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Review Article

Endorectal ultrasound with elastography for differentiating benign and malignant rectal tumors: a systematic review and meta-analysis

Qinyi Qian[1*], Xinxian Gu[1*], Bo Shi[2*], Chen Shen[1*], Yinkai Xu[2], Wen Gu[2]

[1]Department of Ultrasound, The Fourth Affiliated Hospital of Soochow University, Suzhou, Jiangsu, China; [2]Department of General Surgery, The First Affiliated Hospital of Soochow University, Suzhou, Jiangsu, China. [*]Equal contributors and co-first authors.

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Abstract: Background: Timely and precise diagnosis of rectal tumors is pivotal for improving patient outcomes. Despite advances in imaging technologies, differentiating benign adenomas from early-stage rectal cancer remains a significant challenge. The aim of this study was to assess the effectiveness of endorectal ultrasound (ERUS) elastography in differentiating rectal adenomas from cancer. Methods: In accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a comprehensive search of the PubMed, Embase, and Cochrane databases was performed to identify studies that used ERUS elastography to assess rectal adenomas and cancer. A random effects model was employed to pool the sensitivity, specificity, and diagnostic odds ratio (DOR) for ERUS elastography in the diagnosis of rectal tumors. Results: Ten studies encompassing a total of 722 patients with rectal tumors were included in this meta-analysis. The pooled sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), and DOR of ERUS elastography for distinguishing benign from malignant rectal tumors were 93% (95% confidence intervals (CI), 88%-96%), 86% (95% CI, 78%-92%), 6.71 (95% CI, 4.14-10.86), 0.08 (95% CI, 0.05-0.14), and 84 (95% CI, 38-186), respectively. The summary receiver operating characteristic (SROC) curve demonstrated an area under the curve (AUC) of 0.95 (95% CI, 0.93-0.97). Conclusion: ERUS elastography greatly enhances diagnostic precision by distinguishing rectal adenomas from cancer, providing an effective approach to differentiate benign from malignant rectal lesions.

Keywords: Rectal neoplasms, elastography, ultrasound, diagnosis

Introduction

With the rapid advancement of rectal cancer screening technologies, the detection rates of early-stage rectal cancer and advanced adenomas have significantly increased [1, 2]. This trend not only emphasizes the importance of early intervention but also demands greater precision in treatment strategies. The diversification of treatment modalities for rectal tumors-ranging from minimally invasive endoscopic surgeries to complex multiorgan resections-highlights the central tenets of personalized medicine and organ preservation [3, 4]. The ultimate goal is to achieve optimal therapeutic outcomes while minimizing physiological and psychological trauma to the patient. In this context, precise diagnostic techniques are pivotal for guiding treatment decisions [5].

At present, magnetic resonance imaging (MRI) is the favored technique for diagnosing suspected rectal malignancies, particularly for staging advanced tumors and evaluating their invasion into nearby pelvic structures [6, 7]. Nevertheless, MRI often overestimates tumor staging in cT1-2 cancers, which may preclude patients from benefiting from organ-preserving treatments-a critical issue that warrants attention. ERUS, owing to its high resolution and precise delineation of the layered architecture of the rectal wall, is crucial for the local staging of early rectal tumors [8, 9]. However, similar to MRI, ERUS is also susceptible to overstaging.

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In recent years, the advent of shear wave elastography (SWE), an innovative ultrasound technique, has introduced new possibilities in disease diagnostics by quantifying tissue stiffness [10]; its successful application in liver, breast, and thyroid diseases has paved the way for exploring its potential in the evaluation of intestinal disorders [11-13].

Although the use of SWE in intestinal disease diagnosis remains in its infancy [14], its integration with ERUS has shown promise in assessing rectal wall elasticity, differentiating benign rectal lesions from malignant lesions, and monitoring the progression of inflammatory bowel disease. However, a comprehensive and systematic evaluation of the diagnostic efficacy of ERUS elastography in differentiating rectal adenomas from carcinomas is still lacking.

Therefore, the aim of this study was to conduct a systematic review and synthesis of existing research using a meta-analysis to comprehensively assess the diagnostic accuracy and clinical significance of ERUS elastography in differentiating rectal adenomas from rectal carcinomas.

Materials and methods

Data sources and search strategy

This meta-analysis followed a pre-registered protocol (PROSPERO: CRD42024590956). A thorough search of the PubMed, EMBASE, and Cochrane databases was conducted to identify studies evaluating the diagnostic performance of elastography in distinguishing rectal tumors. The detailed search strategy is outlined in Table S1. Studies identified as potentially eligible based on the titles and abstracts were further evaluated for inclusion in this meta-analysis. In addition, the references of the selected articles were reviewed to identify additional relevant studies through cross-referencing.

Study selection

Two reviewers (Qinyi Qian and Xinxian Gu) independently assessed the identified studies, first by screening titles and abstracts, followed by a full-text evaluation of the potentially eligible articles. Any conflicts between the two reviewers were settled through consultation with a third reviewer (Bo Shi), who mediated to reach a consensus, ensuring that all included studies adhere to the predefined eligibility criteria. Studies were considered eligible if they assessed the ability of elastography to differentiate rectal adenomas from cancers. The inclusion criteria are outlined as follows: 1. Original research articles, including research reports and experimental studies; 2. Independent primary data, not duplicated from other studies; 3. Study participants were patients with newly diagnosed rectal tumors; 4. Study participants were adults (≥18 years) with rectal lesions; 5. The study utilized ERUS technology combined with elastography; 6. The main objective of the study was to evaluate the effectiveness of ERUS elastography in accurately differentiating benign from malignant rectal lesions; 7. Histopathological examination was used as the diagnostic reference standard.

Data extraction

Two reviewers (Qinyi Qian and Xinxian Gu) separately collected data and evaluated the quality of the included studies, employing standardized data extraction forms. The following data were collected from each study: 1. Study characteristics: Publication year, patient recruitment period, authors, journal, and study design; 2. Population characteristics: Sample size, age, sex, surgical approach, histopathological findings, and TNM stage; 3. Elastography characteristics: Probe type, wave transmission frequency, number of measurements, and measurement mode.

Assessment of the quality of included studies

The quality of each included study was assessed using the QUADAS-2 tool, which focuses on key aspects of the study design. Two reviewers independently assessed the risk of bias and applicability concerns. Studies rated as ‘low’ risk across all domains related to bias and applicability were considered to have an overall ‘low risk of bias’ and ‘low concern regarding applicability’. In contrast, studies that were rated as ‘high’ or ‘unclear’ in any domain were categorized as having a ‘high risk of bias’ or raising ‘concerns regarding applicability’.

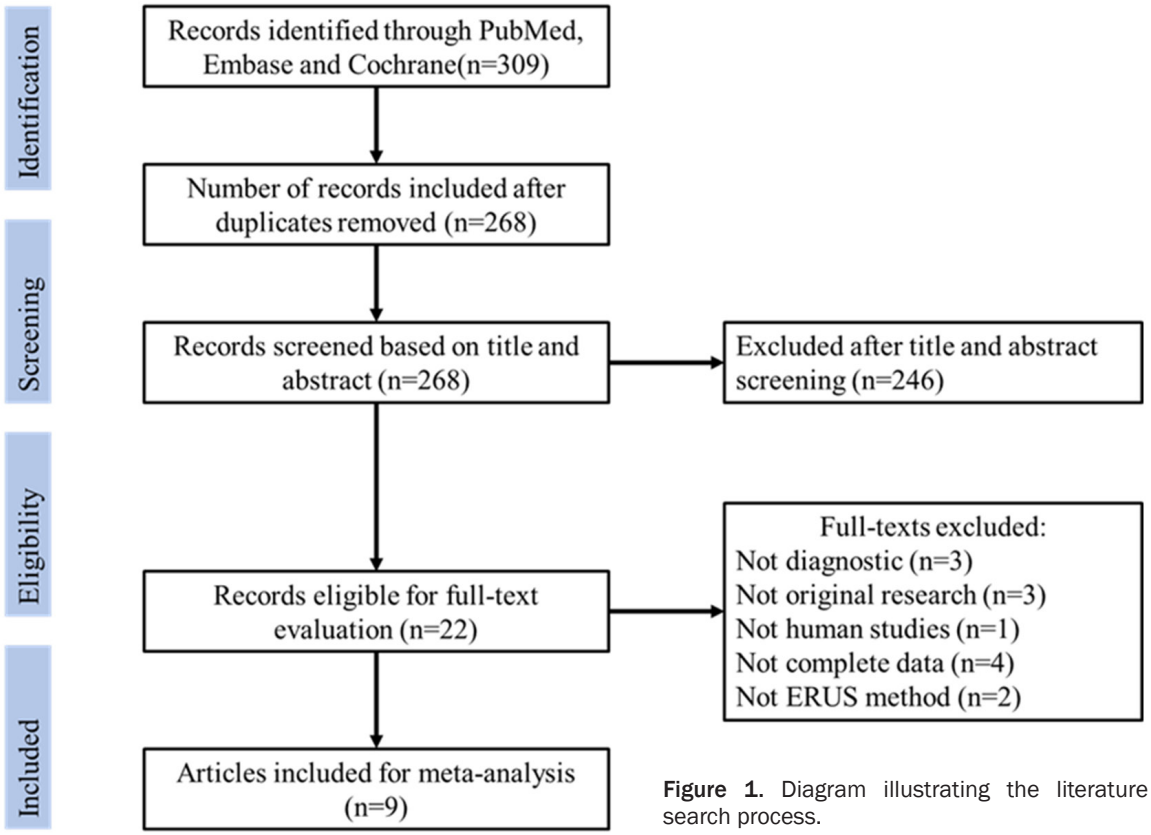

Figure 1. Diagram illustrating the literature search process.

Statistical analysis

The primary outcome measures for this analysis include combined estimates of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy. Heterogeneity among studies was assessed via the QUADAS tool. Sensitivity analyses was conducted to assess the effect of excluding studies that might affect the overall results. Given the expected variability in the accuracy of ERUS elastography across studies, a random effects model was employed for the meta-analysis of diagnostic accuracy. Study heterogeneity was evaluated using the I^2 statistic, with thresholds of 25%, 50%, and 75% corresponding to low, moderate, and high heterogeneity, respectively. The diagnostic performance of ERUS was further assessed using the SROC model.

All *p* values are two-sided. Outcome measures were reported with 95% CIs or interquartile ranges, as appropriate. All of the statistical analyses was conducted via Stata 18 (Stata Corp., College Station, TX, USA), and a *p* value < 0.05 was considered statistically significant.

Results

The literature search yielded 309 potentially relevant articles. Following a review of the titles and abstracts, 246 articles were excluded because they did not meet the inclusion criteria. The remaining 22 articles underwent a full-text review, which led to the exclusion of an additional 13 studies. In the end, 9 articles encompassing 10 studies, involving a total of 722 patients, were deemed eligible for inclusion in the meta-analysis [15-23]. The detailed process of study selection is depicted in the flow diagram (**Figure 1**).

The quality of the 10 studies was assessed using the QUADAS tool. Among those evaluating the effectiveness of ERUS elastography in distinguishing between benign and malignant rectal tumors, 3 studies were rated as having an overall 'low risk of bias', whereas the remaining 7 studies were classified as having 'a risk of bias'. Furthermore, all 10 studies were rated as having 'low concerns regarding applicability', with none deemed to have 'concerns regarding applicability'. The overall QUADAS scores for each study are shown in **Figure 2A**, **2B**.

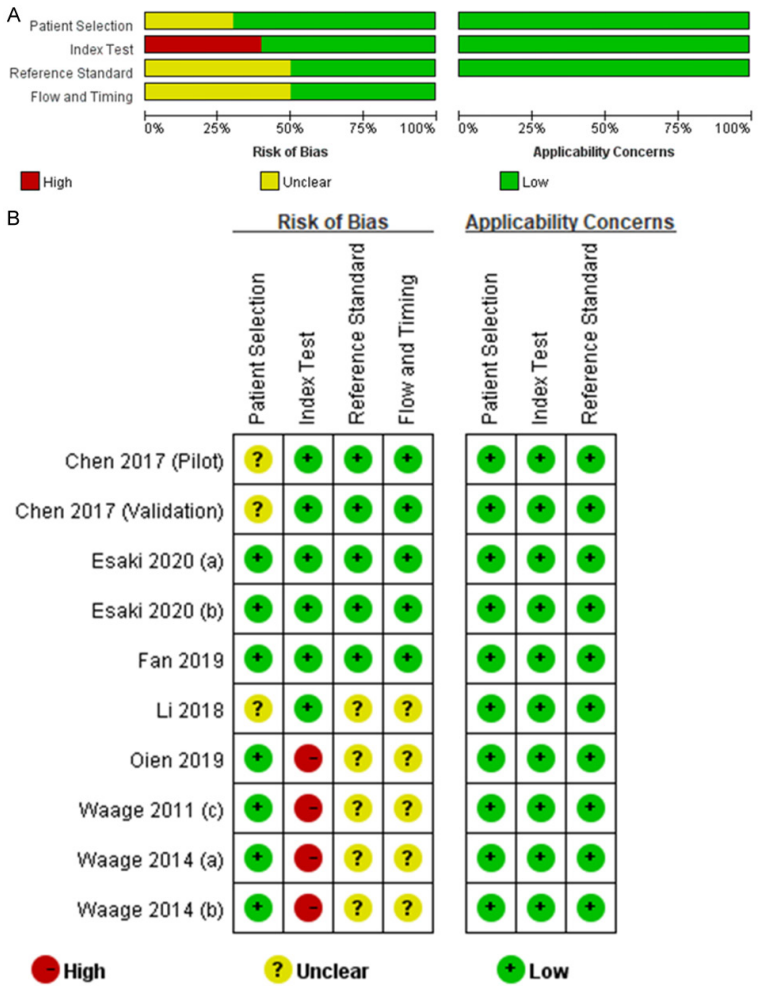

Figure 2. The quality evaluation of the included studies was performed using QUADAS-2, which summarizes "risk of bias" and "applicability concerns" by assessing each domain for every study included. A. Evaluation of risk of bias in the included studies. B. Assessment of applicability concerns in the included studies.

Data from 10 eligible studies, derived from 9 articles, were included in the analysis, encompassing a total of 722 patients with rectal tumors who underwent ERUS elastography. The patient count in each study varied between 30 and 120. All studies were single-center studies that were prospectively designed and conducted between 2011 and 2020. Notably, two studies utilized training and validation cohorts from the same article. **Table 1** provides a summary of the key characteristics of the included studies. Among the 10 studies, 6 relied solely on surgical specimens for histopathological evaluation, whereas 4 combined surgical specimens with biopsy samples for histopathological assessment. Two studies focused on distinguishing benign tumors from early-stage malignant tumors, five assessed tumor infiltration depth (T stage), and three aimed to differentiate benign from malignant tumors.

In the analysis of the 10 studies, considerable heterogeneity was observed in both sensitivity and specificity (I^2=66.35% and I^2=54.43%, respectively) (**Figure 3A**, **3B**). Consequently, a random effects model was employed in subsequent analyses to better account for the impact of this heterogeneity. The meta-analysis results demonstrated a pooled sensitivity of 93% (95% CI, 88%-96%) and a pooled specificity of 86% (95% CI, 78%-92%) for ERUS elastography in the diagnosis of rectal tumors. In contrast, MRI demonstrated a pooled sensitivity of 97% (95% CI, 92%-99%) and a pooled specificity of 77% (95% CI, 58%-89%) for diagnosing rectal tumors. Subsequent subgroup analyses, stratified by T stage and pathological outcomes, revealed that ERUS elastography offered greater diagnostic value in patients with early-stage rectal tumors (T0-T2), whereas patients with T3-T4 stage rectal tumors benefited less from ERUS elastography diagnosis (**Table 2**).

Given that the PLR and NLR are frequently viewed as more clinically relevant than sensitivity and specificity alone, we further calculated and pooled the PLR and NLR to emphasize the clinical significance of this technique. The pooled PLR was 6.71 (95% CI, 4.14-10.86), whereas the pooled NLR was 0.08 (95% CI, 0.05-0.14) (**Figure 4A**, **4B**). **Table 2** lists additional summary metrics for the diagnostic performance of ERUS and MRI. These significant results indicate that when an ERUS reveals malignant features, the likelihood of the tumor being genuinely malignant is substantially greater than the risk of misdiagnosis of a non-malignant tumor as malignant. Additionally, the probability of a tumor being malignant when ERUS suggests benign characteristics is

Table 1. Characteristics of the included studies

Author	Year	Design	Sample Size n	Age, Years Median (Range) Mean Age ± SD	Sex	Reference Standard	Research Question
Chen [15]	2017	Retrospective	Pilot: 70 Validation: 30	Pilot: 60±12 Validation: 50±11	Pilot: M/F: (42/28) Validation: M/F: (18/12)	Surgical specimen	Cutoff values T-stages
Waage -a [16]	2014	Retrospective	120	66 (25-88)	M/F: (67/53)	Surgical specimen or biopsy	Benign vs. malignant
Waage -b [18]	2014	Retrospective	59	NR	NR	Surgical specimen	Benign vs. pT1-2
Waage -c [17]	2011	Retrospective	68	70 (35-92)	M/F: (42/26)	Surgical specimen	Benign vs. malignant
Esaki -a [19]	2020	Retrospective	88	70 (34-87)	M/F: (49/39)	Surgical specimen or biopsy	Cutoff values T-stages
Esaki -b [20]	2020	Retrospective	40	70 (45-85)	M/F: (26/14)	Surgical specimen or biopsy	Cutoff values T-stages
Fan [21]	2019	Retrospective	55	59±12	M/F: (32/23)	Surgical specimen	Cutoff values T-stages
Li [22]	2018	Retrospective	96	NR	M/F: (55/41)	Surgical specimen or biopsy	Benign vs. malignant
Oien [23]	2019	Retrospective	96	68 (31-91)	NR	Surgical specimen	Benign vs. pT1-2

NR, not reported; M/F, Male/Female; SD, standard deviation; vs., versus.

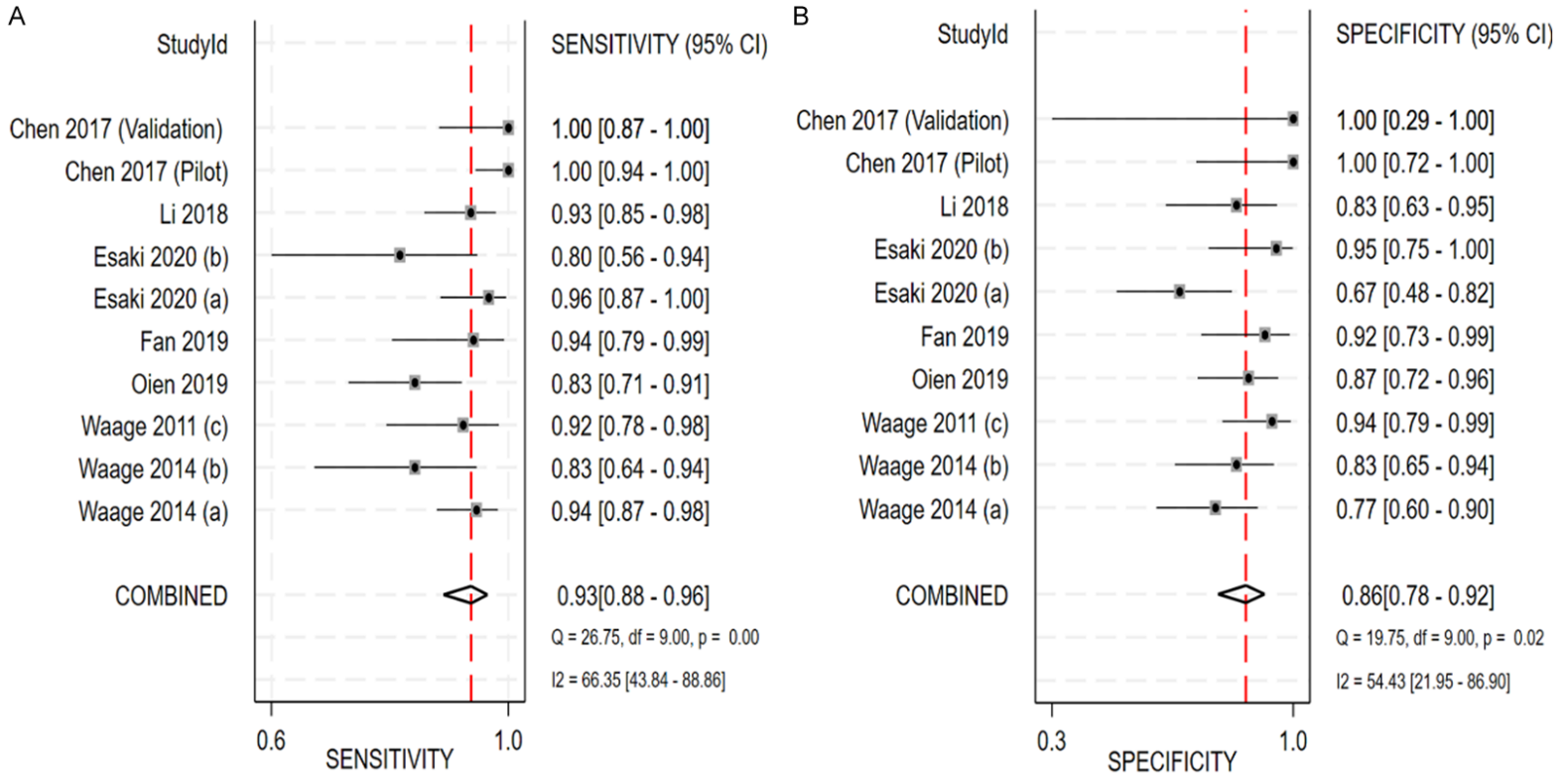

Figure 3. Forest plot of included studies evaluating the sensitivity and specificity of ERUS with elastography in distinguishing benign from malignant rectal tumors. A. Sensitivity evaluation of ERUS with elastography in distinguishing rectal tumors. B. Specificity evaluation of ERUS with elastography in distinguishing rectal tumors. CI, confidence intervals.

Table 2. Aggregated indices of diagnostic accuracy

	Sensitivity	Specificity	PLR	NLR	DOR	AUC
ERUS elastography T	93% (95% CI, 88%-96%)	86% (95% CI, 78%-92%)	6.71 (95% CI, 4.14-10.86)	0.08 (95% CI, 0.05-0.14)	84 (95% CI, 38-186)	0.95 (95% CI, 0.93-0.97)
MRI T	97% (95% CI, 92%-99%)	77% (95% CI, 58%-89%)	4.3 (95% CI, 2.2-8.4)	0.04 (95% CI, 0.02-0.10)	109 (95% CI, 38-308)	0.96 (95% CI, 0.93-0.97)
ERUS elastography Benign	88% (95% CI, 79%-94%)	83% (95% CI, 69%-91%)	5.2 (95% CI, 2.8-9.8)	0.14 (95% CI, 0.07-0.26)	37 (95% CI, 13-105)	0.93 (95% CI, 0.90-0.95)
ERUS elastography Malignant	95% (95% CI, 87%-98%)	90% (95% CI, 78%-96%)	9.4 (95% CI, 4.1-21.9)	0.05 (95% CI, 0.02-0.16)	184 (95% CI, 32-1073)	0.97 (95% CI, 0.95-0.98)
ERUS elastography T0	88% (95% CI, 55%-98%)	88% (95% CI, 51%-98%)	7.2 (95% CI, 1.1-46.4)	0.14 (95% CI, 0.03-0.77)	51 (95% CI, 2-1443)	0.94 (95% CI, 0.92-0.96)
ERUS elastography T1	94% (95% CI, 80%-98%)	87% (95% CI, 65%-96%)	7.0 (95% CI, 2.3-21.1)	0.07 (95% CI, 0.02-0.26)	101 (95% CI, 14-709)	0.92 (95% CI, 0.90-0.94)
ERUS elastography T2	95% (95% CI, 79%-99%)	93% (95% CI, 67%-99%)	13.5 (95% CI, 2.3-79.0)	0.05 (95% CI, 0.01-0.27)	266 (95% CI, 15-4712)	0.98 (95% CI, 0.96-0.99)
ERUS elastography T3-4	92% (95% CI, 73%-98%)	90% (95% CI, 68%-97%)	9.2 (95% CI, 2.5-34.4)	0.09 (95% CI, 0.02-0.34)	103 (95% CI, 13-808)	0.96 (95% CI, 0.94-0.98)

PLR, positive likelihood ratio; NLR, negative likelihood ratio; DOR, diagnostic odds ratio; AUC, area under the curve; ERUS, endorectal ultrasound; CI, confidence intervals; MRI, magnetic resonance imaging.

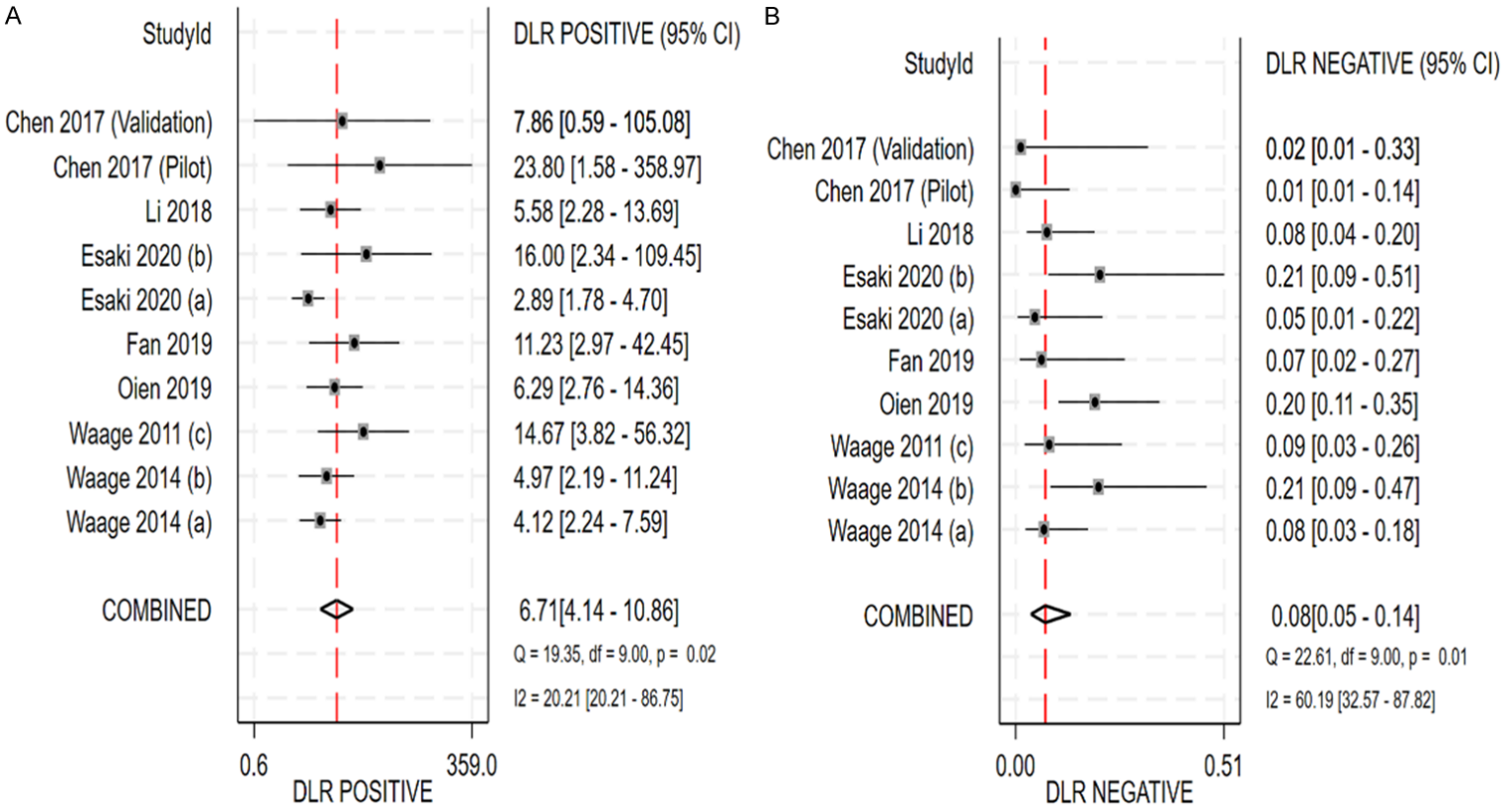

Figure 4. Forest plot of included studies assessing the NLR and PLR of ERUS with elastography in differentiating benign and malignant rectal tumors. A. PLR evaluation of ERUS with elastography in differentiating rectal tumors. B. NLR evaluation of ERUS with elastography in differentiating rectal tumors. CI, confidence intervals.

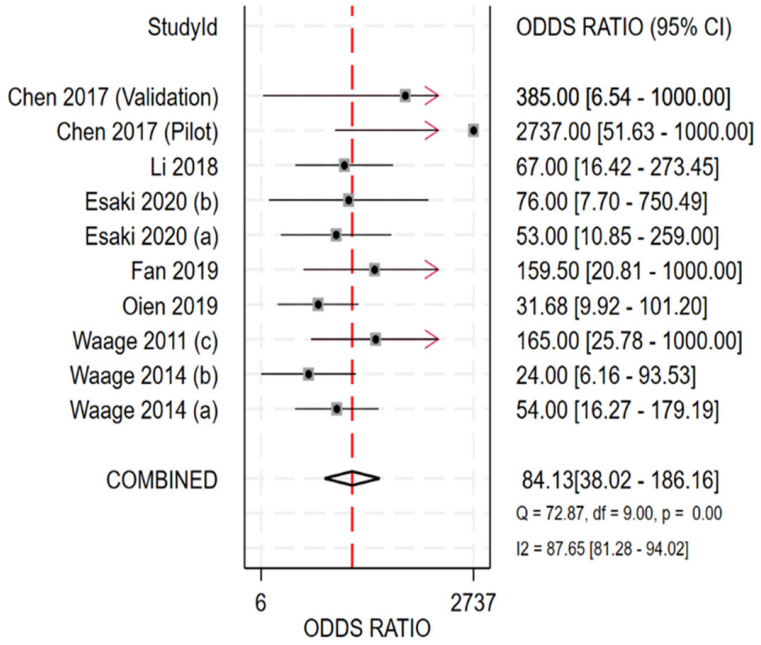

Figure 5. Forest plot of included studies assessing the DOR of ERUS with elastography in differentiating benign and malignant rectal tumors. CI, confidence intervals.

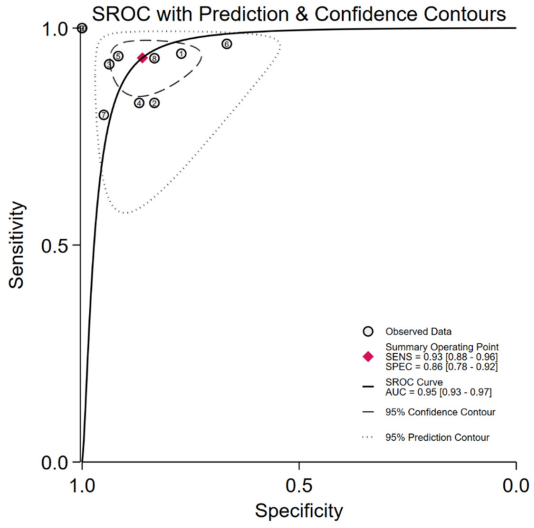

Figure 6. SROC curve of ERUS with elastography in differentiating benign and malignant rectal tumors. SROC curves of ERUS with elastography for assessing the differentiation between benign and malignant rectal tumors illustrate its diagnostic performance. Each circle represents a study. The SROC curve is symmetric, and the AUC is 0.95, indicating excellent diagnostic accuracy for this evaluation. SROC, summary receiver operating characteristic; AUC, area under the curve.

exceedingly low. This low false-positive rate and high specificity render ERUS highly effective in excluding malignant lesions. The DOR was calculated at 84 (95% CI, 38-186) (**Figure 5**). The SROC curve for the included studies exhibited an AUC of 0.95 (95% CI, 0.93-0.97) (**Figure 6**), indicating excellent diagnostic accuracy.

Subsequently, publication bias in the meta-analysis was assessed via Deeks' funnel plot. The funnel plot displayed symmetry, with a *p* value of 0.10, suggesting that there was no significant publication bias in this meta-analysis (**Figure 7**).

Discussion

This meta-analysis included 10 studies and revealed that ERUS elastography has a sensitivity of 93% (95% CI, 88%-96%) and a specificity of 86% (95% CI, 78%-92%) in distinguishing between benign and malignant rectal tumors. The PLR was 6.71 (95% CI, 4.14-10.86), and the NLR was 0.08 (95% CI, 0.05-0.14), resulting in a DOR of 84 (95% CI, 38-186).

Compared with traditional imaging diagnostic tools, ERUS elastography offers significant advantages in detecting differences in tumor tissue stiffness and elasticity, especially given its strong ability to distinguish malignant tumors from benign lesions [24-26]. Compared with the single-center study conducted by Oien et al. in 2019, our results demonstrated greater diagnostic efficacy. Oien et al. reported the diagnostic performance of ERUS elastography, revealing an accuracy of 84.00%, a sensitivity of 82.00%, a specificity of 87.00%, a PPV of 88.00%, and an NPV of 81.00% [23]. The observed differences may stem from our inclusion of a more diverse patient population and various technical implementation conditions across different regions and centers.

In any meta-analysis, examining heterogeneity is a crucial step in aggregating study results to

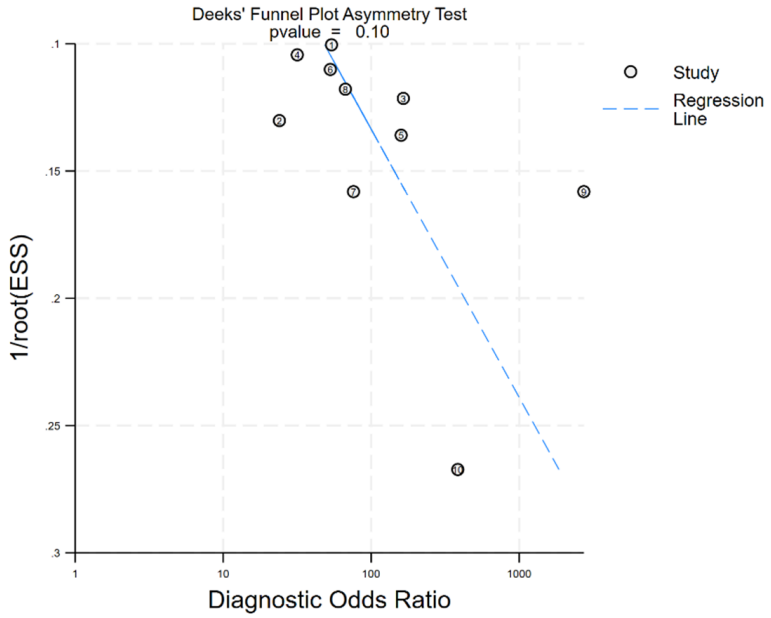

Figure 7. Deeks' test results for the assessment of publication bias in ERUS with elastography studies. Each circle corresponds to a single study, and the line represents the regression line. Because the *p* value is greater than 0.05, no publication bias is present. ESS, effective sample size.

derive more accurate conclusions. In this study, we identified a degree of heterogeneity between sensitivity and specificity, with an I^2 of 66.35% (95% CI, 43.84%-88.86%) for sensitivity and an I^2 of 54.43% (95% CI, 21.95%-86.9%) for specificity. Consequently, a random effects model was employed for subsequent analyses.

Another important consideration in meta analyses is study selection. Limiting the sample to published studies can introduce publication bias, adversely affecting the reliability of the meta-analysis conclusions, as published studies tend to report positive results [27]. Fortunately, Deeks' funnel plot analysis revealed no indication of publication bias in our meta-analysis.

Preoperative differentiation of benign and malignant rectal tumors is crucial for selecting the appropriate treatment strategy. Currently, common imaging modalities for rectal tumors include computed tomography (CT), MRI, and ERUS. Owing to its relatively low soft tissue resolution, CT cannot clearly differentiate the layered structure of the bowel wall, and its accuracy in assessing perirectal fat invasion is inferior to that of other imaging techniques. Therefore, CT is not routinely recommended for local staging of rectal cancer [28]. ERUS and MRI are the currently recommended imaging methods for preoperative T staging of rectal tumors [29]. Compared with MRI, ERUS can clearly visualize the five-layer structure of the rectal wall, especially in early rectal cancer, with greater staging accuracy. On the other hand, MRI may occasionally overestimate staging owing to image artifacts caused by factors such as inflammation, fibrosis, or bowel peristalsis, which can mimic tumor infiltration [30]. However, ERUS is highly operator-dependent and has a limited field of view, making it difficult to assess the entire mesorectum, peritoneal reflections, and pelvic wall structures comprehensively. As a result, it is less effective than MRI in evaluating lesions outside the tumor and may lead to both overstaging and understaging [31]. With its ability to clearly delineate the layers of the rectal wall and surrounding soft tissues, particularly the mesorectum, MRI can accurately assess the depth of tumor invasion. Therefore, MRI is more accurate than ERUS in staging advanced rectal cancers. Nonetheless, both techniques may encounter challenges related to overstaging or understaging in clinical practice, which can lead to unnecessary treatments or missed therapeutic opportunities. Research indicates that such misjudgments may be related to inflammation surrounding the tumor and the fibrotic response-reactive changes in the surrounding tissue that often alter tissue stiffness [32]. These factors can complicate the differentiation of true tumor margins using MRI and ERUS.

In clinical practice, MRI offers excellent tissue contrast and resolution for rectal tumors, allowing for effective detection of tumor location and morphology, local staging, and assessment of mesorectal fascia (MRF) involvement [33]. However, MRI is costly, time-consuming, and cannot be performed in patients with internal metal devices, such as pacemakers. In con-

trast, ERUS can clearly distinguish the five-layer structure of the rectal wall, accurately assess tumor invasion depth, and has the advantages of being repeatable, simple, affordable, well-accepted, safe, and noninvasive. As a result, ERUS has become one of the most accurate imaging methods for assessing tumor invasion depth and is highly reliable in evaluating rectal cancer infiltration [34]. Studies have shown that MRI is effective in revealing the relationship between rectal tumors and the bowel wall, with an overall accuracy of 75%-90% for T staging of rectal cancer. Although MRI has excellent soft tissue resolution, it struggles to differentiate between the mucosa, submucosa, and muscularis propria. ERUS, however, is better at distinguishing the different layers of the rectal wall because of varying levels of acoustic impedance in these layers, especially in the early stages of rectal cancer. According to Phang, ERUS can visualize the MRF, the fat between the pelvic wall and surrounding mesorectal fat, with a strong echogenic interface that corresponds to the MRF [35]. Studies have shown that ERUS has a 95% detection rate for MRF, making it highly accurate for diagnosing circumferential resection margin (CRM) involvement in rectal cancer, particularly in lower and middle rectal cancers. Research by Castro supports this notion, demonstrating that ERUS, with its superior resolution for nearby tissues, can clearly delineate the MRF and complement MRI in diagnosing CRM involvement in middle and lower rectal cancers [36]. These findings highlight the high diagnostic value of ERUS in assessing T stage, particularly for early-stage and lower and middle rectal cancers, as well as for evaluating CRM involvement. Therefore, ERUS should be considered early in clinical practice, especially when precise tumor staging and evaluation of the mesorectal fascia are critical for treatment planning.

Elastography, an imaging technique based on tissue stiffness, offers comparative information regarding the hardness of tumor tissue relative to surrounding normal tissue. This capability can assist clinicians in more accurately assessing the benignity or malignancy of tumors. Research indicates that rectal cancer tissue is typically more rigid than normal rectal tissue [37]. Notably, Wagner et al. (2011, 2015) utilized strain elastography to evaluate the stiffness of the rectal wall, confirming the technique's effectiveness in differentiating early rectal cancer from adenomas by comparing tumor tissue stiffness with that of the surrounding normal tissue [17, 18].

In recent years, SWE has been increasingly utilized for diagnosing lesions in the liver, breast, thyroid, and cervix [38]. However, its application in rectal lesions remains relatively underexplored. Li employed SWE to evaluate rectal tumors and reported a significant difference in stiffness between benign and malignant tumors, with SWE demonstrating greater accuracy than ERUS alone [22]. These findings suggest that SWE can offer clinicians valuable additional insights into tissue stiffness, particularly in cases where the diagnosis is uncertain, thereby improving overall diagnostic precision.

Furthermore, ERUS elastography, an emerging minimally invasive diagnostic technique, has demonstrated its potential in the assessment of rectal cancer. In recent years, numerous research teams have focused on optimizing ERUS elastography to enhance the recognition of tumor characteristics. This technique shows significant advantages in detecting early rectal cancer, with notably greater accuracy than traditional imaging methods such as MRI and CT, particularly in distinguishing benign from malignant lesions [23]. Several studies suggest that ERUS elastography offers more accurate data on tissue stiffness, thereby enhancing the sensitivity of early diagnosis. Consequently, ERUS elastography has emerged as a promising minimally invasive assessment tool with substantial advantages in rectal cancer screening.

Although our results indicate promising prospects, this meta-analysis has certain limitations. First, some studies included in the sample had limited patient populations, which may lead to an uneven ratio of benign to malignant lesions, potentially introducing selection bias. Second, although we assessed the overall efficacy of ERUS elastography, the inconsistency in technical standards and parameters across different studies may impact the comparability and reliability of the results. Additionally, data on interobserver variability are relatively scarce, and many studies do not provide detailed descriptions of their evaluation processes, resulting in a lack of adequate repeatability testing.

These limitations suggest that caution is warranted when considering the broader application of ERUS elastography. Future research should address these areas more comprehensively to increase the robustness and applicability of the findings.

Conclusion

In conclusion, this meta-analysis demonstrated that ERUS elastography has substantial diagnostic ability in differentiating between benign and malignant rectal tumors and has high sensitivity and specificity. As a minimally invasive assessment tool, this technique not only offers good tolerability but also holds significant potential for broader implementation across various levels of health care institutions. To further validate its practical utility in clinical practice, larger-scale prospective studies are urgently needed.

Disclosure of conflict of interest

None.

Address correspondence to: Wen Gu and Yinkai Xu, Department of General Surgery, The First Affiliated Hospital of Soochow University, 188#Shizhi Street, Suzhou 215000, Jiangsu, China. E-mail: dr_guwen@163.com (WG); xuyinkai@suda.edu.cn (YKX)

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Table S1. Search query used for PubMed, Embase and Cochrane databases

Pubmed:		
ID	Search	Results
#1	Elasticity Imaging Techniques[MeSH Terms]	12623
#2	((((((((((((((((((((((((((((((Elasticity Imaging Technique[Title/Abstract]) OR (Imaging Technique, Elasticity[Title/Abstract])) OR (Imaging Techniques, Elasticity[Title/Abstract])) OR (Technique, Elasticity Imaging[Title/Abstract])) OR (Techniques, Elasticity Imaging[Title/Abstract])) OR (Elastography[Title/Abstract])) OR (Elastographies[Title/Abstract])) OR (Tissue Elasticity Imaging[Title/Abstract])) OR (Elasticity Imagings, Tissue[Title/Abstract])) OR (Elasticity Imaging, Tissue[Title/Abstract])) OR (Imagings, Tissue Elasticity[Title/Abstract])) OR (Imaging, Tissue Elasticity[Title/Abstract])) OR (Tissue Elasticity Imagings[Title/Abstract])) OR (Elastograms[Title/Abstract])) OR (Elastogram[Title/Abstract])) OR (Vibro-Acoustography[Title/Abstract])) OR (Vibro-Acoustographies[Title/Abstract])) OR (Vibro Acoustography[Title/Abstract])) OR (Sonoelastography[Title/Abstract])) OR (Sonoelastographies[Title/Abstract])) OR (Magnetic Resonance Elastography[Title/Abstract])) OR (Elastographies, Magnetic Resonance[Title/Abstract])) OR (Elastography, Magnetic Resonance[Title/Abstract])) OR (Magnetic Resonance Elastographies[Title/Abstract])) OR (Resonance Elastographies, Magnetic[Title/Abstract])) OR (Resonance Elastography, Magnetic[Title/Abstract])) OR (Acoustic Radiation Force Impulse Imaging[Title/Abstract])) OR (ARFI Imaging[Title/Abstract])) OR (ARFI Imagings[Title/Abstract])) OR (Imaging, ARFI[Title/Abstract])) OR (Imagings, ARFI[Title/Abstract])	22879
#3	#1 or #2	24742
#4	Colorectal Neoplasms [MeSH Terms]	248855
#5	((((((((((((((Colorectal Neoplasm[Title/Abstract]) OR (Neoplasm, Colorectal[Title/Abstract])) OR (Colorectal Tumors[Title/Abstract])) OR (Colorectal Tumor[Title/Abstract])) OR (Tumor, Colorectal[Title/Abstract])) OR (Tumors, Colorectal[Title/Abstract])) OR (Neoplasms, Colorectal[Title/Abstract])) OR (Colorectal Cancer[Title/Abstract])) OR (Cancer, Colorectal[Title/Abstract])) OR (Cancers, Colorectal[Title/Abstract])) OR (Colorectal Cancers[Title/Abstract])) OR (Colorectal Carcinoma[Title/Abstract])) OR (Carcinoma, Colorectal[Title/Abstract])) OR (Carcinomas, Colorectal[Title/Abstract])) OR (Colorectal Carcinomas[Title/Abstract])	161863
#6	#4 or #5	297026
#7	#3 and #6	74
Embase:		
ID	Search	Results
#1	exp elastography	29954
#2	elasticit* or ARFI or (acouistic adj3 radiation adj3 force) or vibro-acoustograph* or (vibro adj3 acoustograph*) or elastogra* or sonoelastogr* or acoustogra*.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	75621
#3	#1 or #2	83654
#4	exp Colorectal Neoplasms /	233452
#5	((rect* or colorec*) adj7 (neoplas* or cancer* or carc* or tumo* or adenocarc* or polyp* or adenom* or malign* or benign*)).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	337655
#6	#4 or #5	333659
#7	#3 and #6	232
Cochrane:		
ID	Search	Results
#1	MeSH descriptor: [Elasticity Imaging Techniques] explode all trees	262
#2	(Imagings, ARFI):ti,ab,kw OR (ARFI Imagings):ti,ab,kw OR (Imaging, ARFI):ti,ab,kw OR (Acoustic Radiation Force Impulse Imaging):ti,ab,kw OR (ARFI Imaging):ti,ab,kw	29

#3	(Elastogram; Elastograms):ti,ab,kw OR (Magnetic Resonance Elastographies):ti,ab,kw OR (Elastographies, Magnetic Resonance):ti,ab,kw OR (Elastography, Magnetic Resonance):ti,ab,kw OR (Resonance Elastographies, Magnetic):ti,ab,kw	217
#4	(Resonance Elastography, Magnetic):ti,ab,kw OR (Magnetic Resonance Elastography):ti,ab,kw OR (Tissue Elasticity Imaging):ti,ab,kw OR (Tissue Elasticity Imagings):ti,ab,kw OR (Techniques, Elasticity Imaging):ti,ab,kw	735
#5	(Imaging, Tissue Elasticity):ti,ab,kw OR (Elasticity Imaging Technique):ti,ab,kw OR (Imaging Technique, Elasticity):ti,ab,kw OR (Elastography):ti,ab,kw OR (Elasticity Imagings, Tissue):ti,ab,kw	1533
#6	(Imaging Techniques, Elasticity):ti,ab,kw OR (Imagings, Tissue Elasticity):ti,ab,kw OR (Sonoelastographies):ti,ab,kw OR (Sonoelastography):ti,ab,kw OR (Vibro-Acoustography; Vibro-Acoustographies):ti,ab,kw	591
#7	#1 or #2 or #3 or #4 or #5 or #6	1567
#8	MeSH descriptor: [Colorectal Neoplasms] explode all trees	12914
#9	(Colorectal Neoplasms):ti,ab,kw OR (Colorectal Neoplasm):ti,ab,kw OR (Neoplasm, Colorectal):ti,ab,kw OR (Colorectal Tumors):ti,ab,kw OR (Colorectal Tumor):ti,ab,kw	14594
#10	(Tumor, Colorectal):ti,ab,kw OR (Tumors, Colorectal):ti,ab,kw OR (Neoplasms, Colorectal):ti,ab,kw OR (Colorectal Cancer):ti,ab,kw OR (Cancer, Colorectal):ti,ab,kw	20939
#11	(Cancers, Colorectal):ti,ab,kw OR (Colorectal Cancers):ti,ab,kw OR (Colorectal Carcinoma):ti,ab,kw OR (Carcinoma, Colorectal):ti,ab,kw OR (Carcinomas, Colorectal):ti,ab,kw	3862
#12	(Colorectal Carcinomas):ti,ab,kw	193
#13	#8 or #9 or #10 or #11 or #12	24709
#14	#7 and #13	3