ULTRA SONO GRAPHY

Correlations of third-trimester hiatal biometry obtained using four-dimensional translabial ultrasonography with the delivery route in nulliparous pregnant women

ORIGINAL ARTICLE

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Purpose: The goal of this study was to evaluate normal hiatal dimensions in the third trimester in nulliparous Thai pregnant women and to establish which biometric factors were associated with various pregnancy outcomes.

Methods: Fifty-seven consecutive nulliparous pregnant Thai women in their third trimester were recruited on a voluntary basis from April to October 2014. All subjects underwent four-dimensional (4D) translabial ultrasonography. Hiatal biometric parameters were measured at rest, while performing a Valsalva maneuver, and during contraction. Information about the patients' eventual deliveries was obtained from their medical records.

Results: The mean values of the patients' age, body mass index, and gestational age at the time of examination were 27.4±5.47 years, 26.7±3.48 kg/m^2, and 36.6±1.49 weeks, respectively. No subjects had vaginal lumps or experienced prolapse greater than stage 1 of the Pelvic Organ Prolapse Quantification system. Ultrasonography showed that the mean values of the hiatal area at rest, while performing a Valsalva maneuver, and during contraction were 13.10±2.92 cm^2, 17.50±4.81 cm^2, and 9.69±2.09 cm^2, respectively. The hiatal area at rest, the axial measurement at rest, and the axial measurement while performing a Valsalva maneuver were significantly associated with the route of delivery (P=0.02, P=0.04, and P=0.03, respectively).

Conclusion: The route of delivery was associated with hiatal biometric values measured using 4D translabial ultrasonography, based on the results of nulliparous Thai women in the third trimester.

Keywords: Hiatal dimension; Delivery, obstetric; Ultrasonography, four-dimensional

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Introduction

The levator ani muscle plays an important role in supporting the pelvic organs. The puborectalis

muscle, which forms a U-shaped muscular sling, is a major component of the levator ani complex. This muscular sling inserts anteriorly on the os pubis and fuses together behind the rectum at the top of the anal canal. The puborectalis muscle closes the pelvic cavity and defines the levator hiatus [1].

It has recently become possible to assess the puborectalis component of the levator ani using four-dimensional (4D) translabial ultrasonography, a technique that is well tolerated by the patient, inexpensive, and highly reproducible [2]. This technique is simple and does not require a high degree of technical skill, enabling technicians to complete their training within a few weeks. Standardized methods that evaluate both the function and anatomy of the puborectalis muscle have been developed and proven to be replicable [3–5]. The hiatal biometry and elasticity of the levator ani can be determined using 4D pelvic floor ultrasonography. Clinically, the area of the levator hiatus has been associated with mobility and prolapse of the pelvic organs [3,6]. Hiatal biometry can also be used to predict the duration of labor [7]. An inverse correlation between the length of the second stage of labor and hiatal dimensions has been reported in Caucasians who delivered vaginally [7].

Hiatal biometry may vary among different ethnicities. The majority of the published data has been obtained from Caucasians, and consequently may have limited applicability to other populations [2–4,6,7]. Therefore, studies of the normal values of hiatal biometry in each population group are needed for future comparisons with regard to various diseases and conditions. No data have yet been reported on hiatal biometry in Thai pregnant women. We aimed to study the normal hiatal diameter values in nulliparous Thai women in the third trimester of pregnancy and to establish which biometric factors were associated with the eventual outcomes of pregnancy.

Materials and Methods

After informed consent was obtained, 57 nulliparous Thai women in the third trimester of pregnancy who attended the antenatal clinic at King Chulalongkorn Memorial Hospital from April to October 2014 were recruited into this study. Demographic data (age, gravida status, parity, expected due date, weight, height, and familial history of Caesarean sections) were collected. The inclusion criteria were nulliparous and singleton status, as well as vertex presentation at the time of examination. The exclusion criteria were symptoms of vaginal lumps and prolapse greater than stage 1 of the Pelvic Organ Prolapse Quantification (POP-Q) system. Vaginal digital examination was performed to evaluate the POP-Q stage and levator ani tone at rest and during contraction. Contractions on both sides were graded using the modified Oxford scale [8], while resting tone was graded using the scale developed by Thyer et al. [9].

Only the first investigator (T.T.) performed 4D translabial ultrasonography. Pelvic floor ultrasonography was performed in the supine position with both knees flexed and both ankles close to the patient's buttocks after the bladder was emptied. A GE Voluson E8 system (GE Healthcare, Zipf, Austria) with an 4–8 MHz volume transducer was used with an acquisition angle of 85°, as previously described [2]. The transducer was placed against the perineum in the midsagittal plane. 4D ultrasonography volume datasets were obtained from each patient at rest, at the point of maximal contraction of the pelvic floor muscle, and at the point of a maximal Valsalva maneuver. The best Valsalva and maximum contraction volume datasets were used for analysis. The dimensions of the hiatal area of the levator ani were measured using 4D pelvic floor ultrasonography on the axial plane. The hiatal area, circumference, axial diameter, and coronal diameter were measured on the plane of the minimal hiatal diameter, which is defined on the midsagittal plane as the minimal distance from the hyperechogenic posterior aspect of the symphysis pubis to the hyperechogenic anterior border of the levator ani muscle [3]. Hiatal biometric parameters at rest, during a Valsalva maneuver, and during contraction were measured as shown in Fig. 1. Information about the eventual deliveries was obtained from the patients' medical records. The gestational age at delivery, the route of delivery, the use of an intrapartum epidural, oxytocin use, episiotomy, the presence of perineal laceration, birth weight, head circumference, and Apgar scores were recorded. The study was approved by the Ethics Committee of the Faculty of Medicine, Chulalongkorn University.

The sample size was calculated using the following formula: $n=(z_{\alpha/2}\ SD/d)^2$, where z is statistical measurement of a score's relationship to the mean in a group of scores, α is type I error, SD is standard deviation, and d is the acceptable error, using the values from a pilot study of 20 nulliparous Thai women in the third trimester of pregnancy. The mean hiatal area during the maximal Valsalva maneuver was 16.12±3.08 cm^2. The acceptable error was 5%. The estimated sample size for this study was 56 subjects.

Statistical Analysis

The data were analyzed using SPSS ver. 22.0 (IBM Co., Armonk, NY, USA). The descriptive data were presented as percentages, means, and medians. The chi-squared test was used to evaluate associations between hiatal biometric parameters and pregnancy outcomes. P-values of <0.05 were considered to indicate statistical significance. Multiple logistic regression analysis (forward stepwise) was used for multivariate analysis.

Results

The mean values of the patients' age, body mass index, and gestational age at the time of examination were 27.4±5.47 years, 26.7±3.48 kg/m^2, and 36.6±1.49 weeks, respectively. Stress urinary incontinence was the most common lower urinary tract symptom (29.8%) in our sample of patients (Table 1). Levator avulsion was not detected by digital examination in any cases.

The results of 4D translabial ultrasonography showed that the mean hiatal areas at rest, while performing a Valsalva maneuver, and during contraction were 13.10±2.92 cm^2, 17.50±4.81 cm^2, and 9.69±2.09 cm^2, respectively (Table 2). The imaging of the hiatal area at rest, at maximal contraction, and during a maximal Valsalva maneuver are presented in Fig. 1. Before delivery, no puborectalis muscle avulsion was observed on the three central slices of tomographic ultrasound imaging, as previously described [3].

The premature birth rate in our sample was 1.75%. Thirty-nine women (68.42%) underwent a vaginal delivery (68.42%), with five cases of operative vaginal deliveries. Eighteen women (31.58%) had a Caesarean section; three cases (5.26%) were due to fetal distress, and fifteen cases (26.32%) were due to cephalopelvic disproportion. Cephalopelvic disproportion is defined as a mismatch in size between the fetal head and the maternal pelvis, and was diagnosed using criteria based on abnormal findings during labor, as suggested in the guidelines of the American Congress of Obstetricians and Gynecologists [10].

Thirteen patients were delivered by Caesarean section during the first stage of labor and two patients were delivered in the second stage of labor.

Second-degree perineal laceration was the most common complication after vaginal birth (56.1%) (Table 3). Fourth-degree tearing was detected in one case after a delivery with forceps. The

Table 1. Characteristics of the patients (n=57)

Characteristic	Value
Age (yr)	27.39±5.47
Weight (kg)	66.68±10.04
Height (cm)	157.93±5.37
BMI (kg/m^2)	26.68±3.48
Gestational age on examination (wk)	36.60±1.49
Times per day	8.75±2.88
Times per night	2.70±1.31
Stress urinary incontinence	17 (29.8)
Urgency urinary incontinence	4 (7)
Mixed urinary incontinence	1 (1.8)

Values are presented as mean±SD or number (%).
BMI, body mass index.

Table 2. Hiatal biometric measurements using four-dimensional ultrasonography (n=57)

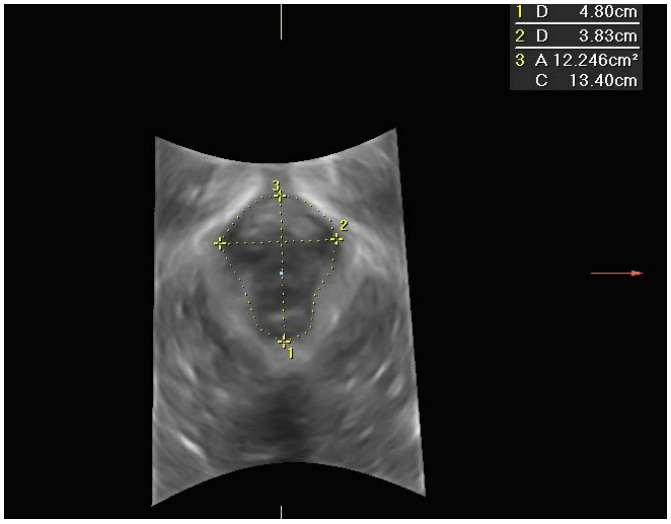
Metric	Value
Residual urine (mL)	9.69±10.93
Bladder neck descent (mm)	11.76±7.38
Bony arch length (mm)	46.09±5.25
Bony angle (°)	126.81±9.60
AP diameter at rest (mm)	49.26±7.55
Coronal diameter at rest (mm)	38.96±4.22
Hiatal area at rest (cm^2)	13.10±2.92
AP diameter while performing a Valsalva maneuver (mm)	53.11±8.45
Coronal diameter while performing a Valsalva maneuver (mm)	45.13±5.96
Hiatal area while performing a Valsalva maneuver (cm^2)	17.50±4.81
AP diameter during contraction (mm)	38.84±5.84
Coronal diameter during contraction (mm)	35.21±3.49
Hiatal area during contraction (cm^2)	9.69±2.09

Values are presented as mean±SD.
AP, anteroposterior.

Table 3. Pregnancy outcomes (n=57)

Factor	Value
Delivery outcomes	
Term delivery	56 (98.25)
Preterm delivery	1 (1.75)
Route of delivery	
Vaginal birth	39 (68.42)
Caesarean section	18 (31.58)
Vacuum delivery	2 (3.5)
Forceps delivery	3 (5.3)
Intrapartum intervention	
Intrapartum oxytocin use	33 (57.9)
Perineal tearing	
No tearing	18 (31.6)
First-degree tearing	2 (3.5)
Second-degree tearing	32 (56.1)
Third-degree tearing	4 (7.0)
Fourth-degree tearing	1 (1.8)
Fetal outcomes	
Birth weight (g)	3,099.68±338.45
Head circumference (cm)	33.20±1.12
Apgar score at 1 minute	8.75±1.10
Apgar score at 5 minutes	9.73±1.24

Values are presented as number (%) or mean±SD.



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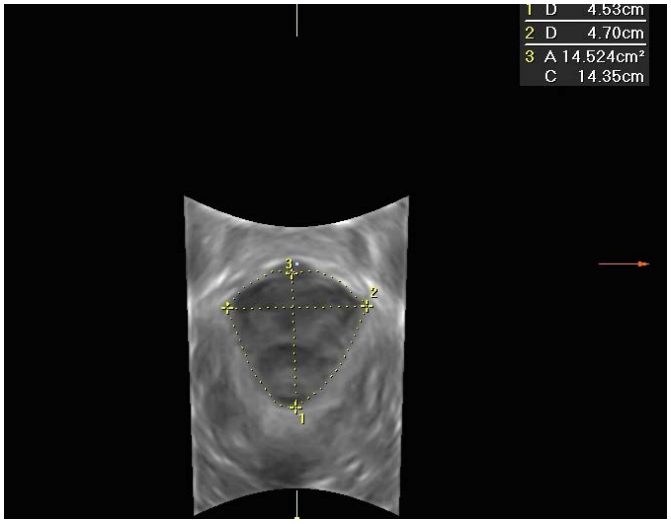

C

Fig. 1. Axial plane image of hiatal area of 4D translabial ultrasonography.
A–C. The figure illustrates the axial plane of hiatal area of 4D translabial ultrasonography at rest (A), during contraction (B) and during Valsalva (C).

mean birth weight was 3,099.68±338.45 g. Low birth weight was noted in four patients (7.2%). The mean fetal head circumference was 33.20±1.12 cm. Fatal birth asphyxia was reported in one case, after an emergency Caesarean section due to a non-reassured fetal heart rate.

The factors that significantly affected the delivery route were the hiatal area at rest, the axial diameter at rest and while performing a Valsalva maneuver, and the length of the bony arch (Table 4). Changes in the hiatal area from rest to contraction and changes in the hiatal area from a Valsalva maneuver to rest did not predict the delivery route.

When multivariate analysis using the forward stepwise method was applied by adjusting for fetal birth weight and fetal head circumference, we found that the hiatal area at rest, the axial diameter at rest, and the axial diameter while performing a Valsalva maneuver were associated with the delivery route to a statistically significant extent (P=0.02, P=0.04, and P=0.03, respectively) (Table 5).

Among women who underwent a vaginal delivery, no hiatal biometric parameters were able to predict whether the second stage of labor would last more than 120 minutes.

Discussion

We found that the mean hiatal areas of nulliparous Thai women in the third trimester of pregnancy were similar to those of their Caucasian and Chinese counterparts [7,11,12].

Our study found that the bladder neck descent value at the maximal point of a Valsalva maneuver was 11.76±7.38 mm, which was similar to that observed in Chinese pregnant women

Table 4. Univariate analysis of factors associated with the delivery route (n=54)

Measurement	Vaginal delivery group (n=39)	Caesarian section delivery group (n=15)	P-value
Ultrasonographic parameters			
AP diameter at rest (mm)	50.67±7.52	46.22±6.87	0.04*
Coronal diameter at rest (mm)	39.57±4.31	37.65±3.81	0.11
Hiatal area at rest (cm^2)	13.72±3.00	11.75±2.25	0.02*
AP diameter while performing a Valsalva maneuver (mm)	54.47± 9.28	50.14±5.40	0.03*
Coronal diameter while performing a Valsalva maneuver (mm)	45.25±6.15	44.85±5.70	0.82
Hiatal area while performing a Valsalva maneuver (cm^2)	18.21±5.33	15.96±3.01	0.10
AP diameter during contraction (mm)	39.85±5.79	36.66±5.47	0.05
Coronal diameter during contraction (mm)	35.46±3.79	34.63±2.73	0.41
Hiatal area during contraction (cm^2)	10.05±2.20	8.91±1.59	0.05
Bony arc length (mm)	47.02±5.19	44.09±4.92	0.04*
Bony angle (°)	126.81±9.90	126.89±9.21	0.99
Bladder neck descent (mm)	12.52±8.15	10.12±5.18	0.26
Fetal outcomes			
Birth weight (g)	3033.72±349.27	3242.61±270.28	0.03*
Head circumference (cm)	33.05±1.03	33.50±1.27	0.17
Maternal BMI (kg/m^2)	26.89±3.58	26.24±3.33	0.52

Values are presented as mean±SD or number.
AP, anteroposterior; BMI, body mass index.
*Statistical significance at the level of P<0.05.

Table 5. Multivariate analysis of the factors associated with the delivery route (n=54)

Ultrasonographic parameters	OR	95% CI	P-value
Hiatal area at rest (cm^2)	0.74	0.57–0.97	0.02*
AP diameter at rest (mm)	0.91	0.83–0.99	0.04*
AP diameter while performing a Valsalva maneuver (mm)	0.90	0.82–0.99	0.03*

OR, odds ratio; CI, confidence interval; AP, anteroposterior.
*Statistical significance at the level of P<0.05.

(10.80±6.70 mm) [12], but lower than that observed in Caucasian women (15.30±8.41 mm) [12]. This discrepancy may be due to differences in body mass index or due to racial differences between Asians and Caucasians.

Regarding the biometric parameters that predict delivery outcomes, Lanzarone and Dietz [7] found an inverse correlation between hiatal area at contraction and length of the second stage of labor. In contrast, our study found no parameters correlated with the length of the second stage of labor. However, we found that the hiatal area at rest, the axial diameter at rest, and the axial diameter while performing a Valsalva maneuver were significantly associated with the route of delivery. The reason why the hiatal area at rest could predict the delivery route, while the hiatal area during a Valsalva maneuver could not, was mostly likely because the Valsalva maneuver produced individual variations in abdominal pressure that were not found at rest.

The main limitation of our study was the small sample size relative to the primary aim of this study (the assessment of hiatal biometric values in nulliparous Thai women in the third trimester of pregnancy). A sample size was not calculated for the secondary aim (establishing the biometric factors associated with the outcomes of pregnancy). Therefore, further studies with a larger sample size are needed. In the present study, only one ultrasonographer performed the 4D translabial ultrasonography measurements, and interobserver variation could not be evaluated.

In conclusion, the mean hiatal areas of nulliparous Thai women in the third trimester of pregnancy at rest and during a Valsalva maneuver were 13.10±2.92 cm^2 and 17.50±4.81 cm^2, respectively, and the route of delivery was significantly associated with certain hiatal biometric findings (hiatal area at rest, the axial diameter at rest, and the axial diameter while performing a Valsalva maneuver). The present study is the first study to establish normal values of hiatal biometry in nulliparous pregnant Thai women. These data could be used as reference values for further studies in the future.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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