The pooled studies were heterogeneous (I^2=99, P<0.0001), and heterogeneity could not be resolved due to relative variations between the included studies [5,15,16,18–35] (Fig. 10).

Figure 9

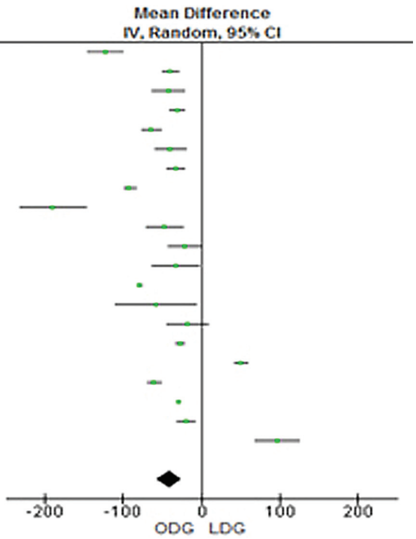


Funnel plot of no of harvest lymph nodes for laparoscopic versus open D2 gastrectomy.

Figure 10

Study or Subgroup	ODG Mean	ODG SD	ODG Total	LDG Mean	LDG SD	LDG Total	Weight	Mean Difference IV, Random, 95% CI	Year
1-Xu- 2017	203	49	67	326	82	67	4.7%	-123.00 [-145.87, -100.13]	2017
2 -Zhang - 2017	245	42	85	285	21	69	5.1%	-40.00 [-50.21, -29.79]	2017
4-Ludwig -2018	193	54	45	235	46	45	4.7%	-42.00 [-62.73, -21.27]	2018
5-Shi-2018	207	42	160	238	52	162	5.1%	-31.00 [-41.32, -20.68]	2018
6-Huang-2019	224	39	238	288	55	110	5.1%	-64.00 [-75.41, -52.59]	2019
7-Shibuya-2019	198	45	27	238	50	87	4.8%	-40.00 [-59.96, -20.04]	2019
8-Wang-2019	210	54	220	243	64	222	5.1%	-33.00 [-44.04, -21.96]	2019
9-Xu - 2019	192	51	768	284	70	430	5.1%	-92.00 [-99.54, -84.46]	2019
10-Ammori-2020	215	24	18	405	89	18	3.7%	-190.00 [-232.58, -147.42]	2020
11-Garbarino - 2020	200	62	45	247	51	46	4.6%	-47.00 [-70.35, -23.65]	2020
12-Wang, N-2020	201	57	221	222	70	49	4.7%	-21.00 [-41.99, -0.01]	2020
13-Xi -2020	229	74	45	262	74	45	4.3%	-33.00 [-63.58, -2.42]	2020
14-Feng-2021	182	12	266	261	26	322	5.2%	-79.00 [-82.19, -75.81]	2021
15-Fujisaki - 2021	322	61	21	380	102	20	3.2%	-58.00 [-109.76, -6.24]	2021
16-Khaled- 2021	280	71	47	298	56	41	4.5%	-18.00 [-44.57, 8.57]	2021
17-Long - 2021	212	36	334	239	36	334	5.2%	-27.00 [-32.46, -21.54]	2021
18-Trastulli- 2021	244	87	624	193	73	624	5.1%	51.00 [42.09, 59.91]	2021
19-Wang - 2021	205	16	46	265	17	23	5.1%	-60.00 [-68.35, -51.65]	2021
20-WU - 2021	277	7	192	305	8	189	5.2%	-28.00 [-29.51, -26.49]	2021
21-Caruso - 2022	192	43	120	212	47	120	5.1%	-20.00 [-31.40, -8.60]	2022
22-Wei - 2022	348	93	81	251	73	53	4.4%	97.00 [68.78, 125.22]	2022
Total (95% CI)			**3670**			**3076**	**100.0%**	**-41.34 [-56.50, -26.17]**	

Heterogeneity: Tau^2 = 1149.90; Chi^2 = 1654.27, df = 20 (P < 0.00001); I^2 = 99%
Test for overall effect: Z = 5.34 (P < 0.00001)

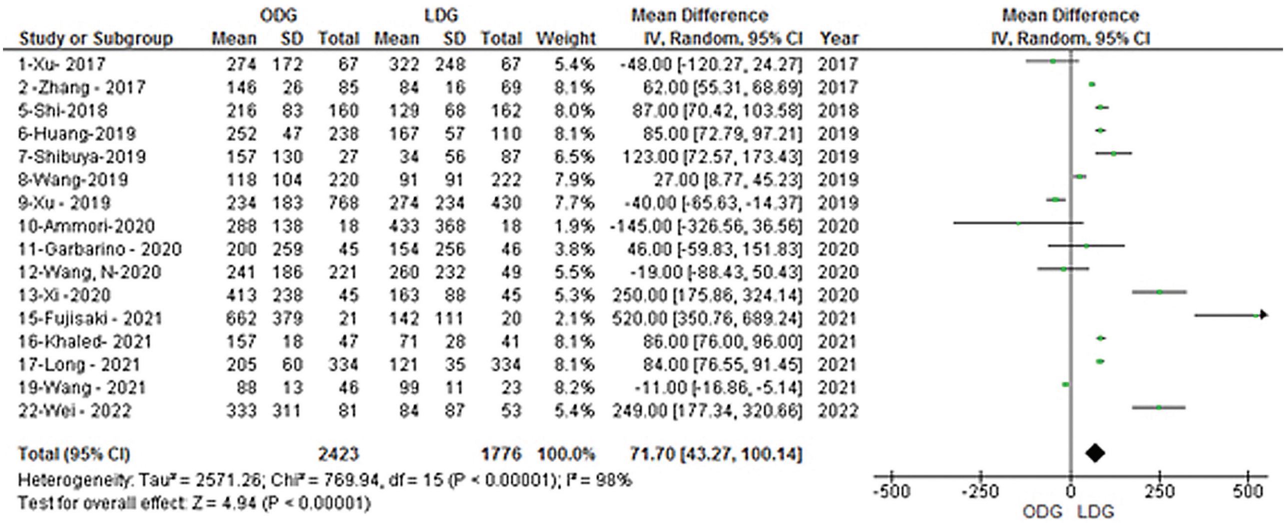


Forest plot of operative time (min) for LD2G and OD2G.

Blood loss (mm): the MD for blood loss (ml) for laparoscopic versus open D2 gastrectomy was estimated by data available in 16 studies. An analysis of the included studies showed that the MD for blood loss was significantly higher for ODG [MD=71.70 ml; 95% CI: (43.27, 100.14), $P<0.001$] meaning that the blood loss in LDG was less than in ODG. The pooled studies were heterogeneous (I^2=98, $P<0.0001$), and heterogeneity could not be resolved due to relative variations between the included studies [5,15,16,19–26,28,29,31,32,35] (Fig. 11).

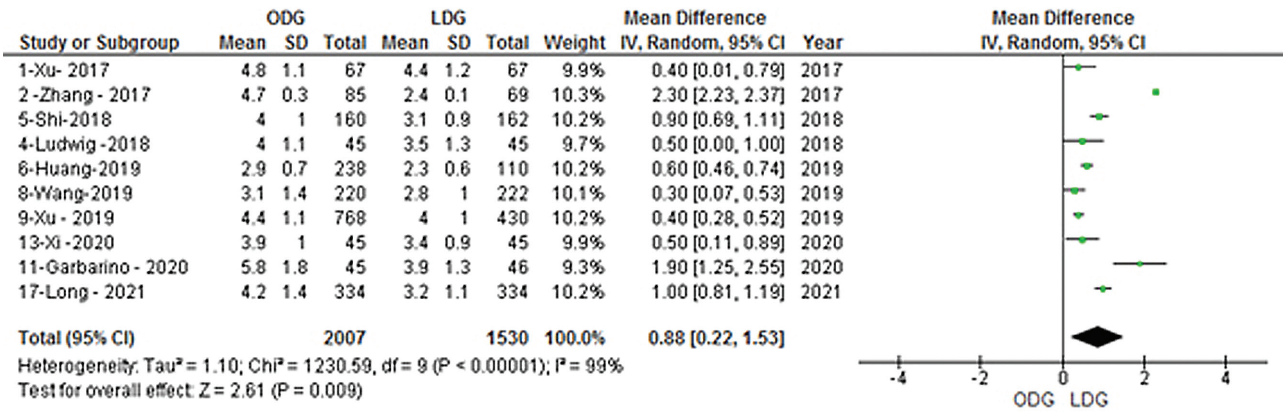
First flatus (day): first flatus (days) for laparoscopic versus open D2 gastrectomy was reported in 10 studies. The overall effect was significantly shorter in the LD2G compared with OD2G [MD=0.88 day; 95% CI: (0.22, 1.53), $P<0.001$]. The pooled studies were heterogeneous (I^2=99%, $P<0.0001$), and

Figure 11



Forest plot of blood loss (ml) for LD2G and OD2G.

Figure 12



Forest plot of first flatus (day) for LD2G and OD2G.

heterogeneity could not be resolved due to relative variations between the included studies [5,15,16,18,19,21,22,26–30] (Fig. 12).

First oral intake (day): the time to first oral intake (days) for laparoscopic versus open D2 gastrectomy was reported in nine studies. The overall effect was significantly shorter in the LD2G compared with OD2G [MD=1.17 day; 95% CI: (0.83, 1.52), $P<0.001$). The pooled studies were heterogeneous (I^2=81%, $P<0.0001$), and heterogeneity could not be resolved due to relative variations between the included studies [5,19,21,22,24,25,28,30,35] (Fig. 13).

Pathological outcomes

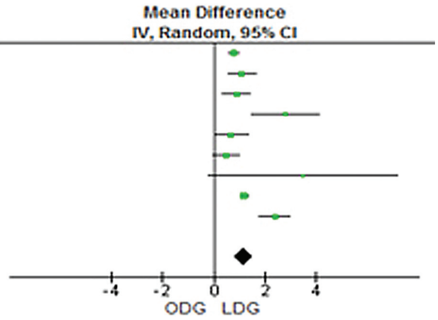
Number of harvest lymph nodes: 21 studies reported the number of harvest lymph nodes for laparoscopic versus open D2 gastrectomy. The overall effect showed a nonsignificant MD between LD2G compared with OD2G [MD=-0.63; 95% CI: (-2.41, 1.14), P=0.48). The pooled studies were heterogeneous (I^2=96, P=0.0001), and heterogeneity could not be resolved due to relative variations between the included studies [5,15,16,18–35] (Fig. 14).

Number of positive lymph nodes: six studies reported positive lymph nodes for laparoscopic versus open D2 gastrectomy. The overall effect was significantly shorter in the LD2G compared with OD2G. [MD=1.42; 95% CI: (0.56, 2.27), P=0.001]. The test of heterogeneous for pooled studies indicates that the used studies were homogeneous (I^2=35%, P=0.19). Therefore, the fixed effect model was used [15,19,24,26,29,32] (Fig. 15).

Figure 13

Study or Subgroup	ODG Mean	ODG SD	ODG Total	LDG Mean	LDG SD	LDG Total	Weight	Mean Difference IV, Random, 95% CI	Year
5-Shi-2018	4.4	1	160	3.6	1	162	16.6%	0.80 [0.58, 1.02]	2018
6-Huang-2019	7.8	2.6	238	6.7	2.4	110	12.2%	1.10 [0.54, 1.66]	2019
8-Wang-2019	7.9	3.7	220	7	1.8	222	12.4%	0.90 [0.36, 1.44]	2019
11-Garbarino - 2020	7.5	4.4	45	4.7	1.4	46	4.9%	2.80 [1.45, 4.15]	2020
13-Xi -2020	4.9	1.9	45	4.2	1.1	45	11.1%	0.70 [0.06, 1.34]	2020
19-Wang - 2021	6	1	46	5.5	1	23	13.0%	0.50 [-0.00, 1.00]	2021
15-Fujisaki - 2021	11.3	7.3	21	7.8	4.5	20	0.8%	3.50 [-0.19, 7.19]	2021
17-Long - 2021	4.2	1.1	334	3	1	334	17.2%	1.20 [1.04, 1.36]	2021
22-Wei - 2022	5.4	1.4	81	3	1.9	53	11.7%	2.40 [1.80, 3.00]	2022
Total (95% CI)			**1190**			**1015**	**100.0%**	**1.17 [0.83, 1.52]**	

Heterogeneity: Tau² = 0.18; Chi² = 42.20, df = 8 (P < 0.00001); I² = 81%
Test for overall effect: Z = 6.61 (P < 0.00001)

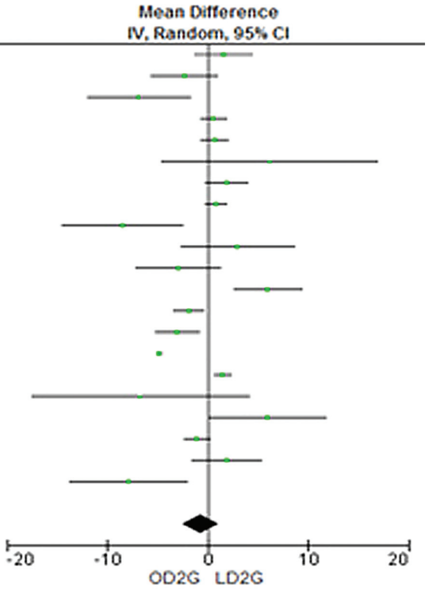


Forest plot of first oral intake (day) for LD2G and OD2G.

Figure 14

Study or Subgroup	OD2G Mean	OD2G SD	OD2G Total	LD2G Mean	LD2G SD	LD2G Total	Weight	Mean Difference IV, Random, 95% CI	Year
1-Xu- 2017	25.6	8.8	67	24	8.2	67	5.3%	1.60 [-1.28, 4.48]	2017
2 -Zhang - 2017	37.9	9.6	85	40.2	11.2	69	5.0%	-2.30 [-5.64, 1.04]	2017
4-Ludwig -2018	31.9	10.8	45	38.8	13.8	45	4.0%	-6.90 [-12.02, -1.78]	2018
5-Shi-2018	32.2	6.1	160	31.6	5.9	162	5.9%	0.60 [-0.71, 1.91]	2018
6-Huang-2019	30.6	5.4	238	29.9	6.5	110	5.9%	0.70 [-0.70, 2.10]	2019
7-Shibuya-2019	53.6	25.9	27	47.4	15.2	45	1.9%	6.20 [-4.53, 16.93]	2019
8-Wang-2019	31.4	12.3	220	29.5	10.4	222	5.6%	1.90 [-0.22, 4.02]	2019
9-Xu - 2019	22.4	10.3	768	21.6	8.6	430	6.0%	0.80 [-0.29, 1.89]	2019
10-Ammori-2020	31	7.3	18	39.5	10.8	18	3.6%	-8.50 [-14.52, -2.48]	2020
11-Garbarino - 2020	27.6	16.3	45	24.6	10.3	46	3.8%	3.00 [-2.62, 8.62]	2020
12-Wang, N-2020	30	14	221	32.9	13.6	49	4.5%	-2.90 [-7.13, 1.33]	2020
13-Xi -2020	36	9	45	30	7.5	45	5.0%	6.00 [2.58, 9.42]	2020
18-Trastulli- 2021	31.3	14.1	624	33.2	12.6	624	5.8%	-1.90 [-3.38, -0.42]	2021
19-Wang - 2021	31.8	3.3	46	34.8	4.8	23	5.6%	-3.00 [-5.18, -0.82]	2021
20-WU - 2021	25.4	1.1	192	30.2	1.1	189	6.1%	-4.80 [-5.02, -4.58]	2021
14-Feng-2021	31.6	4.4	225	30.1	4.7	225	6.0%	1.50 [0.66, 2.34]	2021
15-Fujisaki - 2021	41.8	13.8	21	48.5	20.8	20	1.9%	-6.70 [-17.56, 4.16]	2021
16-Khaled- 2021	27.6	16.5	43	21.6	10.3	41	3.7%	6.00 [0.15, 11.85]	2021
17-Long - 2021	30.6	8.9	334	31.7	8	334	5.9%	-1.10 [-2.38, 0.18]	2021
21-Caruso - 2022	33.3	15.4	120	31.4	11.4	120	5.0%	1.90 [-1.53, 5.33]	2022
22-Wei - 2022	36.7	16.2	81	44.6	17.3	53	3.7%	-7.90 [-13.74, -2.06]	2022
Total (95% CI)			**3625**			**2937**	**100.0%**	**-0.63 [-2.41, 1.14]**	

Heterogeneity: Tau² = 13.44; Chi² = 515.74, df = 20 (P < 0.00001); I² = 96%
Test for overall effect: Z = 0.70 (P = 0.48)



Forest plot of number of harvest lymph nodes for LD2G and OD2G.

Resection margin (cm)

Proximal resection margin (cm): seven studies reported proximal resection margin (cm) for laparoscopic versus open D2 gastrectomy. The overall effect showed a nonsignificant MD between LD2G compared with OD2G [MD=–0.05; 95% CI: (–0.83, 0.74), P=0.91]. The pooled studies were heterogeneous (I^2=98, P<0.0001), and heterogeneity could not be resolved due to relative variations between the included studies [15,16,21–24,29] (Fig. 16).

Distal resection margin (cm): regarding the MD for distal resection margin (cm) for laparoscopic versus open D2 gastrectomy, data was available in five studies; the analysis of the included studies showed a nonsignificant MD between LD2G and OD2G using the random effect model [MD=0.20; 95% CI: (–0.39, 0.79), P=0.51]. The pooled studies were heterogeneous (I^2=79%, P=0.0007), and heterogeneity could not be resolved due to relative variations between the included studies [15,16,22,26,29] (Fig. 17).

Tumor size (cm): seven studies reported tumor size (cm) for laparoscopic versus open D2 gastrectomy. The overall effect showed a nonsignificant MD between LD2G compared with OD2G [MD=0.17; 95% CI: (–0.28, 0.62), P=0.46]. The pooled studies were heterogeneous (I^2=77, P=0.0003), and heterogeneity could not be resolved due to relative variations between the included studies [5,15,16,18,19,21,28] (Fig. 18).

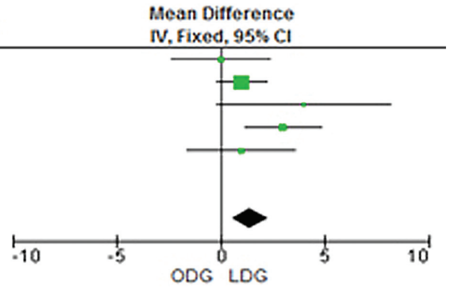
Discussion

A comparison between laparoscopic and OG was conducted using multiple meta-analyses for gastric

Figure 15

Study or Subgroup	ODG Mean	ODG SD	ODG Total	LDG Mean	LDG SD	LDG Total	Weight	Mean Difference IV, Fixed, 95% CI	Year
1-Xu- 2017	6	7	67	6	7	67	13.1%	0.00 [-2.37, 2.37]	2017
6-Huang-2019	7	6	238	6	5	110	50.7%	1.00 [-0.21, 2.21]	2019
11-Garbarino - 2020	9	13	45	5	6	46	4.2%	4.00 [-0.18, 8.18]	2020
13-Xi -2020	11	5	45	8	4	45	21.0%	3.00 [1.13, 4.87]	2020
16-Khaled- 2021	4	8	47	3	4	41	10.9%	1.00 [-1.59, 3.59]	2021
19-Wang - 2021	0	0	46	1	1	23		Not estimable	2021
Total (95% CI)			**488**			**332**	**100.0%**	**1.42 [0.56, 2.27]**	

Heterogeneity: $Chi^2 = 6.15$, df = 4 (P = 0.19); $I^2 = 35\%$
Test for overall effect: Z = 3.23 (P = 0.001)

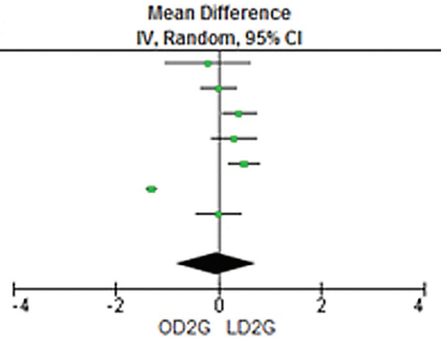


Forest plot of number of positive lymph nodes for LD2G and OD2G.

Figure 16

Study or Subgroup	OD2G Mean	OD2G SD	OD2G Total	LD2G Mean	LD2G SD	LD2G Total	Weight	Mean Difference IV, Random, 95% CI	Year
1-Xu- 2017	4.6	2.4	67	4.8	2.5	67	12.8%	-0.20 [-1.03, 0.63]	2017
2 -Zhang - 2017	5.1	1	85	5.1	1.1	69	14.6%	0.00 [-0.34, 0.34]	2017
8-Wang-2019	5.4	2.9	768	5	2.8	430	14.6%	0.40 [0.07, 0.73]	2019
9-Xu - 2019	5.3	2.5	220	5	2.2	222	14.3%	0.30 [-0.14, 0.74]	2019
13-Xi -2020	2.8	0.9	45	2.3	0.5	45	14.6%	0.50 [0.20, 0.80]	2020
14-Feng-2021	2	0.3	266	3.3	0.8	322	14.9%	-1.30 [-1.39, -1.21]	2021
19-Wang - 2021	2.9	0.9	46	2.9	0.9	23	14.2%	0.00 [-0.45, 0.45]	2021
Total (95% CI)			**1497**			**1178**	**100.0%**	**-0.05 [-0.83, 0.74]**	

Heterogeneity: $Tau^2 = 1.07$; $Chi^2 = 284.20$, df = 6 (P < 0.00001); $I^2 = 98\%$
Test for overall effect: Z = 0.11 (P = 0.91)

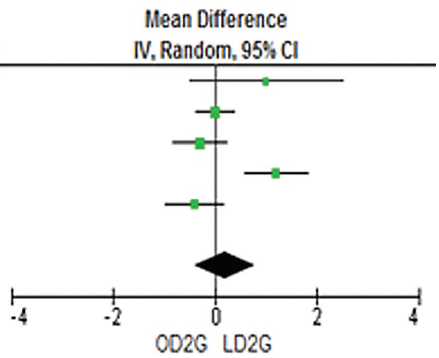


Forest plot of proximal resection margin (cm) for LD2G and OD2G.

Figure 17

Study or Subgroup	OD2G Mean	OD2G SD	OD2G Total	LD2G Mean	LD2G SD	LD2G Total	Weight	Mean Difference IV, Random, 95% CI	Year
1-Xu- 2017	7.6	4.7	67	6.6	4.2	67	9.8%	1.00 [-0.51, 2.51]	2017
2 -Zhang - 2017	6.1	0.9	85	6.1	1.4	69	24.6%	0.00 [-0.38, 0.38]	2017
9-Xu - 2019	6.9	4.6	768	7.2	4.3	430	22.6%	-0.30 [-0.82, 0.22]	2019
13-Xi -2020	5.8	1.5	45	4.6	1.45	45	21.2%	1.20 [0.59, 1.81]	2020
19-Wang - 2021	9.6	1.4	46	10	1	23	21.8%	-0.40 [-0.98, 0.18]	2021
Total (95% CI)			**1011**			**634**	**100.0%**	**0.20 [-0.39, 0.79]**	

Heterogeneity: $Tau^2 = 0.33$; $Chi^2 = 19.29$, df = 4 (P = 0.0007); $I^2 = 79\%$
Test for overall effect: Z = 0.66 (P = 0.51)

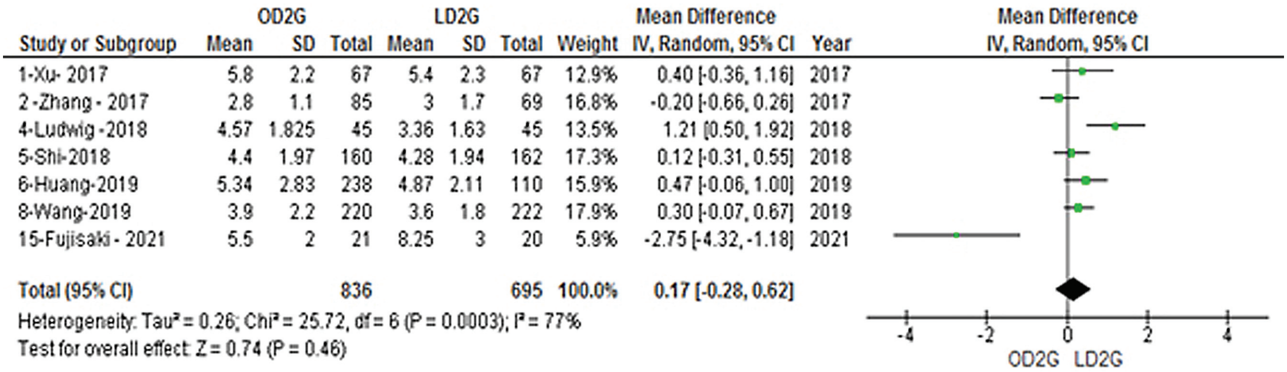


Forest plot of distal resection margin (cm) for LD2G and OD2G.

cancer. Most of this research are limited to individuals with EGC. Furthermore, a few of the papers that were part of previous meta-analyses included cases of patients, who had undergone varying degrees of lymphadenectomy in addition to their emphasis on distal gastric cancer. Furthermore, prior meta-analyses that compared laparoscopic and OG for AGC and reported data from different gastrectomy types ignored the considerable difficulty associated with completing a whole or proximal LG [36].

The utilization of laparoscopic surgery in the treatment of stomach cancer is on the rise as it has demonstrated several benefits over open surgery. Nevertheless, because of its technical difficulties and lack of strong evidence to support its use, laparoscopic whole gastrectomy is less common than laparoscopic distal gastrectomy [37]. Treatment of early and advanced stomach cancer is becoming more common thanks to technological advancements, improved instrumentation, and more surgical expertise [38].

Figure 18



Forest plot of tumor size (cm) for LD2G and OD2G.

For patients with AGC, our meta-analysis contrasts laparoscopic and OG procedures. The results of research particularly conducted on AGC patients who underwent D2 lymphadenectomy are compiled in this meta-analysis, which covers data updated within the previous several years.

According to our analysis, the LD2G group's operating time was noticeably longer than the OD2G group's. This might be the result of the procedure's learning curve or the fact that LD2G is more technically difficult than OD2G [37,39,40].

The learning curve effect: several studies have shown that because there is a lower incidence of gastric cancer and, consequently, less exposure to gastric cancer surgery, the learning curve for LD2G may be more challenging and time-consuming for surgeons [41,42]. Comparatively speaking, the Western trials' participating surgeons had less expertise doing laparoscopic stomach cancer surgery. Although sufficient expertise in laparoscopic procedures is required, an experienced laparoscopic surgeon would not need additional time to execute LTG than OTG [43].

The technical proficiency of a surgeon can have a significant impact on the results of an operation. The two key factors impacting the length of LTGD2 surgery are the doctors' competence with laparoscopic equipment and their level of collaboration with their helpers [44].

When carried out by skilled surgeons [45,46], there are no statistically significant variations in the length of the procedure between LDGD2 and ODGD2.

The operation time result was supported by authors [42–51] They reported that the duration of surgery was longer in LD2G compared with OD2G, and the length of operation was longer in LD2G. The quantity of lymphadenectomy, lengthy learning curves, lengthy equipment setup periods, lack of tactile feeling, and post-resection gastrointestinal tract reconstruction long operations in LGD2 are mostly caused by the ongoing requirement to replace instruments and clean cameras.

The LGD2 process is not without its difficulties, though. For example, there is a learning curve for training and mastering the fundamentals of distal LG with systemic lymphadenectomy, a surgery that requires expertise with 60–90 cases to treat significant EGC. As a result, Zou *et al.* [45] warn against using LGD2 in small-volume facilities. The length of the procedure for LTG may be further reduced with more advancements in surgical methods, particularly in the area of anastomosis and novel devices [39].

However, our meta-analysis revealed that ODG had a substantially greater MD for blood loss. This outcome was consistent with the conclusions drawn by the authors [41–50], who found that laparoscopic surgery resulted in less intraoperative blood loss than OG.

According to Shi *et al.* [5], LD2G was linked to a much decreased intraoperative blood loss. However, this is dependent on the surgeon's expertise and competence as well as the length of the incision. A more sensitive surgical manipulation of the organs, veins, and nerves may be accomplished during an operation. Moreover, less postoperative discomfort and a quicker recovery of bowel function [52].

Ten studies reported on the overall effect of MD for first oral intake (days) and first flatus (days) between laparoscopic and open D2 gastrectomy. The LD2G group saw a considerably shorter MD than the OD2G group. The same result was obtained by some previous studies that concluded that the time of first flatus and first oral intake showed a significantly shorter time in the LGD2 than in the OGD2 group [41,42,45,47–50].

Despite the lengthier surgical time, which has already been widely detailed, this meta-analysis validated the improved short-term results of LG: less blood loss, less time to first flatus, less time to first oral intake, and fewer analgesic doses. This research also suggests that a LG be performed.

Regarding pathological outcomes such as type of gastrectomy by laparoscopic versus open D2 gastrectomy, the overall effect showed a non-significant risk difference between LD2G compared to OD2G for distal and total gastrectomy [53]. They stated that the two groups' types of radical resection did not differ significantly from one another (Figs 1–4).

Regarding oncological safety, LD2G and OD2G had similar results. One of the main problems with laparoscopy's use in AGC [54] was how successful it was for lymphadenectomy. Adequate lymph node dissection is a necessary part of the treatment for gastric cancer to reduce the risk of metastasis and recurrence [55].

According to our findings, the quantity of HLNs is thought to represent a significant short-term oncological consequence of laparoscopic D2 dissection. According to our findings, LD2G and OD2G are not significantly different from one another [5,45,47,50,53,56,57]. They said that in lymph nodes that had been collected, there were no appreciable variations between LGD2 and OGD2. Even if our findings conflicted with those of Deng *et al.* [49], it has been concluded that there was a substantial difference between LD2G and OD2G in terms of the number of lymph nodes extracted. Moreover, all investigations showed that the number of lymph nodes taken by LD2G was sufficient (minimum=21.6 and maximum=48.5), and the Union for International Cancer Control stipulates that at least 15 lymph nodes must be removed during D2 dissection to conduct pathological testing. The lymph node yield in LDG and ODG were comparable [50]. The majority of studies followed the Dutch and Japanese standards, which call for the removal of at least 15 lymph nodes.

This meta-analysis revealed that there was no statistically significant difference in the number of LNs recovered in LG with D2 lymphadenectomy and that in OG. Because of this, and possibly because of greater use of LG as well as advancements in laparoscopic equipment and surgical procedures, LG may recover the same amount of LNs as OG, indicating that LG and OG have similar lymphadenectomy effectiveness.

When comparing laparoscopic to open D2 gastrectomy, the overall effect on the rate of positive lymph nodes was substantially lower in LD2G than in OD2G. Fewer positive lymph nodes were excised in the LG group (2.4 vs. 6.0; P=0.0001) compared with the OG group [26]. Laparoscopic methods are subject to some limitations, such as the difficult management of large primary tumors or tumors with large metastasis-positive nodes. Furthermore, neoadjuvant treatment may result in atypical tissue fibrosis or edema, which increases surgical difficulty. This finding contradicted the findings of Xu *et al.* [15], Lu *et al.* [56], and Hamab *et al.* [58], who found no discernible variation in the percentage of positive lymph nodes across the groups.

According to some earlier research, the surgical margin status may be taken into account as a separate prognostic factor for patients with GC. The resection margin distance is another element that affects oncological outcomes. The complete removal of the tumor mass is the main goal of radical resection, and it is commonly recognized that in many cancers, a positive resection margin is linked to an increased risk of local recurrence [59,60].

According to our meta-analysis, seven studies provided the proximal resection margin (in cm), while five reported the radical distal resection margin. Overall, the proximal and radical resection margins indicated a nonsignificant MD between LD2G and OD2G. All resection margins were negative in both groups and the average distance between the proximal and distal resection margins was identical between the groups [15].

Enough space between the resection margin and the tumor edge ensures that all tumor tissue is removed and reduces the likelihood of a positive resection margin [61]. Thus, assessing the resection margin distance can be useful in determining the likelihood of a surgical procedure being successful. This allowed us to determine that the proximal and distal resection margin lengths between LG and OG were identical, indicating that LG's tumor safety and curability were on par with those of OG.

A crucial clinicopathological indication that should be included in the prognosis of GC patients is the tumor size [49]. There were few comparisons for this component in previous meta-analyses. Surprisingly, we discovered that the tumor size in LG was considerably larger than the tumor size in OG, indicating that LG would fare better. This difference led us to believe that LG may be easier to treat than OG, although there was some significant diversity across the studies that were included [54].

Our findings showed that there was an overall nonsignificant MD in tumor size (cm) between LD2G and OD2G for laparoscopic versus open D2 gastrectomy. There was no significant difference between LDG and ODG. Although the average tumor diameter was considerably higher in the OG group than in the LAG group, our results did not support their finding [56,58].

The short-term results of LG were shown to be considerably better in this research than those of OG. This research also suggests that LG be performed [54]. The benefit of laparoscopic surgery may also be responsible for this shift as patients need less time in the hospital to recuperate, which decreases the chance of contracting nosocomial infection. Patients with LG backgrounds were able to resume their physical activities at a decreased risk of hypostasis and deep venous thrombosis compared with their OG counterparts [62,63].

The present meta-analysis's findings indicate that while LD2G and OD2G have similar rates of problems, LD2G is a practicable, safe oncologic procedure that has a quicker rate of patient recovery. The use of LD2G in the treatment of patients with stomach cancer was validated by these findings [41,49,51]. An extensive assessment of the ontological adequacy of a reduction surgical method such as LD2G should be carried out before its application in the treatment of gastric cancer.

Conclusion

Early postoperative course and pathological outcomes for meta-analysis of laparoscopic versus open D2 gastrectomy in managing locally advanced gastric cancer were used in this meta-analysis.

Our study concluded that laparoscopic D2 dissection is safe, with less blood loss, less time to first flatus, less time to first oral intake, and reduced analgesic requirements despite the longer surgical time, as already extensively described. According to this finding, LG should also be recommended.

According to the current meta-analysis, laparoscopic distal gastrectomy is oncological suitable in terms of resection quality, lymph node yield, and survival. Patients who receive LDG may experience a decreased risk of surgical complications and a quicker recovery time. The findings of this study are in favor of LDG implementation in facilities with the necessary training and experience.

Finally, utilizing laparoscopy with D2 lymph node dissection is a safe and practical procedure for treating patients with advanced gastric cancer as it results in less blood loss, a faster recovery after surgery, equivalent postoperative complications, and similar oncological safety.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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