

Original Article

Accuracy of ultrasound in the diagnosis of placenta accreta: an updated meta-analysis

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Abstract: The aim of this study is to evaluate the accuracy of ultrasound in the diagnosis of placenta accreta. A computerized literature search of PubMed and Chinese National Knowledge Infrastructure (CNKI) databases was conducted to identify relevant published articles on the diagnostic accuracy of ultrasound in detection placenta accreta. Two reviewers independently screened literature according to the inclusion and exclusion criteria, extracted data, and assessed the quality. Meta-Disc 1.4 and RevMan 5.3 were used to meta-analysis. 28 eligible studies included 2847 patients at risk for placenta accreta were identified. The overall performance of ultrasound for the detection of the placenta accreta was as follows: the pooled sensitivity, 78% (95% CI, 74-81%); the pooled specificity, 94% (95% CI, 93-95%); LR+, 8.45 (95% CI, 5.50-12.97); LR-, 0.25 (95% CI, 0.19-0.32) and DOR, 46.51 (95% CI, 29.18-74.13). The AUC was 0.9287 (standard error (SE), 0.0135). The Q* was 0.8636 and the SE (Q*) was 0.0161. Ultrasound has high accuracy for diagnosis of placenta accreta in high risk women.

Keywords: Accuracy, ultrasound, placenta accreta, meta-analysis

Introduction

Placenta accreta is a considerable contributor to maternal morbidity and mortality and is presently the most common reason for emergency postpartum hysterectomy. It is an abnormal firm attachment of the placenta to the uterine wall [1], and occurs a defect of the decidua basalis allows the chorionic villi to invade the myometrium and serosa [2]. The depth of myometrium invasion determines the precise classification of the variant forms. In placenta accreta, villi are attached to the myometrium but do not invade the muscle; in placenta increta, villi partially invade the myometrium; the most severe type is placenta percreta, in which villi penetrate through the entire myometrial thickness or beyond the serosa [3]. In our article, all of the variant forms are referred to as Placenta accreta.

Placenta previa and previous cesarean section represent the two of the strongest reported risk factors for Placenta accreta. Women with placenta previa have a 3% risk of placenta accreta

[4]. The prevalence of placenta accreta seem to parallel the increasing occurrence of cesarean delivery. The risk of placenta accreta was present in 0.24%, 0.31%, 0.57%, 2.13%, 2.33%, and 6.74% women undergoing their first, second, third, fourth, fifth, and sixth or more cesarean deliveries, respectively [5]. Other reported minor risk factors which include multiparity [6], advanced maternal age [7, 8], hypertensive disorders, smoking [9], previous uterine surgery [10] and a female fetus [11] have previously been suggested as being associated with placenta accreta. Once placenta accreta occurs, it may threaten the life of the mother and fetus. For mother, it would lead to massive hemorrhage, disseminated intravascular coagulopathy, hysterectomy and other surgical complications [12]. Given the various complications associated with placenta accreta, accurate prenatal diagnosis of placental accreta is principal.

Ultrasound is known to be a useful tool for diagnosing placenta accreta and its variants. The diagnosis criteria of placenta accreta include

Accuracy of ultrasound in the diagnosis of placenta accreta

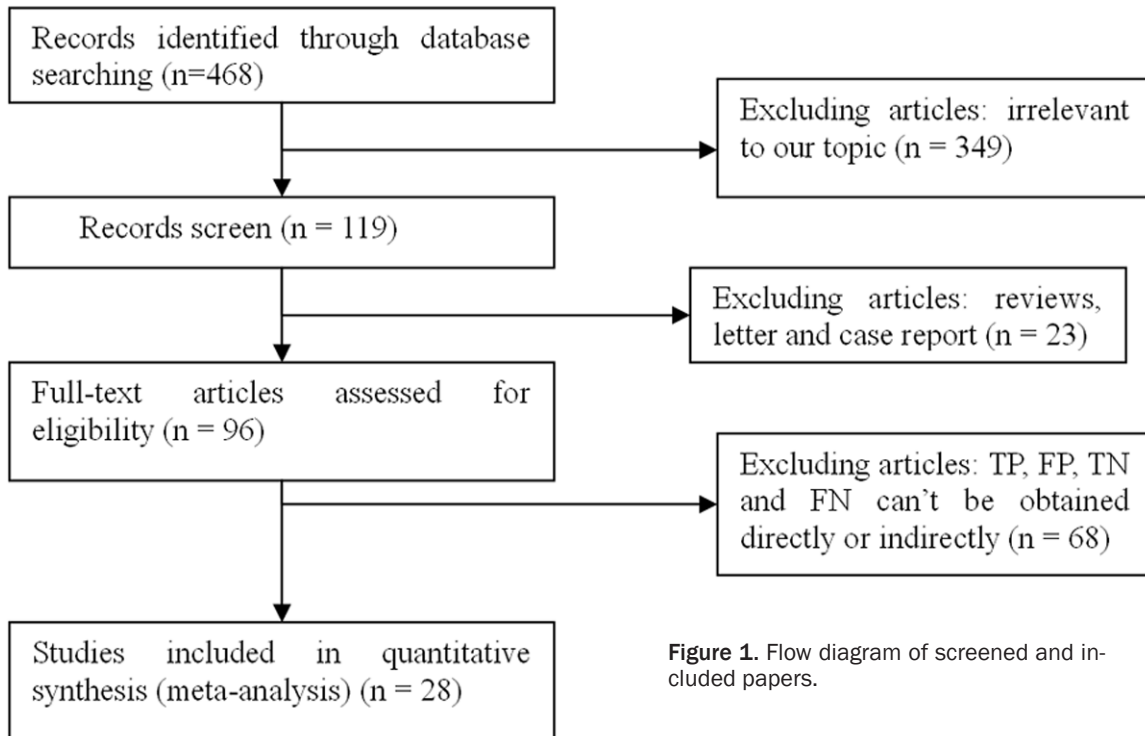


Figure 1. Flow diagram of screened and included papers.

Table 1. Characteristics of subjects in eligible studies

First author	Year	Country	Language	Sample size	TP	FP	TN	FN	Average gestational age (wk)	Probe type	Probe frequency (MHz)	Color and power Doppler imaging
HJ Finberg [21]	1992	America	English	34	14	4	15	1	/	TA/TV	/	Not used
Lerner et al [22]	1995	America	English	21	5	1	15	0	34.2 (30-37)	TV	5.0-6.5	used
Levine D [23]	1997	Israel	English	19	6	1	11	1	31.2 (26-37)	TA/TV	3.5-7.0	used
Chou MM [15]	2000	China	English	80	14	2	61	3	30.5 (16-36)	TA	3.5	used
Lam G [24]	2002	USA	English	13	4	0	1	8	/	TA	5.0-7.0	Not used
Warshark CR [25]	2006	USA	English	453	30	16	398	9	25 (11-37)	TA/TV	3.5-5.0	used
Japaraj RP [26]	2007	Malaysia	English	21	7	0	14	0	third trimester	TA/TV	3.5-5.0	used
Dwyer BK [27]	2008	USA	English	32	14	5	12	1	/	TA	4.0-6.0	used
Masselli G [28]	2008	Italy	English	50	11	0	38	1	30 (22-37)	TA	/	used
Jie Yang [29]	2008	China	Chinese	18	4	1	11	2	/	/	3.5	used
Shuwen Chen [30]	2010	China	Chinese	131	33	6	82	10	/	TA/TV	3.5-7.5	used
Ying Zhang [31]	2010	China	Chinese	453	30	16	398	9	36.1 (29-40)	TA	/	used
Hong Cao [32]	2010	China	Chinese	190	70	10	80	0	/	TA	/	used
Lim PS [4]	2011	USA	English	13	6	2	2	3	Second trimester	TA	4.0-6.0	used
Esakoff TF [33]	2011	USA	English	108	17	8	81	2	Third trimester	TA	4.0-6.0	used
Xinhong Han [34]	2011	China	Chinese	289	12	2	270	5	/	TA/TV	3.5-7.5	used
Ting Ji [35]	2012	China	Chinese	80	24	5	44	7	/	/	3.5	used
Zhiyuan Feng [36]	2012	China	Chinese	95	29	4	55	7	/	/	/	used
Jiqiang Chen [37]	2012	China	Chinese	23	8	2	9	4	/	TA/TV	/	used
Huafang Shi [38]	2012	China	Chinese	41	20	2	18	1	35 (28-38)	/	3.5	used
Shuxin Wang [39]	2012	China	Chinese	138	28	4	80	26	/	TA	/	used
Elhawary TM [40]	2013	Egypt	English	39	8	3	26	2	29.3 (26-32)	TA	3.5-7.5	used
Chalubinski KM [41]	2013	Austria	English	232	32	8	189	3	/	TA/TV	3.75-7.5	used
Linghong Wang [42]	2013	China	Chinese	93	19	5	68	1	26.4 (18-39)	TV	7	used
Cheng Zhou [43]	2013	China	Chinese	48	35	9	13	4	/	TA	3.5	used
Chunlian Zeng [44]	2014	China	Chinese	35	11	1	22	1	/	TA/TV	3.5-7.5	used
Riteau AS [45]	2014	France	English	42	26	10	6	0	/	TA/TV	3-9	used
Bei Zhang [46]	2015	China	Chinese	56	16	4	24	12	36 (33-39)	/	/	used

TP = true-positive; FP = false-positive; FN = false-negative; TN = true-negative; TA = transabdominal; TV = transvaginal.

Accuracy of ultrasound in the diagnosis of placenta accreta

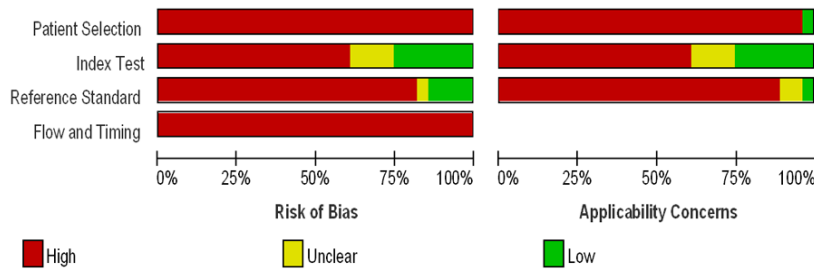


Figure 2. Risk of bias and applicability concerns graph.



Figure 3. Risk of bias and applicability concerns summary.

one or more of the following: (1) irregularly shaped lacunae within the placenta (2) loss of normal hypoechoic retroplacental zone (3) interruption of the bladder line and/or focal exophytic masses extending into the bladder space and (4) thinning of the myometrium overlying the placenta (5) color Doppler abnormalities such as abnormal blood vessels at the myometrium-bladder interface, turbulent flow

through the lacunae [13-17].

The purpose of this study is to evaluate the accuracy of ultrasonography in the diagnosis of placenta accreta.

Methods

Search strategy

A computerized literature search of PubMed and Chinese National Knowledge Infrastructure (CNKI) databases was conducted to identify relevant published articles on the diagnostic accuracy of ultrasonography in detection placenta accreta. We used the following search terms: 'placenta accreta' or 'placenta increta' or 'placenta percreta' or 'invasive placenta', 'ultrasound' or 'ultrasonography' or 'US', 'diagnosis' or 'detection' and 'magnetic resonance imaging' or 'MRI'. We only searched the article written in English and Chinese. The electronically databases were searched up to August 2015. In addition, we also searched the reference lists of the initially identified studies.

Study selection

We reviewed the titles and abstracts of all citations and retrieved literature. Only the studies that satisfied all of the following criteria were included: 1) the patients with a history of previous cesarean section, a diagnosis of placenta accreta or other risk factors for placenta accreta; 2) use ultrasound to detect; 3) sample size greater than eight patients; 4) original data of the diagnostic test can be obtained directly or indirectly, like TP, FP, TN and FN; 5) all cases

Accuracy of ultrasound in the diagnosis of placenta accreta

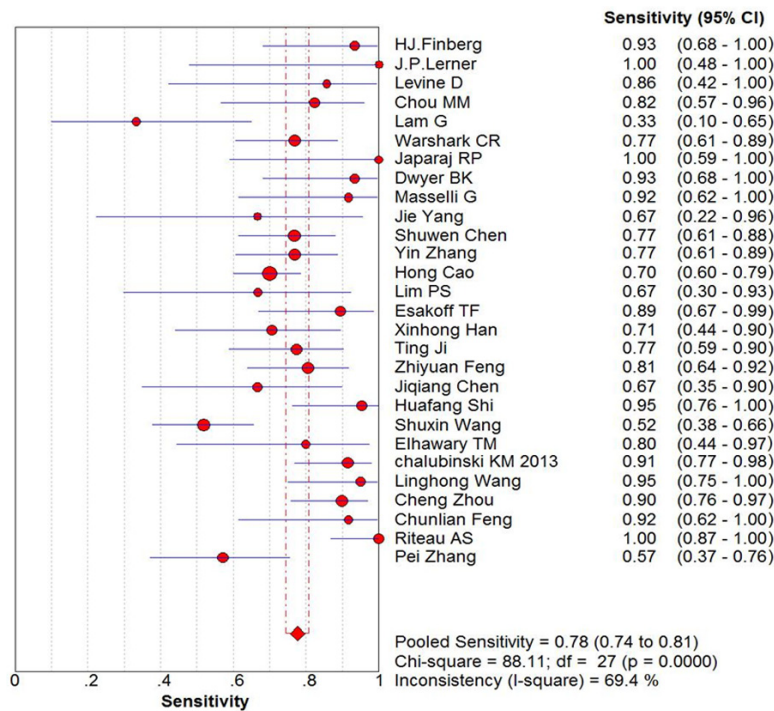


Figure 4. Sensitivity of ultrasound in the diagnosis of placenta accreta.

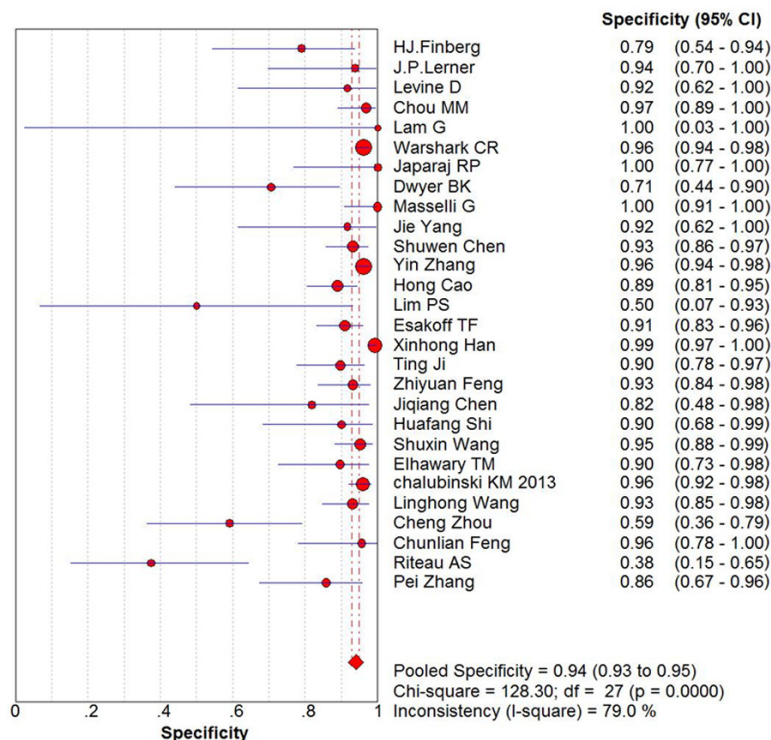


Figure 5. Specificity of ultrasound in the diagnosis of placenta accreta.

were confirmed by “gold standard” which include histopathologic analysis and/or intraoperative finding; 6) language were limited to English and Chinese.

The exclusion criteria were: 1) articles not within the field of interest of this review; 2) cases were not confirmed by “gold standard”; 3) review articles, letters and comments; 4) case reports or case series; 5) data is insufficient, for example, TP, FP, TN and FN can't be obtained directly or indirectly 6) duplicate data.

Data extraction

The reference lists of the identified articles were also examined by two independent reviewers. Disagreements of the results were resolved via consensus. For those studies included, extracted data included information on the first author, year of publication, the countries where the patients come from, language of publication, study design (prospective or retrospective), sample size, patient characteristics (average gestational age) and technical aspects. The number of TP, FP, TN and FN were recorded.

Quality assessment

The quality of the articles was assessed using the updated tool for the quality assessment of diagnostic accuracy studies (QUADAS-2) using RevMan 5.3. Each item is rated as ‘yes’ or ‘no’, or ‘unclear’. If there is insufficient data, then we used the “unclear” category.

Statistical analysis

Data was analyzed by Meta-DiSc 1.4 [18]. The Spearman correlation coefficients were used to test the threshold effect. Statistical heterogeneity among studies was assessed with the Q and I^2 statistics [19]. I^2 values of 25%, 50% and 75% were assigned as low,

Accuracy of ultrasound in the diagnosis of placenta accreta

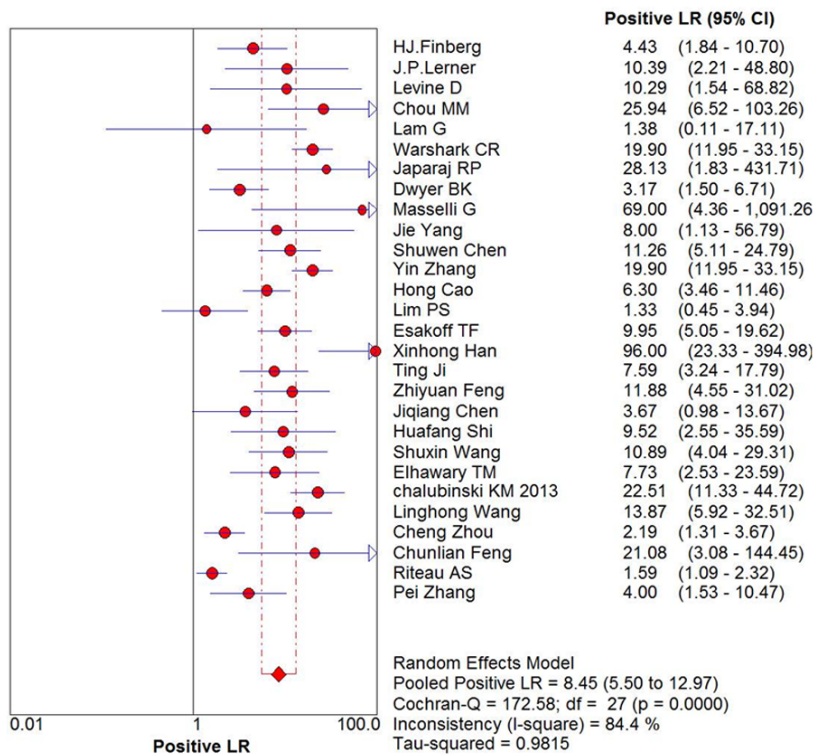


Figure 6. Positive LR of ultrasound in the diagnosis of placenta accreta.

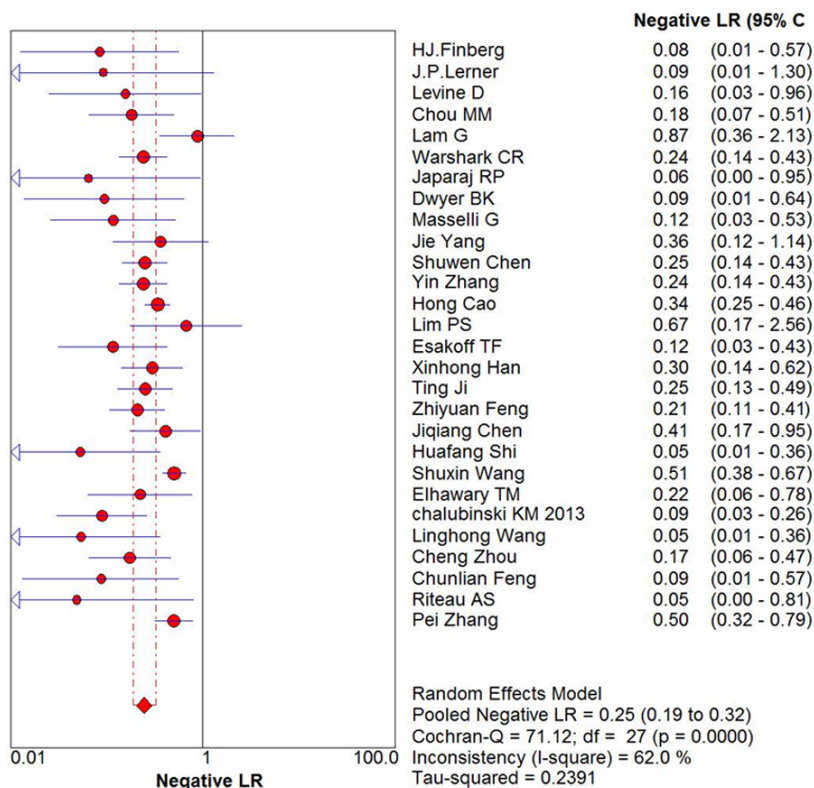


Figure 7. Negative LR of ultrasound in the diagnosis of placenta accrete.

moderate, and high heterogeneity, respectively. Generally, If $I^2 > 50\%$, the random effects model would be used. If not, fixed-effects model would be applied. According to the results of heterogeneity test, one of the models was used to pool the sensitivity, specificity, positive likelihood ratio (LR+), negative likelihood ratio (LR-) and diagnostic odds ratio (DOR). Additionally, summary receiver-operating characteristics (SROC) curves, the area under the curve (AUC) and the Q^* index were plotted to evaluate the overall performance of the diagnostic test accuracy. The AUC of an SROC curve is a measure of the overall performance of a diagnostic test. The Q^* index refers to the points on the SROC curve where sensitivity and specificity are equal. Both values range between 0 and 1, with higher values indicating better test performance [20]. Subgroup analyses were used to identify associations between the accuracy of ultrasound in the diagnosis of placenta accreta and other relevant study characteristics as possible sources of heterogeneity.

Results

Search results and characteristics of the studies included

The literature search identified a total of 468 primary articles. These articles were included for

Accuracy of ultrasound in the diagnosis of placenta accreta

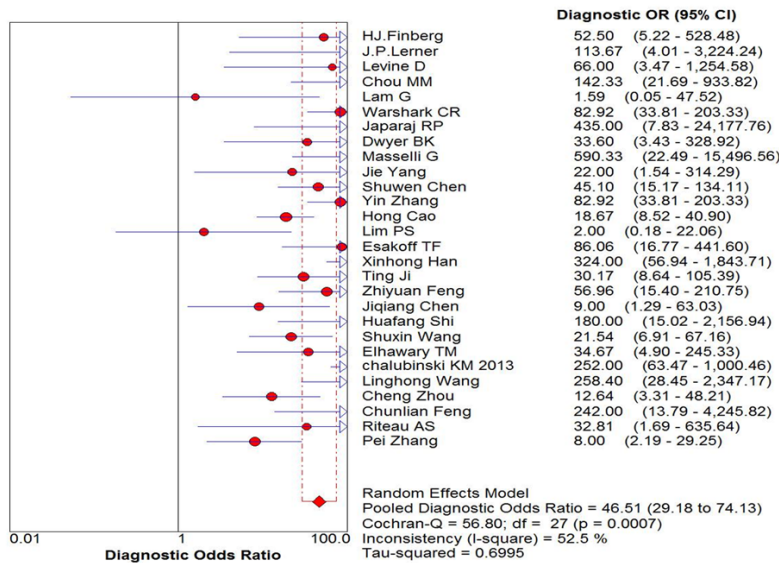


Figure 8. DOR of ultrasound in the diagnosis of placenta accreta.

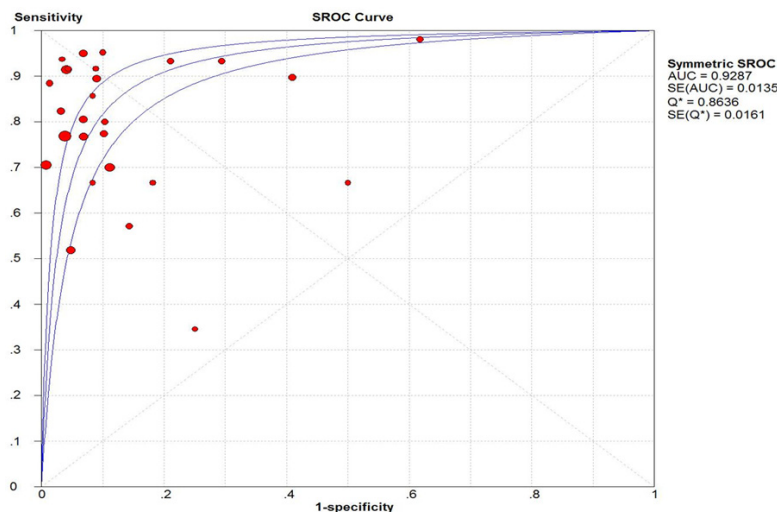


Figure 9. The SROC of ultrasound for the detection of the placenta accreta.

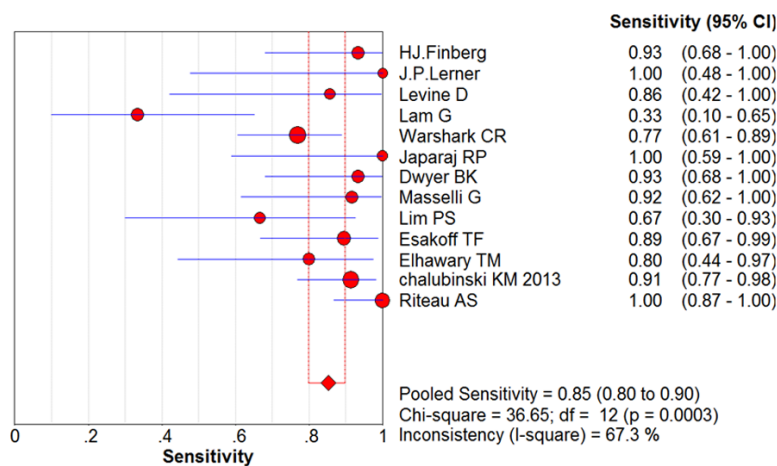


Figure 10. Sensitivity of ultrasound in the diagnosis of placenta accreta in foreigner literatures.

full-text assessment, of which 441 were excluded for one of the following reasons: 1) irrelevant to our topic (n = 349), 2) non-original articles (reviews, letters and case reports) (n = 23), 3) TP, FP, TN and FN can't be obtained directly or indirectly (n = 68). Overall, 28 studies were included in the final analysis. These 28 studies included 2847 patients at risk for placenta accrete. A flow diagram of the study selection process is presented in Figure 1. The characteristic of the included articles are showed in Table 1.

Quality assessment

A quality assessment of the included studies based on the updated QUADAS-2 is demonstrated in Figures 2, 3. Overall, the quality of the studies was satisfactory.

Statistical analysis

The overall performance of ultrasound for the detection of the placenta accreta was as follows: the pooled sensitivity, 78% (95% CI, 74-81%); the pooled specificity, 94% (95% CI, 93-95%); LR+, 8.45 (95% CI, 5.50-12.97); LR-, 0.25 (95% CI, 0.19-0.32) and DOR, 46.51 (95% CI, 29.18-74.13) (Figures 4-8). The SROC for the performance of ultrasound for the detection of the placenta accreta was shown in Figure 9. The AUC was 0.9287 (standard error (SE), 0.0135). The Q* was 0.8636 and the SE (Q*) was 0.0161.

Accuracy of ultrasound in the diagnosis of placenta accreta

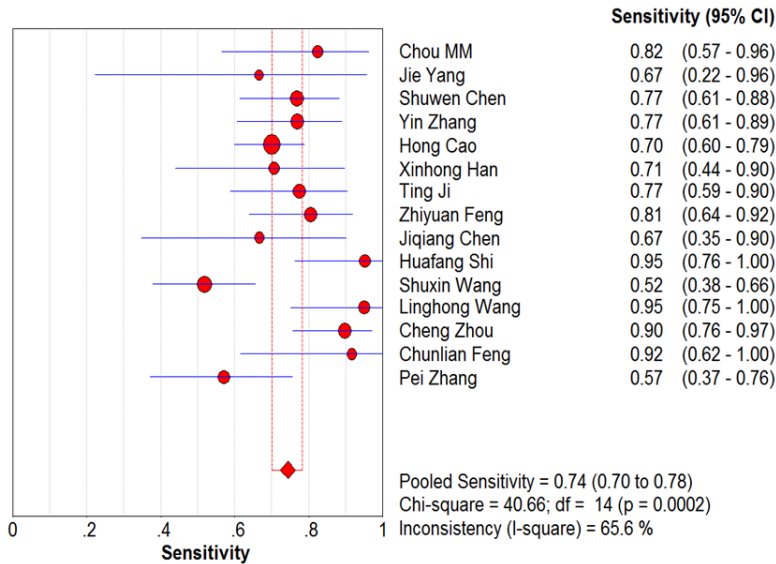


Figure 11. Sensitivity of ultrasound in the diagnosis of placenta accreta in Chinese literatures.

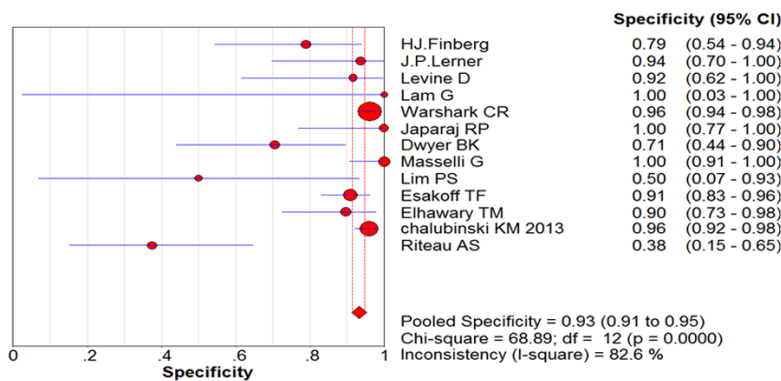


Figure 12. Specificity of ultrasound in the diagnosis of placenta accreta in foreigner literatures.

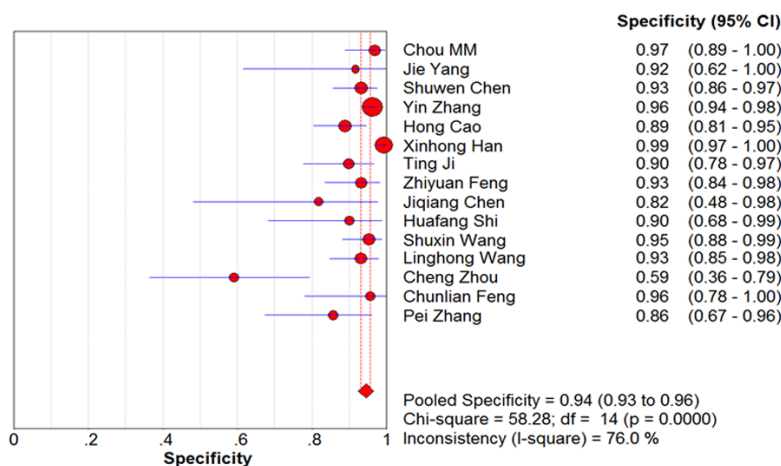


Figure 13. Specificity of ultrasound in the diagnosis of placenta accreta in Chinese literatures.

The subgroup analysis showed that the patients from different countries may have influence on the accuracy of ultrasound in the diagnosis of placenta accreta. In the subgroup meta-analysis, the pooled sensitivity, 85% (95% CI, 80-90%) (**Figure 10**); the pooled specificity, 93% (95% CI, 91-95%) (**Figure 12**); DOR, 56.47 (95% CI, 25.29-126.07) (**Figure 14**); AUC = 0.9421; SE (AUC) = 0.0160; $Q^* = 0.8801$ and SE (Q^*) = 0.0161 were in foreigner literatures (**Figure 16**); the pooled sensitivity, 74% (95% CI, 70-78%) (**Figure 11**); the pooled specificity, 94% (95% CI, 93-96%) (**Figure 13**); DOR, 41.08 (95% CI, 23.26-72.26) (**Figure 15**); AUC = 0.9171; SE (AUC) = 0.0223; $Q^* = 0.8501$ and SE (Q^*) = 0.0253 in Chinese literatures (**Figure 17**).

Discussion

Currently, there are a few articles on the diagnostic value of placenta accreta by ultrasound. Moreover, the sample size is small in each study and there is large heterogeneity among those studies. Meta-analysis can effectively combine comparable studies, increase the sample size, reduce the random error, and improve the statistical power of the test through analysis multiple independent results of the same research purposes. In 2013, in order to evaluate the diagnostic value of ultrasound (US) as compared with magnetic resonance imaging (MRI) in the detection of placenta accreta, Meng X et al. performed a meta-analysis [47]. But the number of studies included

Accuracy of ultrasound in the diagnosis of placenta accreta

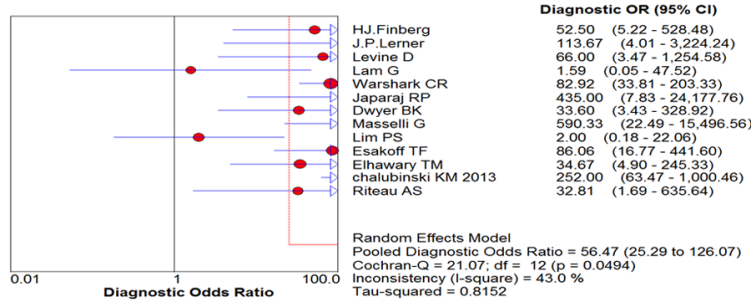


Figure 14. DOR of ultrasound in the diagnosis of placenta accreta in foreigner literatures.

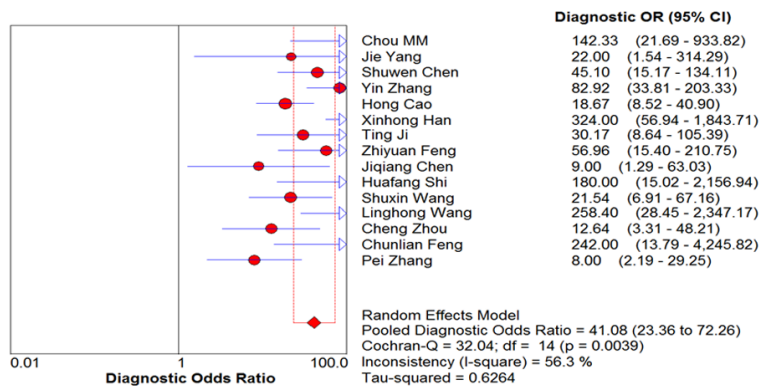


Figure 15. DOR of ultrasound in the diagnosis of placenta accreta in Chinese literatures.

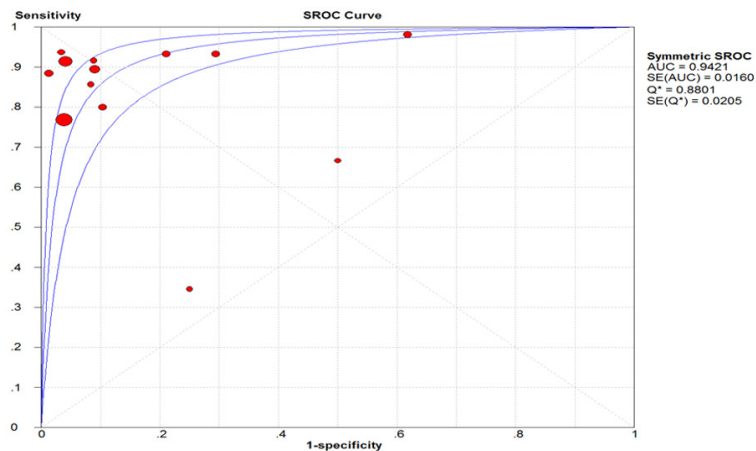


Figure 16. SROC of ultrasound in the diagnosis of placenta accreta in foreigner literatures.

was small and the language was limited to English. In order to avoid these limitations, we expand and refresh some literatures. In our meta-analysis, 28 eligible studies included 2847 patients at risk for placenta accreta were identified.

ent types of design, the average age of diagnosis and the type and frequency of probe also should be considered.

Although Elhawary TM et al. have reported MRI is most clearly indicated when US findings are

Based on the present meta-analysis, the overall data showed that ultrasound has a high accuracy for diagnosis of placenta accreta at high risk women. Considering the fact that diagnostic performance is determined by sensitivity as well as specificity, a meta-analysis that considers the two factors is necessary. The sensitivity, specificity, and AUC were pooled both in the previous meta-analysis and present. Compared with the previous meta-analysis, which showed the overall performance of ultrasound for the detection of the placenta accreta as follows: the pooled sensitivity, 83% (95% CI, 77-88%); the pooled specificity, 95% (95% CI, 93-96%); DOR, 63.41 (95% CI, 29.04-138.48); AUC = 0.9485; SE (AUC) = 0.0148; Q* = 0.8884; SE (Q*) = 0.0198, our meta-analysis demonstrated the overall performance of ultrasound as follows: the pooled sensitivity, 78% (95% CI, 74-81%); the pooled specificity, 94% (95% CI, 93-95%); DOR, 46.51 (95% CI, 29.18-74.13); AUC = 0.9287; SE (AUC) = 0.0135; Q* = 0.8636; SE (Q*) = 0.0161. In addition, according to the results of subgroup, ultrasound has a lower accuracy for diagnosis of placenta accreta in China than other foreigner countries. Thus, we may infer the heterogeneity was derived from the patients of different countries. Additional possible factors such as the different diagnostic technique, different diagnostic experiences, the study of different

Accuracy of ultrasound in the diagnosis of placenta accreta

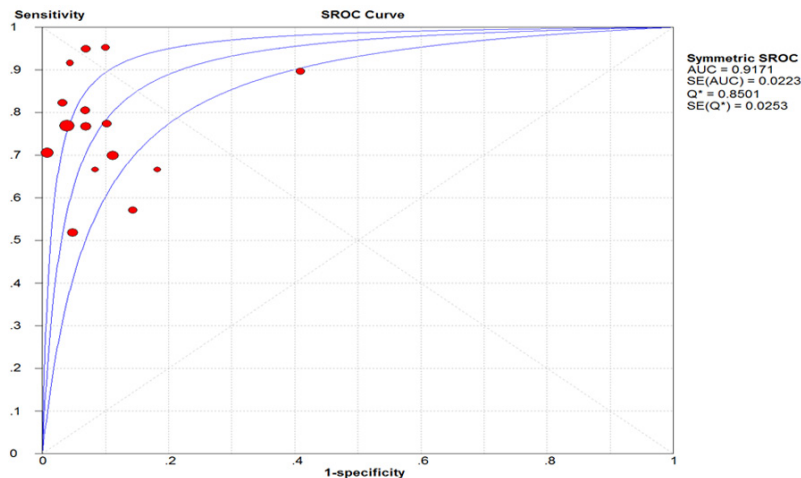


Figure 17. SROC of ultrasound in the diagnosis of placenta accreta in Chinese literatures.

ambiguous or there is a posterior placenta [40] and Dwyer BK et al. have reported that both sonography and MRI have fairly good sensitivity for prenatal diagnosis of placenta accreta [48], Ultrasound is still the most commonly used imaging technique for the diagnosis of placental accreta because it is an inexpensive, non-invasive and time-saving method.

To some extent, some limitations have affected the objectivity of the conclusions. Because it is a meta-analysis, the validity of our results is dependent on the validity of the reviewed studies. First, Meta-analysis is a combination of some similarly clinical and methodological studies, the heterogeneity is inevitable. Second, given that only published studies were included in the meta-analysis, a publication bias may have occurred. Third, because it only contained Chinese and English language literature, a language bias may have occurred. All these limitations should be considered when interpreting the results.

In conclusion, ultrasound has high accuracy for diagnosis of placenta accreta in high risk women.

Disclosure of conflict of interest

None.

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Accuracy of ultrasound in the diagnosis of placenta accreta

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