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META-ANALYSIS

Diagnostic value of magnetic resonance cholangiopancreatography in choledocholithiasis

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Abstract

AIM: To evaluate the diagnostic accuracy of magnetic resonance cholangiopancreatography (MRCP) in patients with choledocholithiasis.

METHODS: We systematically searched MEDLINE, EMBASE, Web of Science, and Cochrane databases for studies reporting on the sensitivity, specificity and other accuracy measures of diagnostic effectiveness of MRCP for detection of common bile duct (CBD) stones. Pooled analysis was performed using random effects models, and receiver operating characteristic curves were generated to summarize overall test performance. Two reviewers independently assessed the methodological quality of studies using standards for reporting diagnostic accuracy and quality assessment for studies of diagnostic accuracy tools.

RESULTS: A total of 25 studies involving 2310 patients with suspected choledocholithiasis and 738 patients with CBD stones met the inclusion criteria. The average inter-rater agreement on the methodological quality checklists was 0.96. Pooled analysis of the ability of MRCP to detect CBD stones showed the following effect estimates: sensitivity, 0.90 (95%CI: 0.88-0.92, χ^2 = 65.80; P < 0.001); specificity, 0.95 (95%CI: 0.93-1.0, χ^2 = 110.51; P < 0.001); positive likelihood ratio, 13.28 (95%CI: 8.85-19.94, χ^2 = 78.95; P < 0.001); negative likelihood ratio, 0.13 (95%CI: 0.09-0.18, χ^2 = 6.27; P < 0.001); and diagnostic odds ratio, 143.82 (95%CI: 82.42-250.95, χ^2 = 44.19; P < 0.001). The area under the receiver operating characteristic curve was 0.97. Significant publication bias was not detected (P = 0.266).

CONCLUSION: MRCP has high diagnostic accuracy for the detection of choledocholithiasis. MRCP should be the method of choice for suspected cases of CBD stones.

Key words: Choledocholithiasis; Diagnosis; Magnetic resonance cholangiopancreatography; Common bile duct; Meta-analysis

Core tip: Unlike endoscopic retrograde cholangiopancreatography, magnetic resonance cholangiopancreatography (MRCP) is noninvasive, can be performed rapidly and has demonstrated good results for the detection of common bile duct stones. Moreover, MRCP does not expose patients to ionizing radiation or iodinated contrast media, which is useful for evaluating biliopancreatic disease. However, the selective use of MRCP in clinically equivocal situations has not been explored until now. The goal of this study was to evaluate the effectiveness of MRCP for the detection of common bile duct stones in patients with suspected choledocholithiasis.

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INTRODUCTION

The incidence of choledocholithiasis in patients with the common disorder, cholelithiasis, varies between 7% and 20%, of which 5% are asymptomatic[1,2]. Although common bile duct (CBD) stones may be silent, the development of complications such as cholangitis and acute pancreatitis is associated with major morbidity and mortality. Therefore, the detection and treatment of CBD stones is mandatory.

Usually, the diagnosis of choledocholithiasis is based on a combination of clinical suspicion (biliary colic, jaundice and cholangitis), biochemical analysis (raised conjugated bilirubin and alkaline phosphatase levels) and imaging findings. Individually, these indicators have varying levels of diagnostic accuracy and none represent a completely reliable method for identifying bile duct stones[3]. Intraoperative cholangiography (IOC) is standard procedure during open cholecystectomy that can detect CBD stones with a sensitivity of 100% and specificity of 98%[4]. It is an invasive investigation with intraoperative and postoperative morbidity of 6.3% and 15.9%, respectively. Its routine use is associated with increased cost and operating time[5].

Endoscopic retrograde cholangiopancreatography (ERCP) is the gold standard for both diagnosis and treatment of CBD stones. It also allows direct visualization of duct anatomy. However, the procedure is associated with an overall complication rate of 5%-10% and mortality rate of 0.02%-0.50%[6-8]. Ductal cannulation is difficult or impossible in patients who have undergone previous surgery, which includes Billroth type Ⅱ gastrectomy and hepaticoenterostomy. Early ERCP and stone extraction after endoscopic sphincterotomy decrease morbidity in patients with severe biliary pancreatitis. However, ERCP and endoscopic sphincterotomy are invasive procedures that may cause serious complications[7,9] and can potentially exacerbate acute pancreatitis[6]. Therefore, an accurate, safe, and efficacious method is needed to diagnose CBD stones in a definitive manner.

The diagnostic accuracy of endoscopic ultrasonography (EUS) for biliary tract stone disease is > 95%, which is less invasive than ERCP and is reliable at identifying bile duct stones[10-13]. However, its results are highly dependent on the operator, and the procedure is not widely available in clinical practice. In addition, visualization of all segments of the biliary tract may be incomplete or unsuccessful during EUS[11].

In many institutions, magnetic resonance cholangiopancreatography (MRCP) is replacing ERCP as a diagnostic procedure for the investigation of benign biliary obstructions and chronic pancreatitis, in part due to its comparable accuracy[14]. MRCP has an advantage because of its technical versatility, multiplanar capability, superior soft tissue resolution, and the potential to evaluate choledocholithiasis accurately in the preoperative acute calculous cholecystitis setting. Unlike ERCP, MRCP is noninvasive, can be performed rapidly, does not expose the patients to ionizing radiation or iodinated contrast materials[15], which is useful for evaluating biliopancreatic disease, and has good results for detecting CBD stones[16]. All segments of the biliary tree can be visualized using MRCP. Although ERCP is considered the standard for diagnosis of bile duct stones, small bile duct stones can be overlooked[17]. However, the selective use of MRCP in clinically equivocal situations has not been explored until now. The goal of this study was, therefore, to rigorously evaluate the effectiveness of MRCP for detection of CBD stones in patients with suspected choledocholithiasis *via* systematic review and meta-analysis.

MATERIALS AND METHODS

Search strategy

In March 2014, we searched MEDLINE (1980-2014), EMBASE (1980-2014), Web of Science (1990-2014) and Cochrane databases to identify studies. Although no language restrictions were imposed initially, only English-language articles were included for the full-text review and final analysis. Additional articles were searched using the "Related articles" function in PubMed and by manually searching reference lists of identified articles and review articles. The following search terms were used: "magnetic resonance cholangiopancreatography" or "MRCP" and "common bile duct" or "choledocholithiasis" and "diagnosis" and "sensitivity" and "specificity." We contacted experts in the field to ask about studies that we may have missed in the databases. Conference abstracts and letters to the editor were excluded because of the limited data they contained.

Study inclusion criteria

A study was included when it provided both the sensitivity (true-positive rate) and specificity (false-positive rate) of using MRCP for detection of CBD stones in patients of any age with suspected choledocholithiasis. Studies were also included if they reported the values of MRCP effectiveness in a scatter plot format that allowed patient data to be extracted. Studies were excluded if they involved fewer than ten patients with suspected choledocholithiasis to reduce selection bias due to small numbers of participants. Patients had to be diagnosed with choledocholithiasis based on ERCP and/or IOC. Two reviewers (Mo JJ, Lin L) independently determined study eligibility, and disagreements were resolved by consensus.

Data extraction and *quality assessment*

Two reviewers (Mo JJ, Lin L) independently confirmed the eligibility of the final set of studies and extracted the following data: first author, publication year, participant characteristics, assay methods, sensitivity and specificity data, and methodological quality. The values of MRCP effectiveness provided in scatter plots were extracted by placing scalar grids over the plots. A receiver operating characteristic (ROC) curve was calculated for each study (IBM Inc., Armonk, NY, United States).

To enable us to assess the methodological quality of the included studies, we extracted data on the following study design characteristics: (1) cross-sectional or case-control design; (2) consecutive or random sampling of patients; (3) blinded (single or double) or non-blinded interpretation of experimental and reference measurements; and (4) prospective or retrospective data collection. The two reviewers (Mo JJ, Lin L) independently assessed the methodological quality of studies using the standards for reporting diagnostic accuracy (STARD) guidelines[18], which provide for a maximum score of 25, and quality assessment for studies of diagnostic accuracy (QUADAS) guidelines[19], which provide for a maximum score of 14. Average inter-rater agreement on the methodological quality checklists was 0.96. If primary studies did not report information needed to assess methodological quality, we contacted the authors in an effort to obtain the data. If the authors did not respond, we changed the response for the relevant items from "not reported" to "no" on the assessment instruments.

Statistical analysis

Standard methods recommended for meta-analyses of diagnostic test evaluations were used[20]. Analyses were performed using professional statistical software program (Meta-DiSc for Windows; XI Cochrane Colloquium; Barcelona, Spain) and Stata version 12.0 (Stata Corporation, College Station, TX, United States). The following measures of test accuracy were analyzed for each study: sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR) and diagnostic odds ratio (DOR). A summary ROC (SROC) curve[21] was generated for each study based on a single test threshold for sensitivity and specificity[20,22]. A random effects model was adopted to calculate the average sensitivity, specificity, and other measures across studies[23,24].

To assess the effects of STARD and QUADAS scores on the diagnostic power of MRCP, we included them as covariates in a univariate, inverse variance-weighted meta-regression. We also analyzed the effects of other covariates on DOR, such as cross-sectional design, consecutive or random sampling of patients, single- or double-blinded interpretation of experimental and reference measurements, and prospective or retrospective data collection. The relative DOR (RDOR) was calculated to analyze the change in diagnostic precision in each study per unit increase in the covariate[25,26].

The heterogeneity, or variability, across studies was assessed for statistical significance using the χ^2 and Fisher's exact tests. Publication bias can pose problems for meta-analyses of diagnostic studies, therefore, we tested for the potential presence of this bias with funnel plots and the Egger's test[27].

RESULTS

Selection and summary of studies

We identified 292 citations *via* electronic searches, and 40 were retrieved for detailed analysis (Figure 1). Six studies were excluded for failing to satisfy the inclusion criteria[28-33], and another three were excluded because they failed to provide sufficient information[34-36]. Two articles were meta-analyses[37,38]. One paper was excluded because it was a Chinese study[39]. One study was a duplicate publication[3]. One study was excluded for being a reply letter[40] and one paper was excluded for involving fewer than 10 participants[41]. In the end, 25 publications were included in the analysis[42-66], involving 2310 patients with suspected choledocholithiasis and 738 with CBD stones. The average sample size of the studies was 69 patients (range: 27-278). Table 1 summarizes the clinical characteristics of participants in each study; numbers of true positives, false positives, false negatives and true negatives; and STARD and QUADAS scores.

Methodological quality of the included studies

Of the 25 studies in the meta-analysis, 23 had STARD scores $\geqslant$ 13, and 21 had QUADAS scores $\geqslant$ 10. All studies collected data from consecutive patients. There were nine randomized, prospective, blinded trials according to the corresponding reference measurements (Table 2).

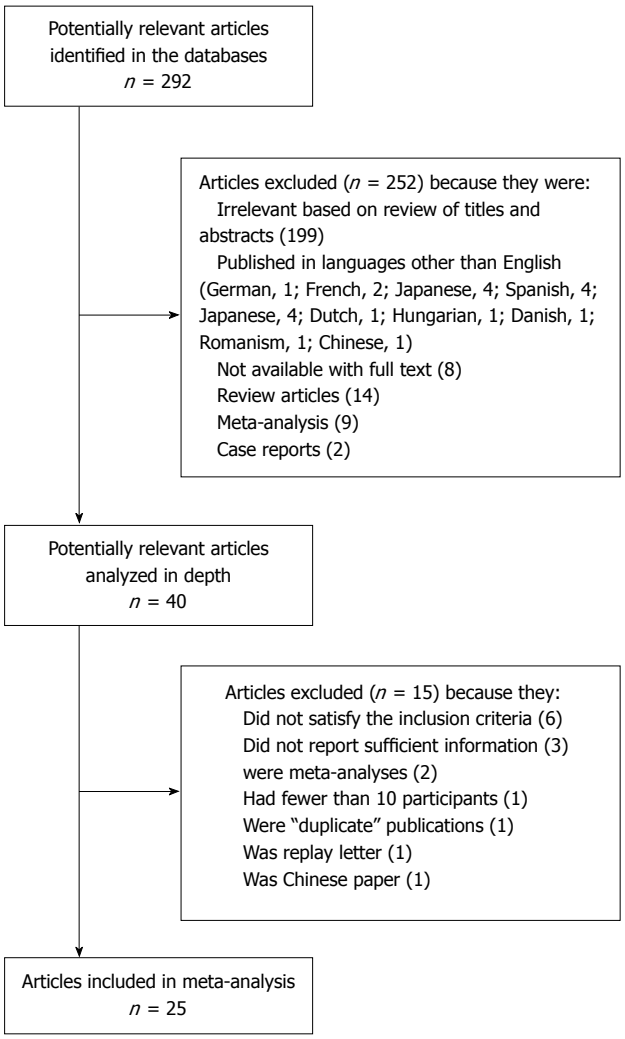

Figure 1 Flow chart of study selection.

Diagnostic accuracy

A Forest plot of MRCP values in all 25 included studies showed that the sensitivity of MRCP in detection of CBD stones ranged from 0.38 to 1.0 (mean 0.90, 95%CI: 0.88-0.92, χ^2 = 65.80; P < 0.001), while the specificity ranged from 0.19 to 1.0 (mean 0.95, 95%CI: 0.93-1.00, χ^2 = 110.51; P < 0.001) (Figure 2). The PLR was 13.28 (95%CI: 8.85-19.94, χ^2 = 78.95; P < 0.001), NLR was 0.13 (95%CI: 0.09-0.18, χ^2 = 66.27; P < 0.001) and DOR was 143.82 (95%CI: 82.42-250.95, χ^2 = 44.19; P < 0.001). These χ^2 and associated P values indicate significant heterogeneity among studies. The ten randomized controlled trials (RCTs) showed that the sensitivity, specificity, PLR, NLR and DOR of MRCP in detection of CBD stones was 0.91, 0.95, 10.83, 0.13 and 136.32, respectively.

Unlike the traditional ROC plot for assessing diagnostic power, an SROC plot reveals the effect of varying thresholds on sensitivity and specificity in a single study. Different studies appear as different data points in an SROC plot. In this way, SROC curves provide a global summary of test performance and illustrate the trade-off between sensitivity and specificity. Figure 3 shows an SROC curve for rates of true and false positives from individual studies of MRCP detection. Using this plot, we determined the Q value, defined as the point of intersection of the SROC curve with a diagonal line extending from the left upper corner to the right lower corner of the plot. The Q value indicates the highest identical value of sensitivity and specificity, thereby serving as an overall measure of the discriminatory power of a test. Our SROC curve was desirably positioned near the upper left corner, and the maximum joint sensitivity and specificity was 0.92. The area under the curve was 0.97, indicating high overall accuracy.

Multiple regression analysis and publication bias

Quality scores based on the STARD[18] and QUADAS[19] guidelines were generated for every study on the basis of the title and introduction, methods, results and discussion (Table 1). These scores were used in a meta-regression to assess the effect of study quality on the RDOR of MRCP in the diagnosis of CBD stones. As shown in Table 3, studies of higher quality (STARD score ⩾ 13; QUADAS score ⩾ 10) produced RDOR values similar to those of lower-quality studies. In addition, RDOR values did not differ significantly as a function of blinding, cross-sectional or case-control design, consecutive or random sampling, prospective or retrospective design (all P > 0.05). These results suggest that study design did not significantly affect diagnostic accuracy and that the risk of detection bias was lower. The Egger's test showed no evidence of significant publication bias in the reporting of MRCP detection as a method for diagnosis of CBD stones (P = 0.266).

DISCUSSION

Although MRCP can provide an accurate diagnosis of CBD stones, only a few investigators have evaluated its utility in the preoperative evaluation of symptomatic gallstones. Accordingly, the precise role of MRCP in this regard has yet to be determined. Some authors recommend MRCP for patients with a moderate risk of CBD stones and ERCP before any other imaging examination for patients who are at high risk[67,68]. Others recommend MRCP for patients with a high or moderate risk for CBD stones and ERCP for patients in whom stones have been depicted by other imaging modalities[69].

MRCP has recently been developed as a noninvasive, yet highly sensitive, method for diagnosing diseases of the biliary tract. One meta-analysis that included 15 studies concluded that the sensitivity of MRCP for diagnosis of choledocholithiasis ranged from 0.5 to 1.0, while specificity ranged from 0.83 to 1.0[37]. Another systematic review including five RCTs showed that the aggregated sensitivity and specificity of MRCP for the detection of choledocholithiasis were 0.85 and

Table 1 Summarized details of magnetic resonance cholangiopancreatography detections and overall methodological quality of included studies

Ref.	Year	Patients, *n*	Assay method	Assay system	Assay results				Quality score	
					TP	FP	FN	TN	STARD	QUADAS
Hochwald *et al*[42]	1998	48	MRCP, ERCP	1.5 T machine	19	3	1	25	15	11
Boraschi *et al*[43]	1999	278	MRCP, ERCP	1.5 T MR unit	71	5	5	197	16	11
de Lédinghen *et al*[44]	1999	32	EUS, MRCP, ERCP	1 T system	10	6	0	16	20	13
Lomas *et al*[45]	1999	69	MRCP, ERCP	1.5 T MR system	9	2	0	58	13	9
Varghese *et al*[46]	1999	100	MRCP, ERCP	1.5 GE unit	28	1	2	69	17	12
Stiris *et al*[47]	2000	50	MRCP, ERCP	1.0 T	28	1	4	17	17	12
Taylor *et al*[48]	2002	129	MRCP, ERCP	1.5 T MR system	45	9	1	74	18	12
Topal *et al*[49]	2003	69	MRCP, ERCP	1.5 T MR system	18	0	1	50	14	10
Kejriwal *et al*[50]	2004	81	MRCP, ERCP	Vision 1.5T MRI	20	1	2	58	13	10
Simone *et al*[51]	2004	65	MRCP, ERCP, IOC	1.0 T gyroscan NT	13	6	8	38	13	9
Dalton *et al*[52]	2005	69	MRCP, ERCP, IOC	1.5 T MR unit	16	2	1	50	11	7
Hallal *et al*[53]	2005	27	MRCP, ERCP, IOC	Unknown	4	2	0	21	14	10
Kondo *et al*[54]	2005	28	EUS, MRCP, HCT-C	1.5 T MR system	21	1	3	3	18	13
Moon *et al*[55]	2005	29	IDUS, MRCP, ERCP	1.5T MR system	16	1	4	8	17	11
Okada *et al*[56]	2005	40	CTCh, MRCP	1.5 T system	12	3	3	22	13	9
Shanmugam *et al*[57]	2005	221	MRCP, ERCP, EUS	0.5 T MRI	97	19	2	103	18	14
De Waele *et al*[58]	2007	104	MRCP, ERCP, EUS	1.5 T unit	19	2	4	79	16	11
Schmidt *et al*[59]	2007	57	MRCP, ERCP, EUS	1 T magnet	17	2	5	33	15	10
Hekimoglu *et al*[60]	2008	269	MRCP, ERCP	1.5 T unit	16	0	2	251	19	14
Nandalur *et al*[61]	2008	95	MRCP, ERCP	1.5 T system	21	1	7	66	18	13
Norero *et al*[62]	2008	125	MRCP, ERCP, CT	1.5 T MR system	83	10	3	29	15	11
Srinivasa *et al*[63]	2010	117	MRCP, ERCP, IOC	Siemens Vision 1.5 T	15	2	8	102	16	12
Bilgin *et al*[64]	2012	108	MRCP, ERCP, IOC	1.5 T MR scanner	28	3	6	71	16	11
Zhang *et al*[65]	2012	70	MRCP, MDCT	1.5 T MR system	19	2	1	48	18	13
Mandelia *et al*[66]	2013	30	MRCP, USG	1.5 T MR system	19	1	1	9	17	12

CT: Computed tomography; CTCh: Cholangiography computed tomography; ERCP: Endoscopic retrograde cholangiopancreatography; EUS: Endoscopic ultrasonography; FN: False-negative; FP: False-positive; HCT-C: Helical-computed-tomographic cholangiography; IDUS: Intraductal ultrasonography; IOC: Intraoperative cholangiography; MDCT: Multidetector-row computed tomography; MR: Magnetic resonance; MRCP: Magnetic resonance cholangiopancreatography; QUADAS: Quality assessment for studies of diagnostic accuracy; STARD: Standards for reporting diagnostic accuracy; TN: True-negative; TP: True-positive; USG: Ultrasonography.

Table 2 Additional characteristics of patients and methodologies in the included studies

Ref.	Year	Country	CBD/N-CBD, *n*	Reference standard	Cross-sectional design	Consecutive or random sampling	Blinded design	Prospective design
Hochwald *et al*[42]	1998	United States	20/28	ERCP	No	Yes	No	No
Boraschi *et al*[43]	1999	Italy	76/202	ERCP, PTC, IOC	No	Yes	No	No
de Lédinghen *et al*[44]	1999	France	10/-22	ERCP, IOC	Yes	Yes	Yes	Yes
Lomas *et al*[45]	1999	United Kingdom	9/60	ERCP	No	Yes	No	Yes
Varghese *et al*[46]	1999	Ireland	30/70	ERCP	No	Yes	Yes	Yes
Stiris *et al*[47]	2000	Norway	32/18	ERCP	Yes	Yes	Yes	Yes
Taylor *et al*[48]	2002	Australia	46/83	ERCP	Yes	Yes	Yes	Yes
Topal *et al*[49]	2003	Belgium	19/50	ERCP, IOC	No	Yes	No	No
Kejriwal *et al*[50]	2004	New Zealand	22/59	ERCP	No	Yes	No	No
Simone *et al*[51]	2004	France	21/44	ERCP, IOC	No	Yes	Yes	Yes
Dalton *et al*[52]	2005	United Kingdom	17/52	ERCP, IOC	No	Yes	No	Yes
Hallal *et al*[53]	2005	United States	4/-23	IOC	Yes	Yes	Yes	Yes
Kondo *et al*[54]	2005	Japan	24/-4	ERCP	Yes	Yes	Yes	Yes
Moon *et al*[55]	2005	South Korea	20/-9	ERCP, IDUS	No	Yes	Yes	Yes
Okada *et al*[56]	2005	Japan	15/25	IOC	No	Yes	Yes	No
Shanmugam *et al*[57]	2005	United Kingdom	99/122	ERCP, IOC	Yes	Yes	No	No
De Waele *et al*[58]	2007	Belgium	23/81	ERCP, IOC	No	Yes	No	Yes
Schmidt *et al*[59]	2007	Switzerland	22/35	EUS, ERCP	No	Yes	No	Yes
Hekimoglu *et al*[60]	2008	Turkey	18/251	ERCP	No	Yes	Yes	Yes
Nandalur *et al*[61]	2008	United States	28/67	ERCP, PTC	Yes	Yes	No	No
Norero *et al*[62]	2008	Chile	86/39	ERCP	No	Yes	No	No
Srinivasa *et al*[63]	2010	Australia	23/104	ERCP, IOC	No	Yes	No	No
Bilgin *et al*[64]	2012	Turkey, Germany	34/74	ERCP, PTC	No	Yes	No	No
Zhang *et al*[65]	2012	China	20/50	MDCT	No	Yes	Yes	No
Mandelia *et al*[66]	2013	India	20/-10	ERCP	No	Yes	No	Yes

CBD: Common bile duct; ERCP: Endoscopic retrograde cholangiopancreatography; EUS: Endoscopic ultrasonography; IDUS: Intraductal ultrasonography; IOC: Intraoperative cholangiography; MDCT: Multidetector-row computed-tomography; PTC: Percutaneous transhepatic cholangiography.

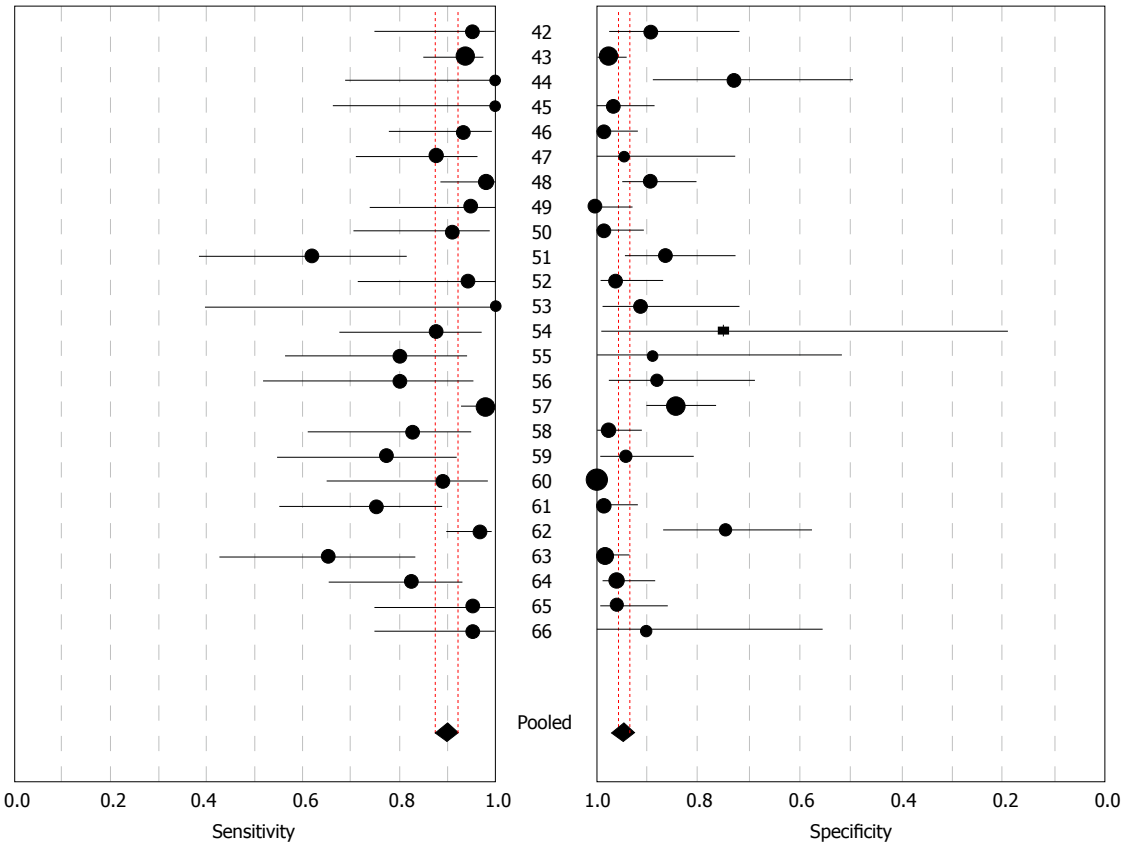

Figure 2 Forest plot showing sensitivity and specificity of magnetic resonance cholangiopancreatography in the diagnosis of choledocholithiasis. The point estimates of sensitivity and specificity from each study are shown as solid circles. Horizontal error bars indicate 95%CIs. Numbers between the plots refer to references. Pooled estimates for the magnetic resonance cholangiopancreatography detections were 0.90 for sensitivity (95%CI: 0.88-0.92) and 0.95 for specificity (95%CI: 0.93-1.0).

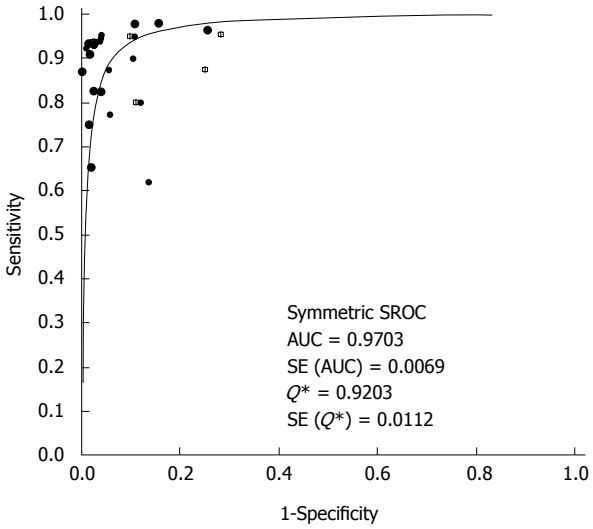

Figure 3 Summary receiver operating characteristic curves for magnetic resonance cholangiopancreatography detection. Solid circles represent each study included in the meta-analysis. The size of each study is indicated by the size of the solid circle. Summary receiver operating characteristic (SROC) curves summarize the overall diagnostic accuracy; AUC: Area under the curve.

0.93, respectively[38]. In this review, we provide high-quality systematic evidence for MRCP as a predictor of choledocholithiasis, demonstrating high sensitivity and specificity for predicting CBD stones with high overall accuracy.

DOR is an indicator of test accuracy that combines sensitivity and specificity data into a single number[70]. The DOR is the ratio of the odds of positive test results in patients with disease relative to the odds of positive test results in patients without disease. The value of a DOR ranges from 0 to infinity, with higher values indicating better discriminatory test performance (higher accuracy). A DOR of 1.0 indicates that a test does not discriminate between patients with the disorder and those without it. Thus, higher DOR values indicate better discriminatory test performance. The mean DOR in our study was 143.82, indicating a high level of overall accuracy.

The SROC curve and DOR are difficult to interpret and relate to clinical practice, whereas likelihood ratios are more clinically meaningful[71], therefore, we also calculated PLRs and NLRs to assess diagnostic accuracy. Likelihood ratios of > 10.0 or < 0.1 indicate high accuracy. The overall PLR value in our meta-analysis indicates that patients with CBD stones have an approximately 13-fold higher chance of being positive for MRCP detection compared with patients without choledocholithiasis. This high probability is considered sufficient to begin or continue ERCP/IOC

Table 3 Weighted meta-regression for the effects of design, methods and quality of studies on diagnostic accuracy of magnetic resonance cholangiopancreatography detections

Covariate	Studies (*n*)	Coefficient	RDOR (95%CI)	*P* value
QUADAS ⩾ 10	21	0.0830	1.09 (0.14-8.50)	0.9334
STARD ⩾ 13	23	1.5100	4.53 (0.51-40.21)	0.1637
Prospective design	14	0.1260	1.13 (0.27-4.82)	0.8564
Cross-sectional design	7	0.0980	1.10 (0.24-5.06)	0.8936
Blinded design	11	-0.6850	0.50 (0.13-2.02)	0.3130
Consecutive/ random sampling	25	-	-	-

RDOR: Relative diagnostic odds ratio; STARD: Standards for reporting diagnostic accuracy; QUADAS: Quality assessment for studies of diagnostic accuracy.

treatment of choledocholithiasis patients. In contrast, the NLR value in our meta-analysis indicates that a patient without choledocholithiasis would still have a 13% chance of having CBD stones, which is insufficient to rule out choledocholithiasis. These findings suggest that a negative MRCP detection result should not be used alone as a justification to deny or discontinue CBD stone therapy. A better approach may be a combined diagnostic strategy drawing on clinical information as well as findings from clinical symptoms, ERCP, EUS, and/or serum bilirubin, alkaline phosphatase, aspartate aminotransferase, and alanine aminotransferase levels.

An exploration of the reasons for heterogeneity rather than the computation of a single summary measure is an important goal of meta-analyses[72]. In our study, both STARD and QUADAS scores were used in the meta-regression analysis to assess the effect of study quality on RDOR. Most of the studies were high quality (STARD score ⩾ 13 or QUADAS score ⩾ 10). We found that there was no statistical heterogeneity for sensitivity, specificity, PLR, NLR, or DOR among the studies, which indicates that the differences for studies with or without blinded, cross-sectional, consecutive/random and prospective designs did not reach statistical significance, and the study design did not substantially affect diagnostic accuracy.

The present meta-analysis had several limitations. First, the exclusion of conference abstracts, letters to editors, and non-English-language studies may have led to publication bias, although our bias analysis suggests that this was not a significant problem. Second, nonrandom misclassification bias may have occurred due to the fact that different studies used various approaches to diagnose choledocholithiasis, including ERCP, IOC and/or EUS. Third, we did not identify multicenter and large, blinded RCTs that satisfied our inclusion criteria.

In conclusion, MRCP is a noninvasive investigation with fewer complications and it has high sensitivity, specificity and positive and negative predictive values for detection of CBD stones. We propose MRCP as the best method of choice for suspected cases of CBD stones, instead of ERCP, IOC and EUS, because of its high diagnostic accuracy and excellent features with technical versatility, multiplanar capability, and noninvasive nature.

COMMENTS

Background

Endoscopic retrograde cholangiopancreatography (ERCP) is applied both as a diagnostic and therapeutic tool. However, ERCP has significant morbidity of l%-7% and mortality of 0.2%-1.0%. Unlike ERCP, magnetic resonance cholangiopancreatography (MRCP) is noninvasive, can be performed rapidly, and does not expose the patients to ionizing radiation or iodinated contrast materials, which is useful for evaluating biliopancreatic disease. Moreover, MRCP has demonstrated good results for detecting common bile duct (CBD) stones. However, the selective use of MRCP in clinically equivocal situations has not been explored until now.

Research frontiers

MRCP is a noninvasive method for diagnosing choledocholithiasis. The selective use of MRCP in clinically equivocal situations has not been explored until now.

Innovations and breakthroughs

This study is believed to be the first rigorous evaluation of the effectiveness of MRCP for detection of CBD stones in patients with suspected choledocholithiasis, using a meta-analysis.

Applications

MRCP should be the method of choice for suspected cases of CBD stones because of its technical versatility, multiplanar capability, and noninvasive nature.

Peer-review

This is a very interesting and useful paper. The manuscript is well written and the method for statistical evaluation is properly used. In the clinical situation, it is sometimes difficult to correctly detect small stones or sludge as well as multiple stones by MRCP.

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