OBSTETRICS

Fetal head descent assessed by transabdominal ultrasound: a prospective observational study

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BACKGROUND: Determining fetal head descent, expressed as fetal head station and engagement is an essential part of monitoring progression in labor. Assessing fetal head station is based on the distal part of the fetal skull, whereas assessing engagement is based on the proximal part. Prerequisites for assisted vaginal birth are that the fetal head should be engaged and its lowermost part at or below the level of the ischial spines. The part of the fetal head above the pelvic inlet reflects the true descent of the largest diameter of the skull. In molded (reshaped) fetal heads, the leading bony part of the skull may be below the ischial spines while the largest diameter of the fetal skull still remains above the pelvic inlet. An attempt at assisted vaginal birth in such a situation would be associated with risks. Therefore, the vaginal or transperineal assessments of station should be supplemented with a transabdominal examination. We suggest a method for the assessment of fetal head descent with transabdominal ultrasound.

OBJECTIVE: To investigate the correlation between transabdominal and transperineal assessment of fetal head descent, and to study fetal head shape at different labor stages and head positions.

STUDY DESIGN: Women with term singleton cephalic pregnancies admitted to the labor ward for induction of labor or in spontaneous labor, at the Cairo University Hospital and Oslo University Hospital from December 2019 to December 2020 were included. Fetal head descent was assessed with transabdominal ultrasound as the suprapubic descent angle between a longitudinal line through the symphysis pubis and a line from the upper part of the symphysis pubis extending tangentially to the fetal skull. We compared measurements with transperineally assessed angle of progression and investigated interobserver agreement. We also measured the part of fetal head above and below the symphysis pubis at different labor stages.

RESULTS: The study population comprised 123 women, of whom 19 (15%) were examined before induction of labor, 8 (7%) in the latent phase, 52 (42%) in the active first stage and 44 (36%) in the second stage. The suprapubic descent angle and the angle of progression could be measured in all cases. The correlation between the transabdominal and transperineal measurements was −0.90 (95% confidence interval, −0.86 to −0.93). Interobserver agreement was examined in 30 women and the intraclass correlation coefficient was 0.98 (95% confidence interval, 0.95–0.99). The limits of agreement were from −9.5 to 7.8 degrees. The fetal head was more elongated in occiput posterior position than in non-occiput posterior positions in the second stage of labor.

CONCLUSION: We present a novel method of examining fetal head descent by assessing the proximal part of the fetal skull with transabdominal ultrasound. The correlation with transperineal ultrasound measurements was strong, especially early in labor. The fetal head was elongated in the occiput posterior position during the second stage of labor.

Key words: angle of progression, engagement, fetal position, head descent, labor, molding, suprapubic descent angle, ultrasound

Introduction

Determining fetal head descent, expressed as fetal station and engagement is an essential part of monitoring progression in labor. Assessing fetal head station is based on the distal part of the fetal skull, whereas assessing engagement is based on the proximal part. A prerequisite for assisted vaginal birth is that the fetal head station should be at the level of the ischial spines or lower.[1–3] Another prerequisite is fetal head engagement,[2–4] which occurs when the widest part of the fetal head has descended below the pelvic inlet and two fifths of the head or less is palpable above the brim.[5,6] Fetal head station correlates with fetal head engagement, but station does not always truly indicate fetal head engagement. In flexed occiput anterior (OA) position, fetal head engagement occurrs when the leading bony part of the skull is at the level of the ischial spines.[7–9] In malpositions and molded (reshaped) fetal heads, the leading bony part of the skull may be below the ischial spines when the largest diameter of the fetal skull is still above the pelvic inlet,[10,11] An attempt at assisted vaginal birth in such a situation would be associated with risks of maternal and neonatal complications, and therefore, contraindicated in modern obstetrics. To avoid this mismanagement, a vaginal or transperineal assessment of fetal head descent should be supplemented with abdominal examination, as recommended in several guidelines and the World Health Organization partograph.[1,2,12] Unfortunately, abdominal examination to determine the fifths of the head above the symphysis pubis was inexact and poorly reproducible.[13] An objective abdominal assessment of the proximal fetal head descent is warranted.

Distal fetal head descent can be examined with transperineal ultrasound[14–17] and angle of progression (AoP) is a well-established ultrasound method.[14,18,19] Transabdominal ultrasound examination of fetal head

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AJOG at a Glance

Why was this study conducted?

Engagement is a prerequisite for operative vaginal attempts, and it occurs when the largest diameter of the fetal head passes the pelvic inlet. Fetal head molding (reshaping) may lead to overestimating descent by clinical vaginal and transperineal ultrasound examinations. Fetal head descent assessments should be supplemented with an abdominal examination. Because clinical abdominal examination has shown to be inaccurate, an objective transabdominal ultrasound assessment is warranted.

Key findings

Transabdominal ultrasound examination of fetal head descent was feasible in this study and the correlation between transabdominal and transperineal ultrasound measurements of fetal descent was strong (r=−0.90; 95% confidence interval, −0.86 to −0.93). The fetal head was elongated in the second stage of labor in occiput posterior positions.

What does this add to what is known?

We present a novel method for examining fetal head descent by assessing the proximal part of the fetal skull with transabdominal ultrasound.

descent might be easier to perform for most clinicians and is not affected by fetal head molding. Moreover, women prefer transperineal ultrasound over clinical vaginal examinations, and transabdominal scanning might be even more acceptable to laboring women.[20] A previous study investigated fetal head engagement with transabdominal ultrasound but failed to visualize the sacral promontory with ultrasound.[5]

We suggest measuring the suprapubic descent angle (SDA) transabdominally, as the angle between a longitudinal midline through the symphysis pubis and a line from the upper part of the symphysis pubis extending tangentially to the fetal skull. We aimed to investigate the correlation between transabdominal and transperineal assessment of fetal head descent, and to study fetal head shape at different labor stages and head positions.

Materials and Methods

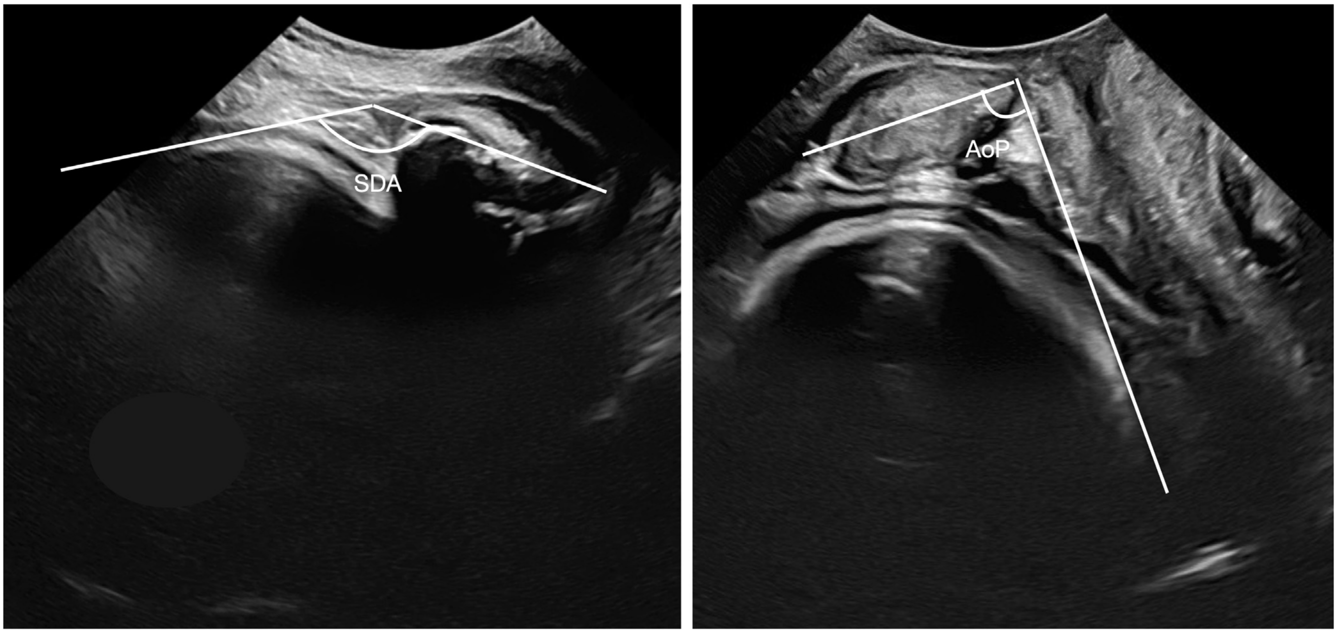
We conducted a prospective observational study in non-consecutive case series at Cairo University Hospital, Cairo, Egypt, and Oslo University Hospital, Oslo, Norway, from December 2019 to December 2020. Women were included when a member from the research team was on call. Women with uncomplicated singleton, cephalic, term pregnancies were eligible for recruitment. Women were recruited at the start of induction of labor, in the latent phase, or in the active stages of labor. A total of 83 women were included from Cairo and 40 from Oslo. All women were informed and consented to participate in the study. Ethical approval given by the Regional Committees for Medical and Health Research Ethics, Norway on February 12, 2018 (reference number 2018/176 /REK nord) and by the Research Scientific and Ethical Committee, Department of Obstetrics and Gynecology, Cairo University, Giza, Egypt, on October 20, 2019 (reference number O19005).

The ultrasound devices used for scanning were GE Voluson S6 or E10 (GE Medical Systems, Zipf, Austria) and Samsung Sonoace R3 (Samsung Medison, Seoul, Republic of Korea). We used transabdominal curvilinear transducers. First, a transabdominal scan was done to visualize the midsagittal plane. Then, the probe was placed vertically above the upper part of the symphysis pubis to enable visualization of the pubic bone. A longitudinal line was drawn through the symphysis pubis in the midline and a second line was drawn from the upper point of the symphysis pubis tangentially to the upper part of the fetal skull (Figure 1, Video 1). The upper and lower poles, the longitudinal contours and the central calcifications were used as references when the longitudinal line through the midline of the symphysis pubis was drawn. The symphysis pubis was orientated to look horizontal or slightly oblique on the ultrasound images. In fetuses with the head below the symphysis pubis the second line was drawn to the junction of the cervical spine and occipital bone (Figure 2, Video 2). The angle between the lines were measured as the SDA. We drew a line perpendicular to the upper point of the symphysis pubis (suprapubic line) and measured the distances from this line to the highest point of the fetal skull (Figure 3), as suggested previously.[21] The bladder should be empty.

Thereafter, the woman was placed in a semirecumbent position and a transperineal scan was performed. AoP was measured as the angle between a longitudinal line through the symphysis pubis and a line from the lowest point of the symphysis pubis tangentially to the fetal skull as previously described (Figure 1, Videos 3 and 4).[14] The longitudinal line through the symphysis pubis was drawn as described above. We also measured the distance between a line perpendicular to the lowest point of the symphysis pubis (infrapubic line) and the lowest part of the fetal skull as previously described as progression distance (Figure 3).[15] The shape of the fetal head was assessed as the sum of the distance from the suprapubic line to the upper part of the fetal skull (D1) and the distance below the infrapubic line (D2), D1+D2 (Figure 3).

Fetal head position was examined both transabdominally and transperineally by the same examiner sequentially. The occiput position was recorded in relation to a clock-face and categorized as OA (≥10 and ≤2 o'clock), left occiput transverse (LOT; >2 and <4 o'clock), occiput posterior (OP; ≥4 and ≤8 o'clock) and right occiput transverse positions (ROT; >8 and <10 o'clock).[22,23] The fetal spine, orbits, midline structures, and choroid plexus

FIGURE 1
Fetal head descent measured with SDA and AoP



Fetal descent examined with transabdominal ultrasound (left image) and fetal descent examined with transperinal ultrasound (right image). SDA is the angle between a longitudinal line through the symphysis pubis and a line from the upper part of the symphysis pubis tangentially to the upper part of the fetal skull. AoP is the angle between a line through the symphysis pubis and a line from the lower part of the symphysis pubis tangentially to the lower part of the skull. SDA=145° and AoP=90°.

AoP, angle of progression; *SDA*, suprapubic descent angle.

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were used to determine the fetal position with ultrasound.

All measurements were done offline at a later stage. The interobserver variation was investigated by examiner 1 in Egypt (R.K.) and examiner 2 in Norway (T.M.E.). Examiner 1 measured short time after recording and examiner 2 measured at a later stage. None of them were informed about clinical outcomes. They examined 30 transabdominal scan images of the SDA, independently and blinded to each other's measurements.

Statistical analysis

Categorical variables were compared with Fisher exact test and continuous variables were compared with *t* test and 1-way analysis of variance. The association between continuous variables was analyzed using linear regression and Pearson correlation coefficient. Interobserver agreement was expressed with the intraclass correlation coefficient and with limits of agreement and illustrated with a Bland-Altman plot. *P* values of <.05 were considered significant. Data were analyzed with the statistical software package SPSS Statistics, version 25.0 (IBM SPSS; IBM Corporation, Armonk, NY,) and with VassarStats (http://vassarstats.net).

Results

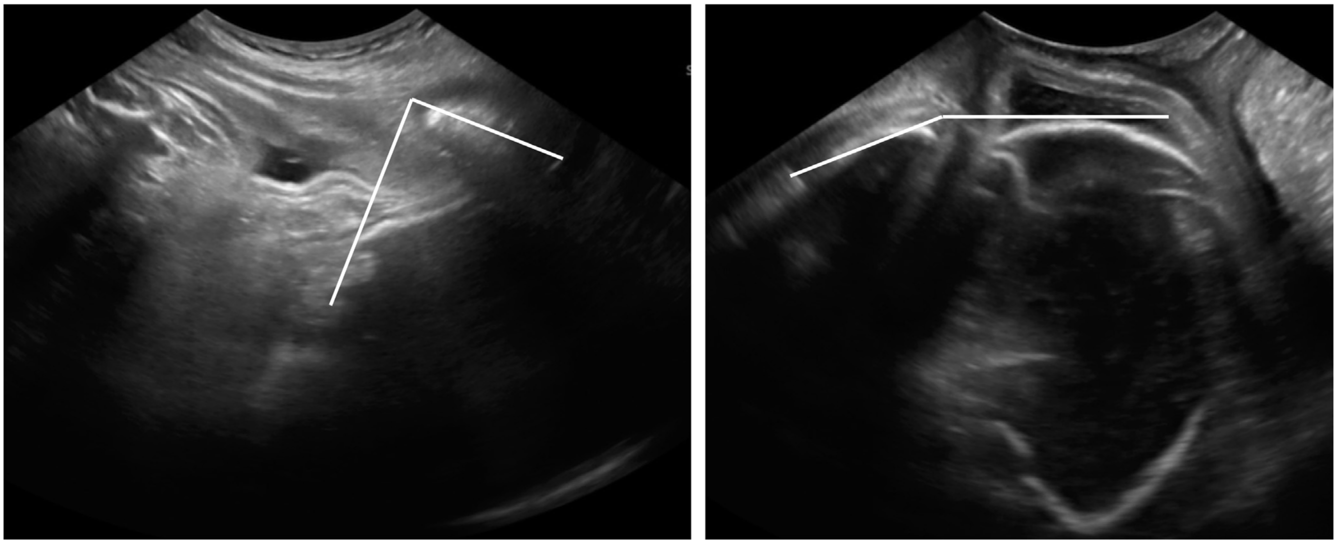
Study population

The study population comprised 123 women, of whom 19 (15%) were examined before induction of labor, 8 (7%) in the latent phase, 52 (42%) in the active first stage and 44 (36%) in the second stage. The mean maternal age was 29 (standard deviation [SD], 6) years, 70 (57%) were nulliparous women, mean body mass index was 28 (SD, 5) kg/m^2 and median gestational age was 278 (range, 259−296) days. Characteristics of fetal position and station differentiated according to labor phases and stages are shown in the Table.

The SDA and the AoP could be measured in all cases. Figure 1 shows SDA and AoP with the fetal head at a high station before start of active labor (SDA=145° and AoP=90°) (Videos 1 and 3, respectively). Figure 2 shows a fetus at a low station where the uppermost part of the fetal head was at the level of the superior edge of the symphysis pubis (SDA=90° and AoP=157°) (Videos 2 and 4, respectively). Figure 4 shows a fetus moving under the symphysis pubis short time before the delivery (Videos 5 and 6). The fetus is in OA position with an extended attitude (SDA=65° and AoP=150°).

A strong correlation was found between the SDA and AoP (r=−0.90 [95% confidence interval [CI], −0.86 to −0.93]) (Figure 5) and the linear regression equation was y=215−0.85x. The correlation was observed to be the best in the first stage of labor. The various correlations according to the stages of labor are presented in the Table.

FIGURE 2
SDA and AoP at low station



The SDA in the left image and AoP measured in a fetus with the whole head below the symphysis. SDA=90° and AoP=157°.
AoP, angle of progression; *SDA*, suprapubic descent angle.
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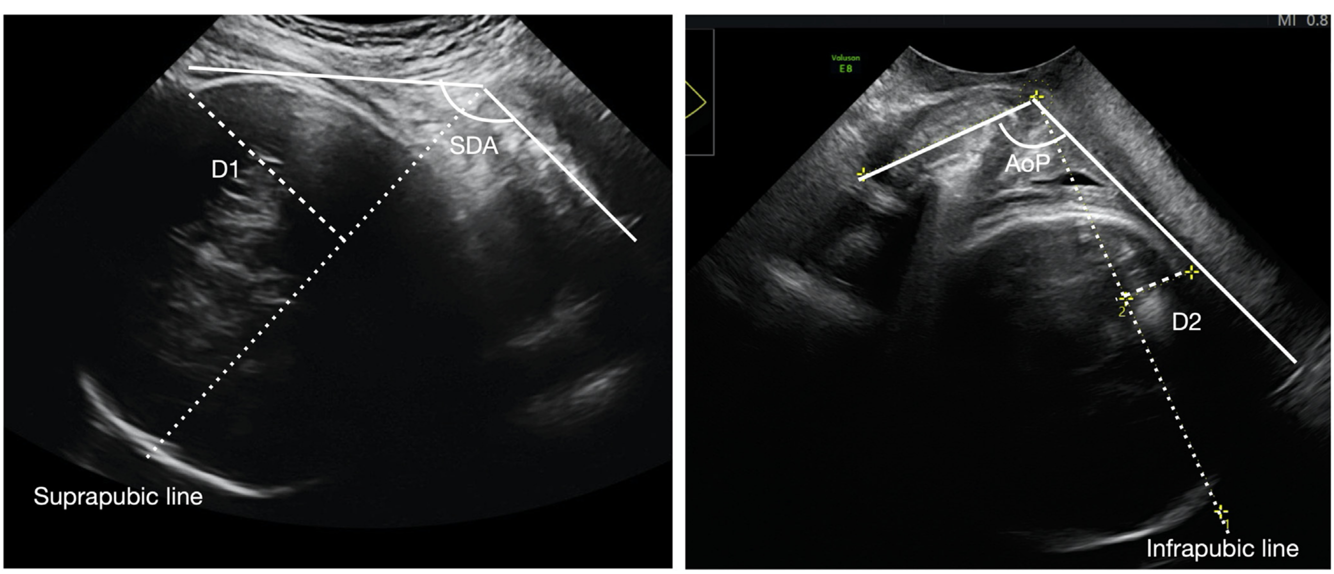
An AoP of 116° correlated with an SDA of 117° (Figure 5).

The distance from the infrapubic line to the lowest part of the skull could be measured in all cases, but measurement from the suprapubic line to the upper part of the skull failed in 1 case. The correlation between the head above the suprapubic line and the distance below the infrapubic line was observed to be r=−0.78 (95% CI, −0.70 to −0.84) and the regression equation expressed as

FIGURE 3
Measurement of fetal head elongation and station



The part of fetal head above the suprapubic line (D1) is illustrated on the left image and the part of the fetal head below the infrapubic line (D2) is illustrated on the right image. The suprapubic line is drawn perpendicular to the longitudinal line through the symphysis pubis from the upper part of the symphysis pubis, and the infrapubic line is drawn perpendicular to the longitudinal line through the symphysis pubis from the lower part of the symphysis pubis.
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TABLE
Fetal head station and position differentiated into labor phase and labor stages

Characteristics	Before active phase (N=27)	First active stage (N=52)	Second active stage (N=44)
SDA (°)	150 (11)	134 (15)	87 (20)
AoP (°)	79 (9)	98 (17)	148 (18)
Correlation between SDA and AoP, *r* (95% CI)	−0.58 (−0.26 to −0.79)	−0.77 (−0.63 to −0.86)	−0.52 (−0.26 to −0.70)
Distance above suprapubic line (mm)	49 (14)	43 (15)	−4 (17)
Distance below the infrapubic line (mm)	−18 (14)	5 (19)	51 (14)
Sum of distance above the suprapubic line and distance below the infrapubic line (mm)	31 (18)	48 (21)	47 (18)
OA position, n (%)	5 (18.5)	23 (44.2)	36 (81.8)
OT position, n (%)	14 (51.9)	24 (46.2)	1 (2.2)
OP position, n (%)	8 (29.6)	5 (9.6)	7 (15.9)

Data are presented as mean (standard deviation), Pearson correlation coefficient (95% CI), or number (percentage).

AoP, angle of progression; *CI*, confidence interval; *OA*, occiput anterior; *OP*, occiput posterior; *OT*, occiput transverse; *SDA*, suprapubic descent angle.

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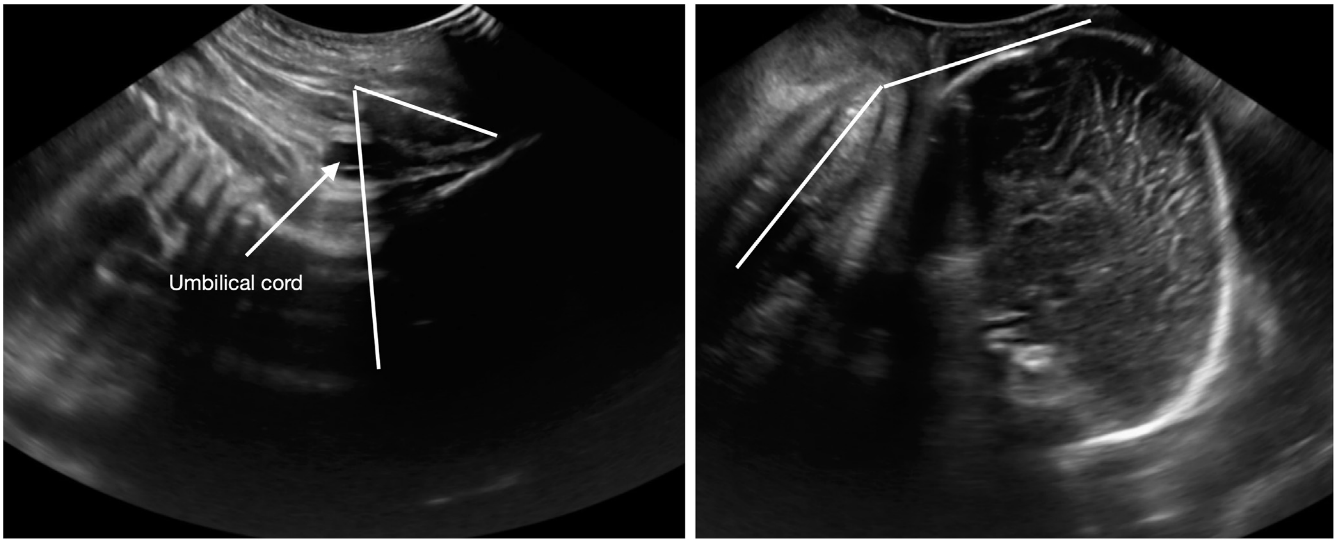
y=39−0.69x. The sum of the distance above the suprapubic line and the distance below the infrapubic line was considerably higher in fetuses examined during the active phase of labor than in fetuses examined, before the start of the active phase (Table).

Before the beginning of the active phase, the sum of the distance above the suprapubic line and distance below the infrapubic line was 31 mm (95% CI, 22−40 mm) in OA/OT position vs 32 mm (95% CI, 18−45 mm) in OP position (P=.92), and in the first stage of labor it was 48 mm (95% CI, 42−55 mm) in OA/OT position vs 49 mm (95% CI, 25−75 mm) in OP positions (P=.94). In the second stage of labor, the upper part of the fetal skull was below the suprapubic line in 22 of 37 (59%) of the OA/OT cases, but the upper part of the fetal skull was above the suprapubic line in all 7 OP cases (P<.01). The sum of distance above the suprapubic line and distance below the infrapubic line in the second stage of labor was 45 mm (95% CI, 39−50 mm) in OA/OT positions vs

FIGURE 4
The SDA and AoP measured in a fetus short time before delivery



SDA=65° and AoP=150°.

AoP, angle of progression; *SDA*, suprapubic descent angle.

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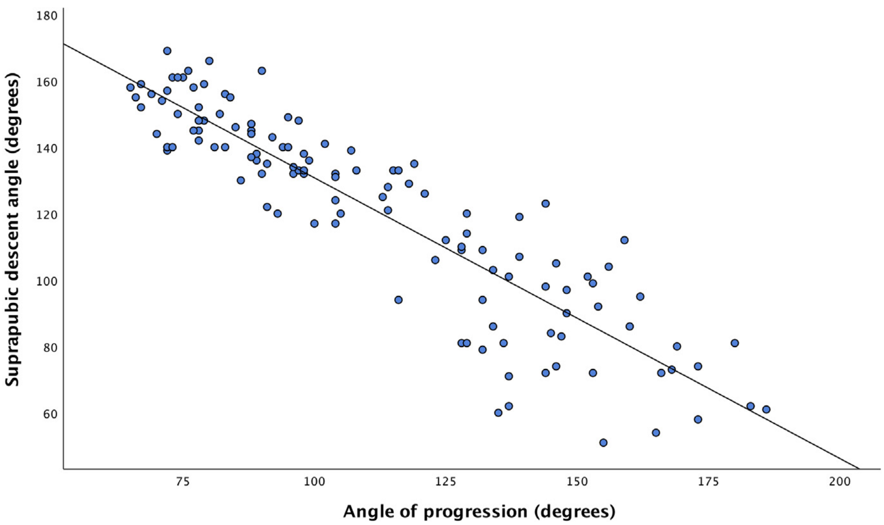
FIGURE 5
The correlation between the suprapubic descent angle and the angle of progression



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60 mm (95% CI, 42−77 mm) in OP positions (P=.04), indicating a longer and more elongated head shape. Figure 6 shows a fetus in OP position at a low station (AoP =136°) but a large part of the fetal head was still above the symphysis pubis (SDA=120°) (Videos 7 and 8). The nasal bone and a fetal eye are seen on Video 7 as landmarks for the fetal position. Fronto-parietal molding can be seen on the image and on Video 8.[11]

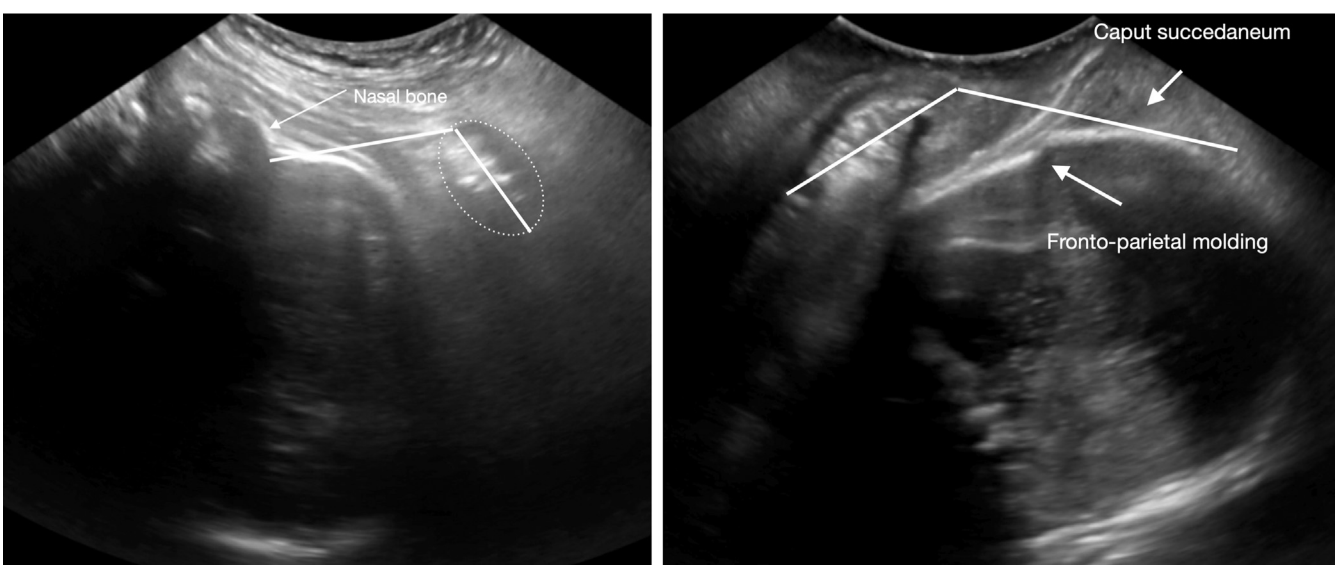
In our study, 30 cases were included in the reproducibility analyses. The mean SDA was 139°, the median value was 142°, and the range was 80° to 167°. The mean difference between the 2 observers was −0.9 degrees (95% CI, −2.5 to 0.8). The CI intervals are crossing 0, showing no significant difference between observers. The intraclass correlation coefficient was 0.98 (95% CI, 0.95−0.99). The limits of agreement were from −9.5 (95% CI, −12.2 to −6.8) to 7.8 (95% CI, 5.1−10.5) (Figure 7). We observed 1 outlier with a 20° difference between measurements. The difference ranged from −6° to 3° degrees if the outlier was excluded (Figure 7).

Comment

Principal findings

In this study, we present a novel method for assessing the fetal head descent with transabdominal ultrasound. We found a strong correlation between transabdominally measured SDA and transperineally measured AoP and a good interobserver agreement of SDA measurements. The fetal head was more

FIGURE 6
Discrepancy between SDA and AoP in occiput posterior fetus at low station



The figure shows a fetus in occiput posterior position at a low station (AoP=136°) and a large part of the fetal head above the symphysis pubis (SDA=120°). The symphysis pubis is marked on the left image. Fronto-parietal molding can be seen on the right image.

AoP, angle of progression; *SDA*, suprapubic descent angle.

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elongated in fetuses examined in the active phase of labor than in fetuses examined before start of the active phase. The most elongated heads were found in OP positions during the second stage.

Clinical significance

The fetal skull is compressed and reshaped when passing through the narrow birth canal, a phenomenon called molding.[10,24] Reshaping of the fetal skull is possible because the skull bones can overlap.[11] During this process the fetal head gets elongated with increased longitudinal diameter and reduced transverse diameter, increasing the probability of a vaginal delivery.[25] We found longer heads in fetuses in active labor than those examined before the start of active phase. This may be because of molding, but could also be caused by different head sizes and positions. To assess the dynamic effect of labor forces on the fetal head shape, a longitudinal study design is needed. Nulliparity, oxytocin augmentation, instrumental delivery and malpositions are variables associated with molding of the fetal head and our findings confirmed this with ultrasound measurements in OP positions in the second stage.[26] In cases with marked molding, the widest, proximal part of the head may still be above the pelvic inlet when the leading, distal point of the fetal skull is below the ischial spines because of marked elongation of the fetal skull. Special attention is needed before an operative vaginal delivery in OP positions (Figure 6). The advantage of our proposed method, is that it measures the proximal part of the fetal skull, which is unaffected by molding. The SDA may serve as an objective replacement for the clinical abdominal assessment of fifths above the symphysis pubis and offer an objective assessment of true fetal head descent.

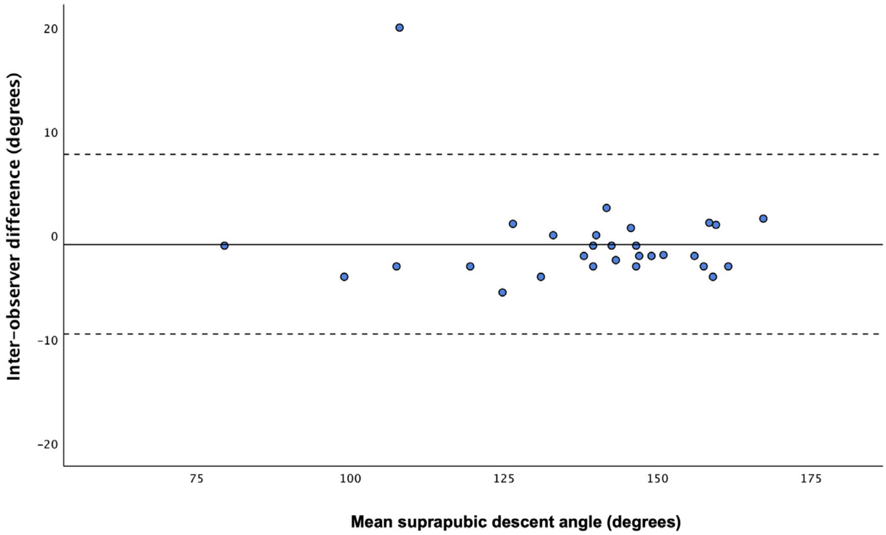
Assessment of fetal head descent is essential for monitoring labor progress. Friedman and Sachtleben[27−31] published descent patterns during the 1960s and their important work has been implemented into clinical practice worldwide, but the clinical examination has shown to be inaccurate.[32] Ultrasound labor curves resemble the clinical curves, but the fetal station was found higher during the first stage of labor.[33] Ultrasound is an objective method in which images can be stored for offline analysis later on, which may be important for documentation, and in cases with litigation. The International Society of Ultrasound in Obstetrics and Gynecology recommends using ultrasound to examine fetal station in cases with slow progress, in cases with malpresentations and before an assisted vaginal birth.[18] The American College of Obstetricians and Gynecologists guidelines and the Royal College of Obstetricians and Gynaecologists Green Top Guidelines from 2020 say that an operative vaginal birth is contraindicated if the fetal head is unengaged and the position of the fetal head is unknown.[2,3] The checklist of the Society for Maternal-Fetal Medicine for operative vaginal delivery, published in 2020, also includes assessment of engagement and position of the fetal head.[4] The main benefit with our method is the transabdominal approach, which may have a lower threshold for clinical use, and adds information about fetal head engagement that cannot be objectively obtained otherwise. Many studies have documented the accuracy of examining fetal position with ultrasound.[22,34−39] Ultrasound adds information and has the potential to reassure clinicians and increase the safety of operative vaginal deliveries by proper selection of cases eligible for assisted vaginal birth.[5,17−19,22,23,34,37,40−54]

Our finding of elongation of the fetal head in the second stage is in line with theories and publications about labor mechanics, which dictates that the distal part of the skull is subject to labor forces that affect its value as an anatomic landmark. It is in line with the guidelines recommending that assessment of fetal head engagement based on the proximal part of the fetal skull is an obligate part of the examination before assisted vaginal birth,[2−4] The SDA holds potential for diagnosing labor progress more objectively in an easy and accessible way. Further studies with clinical outcomes are necessary before this method is widely adopted in clinical practice.

Research implications

Examination of true fetal head descent with ultrasound is considered the “holy grail” of intrapartum ultrasound imaging.[55] Lewin et al,[56] in 1977, suggested to examine fetal head station using

FIGURE 7
Bland-Altman plots of interobserver agreement in measuring suprapubic descent angle



Mean difference between the 2 observers and limits of agreement are shown.

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ultrasound. They measured the distance from the coccygeal bone to the fetal head.[56] Katanozaka et al[57] measured the obstetrical conjugate with ultrasound in pregnancy at 28 and 36 weeks' gestation, and found a good correlation with x-ray pelvimetry. Sherer and Abulafia[5] tried to examine fetal descent with transabdominal ultrasound and defined engagement as the biparietal diameter below the pelvic inlet, but they could not see the promontory during labor because of shadowing from the fetal skull.

For measuring fetal head descent, a transperineal approach has been preferred in later studies. Dietz and Lanzarone[15] published progression distance. We used this method in our study when examining the part of the fetal head below the symphysis pubis.[17] Eggebø et al[16] suggested to measure head-perineum distance, Youssef et al[17] introduced head-symphysis distance and Barbera et al[14] measured AoP as the angle between a line through the symphysis pubis and a line from the lowermost part of the symphysis pubis tangentially to the fetal skull.[14] This method was called "angle of head descent" in the original publication, but the term "angle of progression" has later been well established internationally for this assessment of fetal descent.[18] An AoP of 116° has been found to correlate with clinically assessed station 0.[58] We found AoP 116° to correlate with SDA 117°, indicating that engagement has occurred with SDA of 120°, but a new study comparing SDA with clinical assessment of engagement is necessary.

Although transperineal ultrasound has been recommended in recent guidelines,[18] not all clinicians are comfortable with transperineal scanning. Iversen and Eggebø[21] suggested a transabdominal ultrasound approach similar to the clinical "fifth method" and compared the distance above and below the suprapubic line. However, the visualization of the lower part of the skull is often difficult at low stations because of shadowing from the symphysis pubis.

We suggest the measurement of the SDA. This method is a "mirror image" of AoP using the upper part of the symphysis pubis as a reference point with the benefit of measuring the part of the fetal skull that is not affected by molding. A transabdominal transducer can be used and placed on the upper part of the symphysis pubis. A wide scanning sector is preferred and the focus should be close to the skin for a good visualization of the symphysis pubis. In this study, we have demonstrated a strong correlation between SDA and AoP. A change of 1° in SDA corresponded to a 0.85° change in AoP. The interobserver agreement was very good, with only 1 outlier. While examining this outlier later, the symphysis pubis was not well presented on the image. The repeatability should be tested at lower stations in future studies, preferably in recorded videos instead of on recorded images.

Strengths and limitations

An international 2-center design and the fact that women in different labor phases and stages were included are strengths of the study. The relatively small study population is a limitation. We have no clinical outcomes in this study. A longitudinal design with repeated measurements would be beneficial when studying reshaping of the fetal head. We did not observe any fetuses in OP position with the whole head below the symphysis pubis, but we suggest using the tip of the chin as reference point in such cases.

A limitation with ultrasound is that it cannot visualize all parts of the maternal bony pelvis, which makes it unsuitable for assessing cephalopelvic disproportion directly, and shadows makes it difficult to visualize the whole fetal head at once. Moreover, the biparietal diameter is difficult to measure when the fetal head is in oblique positions. It is, however, easy to visualize the symphysis pubis, and because the SDA only measures how much of the fetal head that is above the symphysis pubis, it will work independently of fetal head position.

Ideally, the symphysis pubis should be orientated horizontally on the images, but less shadowing occurs when the symphysis pubis is orientated slightly obliquely. The symphysis pubis is a fixed structure, and the angle measurements are not affected. Transabdominal scanning can be challenging in obese women, but the transducer should be placed longitudinally close to and partly over the symphysis pubis while measuring the SDA. In this way, the excess shadowing in obese women is reduced. Three-dimensional ultrasound techniques have the potential to improve the visualization of different structures and should be investigated in new studies.

Conclusions

We present a novel method for examining fetal head descent using transabdominal ultrasound. We found strong correlation with transperineal ultrasound and good interobserver agreement. The fetal head was more elongated in fetuses examined in the active phase of labor than those examined before the start of the active phase. The most elongated heads were found in OP positions during the second stage. ■

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