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ORIGINAL ARTICLE

The value of four imaging modalities in diagnosing lymph node involvement in rectal cancer: an overview and adjusted indirect comparison

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Abstract

Several systematic reviews have investigated the accuracy of imaging modalities for lymph node involvement of rectal cancer, but there are considerable differences in conclusions. This overview aimed to assess the methodological and reporting quality of systematic reviews that evaluated the diagnostic value of imaging modalities for lymph node involvement in patients with rectal cancer and to compare the diagnostic value of different modalities for lymph node involvement. The PubMed, EMBASE, Cochrane Library and Chinese Biomedicine Literature were searched to identify relevant systematic reviews. The methodological quality was assessed using the AMSTAR checklist, and the reporting quality was assessed using PRISMA-DTA checklist. The indirect comparison was conducted to compare the accuracy of different imaging modalities. Seven systematic reviews involving 353 primary studies were included. The median (Range) AMSTAR scores were 6.0 (4.0–9.0); the median (Range) PRISMA-DTA scores were 18.0 (11.0–23.0). Sensitivity of MRI [0.69 (95% CI 0.63, 0.77)] was significantly higher than that of ERUS [0.57 (95% CI 0.53, 0.62)]. Specificity of ERUS [0.80 (95% CI 0.77, 0.83)] was significantly higher than that of CT [0.72 (95% CI 0.67, 0.78)]. Positive likelihood ratio of EUS [3.04 (95% CI 2.75, 3.36)] was significantly higher than that of CT [2.21 (95% CI 1.69, 2.90)]. EUS had better diagnostic value than CT and ERUS in the diagnosis of lymph node involvement. Compared with CT and ERUS, MRI was more sensitive. EUS and MRI had comparable diagnostic accuracy, but no modality was proved to be particularly accurate.

Keywords Rectal cancer · Lymph node involvement · Imaging modality · Diagnostic accuracy · Overview

Abbreviations

SR	Systematic review
EUS	Endoscopic ultrasound
CT	Computed tomography
MRI	Magnetic resonance imaging
ERUS	Endorectal ultrasonography
SEN	Sensitivity
SPE	Specificity
DOR	Diagnostic odds ratio
PLR	Positive likelihood ratio
NLR	Negative likelihood ratio
CI	Confidence interval

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AMSTAR	Assessment of multiple systematic reviews
PRISMA-DTA	Preferred reporting items for systematic reviews and meta-analysis diagnostic test accuracy

Introduction

Rectal cancer is one of the most common tumors, originating from the rectum within 15 cm of the anal margin, with an incidence of 40 in 100,000 [1–5]. Rectal cancer is the leading cause of cancer-related deaths in developed countries, especially in Western Europe and North America [6–8]. Risk factors for rectal cancer include the history of adenomatous polyps, familial polyp syndromes, obesity, diabetes, smoking, and excessive drinking [8–13]. Preoperative treatment can reduce the risk of recurrent rectal cancer, improve survival rate, reduce tumor size, and make tumors more operable [14–17]. However, the prognosis of patients with rectal cancer depends on the stage of the disease at the time of diagnosis; therefore, accurate disease assessment is necessary for the correct treatment of rectal cancer [6, 18, 19].

Meta-analysis and systematic review (SR) are often considered the best way to obtain evidence of healthcare decisions and can be used to address a wide range of clinical issues [20, 21]. SRs of diagnostic test accuracy synthesize data from preliminary studies to provide insight into the ability of medical tests to detect target conditions; they also provide the softest performance estimates, allow comparisons of the accuracy of different tests, and facilitate the identification of sources of variability [22]. Because decision makers need to examine evidence before implementing new diagnostic techniques, the role of systematic reviews (SRs) of diagnostic tests is increasingly important in healthcare [23, 24]. Therefore, it is critical that SRs of diagnostic tests provide reliable and valid evidence. However, there are many SRs evaluating the same intervention under the same subject, but there is no consistent conclusion [20].

The role of lymph node status in the treatment of rectal cancer is critical because patients with lymph node involvement often receive neoadjuvant therapy and are often associated with poor prognosis [25, 26]. In order to accurately diagnose lymph node status, many diagnostic imaging techniques have been used, such as endoscopic ultrasound (EUS), computed tomography (CT), magnetic resonance imaging (MRI), and endorectal ultrasonography (ERUS). Recently, some SRs have compared the diagnostic accuracy of different imaging techniques for lymph node involvement [17, 26–28], but there are considerable differences in conclusions. Therefore, it is important to reanalyze these SRs. The objectives of this overview were to assess the methodological quality and reporting quality of SRs that evaluated the diagnostic value of index tests for lymph node involvement in patients with rectal cancer and to compare the diagnostic value of different diagnostic imaging techniques for lymph node involvement by reanalyzing the results of the meta-analysis.

Methods

Protocol

The protocol for this overview has been registered on PROSPERO (International Prospective Register of Systematic Reviews). The registration number is CRD CRD42018104906.

Inclusion and exclusion criteria

We included studies that have to meet the following criteria: (1) rectal cancer patients with lymph node involvement regardless of treatment; (2) SRs of diagnostic tests regardless of index tests; (3) fully published studies in English or Chinese. When SRs had been updated, the latest one was included. SRs that were published in more than one source were treated as linked reviews and only the most comprehensive paper was included [29]. Excluded from the overview were the following: (1) diagnostic tests for patients with colorectal cancer; (2) SRs without meta-analysis; (3) protocols and methodological articles.

Search strategy

Two authors independently searched the PubMed, EMBASE, Cochrane Library, and Chinese Biomedicine Literature to identify relevant studies. The searches were conducted initially in April 2018 and updated in June 2018. We did not restrict the study to country or date. The databases were searched using search terms related to rectal neoplasm, sensitivity, specificity, receiver operating characteristic, meta-analysis, and systematic review. The literature search strategies were reported in detail in Supplementary 1. In addition, reference lists of included studies were manually searched for additional references.

Study selection and data extraction

Literature search records were imported into ENDNOTE X7 literature management software. Two independent reviewers (YG and JL) screened out possibly relevant studies independently based on the title and abstract. Then, the same two reviewers retrieved the full text of all possibly relevant studies to screen out the studies that met the inclusion criteria.

Disagreements were resolved by consensus or by discussion with a third reviewer (JT).

We extracted study characteristics from systematic reviews included the following items: author name, year of publication, country of first author, number of author, journal name, country of journal, funding, number and name of index test, number and name of reference test, outcomes; methodological characteristics of systematic reviews such as types of included studies, number of included studies, samples, supplemental literature search; results of statistical analysis including sensitivity, specificity, likelihood ratio, predictive value, diagnostic odds ratio and area under curve.

Quality assessment

We assessed the methodological quality of included SRs using the Assessment of Multiple Systematic Reviews (AMSTAR) checklist. This checklist includes 11 items, with possible responses of "Yes" (item/question fully addressed), "No" (item/question not addressed), "Cannot answer" (not enough information to answer the question), and "Not applicable." A score of "1" was attributed for each "Yes," "0" point for each "Cannot answer," "No," and "Not applicable" [30]. Based on previous overviews, we considered studies with a score between 0 and 4.0 to be of low quality, 5.0 and 8.0 to be of moderate quality, and 9.0 and 11.0 to be of high quality [31, 32].

The reporting quality of included SRs was assessed according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis diagnostic test accuracy (PRISMA-DTA) checklist. The PRISMA-DTA Statement is an expanded checklist of original PRISMA, which aims to improve the completeness and transparency of reporting of systematic reviews of diagnostic test accuracy studies [22]. This checklist consists of 27 items. To indicate the degree of compliance, each checklist item was assigned one of the following three responses: "Yes" for total compliance; "Partial" for partial compliance; and "No" for non-compliance. Each of the "Yes" was scored "1," each "Partial" was scored "0.5" and each "No" was scored "0." The maximum score on the PRISMA-DTA is 27. The review was considered to have major flaws if it received a total score of ≤ 15.0, minor flaws if it received a total score of 15.5–21.0, and minimal flaws if it received a total score 21.5–27.0 [33]. The quality assessment of the included SRs was performed independently by the two authors (XM and JW), and the differences were resolved through discussion to reach a consensus.

Statistical analysis

We performed the meta-analysis with the data of pooled sensitivity (SEN), specificity (SPE), diagnostic odds ratio (DOR), positive likelihood ratio (PLR), negative likelihood ratio (NLR) and their 95% confidence interval (CI) lower limit, 95% CI upper limit using random effects model. We calculated relative diagnostic outcomes between index tests including relative sensitivity, relative specificity, relative DOR, relative PLR, and relative NLR. Then, we conducted indirect comparisons using the relative diagnostic outcomes. All analyses were performed using Stata software (Version 12.0, Stata Corp, College Station, TX, USA). The statistical level of significance was set at $P \leq 0.05$.

Results

Search results

In total, 651 studies were obtained through systematic electronic searches. A total of 47 articles were duplicates and were excluded. After screening titles and abstracts, 563 articles were excluded. The full text of the 41 remaining studies was investigated in detail and a further 34 studies were excluded because 26 studies did not assess lymph node involvement, 3 studies were abstracts or reviews, 2 studies were repeated data from another included study, and 3 studies cannot extract full data. Finally, 7 SRs were included in our overview. Details of the flowchart of the literature search for the overview are shown in Fig. 1.

Study characteristics

Seven eligible [8, 17, 26–28, 34, 35] SRs included 353 primary studies. All SRs were published in English, the median number of authors was 5 (Range 3–9), and 2 SRs [26, 34] were funded. Three SRs [17, 26, 27] assessed the diagnostic accuracy of three modalities for evaluating lymph node involvement, one SR [28] assessed diagnostic accuracy of two modalities and three SRs [8, 34, 35] assessed diagnostic accuracy of one modality. The gold standard for the diagnosis of lymph node involvement in all SRs [8, 17, 26–28, 34, 35] was postoperative histopathology. All SRs [8, 17, 26–28, 34, 35] retrieved English databases, but only 1 study [35] retrieved Chinese databases. All studies [8, 17, 26–28, 34, 35] reported inclusion criteria, four studies [17, 27, 28, 34] reported exclusion criteria, five studies [17, 26–28, 34] reported search strategy, and five studies [17, 26, 28, 35] conducted supplemental literature search. Five SRs [8, 17, 26, 28, 34] assessed the methodological quality, 4 SRs [8, 17, 28, 34] used QUADAS (Quality Assessment of Diagnostic Accuracy Studies), and 1 SR [26] used QUADAS-2. All SRs [8, 17, 26–28, 34, 35] assessed the heterogeneity, but only 3 SRs [8, 17, 26] evaluated the publication bias. The details of the study characteristics were presented in Supplementary 2.

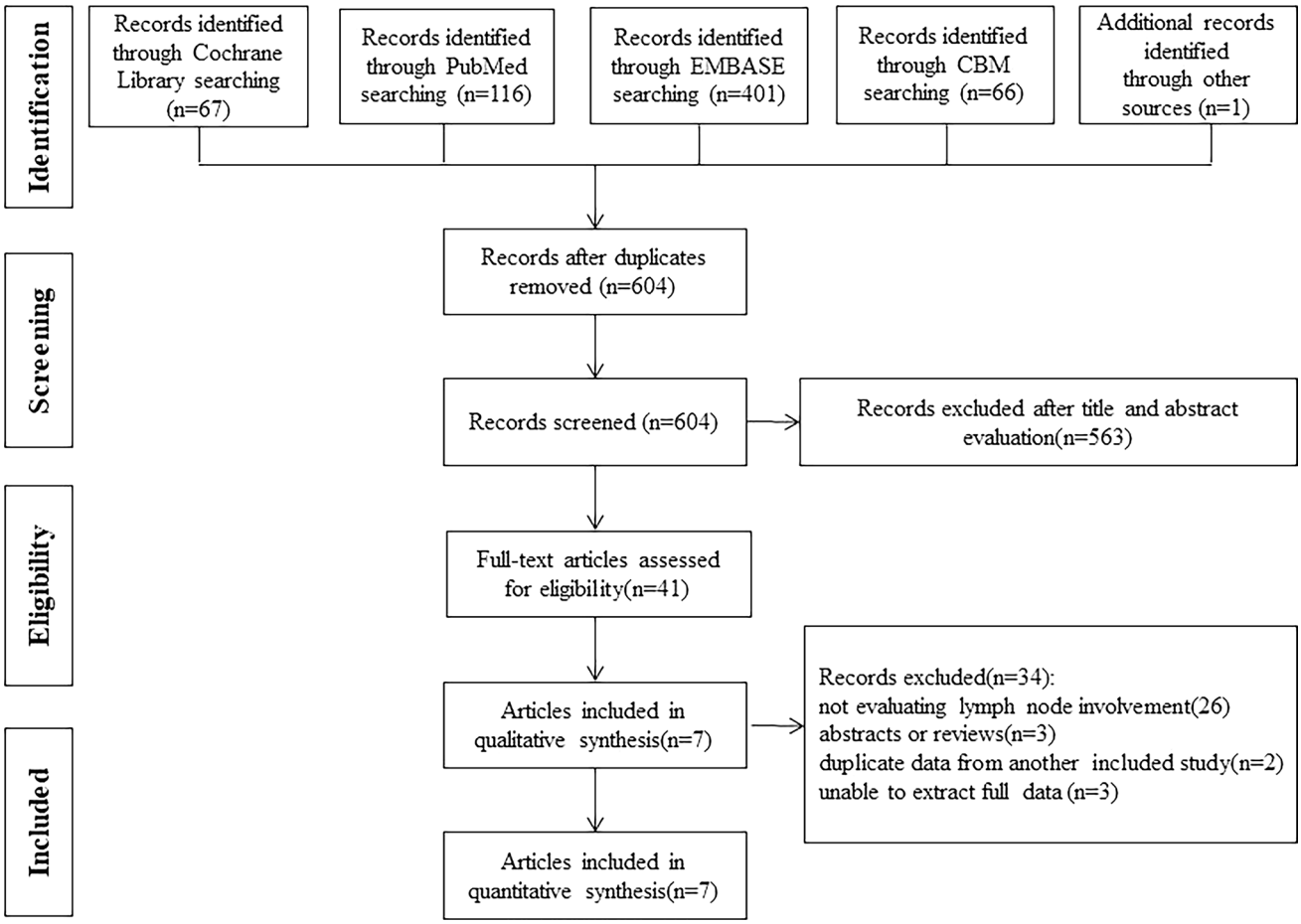

Fig. 1 Flow diagram of the literature search. *CBM* Chinese biomedicine literature

Quality assessment

In the AMSTAR assessment, items 1 and 2 were fully reported. The methodological quality assessment results suggested that SRs were scored from 4.0 to 9.0 (median = 6.0), 2 SRs [27, 35] scored 4.0, 4 SRs [8, 17, 28, 34] scored 5.0–8.0, and 1 SR [26] scored 9.0. In general, 57.14% SRs were of moderate quality (Fig. 2, Supplementary 3).

The PRISMA-DTA scores of SRs were presented in Supplementary 4. The median (Range) PRISMA-DTA scores were 18.0 (11.0–23.0). Three items were fully reported, but all SRs [8, 17, 26–28, 34, 35] did not report the protocol and registration. Results showed 1 SR [35] had serious reporting flaws (PRISMA-DTA score lower than 15.0), 4 SRs [8, 17, 27, 28] had minor flaws (PRISMA-DTA score 15.5–21.0), 2 SRs [26, 34] had minimal flaws (PRISMA-DTA score 21.5–27.0).

Diagnostic value of EUS, CT, MRI, and ERUS for detecting lymph node involvement

A total of 4 SRs [8, 26–28] evaluated the value of EUS to detect lymph node involvement. The pooled estimates of these SRs were: sensitivity, 0.64 (95% CI 0.57–0.72); specificity, 0.78 (95% CI 0.75–0.80); DOR, 6.30 (95% CI 4.53–8.76); PLR, 3.04 (95% CI 2.75–3.36); NLR, 0.45 (95% CI 0.36–0.55). The details are shown in Figs. 3a–d, 4 and Table 1.

A total of 3 SRs [17, 26, 27] evaluated the ability of CT to detect lymph node involvement. The pooled estimates of these SRs were: sensitivity, 0.63 (95% CI 0.54–0.73); specificity, 0.72 (95% CI 0.67–0.78); DOR, 7.00 (95% CI 4.22–11.61); PLR, 2.21 (95% CI 1.69–2.90); NLR, 0.54 (95% CI 0.41–0.70). The details are shown in Figs. 3a–d, 4 and Table 1.

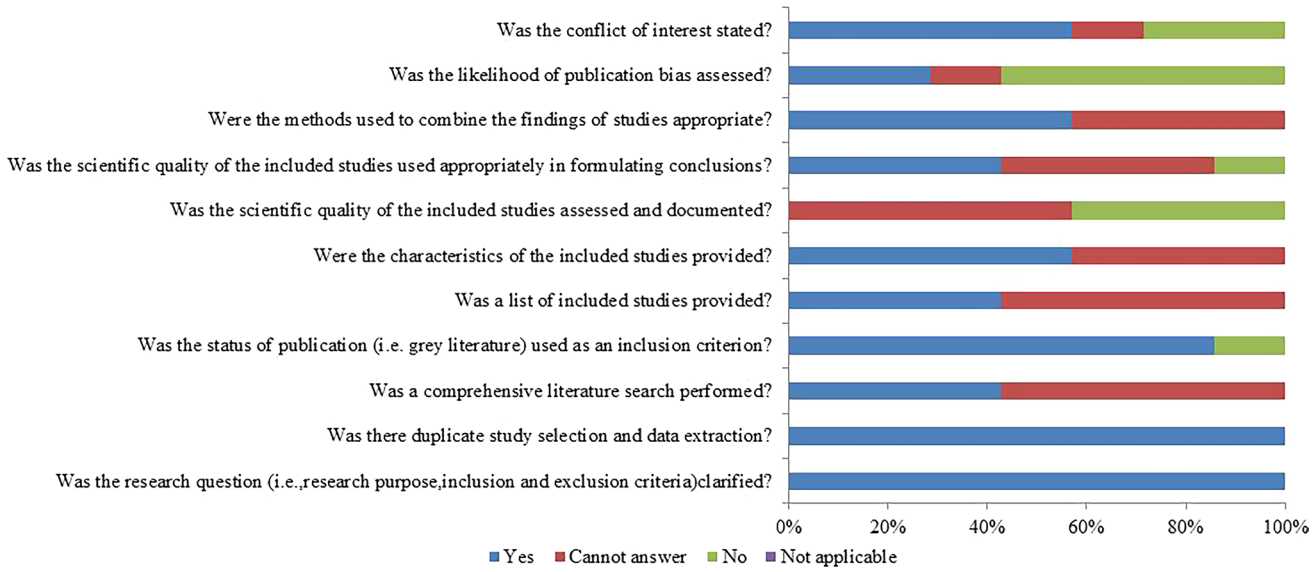

Fig. 2 Methodological quality of the included systematic reviews with AMSTAR checklist

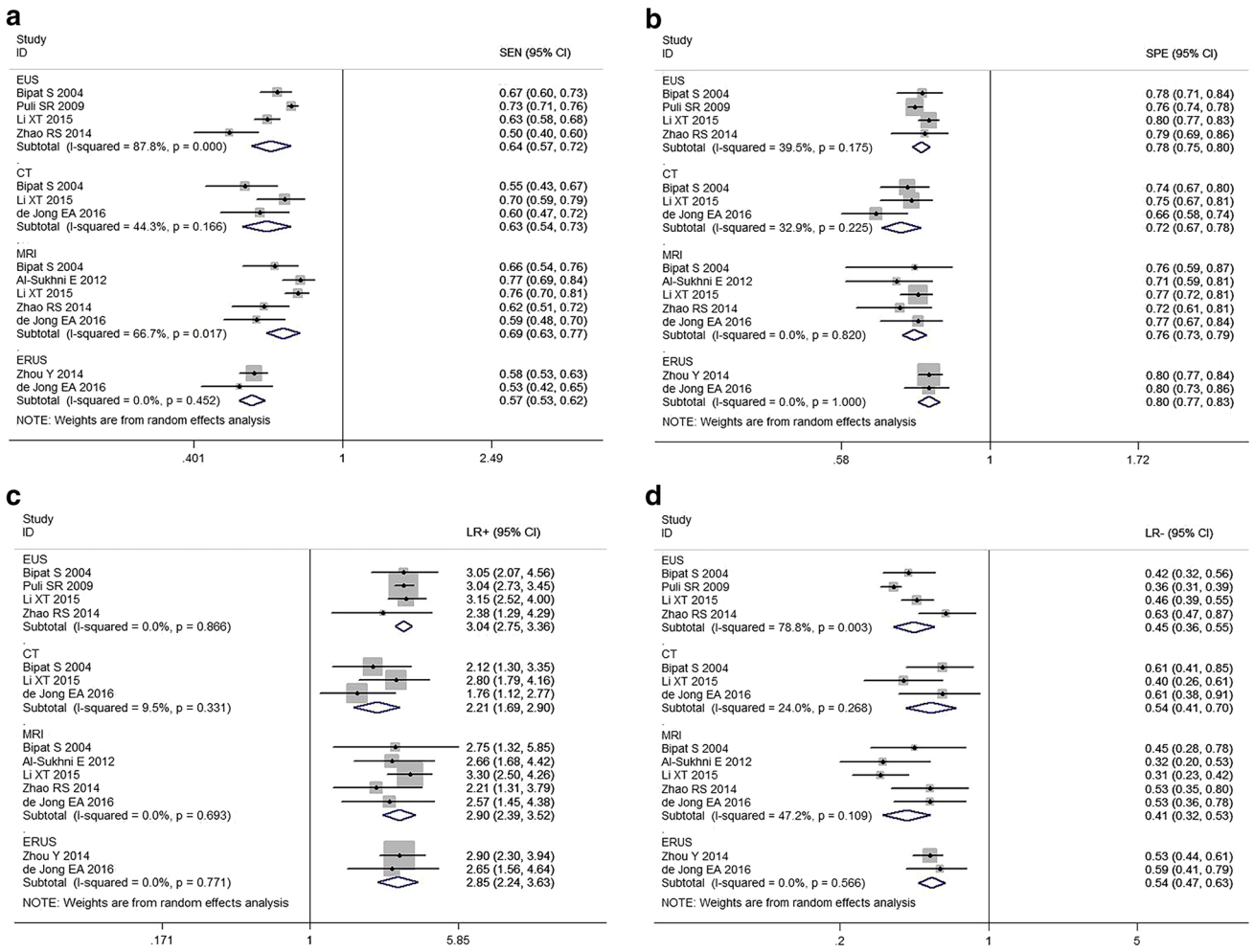

Fig. 3 Sensitivity (**a**), specificity (**b**), positive likelihood ratio (**c**), and negative likelihood ratio (**d**) for EUS, CT, MRI, and ERUS in detecting lymph node involvement. *EUS* endoscopic ultrasound, *CT* computed tomography, *MRI* magnetic resonance imaging, *SEN* sensitivity, *SPE* specificity, *LR+* positive likelihood ratio, *LR−* negative likelihood ratio

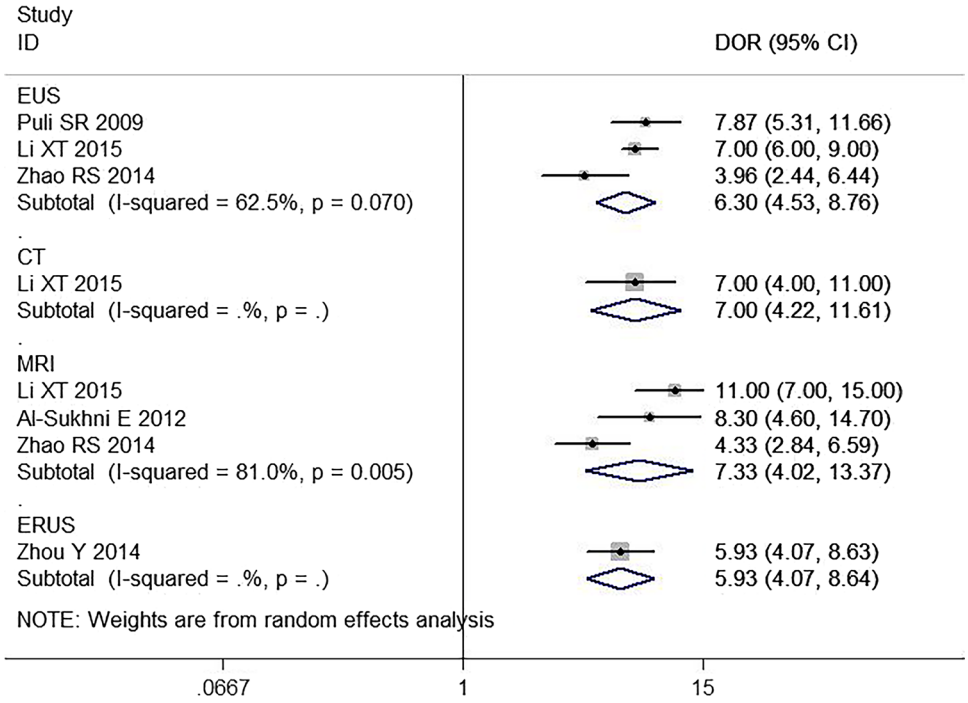

Fig. 4 Diagnostic odds ratio for EUS, CT, MRI, and ERUS in detecting lymph node involvement. *EUS* endoscopic ultrasound, *CT* computed tomography, *MRI* magnetic resonance imaging, *ERUS* endorectal ultrasonography, *DOR* diagnostic odds ratio

Table 1 Pooled diagnostic accuracy estimates for EUS, CT, MRI, and ERUS in detecting lymph node involvement

Index test	SEN (95% CI)	SPE (95% CI)	DOR (95% CI)	PLR (95% CI)	NLR (95% CI)
EUS	0.64 (0.57,0.72)	0.78 (0.75,0.80)	6.30 (4.53,8.76)	3.04 (2.75,3.36)	0.45 (0.36,0.55)
CT	0.63 (0.54,0.73)	0.72 (0.67,0.78)	7.00 (4.22,11.61)	2.21 (1.69,2.90)	0.54 (0.41,0.70)
MRI	0.69 (0.63,0.77)	0.76 (0.73,0.79)	7.33 (4.02,13.37)	2.90 (2.39,3.52)	0.41 (0.32,0.53)
ERUS	0.57 (0.53,0.62)	0.80 (0.77,0.83)	5.93 (4.07,8.64)	2.85 (2.24,3.63)	0.54 (0.47,0.63)

EUS endoscopic ultrasound, *CT* computed tomography, *MRI* magnetic resonance imaging, *ERUS* endorectal ultrasonography, *SEN* sensitivity, *SPE* specificity, *DOR* diagnostic odds ratio, *PLR* positive likelihood ratio, *NLR* negative likelihood ratio

Five studies [17, 26–28, 34] reported the diagnostic efficacy of MRI for lymph node involvement. The pooled sensitivity, specificity, DOR, PLR, and NLR were 0.69 (95% CI 0.63–0.77), 0.76 (95% CI 0.73–0.79), 7.33 (95% CI 4.02–13.37), 2.90 (95% CI 2.39–3.52), and 0.41 (95% CI 0.32–0.53), respectively (Fig. 3A, 3B, 3C, 3D, 4 and Table 1).

Two studies [17, 35] reported the diagnostic efficacy of ERUS for lymph node involvement. The pooled sensitivity, specificity, DOR, PLR, and NLR were 0.57 (95% CI 0.53–0.62), 0.80 (95% CI 0.77–0.83), 5.93 (95% CI 4.07–8.64), 2.85 (95% CI 2.24–3.63), and 0.54 (95% CI 0.47–0.63), respectively (Figs. 3A, 3B, 3C, 3D, 4 and Table 1).

Indirect comparisons between EUS, CT, MRI, and ERUS

The relative sensitivity of EUS vs. CT, EUS vs. MRI, EUS vs. ERUS, CT vs. MRI, CT vs. ERUS, and MRI vs. ERUS were 1.02 (95% CI 0.84–1.23), 0.93 (95% CI 0.80–1.08), 1.12 (95% CI 0.98–1.29), 0.91 (95% CI 0.76–1.09), 1.11 (95% CI 0.97–1.26), and 1.21 (95% CI 1.07–1.37), respectively. The sensitivity of MRI was significantly higher than that of ERUS ($P < 0.05$), Fig. 5.

The specificity of EUS was higher than CT and MRI, but the differences between them were not statistically significant ($P > 0.05$). Compared with MRI, CT had a lower specificity, ERUS had a higher specificity, but no differences were observed between them ($P > 0.05$). There was a statistically significant difference in specificity between CT and ERUS ($P < 0.05$), as shown in Fig. 5.

The relative DOR of EUS vs. CT, EUS vs. MRI, EUS vs. ERUS, CT vs. MRI, CT vs. ERUS, and MRI vs. ERUS were 0.90 (95% CI 0.49–1.65), 0.86 (95% CI 0.43–1.71), 1.06 (95% CI 0.64–1.75), 0.95 (95% CI 0.44–2.09), 1.18 (95% CI 0.63–2.22), and 1.24 (95% CI 0.61–2.51), respectively. There were no statistically significant differences between different index tests ($P > 0.05$), as shown in Fig. 5.

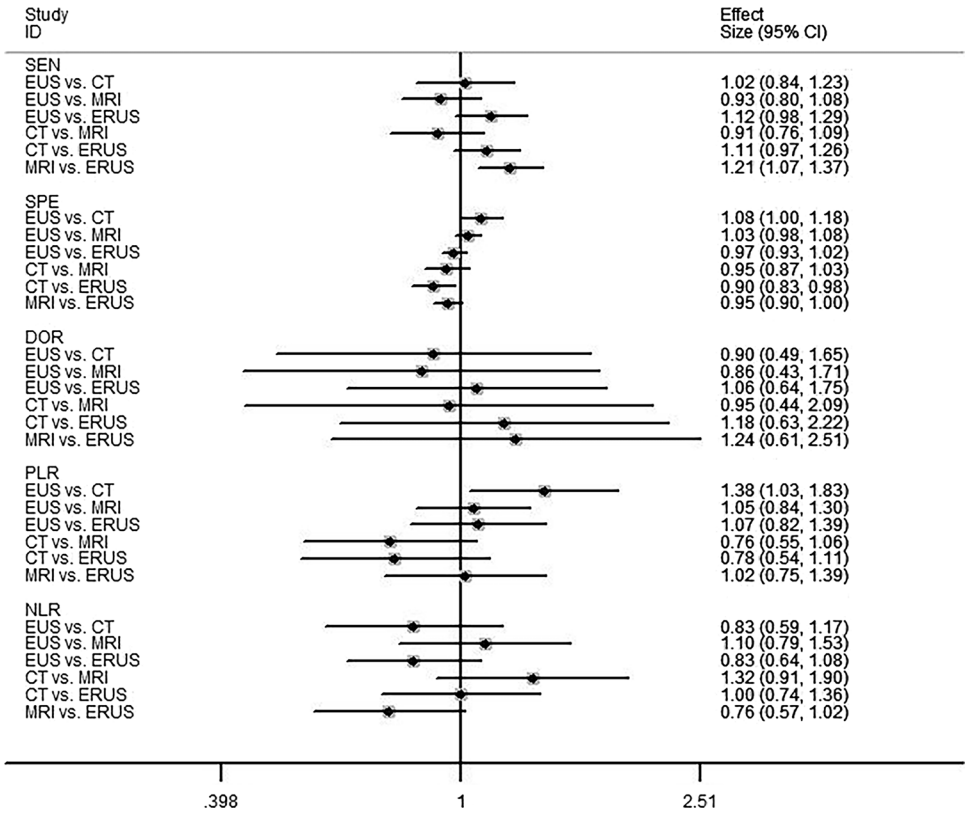

Fig. 5 Indirect comparisons for EUS, CT, MRI, and ERUS in detecting lymph node involvement. *EUS* endoscopic ultrasound, *CT* computed tomography, *MRI* magnetic resonance imaging, *ERUS* endorectal ultrasonography, *SEN* sensitivity, *SPE* specificity, *DOR* diagnostic odds ratio, *PLR* positive likelihood ratio, *NLR* negative likelihood ratio

As shown in Fig. 5, EUS had a higher PLR than CT, and the difference between them was statistically significant. The PLR of MRI was lower than EUS, but higher than CT and ERUS, although there were no statistically significant differences between them ($P > 0.05$). Compared with ERUS, EUS and MRI had higher PLRs, but no statistically significant differences were found ($P > 0.05$).

The comparisons between EUS and CT, MRI, ERUS showed relative NLRs of 0.83 (95% CI 0.59–1.17), 1.10 (95% CI 0.79–1.53), 0.83 (95% CI 0.64–1.08), and there were no statistically significant differences between them ($P > 0.05$). Compared with MRI, CT and ERUS had higher NLRs, although there were no statistically significant differences between them ($P > 0.05$), as shown in Fig. 5.

Discussion

In the past 20 years, the treatment of rectal cancer has changed from local resection to radical rectal resection with lymph node dissection [36]. Therefore, the evaluation of tumor invasion and lymph node involvement before surgery is important for determining treatment options for patients with rectal cancer [35, 37]. This overview examined the diagnostic value of EUS, CT, MRI, and ERUS for detecting lymph node involvement in patients with rectal cancer. A comprehensive search of four electronic databases was performed, and eventually, we included 7 SRs. We assessed the methodological quality using the AMASAR checklist and assessed the reporting quality using the PRISMA-DTA checklist. Moreover, indirect comparisons between different imaging modalities were performed.

Diagnostic value of EUS, CT, MRI, and ERUS for detecting lymph node involvement

The current study showed MRI had the highest sensitivity among the four modalities. This indicated that MRI can better diagnose lymph node involvement in patients with rectal cancer. However, the sensitivity of these four modalities was lower than 0.70, which means that 30.00% of patients with lymph node involvement may not be diagnosed. The combination of two diagnostic modalities may improve the sensitivity of the diagnosis of lymph node involvement, but there is currently no relevant meta-analysis report to this subject. Therefore, more research is still needed to explore these combined diagnostic methods. ERUS is one of the tools commonly used for clinical staging of rectal tumors [35, 38]. Compared with EUS, CT, and MRI, ERUS had higher specificity. Most patients without lymph node involvement can be identified by ERUS. But the specificity of ERUS was lower than 0.85. When ERUS showed that a rectal cancer patient's lesion did not involve the lymph nodes, we could not really determine that the patient had no lymph node involvement.

Diagnostic odds ratio is defined as the probability of performing a positive test in a patient with a true anatomical stage compared to a patient without a disease [8]. The current study indicated that DOR of EUS, CT, MRI, and ERUS was comparable. Positive likelihood ratio is a measure of the extent to which the diagnostic test correctly identifies the stage of the disease. In contrast, the negative likelihood ratio of a diagnostic test is a measure of the extent to which the disease stage is correctly excluded [8]. In our overview, EUS had the highest PLR, it can better identify the lymph node involvement. MRI had the lowest NLR, which had a better ability to exclude lymph node involvement.

Indirect comparisons between EUS, CT, MRI, and ERUS

Previous studies have shown that EUS was particularly effective for assessing the depth of tumor invasion into the rectal wall [6, 39, 40]. The results of indirect comparisons showed that the PLR of EUS for rectal cancer diagnosis was significantly higher than that of CT, and the differences of sensitivities, specificities, DORs, and NLRs between them were not significant, which suggested that EUS had better diagnostic value than CT in the diagnosis of lymph node invasion. The sensitivity, DOR, and PLR of EUS were higher than that of ERUS, although there were no statistically significant differences between them. Therefore, the diagnostic accuracy for lymph node invasion of EUS was slightly superior to ERUS. In addition, Puli SR et al. [8] reported that the SROC curve for EUS showed that the value of AUC was very close to 1, indicating that EUS was an excellent diagnostic test for staging lymph node involvement of rectal cancer.

CT is often used as the initial staging method for rectal cancer because of its wide availability and fast scan times [6]. CT can also assess the entire abdomen, pelvis, and chest, as well as assessment of local staging and distant metastases [41, 42]. However, the current study showed the sensitivity, specificity, DOR, and PLR of CT were lower than MRI, suggesting that CT had worse diagnostic accuracy than MRI. CT was less specific in evaluating lymph node involvement when compared to ERUS, although both modalities had similar sensitivities, DORs, PLRs, and NLRs. Studies have shown that CT has a lower diagnostic value for lymph node invasion because CT does not map microscopic metastases in normal-sized lymph nodes [6]. In addition, accurate assessment of lymph node status by CT remains challenging, even as its resolution is increasing [6].

According to the results of indirect comparisons, the sensitivity and DOR of MRI were higher than that of EUS, but the specificity and PLR were lower than EUS. However, there were no statistical differences between them. This indicated that MRI and EUS had comparable diagnostic value for evaluating lymph node involvement. When compared with ERUS, MRI was more sensitive in predicting the lymph node involvement in patients with rectal cancer. These results were different from previous studies. Previous studies have shown the inherent limitation in the capacity of current MRI technology to detect lymph node involvement accurately [27, 34, 43]. There are two reasons for this difference. Firstly, our overview included seven SRs with a larger sample size compared to the previous studies, which could improve the representativeness and statistical power [44]. Moreover, previous studies compared the performance of MRI for lymph node invasion with its performance for T category and CRM, while in our study, we compared the performance of different modalities for lymph node involvement. Thus, we should consider different reference standards and different objects when comparing the outcomes.

Quality assessment

High-quality diagnostic SRs can provide the best evidence for clinical decision makers, while low-quality SRs may mislead clinical practice. Therefore, it is vital to assess the quality of diagnostic SRs before being used for healthcare policy or clinical decision making [24, 45, 46]. The AMSTAR methodological quality assessment was performed on the included SRs, and the results showed that all the included SRs fully reported the clarification of the research question, the duplicate study selection, and data extraction. However, all the SRs did not completely assess and document the scientific quality of the included studies and 71.43% of the studies did not assess the publication bias. The quality of the SRs needs to be further improved because 85.71% of the studies were of moderate quality or below. Our PRISMA-DTA results indicated that 14.29% SRs had serious reporting flaws, 57.14% SRs had minor flaws. The reporting flaws were found included the following items: protocol and registration, study selection, additional analyses, bias risk and applicability, results of individual studies, and funding. Among them, all the SRs did not report the protocol and registration, which was similar to previous studies [23, 24]. The PRISMA Diagnostic Test Accuracy Checklist provides excellent guidance for systematic reviews diagnostic test accuracy studies [22]. Authors should follow the PRISMA-DTA checklist to improve the reporting quality of diagnostic test accuracy studies.

Strengths and limitations

To be the best of our knowledge, this is the first overview to assess the methodological quality using AMASAR checklist and reporting quality using PRISMA-DTA checklist of SRs evaluating the diagnostic value of imaging modalities for lymph node involvement in patients with rectal cancer.

Moreover, we performed indirect comparisons between different diagnostic imaging techniques, which can clearly show the differences between different modalities. However, there were some limitations in our study. First, we only included seven SRs in our overview; the results may not be comprehensive, although both Chinese and English databases were searched. Second, English language systematic reviews were included, but there was no non-English language literature that meets our criteria, which may lead to language bias. Third, we did not perform subgroup analysis due to lack of sufficient data. Finally, methodological limitations and reporting deficiencies of the included SRs may affect the quality of the evidence summarized in this overview.

Conclusions

The results of the overview indicated that EUS had better diagnostic value than CT and ERUS in the diagnosis of lymph node invasion. Compared with CT and ERUS, MRI was more sensitive. ERUS was more specific when compared to CT. EUS and MRI had comparable diagnostic accuracy for evaluating lymph node involvement, but no modality was particularly accurate. However, based on current technology and conditions, EUS and MRI may be choices for diagnosing lymph node involvement in patients with rectal cancer.

Author contributions YG, JT, and GC planned and designed the study. YG and JL screened potential studies and extracted data from the included studies. XM, JW, and BW assessed the risk of bias and summarized the evidence. YG and JT performed the statistical analysis. YG and GC wrote the first draft. JT and GC revised the draft. All authors approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

Ethical approval Ethical approval and patient consent are not required since this is an overview based on published studies.

Informed consent All analyses were based on previously published studies; thus, no informed consent is required.

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