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Evaluation of Levator ani muscle injury in primiparous women at one and six weeks' post-partum using 3D transperineal ultrasound: comparative Cohort study

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ABSTRACT

Background. Vaginal birth is known to be the main etiological factor for development of levator ani defects. Transperineal ultrasonography has been used extensively for pelvic floor assessment with minimal discomfort to the patient and lower cost. The aim is to define and evaluate changes in the levator ani muscle in the first week and at 6 weeks after delivery with 3D Transperineal ultrasonography.
Patients and Methods. Retrospective study of 355 eligible primiparous women who delivered vaginally and had been examined within the first week and 6 weeks after delivery with 3D transperineal ultrasonography.
Results. Women showed a significantly larger hiatal area at rest and on Valsalva, 6 weeks post-partum, LAM avulsions decreased at 6 weeks to be 13.2%.
Conclusions. First vaginal delivery led to persistent hiatal area enlargement. Levator ani muscle avulsions can be diagnosed easily by 3D ultrasound, and they are not the only cause of stress urinary incontinence after vaginal delivery.

INTRODUCTION

Levator ani muscle (LAM) has an essential role in pelvic organ support and urinary continence [1]. Loss of LAM function in addition to other factors such as aging lead to pelvic organ prolapse (POP) and/or pelvic floor dysfunction syndrome with its adverse effect on the female quality of life. Deterioration of LAM function occurs secondary to trauma or over stretch and unfortunately both trauma and over stretch usually occurs during childbirth [2].

Various pathophysiological mechanisms were suggested to explain the relation between childbirth and levator ani muscle detriment function. First mechanism is the affection of levator ani muscle fibers through avulsion or hematoma formation which subsequently heals by fibrosis and loss of muscle bulk. Second mechanism is the affection of the nerve fibers which supply the muscle and unfortunately results in loss of tone and contractility of the muscle [3, 4].
Many authors described and compared different surgical approaches for POP treatment using

women native tissue or other synthetic materials; they concluded that the choice of surgical procedure should be individualized according to the POP grade and women tissues [5-7].

For decades, Different methods had been described to determine and evaluate levator ani muscle function and structure, for example: palpation, visual observation, electromyography, perineometry, magnetic resonance imaging (MRI) and (2D) translabial ultrasound [8].

There is no agreement about the best method to study levator ani muscles, because of its unique and peculiar shape and anatomy as it forms a cone shape structures that cannot be totally seen in one axial plane [9].

The 3D transperineal ultrasound helped a lot to study the pelvic floor muscles quantitatively [10, 11]. And more overusing 4D ultrasound which is a dynamic imaging enabled researchers to study the function of levator ani muscle and levator hiatus qualitatively during maneuvers like valsalva and squeezing of the perineum [12].

Ultrasound, in general, is considered easily accessed as it is widely available. The ultrasound use is also safer and cheaper in comparison to MRI especially during pregnancy and post-partum period [13]. The learning curve of the technique to acquire and interpret ultrasound data is not long. The stored data and 3D volume are available for analysis and interpretation at any time [14].

All these advantages of 3D ultrasound encouraged us to perform this descriptive analytic study, which aimed to define and evaluate changes in the levator ani in the first week and at 6 weeks after the first vaginal delivery using the 3D Transperineal ultrasound.

PATIENTS AND METHODS

A retrospective descriptive analysis of US volume data sets of 355 Egyptian women who delivered at Shatby maternity university hospital from January 2019 until December 2020. Alexandria university medical ethical committee approval number is 0305228. Clinical trial ID: NCT04980235.

The study included all primipara who delivered singleton full-term fetus with cephalic presentation, and they were recruited during their first post-partum visit and one week post-delivery. The study did not include any woman who had multifetal pregnancy or congenital anomalies of the genital tract.

All data about maternal medical, surgical and obstetrical history, maternal age, and maternal body mass index, duration of second stage of labor, episiotomy, maternal injuries, neonatal birth weight, and neonatal head circumference were obtained from the files. Also records of vaginal examination and pelvic organ prolapse quantification were obtained and analyzed. The modified questionnaire on symptoms of pelvic floor dysfunction was filled by the patients in both visits.

Offline analysis of the stored volumes of the two 3D ultrasound examinations was done. The first examination was performed 7 days after delivery and the second examination was done 6 weeks post-delivery by experienced sonographers using a GE Voluson p8 (GE Healthcare) equipped with a 4-8-MHz curved array 3D ultrasound transducer. The field of view angle was set to a maximum of 70° in the sagittal plane and the volume acquisition angle to 85° in the axial plane. Two 3D volumes (one with the patient at rest and one during valsalva maneuver), were recorded. Ultrasound images were obtained after empting the bladder, while the patient in the supine position. Measurements were performed in the axial plane at the level of "minimal hiatal dimensions".

The following sonographic parameters were measured and recorded:

1. maximum diameters of the levator hiatus (anteroposterior and transverse), with the woman at rest and during Valsalva;
2. area of the levator hiatus at rest and during Valsalva;
3. pubovisceral muscle thickness (to left and right of rectum) at the level of maximum muscle thickness);
4. levator ani muscle (LAM) avulsion was diagnosed on tomographic ultrasound imaging. A set of eight tomographic slices are evaluated at intervals of 2.5 mm, in which both muscle sides are scored separately, resulting in a defect score ranging from no defect, partial defect or complete avulsion. A complete avulsion is diagnosed if the reference slice, *i.e.*, the slice that represents the plane of minimum hiatal dimensions, as well as the two slices, immediately cranial to this plane, shows an avulsion. Partial avulsion is diagnosed when any of the slices are abnormal;
5. the urethrovesical junction angle.

RESULTS

Data of 355 primipara Egyptian women, who were assessed by 3D transperineal ultrasound 1 week

and 6 weeks post vaginal delivery of a singleton full-term fetus, were obtained and analyzed.
The mean age was 26.7 (range: 16-34) years and the mean body mass index was 28.2 (range: 17-40) kg/m^2. The mean gestational age at delivery was 38.9 (range: 36-42) weeks. The mean birth weight was 3273 (range: 1985-4230) g and the mean head circumference was 34.5 (range: 33-39) cm. The median duration of second-stage labor was 97.1 (range: 40-230) min. An episiotomy was performed in 76.6% of them.
Data of the first assessment (7 days post-partum) revealed that 8/355 (2.2%) had fecal incontinence and 98/355 (27.6%) women reported stress urinary incontinence. Also 102/355 (28.7%) had urgency and urge urinary incontinence.
Data of the second assessment at 6 weeks post-partum revealed that 5/8 of women with fecal incontinence persisted to have flatus incontinence. And 42/98 women persisted to have stress urinary incontinence, also 56/102 persisted to have urge incontinence.
Data at 6 weeks post-partum showed that our study group women had a significantly larger hiatal area at rest and on Valsalva, compared with the data at first week post-partum ($p<0.01$, **Table 1**).
Data of women with urinary incontinence especially those with persistent stress urinary incontinence had a significantly larger hiatal area during Valsalva than did women with no stress incontinence (**Table 2**).
In this study, there was a non-significant correlation between levator ani avulsions and stress urinary incontinence at both visits of follow up.
Descriptive analysis, independent sample t-test, non-parametric testing, Chi-squared test and two-sided Fisher's exact test were used. $P<0.05$ was considered statistically significant.

DISCUSSION

The first vaginal delivery has the strongest impact on levator ani muscle (LAM), which is stretched greatly during vaginal delivery and could be torn from its insertion on the anterior pubic rami. The levator hiatus had a compact structure outlined by the pubis and puborectalis. The puborectalis normally forms a V-shaped sling running from the pelvic sidewall towards the anorectal junction. Puborectalis avulsion was identified as a loss of continuity between the muscle and the pelvic sidewall with no muscle remaining (**Figure 1**) [15].

Table 1. *Parameters of the levator hiatus in our study group.*

Parameter	First assessment 7 days post-partum (n = 355)		p	Second assessment 6 weeks post-partum (n = 355)		p
	At rest	During valsalva		At rest	During valsalva	
Levator thickness (mm)	10.2 ± 1.3	9.9 ± 0.9	NS	10.0 ± 1.0	9.7 ± 0.8	NS
Hiatal Transverse diameter (mm)	39.4 ± 4.3	44.3 ± 5.9	< 0.05	40.9 ± 4.5	46.3 ± 9.4	< 0.05
Hiatal Anteroposterior diameter (mm)	55.9 ± 6.3	57.4 ± 7.5	NS	56.2 ± 7.1	59.1 ± 9.9	NS
Hiatal area (cm^2)	16.3 ± 2.3	19.2 ± 5.1	< 0.01	16.8 ± 2.8	21.9 ± 7.9	< 0.01
The urethrovesical junction angle (degrees)	92 ± 6.4	98.3 ± 7.8	< 0.01	93.2 ± 7.2	99.7 ± 6.9	< 0.01
Levator ani avulsions and or hematoma	59			47		

Table 2. *Parameters of the levator hiatus in our study stress urinary incontinent sub group.*

Parameter	Stress incontinence group 7 days post-partum		p[a]	Stress incontinence group 6weeks post-partum		p[a]
	Present (n = 98) mean ± SD	**Absent (n = 257)** mean ± SD		**Present (n = 42)** mean ± SD	**Absent (n = 313)** mean ± SD	
Levator thickness (mm)	10.1 ± 1.2	10.0 ± 1.1	NS	10.3 ± 0.9	9.9 ± 1.3	NS
Hiatal Transverse diameter (mm)	39.8 ± 4.9	38.0 ± 3.9	< 0.01	40.2 ± 4.1	38.2 ± 4.2	< 0.01
Hiatal Anteroposterior diameter (mm)	56.8 ± 5.9	53.7 ± 6.1	< 0.05	57.8 ± 6.5	54.1 ± 3.2	< 0.05
Hiatal area (cm^2)	16.9 ± 2.9	15.2 ± 2.7	< 0.01	16.9 ± 3.0	15.6 ± 2.6	< 0.01
Levator hematoma/avulsion	20	39	NS	16	31	NS
The urethrovesical junction angle	94.8 ± 10.8	93 ± 4.7	< 0.01	96.2 ± 8.9	94.2 ± 5.1	< 0.01

[a]t-test; NS: not significant.

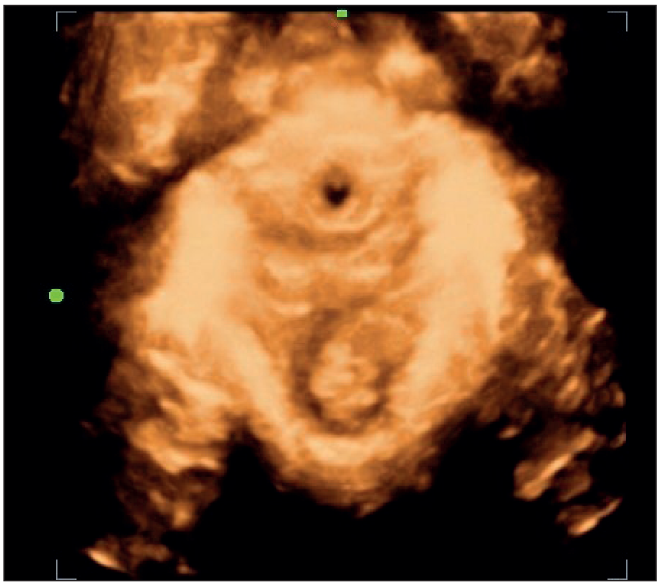

Figure 1. *3D ultrasound image of intact levator ani muscle.*

In this study the incidence of LAM avulsions and hematomas was 16.6% at the first visit, which was lower than those detected by Van Gruting *et al*., which was 21% [16]. The incidence of LAM avulsions which were observed by Iva Urbankova *et al*. at 1 year follow up was 27.1% in total. They observed unilateral LAM avulsion in 18.1% and bilateral in 9.0%. They also found that LAM avulsion was 3.2 more likely in women who had forceps-assisted vaginal birth [17]. These non-matching results could be explained by the difference in ethnicity between the studied populations and exclusion of instrumental delivery in this study.
The incidence of LAM avulsions decreased at 6 weeks follow up to be 13.2%. It could be explained that we included both minor avulsions and hematomas, which are possibly disappeared in comparison to major injuries. A similar decrease in the incidence of LAM avulsion was also observed in several studies [18-20].
In this study, there was a non-significant correlation between levator ani avulsions and stress urinary incontinence which matches what have been observed by Delaney *et al*. who found that visible defects in the levator ani muscle occurred with similar frequency in cases of SUI and controls [21]. On the other hand, Morgan *et al*. found that women with major LAM defects were less likely to experience SUI, whereas the risk increased in those with minor LAM defects [22]. While Iva Urbankova *et al*. differently found that urinary incontinence was 1.6 more likely in women with LAM avulsion [17].
This study showed significant difference in levator ani muscle dimensions and hiatal area detected by 3D transperineal ultrasound at 1 week and 6 weeks post first vaginal delivery (**Figures 2** and **3**). These findings were also observed by other researchers who found that vaginal delivery led to enlargement and increased dispensability of the levator hiatus, even without macroscopic levator trauma [23-25].
Increase and ballooning of levator ani hiatus [17], but not change in hiatal shape [26] are factors require fewer additional cofactors [27] for development of POP. This supports our postulation that some women in this study may develop POP later in life, which may be caused by another mechanism other than LAM avulsion.
One of the limitations in this study was the short follow up period. So the correlation between the detected levator ani muscle abnormalities and development of pelvic organ prolapse couldn't be evaluated.

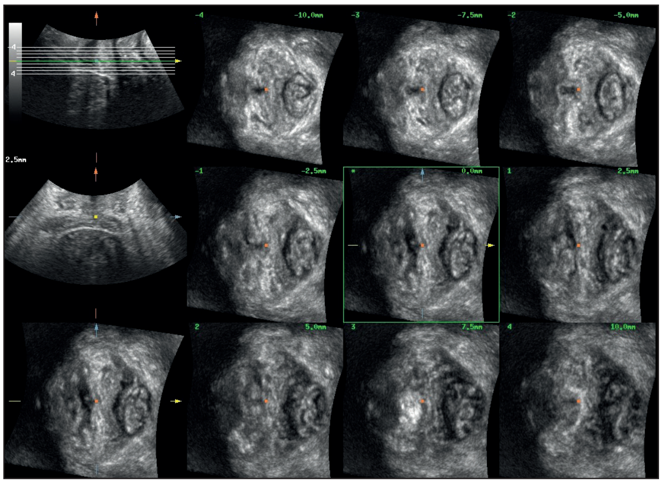

Figure 2. *Tomographic ultrasound image of intact levator ani muscle.*

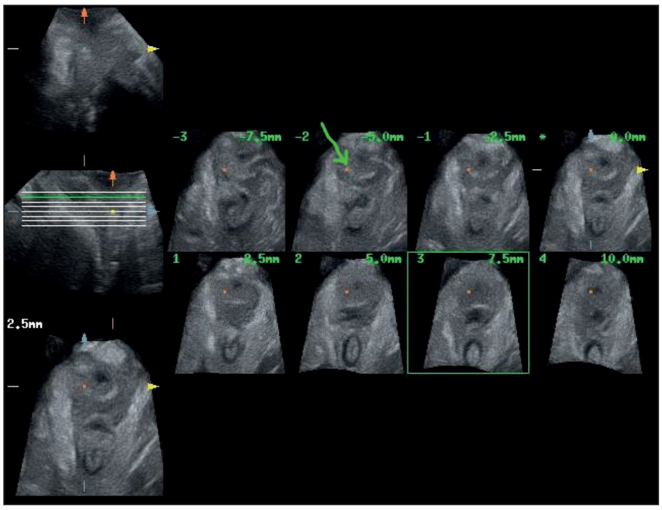

Figure 3. *Tomographic ultrasound image of levator ani muscle avulsion (green arrow).*

CONCLUSIONS

First vaginal delivery leads to persistent hiatal area enlargement. Levator ani muscle avulsions can be diagnosed easily by 3D ultrasound, and they are not the only cause of stress urinary incontinence after vaginal delivery.

COMPLIANCE WITH ETHICAL STANDARDS

Authors contribution

M.A.E.: Study design, Data collection, Writing - Original & Draft preparation, Writing - Review & editing.

Funding

None.

Study registration

Clinical trial ID: NCT04980235.

Disclosure of interests

Author declares that she has no conflict of interests.

Ethical approval

Alexandria University Medical Ethical Committee; protocol number 0305228.

Informed consent

Patients who fulfilled the selection criteria were counseled and informed about the trial protocol and a written consent according to declaration of Helsinki was signed.

Data sharing

Data are available under reasonable request to the corresponding author.

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