



Review article

The value of intrapartum ultrasound in the prediction of persistent occiput posterior position: Systematic review and meta-analysis



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ABSTRACT

Objective: To determine whether ultrasound-assessed occiput posterior (OP) position during labor can predict OP position at delivery.

Study design: We performed a systematic literature search in PubMed, EMBASE and the Cochrane Library from inception to February 2019. Included studies needed to report both the fetal head position in labor, as assessed by ultrasound, and the corresponding actual occiput position at delivery. We used a bivariate mixed-effects model to synthesis data. We also calculated I^2 to test heterogeneity and explored the source of heterogeneity by meta-regression and subgroup analysis.

Results: Sixteen primary articles were included in this meta-analysis. Overall sensitivity and specificity of intrapartum ultrasound for prediction of persistent OP position were 0.85 (95%CI: 0.67 to 0.94) and 0.83 (95%CI: 0.77 to 0.87), respectively. The area under the receiver operating characteristic curve was 0.89 (95%CI: 0.86 to 0.91). Substantial heterogeneity was detected ($I^2 = 98$, 95%CI: 97–99), and the labor stage at ultrasound examination may be the source of heterogeneity ($P = 0.00$). After the stratification by extent of cervical dilatation, the predictive sensitivity and specificity at cervical dilatation ≥ 4 cm reached 0.92 (95%CI: 0.85 to 0.99) and 0.85 (95%CI: 0.80 to 0.91), respectively.

Conclusion: Intrapartum ultrasound is a helpful tool for predicting persistent OP position, but the results of the test, especially the ultrasound examination before or at the beginning of labor, must be interpreted with caution. Re-evaluation at late labor is usually necessary.

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Contents

| | |
|---|----|
| Introduction | 26 |
| Materials and methods | 26 |
| Search strategy | 26 |
| Study selection | 26 |
| Data extraction and quality assessment | 26 |
| Statistical analysis | 26 |
| Results | 27 |
| Characteristics of the included studies | 27 |
| Quality assessment | 27 |
| Diagnostic accuracy | 27 |
| Heterogeneity and sensitivity analysis | 27 |
| Publication bias | 29 |
| Discussion | 29 |
| Conflicts of interest | 31 |
| References | 31 |

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Introduction

Occiput posterior (OP) position is the most common malposition during labor [1]. Its incidence has been reported about 30% at the onset of labor and 5–7% at delivery [2]. As a result of persistence of initial OP position or malrotation from an occiput anterior (OA) or occiput transverse (OT) position [3–5], OP position at delivery increases the rates of dystocia, cesarean delivery, operative vaginal delivery, third and fourth degree perineal lacerations and birth trauma [6]. Therefore, it is necessary to predict delivery position in advance, so that we have more time to prepare for some operations such as manual rotation [7] and instrumental rotation [8] to avoid OP position at delivery.

Intrapartum ultrasound is the most precise approach for diagnosing fetal head position [9]. However, about the accuracy of ultrasound-assessed fetal head position during labor to predict fetal head position at delivery, the literature is inconsistent. Lieberman et al [10] and Eggebo et al [11] found OP position during labor failed to predict the same position at birth, whereas Blasi et al [12] suggested that the position of fetal head and spine during the second stage of labor were useful indicators for predicting OP position at delivery. This inconsistency may mainly be due to the different timings of the ultrasound examinations (i.e. at which stage of labor) in each study. A meta-analysis investigated the value of sonographic occipital position for predicting the position of fetal head at delivery [13], but it only selected the studies that assessed fetal head position before or at the beginning of labor, not including the studies performed in late labor. In addition, the meta-analysis showed a substantial heterogeneity but did not analyze the sources of heterogeneity. Furthermore, new studies after this meta-analysis have been published and our understanding of this issue is still developing.

The purpose of this study was to systematically review and meta-analyze all available evidences to evaluate the accuracy of ultrasound-assessed OP position during labor in predicting OP position at delivery, and address the heterogeneity of patients and the influence of individual covariates.

Materials and methods

Search strategy

We systematically searched PubMed, EMBASE and the Cochrane Library for studies that assessed the accuracy of intrapartum ultrasound for the diagnosis of fetal head position on February 16, 2019. The following medical subject headings (MeSH) and free-text words were used in combination: “fetal head position”, “position of fetal head”, “fetal occiput position”, “occiput posterior position”, “occipitoposterior position”, “ultrasonography”, “echography”, “ultrasound imaging”, “imaging, ultrasound”, “imagings, ultrasound”, “ultrasound imagings”, “ultrasonic imaging”, “imaging, ultrasonic”, “sonography, medical”, “medical sonography”, “diagnostic ultrasound”, “diagnostic ultrasounds”, “ultrasound, diagnostic”, “ultrasounds, diagnostic”, “echotomography”, “diagnosis, ultrasonic”, “diagnoses, ultrasonic”, “ultrasonic diagnoses”, “ultrasonic diagnosis”, “echotomography, computer”, “computer echotomography”, “tomography, ultrasonic”, “ultrasonic tomography”. The search strategies in PubMed were shown in Supplementary Table S1. Reference lists of included studies were also searched for additional reports. Language restrictions were not applied.

Study selection

The primary eligibility criteria were articles that correlated ultrasound-assessed fetal head position in labor with fetal head

position at delivery. To be clear, the index test was various ultrasound examinations, such as transabdominal ultrasound, transperineal ultrasound or combination of them, with the specific aim of diagnosing fetal head position before or during labor. The reference standard was the actual position of fetal head, as determined by direct visualization at vaginal delivery or at cesarean section. Both prospective cross-sectional studies and cohort studies were analyzed. Furthermore, studies had to provide sufficient data to construct a 2×2 table that contained true positive (TP), false positive (FP), true negative (TN), and false negative (FN). We only included articles published in English or Chinese. Studies presented with reviews, letters and insufficient data were excluded.

Data extraction and quality assessment

Two investigators independently reviewed eligible articles and extracted the following data: the first author, publication year, country, number of patients, labor stage at ultrasound examination and the type of ultrasound examination. And TP, FP, TN, FN were recorded for the 2×2 contingency table. Herein, we classified the fetal head position as OP position and non-OP position, with the latter including both OT and OA position. OP position was regarded positive and non-OP position was negative. We assessed the quality of the studies using the Quality Assessment of Diagnostic Accuracy Studies tool (QUADAS-2). When there was a high risk of bias for one or more QUADAS-2 items, the study was considered to be of low quality [14]. Any disagreements were resolved by consensus.

Statistical analysis

We performed statistical analysis using MIDAS module for STATA 14.0. Coupled forest plots were constructed to display the individual and pooled sensitivities, specificities and their 95% confidence intervals (CI) of all included studies. Other commonly used indicators for evaluating the accuracy of diagnostic tests, such as positive likelihood ratio (PLR), negative likelihood ratio (NLR), and diagnostic odds ratio (DOR) were also calculated. $PLR = \text{sensitivity} / (1 - \text{specificity})$, which measured the ability of ultrasound to accurately predict OP position. $NLR = (1 - \text{sensitivity}) / \text{specificity}$, reflecting the probability that ultrasound mistakenly predicted OP position as non-OP position. $DOR = PLR / NLR$, which was a comprehensive indicator to evaluate how many times the correct predictions were the wrong predictions. In this meta-analysis, we used a bivariate mixed-effects regression model for data synthesis. This model takes into account the negative correlation between sensitivity and specificity, and maintains the bivariate nature of the original data. Based on this model, a summary receiver operating characteristic (SROC) curve was plotted. The area under the curve (AUC) was calculated to reflect the diagnostic accuracy. The closer the AUC is to 1, the higher the accuracy of the diagnosis will be. Additionally, we constructed a likelihood ratio (LR) scattergram to evaluate the clinical utility of intrapartum ultrasound. And a Fagan's nomogram was created, which enabled clinicians to estimate a patient's probability of having OP position at delivery (post-test probability) via the results of the ultrasound examination at labor. We computed I^2 to assess heterogeneity. If heterogeneity among studies was recorded, subgroup analysis and meta-regression were used to investigate sources of heterogeneity. Relevant covariates included publication year, labor stage, type of ultrasound examination and study quality. Sensitivity analysis was conducted to estimate the impact of low-quality study on the meta-analysis results. Moreover, publication bias was assessed by Deeks' funnel plot.

Results

Characteristics of the included studies

The search yielded 341 relevant records. By reading titles and abstracts we excluded 258, and by reading full texts we eliminated another 67. Finally, 16 articles comprising 5648 patients were included for this meta-analysis (Fig. 1) [1,3–5,10–12,15–23]. Because in three articles investigators divided the labor stage into two [22] or three parts [1,3] and reported their respective diagnostic accuracy, thus we actually analyzed 21 studies. The main characteristics of the eligible studies were summarized in Table 1. All studies reported the inclusion criteria of women with singleton cephalic presentation at term pregnancies.

Quality assessment

Overall, the quality of eligible studies was good, as shown in Fig. 2. No studies presented high risk of bias for the four domains. And there were no concerns about applicability of index text and reference standard in all 21 studies. However, three studies raised high concerns regarding applicability of patient selection [18,21,23]. Because they both enrolled women with prolonged or arrested labor, who might have a higher risk of having OP position at delivery.

Diagnostic accuracy

The separate and combined sensitivities and specificities of all studies were shown in Fig. 3. Pooled sensitivity and specificity were 0.85 (95%CI: 0.67 to 0.94) and 0.83 (95%CI: 0.77 to 0.87), respectively. PLR, NLR and DOR were 4.9 (95%CI: 3.4 to 7.2), 0.18 (95%CI: 0.08 to 0.44) and 27 (95%CI: 8 to 86), respectively. The corresponding SROC curve was illustrated in Fig. 4. And the area under the curve was 0.89 (95%CI: 0.86 to 0.91). It can be concluded, from these results, that the accuracy of ultrasound-assessed occiput position in labor for the prediction of fetal head position at delivery was relatively high. Nevertheless, as shown in the forest plot and the predictive region of SROC curve, substantial heterogeneity existed among studies. And the variability of

sensitivity was greater than specificity, indicating that intrapartum ultrasound might be less reliable in predicting OP position compared to non-OP position.

The LR scattergram and the Fagan plot were applied to evaluate the clinical utility of intrapartum ultrasound. The LR scattergram was divided into four quadrants by a horizontal line of PLR = 10 and a vertical line of NLR = 0.1. As shown in Fig. 5A, the summary point of positive and negative LR was located in the right lower quadrant (RLQ). RLQ corresponds to PLR < 10 and NLR > 0.1, indicating that the diagnostic test can neither confirm the disease in positive findings nor exclude the disease in negative findings. In detail, intrapartum ultrasound had great potential but still cannot make a definite prediction either for OP position or non-OP position. In addition, the individual points of positive and negative LR of studies were located near the diagonals of LUQ and RLQ. This suggested that the studies we included were either with high accuracy or with low accuracy but no with moderate accuracy. It meant that a significant heterogeneity existed among these studies. The Fagan plot was exhibited in Fig. 5B. The pre-test probability was determined to be 20% based on the incidence of OP position at enrollment. Reportedly, the incidence of OP position is about 30% at the onset of labor and 5–7% at delivery [2]. Considering that our meta-analysis included the patients in different stages of labor, we made a compromise and took the median of the incidence as the pre-test probability. The Fagan plot demonstrated that the post-test probability for a positive test result was 55% and that for a negative result was 4%. That is to say, when ultrasound assessed fetal head position as OP, the probability of OP position at delivery was increased from 20% to 55%, while when ultrasound assessed it as non-OP, the probability of OP position at delivery was reduced from 20% to 4%.

Heterogeneity and sensitivity analysis

As mentioned above, obvious heterogeneity among studies could be seen directly from the forest plot, the SROC curve and the LR scattergram. And the value of I^2 (98, 95%CI: 97–99) further confirmed the existence of significant heterogeneity. The threshold effect, namely the proportion of heterogeneity likely due to different definition of OP position, was 14%. To explore the other

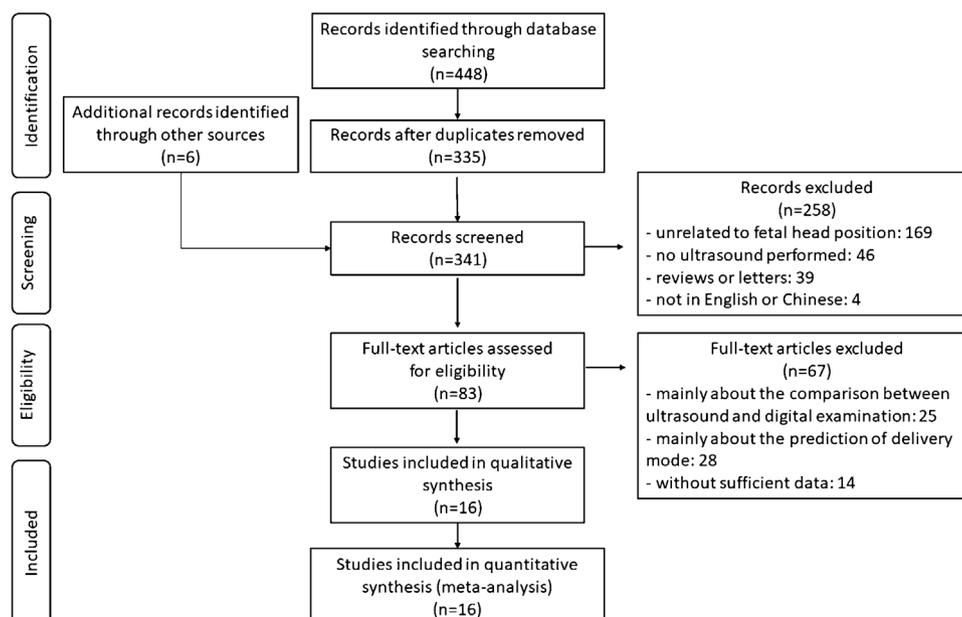


Fig. 1. Flowchart of study selection process (following PRISMA statement).

Table 1
Main characteristics of studies reporting the use of intrapartum ultrasound in predicting persistent occiput posterior position.

| Num. | Author | Year | Country | Case number | Labor stage (cervical dilation) | Ultrasonic examination | TP | FP | TN | FN |
|------|------------|----------|-------------------|-------------|--------------------------------------|---|----|-----|------|-----|
| 1 | Adam | 2014 | România | 187 | active labor (≥ 4 cm) | transperineal | 2 | 8 | 173 | 4 |
| 2 | Akmal | 2004 (1) | UK | 452 | active labor (3-5 cm) | transabdominal | 32 | 117 | 289 | 14 |
| 3 | Akmal | 2004 (2) | UK | 298 | active labor (6-9 cm) | transabdominal | 32 | 69 | 194 | 3 |
| 4 | Akmal | 2004 (3) | UK | 168 | active labor (10 cm) | transabdominal | 14 | 18 | 136 | 0 |
| 5 | Blasi | 2010 | Germany& Italy | 100 | second stage | transabdominal | 6 | 17 | 61 | 0 |
| 6 | Chou | 2004 | USA | 88 | second stage | combined transabdominal and transperineal | 13 | 7 | 68 | 0 |
| 7 | Eggebo | 2008 | Norway | 152 | before labor | transabdominal | 6 | 34 | 108 | 4 |
| 8 | Gardberg | 1998 | Finland | 408 | at the onset of labor | undetermined | 8 | 53 | 334 | 13 |
| 9 | Gizzo | 2014 (1) | Italy | 256 | first stage (≥ 3 cm) | transabdominal | 15 | 87 | 107 | 1 |
| 10 | Gizzo | 2014 (2) | Italy | 256 | second stage | transabdominal | 14 | 26 | 168 | 2 |
| 11 | Kahrs | 2018 | Norway | 165 | prolonged second stage | transabdominal or transperineal | 10 | 15 | 131 | 7 |
| 12 | Lieberman | 2005 | USA | 1562 | at enrollment, most <4 cm | transabdominal | 59 | 318 | 1054 | 131 |
| 13 | Peregrine | 2007 | UK | 289 | before induction of labor | transabdominal | 8 | 89 | 156 | 17 |
| 14 | Rayburn | 1989 | USA | 86 | arrested late labor (≥ 7 cm) | transabdominal | 15 | 1 | 70 | 0 |
| 15 | Souka | 2003 | Greece | 148 | active labor (≥ 4 cm) | transabdominal | 3 | 37 | 65 | 1 |
| 16 | Svelato | 2017 | Italy | 86 | second stage | transabdominal | 7 | 5 | 61 | 0 |
| 17 | Torkildsen | 2012 | Norway | 105 | prolonged first stage (≥ 4 cm) | transabdominal | 11 | 30 | 56 | 8 |
| 18 | Verhoeven | 2012 | Netherland | 183 | before induction of labor | transabdominal | 11 | 39 | 117 | 3 |
| 19 | Vitner | 2015 (1) | Israel&USA&France | 137 | station above -2 | transabdominal | 3 | 25 | 104 | 5 |
| 20 | Vitner | 2015 (2) | Israel&USA&France | 449 | station between -2 and <0 | transabdominal | 26 | 77 | 346 | 0 |
| 21 | Vitner | 2015 (3) | Israel&USA&France | 270 | station at or below 0 | transabdominal | 10 | 17 | 243 | 0 |

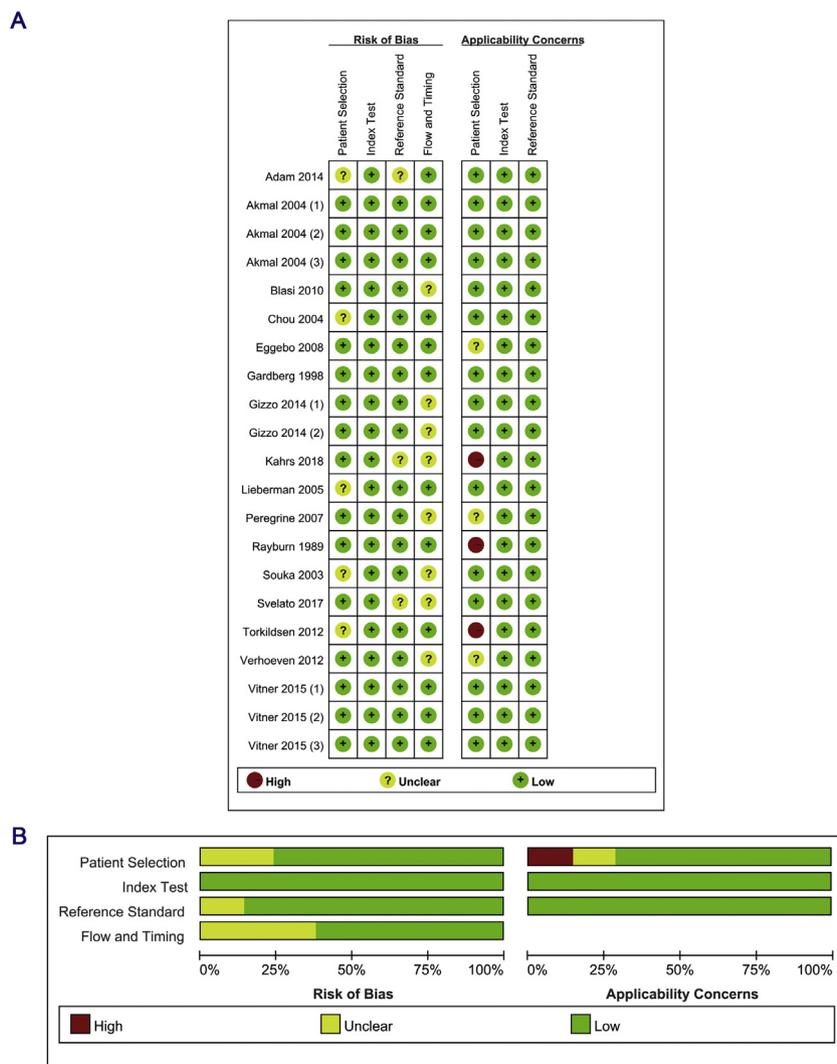


Fig. 2. Risk of bias and applicability concerns of included studies. (A) QUADAS-2 assessments for each included study; (B) proportion of studies with high, low, unclear risk or concern.

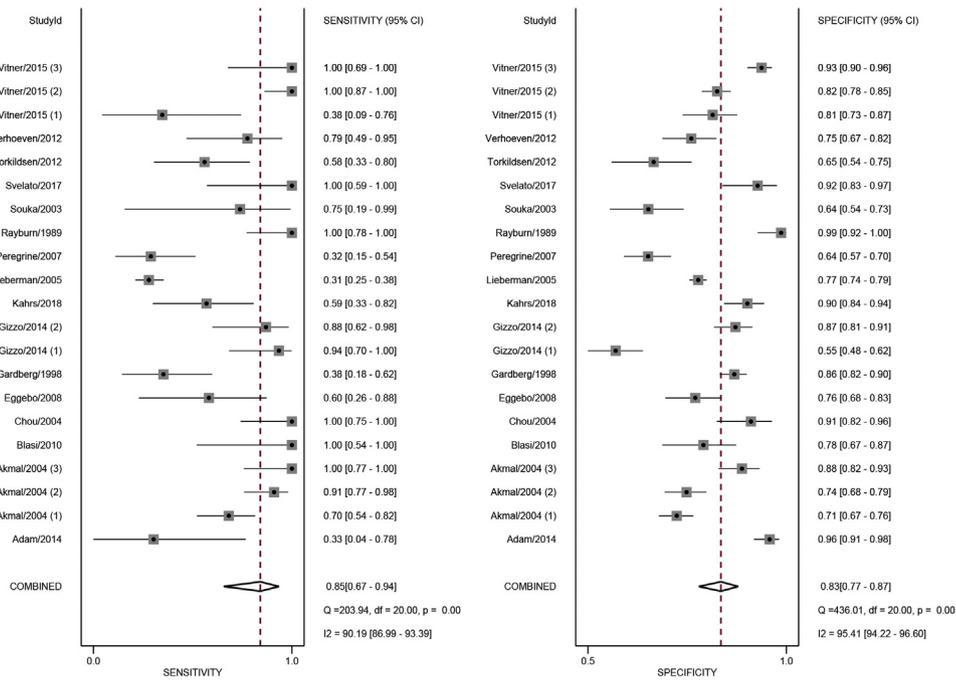


Fig. 3. Forest plots for sensitivity and specificity of intrapartum ultrasound in predicting persistent occiput posterior position. Only first author of each study is given.

sources of heterogeneity, we performed meta-regression analysis (Table 2). Regarding to the covariate - type of ultrasound examination, there was one study that didn't explicitly describe it [5]. We contacted the author but received no response. Therefore, we classified this study as transperineal or other type group. As for the covariate - labor stage at ultrasound examination, most studies assessed it by the extent of cervical dilatation, but three studies by the descending degree of fetal head [1]. According to the relationship between fetal head station and cervical dilatation [24], we roughly sorted the study of fetal head station above -2 into the group of cervical dilatation <4 cm, and the studies of fetal head station between -2 and <0 and at or below 0 into the

group of cervical dilatation ≥4 cm. The result of meta-regression analysis demonstrated that the labor stage might be the primary cause of heterogeneity (P=0.00). The sensitivity and specificity of the group of cervical dilatation ≥4 cm were much higher than those of the group of cervical dilatation <4 cm, with 0.92 (95%CI: 0.85–0.99) vs 0.50 (95%CI: 0.25–0.74) and 0.85 (95%CI: 0.80–0.91) vs 0.76 (95%CI: 0.66–0.87), respectively. In addition, the sensitivity analysis indicated that the diagnostic accuracy of intrapartum ultrasound was stable, since there were no significant changes after exclusion of low-quality studies (Table 2).

Publication bias

As presented in Fig. 6, significant publication bias was identified by Deeks' funnel plot asymmetry test (P=0.01).

Discussion

The findings from this review showed that overall performance of ultrasound-assessed fetal head position during labor to predict fetal head position at delivery was good although not optimal. Especially when ultrasound examinations were performed at cervical dilatation above 4 cm, the predictive sensitivity and specificity were up to 0.92 and 0.85, respectively.

Intrapartum ultrasound is regarded as the gold standard for evaluating the position of fetal head, with the higher accuracy and the easier learning than digital examination [25–27]. In particular, if fetal head position is OP position, digital examination is always more difficult and less accurate than OA position, while ultrasound examination might still objective and precise [16,28,29]. Nevertheless, because OP position may rotate to OA position during labor, the value of intrapartum ultrasound in predicting persistent OP position is changing with the progress of labor [10]. And since the rotation is more likely to occur in early labor, the prediction would be more accurate when ultrasound examination is performed near birth [1,3]. Our research showed that after the stratification of original studies, the detection rate of persistent OP position at cervical dilatation above 4 cm was as high as 0.92,

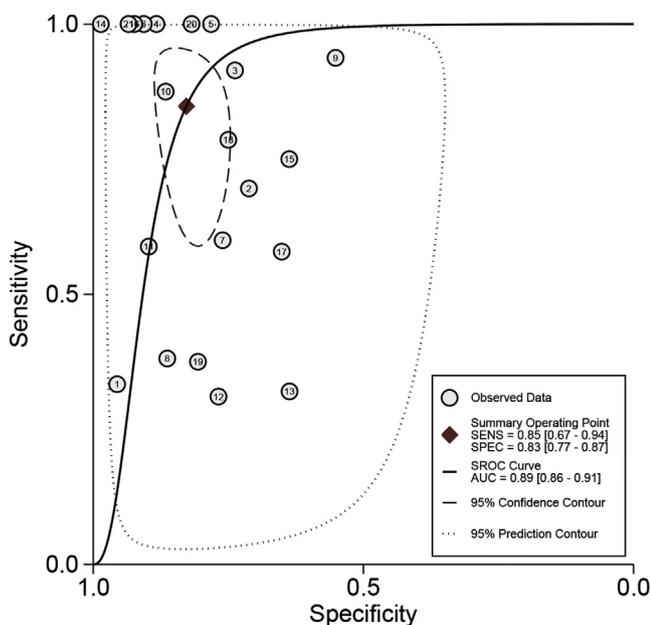


Fig. 4. Summary receiver operating characteristic curve with 95% confidence contour and 95% prediction contour.

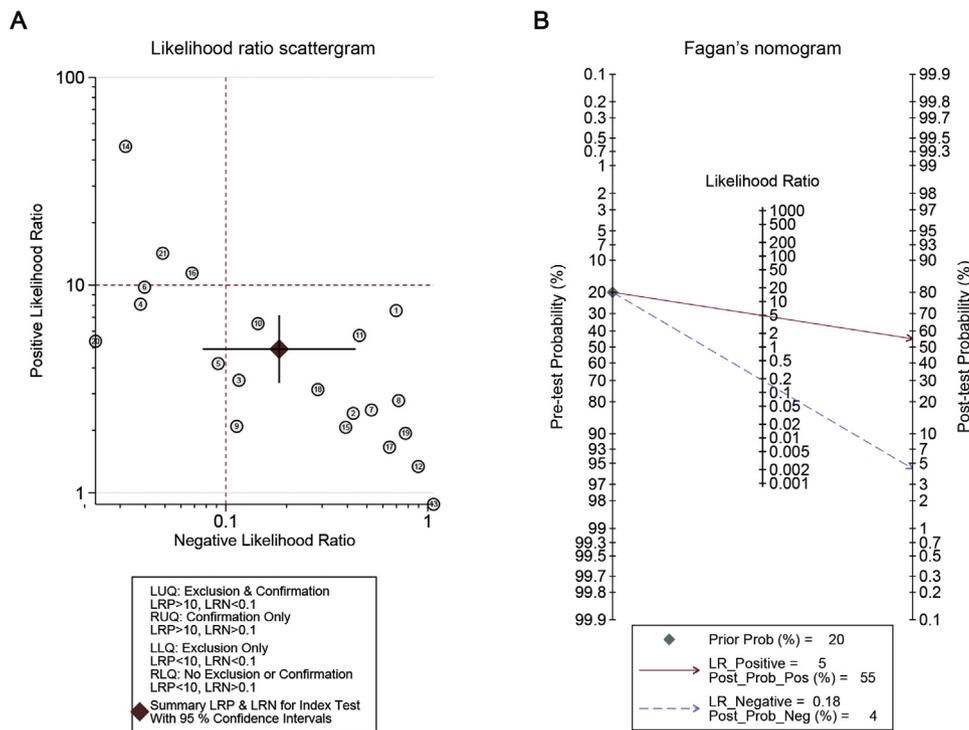


Fig. 5. The likelihood ratio scattergram and Fagan's nomogram. (A) The likelihood ratio scattergram is divided into four quadrants by a horizontal line of PLR = 10 and a vertical line of NLR = 0.1. RLQ (right upper quadrant) corresponds to PLR < 10 and NLR > 0.1. The diamond symbol located in RUQ indicated that the intrapartum ultrasound cannot make a definite prediction either for OP position or non-OP position. (B) Fagan's nomogram consists of a vertical axis on the left with the pretest probability, an axis in the middle with the likelihood ratio, and a vertical axis on the right with the post-test probability. Given a pretest probability of 20%, the post-test probability for a positive test result was 55% and that for a negative result was 4%. PLR, positive likelihood ratio; NLR, negative likelihood ratio.

Table 2
Subgroup and sensitivity analysis for persistent occiput posterior position.

| Variable | Category | Studies | Sensitivity (95% CI) | Specificity (95% CI) | P value* |
|-----------------------------------|-----------------------------|---------|----------------------|----------------------|----------|
| Year of publication | 2009 or later | 11 | 0.88 [0.73–1.00] | 0.84 [0.77–0.91] | 0.59 |
| | before 2009 | 10 | 0.81 [0.61–1.00] | 0.81 [0.74–0.89] | |
| Labor stage (cervical dilatation) | <4 cm | 7 | 0.50 [0.25–0.74] | 0.76 [0.66–0.87] | 0.00 |
| | ≥4 cm | 14 | 0.92 [0.85–0.99] | 0.85 [0.80–0.91] | |
| Ultrasound examination | Transabdominal | 17 | 0.89 [0.77–1.00] | 0.80 [0.74–0.85] | 0.13 |
| | Transperineal or other type | 4 | 0.66 [0.20–1.00] | 0.91 [0.86–0.97] | |
| Quality | High | 18 | 0.85 [0.72–0.99] | 0.82 [0.76–0.87] | 0.61 |
| | Low | 3 | 0.84 [0.52–1.00] | 0.89 [0.79–0.99] | |

CI: confidence interval.

* P values are from likelihood ratio test for model with and without the covariate, to identify diagnostic performance differences across variable categories.

which was consistent with the results of Chou et al [16] and Vitner et al [1]. Meanwhile, a previous meta-analysis by Verhoeven et al [13] also supported our data at cervical dilatation below 4 cm, in which the predictive sensitivity varied from 0.25 to 0.74 and specificity from 0.66 to 0.87.

Accurate prediction of delivery position is essential for clinical decision-making during labor [30,31]. In cases of predicted OP position, manual rotation is a simple and effective technique to prevent its actual occurrence [6]. Correspondingly, manual rotation reduces the complications associated with persistent OP position, such as cesarean section, instrumental delivery and perineal lacerations, and almost doesn't cause any side effects [32–34]. More importantly, manual rotation is recommended to perform earlier at second stage of labor, because prophylactic rotation is more likely to succeed than rotation for failure to progress [35]. This from another perspective highlights the need to predict fetal head position at delivery in advance. Furthermore, if manual rotation fails, instrumental rotation may be a good choice, with a lower rate of episiotomy, severe perineal lacerations,

perineal hematomas and postpartum hemorrhage compared to operative vaginal delivery in OP position [8]. By contrast, in cases of predicted OA position, there is often no need for additional interventions unless exceptional circumstances.

The main strength of this review is that we included women at all stages of labor and stratified them according to the extent of cervical dilatation, ensuring comprehensive and credible results. In addition, we applied the bivariate mixed-effects model to synthesis data, which retains the two-dimensional character of original data and is considered as the standard method for meta-analysis of diagnostic accuracy [36]. Moreover, we not only performed a conventional meta-analysis using forest plots and SROC curve, but also evaluated the clinical use of intrapartum ultrasound using Fagan plot and LR scattergram.

However, there are still several limitations in this study. First, heterogeneity was remarkably high, which may partially undermine the reliability and extensibility of our conclusion. But, fortunately, using meta-regression tests, we identified the stage of labor as a source of heterogeneity, and found that the predictive

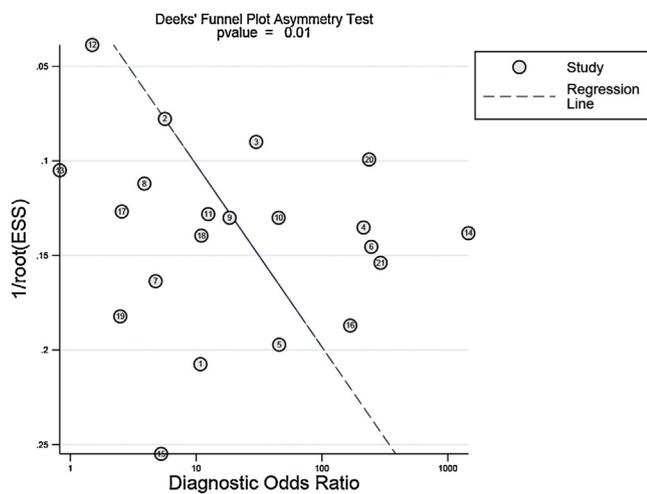


Fig. 6. Deeks' funnel plot to evaluate publication bias.

accuracy was promoted at cervical dilation above 4 cm after stratification. Second, the experience level of sonographers was not explored as a reason for observed heterogeneity, as such information was unavailable in most studies. Whereas, we investigated the relationship between publication year and heterogeneity, based on the premise that over time the application of intrapartum ultrasound is more common and sonographers are more experienced, but found that publication year had no significant effect on heterogeneity. Third, obvious publication bias was detected, which may exaggerate the overall diagnostic accuracy. To solve this problem, we expanded search to another database – Web of Science, but did not find additional relevant articles.

In conclusion, intrapartum ultrasound is a helpful tool for predicting persistent OP position. However, in view of the substantial heterogeneity, it is not recommended to apply ultrasound examinations just before or at the beginning of labor. Ultrasound-assessed fetal head position at late labor would be more useful to guide obstetrician to estimate fetal head position at delivery and thus decide which treatment strategy to take. Moreover, further study into the influence of ultrasound assessment of fetal head position on delivery outcomes is needed.

Conflicts of interest

The authors have no conflicts of interest.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ejogrb.2019.04.041>.

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