Alteration of pelvic floor biometry in different modes of delivery

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Abstract—

Objective: *The objective of this study is to investigate and compare the effects of different modes of delivery on bladder neck mobility, anorectal angle and levator hiatus distensibility detected by ultrasound assessment.*

Methods: *Two hundreds nulliparous women were divided into two groups based on their type of delivery, vaginal delivery (VD) group and cesarean section (CS) group. The biometry of pelvic floor, including bladder neck mobility, anorectal angle and levator hiatus distensibility, in both groups of women was observed and compared at 6-8 weeks after delivery by perineal ultrasound assessment.*

Results: *On valsalva, the bladder neck mobility in the VD group was significantly increase, when compared with CS group (P<0.05). However, here was no significant difference between two groups at rest. The anorectal angle (ARA) was no significant differences between two groups at rest and on valsalva. Compared with the CS group, transverse diameters (LR), anteroposterior (AP) and levator hiatal area (LHA) of levator hiatus in VD group were significantly increased at rest and on valsalva (P<0.05)*

Conclusion: *Perineal ultrasound can objectively and movably detect pelvic floor dysfunction of women after different modes of delivery, and a normal VD may be a risk factor for pelvic floor dysfunction.*

Keywords— Pevic floor biometry; Delivery; Ultrasound.

I. INTRODUCTION

Pelvic floor dysfunction (PFD) occurring in women comprises a board range of clinical scenarios such as lower urinary tract excretory and defecation disorders because of urinary and anal incontinence, overactive bladder, pelvic organ prolapsed as well as sexual disorders. [1] In developing countries, the prevalence of pelvic organ prolapse, urinary and fecal incontinence is 19.7%, 28.7%, and 6.9%, respectively. Pelvic organ prolapse is also a major health problem in developed countries. [2] It is estimated that women have a 12% lifetime risk (by age 80) of undergoing surgical treatment for urinary incontinence or prolapse. [3, 4] At least 11% of women require surgery for pelvic floor disorder. [5]

Age, ethnicity, multiparty, mode of delivery, history of pelvic surgery, pregnancy, chronic cough, obesity, spinal cord disorders, family history, and genetics are the most common identifiable risk factors for the development of PFD. [6] Reported pregnancy-related risk factors include pregestational body mass index (BMI). The other risk factors include past histories of previous lower abdominal surgeries such as laparoscopic and hysteroscopic procedures, uterine curettage, and urinary incontinence surgery. [7]

Pregnancy and childbirth are the cause of PFD including increase in urethral and pelvic organ mobility, hiatal distension, and levator ani muscle (LAM) injury. [8] It is believed that the strain of the gravid uterus and hormonal changes during pregnancy lead to connective tissue remodeling and disruption of normal pelvic floor function. During vaginal delivery, injury to the puborectal fascicle of the levator ani muscle may occurs, and it may be an etiological factor for uterine prolapsed, cystocele and rectocele. [9, 10] Furthermore, distension of the levator ani, ranged 25-245%, allows the hiatus to widen during crowning of the fetal head, resulting in marcoscopically visible [11] and microscopic/ultra structural[12] damage to the puborectal fascicle of the levator ani muscle[13]. Thus, the orphological changes of levator hiatus have clinical significance in the subsequent development of PFD. The enlargement of hiatus is more obvious especially after levator ani avulsion.

Recently, despite of reducing cesarean delivery rate suggested by obstetric practice guidelines developed over the past decade, the proportion of caesarean sections has significantly increased in high-income countries, [14] such as in Norway from just <2% in 1967 to 17% in 2010. [15] In fact, there are large variations between countries. For example, in 2011 the proportion of CS was 24% in the UK and 14% in the Netherlands. [16] At two of our largest maternity institutions, Oslo University Hospital, Ulleval, and Haukeland University Hospital, CSs represented 18.3% and 13.6% of the deliveries in

2013, respectively. [15] Such differences indicate that the proportion of CSs is not dictated solely by objective medical factors - there must also be cultural differences between the institutions or societies. [17]

To date, two-dimensional ultrasonography has been used to assess bladder neck mobility as an indicator of stress urinary incontinence [18] and the integrity of the puborectal fascicle of the levator ani muscle. [19] With the emergence of three-dimensional (3D) ultrasonography, assessment of the levator ani muscle becomes easier due to the ability of this technique to visualize the axial plane, which could be accessed by magnetic resonance imaging. [20] Rendered 3D volumes and 4D cine loop capabilities of ultrasonography enable the assessment of the functional anatomy with good spatial and superior temporal resolution, and multiple volume data sets obtained per second. [21]

Findings on pelvic floor biometry have been shown to be associated with symptoms of pelvic floor disorder in women, for example, urethral mobility is associated with urinary incontinence, [22] and the hiatal area is correlated with signs and symptoms of prolapse. [23]

II. MATERIALS AND METHODS

2.1 Subjects

Two hundred women who gave birth were recruited randomly by computer in our hospital, where about 3000 deliveries took place per year. Inclusion criteria were ethnic Chinese, nulliparous and singleton pregnant women who had no urinary or fecal incontinence or prolapsed symptoms at least 1 year prior to pregnancy. Exclusion criteria were age <18 years, non-Chinese ethnicity or mental incapacity. The women were divided into two groups based on their type of delivery, vaginal delivery (VD) group and cesarean section (CS) group. All of the vaginal primipara showed cephalic presentation and had a spontaneous VD without instrument-assisted. At the first visit, procreative data including maternal height and weight were obtained. This study was approved by Research Ethics Committee of our hospital, and informed consent was obtained from the participating patients.

2.2 Ultrasound examination

A GE Voluson 730 Expert three-dimensional (3D) ultrasound system (GE Medical System, Zipf, Austria) with a 5-9 MHz autosweep transducer was used for image acquisition.

The examination was performed with the patient in the lithotomy position and with a half-filled bladder. After application of a thin layer of ultrasound gel, the probe covered with a condom was placed on the vulvar rim, not penetrating into the vagina but remaining just external to the hymen plane. The probe was directed towards the anterior or posterior aspect of the perineum to better visualize the target structures, or turned transversally to provide images in a coronal plane. Images displayed with the ultrasound beam originating from the bottom of the monitor; the inferior portion of the woman’s anatomy was displayed in the lower portion of the image. The probe was held so that the anterior portion of the woman’s anatomy was placed on the left side and the posterior portion on the right side of the monitor. With a sweep angle of 80 degree, 3D ultrasound scans of pelvic floor anatomy were obtained at rest and on valsalva maneuver (VM). Women were asked to perform VM several times until a satisfactory performance was achieved. At most three VMs were performed; the most satisfactory was used for evaluation. Volume datasets were saved.

All translabial ultrasound volume datasets were analyzed in a standardized way. [21] Positions of the pelvic organs, relative to the posterior edge of the pubic symphysis, were measured in cm at rest and on VM. Vertical distances to the level of the reference point were measured from the bladder neck (Figure 1). The anorectal angle, defined as the angle that the rectal ampulla forms with the anal canal, was then measured initially with the patient at rest. Anorectal angle was calculated as the difference between the obtain values (rest-VM) (Figure 2). In addition, the axial plane of the minimal hiatal dimensions was used for measurement of transverse diameters (LR), anteroposterior (AP) and levator hiatal area (LHA) (Figure 3A&B). The plane of minimal hiatal dimensions is the horizontal line between the pubic symphysis and the anorectal junction in the mid-sagittal orientation. Area of the levator hiatus at rest and during VM was measured. All ultrasound volumes were acquired at 6-8 weeks after delivery by 4 experienced sonographers. Ultrasound examination and offline analysis of the stored volumes were performed by the same sonographers.

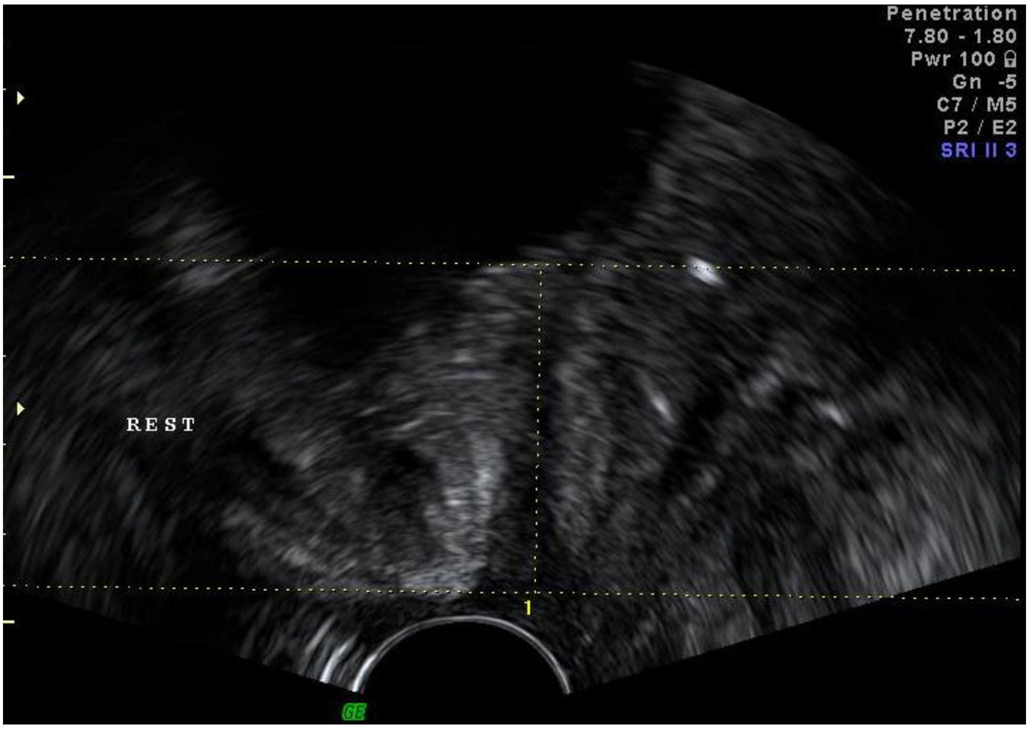

FIGURE 1: VERTICAL DISTANCE OF BLADDER NECK (ARROW LINE) IS THE DISTANCE FROM REFERENCE LINE TO BLADDER NECK. THE REFERENCE LINE IS A HORIZONTAL LINE PLACED AT THE INFEROPOSTERIOR MARGIN OF THE SYMPHYSIS PUBIS.

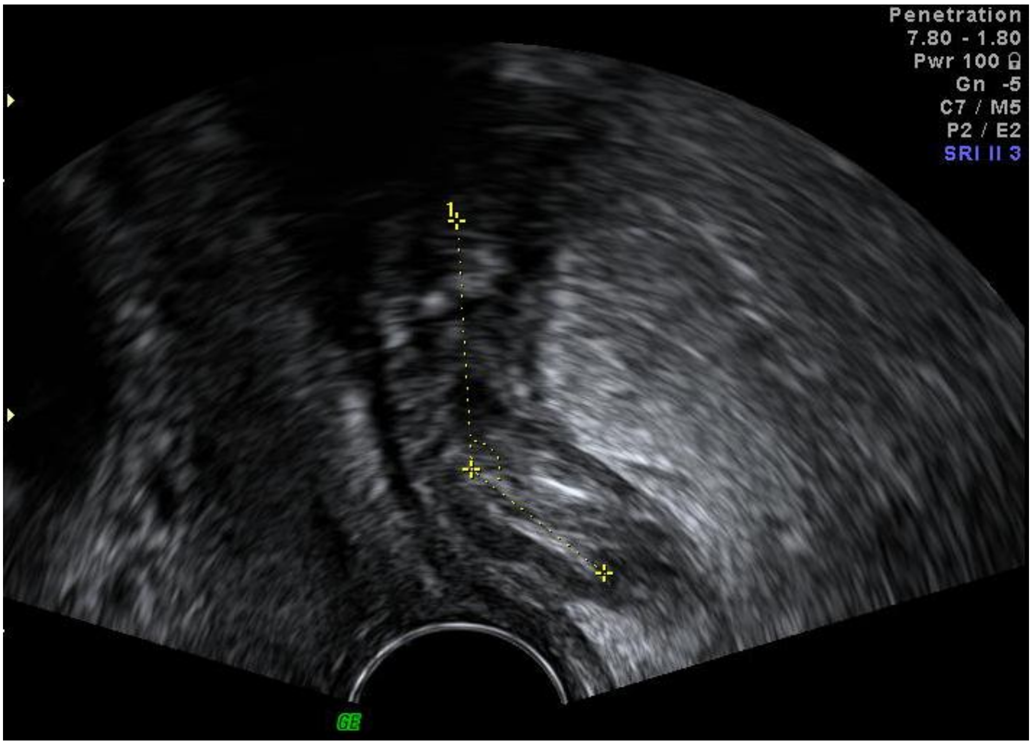

FIGURE 2: THE ANORECTAL ANGEL IS DEFINED AS THE ANGLE THAT THE RECTAL AMPULLA FORMS WITH THE ANAL CANEL.

FIGURE 3A: THE HIATAL ANTEROPOSTERIOR (AP) AND TRANSVERSE DIAMETERS (LR) WERE MEASURED IN AXIAL PLANE OF THE MINIMAL HIATAL DIMENSIONS.

FIGURE 3B: THE HIATAL AREA (LHA) WAS OBTAINED IN AXIAL PLANE OF THE MINIMAL HIATAL DIMENSIONS.

2.3 Statistical analysis

Statistical analysis was performed after normality testing using SPSS 18.0 (SPSS, Chicago, IL, USA). T-test was used. A value of $P<0.05$ was considered statistically significant.

III. RESULTS

All of participants were Chinese and singleton pregnancies. None of them had symptoms of PFD; hence, all met the inclusion/exclusion criteria. The general information of both groups is presented in Table 1. The mean age was 28 (range, 19-44) years, the mean body mass index was 20.08 (range 15.82-31.55) kg/m2 and the mean height was 160.20 (range 140-174) cm. Out of 200 women, 134 experienced spontaneous VD, 39 had elective CS and 27 had emergency CS. There was no any case of third- or fourth-degree vaginal tear. Instrumental delivery was not attempted in this study. All of participants underwent 2D and 3D ultrasound assessment of the pelvic floor on the 6-8 weeks after delivery. Satisfactory volume datasets and delivery data were obtained in all cases.

TABLE 1
GENERAL INFORMATION OF VAGINAL DELIVERY GROUP AND CESAREAN SECTION GROUP

Variables	Vaginal delivery group (n=134)	Cesarean group (n=66)	*P*
Age (y)	28 ± 4.36	29.72 ± 4.42	< 0.01
Height (cm)	160.20 ± 4.91	159.62 ± 5.71	>0.05
BMI Kg/m^2	20.08 ± 3.04	20.86 ± 3.17	>0.05

Values expressed in mean ± SD; P values obtained by t-test; BMI: body mass index

Pelvic floor biometry in VD group (n=134) and CS group (n=66) is shown in Table 2. The general clinical data were not significantly different between the two groups (*P*>0.05). On valsalva, the bladder neck mobility presented by the vertical distance from bladder neck to upper margin of symphysis pubis (BSD) in VD group was significantly increase (*P*<0.05) compared with CS group, but there were no significant differences between two groups at rest. Moreover, there was no significant difference of the anorectal angle at rest and on valsalva between two groups.

TABLE 2
COMPARISON OF PELVIC FLOOR BIOMETRY IN VD GROUP (N=134) AND CS GROUP (N=66)

Parameter	VD	CS	*P*
At rest			
BSD	2.417 ± 0.526	2.55 ± 0.423	0.066
ARA	124.641 ± 12.702	129.707 ± 24.660	0.057
LR	3.997 ± 0.406	3.810 ± 0.415	0.005
AP	5.617 ± 0.683	5.212 ± 0.72	0.00
LHA*	16.087 ± 2.668	14.642 ± 2.440	0.00
On valsalva			
BSD	0.7261 ± 0.106	1.392 ± 0.739	0.00
ARA	122.943 ± 18.783	123.457 ± 12.311	0.840
LR	4.554 ± 0.652	4.217 ± 0.523	0.00
AP	6.314 ± 0.894	5.572 ± 0.753	0.00
LHA*	20.663 ± 5.182	17.229 ± 3.60	0.00

Data are presented as mean ± SD and measured in cm or *in cm2. BSD: Bladder neck - symphysis pubis inferior margin distance. ARA: Anorectal angle. LR: Transverse diameters. AP: anteroposterior. LHA: levator hiatal area.

Compared with the CS group, the LR, AP and LHA of levator hiatus in VD group were significantly increased at rest and on valsalva (*P*<0.05).

Observed by three-dimensional (3D) ultrasound system the levator hiatus of postpartum female was oval or circle in shape with compact structure outlined by puborectalis and pubis. Puborectalis formed a symmetrical and continuous V-shaped sling running from the pelvic sidewall towards the anorectal junction. On the ventral side, puboretalis closely attached to the interior edge of the pubic ramus and surrounded the posterior rectum on the dorsal side. In axial plane, urethra, vagina and rectum were observed in a line in ventridorsal orientation inside the levator hiatus with clear boundaries. In this study, no women had levator ani muscle injury at 6-8 weeks after delivery.

IV. DISCUSSION

Since PFD disease attracted obstetrics attention, pelvic floor assessment has been widely applied. A majority of women who have given birth could have different degrees of pelvic floor trauma. Clinically, assessment of levator hiatus and diagnosis of levator trauma are more repeatable when undertaken with the help of imaging. Magnetic resonance imaging (MRI) once dominated the assessment of pelvic floor. However, it suffers a number of shortcomings such as high cost, restricted accessibility, and lack of dynamic imaging ability, unsuitable for women with intrauterine device or cardiac pacemaker. With the emergence of 3D ultrasonography, the study of the levator hiatus has become easier. Rendered 3D volume, with datasets obtained every second, enables visualization of the axial plane and provides good spatial and superior temporal resolution. Apart from that, its low cost, easy accessibility and real-time recording of dynamic changes of pelvic floor make it ideal for the study of morphological and functional alterations of pelvis floor.

During pregnancy and childbirth, changes in the pelvic floor may be anticipated due to hormonal changes, weight of gravid uterus and possible trauma during delivery. For instance, enlargement of the hiatal area, distal movement of bladder neck, cervix and anorectal junction of women in pregnancy advances have been documented. [24] In this study, we further assessed and compared pelvic floor biometry in VD and CS women 6-8 weeks after delivery, reasoning that changes in the pelvic floor due to hormonal alterations would be minimal by that time. We found that the bladder neck mobility of VD group were more than that of CS group on valsalva, but not at rest. Meanwhile, the LR, AP and LHA of levator hiatus in VD group were significantly increased than that in CS group on valsalva and at rest. These results suggested that the pelvic floor function is more harmed by VD than CS. It is accepted that levator avulsion occurred during crowning of the fetal head during VD. [25] Major levator ani defects are associated with a decrease in pelvic floor muscle contraction strength [26] and are a risk factor for levator hiatus "ballooning", which the mechanism is leading to pelvic organ prolapse. Levator avulsion, poor pelvic floor muscle contractility and hiatal ballooning were strong risk factor for recurrence after prolapsed repair. [27]

The bladder neck position became lower during pregnancy, and this could be observed even 6-8 weeks after delivery at rest. [28] Elenskaia et al found significant descent of POP-Q C point 14 weeks and descent of the C point 1 year after delivery as compared to the CS. [29]

The excursion of the anorectal angle (ARA) reflects the relaxation ability of the levator ani muscle. In this study ARA was no significant difference between VD group and CS group. Although most VDs involved episiotomy, it was not associated with mobility of the anorectal junction or perineal body. [30] Costantini et al showed the anorectal angle excursion had decreased significantly by the examination 3 months after birth. [31]

The incidence of pelvic organ prolapsed was obviously higher in women who have undergone VD. Thus, our results showed that the hiatal dimensions in VD group were larger than those in CS group either at rest or on valsalva maneuver, like other studies [18, 32]. It is pregnancy rather than parturition that contributes most to PFD in later life. CS, as the only mode of delivery, is not associated with a significant reduction in most types of pelvic floor morbidity [17, 33]. Six months after first delivery stress and flatus incontinence significantly increased after spontaneous delivery. [34] Other study showed that the risk to develop symptoms of urinary and anal incontinence seems to increase with the first delivery, but seems to stay the same after the second. [35]

According to the literature, levator avulsion is found in 10-36% of women after first delivery. [36] In Falkert et al [37] study, there was a unilateral levator avulsion at the time of the follow-up examination in 18% of the patient with VD, one-third of whom already showed clinical signs of pelvic organ prolapsed. In our study, no women had levator avulsion at 6-8 weeks after delivery.

V. CONCLUSION

1. Changes in the levator ani muscle postdelivery are easily demonstrable on pelvic floor 3D ultrasonography.
2. The hiatal dimensions in VD group were larger than those in CS group at rest and on valsalva maneuver.
3. Pregnancy itself is the most important and independent risk factor for PDF. The women with PDF after delivery need rehabilitative treatment.

Conflict of interest

The authors declare there is no any conflict of interest involved in the paper.

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