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Correlation Between Delivery Mode and Pelvic Organ Prolapse Evaluated by Four-Dimensional Pelvic Floor Ultrasonography

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Background: This study explored symptoms and signs of pelvic organ prolapse (POP) evaluated by 4-dimensional pelvic floor ultrasonography and analyzed the relationship between delivery mode and POP.

Material/Methods: A total of 578 women who underwent 4-dimensional transperineal ultrasound were enrolled in this study. Obstetric history together with other clinical information were gathered from clinical questionnaires and gynecologists. Patients were thereafter classified into 4 groups: women with normal vaginal delivery, women with forceps delivery, women with cesarean, and nullipara women. We assessed symptoms and signs of POP among these 4 groups by use of 2 evaluation methods. The first method was clinical assessment applying International Continence Society (ICS) pelvic organ prolapse quantification (POP-Q). The second method was the use of ultrasonography in the quantification of anterior, middle, and posterior compartment prolapse.

Results: Nulliparae women exhibited the lowest probability of POP (POP-Q: cystocele of 15.6%, uterine prolapse of 11.1%, rectocele of 20.0%; ultrasound exam: 6.7%, 8.9%, 13.3% in sequence), while women with forceps delivery had the highest probability of POP (POP-Q: 59.6%, 50.8%, 63.2% in sequence; ultrasound exam: 45.6%, 52.6%, 42.1% in sequence). Regarding the correlation between POP and delivery mode, the adjusted odds ratio was 2.40 (95%CI: 1.301~4.590) and 3.20 (95%CI: 1.651~6.121) in the normal vaginal delivery group and forceps group, respectively, compared with the cesarean group.

Conclusions: Four-dimensional pelvic floor ultrasonography can be used as a preferred method in evaluating POP. Regarding the relationship between delivery mode and POP, there is a significant correlation between vaginal delivery and POP.

MeSH Keywords: Delivery, Obstetric • Female • Pelvic Organ Prolapse • Ultrasonography

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Background

Pelvic organ prolapse (POP) is a common presenting complaint affecting multiparas' quality of life. POP heavily impairs women's physical and mental health as well as their social activities [1]. In the most severe cases, surgical treatment is inevitable. There is an escalating trend of POP prevalence with the increase of life expectancy. Childbirth plays a pivotal role in the occurrence and development of POP. Epidemiological studies have demonstrated that women with more parities have 2–5 times higher risk of POP, compared with cesarean section [2,3]. Previous studies further pointed out that forceps delivery (FD) might be an independent risk factor for POP, but vacuum extraction does not increase the incidence of POP [4,5]. Magnetic resonance imaging (MRI) was first introduced to evaluate levator ani trauma [6]. The ability to present volumetric analysis allows MRI to explore the spatial link with pelvic anatomic structures. However, the limitation of using MRI is quite obvious, and is not only limited to cost and access issues. Prolapse evaluation by MRI may lose information, since over 50% of all women are not able to perform a proper pelvic floor contraction when required [7]; therefore, a Valsalva maneuver may often be affected by concomitant levator activation. With the capability of real-time imaging, these confounders might be controlled. In the progression of ultrasonography, 4-dimensional ultrasound has emerged as an updated tool in evaluation of the pelvic floor, which enables real-time recording with less cost and better access. Furthermore, a cineloop of 64 volumes is able to contain both a levator contraction and a maximal Valsalva, which allows full storage of a complete assessment of functional pelvic floor anatomy. This allows clinicians to have a better view to describe prolapse in terms of defining functional anatomy.

Therefore, the present study aimed to distinguish various forms of prolapse by clinical examination and 4-dimensional pelvic floor ultrasonography. Furthermore, our work was designed to analyze the correlation between mode of delivery and POP.

Material and Methods

Patients and grouping

This prospective study was approved by the Ethics Committee of Shanghai Pudong New Area People's Hospital. All enrolled patients were informed about the examinations and procedure, and all patients provided informed consent.

From August 2015 to December 2016, 578 patients who underwent transperineal ultrasound were recruited into our study. First, all the patients were required to fill in the clinical questionnaire, including the full obstetric history, as a standardized assessment. Thereafter, the patients were further divided in 4 groups: normal vaginal delivery (NVD), FD, cesarean section (CS), and nullipara (NP). Women in the NVD group experienced at least 1 normal vaginal delivery but without use of forceps. Women in the FD group had at least 1 FD history, successful or not. Women who had only caesarean delivery were grouped as CS section, while women without any delivery experience were considered as the contrast group. All the patients were examined clinically by 1 operator. The operator then applied the pelvic organ prolapse quantification (POP-Q) scoring system of the International Continence Society (ICS) to classify symptoms and signs of POP. According to the POP-Q and POP Symptom Score system [8], the following criteria were used in our study in terms of the distance between the most distal portion (MDP) of prolapse and hymens: POP-Q Stage I demonstrated that the MDP of prolapse is more than 10 mm above the level of hymen, and the MDP of the prolapse situated between 10 mm below or above hymen were rated as POP-Q Stage II. POP-Q Stage III indicated the MDP of the prolapse is more than 10 mm below the plane of the hymen but was not entirely out of the vagina, while POP-Q Stage IV referred to those with complete or almost complete procidentia.

Ultrasound protocol

The patients were examined in the lithotomy position by transperineal 4D ultrasound with an empty bladder. We used the GE Voluson E8/Voluson 730 instrument to evaluate pelvic organ descent on maximal Valsalva maneuver. The machine was equipped with an RRE-6-10 3D volume transducer (6~10 MHz). Images were captured with a wide angle of acquisition, maximum to 85°. Thereafter, offline analysis on the volumetric data was interpreted by 3 independent investigators who were all blinded to the clinical data, using 4DView 10.0 software (GE Kretz Medizintechnik, Zipf, Austria). Two-dimensional images for each prolapse were observed and recorded at rest and at maximum Valsalva. Both the maximum mobility of the bladder neck or the lowest point of the bladder (Figure 1) and the measurement of cervix descent were observed in the sagittal direction, taking the symphysis pubis (SP) as the primary landmark. To assess the change in the vagina and rectum, the extent of rotation was measured by comparing the angle of inclination between the proximal urethra at rest and during maximal Valsalva maneuver. By rotating the probe 90°, the operator observed both internal and external anal sphincter in a sagittal view to evaluate the avulsion status of both left and right levator ani muscles on the condition of patient's anal contraction. Meanwhile, a 3D acquisition system was initiated for obtaining images to observe the degree of levator hiatus and the condition of the levator ani muscle (Figure 2). In addition, tomographic ultrasound imaging (TUI) was applied in assisting to evaluate levator avulsion (Figure 3) and was performed on maximal levator contraction. Thereafter, the clinician used the

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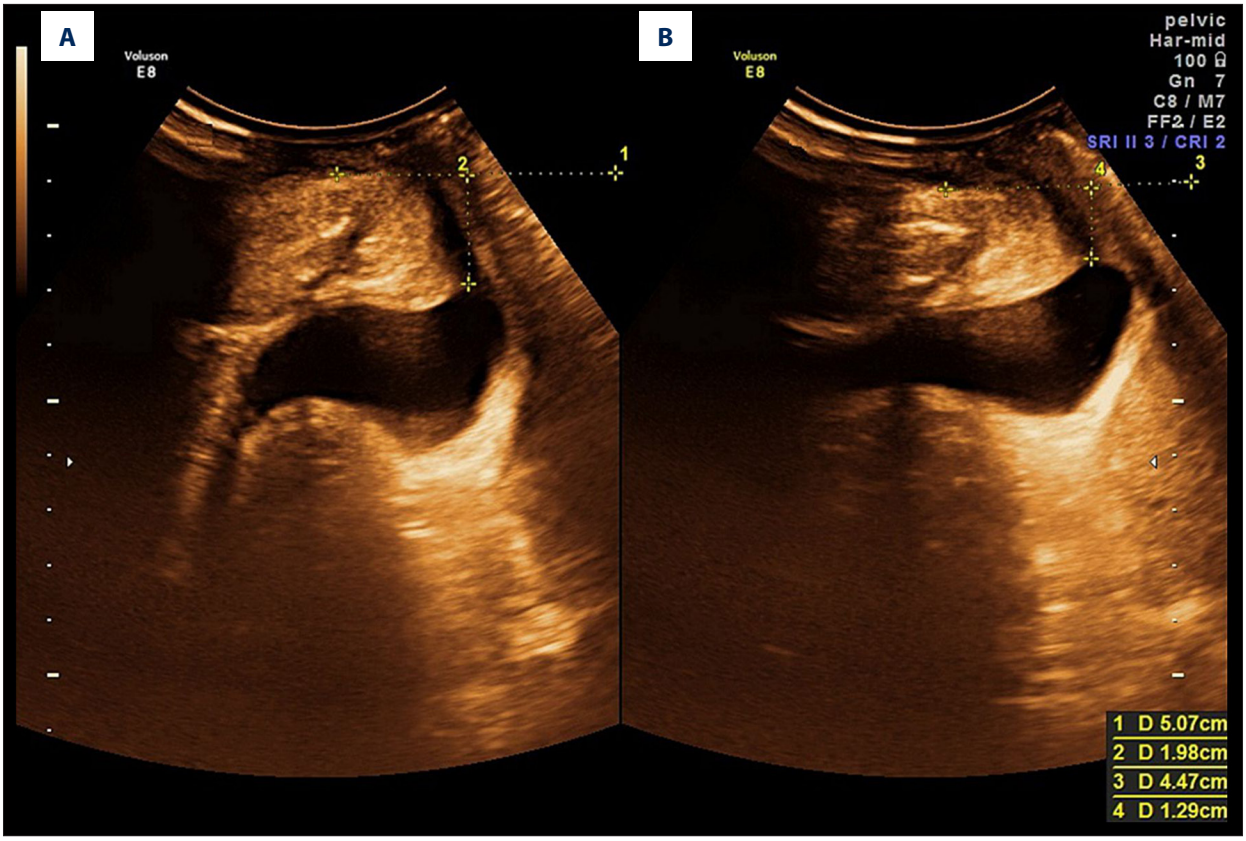

Figure 1. Bladder descent at rest (**A**) and at maximum Valsalva (**B**).

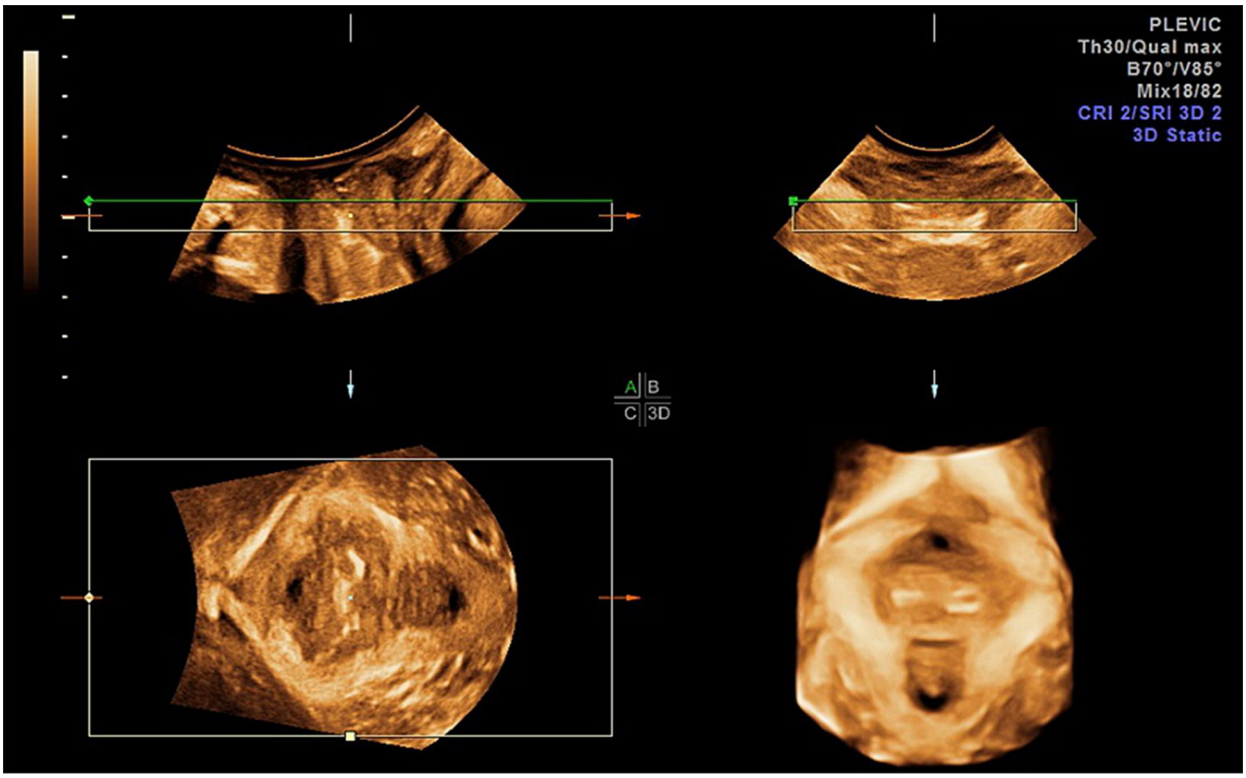

Figure 2. Three-dimensional imaging of levator hiatus.

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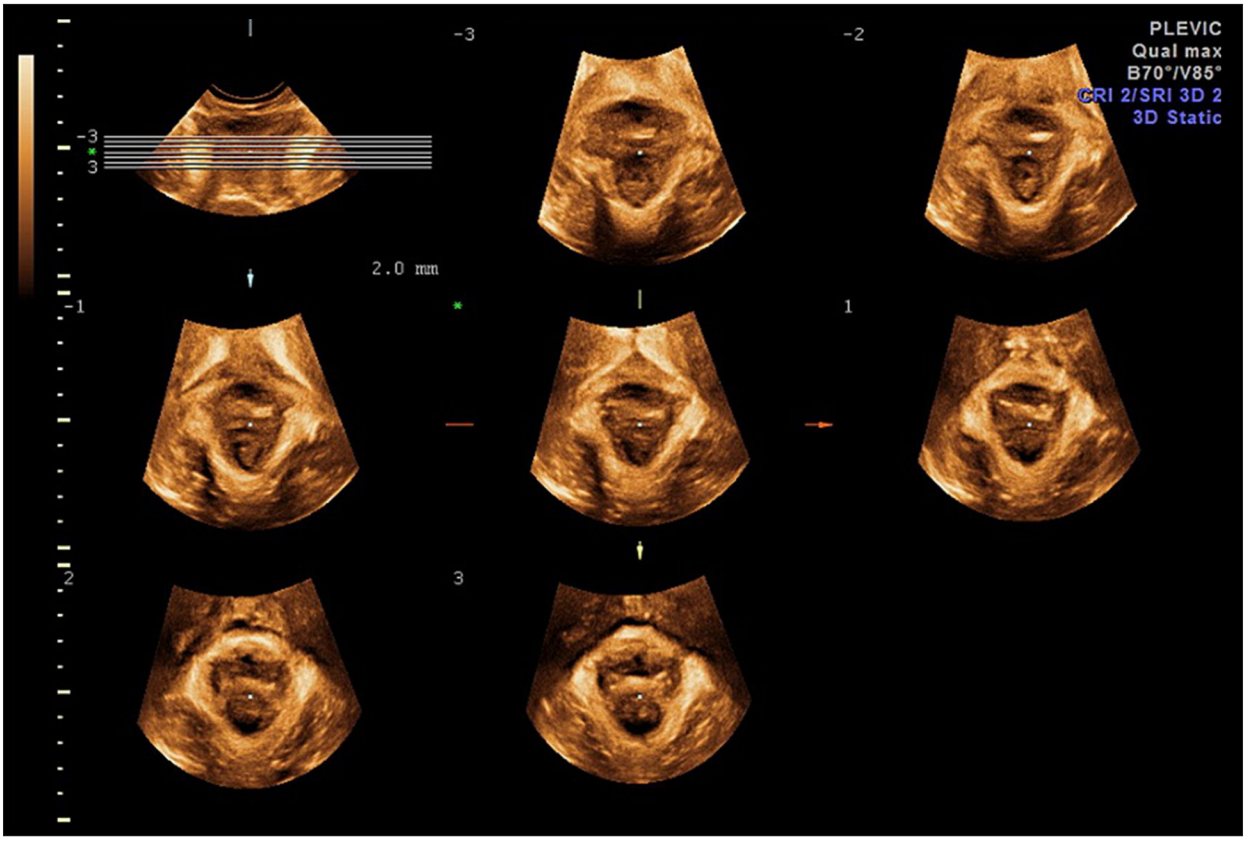

Figure 3. TUI of levator hiatus.

inferior margin of the SP as a reference line to interpret volumetric data of the levator avulsion based on that imaging. For instance, in a 3D plane, complete avulsion was identified when the tearing of the attachment of the inferior of SP occurred. All of the aforementioned anterior, middle, and posterior POP were evaluated by 4D pelvic floor ultrasonography by taking the POP-Q into consideration, meaning that the patients were further allocated into 3 categories by ultrasound assessment [8]: cystocele to at least 1 cm below the SP, uterus descent to ≤1.5 cm above the SP, and rectal ampulla descent to ≥1.5 cm below the SP.

Statistical analysis

The measured parameters are presented as mean positive and negative standard deviation ($\bar{\chi}\pm s$). The chi-squared, chi-squared for trend, and Mann-Whitney *U* test were used for univariate analyses. Logistic regression analysis was used to determine the association between delivery mode, parity, and POP after controlling for confounding factors. Odd ratios (OR) and 95% confidence intervals (95% CI) are presented. Statistical analysis was performed using SAS v9.2 (SAS Institute, NC, USA) software. P<0.05 was considered statistically significant.

Results

Patient characteristics and modes of delivery

Of the 613 women selected, 35 were excluded: 33 of them lacked ultrasound volumetric data and the remaining 2 lacked delivery information. Therefore, a total of 578 women (age range, 27–89 years; mean age, 56±13.7 years) were enrolled in this study. The average body mass index (BMI) was 29.2±6.3 kg/m^2, ranging from 15.1 to 34.7 kg/m^2. Vaginal delivery occurred in 379 out of 578 women (65.6%), including 57 women (9.9%) who experienced at least 1 forceps delivery, 154 patients (26.6%) had caesarean section, and the remaining 45 (7.8%) were nulliparous women (Table 1).

The occurrence rate of POP evaluated by POP-Q

The POP-Q evaluation results demonstrated that there was a significant difference among the 4 groups (p<0.01). The rates of occurrence of cystocele, uterine prolapse, and rectocele in both NVD and FD groups were higher than those of the NP group and CS group (p<0.01, Table 2).

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Table 1. Characteristics and delivery modes of the patients.

Characteristic	NP (n=45)	CS (n=154)	NVD (n=322)	FD (n=57)	*P*
Age/year ($\bar{\chi}$±s)	46.4±19.7	50.6±12.5	57.1±13.3	57.5±12.3	<0.001
Menopause	49.1	52.6	63.1	67.4	<0.001
BMI/(kg·m^{-2}) $\bar{\chi}$±s	27.3±6.2	29.5±6.7	29.1±6.2	29.2±6.2	0.4
Median delivery times (range)	0	2 (1~4)	3 (1~9)	2 (1~8)	<0.001

Table 2. The occurrence rate of POP evaluated by POP-Q.

Category	NP (n=45)	CS (n=154)	NVD (n=322)	FD (n=57)	*P*
Cystocele	7 (15.6)	37 (24.1)	191 (59.3)*#	34 (59.6)*#	<0.01
POP-Q Stage I	6 (85.7)	7 (18.9)	49 (25.7)	3 (8.8)	
POP-Q Stage II	1 (14.3)	21 (56.8)	87 (45.5)	9 (26.5)	
POP-Q Stage III	0 (0.0)	9 (24.3)	49 (25.7)	21 (61.8)	
POP-Q Stage IV	0 (0.0)	0 (0.0)	6 (3.1)	1 (2.9)	
Uterine prolapse	5 (11.1)	10 (6.4)	150 (46.5)*#	29 (50.8)*#	<0.01
POP-Q Stage I	5 (100.0)	4 (40.0)	76 (50.7)	2 (6.9)	
POP-Q Stage II	0 (0.0)	6 (60.0)	38 (25.3)	7 (24.1)	
POP-Q Stage III	0 (0.0)	0 (0.0)	29 (19.3)	19 (65.5)	
POP-Q Stage IV	0 (0.0)	0 (0.0)	7 (4.7)	1 (3.4)	
Rectocele	9 (20.0)	37 (24.0)	176 (54.6)*#	36 (63.2)*#	<0.01
POP-Q Stage I	7 (77.8)	28 (75.7)	83 (47.2)	1 (2.8)	
POP-Q Stage II	2 (22.2)	8 (21.6)	69 (39.2)	29 (80.6)	
POP-Q Stage III	0 (0.0)	1 (2.7)	19 (10.8)	5 (13.9)	
POP-Q Stage IV	0 (0.0)	0 (0.0)	5 (2.8)	1 (2.8)	

* Compared with NP, P<0.01; # compared with CS, P<0.01.

The rate of occurrence of POP and other POP-related parameters evaluated by ultrasound

Women who experienced normal vaginal delivery or forceps delivery had much worse bladder neck descent than those in the NP group and CS group. The same results were also acquired in terms of urethra rotation angle and bladder bulging distance. All *p* values were less than 0.01. Noticeably, women with any forceps delivery had the highest severity of bladder neck descent and the widest angle of urethra rotation, compared with women in the other 3 groups ($p<0.01$). Similarly, ultrasound examination indicated that women in the NVD group and FD group had higher rates of cystocele, uterine prolapse, and rectocele than those in the NP group and CS group ($p<0.01$, Table 3).

POP correlation analysis

In single-variable analysis, age, menopause, parity, and POP surgery history of women in the 4 groups were statistically different. The risk of POP was in an ascending order, from NP group, CS group, NVD group, to FD group. There was a significant difference between non-vaginal delivery groups (NP group, CS group) and vaginal delivery groups (NVD group and FD group). Regarding the correlation between POP and delivery mode, the OR of the NDV group and FD group were 2.40 (95%CI: 1.301~4.590) and 3.20 (95%CI: 1.651~6.121), respectively, compared with that of the CS group. When we compared women in the NVD group with those in the FD group, we found that the visual analogue scale (VAS) scores of women who had a forceps delivery was higher than 3 (OR=1.31; 95%CI: 1.041~1.740), indicating that women who had any forceps delivery were more likely to develop any prolapse symptoms compared to those who had a normal vaginal delivery (OR=1.30; 95%CI: 1.011~1.711).

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Table 3. POP parameters and occurrence rate by ultrasound exam.

Parameters	NP (n=45)	CS (n=154)	NVD (n=322)	FD (n=57)	*P*
Distance of bladder neck descent l/mm $\bar{\chi}$±s	22.15±3.58	23.06±4.06	33.92±4.17*#	36.12±5.59*#@	<0.01
Angle of urethra rotation l/mm $\bar{\chi}$±s	132.90±16.76	138.62±18.12	161.80±20.69*#	178.19±19.65*#@	<0.01
Distance of cystocele l/mm $\bar{\chi}$±s	11.35±4.01	11.51±3.76	23.89±3.71*#	24.01±4.51*#	<0.01
Cystocele, n (%)	3 (6.7)	20 (13.0)	142 (44.0)*#	26 (45.6)*#	<0.01
Uterine prolapse, n (%)	4 (8.9)	13 (8.5)	157 (48.8)*#	30 (52.6)*#	<0.01
Rectocele, n (%)	6 (13.3)	40 (25.9)	135 (42.0)*#	24 (42.1)*#	<0.01

* Compared with NP, P<0.01; # compared with CS, P<0.01; @ compared with NVD, P<0.01.

Discussion

Our study results confirmed that parity history is strongly associated with POP symptoms and signs. Women who had vaginal delivery were twice as likely to develop POP than those who had non-vaginal delivery. In addition, the rate of women who had forceps delivery was further increased. Clinical assessment or ultrasound examinations discovered that the probability of severe prolapse in those who had vaginal delivery was 3–6 times higher than that of caesareans. In terms of the 3 compartments prolapse, bulging bladders and uterine prolapse were most pronounced.

According to our research, vaginal delivery, especially with forceps, was an independent risk factor for POP. Similarly, a cohort study of women with vaginal delivery in the United States found the probability of prolapse in women with a forceps-delivery history nearly doubled after the first delivery within 5 to 10 years. Compared with cesarean delivery only, vaginal delivery is a major risk factor, doubling the likelihood of POP occurring 20 years later. Vaginal birth has been widely accepted as a crucial factor in the occurrence of POP [10]. However, it was only recently that researchers begun to understand the mechanisms leading to the prevalence of POP according to delivery mode. It is difficult to diagnose fascia and nerve trauma in a non-invasive manner, but it is feasible to evaluate pelvic floor muscles by pelvic ultrasound. In the process of vaginal delivery, crowning of the fetal head can lead to partial or complete detachment of levator avulsion. In other words, puborectalis muscle avulsion occurred due to its insertion on the pelvic sidewall, leading to enlargement of the levator hiatus [11]. Forceps delivery, compared to vacuum delivery or NVD, increases pelvic floor trauma because it may require greater space, faster expansion, and stronger force [12]. We attributed the finding that women with a history of forceps delivery tended to have complete levator ani muscle tear to ultrasound exam, compared with those with normal vaginal deliveries. However, that was not the case for caesareans. Tearing is considered as an early indicator of pelvic floor injury in the assessment of obstetric risk factors. The ultrasound assessment for primiparae detected that 13% of women who delivered vaginally or vacuum-assisted suffered complete avulsion, whereas women with caesarean section did not. In our 4D ultrasound examination, the likelihood of having any type of prolapse (cystocele, uterine prolapse, or rectocele) was significantly higher in women with vaginal delivery with or without forceps. For instance, 44.0% of the women with normal vaginal delivery were found to have cystocele, while only 13.0% of women with caesarean had this defect. Furthermore, forceps delivery more than triples the risk of levator ani muscle trauma [13]. Such findings have been reported by many researchers [14–16]. The present study indicates a substantial link between delivery mode and POP prevalence. Previous epidemiological evidence fully supports the role of vaginal delivery in the etiology of POP. Compared with CS, there was an increasing risk of prolapses in the 3 compartments after vaginal delivery. In addition, forceps delivery can further trigger levator avulsion and POP.

Conclusions

Four-dimensional pelvic floor ultrasonography has been widely applied in clinical practice for observing the pelvic floor. The ability to perform a real-time 4D assessment of pelvic floor structures enables the technique to be used as a preferred method in evaluating POP. Not only does it provide accurate functional morphological information, it also enables a non-invasive diagnosis of POP for postpartum women. Its ability to provide real-time acquisition of volume ultrasound data and saving cineloops of volumes is of major importance in pelvic floor imaging. In terms of the correlation between delivery mode and POP, vaginal delivery is significantly correlation with POP.

Conflicts of interest

None.

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