The effectiveness of intrapartum ultrasonography in assessing cervical dilatation, head station and position: A systematic review and meta-analysis

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Abstract

The objective of this review was to assess the effectiveness of intrapartum ultrasonography in measuring cervical dilatation, head station and position. Electronic literature searches were carried out of MEDLINE, CINAHL, and Web of Knowledge, plus manual reference list checks of all relevant articles. All published prospective studies comparing intrapartum ultrasonography with digital VE in the determination of cervical dilatation, head station and position were then evaluated for the success rate and level of agreement between ultrasonography and digital VE. Ultrasonography had higher success rate than digital VE in the determination of fetal head position, with a statistically significant difference in the first stage of labour. Second, although the successful determination of cervical dilatation was in favour of digital VE, the difference was not statistically significant. In addition, there was high agreement between ultrasound and digital VE findings on cervical dilatation. Lastly, a significant but moderate correlation between digital VE and ultrasound methods was found in the assessment of fetal head station. However, no meta-analysis could be done for the fetal head station due to the methodological differences between ultrasound anatomical landmarks and that of digital VE. The findings suggest that ultrasonography is superior to digital VE in the assessment of fetal head position, but has moderate correlation with digital VE in the assessment of head station. It also showed high agreement with digital VE in the assessment of cervical dilatation with no statistically significant difference in terms of success rate.

Introduction

Rationale

The role of digital vaginal examination (digital VE) in the assessment of labour progress includes measuring the cervical dilatation, head station and position. Not only is the procedure highly subjective,[1] but it has also been described by mothers in labour as painful and posing risk of infection.[2] It has been suggested that ultrasonography could become a useful and more objective imaging technique for monitoring labour in

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future,[3] with the potential of minimising risk of infection and discomfort to the mother.

A systematic review was therefore conducted to evaluate published studies on the effectiveness of ultrasonography in assessing cervical dilatation, head station and position during labour.

Objective

The primary objective was to assess the success rate of ultrasonography in the determination of cervical dilatation and position in comparison to digital VE. The secondary objective was to evaluate the level of agreement or correlation between ultrasonography and digital VE in the measurement of cervical dilatation, head station and position.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) is the structure used for this systematic review.[4]

Protocol and registration

The general methods of the review and inclusion criteria were specified in advance. However, there was no registration of the review.

Eligibility criteria

Every type of primary study was eligible for inclusion, whether observational or randomised control trial. The selected study must have reported on the relationship between ultrasonography and digital VE in the measurement of either one or more of the following: cervical dilatation, head station or position. There were no language and date restrictions in the search process.

Information sources

Papers included in the review were obtained from electronic searches of the following databases: PubMed (MEDLINE), CINAHL and Web of Knowledge, all of which reference international journal citations for biomedical literature. It has been demonstrated that using two or more databases will identify a greater percentage of available citations;[5,6] hence, the search was conducted in more than one database. In addition, there was a review of all reference lists of included studies for relevant papers that were not picked up through electronic search, as it was recognised that despite the advantages of electronic databases, they are not infallible.[7]

Search

The search strategy included the breaking down of the research question into component parts, for easy identification of the Population, Intervention, Comparator and Outcomes (PICO), as described by Sayers.[8] Breaking down of the research question into a PICO framework was helpful in the choice of search-terms or key words for effective search. An electronic search of subject-specific databases was then used in identifying relevant articles in PubMed, Web of Knowledge and CINAHL.

The key search terms were reasonably combined in different sets of combinations, using Boolean operators 'AND' and 'OR', and truncations as appropriate. In total, nine steps of combined searches were made in PubMed, Web of Knowledge, and CINAHL on 4 and 5 November 2015. Table 1 shows the nine steps of the search conducted in PubMed.

Table 1. The nine steps of the PubMed Search

Search Number	Terms	Results
S1	transperineal (ultraso* OR sonog*) AND clinical examination in labour	32
S2	transperineal (ultraso* OR sonog*) AND digital examination in labour	23
S3	transabdominal (ultraso* OR sonog*) AND clinical examination in labour	38
S4	transabdominal (ultraso* OR sonog*) AND digital examination in labour	24
S5	Intrapartum (ultraso* OR sonog*) AND rotation	10
S6	Intrapartum (ultraso* OR sonog*) AND position	48
S7	Intrapartum (ultraso* OR sonog*) AND station	18
S8	Intrapartum (ultraso* OR sonog*) AND head descent	11
S9	Intrapartum (ultraso* OR sonog*) AND cervical dilatation	48

Study selection

Records identified through database searching were exported into the EndNote citation manager. After the removal of duplicates, articles were then screened by title and abstract to determine their relevance to the research question. The primary selection criteria for all papers were whether their results had reported on the relationship between ultrasonography and digital VE in measuring cervical dilatation, head station or position. The minimum patient selection criteria for all studies were pregnant women in labour with indication for digital VE for measuring either cervical dilatation, fetal head station or position. In some cases, all three parameters were assessed in one study. The full-text versions of all papers meeting the primary selection criteria were obtained for further evaluation.

Data collection process

Relevant data from all selected papers were entered into a data extraction sheet. The PRISMA diagram (Figure 1) explains the data collection process and the quantity of papers identified by the search.

Data items

Information extracted from all studies included the following: author, year of publication, country of origin, clinical setting, sample size, study design, statistical method and results.

Risk of bias in individual studies

In determining the risk of bias, it was assessed whether there was blinding of the two examiners performing the ultrasound examination and the digital VE.

Data synthesis

Synthesis took a narrative approach using some of the techniques described by Popay et al.,[9] including textual descriptions, tabulations and transformation of data into common rubric. Studies were classified and combined in the analysis in accordance with the type of outcome measured, which included the cervical dilatation group, head station group and head position group. Homogeneous groups of studies were entered into the RevMan 5.3 review manager, to construct forest plots for each classified group. Forest plots
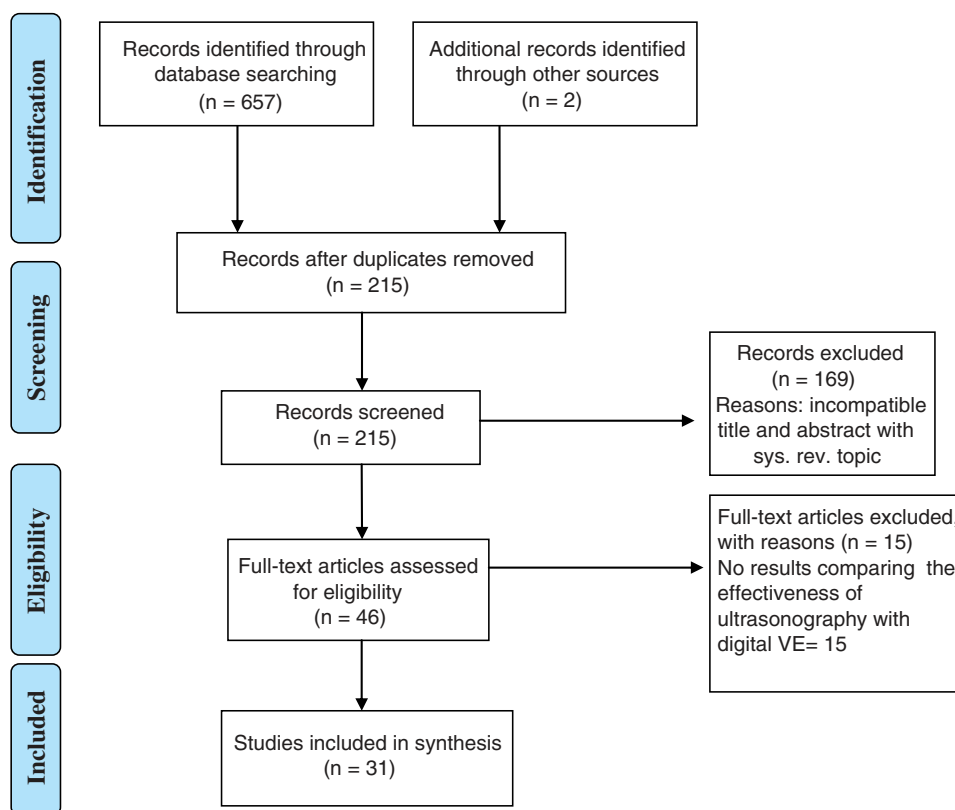

Figure 1. PRISMA flow diagram.

were analysed with the Mantel-Haenszel statistical method.

Risk of bias across studies

The model of analysis was performed using the random effect rather than fixed effect with the assumption that there were some degrees of difference even among homogeneous groups of studies. This was considered in order to minimise the impact of selection bias, sample size, detection bias and other potential sources of bias, as was evident of true effect between studies in performing the meta-analysis ($P < 0.05$).

Results

Study selection

A total of 657 articles were identified through database searching as described, including PubMed, Web of Knowledge and CINAHL. The 657 articles were exported into the citation manager (EndNote), and duplicates were manually removed. Two additional papers were identified by manual search of reference lists. The number of articles remaining for further screening by title and abstract was 215. The number of relevant articles for full text screening was 46, and 31 articles were found to be eligible for inclusion in the systematic review (see Figure 1).

Study characteristics

Table 2 shows study characteristics of articles included in the review. Thirty-one primary studies published between 2001 and 2015 met the eligibility criteria for inclusion in this review. Approximately 53% of these studies originated from Europe, 23% from Asia, 15% from North America, 6% from Africa, and 3% from Australia.

The total sample population of birthing women who participated in these primary studies was 3370, with 47% of them from a European tertiary setting, about 18% of them in an Asian tertiary setting, 17% of them in the USA, 14% in a North African country and 4% in an Australian tertiary clinical setting.

The 31 studies were all observational with a wide range of sample sizes, the smallest sample size being 20 subjects, and the largest sample size being 496 subjects.

Risk of bias within studies

The various forest plots revealed a high percentage of heterogeneity amongst the classified group of studies. As a result, risk ratio was used for the forest plots rather than odd ratios.

Results of individual studies

Fetal head position. It was noted that in 13 out of the 15 studies (87%) that reported on fetal head position, accuracy of digital VE was defined within a range of ±45° agreement limit. Other studies in the minority have used different ranges of agreement limit (other than the 45°) with one study using 60°,[39] and another using 180°.[24] A zero degree agreement limit, for instance, is an absolute agreement with no provision for any margin of error. In one study, the range of agreement limit was unclear.[17] Those isolated studies were therefore excluded from forest plots to minimise the impact of heterogeneity. As the ±45° range of agreement was the widely accepted one, only those studies using that range were included in the statistical analysis. Also, findings on the first stage of labour were analysed separately from the second stage of labour (see Tables 3 and 4).

Figure 2 shows the forest plot of eight studies on ultrasound versus digital VE in assessing fetal head position in the first stage of labour. For the second stage of labour, six studies qualified for inclusion in the meta-analysis as shown in the forest plot of Figure 3.

Cervical dilatation. The forest plot of Figure 4 shows statistically insignificant difference between the success rate of digital VE and that of ultrasound. Again, the high level of agreement reported by the five studies is presented in Table 5.

Fetal head station. Of the 31 studies included in this review, 14 reported the relationship between ultrasonography and digital VE in assessing the station, with seven different ultrasound methods for measuring fetal head station described. However, forest plots could not be constructed because different landmarks and measurement methods were used for ultrasound and digital VE in determining fetal head station. These seven ultrasound methods demonstrated various levels of relationship with digital VE, which uses the ischial spines as the reference landmark. The ultrasound methods described by the 14 studies include:

(1) Angle of Progression, which is also known as the Angle of Descent[12,14,36]
(2) Head Direction[36,20]
(3) Intrapartum translabial ultrasound (ITU) head station[35,36]
(4) Head Progression Distance[16,21]
(5) Head Symphysis Distance[37]
(6) Ultrasound Fetal Head Engagement[32] and
(7) Head Perineum Distance.[14,17,22,27,29,38]

Table 2. Study characteristics

Author	Country	Examination	Labour stage	Sample Size	Study design
Akmal et al.[10]	UK	Position	Second	64	Observational
Akmal et al.[11]	UK	Position	First	496	Observational
Barbera et al.[12]	USA & Italy	Station	First	88	Observational
Benediktsdottir et al.[13]	Sweden	Dilatation	First	86	Observational
Chan et al .[14]	China	Station	First	100	Observational
Chou et al .[15]	USA	Position	Second	88	Observational
Dietz et al.[16]	Australia	Station	First	139	Observational
Dimmasi et al.[17]	Tunisia	Station	First	100	Observational
Dupuis et al.[18]	France	Position	Second	110	Observational
Eggebo et al.[19]	UK & Norway	Position	First	150	Observational
Ghi et al.[20]	Italy	Station	First	60	Observational
Gilboa et al.[21]	Israel	Station	First	65	Observational
Hassan et al.[22]	UK & Norway	Position, Station, Dilatation	First	20	Observational
Hassan et al.[23]	UK & Norway	Dilatation	First	21	Observational
Hidar et al.[24]	Tunisia	Position	First	350	Observational
Kawabata et al.[25]	Japan	Position	First	87	Observational
Kreiser et al.[26]	Israel	Position	Second	44	Observational
Maticot-Baptista et al.[27]	France	Station	First	45	Observational
Molina et al.[28]	UK	Station	First	50	Observational
Rivaux et al.[29]	France	Station	First	100	Observational
Sherer et al (2002a)[30]	USA	Position	First	102	Observational
Sherer et al (2002b)[31]	USA	Position	Second	112	Observational
Sherer et al.[32]	USA	Station	First	222	Observational
Shetty et al.[33]	India	Position	First	165	Observational
Souka et al.[34]	Greece	Position	Second	148	Observational
Tutschek et al.[35]	Norway	Station	First	106	Observational
Tutschek et al.[36]	Switzerland	Station	First	50	Observational
Youssef et al.[37]	Italy	Station	First	47	Observational
Yuce et al.[38]	Turkey	Position, Station, Dilatation	First	43	Observational

Table 2. Continued

Author	Country	Examination	Labour stage	Sample Size	Study design
Zahalka et al.[39]	Israel	Position	First	60	Observational
Zimerman et al.[40]	Israel	Dilatation	First	52	Observational
Totals: 31				3370	

Table 3. Agreement between ultrasound and digital VE on head position at the first stage of labour

Author	Statistical method	Ultrasound – Digital VE agreement
Hassan et al.[22]	Simple percentage agreement plus average mean difference with Bland–Altman plots	39%; MD: −3.9°
Sherer et al.[30]	Cohen's Kappa analysis	47%
Akmal et al.[11]	Simple percentage agreement	49%
Souka et al.[34]	Cohen's Kappa analysis	31%
Kawabata et al.[25]	Simple percentage agreement	40%
Shetty et al.[33]	Cohen's Kappa analysis	32%
Eggebo et al.[41]	Cohen's Kappa analysis	32%
Yuce et al.[38]	Simple percentage agreement	24%

However, the widely used methods were the Angle of progression (AoP) and the Head perineum distance (HPD).

The angle of progression method. Results on the effectiveness of ultrasonography in relation to digital VE all showed moderate correlation with station.[12,14,36] These studies had all included multiparous and nulliparous women at different stages of active labour in their study population.

Head perineum distance. Chan et al.,[14] Hassan et al.[22] and Yuce et al.[38] have all reported moderate correlation between digital VE and the HPD. Also, Dimassi et al.,[17] Maticot-Baptista et al.[27] and Rivaux et al.[29] all reported on the diagnostic value of the distance from the head to the perineum in diagnosing fetal head engagement using digital VE as the comparator. Dimassi et al.[17] reported sensitivity and specificity of 86.7% and 94.1%, respectively, for diagnosing fetal head engagement, using a distance of 55 mm from the fetal head to the perineum as their predictive value.

Maticot-Baptista et al.[27] also obtained a sensitivity of 97.8% in predicting fetal head engagement, using a distance of <60 mm from the fetal head to the perineum. Maticot-Baptista et al.[27] added that whenever a distance of more than 60 mm was obtained, digital VE diagnosed fetal head as 'non-engaged' with a specificity of 89.0%. Likewise, Rivaux et al.[29] reported that the fetal head was not engaged upon digital VE assessment whenever ultrasound recorded a mean distance of 66.4 mm (±7.53 mm) from the fetal head to the perineum.

Discussion

The general results of this systematic review suggest that ultrasonography could be as effective as the conventional digital VE for assessing cervical dilatation, head station and position. However, its applicability in the wider non-tertiary settings and the general

Table 4. Agreement between ultrasound and digital VE on head position at the second stage of labour

| Author	Statistical method	Ultrasound – Digital VE agreement
Kreiser et al.[26]	Simple percentage agreement	70%
Sherer et al.[31]	Cohen's Kappa analysis	61%
Akmal et al.[10]	Simple percentage agreement	73%
Chou et al.[15]	Simple percentage agreement	72%
Souka et al.[34]	Cohen's Kappa analysis	65%
Dupuis et al. [18]	Cohen's Kappa analysis	80%
Zahalka et al.[39]	Simple percentage agreement	79%
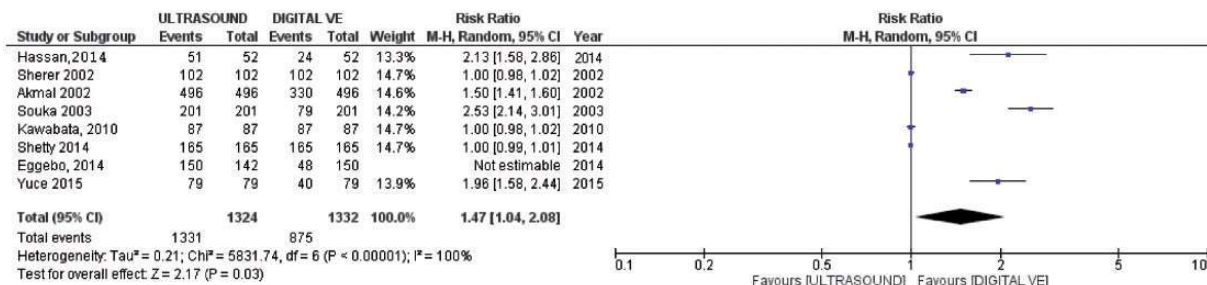
Figure 2. Forest plot in favour of ultrasonography on the success rate of fetal head position determination in the first stage of labour.
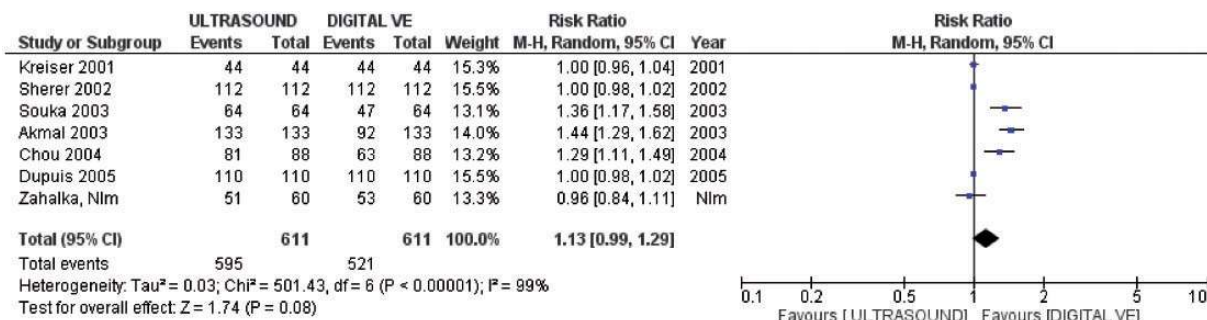

Figure 3. Forest plot in favour of ultrasonography on the success rate of fetal head position determination in the second stage of labour.

population remain unclear, as studies have largely been limited to tertiary settings. It will therefore be worth investigating its applicability in the general non-tertiary clinical settings, including developing country settings.

In assessing fetal head position in labour, findings indicate that in comparison to ultrasound, digital VE is less successful in the first stage than the second stage. The level of agreement with ultrasound doubles in the second stage from approximately 35% in the first stage to 70% in the second stage. This suggests that ultrasonography is a better option than digital VE for assessing fetal head position, using the transabdominal scanning approach. It is also worth noting that the average accuracy level was slightly higher for digital VE in studies that use simple percentage agreement statistics rather than kappa,
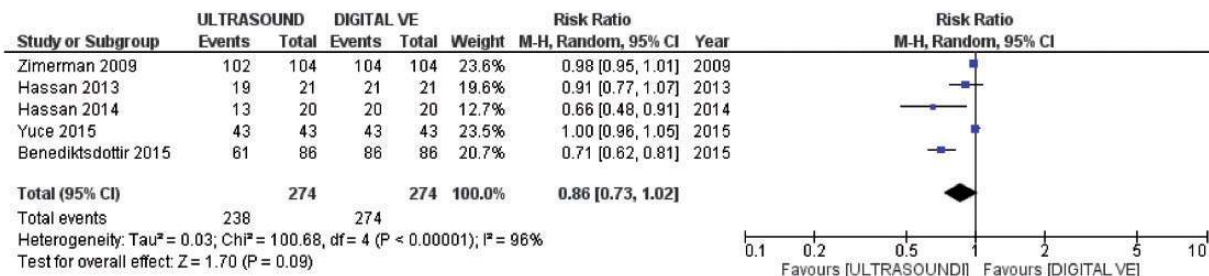
Study or Subgroup	ULTRASOUND Events	Total	DIGITAL VE Events	Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Zimerman 2009	102	104	104	104	23.6%	0.98 [0.95, 1.01]	2009
Hassan 2013	19	21	21	21	19.6%	0.91 [0.77, 1.07]	2013
Hassan 2014	13	20	20	20	12.7%	0.66 [0.48, 0.91]	2014
Yuce 2015	43	43	43	43	23.5%	1.00 [0.96, 1.05]	2015
Benediktsdottir 2015	61	86	86	86	20.7%	0.71 [0.62, 0.81]	2015
Total (95% CI)		274		274	100.0%	0.86 [0.73, 1.02]	
Total events	238		274				

Heterogeneity: Tau² = 0.03; Chi² = 100.68, df = 4 (P < 0.00001); I² = 96%
Test for overall effect: Z = 1.70 (P = 0.09)

Figure 4. Forest plot in favour of digital VE over ultrasonography on the success rate of the determination of cervical dilatation.

Table 5. Results of individual studies on cervical dilatation

Author	Statistical Method	Agreement between ultrasound and digital VE
Benediktsdottir et al.[13]	linear regression	$r^2 = 0.72$
Hassan et al.[22]	linear regression	$r^2 = 0.68$
Hassan et al.[23]	Pearson correlation coefficient	$r = 0.82$
Yuce et al.[38]	Pearson correlation coefficient	$r = 0.82$
Zimerman et al.[40]	Simple linear regression	$r^2 = 0.61$

which does not account for agreement by chance.[42] Given that slightly lower agreement values were obtained by digital VE in studies analysed with kappa, it can be assumed that the accuracy level of ultrasound in the second stage of labour may also be slightly lower than the over 90% reported by Chou et al.[14] and Kreiser et al.,[25] since these were analysed with simple percentage agreement rather than by kappa statistics.

In the ultrasound measurement of cervical dilatation, there was consensus among studies on the use of the transperineal scanning approach rather than the transvaginal, with measurements obtainable in both transverse and vertical planes (see the transverse and anterior-posterior measurement options demonstrated in Figure 5). This may give ultrasound an edge over digital VE if its effectiveness is explored further, since that may provide mothers with a non-invasive option for measuring cervical dilatation, especially in cases where the risk of infection transfer is a major concern.

However, some of the included studies had very low sample sizes, and the effect of labour characteristics on the success rate is generally unclear. For example, the extent to which success rate is affected by ruptured or

Figure 5. Cervical dilatation measurement.

unruptured membrane, latent versus active phase, could not be assessed extensively because of low sample size.

Lastly, although several methods for assessing the fetal head station have been found, the widely
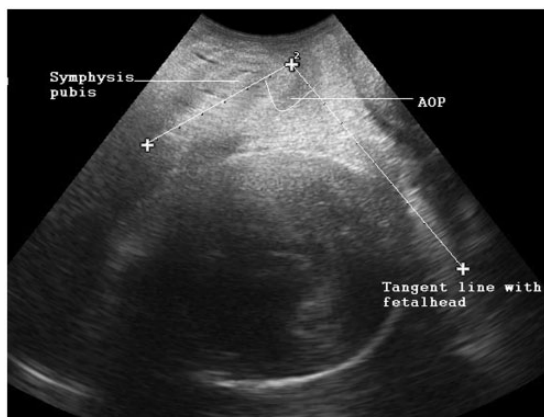
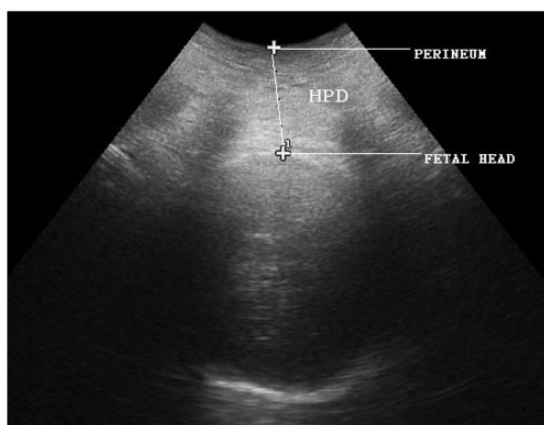**Figure 6.** The angle of progression measurement.

Figure 7. Head perineum distance measurement.

reported methods are the AoP and the HPD. The AoP is described as an angle formed by a line drawn through the long axis of the pubic symphysis and another tangential line drawn from the leading edge of the fetal head cranium (see Figure 6). The HPD also refers to the shortest obtainable distance from the leading edge of the fetal head cranium to the skin surface of the perineum (see Figure 7). Their level of correlation with digital VE on station was reported by the individual studies as moderate but statistically significant. Given that the digital VE itself is known to be subjective, the possible advantage ultrasound may have is that, since it has more than one measurement method, a high level of agreement amongst the ultrasound methods may indicate reliability for users. Future studies could therefore concentrate on exploring the level of agreement between these ultrasound methods.

Conclusion

Findings suggest that ultrasonography is superior to digital VE in the assessment of fetal head position with a statistically significant difference in success rate in favour of ultrasound in the first stage of labour.

Second, there is no statistically significant difference between the success rate of ultrasound and digital VE in the determination of cervical dilatation. And again, there is high level of agreement on cervical dilatation between the two methods.

Lastly, whilst primary studies were in agreement on a significant but moderate correlation between ultrasound and digital VE in the assessment of fetal head station, a comparison of their success rate could not be determined.

Recommendations

- Future studies could extend to non-tertiary settings in a much more representative general population of women in labour, including developing country settings.
- Although findings suggest no statistically significant difference in success rate between ultrasound and Digital VE on cervical dilatation, future studies should target larger sample sizes to enable detailed evaluation of possible influencing factors of success rate.
- Again, assessing the specificity and sensitivity of ultrasonography in diagnosing active labour would add in-depth knowledge on its effectiveness. This could be defined by using a ≥ 4 cm threshold of cervical dilatation determined by digital VE.
- Lastly, although ultrasound is highly recommended over digital VE in the assessment of fetal head position, future studies could evaluate the effectiveness further, using a much more robust statistical method.

Declaration of Conflicting Interests

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Ethical approval

Not applicable

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