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Full length article

Does the fetal head station and position affect the pelvic floor muscles in labour? A prospective study using 3 dimensional transperineal ultrasound

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A R T I C L E I N F O

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A B S T R A C T

Aims: The passage of the fetus through the birth canal, stretches the soft tissues of the pelvic floor, in particular the levator ani muscle. Excessive distension of the levator ani muscle (LAM) hiatus and LAM avulsions are associated with pelvic organ prolapse. Our aim was to evaluate the impact of the fetal head position and station on the LAM.

Methods: A prospective cross-sectional observational study of women undergoing their first vaginal birth. Women were examined vaginally by a doctor or midwife to assess the fetal head station in relation to the ischial spines. Three dimensional transperineal ultrasound (3D TPUS) was performed on these women in the second stage of labour when they had a vaginal examination. The 3D TPUS was done to identify LAM avulsion and measure the anteroposterior (AP) diameter and the hiatal area. In addition, transabdominal ultrasound (TAUS) was used to determine the fetal head position. A Kruskal-Wallis test was performed to compare non-parametric variables.

Results: 274 women were invited and 264 (95 %) agreed to participate. 52 women had a TPUS performed during the second stage of labour. The fetal head position was occiput anterior (OA) 32 (62 %), occiput posterior (OP) 9 (17 %), and occiput transverse (OT) 11 (21 %).

There was a significant increase in the AP diameter and hiatal area as the fetal head descended from −1 to +2. (AP diameter: 6.1 vs 8.1 cm, $p = 0.002$; hiatal area: 16.3 vs 30.3 cm^2, $p = 0.01$).

The fetal head position did not affect the AP diameter or hiatal area measurements. No LAM avulsions were diagnosed in the second stage of labour before birth.

No LAM avulsions were found following caesarean section ($n = 7$). Women who gave birth vaginally were invited to have a repeat scan after three months, and 35/45 (78 %) came for follow-up. LAM avulsions were diagnosed three months postpartum in 10/35 (29 %) women following their vaginal birth.

Conclusions: This is the first study to evaluate how the fetal head station and position affect the LAM after active second stage of labour. There is a 25 % increase in AP diameter and a doubling of the hiatal area as the head descends from station −1 to +2. LAM avulsions are known to occur following a vaginal birth, and this study demonstrates that LAM avulsions do not occur until the birth of the head. It also highlights that despite pushing in the active second stage of labour, an unsuccessful vaginal delivery followed by CS is not associated with a LAM avulsion. This information will be useful to counsel women regarding mode of delivery.

Introduction

During pregnancy and childbirth, the pelvic floor undergoes significant changes. In pregnancy, there is pressure from the gravid uterus and alteration of the pelvic floor connective tissue [1]. During vaginal birth, the rigid bony pelvis, cervix, and levator ani muscles (LAM) create resistance as the fetal head moves through the birth canal. Computerized models have shown that the greatest distension of the pelvic floor occurs

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when the fetal head is delivered [2,3], with the pubococcygeus muscles (part of the LAM) experiencing the most strain. This makes them particularly vulnerable to detachment, known as LAM avulsion, which is a risk factor for pelvic organ prolapse (POP) [4]. POP is common and can significantly affect a woman's quality of life [5]. Between 10–36 % of women with POP have an underlying LAM avulsion [4,6]. Additionally, excessive distension of the hiatal area is associated with POP [7].

Studies using computerized models and 3D transperineal ultrasound (TPUS) have assessed the impact of fetal descent on the pelvic floor [2,3]. A prospective study on 35 primigravidae found that as the fetal head descends, the levator hiatus area increases significantly. However, this study did not evaluate the impact of the fetal head position on the LAM specifically. It is known that an occipitoposterior (OP) fetal position is associated with prolonged labour [8].

Conventionally, digital examination is used to evaluate the fetal head station and position, which is essential in assessing labour progression [9] and deciding whether a vaginal instrumental birth or caesarean section is needed [10,11]. Accurate assessment is crucial, as errors can lead to complications like fetal trauma [12,13]. Clinical examination to determine the fetal head station and position is subjective and can be inaccurate [14,15] Intrapartum TPUS has emerged as a more objective method for assessing fetal head position and station [16], offering parameters such as the angle of progression (AoP) [17,18], which is a reliable measure for determining head station [19–21].

This study aimed to evaluate the impact of the fetal head position and station on the levator ani muscle .

Materials and methods

Women having their first vaginal birth over 16 months between March 2016 and June 2017 at University Hospital Lewisham were invited to participate. Women were given written information about the study at their 20–22 weeks anomaly scan, and written consent was obtained. This study is part of another study on obstetric anal sphincter injuries that has been previously published [22].

Doctors and midwives performed digital vaginal examinations (VE) on women to determine the fetal head station and cervical dilatation when clinically indicated in labour as part of routine labour management. All clinical examinations were performed when there was a clinical indication, and no VE were performed solely for this study. The station was assessed by determining the relationship between the level of the ischial spines and the leading edge of the fetal head [23] from −5 to +5.

The fetal head position was determined when the cervix was fully dilated (10 cm) by vaginal examination. Palpation of the sagittal suture and fontanelles was performed to determine the fetal head position [24,25] which was then classified as occiput anterior (OA), occiput posterior (OP), and left or right occiput transverse (LOT/ROT).

Transabdominal ultrasound (TAUS) was performed using a GE oluson 730 system to assess the fetal head position in labour. A 4–8 MHz transabdominal curved array volume transducer was used. Immediately after the clinical examination, a TAUS was performed to identify the fetal occiput position. The ultrasound scan was performed with the patient in the supine position. An abdominal probe was placed transversely on the woman's abdomen to visualise the axial view of the fetal trunk at the level of the fetal upper abdomen or chest. The fetal spine could then be visualised. The abdominal probe was moved down towards the maternal suprapubic area, and a transverse view of the fetal head was obtained. With TAUS, the landmarks used to determine an OP position were the two fetal orbits; for the OT position, the midline cerebral echo, and for the OA position, it was the occiput itself with the fetal cervical spine in the sagittal plane. The fetal head position was recorded with the short hand of a clockface: OT position between ≥02.30 and ≤03.30 or between ≥08.30 and ≤09.30; OP position between >03.30 and <08.30; and OA position between >09.30 and ≤02.30 [26].

2D TPUS was performed to assess fetal head station in labour by measuring the AoP. TPUS was only performed when the research fellow was available on the birth suite. Two-dimensional TPUS was performed by the clinical research fellow (KW) immediately after each clinical vaginal examination. The 2D TPUS was performed in the supine position between contractions. The probe was placed between the labia and below the pubic symphysis. The long axis of the pubic symphysis was identified in the sagittal view. In the sagittal view two callipers were placed at points to identify the long axis of the pubic symphysis from which a line was drawn. A second line was subsequently drawn from the most inferior portion of the pubic symphysis tangentially to the fetal skull contour. Measurements were then taken from at least three separate scans at each examination. The angle between the two calliper lines was then measured offline by a single operator (KW) who was blinded to the clinical findings, and the mean value of the three measurements was calculated [19].

A 4–8 MHz transabdominal curved array volume transducer was used with an acquisition angle of 85 degrees. The images were acquired at rest. The minimal anteroposterior (AP) diameter of the levator hiatus was identified in the mid-sagittal plane, from the posterior margin of the pubic symphysis to the anterior margin of LAM [7]. The hiatal area and AP diameter were measured from the rendered volume in the axial plane [27]. Tomographic ultrasound imaging at rest was used to assess the entire LAM and to diagnose levator avulsions [28]. Eight slices were obtained in the axial plane from 5 mm below the plane of the minimal hiatal dimension to 12.5 mm above the plane at 2.5-mm slice intervals [28]. Direct visualisation gave Scores as zero or positive for LAM avulsion to the central three slices. LAM avulsions were then scored separately for the left and right sides from 0 (no avulsion) to 3 (complete LAM avulsion) [28]. The final bilateral score was 0 for no LAM avulsion, 1 to 3 for a minor LAM avulsion and either a score of 4 to 6, or a unilateral score of 3 for a major LAM avulsion [29].

Data was entered into a Microsoft Excel database and analysed with SPSS version 26 (Chicago, Illinois, USA). This study was approved by the South East Coast – Surrey Research Ethics Committee (REC 16/LO/

Table 1
Mean values of the angle of progression in relation to the fetal head station determined by digital vaginal examination.

Station	−3 (n = 4)	−2 (n = 25)	−1 (n = 42)	0 (n = 42)	+1 (n = 21)	+2 (n = 8)
AoP Mean (SD)	108.2 (19.2)	111 (13.5)	120.7 (11.7)	134.7 (10.8)	139.9 (15.9)	160.9 (14.9)

AoP, angle of progression; SD, standard deviation.

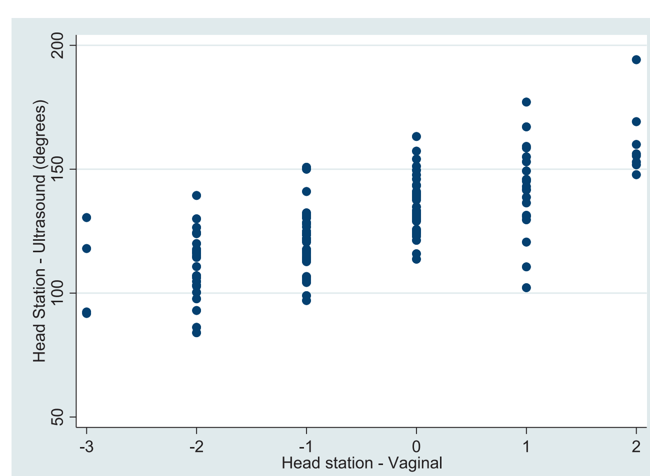

Fig. 1. Association between ultrasound (Angle of Progression) and vaginal examination for fetal head station.

Table 2
Fetal head position in the second stage of labour determined by digital VE and TAUS.

TAUS	Fetal head position – digital VE		
Fetal head position	OA	OP	OT
OA	28	0	1
OP	6	3	0
OT	0	0	11

*The kappa value quantifying the agreement between methods was 0.73, with a corresponding confidence interval from 0.52 to 0.93.
OA, occiput anterior; OA, occiput posterior, OT occiput transverse; TAUS, transabdominal ultrasound, VE vaginal examination

2140).

Results

Eighty nine women participated in the study, a total of 142 TPUS were performed on them. Fifty nine (42 %) of the 142 scans were done in the second stage of labour. Of the 89 women 24 (16.8 %) had a spontaneous vaginal birth, 7 (4.9 %) a vacuum extraction, 21 (14.7 %) a forceps birth and 37 (25.9 %) a caesarean section.

Fetal head station

The station of the head determined by VE was between −3 and +2 in relation to the ischial spines. There was a significant correlation between clinical examination of the head station and the angle of progression 0.71 ($P < 0.001$), see Table 1 and Fig. 1.

Fetal head position

One hundred and thirty four digital VE and ultrasound examinations were done in the first and second stage of labour. Clinicians were unable to determine the fetal head position in 47 (35 %) cases. Of these 47 digital VE, 24 (51 %) were in the OA position, 12 (26 %) in the OP position and 11 (23 %) in the OT position as determined by TAUS. Fifty-nine digital VE were performed in the second stage of labour and ten (17 %) were excluded as the doctor or midwife could not determine the fetal head position. The fetal head position was also determined by ultrasound examination in all 49 cases. Of these 49 women, the fetal head position was OA in 29 (59 %), OP in 9 (18 %) and OT in 11 (22 %) cases. Vaginal digital examination failed to identify the correct fetal head position in 7 (13.4 %) cases (Table 2). Table 2 shows that there is good agreement, the biggest source of disagreement being between those classified as OA on digital VE and OP with ultrasound assessment. The Kappa value quantifying the agreement between methods was 0.73, with a corresponding confidence interval from 0.52 to 0.93. This demonstrates good agreement between the two sets of measurements. All OT positions and 28 of the 29 (97 %) OA were correctly identified with vaginal examination. For babies in OP position clinicians missed the diagnosis in 6 (67 %) of the 9 cases.

Levator hiatal measurements

No levator avulsions were diagnosed in the first or second stage of labour (Figs. 2 and 3). As the fetal head descended (determined by clinical examination or ultrasound) the hiatal area and AP diameter increased significantly (Tables 3 and 4).

A total of 134 ultrasound assessments were undertaken in the first and second stages of labour. Babies in the OA position had a significantly larger hiatal area than those in an OT or OP position (Table 5).

Discussion

This is the first study to evaluate the impact of the fetal head station and position on the integrity of the LAM after second stage of labour. As the head descends the birth canal from −3 above the ischial spines to +2 below the ischial spines, the hiatal area increased 2.5-fold and the AP

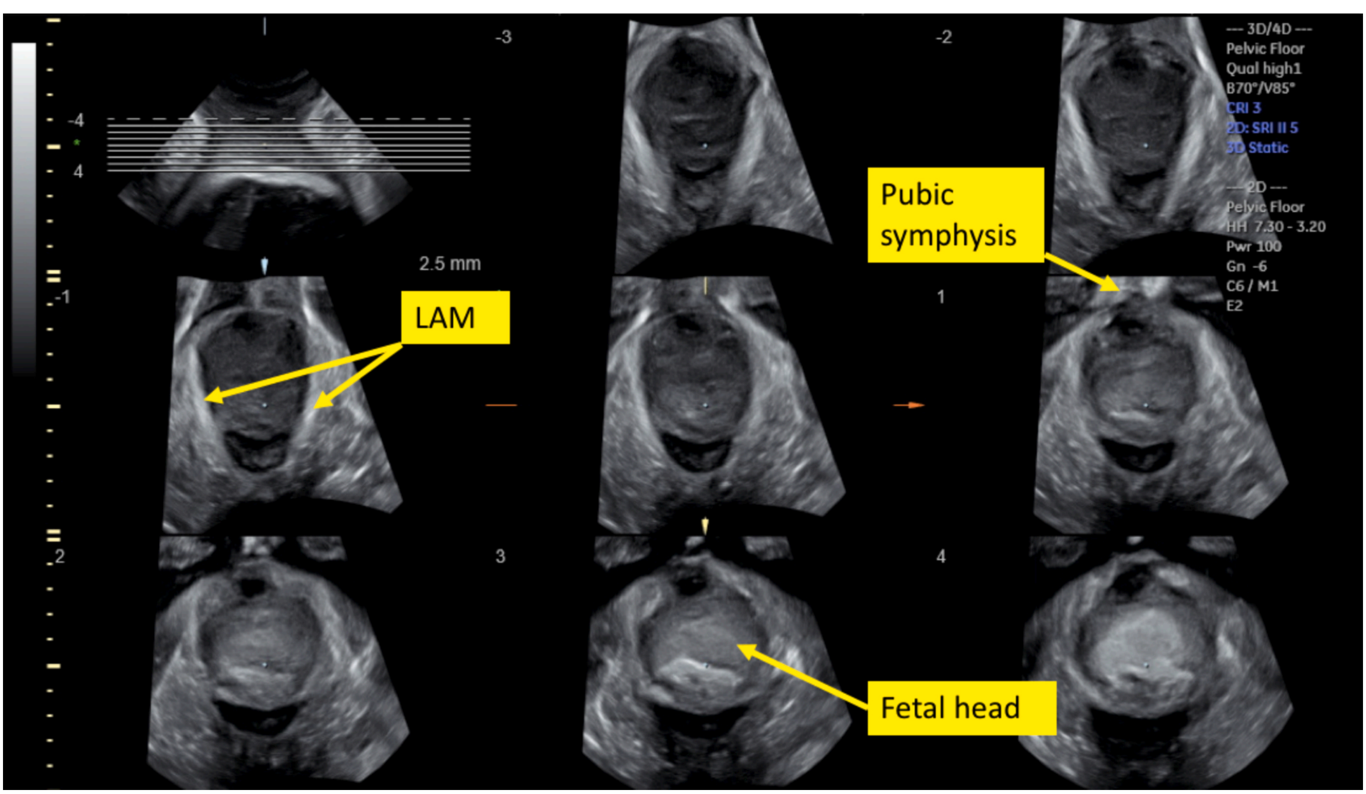

Fig. 2. Transperineal tomographic ultrasound imaging: intact levator ani muscle during the second stage of labour.

Fig. 3. Tomographic ultrasound imaging: intact levator ani muscle during second stage of labour.

Table 3
Associations between levator hiatus measurements and fetal head station.

Variable 1	Variable 2	n	Correlation †	p value
Angle of progression	Hiatal area	142	0.46	<0.001
Angle of progression	AP diameter	142	0.47	<0.001

†Pearson correlation
AP, anteroposterior.

diameter increased by 75 %. In addition, this study shows that LAM avulsions do not occur during the first stage of labour, which is in keeping with the literature [31,32]. We also found that vaginal examination is a poor clinical tool in assessing the position of the fetal head as two thirds of babies in the OP position were missed.

This is the first prospective study to evaluate the association between the fetal head position and levator hiatal measurements. The hiatal area was significantly larger with the fetal head position of OA when compared with OP or OT.

During labour, the fetal head moves through the pelvic floor and birth canal due to uterine contractions, maternal abdominal wall contractions, and diaphragm muscle activity. 3D pelvic floor modelling has demonstrated significant stretching of pelvic floor muscles as the fetal head descends. The LAM faces the highest risk of injury during vaginal birth. However, these models have limitations including assumptions that the fetal head is a perfect sphere without taking into consideration the variable stress of the surrounding tissues. During labour, the fetal head moves through the pelvic floor and birth canal due to uterine contractions, maternal abdominal wall contractions, and diaphragm muscle activity [3]. With the use of a finite element model, Silva et al [30] demonstrated how the LAM causes resistance to the descending fetal head and how it may increase the risk of pelvic floor injury. However, these models do not fully reflect what happens in real life. Assessment of the LAM in labour with TPUS was first described by Blasi et al in 2011 [31]. A prospective study of 56 women who had TPUS performed during the first and second stages of labour found that it was feasible to visualise the LAM in labour. Their study, however, did not evaluate hiatal area measurements or the fetal head station during labour. Another prospective cohort study [32] performed TPUS on 21 primiparous women in labour to assess the hiatal area and AP diameter.

Table 5
Hiatal area and AP diameter in different fetal head positions determined by transabdominal ultrasound.

	OA (n = 56) Mean ± SD	OP (n = 29) Mean ± SD	ROT/LOT (n = 49) Mean ± SD	p value
AP diameter (cm)	6.1 ± 1.4	5.8 ± 0.9	5.5 ± 1.3	0.07
Hiatal area (cm^2)	19.4 ± 6.1	17.1 ± 4.8	16.3 ± 5.6	0.02

§Analysis of Variance (ANOVA).
AP, anteroposterior; OA, occiput anterior; OA, occiput posterior, LOT, left occiput transverse; ROT, right occiput transverse; SD, standard deviation.

Table 4
Median values of hiatal area and AP diameter in relation to fetal head station by digital vaginal examination.

Station Mean (Range) n = 142	−3 n = 4	−2 n = 24	−1 n = 42	0 n = 41	+1 n = 21	+2 n = 8	Correlation ‡	p value
Hiatal area (cm^2)	10.7 (9.5–12)	15.7 (14.5–17.1)	17 (13–21)	18 (13–21)	19 (17–23)	26 (21–30)	0.39	<0.001
AP diameter (cm)	4.2 (3.5–4.9)	5.1 (4–6)	5.6 (4.5–6.7)	5.9 (4.8–7)	6.3 (5–7.5)	7.4 (6–8.8)	0.45	<0.001

‡Pearson correlation

They demonstrated that the hiatal area increased significantly when the fetal head station progressed from −5 to +4. However, the fetal head station was only assessed by clinical examination, which has been shown to be both inaccurate and subjective. In our study, fetal head station was assessed by both clinical examination and ultrasound measurement of the AoP. There was an increase in the hiatal area and the AP diameter as the fetal head descended in the birth canal. The hiatal area and AP diameter were significantly larger at fetal head station of +2 compared with −3, which concurred with the findings of García-Mejido [32]. They [32] performed 3D TPUS on 35 primigravidae in the first and second stages of labour. They demonstrated that the levator hiatus area increases as the fetal head descends in the birth canal. Our findings on levator hiatal dimensions during labour are consistent with previously published data on fetal head size and the degree of pelvic floor stretch required for vaginal delivery. Notably, Svabik et al. [33] reported that the average smallest fetal head circumference is approximately 29 cm^2. This corresponds closely to the mean hiatal area we observed at +2 station in our cohort, suggesting a biomechanical compatibility between the dimensions of the fetal head and the maternal levator hiatus at advanced descent.

As the fetus descends, the fetal head diameter varies due to flexion of the neck. In OP position, the fetal head is typically incompletely flexed, leading to the presentation of the occipitofrontal diameter which measures 11.5 cm. This is larger compared to the smaller diameter associated with the OA position 9.5 cm [34]. Surprisingly we found that hiatal area was larger in OA compared to OP or OT. One would expect that the OP position is associated with larger hiatal area due to the larger presenting diameter. An explanation for this may be that there are other contributing factors, which might include the pressure on the pelvic floor muscle, moulding and caput succedaneum of the fetal head and the degree of the flexion of the fetal neck.

In our study no LAM avulsion was diagnosed in labour, confirming the findings of two other prospective studies [31,32]. Blasi et al. [31] performed TPUS on 35 primiparous women in the first and second stages of labour before birth and found no LAM avulsion. More recently, in 2017 García-Mejido et al. [32] studied 21 primiparous women and found no LAM avulsion during labour but LAM avulsion was only identified after birth of the baby. Caesarean section at full dilatation can be technically challenging and is associated with increased maternal and neonatal morbidity. However, women can be reassured that a caesarean section conducted in the active second stage of labour is not associated with LAM avulsion.

Strengths and limitations

Our study is the first to evaluate the impact of fetal head position on the levator hiatal area and the integrity of the LAM after active second stage of labour. Our study population included women undergoing their first vaginal birth with variations in body mass index, ethnicity and anesthesia. Therefore, our results could be generalizable to other centres with a mixed population. Doctors and midwives remained blinded to the ultrasound findings during all clinical examinations, and the research fellow was blinded to the VE findings; thus the findings on VE and subsequent management did not influence the research findings or vice versa.

This study has limitations, including ultrasound scans being performed only when the research fellow was available, meaning scans weren't conducted after each vaginal examination. The accuracy of ultrasound was assumed to be 100 %, though it may not be entirely precise. Additionally, while ultrasound can assess caput and moulding [35], which can affect labour progress, these measurements were not included in the study.

We also acknowledged that our findings suggest that an AoP of 134 degrees corresponding to station 0, which is different from other literature. These variations may be due to differences in study populations, vaginal examination variability and measurement technique variability.

We agree that the laterality of avulsion remains speculative. While our dataset does not contain diagnosed cases of avulsion during labour (either first or second stage), it offers meaningful insight into how pelvic floor muscles vary with head position and descent.

Conclusions

To date, this is the largest study to evaluate how the fetal head station and position affects the LAM. There is an increase in the AP diameter and the hiatal area doubles as the head descends from a station of −3 to +2. No LAM avulsion occurred in labour but was identified after the birth of the baby. Despite pushing in the active second stage of labour, an unsuccessful vaginal delivery followed by CS is not associated with a LAM avulsion. This information will be useful to counsel women regarding the mode of delivery.

CRediT authorship contribution statement

Ka Woon Wong: Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Abdul H Sultan:** Writing – review & editing, Supervision. **Vasanth Andrews:** Writing – review & editing, Supervision. **Heather Allen-Coward:** Writing – review & editing, Supervision. **Ranee Thakar:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Some of the contents of this paper were included in ''Transperineal Ultrasound Assessment of Pelvic Floor Dysfunction'' for Doctor of Medicine (Research) at St. George's, University of London (Published date 1st July 2021).

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