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Diagnostic accuracy of gastric filling ultrasonography in preoperative invasion depth (T stage) of gastric cancer

Meta-analysis

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Abstract

Objective: This study aimed to evaluate the diagnostic value of gastric filling ultrasonography in the preoperative invasion depth (T staging) of gastric cancer.

Methods: We systematically searched several online electronic databases including CNKI, Wanfang Medical Database, VIP, CBM, Pubmed, Embase, Cochrane Library, and Web of Science from January 2010 to December 2021, identifying the study about gastric filling ultrasonography for diagnostic of invasion depth of gastric cancer. Using bivariate mixed effect model to calculate the sensitivity (Sen), specificity (spe), positive likelihood ratio (PLR), negative likelihood ratio (NLR), and diagnostic odds ratio (DOR) with 95% confidence interval (CI). Draw the summary receiver operating characteristic (sROC) curve, likelihood ratio matrix and fagan diagram to evaluate the diagnostic value of gastric filling ultrasonography in the preoperative invasion depth of gastric cancer. Sen analysis and Publication bias tests were performed.

Results: This study obtained 21 literatures and the quality were good. The pooled Sen and spe of gastric filling ultrasonography was: T1: 0.63 (95% CI:0.51–0.73), 0.96 (95% CI:0.94–0.98); T2: 0.67 (95% CI:0.62–0.71), 0.90 (95% CI:0.88–0.93); T3: 0.79 (95% CI:0.75–0.82), 0.83 (95% CI:0.80–0.86); T4: 0.80 (95% CI:0.73–0.86), 0.96 (95% CI:0.94–0.97), respectively. In addition, the PLR and NLR of gastric filling ultrasonography was: T1: 16.74 (95% CI:9.98–28.09), 0.39 (95% CI:0.29–0.52); T2: 6.98 (95% CI:5.20–9.38), 0.36 (95% CI:0.31–0.42); T3: 4.65 (95% CI:3.78–5.73), 0.26 (95% CI:0.21–0.31); T4: 18.51 (95% CI:12.77–26.83), 0.20 (95% CI: 0.15–0.29), respectively. The DOR of gastric filling ultrasonography in T1-T4 was: 43.17 (95% CI:20.62–90.41),19.13 (95% CI:12.61–29.03), 18.15 (95% CI:12.86–25.62), 90.63 (95% CI:47.36–173.41), respectively. The sROC curve revealed that the area under the curve (AUC) of T1-T4 was: 0.93, 0.82, 0.87, 0.97, respectively. Sen analysis indicated that the study was steadily. And there is no publication bias in this study. But the study has some heterogeneity.

Conclusion: Gastric filling ultrasonography is useful for clinical preoperative T staging of gastric cancer, and the result indicate that the accuracy of gastric filling ultrasonography in discriminating T1-T4 is higher than that in discriminating T2 - T3. It can be used as an imaging diagnostic method for preoperative T staging of gastric cancer.

Abbreviations: AUC = area under the curve, CI = confidence interval, DOR = diagnostic odds ratio, NLR = negative likelihood ratio, PLR = positive likelihood ratio, QUADAS = quality assessment of diagnostic accuracy studies, Sen = sensitivity, spe = specificity, sROC = summary receiver operating characteristic.

Keywords: depth of invasion, gastric cancer, T staging, ultrasonography

1. Introduction

Gastric cancer is a malignant tumor originating from gastric epithelium, in recent years, the incidence and mortality rate of gastric cancer are increasing year by year, has become the fifth most common malignant tumor in the world, the incidence rate is in the second only to lung cancer and the death rate is third[1] (Chen W et al, 2015), and belongs to high incidence in our country. The clinical symptoms of early gastric cancer are not obvious, most findings are already in advanced stage, lost the best period of treatment, which can lead to poor prognosis, one of the causes

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of high mortality rate. Surgical treatment is the first choice for gastric cancer patients, no matter which stage it is in. A guide indicates[2] (China Society of Clinical Oncology Guide Working Committee, 2021): for early gastric cancer, endoscopic mucosal resection and endoscopic submucosal dissection are preferred, for advanced gastric cancer, surgical resection and partial combined chemotherapy is preferred. Therefore, the choice of surgical methods is closely related to preoperative T stage and prognosis of patients. Gastroscopy, endoscopic ultrasonography, enhanced CT and PET can be used as preoperative examination methods for gastric cancer. But each examination method has certain limitation. Gastroscopy can directly observe the tumor and take biopsy, but it cannot judge the invasion depth of tumor. Although endoscopic ultrasonography has always been considered as the most reliable method for T staging, but it belongs to invasive examination, and is easily affected by inflammation and probe angle, which requires high operators. Enhanced CT has certain radiation, limited for the diagnosis of superficial lesions, and mainly used in the diagnosis of lymph node metastasis. PET has high sensitivity (Sen) and specificity (spe) for staging of gastric cancer, but it is expensive and cannot be widely developed. Gastric filling ultrasonography refers to the patients oral gastrointestinal contrast agents, excluding the interference of gas and content in the gastric cavity, can form a homogenous echo of the stomach cavity, similar to the "substantive" organs, it can clearly and intuitively show the level of gastric wall and the location, size, number, invasion depth of lesions. A recent meta-analysis[3] (Zhang DN et al, 2021) showed that the diagnostic accuracy of gastric filling ultrasonography for gastric cancer was as high as 94%. Guidelines for diagnosis and treatment of gastric cancer issued by the National Health Commission (2018 edition)[4] (National Health Commission, 2019) also indicate that ultrasonography can be used as a routine imaging examination for gastric cancer. More and more literatures have also reported its application in the diagnosis of the invasion depth of gastric cancer, but there are large differences between studies and lack of large sample studies. Therefore, this study used systematic evaluation method to evaluate the diagnostic accuracy of gastric filling ultrasonography in preoperative invasion depth of gastric cancer, and to explore its clinical application value.

2. Materials and Methods

This meta-analysis was in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses and has registered in PROSPERO platform, the registered number is CRD42021290561. the study also followed PICOS guidelines, For this study: patients (P): people with gastric cancer; Intervention (I): gastric filling ultrasonography; Comparison/control (C): pathology; Outcomes (O): The invasion depth; Study (S): screening test. This study is a summary of previous studies by others, so no ethical review is required.

2.1. Literature search

We systematically searched several online electronic databases including CNKI, Wanfang Medical Database, VIP, CBM, Pubmed, Embase, Cochrane Library, and Web of Science from January 2010 to December 2021, The Mesh search strategy were: "Stomach Neoplasms" AND "Ultrasonography," at the same time, subject words and free words are used to retrieve the relevant literature more comprehensively, and a comprehensive search was also conducted for references to the included literature.

2.2. Inclusion and exclusion standard

2.2.1. Inclusion standard.

(1) Patients with gastric cancer.
(2) Study evaluated the diagnostic accuracy of gastric filling ultrasonography in the preoperative T staging of gastric cancer.
(3) All patients has accepted gastric filling ultrasonography before operation.
(4) Sample size >30 cases.
(5) Postoperative pathology as gold standard.
(6) The 4 tabular data can be obtained directly or indirectly, including true positive, true negative, false positive and false negative.

2.2.2. Exclusion standard.

(1) Repeated published literature.
(2) Reviews, comments and published meta-analysis etc.
(3) Sample size <30 cases.
(4) Gold standard is not postoperative pathology.
(5) The research indicators are not with T1, T2, T3, T4 as staging.
(6) Ca not obtained the 4 tabular data.

2.3. Literature data extraction and quality evaluation

The literature was carefully read by 2 researchers and the information was extracted independently. if the data is inconsistent, so through the third-party to consult. The following information is extracted: first author, publication year, number of cases, male-female ratio, average age, machine, machine frequency, research type, gold standard, country, true positive, true negative, false positive, false negative. Quality assessment of diagnostic accuracy studies (QUADAS)[5] (Zeng XT et al, 2012) was used to evaluate the quality of the included literature, each according to "Yes (Y)," "No (N)," "Unclear (U)."

2.4. Data analysis

Using Meta-disc 1.4 and Stata 15.1 software to performed data analysis. The heterogeneity of threshold effect should be examined before the bivariate mixed effect model used: The spearman correlation coefficient between Sen logarithm and (1 - Spe) logarithm is analyzed, to observe whether $P \leq .05$, and observe the summary receiver operating characteristic (sROC) curve whether was "shoulder-arm." If $P \leq .05$ or the sROC curve was "shoulder-arm," revealed that there was heterogeneity caused by threshold effect. I2 and Cochran-Q tests were used to examine whether there was heterogeneity caused by non-threshold effect. The test level was $I^2 \leq 50$ %, $P > .1$, as the same time, combined the bivariate box diagram. According to the characteristics of research object, to search for the factors of heterogeneity by meta-regression. Used bivariate mixed effect model to calculate the Sen, spe, positive likelihood ratio (PLR), negative likelihood ratio (NLR), and diagnostic odds ratio (DOR) with 95% confidence interval (CI). The sROC curve was drawn and the area under the curve (AUC) value was calculated. The larger the AUC value, the higher the diagnostic accuracy of gastric filling ultrasonography in the preoperative T staging of gastric cancer. The likelihood ratio matrix and Fagan diagram was used to evaluate its clinical utility. Finally, analyze the Sen of the including literatures, tested the stability and reliability of the study. Draw the Deeks funnel plot, the symmetry of the funnel plot was detected by linear analysis to evaluate whether there was publication bias in the study, if $P < .05$ indicated exist publication bias.

3. Result

3.1. Results of included literature

3.1.1. Literature screening flow chart. We initially obtained 10185 Literatures from the database, 2939 literatures were excluded because of repeated published, reviews, published meta-analysis, and unable to obtain the full text. After preliminary screening of reading topic and abstract, 6781 literatures that did not meet the research content of this study were excluded, so 465 literatures were obtained after preliminary screening. After intensive reading of the full text, 444 literatures that did not meet the inclusion criteria and belongs to low quality were excluded, Finally, 21 literatures were included. See Figure 1 for the literature screening flow chart.

3.1.2. Basic information for the literatures. Twenty-one literatures with 2425 patients were included in this study, the included literatures were from China and Spain. Most of the research types were retrospective studies, and only 2 literatures[6,7] were prospective studies. All studies used abdominal convex probe, and some combined linear high-frequency probe. The ultrasonic frequency ranged from 1.0 to 12 MHz, some studies did not indicate which ultrasonic frequency was used. The gold standard was postoperative pathology. Tables 1 and 2 summarized the basic information on included in the study.

3.1.3. Quality evaluation of included literatures. According to the 14 items of QUADAS, the quality of 21 included literatures in meta-analysis was evaluated. All literatures did not explain whether the gold standard diagnosis was performed on the premise of knowing the ultrasound diagnosis, so article 11 was unclear (U), and part of the research results were explained, so other studies[12,14,19,26] did not conform to article 13, and only 5 literatures[8,9,11,19,26] explained the cases withdrawing from the study, so other studies did not conform to article 14. Shown in Figure 2.

3.2. Meta-analysis

3.2.1. Heterogeneity analysis. The spearman correlation coefficients of Sen logarithm and 1-Spe logarithm of T1-T4 stage obtained in this study were –0.071, –0.169, –0.024, –0.394, all $P > .05$. Furthermore, the sROC curve did not show a typical "shoulder-arm" structure, such as Figure 3, so there was no heterogeneity caused by threshold effect in this study. In addition, the heterogeneity of the diagnostic test is also affected by non-threshold effect factors, such as publication time, number of

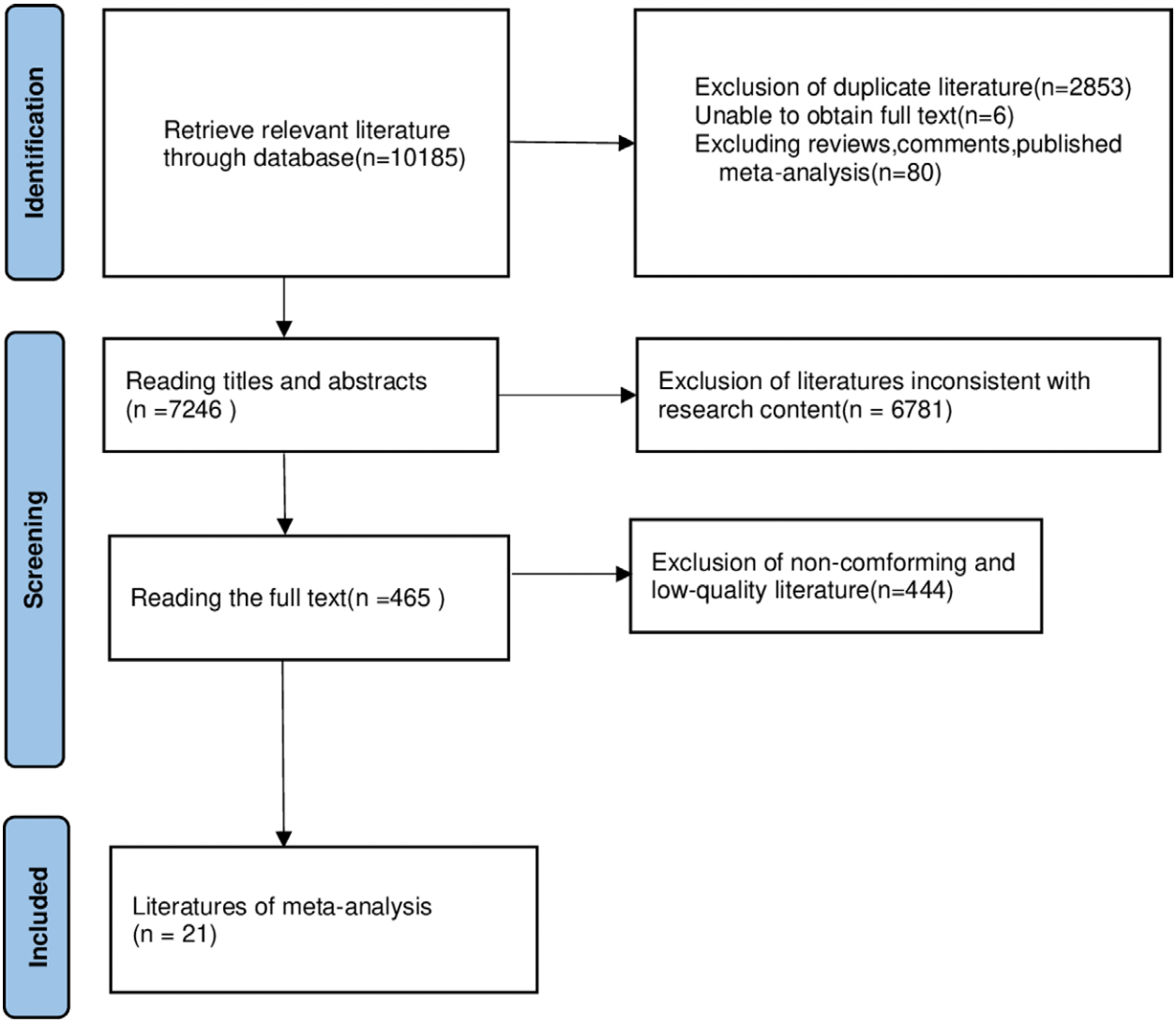

Figure 1. Flow chart of literature screening.

Table 1

Basic information of the included literatures.

Author	Yr	Cases	Male-female ratio	Average age	Machine	Frequency	Research type	Gold standard	Country
Gai[8]	2021	109	68/41	51.37 ± 11.45	Philips IU 22	2.0-5.0	retrospective	pathology	Spain
Ma[9]	2021	171	38/133	62.62 ± 10.32	Philips IU 22	1.0-5.0	retrospective	pathology	China
Geng[10]	2019	85	65/23	50.26 ± 12.81	DC-63500	3.5	retrospective	pathology	China
Wang[11]	2019	42	25/17	72.3 ± 3.4	Philips IU 22	3.5-5.0	retrospective	pathology	China
Yang[12]	2019	120	75/45	57.63 ± 5.42	GELOGIQ 500	—	retrospective	pathology	China
Zhou[13]	2018	55	41/14	52.8 ± 3.4	LOGIQ E9	3.6-9.0	retrospective	pathology	China
He[14]	2018	86	75/11	62.70 ± 4.50	Philips IU 22	—	retrospective	pathology	China
He[15]	2017	42	31/11	64	Hivision Hitachi	2.5-5.0	retrospective	pathology	China
Zhu[16]	2016	168	82/86	56.5	—	—	retrospective	pathology	China
Zhou[17]	2016	74	40/34	57.58 ± 7.78	Sequoia 512	3.5-5.0	retrospective	pathology	China
Shu[18]	2016	40	38/2	53.1	GELOGIQ S8	3.5-7.0	retrospective	pathology	China
Wang[19]	2015	166	124/42	61 ± 11	Philips IU 22	3.5-7.5	retrospective	pathology	China
Zhou[20]	2015	65	44/21	68.4 ± 9.7	Siemens Acuson X300	2.5-5.0	retrospective	pathology	China
Wang[21]	2015	119	86/33	59.8 ± 11.0	Philips HDI-5000 IU 22	2.0-5.0, 5.0-12.0	retrospective	pathology	China
Liu[6]	2015	288	178/110	54.6	Aplio 400, Hitachi 8500 Philips IU22	2.0-5.0	prospective	pathology	China
Yu[22]	2015	40	27/13	49	GELOGIQ 9	3.0-7.0	retrospective	pathology	China
Li[23]	2014	100	58/42	63.1 ± 11.8	Sequoia 512	2.0-5.0	retrospective	pathology	China
Feng[24]	2013	62	49/13	57.2	GELOGIQ 9, GELOGIQ E9	—	retrospective	pathology	China
Li s[7]	2012	350	245/105	63.6 ± 11.8	Sequoia 512	1.0-4.0	prospective	pathology	China
Cui[25]	2010	100	71/29	56.8 ± 11.2	GELOGIQ 9	2.5-10.0	retrospective	pathology	China
Chen[26]	2010	143	89/54	56 ± 11.4	Sequoia 512	2.0-5.0	retrospective	Pathology	China

Table 2

Basic data of the included literatures.

	TI				T2				T3				T4			
Author	TP	FP	FN	TN	TP	FP	FN	TN	TP	FP	FN	TN	TP	FP	FN	TN
Gai	20	3	2	82	26	5	6	70	31	5	6	65	14	3	2	88
Ma	4	3	3	161	18	8	7	138	55	12	9	95	67	4	8	92
Geng	7	13	15	50	5	17	12	51	16	5	10	54	19	3	1	62
Wang	2	2	0	36	7	0	2	31	20	0	0	20	9	0	0	31
Yang	7	1	5	107	11	8	4	97	45	17	12	46	23	6	13	78
Zhou	6	4	4	41	19	9	7	20	9	3	5	38	5	0	0	50
He	3	4	4	75	15	12	10	49	26	8	13	39	12	4	3	67
He	—	—	—	—	1	2	3	36	10	3	3	26	25	1	0	16
Zhu	7	11	9	141	39	19	19	91	45	19	24	80	11	17	14	126
Zhou	0	1	2	72	3	7	2	63	38	6	10	21	15	5	5	50
Shu	2	1	3	34	4	2	4	30	12	6	3	19	10	1	2	27
Wang	10	10	8	138	15	20	14	117	40	26	17	83	39	6	23	98
Zhou	7	2	8	48	8	8	5	44	16	8	5	36	13	3	3	46
Wang	9	0	7	104	7	4	8	101	16	26	2	76	54	0	17	49
Liu	32	4	4	224	54	16	22	172	104	26	18	116	22	6	8	228
Yu	5	1	0	34	5	2	4	29	17	5	3	15	4	1	2	33
Li	6	2	3	77	13	8	8	59	19	13	8	48	24	3	7	54
Feng	6	6	1	49	3	2	1	56	5	4	1	52	36	0	3	23
Li S	0	15	0	335	76	17	32	225	155	32	40	123	32	23	15	280
Cui	2	3	2	93	22	6	8	64	44	8	9	39	10	5	3	82
Chen	—	—	—	—	37	9	14	83	52	22	15	54	17	6	8	112

FN = false negative, FP = false positive, TN = true negative, TP = true positive.

cases, average age and other factors. Therefore, the heterogeneity caused by non-threshold effect was observed by analyzing the DOR, and combining bivariate box diagram (Fig. 4). The results showed that the results of I^2 and Cochran-Q tests in T1-T4 stage were not satisfied with $I^2 < 50\%$ and $P \geq .1$, the bivariate box diagram revealed that although most of the studies are located in the middle region, a small part of the studies in each stage are still outside the region, both suggest that non-threshold effect heterogeneity exists in the study. So we use meta-regression to analyze the possible sources of heterogeneity. Using bivariate mixed effect model to merge effects. The results were shown in Figures 5–7. Likelihood Ratio matrix was shown in Figure 8.

3.2.2. Pooled effect size. Pooled effects of gastric filling ultrasonography in preoperative T staging of gastric cancer following: sen, spe, PLR, NLR, AUG, DOR. AUC represents the area under the curve, the value range from 0.5 to 1, the closer to 1, indicating that the diagnostic accuracy of gastric filling ultrasonography in the preoperative T staging of gastric cancer is higher. The results showed that the AUC values were >0.8, indicating that the diagnostic accuracy of gastric filling ultrasonography in the preoperative T staging of gastric cancer is high, which can be applied to the diagnosis of preoperative T staging of gastric cancer. As shown in Table 3.

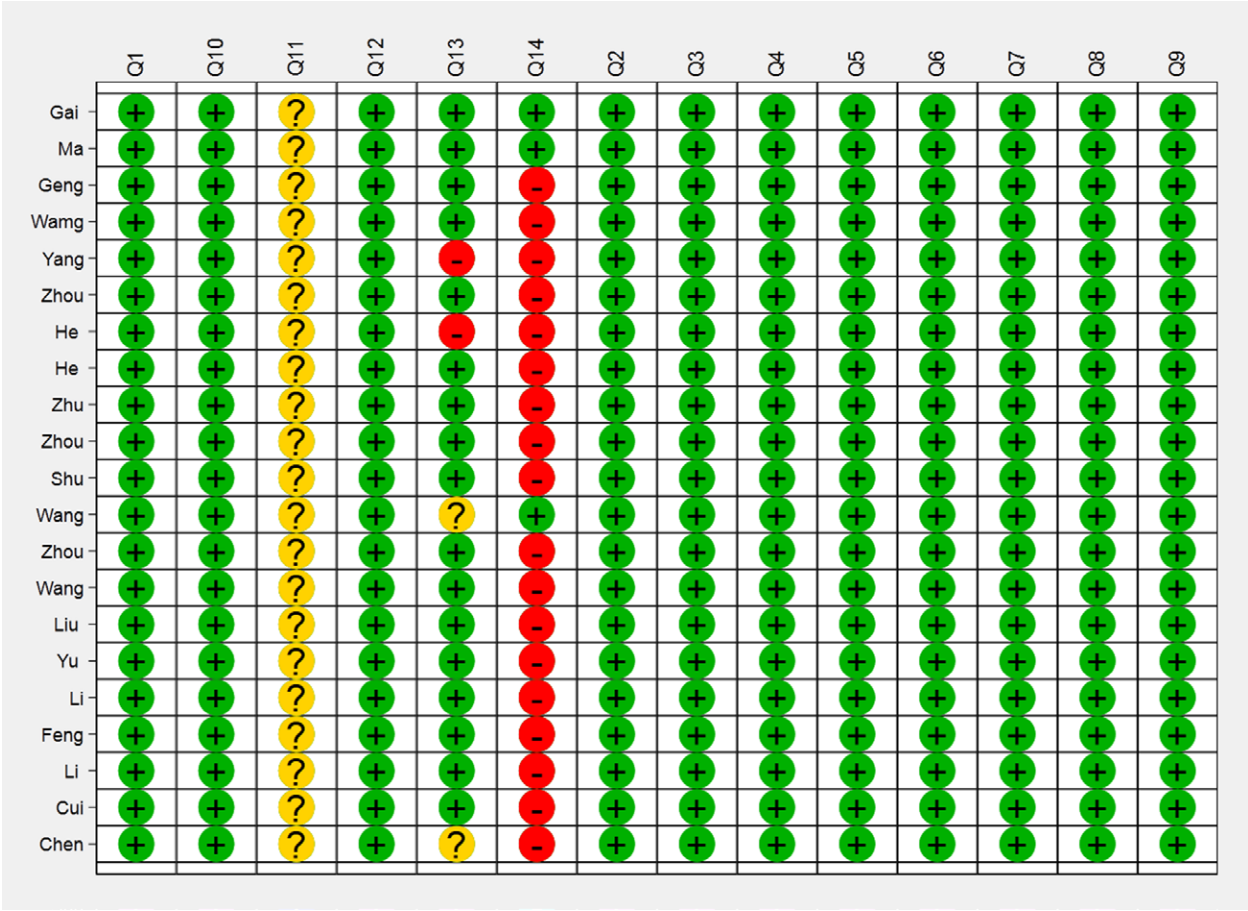

Figure 2. Quality evaluation of included literature.

3.2.3. Meta regression. Meta-Disc software was used to test the heterogeneity of non-threshold effect. According to the characteristics of the research object, non-threshold effect heterogeneity was analyzed with publication time (≤2015 vs >2015), age of patients (<60 vs ≥60) and number of cases (<100 vs ≥100) as influence factors. The results showed that the heterogeneity of T1 was mainly caused by the number of cases, and the accuracy of the study with large number of cases was 4.71 times than the study with small number of cases (DOR = 4.71, P = .05). The heterogeneity of T2 was mainly caused by the number of cases, and the accuracy of the study with large number of cases was 2.71 times than the study with small number of cases (DOR = 2.71, P = .02). The heterogeneity of T3 period is mainly due to the publication time, and the accuracy of the research in the past 10 years is 1.23 times than the previous 10 years (DOR = 1.23, P = .57). The heterogeneity of T4 was mainly due to the age of patients. The accuracy of younger patients was 2.05 times than older patients (DOR = 2.05, P = .26).

3.2.4. Sen analysis. Sen analysis is an important method to evaluate the stability and reliability of the meta-analysis. We conducted Sen analysis by omitting one study each time and pooled the rest of data, to observe whether the heterogeneity and the pooled effects is change. The results showed that the heterogeneity and the results of the pooled effects did not change significantly, indicating that the stability of the meta-analysis was high.

3.2.5. Publication bias. In this study, the Stata 15.1 software was used to draw Deeks funnel plot to evaluate publication bias. The results showed that there was no significant asymmetry in funnel plots of each stage, and the P values of T1-T4 was .30, .45, .26, .12, respectively. Therefore, there was no publication bias in this study (Fig. 9).

4. Discussion

Gastric cancer is one of the common gastrointestinal tumors. At present, the preoperative diagnosis of gastric cancer mainly include endoscopic examination and imaging examination, which is used for the diagnosis of quantify, location and stage of gastric cancer. The commonly used imaging examination for preoperative T staging is enhanced CT examination, but it has certain radiation. With the development of gastrointestinal filling contrast agent, gastric filling ultrasonography examination has become a routine preoperative examination method. After oral gastrointestinal filling contrast agent, gas in the gastric cavity can be effectively excluded, and the hierarchical structure of the gastric wall can be clearly displayed. The gastric filling ultrasonography examination is mainly based on the level of gastric wall damage to determine the invasion depth of gastric cancer. This method has the advantages of simple safety, good repeatability and high compliance of subjects.[27] And many studies have shown that[12,28] gastric filling ultrasonography and MSCT in the diagnostic accuracy of preoperative T staging of gastric cancer was not statistically significant. At present, the diagnostic of preoperative T stage of gastric cancer is mainly based on the eighth edition of diagnostic criteria proposed by the International Union Against Cancer (AJCC/UICC).[29] According to the results of staging, the surgical method of gastric cancer patients was choosed to ensure the maximum benefit of patients. Although many

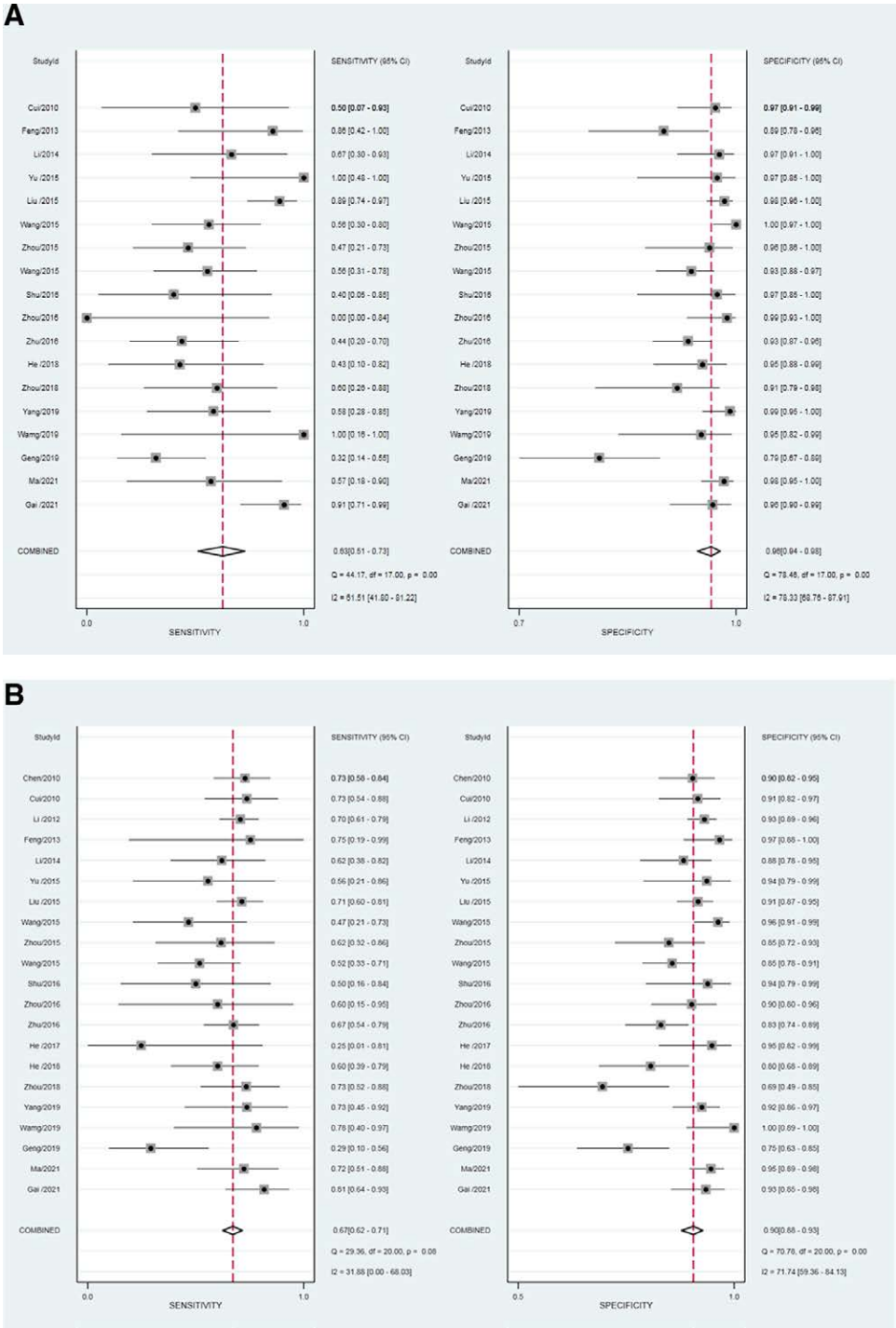

Figure 3. Forest plot of T1 (A), T2 (B), T3 (C), and T4 (D) gastric cancer. The sensitivity and specificity of gastric filling ultrasonography in preoperative T staging of gastric cancer.

scholars at home and abroad have done a lot of research in this area, but so far, there is no consensus on the diagnostic value of gastric filling ultrasonography in the preoperative T staging of gastric cancer. Therefore, this study uses meta-analysis to evaluate the diagnostic value of gastric filling ultrasonography in the preoperative T staging of gastric cancer. Twenty-one literatures with 2425 patients was included in this study. Most of the included literatures were from China, and only one was from Spain, which may be related to the high incidence of gastric cancer in China. The diagnostic test quality evaluation tool QUADAS was used to evaluate the quality of the included literatures, and the quality was good. The results of meta-analysis showed that the pooled Sen, spe, PLR, NLR, DOR and AUC of gastric filling ultrasonography in diagnosing T1 stage were 0.63, 0.96, 16.74, 0.39, 43.17, 0.93, respectively. The pooled Sen, spe, PLR, NLR, DOR and AUC of gastric filling ultrasonography in diagnosing T2 stage were 0.67, 0.90, 6.98, 0.36, 19.13, 0.82, respectively. The pooled Sen, spe, PLR, NLR, DOR and AUC of gastric filling ultrasonography in diagnosing T3 stage were 0.79, 0.83, 4.65, 0.26, 18.15, 0.87, respectively. The pooled Sen, spe, PLR, NLR, DOR and AUC of gastric filling ultrasonography in diagnosing T4 stage were

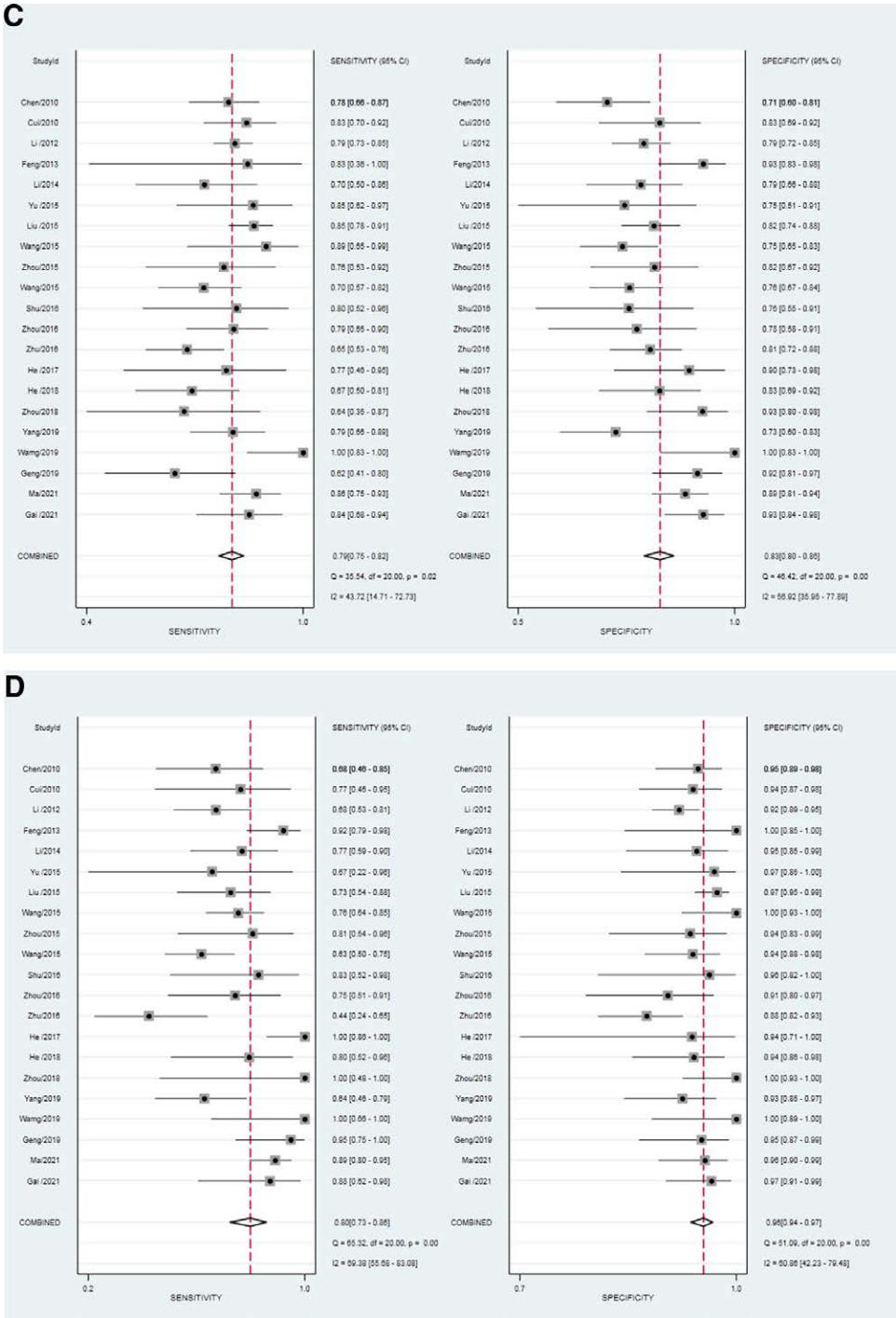

Figure 3. Continued

0.80, 0.96, 18.51, 0.20, 90.63, 0.97, respectively. The results of this study showed that gastric filling ultrasonography was less diagnostic Sen of T1 stage, Previous expert consensus guidelines[30] pointed out that gastric filling ultrasonography examination was not sensitive to early gastric cancer, and the results of this study was also consistent with it. However, the sROC curve showed that the AUC value at T1 stage could reach 0.93. Fagan diagram (Fig. 10) shows that the pre-test probability of T1 stage is 20%. After gastric filling ultrasonography examination, the post-test probability increases by 4.05 times, reaching to 81%. In addition, the likelihood ratio matrix also revealed that gastric filling ultrasound can diagnose preoperative T1 stage, but it cannot exclude the possibility of other stages. Compared with T1 stage, the diagnostic Sen of T2 and T3 was improved, but the diagnostic spe was decreased. The sROC curve showed that AUC value of T2 stage was the lowest, is 0.82. Fagan diagram showed that the prior probability of T3 stage was also 20%, but the post-test probability increased by 2.7 times, which was the least among the all T stages. and The likelihood ratio matrix revealed that gastric filling ultrasonography was not useful in diagnosing preoperative T2 and T3 stage, but could not exclude the possibility of other stages. For T4 stage, the Sen, spe and AUC value are all the highest, with an AUC value of 0.97. Fagan

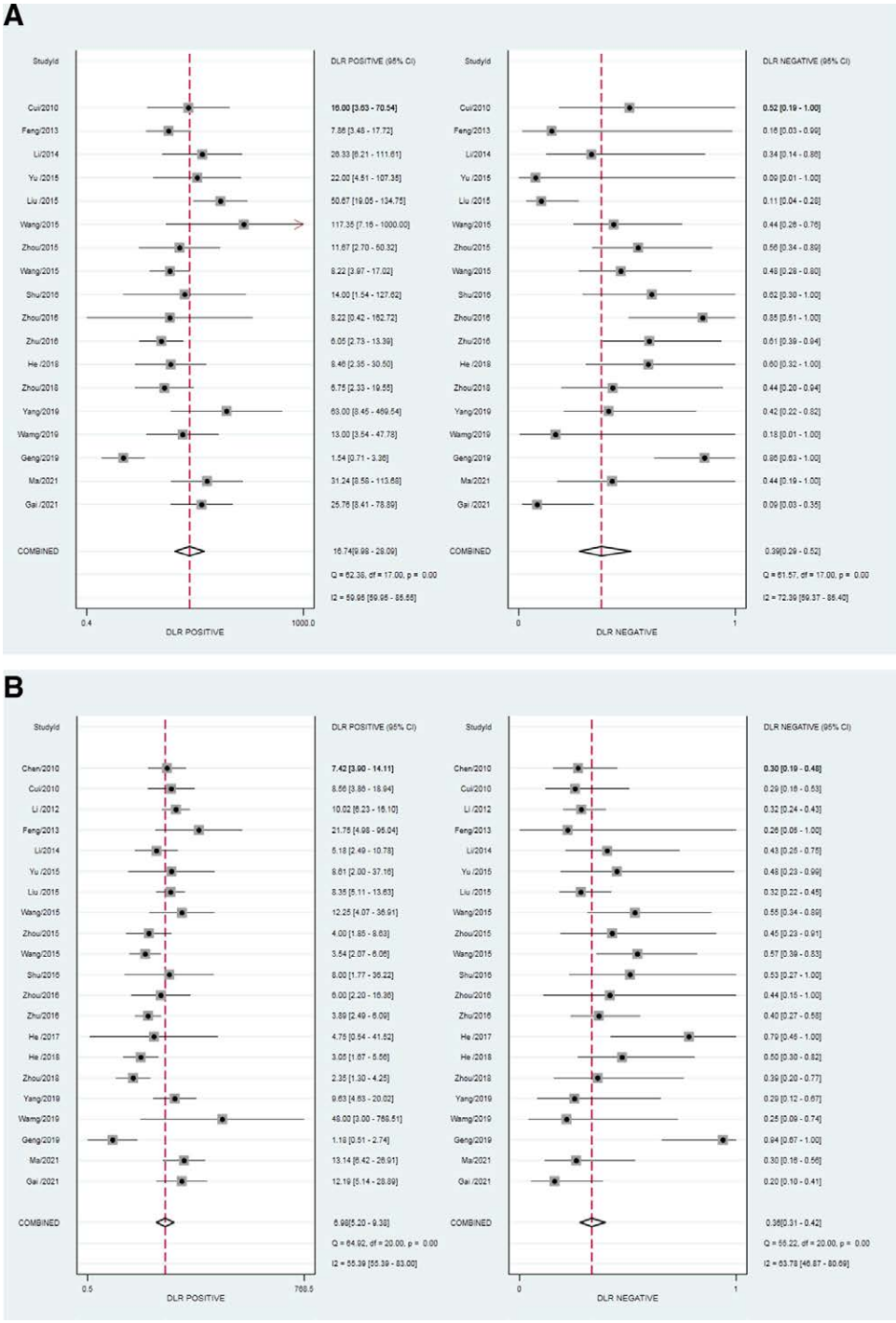

Figure 4. Forest plot of T1 (A), T2 (B), T3 (C), and T4 (D) gastric cancer. The positive likelihood ratio (PLR) and negative likelihood ratio (NLR) of gastric filling ultrasonography in preoperative T staging of gastric cancer.

diagram shows that when the prior probability of gastric filling ultrasonography is 20%, the prior probability increases the most, increasing by 4.1 times, reaching to 82%. Moreover, the likelihood ratio matrix revealed that gastric filling ultrasonography can diagnose preoperative T4 staging, but it cannot exclude the possibility of other stages. Therefore, gastric filling ultrasonography examination can increase the diagnostic accuracy of preoperative T staging, and has a certain value for preoperative T staging. Further analysis found that the accuracy of gastric filling ultrasonography in discriminating T1-T4 is higher than that in discriminating T2 - T3.

There are still some shortcomings in this study: There are some non-threshold effect heterogeneity in each stage of the study. Meta regression analysis shows that the heterogeneity of T1 and T2 in this study is mainly come from the number of cases; the heterogeneity of T3 mainly comes from the publication time; the heterogeneity of T4 mainly comes from age. Most of the studies were retrospective studies, which had certain influence on the accuracy of the results. This study only included Chinese and English literature, and may miss some other language literature. Different ultrasonic instruments used in this study

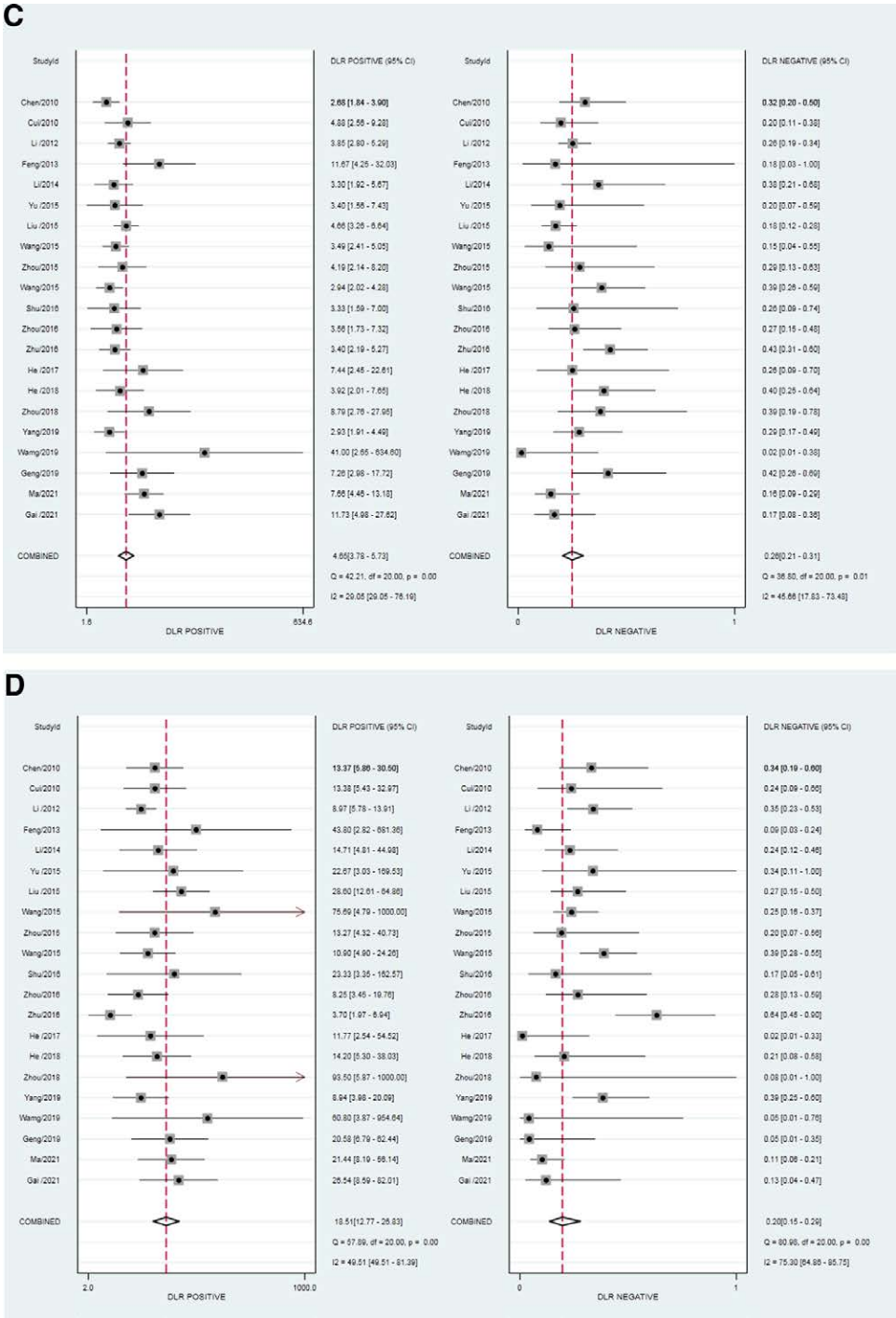

Figure 4. Continued

may affect the diagnostic accuracy of the results. Only one literatures included in this study comes from Spain, rest of them are from China, so there is a certain publication bias. Therefore, in order to further clarify its diagnostic value, more large sample clinical studies are still needed to confirm.

5. Conclusion

Gastric filling ultrasonography is useful for clinical preoperative T staging, in recent years, the diagnostic accuracy has also improved more compared to before, and the accuracy of gastric filling ultrasonography in discriminating T1-T4 is higher than that in discriminating T2 - T3.All in all, was consistent with pathological stages, It is expected to applying in clinical practice and provide a basis for the selection of treatment option.

Authors' contributions

Data curation: Mengmeng Nan, Yu Liu.
Investigation: Weihua Ye.
Methodology: Weihua Ye.
Resources: Zibo Zhang.
Software: Mengmeng Nan, Yu Liu.
Writing – original draft: Mengmeng Nan.

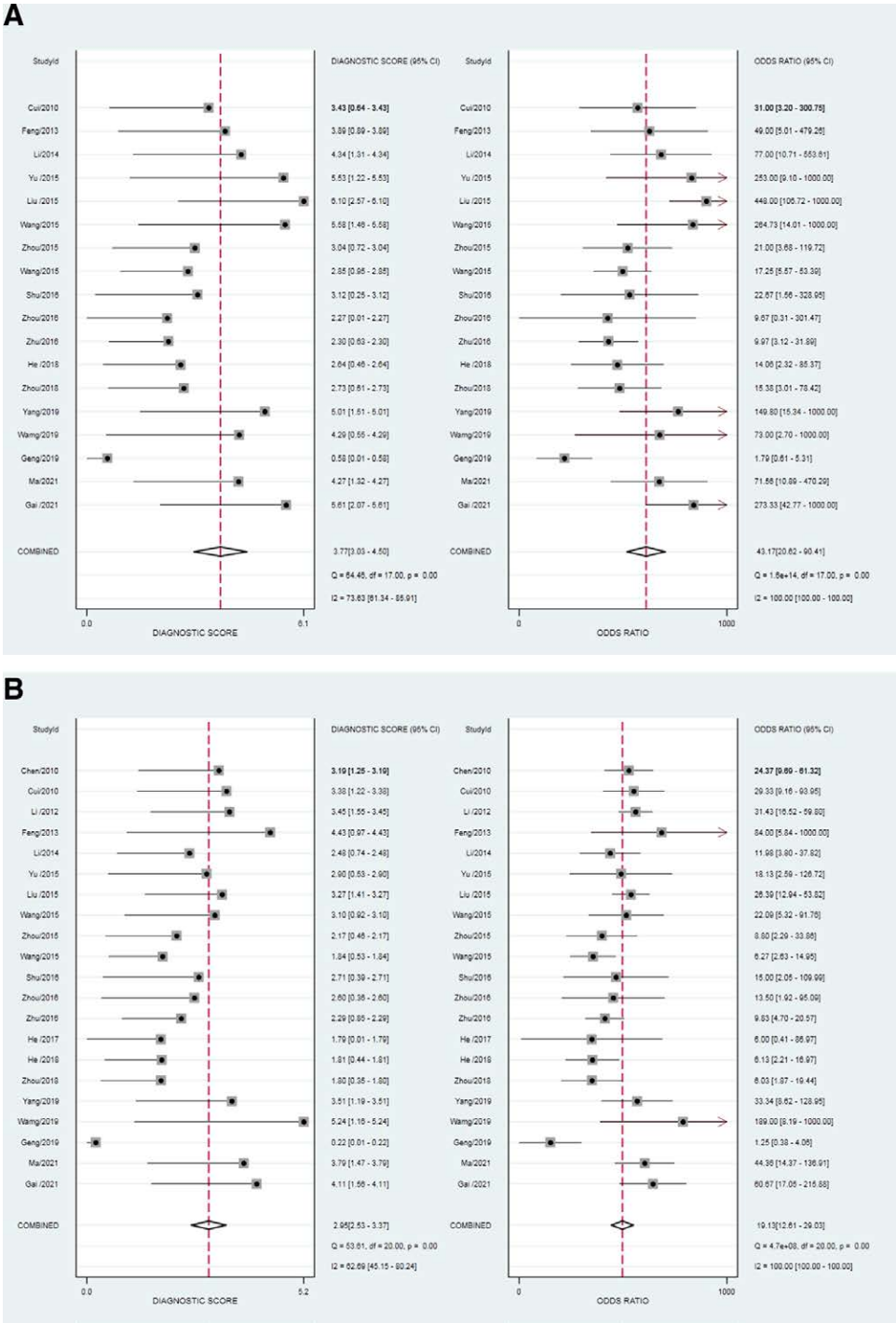

Figure 5. Forest plot of T1 (A), T2 (B), T3 (C), and T4 (D) gastric cancer. The diagnostic odds ratio of gastric filling ultrasonography in preoperative T staging of gastric cancer.

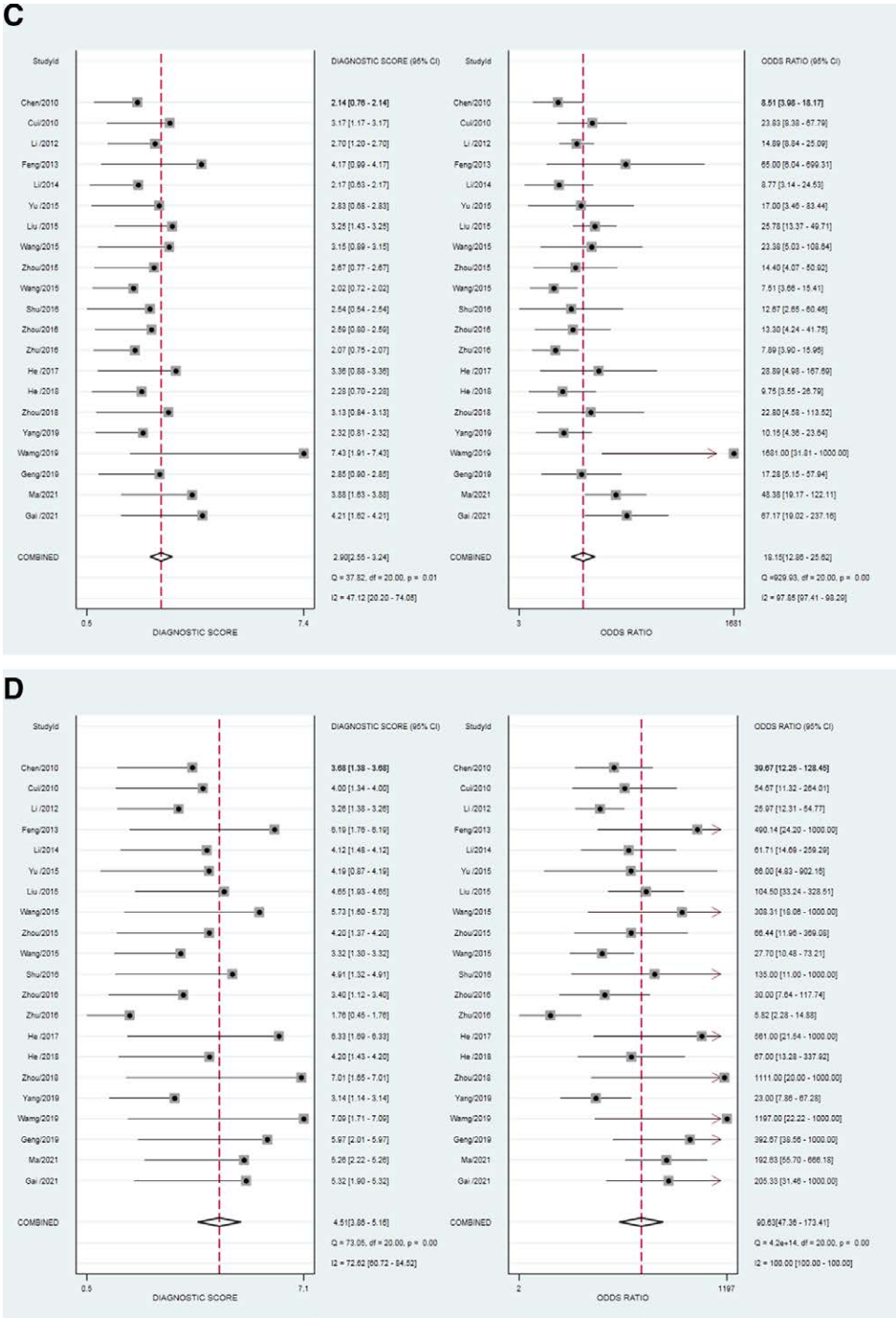

Figure 5. Continued

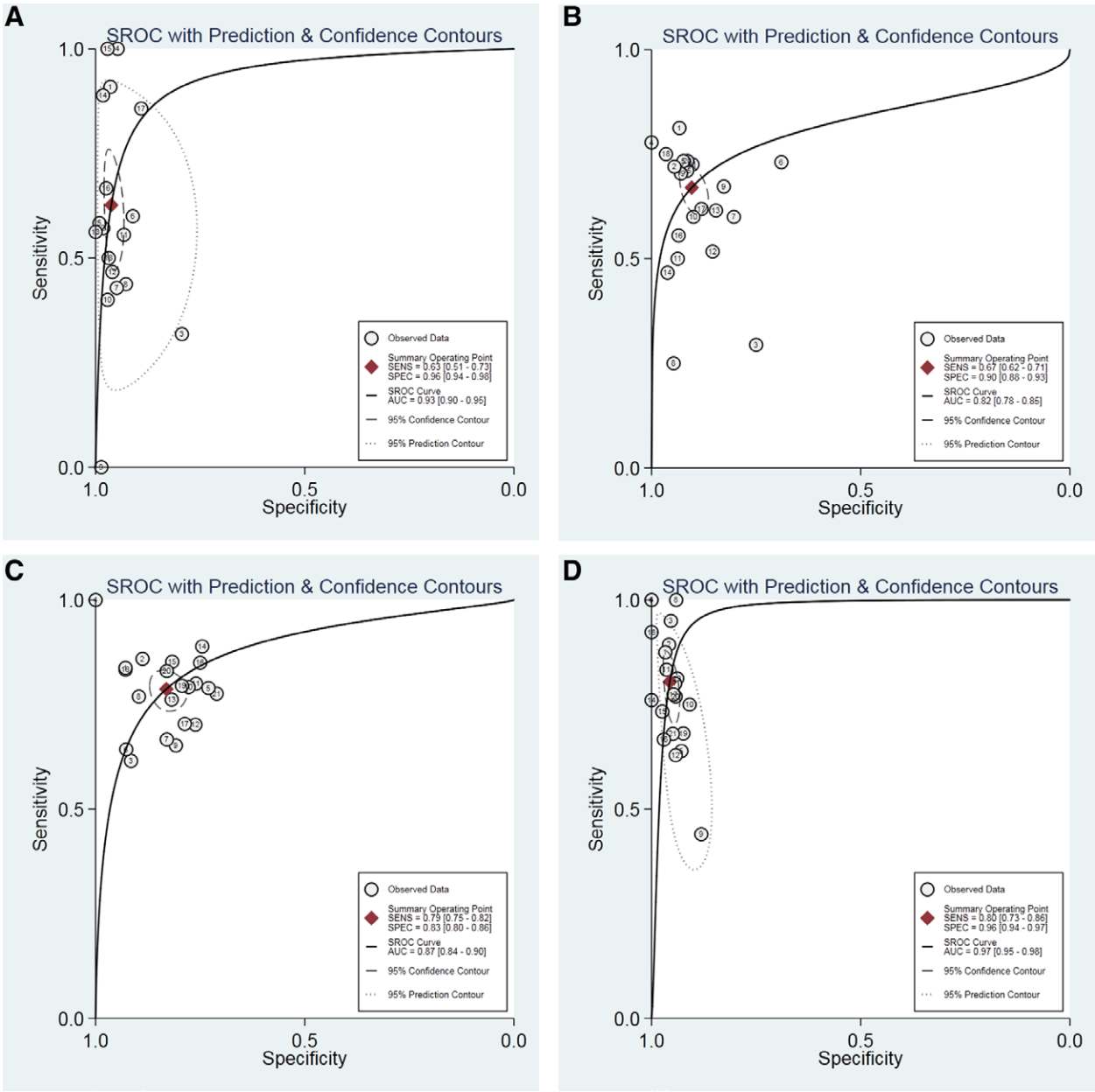

Figure 6. Summary receiver operating characteristic (sROC) curve of gastric filling ultrasonography in preoperative T staging of gastric cancer. T1 (A), T2 (B), T3 (C), and T4 (D).

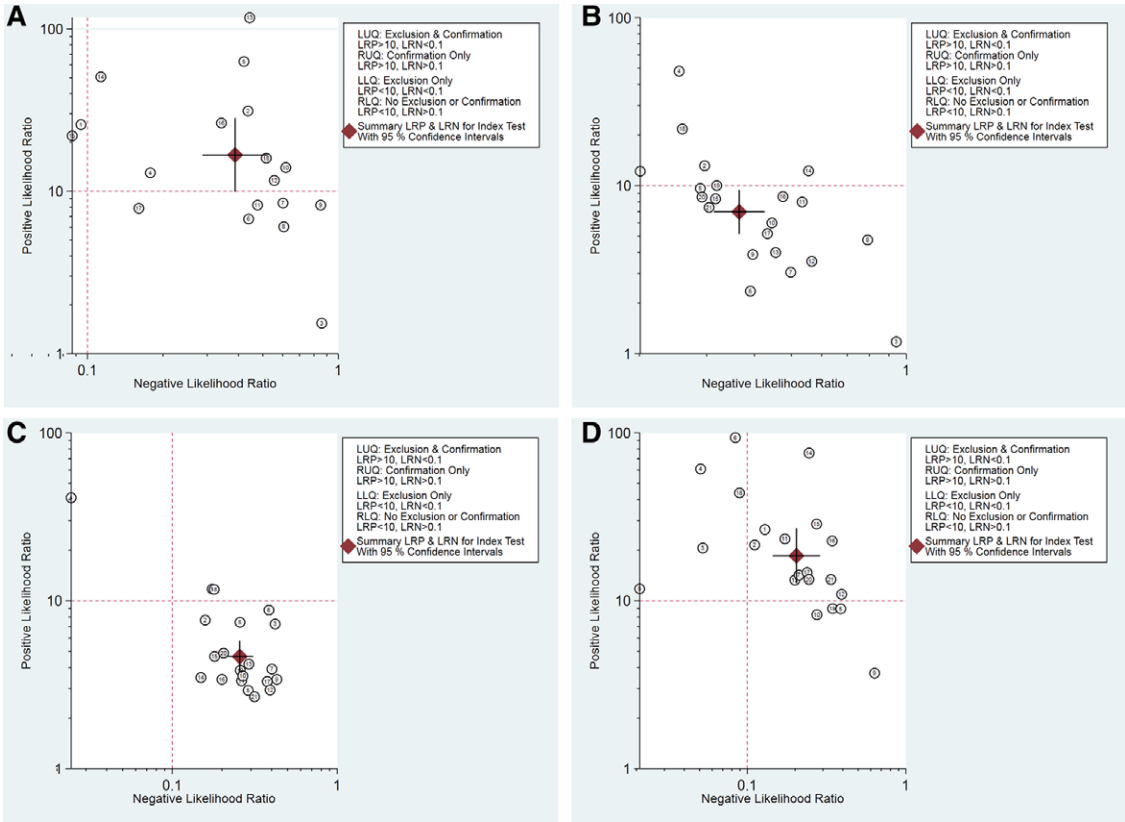

Figure 7. Likelihood ratio (LR) scattergram of gastric filling ultrasonography in preoperative T staging of gastric cancer. T1 (A), T2 (B), T3 (C), and T4 (D).

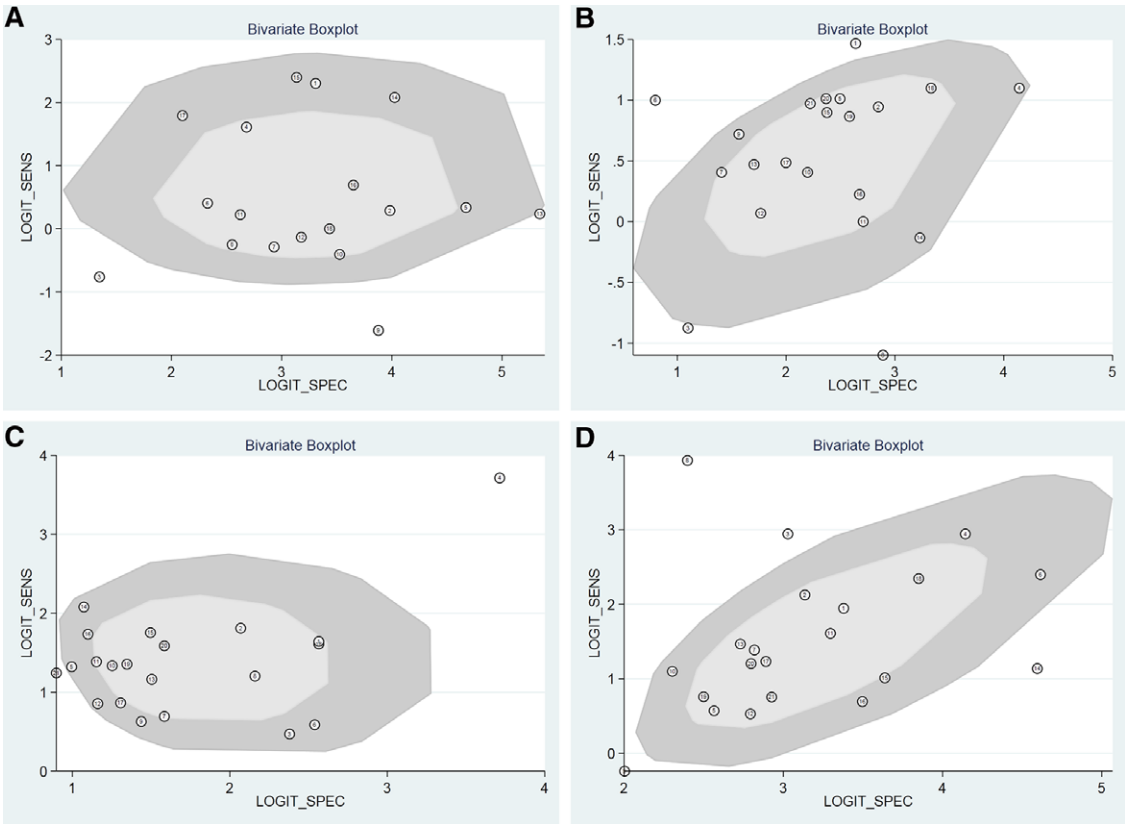

Figure 8. Bivariate box diagram of gastric filling ultrasonography in preoperative T staging of gastric cancer. T1 (A), T2 (B), T3 (C), T4 (D).

Table 3

The pooled effects of gastric filling ultrasonography in preoperative T staging of gastric cancer.

	T1(95%CI)	T2(95%CI)	T3(95%CI)	T4(95%CI)
sen	0.63(0.51-0.73)	0.67(0.62-0.71)	0.79(0.75-0.82)	0.80(0.73-0.86)
spe	0.96(0.94-0.98)	0.90(0.88-0.93)	0.83(0.80-0.86)	0.96(0.94-0.97)
PLR	16.74(9.98-28.09)	6.98(5.20-9.38)	4.65(3.78-5.73)	18.51(12.77-26.83)
NLR	0.39(0.29-0.52)	0.36(0.31-0.42)	0.26(0.21-0.31)	0.20(0.15-0.29)
DOR	43.17(20.62-90.41)	19.13(12.61-29.03)	18.15(12.86-25.62)	90.63(47.36-173.41)
AUC	0.93	0.82	0.87	0.97

AUC = area under the curve, CI = confidence interval, DOR = diagnostic odds ratio, NLR = negative likelihood ratio, PLR = positive likelihood ratio, Sen = sensitivity, spe = specificity.

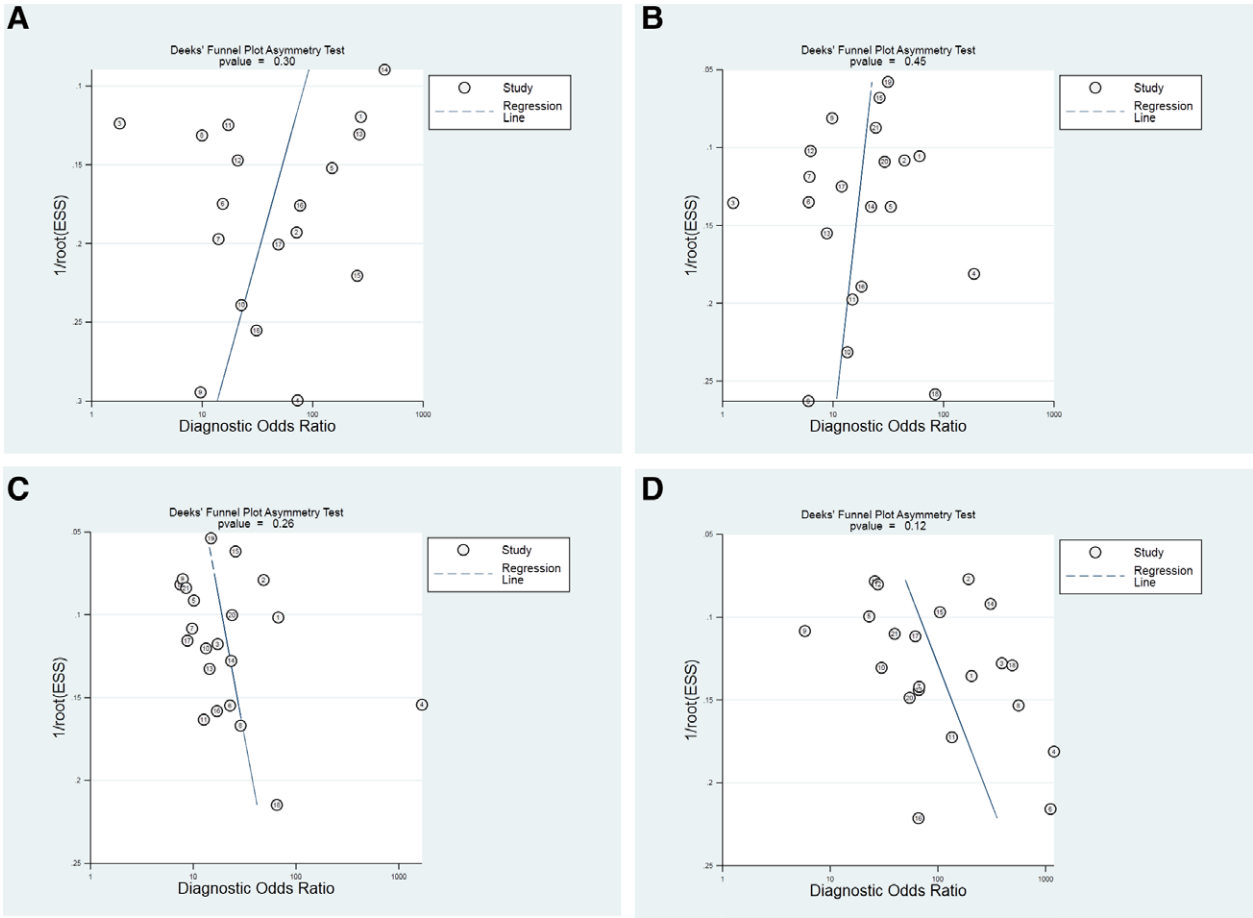

Figure 9. Deeks funnel plot of included literatures. T1 (A), T2 (B), T3 (C), T4 (D).

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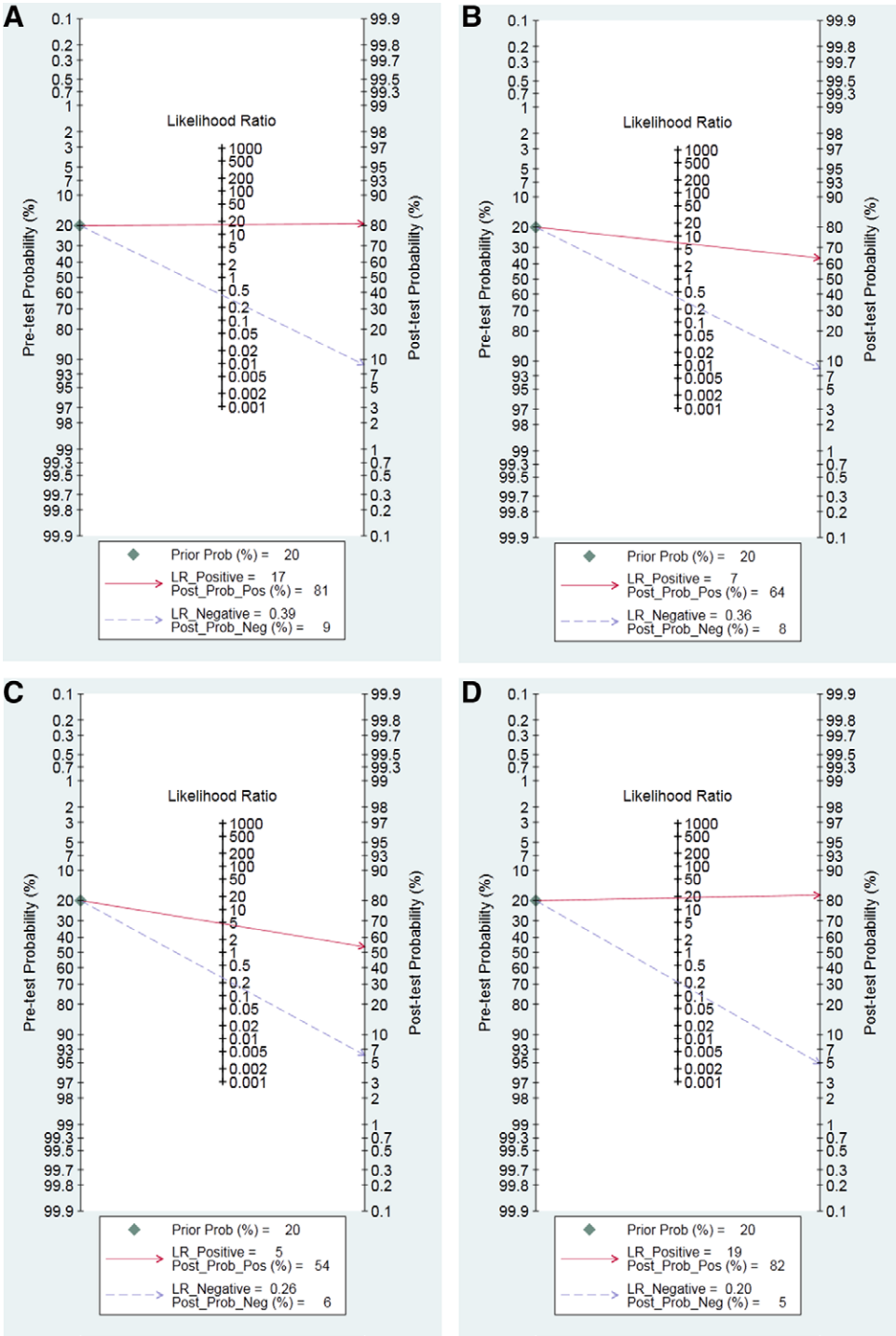

Figure 10. Fagan diagram of gastric filling ultrasonography in preoperative T staging of gastric cancer. T1 (A), T2 (B), T3 (C), T4 (D).

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