EFFECTIVENESS OF INTRAPARTUM ULTRASONOGRAPHY IN ASSESSING CERVICAL DILATATION, HEAD STATION AND POSITION: A SYSTEMATIC REVIEW AND META-ANALYSIS

ABSTRACT

Objective: To assess the effectiveness of intrapartum ultrasonography in measuring cervical dilatation, head station and position.

Methods: Electronic literature search of MEDLINE, CINAHL, and Web Of Knowledge, plus manual reference lists checks of all relevant articles was done. 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.

Results: Ultrasonography had higher success rate than digital VE in the determination of fetal head position, with statistically significant difference in the first stage of labour. Secondly, 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.

Conclusion: Findings suggest that ultrasonography is superior to digital VE in the assessment of fetal head position, but of 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 success rate.

KEYWORDS: Intrapartum; ultrasonography; digital VE; cervical dilatation; head station; position

INTRODUCTION

Rationale

The role of digital vaginal examination (digital VE) in the assessment of labour progress include 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 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, head station 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 and position.

METHOD

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 **P**opulation, **I**ntervention, **C**omparator and **O**utcomes (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 the 4th and 5th of November, 2015. Table I shows the nine steps of search conducted in PubMed.

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 either the cervical dilatation, head station or position. The minimum patient selection criteria for all studies was 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.

Table I: 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

Data collection process

Relevant data from all selected papers were entered into a data extraction sheet. The PRISMA diagram (Figure I) 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 group of studies were entered into the RevMan 5.3 review manager, to construct forest plots for each classified group. Forest plots were analysed with the Mantel-Haenszel statistical method.

Risk of bias across studies

The model of analysis was by random effect rather than fixed effect, in order to minimise the impact of selection bias, detection bias, and other potential sources of bias.

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. 2 additional papers were identified by manual search of reference lists. The remaining number of articles 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 I).

Study Characteristics

Table II 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 have participated in these primary studies are 3370, with 47% of them from European tertiary setting, about 18% of them in Asian tertiary setting, 17% of them in the United States, 14% in a North African country and 4% in Australian tertiary clinical setting.

The thirty-one studies were all observational with a wide range of sample sizes, the least 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

1. Fetal Head Position

It was noted that in thirteen out of the 15 studies (87%) that reported on fetal head position, accuracy of digital VE was defined within a range of $\pm 45^{o}$ agreement limit. Other studies in the minority have used different ranges of agreement limit (other than the 45^{o}) with one study using 60 degrees[39], and another using 180 degrees[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 degrees 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.

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.

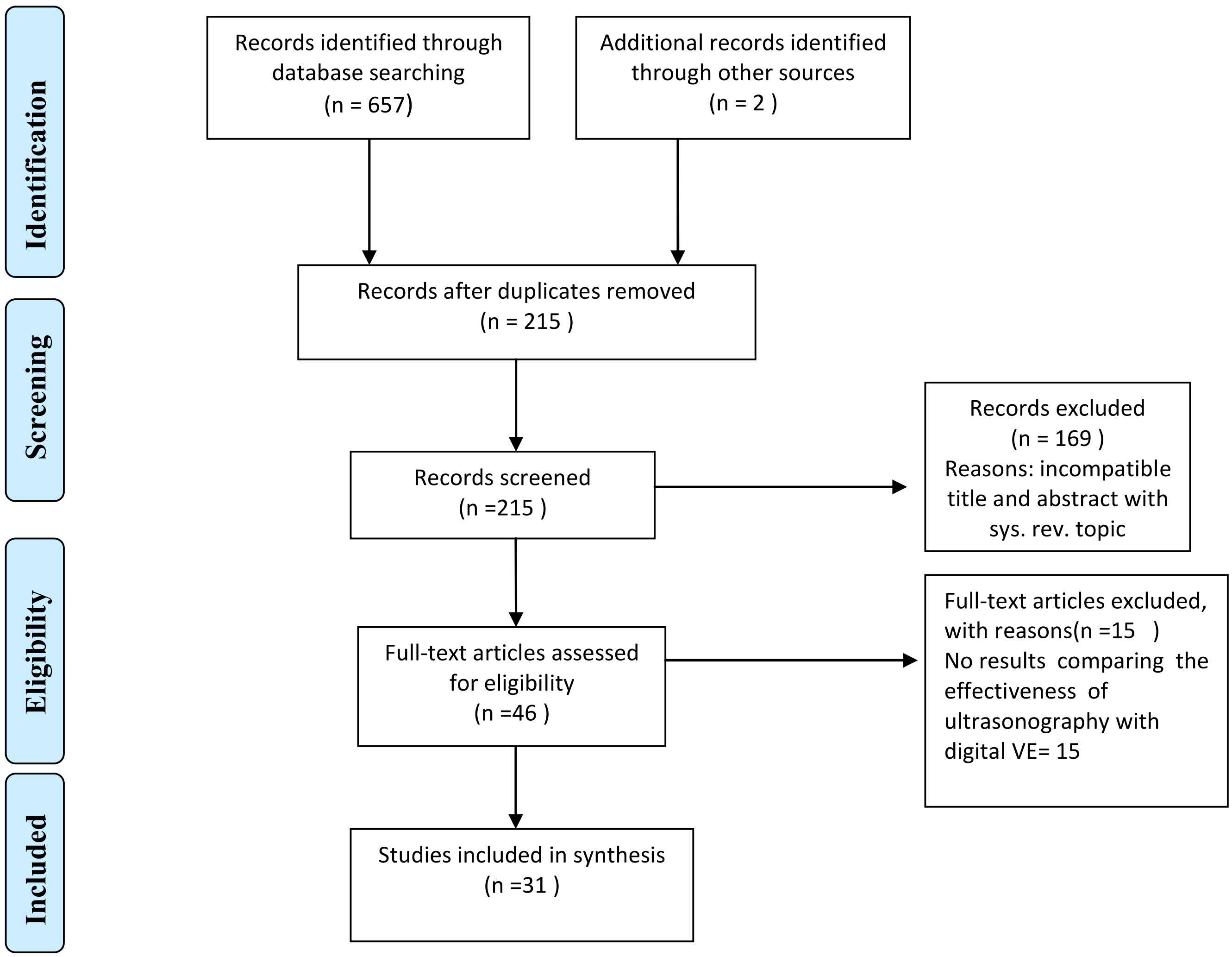

Figure I. PRISMA flow diagram.

Table II, Study Characteristics

	Author	Country	Examination	Labour Stage	Sample Size	Study design
	Akmal et al (2003)[10]	UK	Position	2nd	64	Observational
	Akmal et al (2002)[11]	UK	Position	1st	496	Observational
	Barbera et al (2009)[12]	USA & Italy	Station	1st	88	Observational
	Benediktsdottir et al (2015)[13]	Sweden	Dilatation	1st	86	Observational
	Chan et al (2014)[14]	China	Station	1st	100	Observational
	Chou et al (2004)[15]	USA	Position	2nd	88	Observational
	Dietz et al (2005)[16]	Australia	Station	1st	139	Observational
	Dimmasi et al (2014)[17]	Tunisia	Station	1st	100	Observational
	Dupuis et al (2005)[18]	France	Position	2nd	110	Observational
	Eggebo et al (2014)[19]	UK & Norway	Position	1st	150	Observational
	Ghi et al (2009)[20]	Italy	Station	1st	60	Observational
	Gilboa et al (2013)[21]	Israel	Station	1st	65	Observational
	Hassan et al (2014)[22]	UK & Norway	Position, Station, Dilatation	1st	20	Observational
	Hassan et al (2013)[23]	UK & Norway	Dilatation	1st	21	Observational
	Hidar et al (2006)[24]	Tunisia	Position	1st	350	Observational
	Kawabata et al (2010)[25]	Japan	Position	1st	87	Observational
	Kreiser et al (2001)[26]	Israel	Position	2nd	44	Observational
	Maticot-Baptista et al (2009)[27]	France	Station	1st	45	Observational
	Molina et al (2010)[28]	UK	Station	1st	50	Observational
	Rivaux et al (2012)[29]	France	Station	1st	100	Observational
	Sherer et al (2002a)[30]	USA	Position	1st	102	Observational
	Sherer et al (2002b)[31]	USA	Position	2nd	112	Observational
	Sherer et al (2003)[32]	USA	Station	1st	222	Observational
	Shetty et al (2014)[33]	India	Position	1st	165	Observational
	Souka et al (2003)[34]	Greece	Position	2nd	148	Observational
	Tutschek et al (2013)[35]	Norway	Station	1st	106	Observational
	Tutschek et al (2011)[36]	Switzerland	Station	1st	50	Observational
	Youssef et al (2013)[37]	Italy	Station	1st	47	Observational
	Yuce et al (2015)[38]	Turkey	Position, Station, Dilatation	1st	43	Observational
	Zahalka et al (2005)[39]	Israel	Position	1st	60	Observational
	Zimerman et al (2009)[40]	Israel	Dilatation	1st	52	Observational
Total	**31**				**3370**	

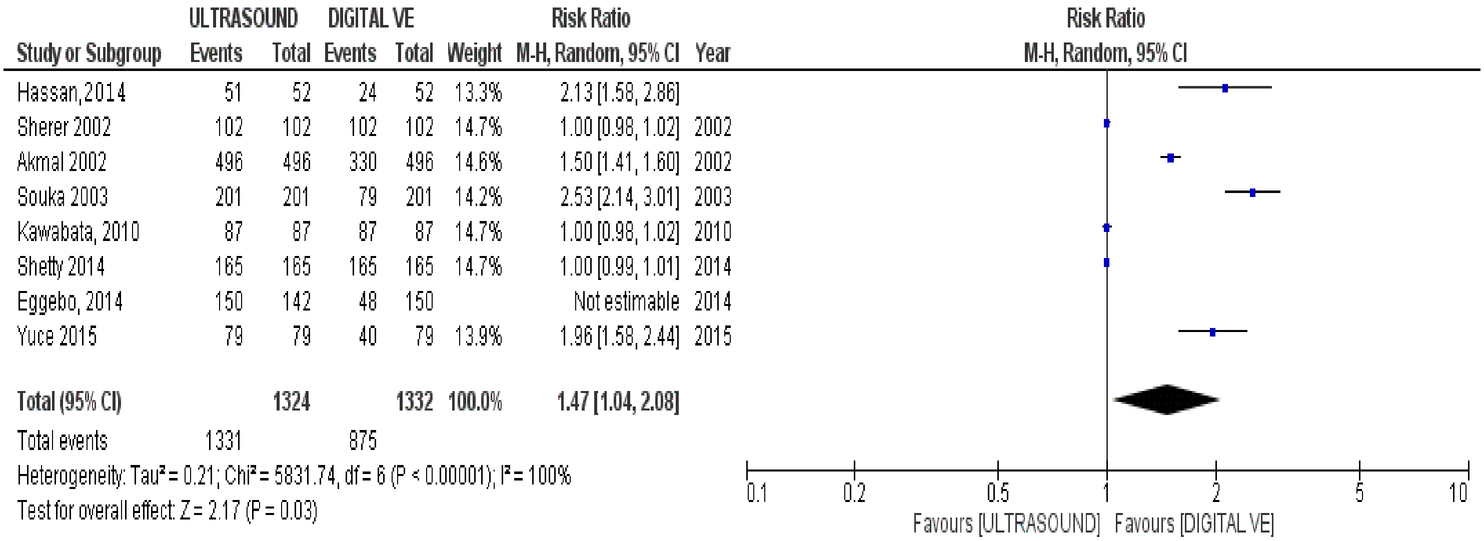

Figure II: Forest plot in favour of Ultrasonography on the success rate of fetal head position determination in the first stage of labour.

Table III: Agreement between ultrasound and digital VE on head position at 1st stage of labour

Author	Statistical method	Ultrasound - Digital VE agreement
Hassan et al (2014)	Simple Percentage agreement plus average mean difference with Bland-Altman plots	39% ; MD: -3.9^0
Sherer et al (2002a)	Cohen's Kappa analysis	47%
Akmal et al (2002)	Simple percentage agreement	49%
Souka et al (2003)	Cohen's Kappa analysis	31%
Kawabata et al (2010)	Simple percentage agreement	40%
Shetty et al(2014)	Cohen's Kappa analysis	32%
Eggebo et al (2014a)	Cohen's Kappa analysis	32%
Yuce et al (2015)	Simple percentage agreement	24%

Study or Subgroup	ULTRASOUND Events	ULTRASOUND Total	DIGITAL VE Events	DIGITAL VE Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Kreiser 2001	44	44	44	44	15.3%	1.00 [0.96, 1.04]	2001
Sherer 2002	112	112	112	112	15.5%	1.00 [0.98, 1.02]	2002
Souka 2003	64	64	47	64	13.1%	1.36 [1.17, 1.58]	2003
Akmal 2003	133	133	92	133	14.0%	1.44 [1.29, 1.62]	2003
Chou 2004	81	88	63	88	13.2%	1.29 [1.11, 1.49]	2004
Dupuis 2005	110	110	110	110	15.5%	1.00 [0.98, 1.02]	2005
Zahalka 2005	51	60	53	60	13.3%	0.96 [0.84, 1.11]	2005
Total (95% CI)		**611**		**611**	**100.0%**	**1.13 [0.99, 1.29]**	
Total events	595		521				

Heterogeneity: Tau² = 0.03; Chi² = 501.43, df = 6 (P < 0.00001); I² = 99%

Test for overall effect: Z = 1.74 (P = 0.08)

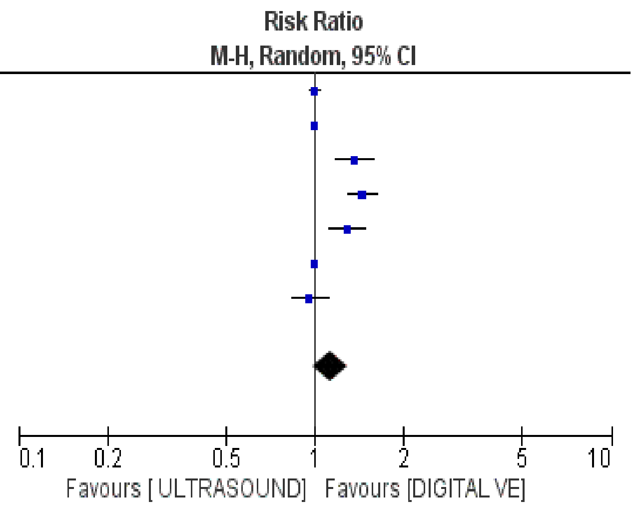

Figure III: Forest plot in favour of Ultrasonography on the success rate of fetal head position determination in the second stage of labour.

Table IV: Agreement between ultrasound and digital VE on head position at 2nd stage of labour

Author	Statistical method	Ultrasound - Digital VE agreement
Kreiser et al (2001)	Simple percentage agreement	70%
Sherer et al (2002b)	Cohen's Kappa analysis	61%
Akmal et al (2003)	Simple percentage agreement	73%
Chou et al (2004)	Simple percentage agreement	72%
Souka et al (2003)	Cohen's Kappa analysis	65%
Dupuis et al (2005)	Cohen's Kappa analysis	80%
Zahalka et al (2005)	Simple percentage agreement	79%

2.Cervical Dilatation

The forest plot of figure IV 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 V.

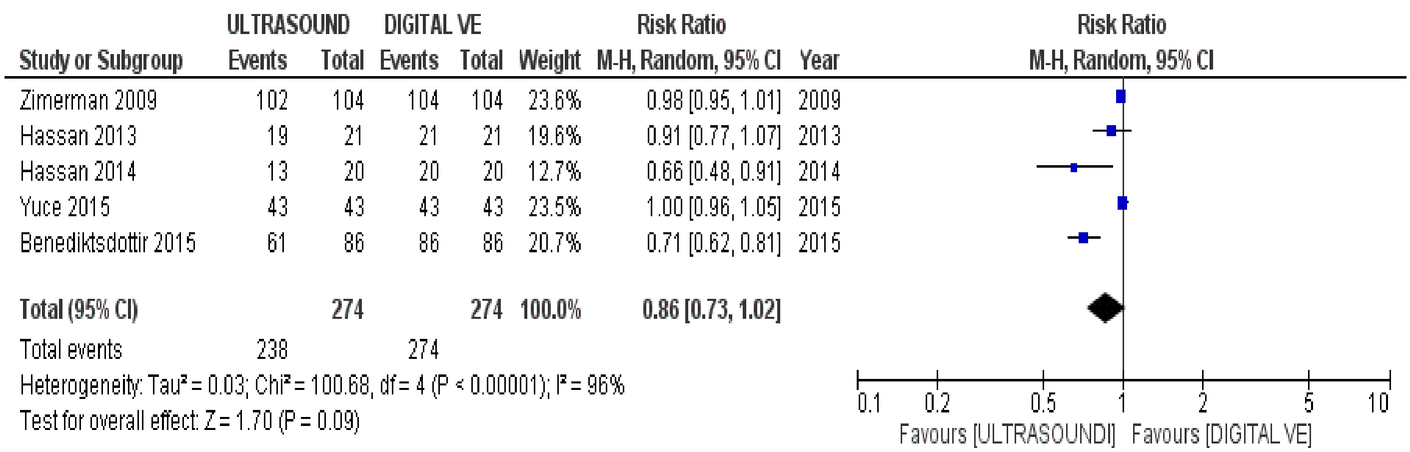

Figure IV: Forest plot in favour of digital VE over Ultrasonography on the success rate of the determination of cervical dilatation.

Table V: Results of individual studies on cervical dilatation

Author	**Statistical Method**	**Agreement between Ultrasound and Digital VE**
Benediktsdottir et al (2015)	linear regression;	r^2= 0.72
Hassan et al (2014)	linear regression	r^2= 0.68
Ha ssan et al (2013)	Pearson correlation coefficient	r= 0.82
Yuce et al (2015)	Pearson correlation coefficient	r= 0.82
Zimerman et al (2009)	Simple linear regression	r^2= 0.61

3. Fetal Head station

Of the 31 studies included in this review, fourteen 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 by ultrasound and digital VE in determining fetal head station.

These seven ultrasound methods demonstrated various levels of relationship with the digital VE which uses the ischial spines as the reference landmark. The ultrasound methods described by the fourteen 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].

However, the widely used methods were the Angle of Progression (AoP) and the Head Perineum Distance (HPD).

3.1 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.

3.2 Head Perineum Distance (HPD)

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 55mm 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 < 60mm from the fetal head to the perineum. Maticot-Baptista et al[27] added that whenever a distance of more than 60mm 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 66.4mm (±7.53mm) from the fetal head to the perineum.

DISCUSSION

The general results of this systematic review suggest that ultrasonography is an effective tool for assessing cervical dilatation, head station and position, which the digital VE has traditionally been used for. However, its applicability in the wider non-tertiary settings and the general population remain unclear, as studies have largely been limited to tertiary settings. It will therefore be worth investigating is applicability in the general non-tertiary clinical settings, including developing countries.

In assessing fetal head position in labour, findings indicate that 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, which does not account for agreement by chance[42]. Given the slightly lower values obtained for 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 V).

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 when the risk infection of infection transfer is high, for example, when the membranes are ruptured.

However, some of the included studies had low sample size and the effect of specific characteristics is generally unclear, such as ruptured versus unruptured membrane, latent versus active phase, early versus late active phase and so on.

Lastly, although several methods for assessing the fetal head station have been found, the widely 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 VI). 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 VI). However, their level of correlation with digital VE on station was just moderate. It is not clear whether the moderate results is due to the subjective nature of digital VE. The advantage for ultrasound, however, is that since it has more than one measurement methods, a high level of agreement amongst ultrasound methods may boost confidence in its use and could be explored further. This may be synonymous to the estimation of gestational age where an agreement between the various parameters of the fetal biometry (for example head circumference, abdominal circumference and femur length) increases the confidence in the results without necessarily comparing it to another method. For instance, although the AoP and HSD are measured in the same plane, the level of agreement between them is unknown. In addition, whilst the sensitivity and the specificity of the HPD in assessing fetal engagement has been reported, we do not know same about the AoP and HSD. It may be interesting to find out the results on these, and how that may boost the confidence in ultrasound for estimating head station or descent.

Figure V: Cervical dilatation measurement

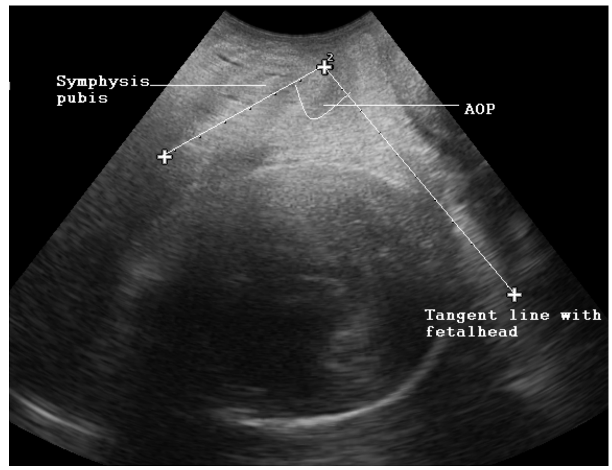

Figure VI: The Angle of Progression (AoP) measurement

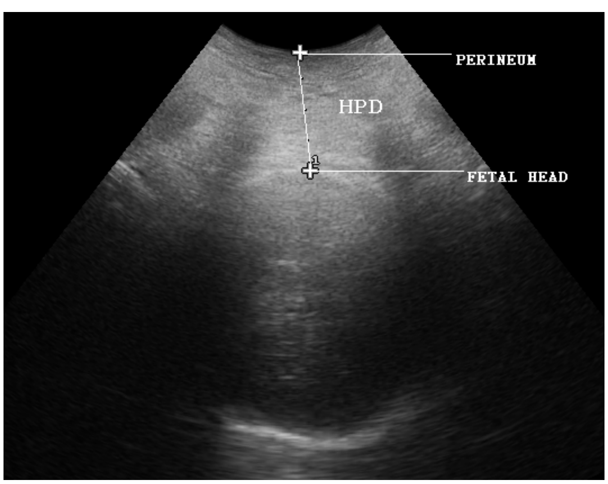

Figure VI: Head Perineum distance (HPD) measurement

CONCLUSION

Findings suggest that ultrasonography is superior to digital VE in the assessment of fetal head position. In addition, the agreement between ultrasound and digital VE was generally twice higher in the second stage of labour than in the first stage.

Secondly, 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.

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.

RECOMENDATION

- 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 a high agreement between ultrasound and Digital VE on cervical dilatation, future studies should target larger sample size to enable extensive evaluation influencing factors of success rate as well as agreement.
- Again, assessing the specificity and sensitivity of ultrasonography in diagnosing active labour would be helpful, which would be defined by ultrasound agreement with digital VE on a cervical dilatation of ≥4cm.
- 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.

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