Systematic Review and Meta-Analysis

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Three-dimensional vs 2-dimensional laparoscopic gastrectomy for gastric cancer

A systematic review and meta-analysis

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Abstract

Background: Both 3-dimensional (3D) laparoscopic gastrectomy (LG) and 2-dimensional (2D) LG are commonly used for gastric cancer (GC). To investigate their safety and efficacy, we performed this meta-analysis.

Methods: PubMed, The Cochrane Library, Science Direct, Embase, Scopus, and Web of Science were systematically searched to identify relevant studies. The total number of lymph node dissections (LNDs), operation time, blood loss, postoperative hospital stay, postoperative complications, and hospitalization cost were extracted as major endpoints.

Results: Among 904 articles that were enrolled, 9 studies were included for analysis. The 3D group was observed to have shorter operation times [95% confidence interval (CI): −0.54 to −0.06; $P = .01$] and less blood loss (95% CI: −0.41 to −0.19; $P < .00001$) than the 2D group. Compared with the 2D group, slightly higher hospitalization cost was found in the 3D group (95% CI: 0.06–0.37; $P = .008$). However, the outcomes among the total LNDs, postoperative hospital stay, and postoperative complications were similar. Subgroup analysis suggested that the 3D LG group had more 11p (2.22 ± 1.80 vs 1.47 ± 1.99, $P = .019$) and 8a (2.52 ± 1.88 vs 1.48 ± 1.43, $P = .001$) LNDs compared to the 2D LG group.

Conclusions: 3D LG has advantages for GC, with shorter operation times, less blood loss, and possibly more LNDs. However, the cost was slightly higher than that of 2D LG.

Abbreviations: 2D = 2-dimensional, 3D = 3-dimensional, CIs = confidence intervals, GC = gastric cancer, LG = laparoscopic gastrectomy, LND = lymph node dissection, MD = mean deviation, PRISMA = Preferred Reporting Items for Systematic Review and Meta-Analysis, RCT = Randomized Clinical Trial, RR = risk ratio, RS = retrospective studies, SMD = standardized mean difference.

Keywords: gastric cancer, 3-dimensional, 2-dimensional, laparoscopic surgery, meta-analysis

1. Introduction

Gastric cancer (GC) is the third major causation of cancer deaths worldwide, with an estimated 720,000 deaths worldwide each year.[1,2] Minimally invasive surgery has been recognized as the main choice for patients with early GC due to its advantages and safety.[3] Two-dimensional (2D) laparoscopic gastrectomy (LG) has been gradually used for patients with early GC since the 1st report of traditional laparoscopy in 1994 by Kitano et al.[4] The 2D laparoscopy procedure poses some challenges for novices because of defects in stereoscopic vision: difficulty in identifying anatomical structures; inability to judge distances between tissues; limited range of motion in laparoscopic instruments; and a longer learning curve.[5] With the progress of medical technology, 3-dimensional (3D) laparoscopy has overcome the shortcomings of traditional 2D laparoscopy to a certain extent.[6]

There is a debate about whether 2D/high-definition (HD) system (Karl Storz, Tuttlingen, Germany or Olympus Corporation, Tokyo, Japan) equipped with a laparoscope with 30° direction of view and a diameter of 10 mm or 3D/HD system (Olympus Corporation) equipped with a flexible 0° direction of view and a 10-mm-diameter laparoscope is better. Several reviews observed that the 3D group compared with the 2D group had shorter operative times, lower error rates, higher early abstinence rates, and a shorter learning curve for beginners.[7,8] In contrast, Ruan et al[9] found more blood loss in the 3D group in comparison with the 2D group. However, several studies have shown that both the 3D group and 2D group were similar in the total number of lymph node dissections (LNDs), operative time, blood loss, and postoperative complications.[10–12] There is a lack of strong prospective evidence about whether 3D LG is superior to 2D LG.

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Therefore, to comprehensively assess the clinical outcomes of 3D LG vs 2D LG, we performed the present meta-analysis for GC with respect to operative indexes, postoperative complications, and hospitalization cost.

2. Materials and methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statements was used to perform this systematic review and meta-analysis. No ethical approval and patient consent are required because all analyses were based on previously published studies.

2.1. Search strategy

PubMed, Science Direct, The Cochrane Library, Embase, Scopus, and Web of Science data were searched to identify all eligible studies up to March 14, 2019. The following are effective terms and related variants were used in the database searches: "three-dimensional," "two-dimensional," and "gastric cancer." The complete keyword search strings we used for PubMed were: (three-dimensional [Mesh] OR 3D [Title/Abstract] OR 3-D [Title/Abstract]) AND (two-dimensional [Mesh] OR 2D [Title/Abstract] OR 2-D [Title/Abstract]) AND (gastric cancer [Mesh] OR stomach cancer [Title/Abstract] OR stomach neoplasm [Title/Abstract] OR gastric neoplasm [Title/Abstract] OR cancer of stomach [Title/Abstract]). Furthermore, we obtained reference lists of all included relevant publications for additional potential articles by hand searching. The search had no language restriction.

2.2. Selection criteria

The inclusion criteria were as follows: all patients were confirmed to have GC; studies compared 3D LG vs 2D LG; and outcomes included total LNDs, operation time, blood loss, postoperative hospital stay, postoperative complications, and hospitalization cost. We did not enroll review articles, expert opinions, letters, noncomparative studies, commentary articles, case reports, and editorials in this meta-analysis.

2.3. Data extraction

The data were extracted independently by 2 reviewers. A 3rd investigator was involved in the discussion if there was a disagreement between the 2 reviewers. Several characteristics (publication year, 1st author, number of participants, study design, type of gastrectomy, and age of participants) and outcome indexes (LND, operation time, blood loss, postoperative hospital stay, postoperative complications, and hospitalization cost) were extracted from included studies.

2.4. Quality assessment

The Newcastle–Ottawa scale (NOS, 9 points) was used for nonrandomized controlled trials in our study. Nine questions were assessed on three major items: selection, comparability, and exposure. The methodological quality of a study was deemed "High" if the NOS points were >7. If the points were >4, we considered the study to be of "medium" quality. In addition, we also used the Cochrane collaboration's tool for RCTs to assess the risk of bias included in our meta-analysis.

2.5. Statistical analysis

These analyses were calculated by using Review Manager Version 5.3 software and STATA version 12.0 software. For dichotomous variables, the relative ratio (RR) with 95% confidence interval (CI) was used. For continuous variables, standardized mean differences (SMDs) with a 95% CI were calculated as summary statistics. We used a Chi-squared test and I^2 ($I^2=[(Q - df)/Q] \times 100\%$) to access the interstudy heterogeneity among studies. A random-effects model was performed when there was significant heterogeneity ($I^2>50\%$ or $P<.1$) between the studies. In contrast, if no heterogeneity was observed between the studies ($I^2<50\%$ or $P>.1$), a fixed model was applied. Subgroup analyses of operative indexes (LND, operation time, and blood loss), postoperative hospital stay, postoperative complications, and hospitalization cost were used to assess whether the results would change according to the study design. In addition, Begg funnel plot and Egger tests were performed for exploration of the publication bias. $P<.05$ indicated statistical significance.

3. Results

3.1. Search results and study quality assessment

Figure 1 presents the process of article selection: 904 full-text articles were 1st identified from the aforesaid 6 databases. After filtering, 9 studies involving 1508 patients (3D group, 739 patients; 2D group, 769 patients) were enrolled for the final evaluation.[12–20] Of the 9 studies, 4 were RCTs[12,15,17,18] and 5 were retrospective studies (RS).[13,14,16,19,20] The characteristics of all studies are collected in Table 1. In addition, based on the NOS score, each study was considered high quality. As shown in Figure 2, no severe risk of bias was found according to the results of the Cochrane risk of bias tool for the RCTs included in our meta-analysis.

3.2. Number of lymph node dissections

The number of LNDs was reported in 5 studies with 948 patients between the 2 groups. The results of LNDs between them were 35.69 (3D) and 33.16 (2D), respectively. The mean deviation (MD) was 0.53. The results showed the total LNDs between the 2 groups was similar (95% CI: −0.06 to 0.35; $P=.17$; Fig. 3). In subgroup analysis, Liu et al[20] revealed that the 3D group had more 11p ($P=.019$) and 8a ($P=.001$) LNDs than the 2D group.

3.3. Operation time

Operation time was reported in 7 of the 9 included studies. The mean operative time in the 3D group was 178.23 and 185.31 minutes in the 2D group. The MD was 7.07 minutes. The results showed that operation times were significantly shorter in the 3D group compared with the 2D group (95% CI: −0.54 to −0.06; $P=.01$; Fig. 4A).

3.4. Blood loss

Six studies with 1287 patients compared the amount of blood loss. The amount of blood loss in the 3D group was 90.02 and 113.30 mL in the 2D group. The MD was 23.28 mL. The results showed that blood loss was significantly less in the 3D group

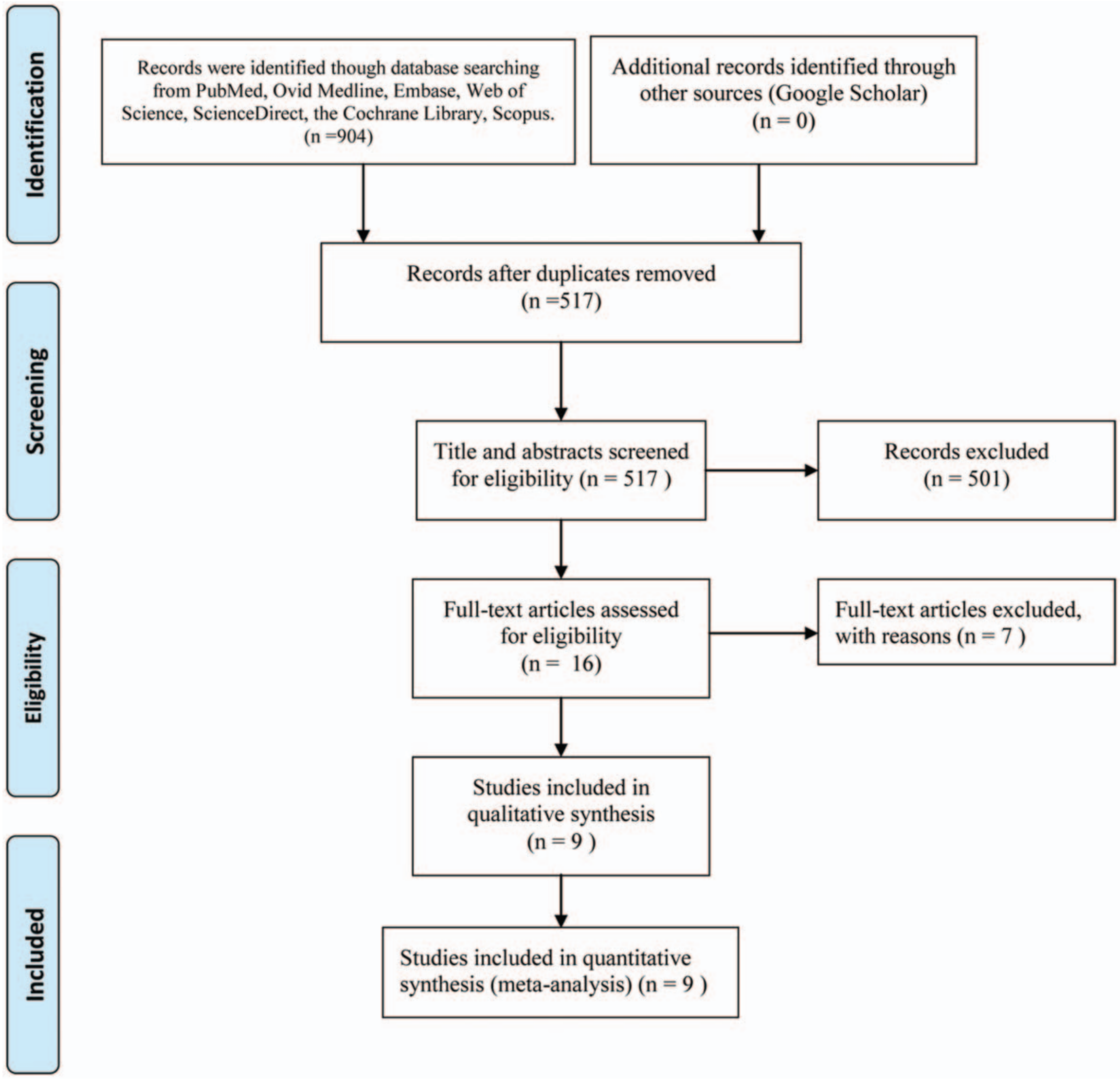


Figure 1. Flow chart of study selection.

compared with the 2D group (95% CI: −0.41 to −0.19; $P < .00001$; Fig. 4B).

3.5. Postoperative complications

From the 3 studies, 659 participants were enrolled to assess postoperative complications between the 2 groups. The results showed there was no statistically significant difference in postoperative complications between the 2 groups (RR = 1.02, 95% CI: 0.70–1.58; $P = .80$; Fig. 5A).

3.6. Postoperative hospital stay

From the three studies, 461 patients were analyzed for postoperative hospital stays between the 2 groups. The mean

Table 1

Characteristics of the included studies in the meta-analysis.

First author	Publication year	Study design	Patients (n) (3D/2D)	Age $X \pm SD$ (3D/2D)	Operation time, min $X \pm SD$ (3D/2D)	Blood loss, mL $X \pm SD$ (3D/2D)	Total gastrectomy (3D/2D)	Partial gastrectomy (3D/2D)	Quality (score)
Chen[13]	2014	RS	40/40	49.0 ± 4.8/51.0 ± 5.2	168.00 ± 36.00/192.00 ± 48.00	110.00 ± 18.00/120.00 ± 21.00	0/0	60/60	8
Jiang[14]	2015	RS	40/40	–	174.30 ± 33.20/205.8.0 ± 32.10	153.80 ± 25.50/169.70 ± 15.50	–	–	7
Reim[15]	2015	RCT	78/101	–	–	130.63 ± 36.00/189.00 ± 163.00	–	–	–
Ji[16]	2016	RS	56/60	61.9 ± 10.4/63.7 ± 11.7	186.20 ± 22.80/198.10 ± 26.40	73.60 ± 28.50/88.10 ± 32.30	21/24	35/36	7
Lin[17]	2016	RCT	97/99	–	183.60 ± 22.80/180.00 ± 37.20	59.60 ± 45.60/69.90 ± 62.40	–	–	–
Lu[18]	2016	RCT	109/112	59.4 ± 10.3/58.2 ± 11.2	184.00 ± 36.00/178.00 ± 37.00	58.00 ± 75.00/78.00 ± 72.00	75/43	37/66	–
Ji[19]	2017	RS	48/45	56.0 ± 8.0/58.0 ± 7.0	185.00 ± 25.00/190.00 ± 27.00	75.00 ± 25.00/80.00 ± 20.00	48/45	0/0	8
Zheng[12]	2017	RCT	211/208	59.0 ± 10.0/58.7 ± 10.7	174.00 ± 33.00/176.00 ± 35.00	61.00 ± 83.00/82.00 ± 119.00	117/132	94/76	–
Liu[20]	2018	RS	60/64	55.9 ± 10.2/55.5 ± 12.5	181.03 ± 36.76/191.47 ± 47.19	160.83 ± 150.66/170.31 ± 147.19	0/0	60/64	8

2D = 2-dimensional, 3D = 3-dimensional, RCT = randomized clinical trial, RS = retrospective study, SD = standard deviation.

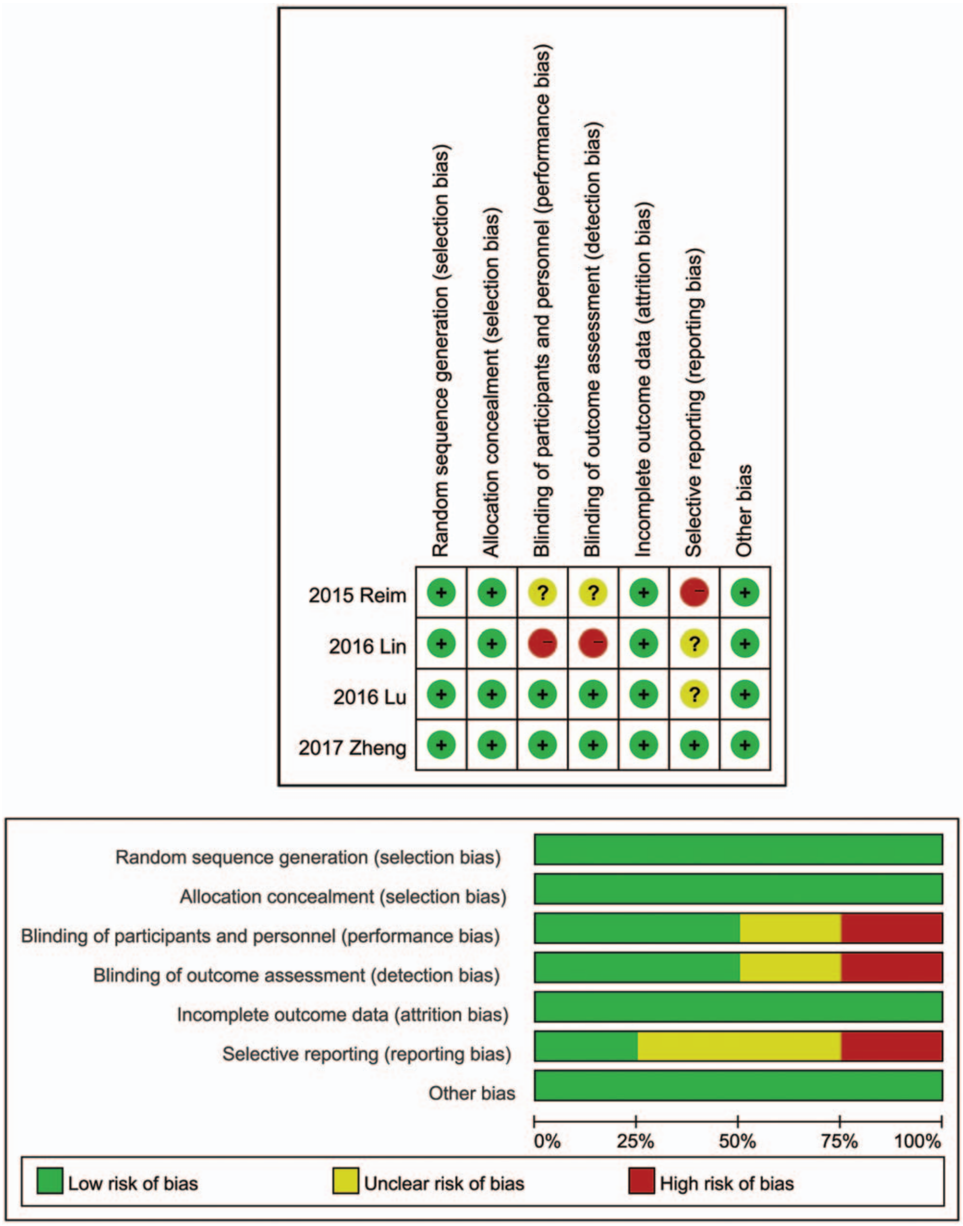


Figure 2. Forest plot of lymph node dissections s associated with 3-dimensionvs 2-dimension.

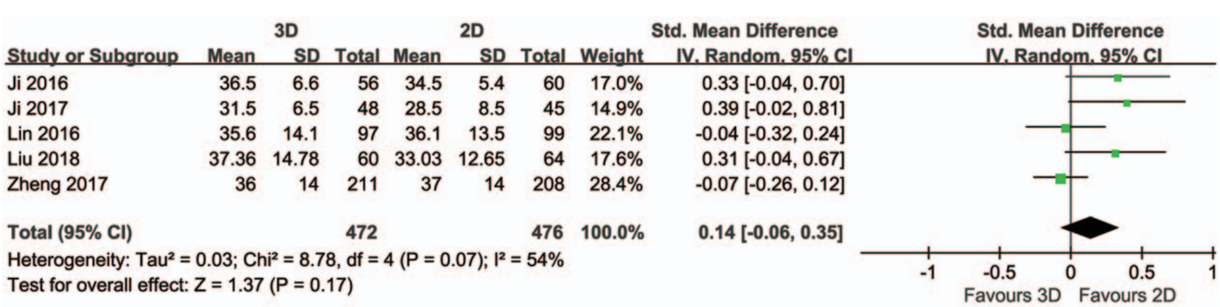


Figure 3. Forest plot of operation times (A) and blood loss (B) associated with 3-dimension (3D) vs 2-dimension (2D). CI = confidence interval.

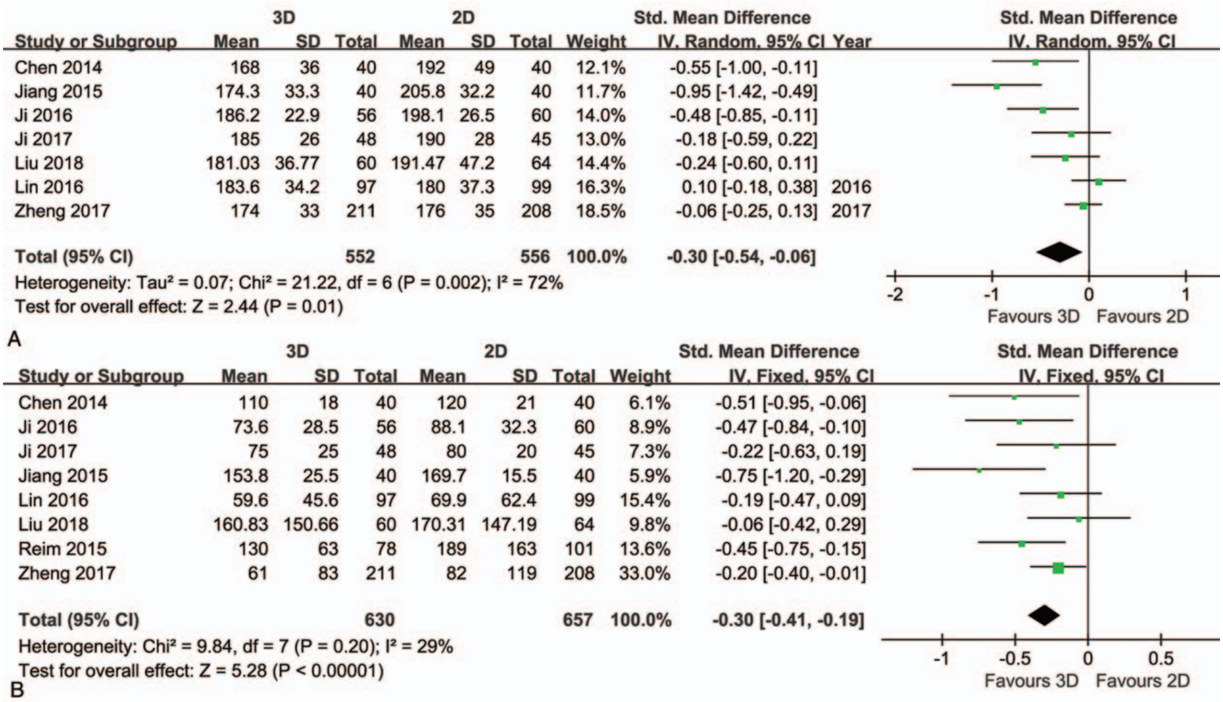


Figure 4. Forest plot of postoperative hospital stays (A) and hospitalization costs (B) associated with 3-dimension (3D) vs 2-dimension (2D). CI = confidence interval.

postoperative hospital stay for the 3D group was 12.20 days, and for the 2D group, it was 12.65 days. The MD was 0.45 days. The results showed there was no statistically significant difference in postoperative hospital stays between the 2 groups (95% CI: −0.30 to 0.06; $P=.20$; Fig. 5B).

3.7. Hospitalization cost

Three studies that assessed 615 participants reported hospitalization cost as an outcome. The cost in the 3D group was $12,562.32, while in the 2D group, it was $12,085.80. The MD was $476.53. The results showed that the 3D group had a slightly higher hospitalization cost compared with the 2D group (95% CI: 0.04–0.35; $P=.02$; Fig. 6).

3.8. Subgroup analysis

Subgroup analysis was also performed according to the study design (RCT or RS) included in the selected studies. For RCTs, the analysis showed that the 3D LG was associated with less

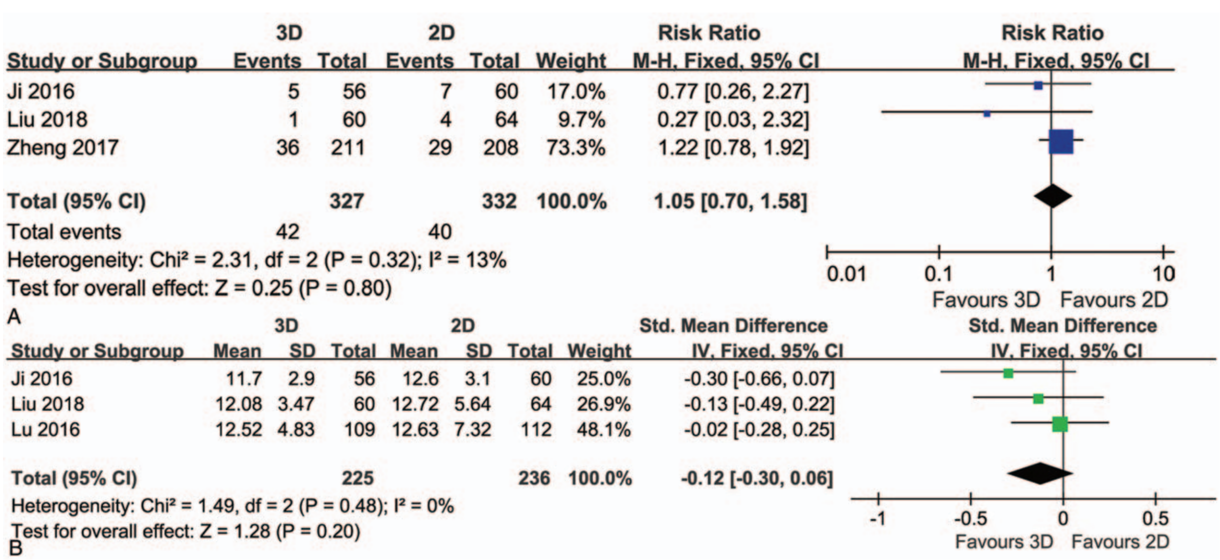


Figure 5. Forest plot of postoperative complications associated with 3-dimension (3D) vs 2-dimension (2D). CI = confidence interval.

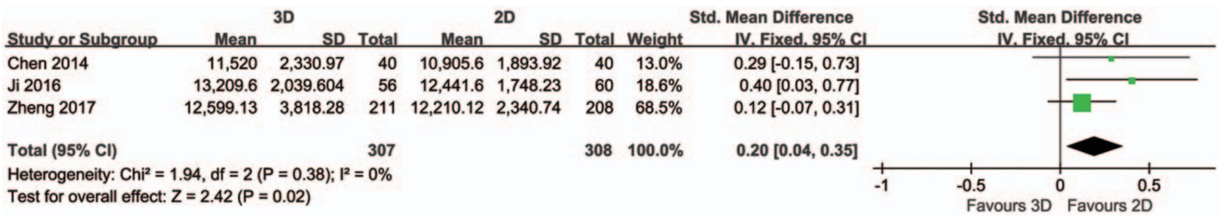


Figure 6. Quality assessment of all included studies. CI = confidence interval, 3D = 3-dimension, 2D = 2-dimension.

blood loss compared with 2D LG (95% CI: −0.40 to −0.11; *P*=.0004). For RS, the analysis showed that 3D LG was associated with shorter operation times (95% CI: −0.71 to −0.21, *P*=.0003), fewer LNDs (95% CI: 0.13–0.56, *P*=.002), and higher hospitalization costs (95% CI: 0.05–0.62, *P*=.02) compared with 2D LG (Table 2).

3.9. Cumulative meta-analysis

Cumulative meta-analysis of operation time (Fig. 7), blood loss (Fig. 8), and LND (Fig. 9) demonstrated that, as high-quality studies were included, the SMDs of the final results became robust within a narrow range. After inclusion of Ji's study,[16] the SMD and 95% CI for operation time and blood loss decreased to <1 and became stable.

3.10. Sensitivity analysis

Both operation time and blood loss were observed to have significant heterogeneity. We evaluated stability and sensitivity according to the influence of each study. The results showed that the outcomes of operation time and blood loss were stable and reliable (Fig. 10).

3.11. Publication bias

A funnel plot based on the operation time (Begg test *P*=.035; Egger test *P*=.048; Fig. 11A) and blood loss (Begg test *P*=.174; Egger test *P*=.152; Fig. 11B) were conducted to evaluate publication bias. The pooled results suggested that there may be publication bias in some of the results.

4. Discussion

Although the 3D laparoscopic system was introduced in the early 1990s,[4] surgeons in clinics have disregarded this system until recently because the old version of the 3D laparoscopic system caused some surgeons discomfort, such as headache, dizziness, and eye strain due to blurring of vision in 3D vision.[21,22] However, these drawbacks of the 3D laparoscopic system have been minimized with the development of medical and optical devices. Therefore, compared with the 2D laparoscopic system, the 3D laparoscopic system has become more comfortable for the surgeon, especially when the surgeon performs difficult surgery that requires meticulous dissection. This is the 1st meta-analysis to compare 3D and 2D LG for GC. The results showed that the 3D group was associated with shorter operation times, less blood loss, and slightly higher hospitalization costs than the 2D group. The total LNDs, postoperative hospital stays, and postoperative complications were similar between the 2 groups.

Our meta-analysis found that 3D laparoscopy was not superior than 2D laparoscopy in terms of total LNDs. Possible reasons include the surgeons were not well experienced in using 3D views; and the patients in our studies were not enough. While the subgroup analysis suggested that the 3D group dissected more 11p and 8a lymph nodes as compared with the 2D group.[20] Yoon et al[23] also reported a higher LN yield in the 3D laparoscopy group. These results may be explained by the advantages of 3D view: preoperative 3D evaluation of the vascular anatomy may help the safe and rapid ligation of vessels and detection of the lymph nodes[24]; and the 3D system provides a good stereoscopic vision sense of anatomical structure to act resolutely when dissecting vessels, organs and tissues, which may have advantages to dissect the lymph nodes.[25] Therefore, we

Table 2

Pooled results of perioperative and postoperative data of both RCTs and observational studies.

Variables	Study design	n	Number of patients (3D/2D)	Heterogeneity I^2	Heterogeneity *P*-value	Effect size	Model	95% CI	*P*-value
Operation time	RCTs	2	308/307	0%	.36	−0.01	Fixed	−0.17–0.15	.92
	RS	5	244/249	48%	.10	−0.46	Fixed	−0.71–−0.21	.0003
Blood loss	RCTs	3	386/408	9%	.33	−0.25	Fixed	−0.40–−0.11	.0004
	RS	5	244/249	81%	.0003	−0.25	Random	−0.67–−0.17	.24
LND	RCTs	2	308/307	0%	.84	−0.06	Fixed	−0.22–0.10	.46
	RS	3	164/169	0%	.96	0.43	Fixed	0.13–0.56	.002
Postoperative complications	RCTs	1	211/208	–	–	1.22	Fixed	0.78–1.92	.38
	RS	2	116/124	0%	.39	0.58	Fixed	0.22–1.52	.27
Postoperative hospital stay	RCTs	1	109/112	–	–	−0.02	Fixed	−0.28–0.25	.90
	RS	2	116/124	0%	.53	−0.21	Fixed	−0.47–0.04	.10
Hospitalization cost	RCTs	1	211/208	–	–	0.12	Fixed	−0.07–0.31	.21
	RS	2	96/100	0%	.69	0.35	Fixed	0.07–0.64	.01

2D=2-dimensional, 3D=3-dimensional, CI=confidence interval, LND= lymph node dissection, RCTs=randomized clinical trials, RS=retrospective study.

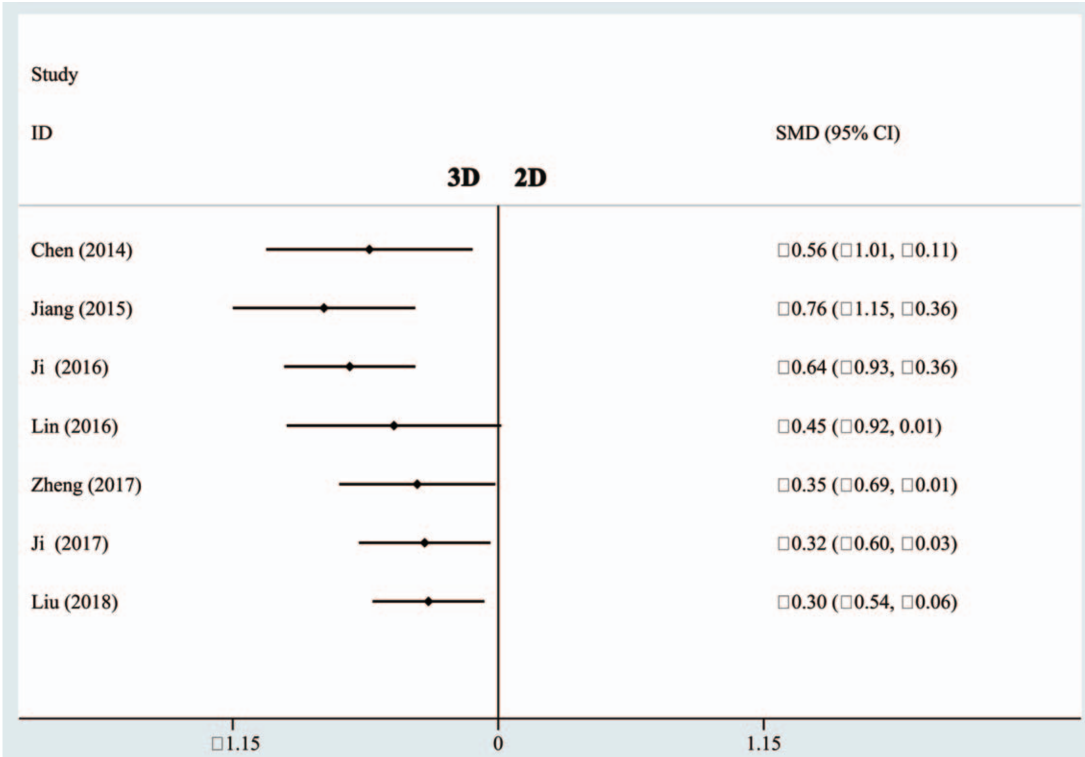


Figure 7. Cumulative meta-analysis related to operation time with 3-dimension (3D) vs 2-dimension (2D). CI = confidence interval, SMD = standardized mean difference.

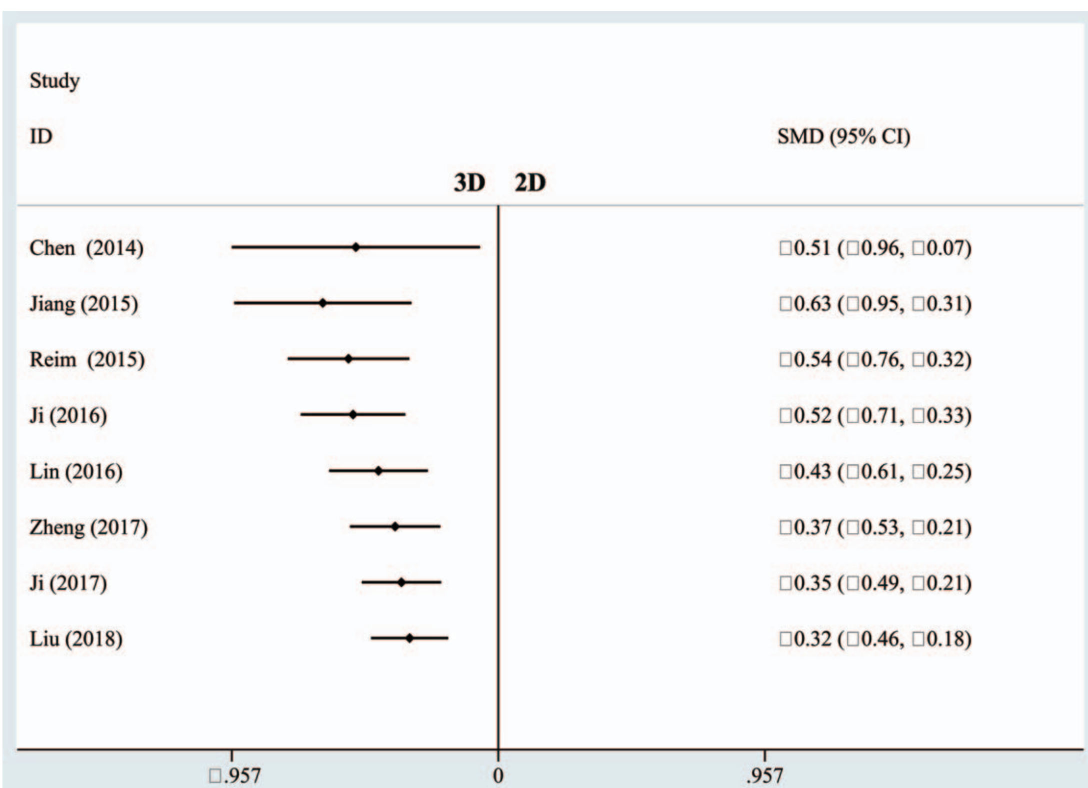


Figure 8. Cumulative meta-analysis related to blood loss with 3-dimension (3D) vs 2-dimension (2D). CI = confidence interval, SMD = standardized mean difference.

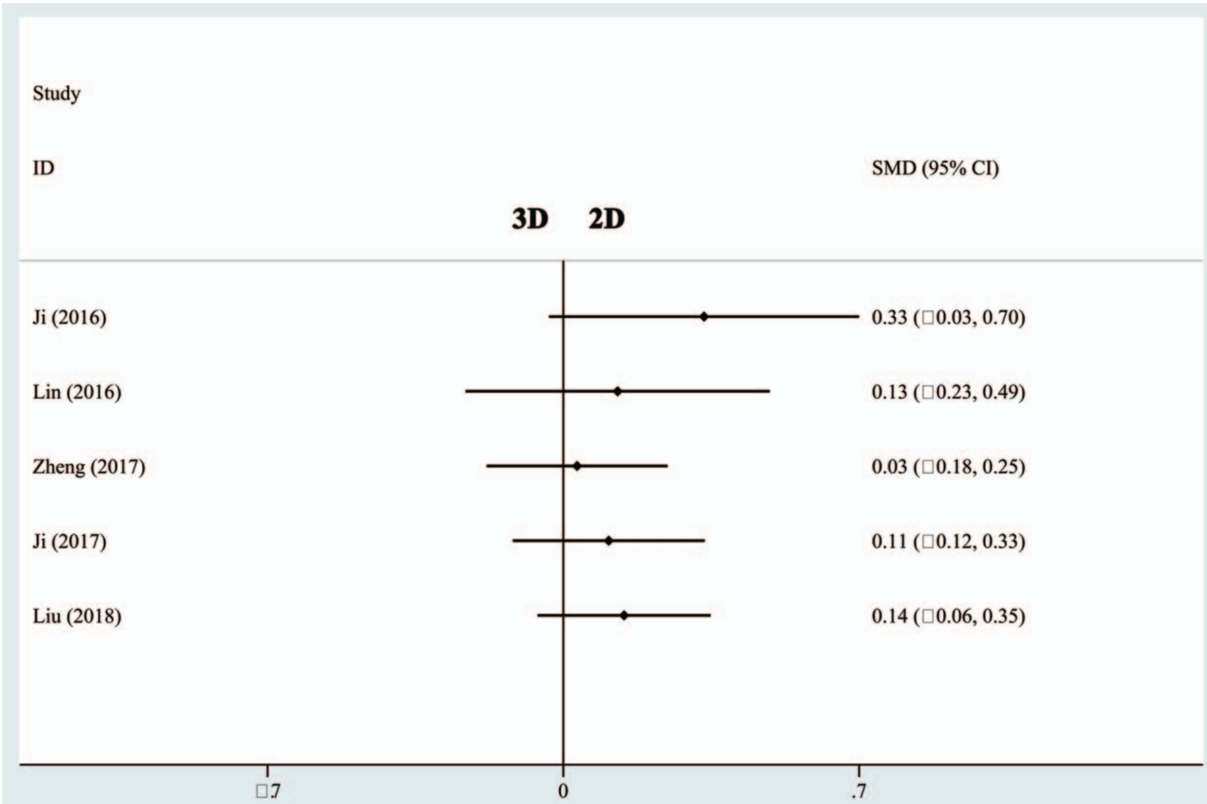
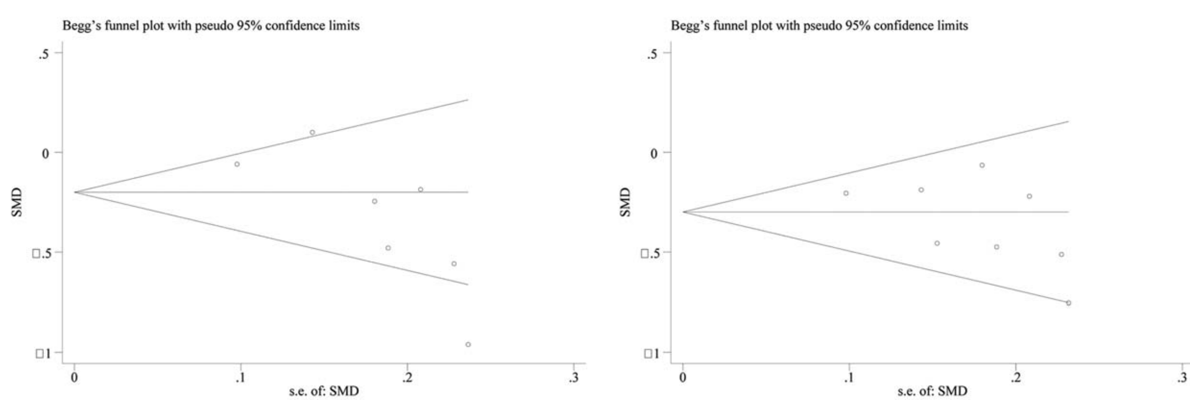


Figure 9. Cumulative meta-analysis related to lymph node dissections s with 3-dimension (3D) vs 2-dimension (2D). CI = confidence interval, SMD = standardized mean difference.

speculated that 3D LG might be better than 2D LG in LNDs for GC. This inference still needs to be validated by more RCTs.

Our results showed that the 3D group had a significantly shorter operation time and less blood loss compared with the 2D group. This finding can be delineated by several different factors: 3D laparoscopy with 3D visualization provided the surgeons with a simpler presentation of the anatomical formations; 3D laparoscopy with 3D visualization helped the surgeons locate the lymph nodes accurately; and the spatial distribution of blood vessels and the anatomic relation between blood vessels were



Egger's test

Std_Eff	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
slope	.44747	.2624389	1.71	0.149	-.2271507	1.122091
bias	-4.254074	1.638162	-2.60	0.048	-8.465103	-.0430449

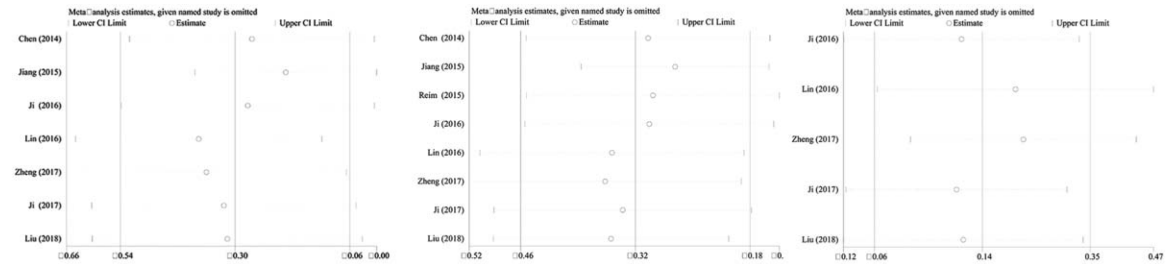
A

Egger's test

Std_Eff	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
slope	.028912	.2088844	0.14	0.894	-.4822098	.5400338
bias	-2.152493	1.312946	-1.64	0.152	-5.365155	1.060168

B

Figure 10. Meta-based influence analysis for comparisons of operation time (A), blood loss (B) and lymph node dissections (C).



Study omitted	Estimate	[95% Conf.	Interval]
Chen (2014)	-.17261101	-.29570833	-.04951369
Jiang (2015)	-.14635004	-.26912048	-.0235796
Ji (2016)	-.16764209	-.29296198	-.04232219
Lin (2016)	-.26546922	-.39647993	-.13445853
Zheng (2017)	-.28764361	-.43883795	-.13644929
Ji (2017)	-.20114547	-.32519892	-.07709203
Liu (2018)	-.19396193	-.3199501	-.06797377
Combined	-.19980069	-.31847877	-.08112262

A

Study omitted	Estimate	[95% Conf.	Interval]
Chen (2014)	-.28503549	-.39881974	-.17125125
Jiang (2015)	-.27039218	-.3840408	-.15674353
Reim (2015)	-.27420688	-.3927947	-.15561907
Ji (2016)	-.28166422	-.3971757	-.16615276
Lin (2016)	-.31909299	-.438977	-.19920899
Zheng (2017)	-.34508845	-.47974181	-.21043511
Ji (2017)	-.30509973	-.41960633	-.19059311
Liu (2018)	-.32442459	-.44050056	-.20834862
Combined	-.29888954	-.40913545	-.18864363

B

Study omitted	Estimate	[95% Conf.	Interval]
Ji (2016)	.04571716	-.09050623	.18194056
Lin (2016)	.11118546	-.03229967	.25467059
Zheng (2017)	.20205189	.03074146	.37336233
Ji (2017)	.04654662	-.08780813	.18090136
Liu (2018)	.04546782	-.09142435	.18235999
Combined	.08053067	-.04716737	.20822871

C

Figure 11. Begg and Egger tests for comparisons of operation times (A) and blood loss (B).

likely clearer. Similar results were also confirmed by Ozsoy's and Fergo's studies.[7,8] Considering these advantages of 3D laparoscopy, surgeons have confidence to perform surgeries and can rapidly improve surgical skills as well as reduce errors rate with HD 3D vision.[26]

In terms of hospitalization expenses, our results showed that the 3D group was associated with a slightly higher but acceptable hospitalization cost compared with the 2D group. This greatly facilitates the development and promotion of 3D operation surgeries. In addition, the operation time of the 3D group was shorter, and the corresponding anesthesia and intraoperative costs were also reduced. Two other 3D displays (3D robotic-assisted and glasses-free 3D endoscopic system) have emerged in recent years.[27,28] They showed less mortality and morbidity in laparoscopic surgery and effectively reduced the side effects and poor lighting for operators. Although they had advanced characteristics (3D visualization, small-wristed instruments, and raised degree of rotational freedom and motion[29]), the cost of conducting the 3D robotic system or the glasses-free 3D display might be too expensive for hospitals and patients. Therefore, the traditional 3D system may be the optimum choice for many centers.

In our meta-analysis, we also acknowledge several limitations. First, not all included studies were RCTs (4 RCTs and 5 RS), which might raise the risk of selection and publication bias. Second, the levels of surgeons' experiences were different, and it is unclear for novices whether 3D laparoscopic surgery can also shorten the operation time and the learning curve. It remains to be proven by more medical evidence. Third, all patients came from Asia (8 studies in China and 1 study in South Korea), and we did not assess the impact of 3D laparoscopic on long-term outcomes. However, our ultimate results attest that the use of the 3D laparoscopic system for gastrectomy is effective based on these short-term clinic results. Last, with restrictions of meta-analyses based on the published literatures instead of the original data, it was difficult to acquire unpublished data.

5. Conclusion

Our meta-analysis suggests that 3D LG is superior to 2D LG with shorter operation time, less blood loss, and probably more LNDs. These results give us a reason to suggest that 3D LG should be considered as a preferable option, particularly for surgeries with difficult procedures or complicated anatomical steps. Thus, wider clinical application of 3D laparoscopy is strongly recommended.

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Author contributions

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References

[1] Siegel RL, Miller KD, Jemal A. Cancer statistics, 2018. CA Cancer J Clin 2018;68:7–30.
[2] Bray F, Jemal A, Grey N, et al. Global cancer transitions according to the Human Development Index (2008–2030): a population-based study. Lancet Oncol 2012;13:790–801.

[3] Reyes CD, Weber KJ, Gagner M, et al. Laparoscopic vs open gastrectomy: a retrospective review. Surg Endosc 2001;15:928–31.
[4] Kitano S, Iso Y, Moriyama M, et al. Laparoscopy-assisted Billroth I gastrectomy. Surg Laparosc Endosc 1994;4:146–8.
[5] Hanna GB, Shimi SM, Cuschieri A. Randomised study of influence of two-dimensional versus three-dimensional imaging on performance of laparoscopic cholecystectomy. Lancet 1998;351:248–51.
[6] Patankar SB, Padasalagi GR. Three-dimensional versus two-dimensional laparoscopy in urology: a randomized study. Indian J Urol 2017;33:226–9.
[7] Ozsoy M, Kallidonis P, Kyriazis I, et al. Novice surgeons: do they benefit from 3D laparoscopy? Lasers Med Sci 2015;30:1325–33.
[8] Fergo C, Burcharth J, Pommergaard HC, et al. Three-dimensional laparoscopy vs 2-dimensional laparoscopy with high-definition technology for abdominal surgery: a systematic review. Am J Surg 2017; 213:159–70.
[9] Ruan Y, Wang XH, Wang K, et al. Clinical evaluation and technical features of three-dimensional laparoscopic partial nephrectomy with selective segmental artery clamping. World J Urol 2016;34:679–85.
[10] Junjun M, Lu Z, Zhou HX. Clinical curative effect of laparoscopic radical resection of 3D. Chin J Digest Surg 2015;3:192–4.
[11] Qiang H, Yong W, Jianjun W. 3D laparoscopic clinical application in radical gastrectomy for gastric cancer. Chin Med J 2014;30:2375–6.
[12] Zheng CH, Lu J, Zheng HL, et al. Comparison of 3D laparoscopic gastrectomy with a 2D procedure for gastric cancer: a phase 3 randomized controlled trial. Surgery 2018;163:300–4.
[13] Haijin C, Yu Jinlong Y, Zonghai H, et al. Application of three-dimensional high-definition laparoscope in laparoscopic radical resection of gastric cancer [in Chinese]. South Med Univ 2014;34:588–90.
[14] Jiang JN, F XD. Comparison of the clinical effect and learning curve of laparoscopic three-and two dimension radical gastrectomy. Eur Surg Acta Chirurg Austriaca 2015;47:S5.
[15] Reim D, Kim YW, Ryu KW. Safety and feasibility of 3d laparoscopy assisted surgery for gastric cancer. Surg Endosc Other Interven Tech 2015;29:S29.
[16] Ji G, Qi S, Ji F, et al. Comparative study of three-dimensional and two-dimensional laparoscopic-assisted D2 radical gastrectomy in short-term efficacy [in Chinese]. Zhonghua Wei Chang Wai Ke Za Zhi 2016; 19:545–8.
[17] Lin JX, Huang C, Zheng C. Clinical outcomes of three-dimensional versus two-dimensional laparoscopic surgery for gastric cancer: a single center, prospective, randomized trial, an interim report. J Clin Oncol 2016;34:53.
[18] Lu J, Zheng CH, Zheng HL, et al. Randomized, controlled trial comparing clinical outcomes of 3D and 2D laparoscopic surgery for gastric cancer: an interim report. Surg Endosc 2017;31:2939–45.
[19] Ji F, Fang X, Fei B. Comparatives study of 3D and 2D laparoscopic surgery for gastrointestinal tumors [in Chinese]. Zhonghua Wei Chang Wai Ke Za Zhi 2017;20:509–13.
[20] Liu J, Zhou H, Qin H, et al. Comparative study of clinical efficacy using three-dimensional and two-dimensional laparoscopies in the treatment of distal gastric cancer. Onco Targets Ther 2018;11:301–6.
[21] Sorensen SM, Savran MM, Konge L, et al. Three-dimensional versus two-dimensional vision in laparoscopy: a systematic review. Surg Endosc 2016;30:11–23.
[22] Tao K, Liu X, Deng M, et al. Three-dimensional against 2-dimensional laparoscopic colectomy for right sided colon cancer. Surg Laparosc Endosc Percutan Tech 2016;26:324–7.
[23] Yoon J, Kang S, Kim MH, et al. Comparison of short-term outcomes between 3D and 2D imaging laparoscopic colectomy with D3 lymphadenectomy for colon cancer. J Laparoendosc Adv Surg Tech A 2019;29:340–5.
[24] Wang JB, Huang CM, Zheng CH, et al. Role of 3DCT in laparoscopic total gastrectomy with spleen-preserving splenic lymph node dissection. World J Gastroenterol 2014;20:4797–805.
[25] Tang FJ, Qi L, Jiang HC, et al. Comparison of the clinical effectiveness of 3D and 2D imaging systems for laparoscopic radical cystectomy with pelvic lymph node dissection. J Int Med Res 2016;44:613–9.
[26] Kyriazis I, Ozsoy M, Kallidonis P, et al. Integrating three-dimensional vision in laparoscopy: the learning curve of an expert. J Endourol 2015;29:657–60.
[27] Liang H, Liang W, Zhao L, et al. Robotic versus video-assisted lobectomy/segmentectomy for lung cancer: a meta-analysis. Ann Surg 2018;268:254–9.
[28] Shao W, Yin W, Wang W, et al. Glasses-free three-dimensional endoscopic bronchoplasty, arterioplasty, and angioplasty of the superior vena cava for the radical treatment of right middle upper lung cancer. J Thorac Dis 2016;8:608–11.
[29] Maeso S, Reza M, Mayol JA, et al. Efficacy of the Da Vinci surgical system in abdominal surgery compared with that of laparoscopy: a systematic review and meta-analysis. Ann Surg 2010;252:254–62.