The diagnostic value of four-dimensional ultrasound examination of perineum in the diagnosis of postpartum pelvic floor dysfunction

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Abstract. Objective to explore the diagnostic value of perineal four-dimensional ultrasound (4D-US) in postpartum pelvic floor dysfunction (PFD) disease. 328 postpartum PFD patients diagnosed by clinical pelvic floor palpation from June 2018 to December 2020 were selected as the PFD group, and 328 patients without PFD were selected as the control group. All participants underwent perineal 4D-US, the indicators were statistically analyzed. The results showed that the LAT of left and right, LHLR, LHAP, LHA, resting state and holding the breath in the PFD group were higher than those in the control group, and the difference was statistically significant (P<0.05). From cervix to lower margin of pubic symphysis, bladder to lower margin of pubic symphysis of the pubic symphysis, and from the ampulla of the rectum to the lower margin of the pubic symphysis, the PFD group was larger than the control group, but the result of urethral rotation was reversed, and the difference was statistically significant (P<0.05). The morphologic features of the levator ani muscle and pelvic fissure can be detected early using 4D-US, which is a reliable technique that can be learned in a short period of time.

1 Instructions

Pelvic floor dysfunction (PFD) is a disease caused by the damage, degeneration, defect or dysfunction of the pelvic support structure. Among them, natural delivery through the vagina is an independent risk factor for PFD that causes varying degrees of damage to the pelvic floor support tissue [1-2]. In the past, finger palpation was mainly used in PFD examinations in clinical practice, but this method cannot completely touch the pelvic floor lesions and cannot guarantee the accuracy of the examination. In recent years, with the continuous development and improvement of ultrasound technology, the use of ultrasound to examine the pelvic floor structure after childbirth has the advantages of non-invasive, simple operation, and high repeatability. It also helps to clarify the pelvic floor tissue damage in time and guides the pelvic floor as soon as possible after childbirth. Functional training provides a reference basis and is of great significance for preventing the occurrence of PFD [3-4]. Transperineal ultrasound has been shown to be a valid, reliable and non-invasive tool for the assessment of pelvic floor morphometry, assessment of the pelvic floor by four-dimensional ultrasound (4D-US) and its application to pelvic pain syndromes constitute a new area of investigation. The purpose of this study was to explore diagnostic value of 4D-US to diagnose postpartum PFD, and the results can provide a reliable basis for clinical investigation of female pelvic floor abnormality and guidance of pelvic floor rehabilitation.

2 Materials and methods

2.1. General materials

328 postpartum PFD patients diagnosed by clinical pelvic floor palpation from June 2018 to December 2020 were selected as the PFD group, aged 22-39 years, with an average age of (29.65±2.21) years. The gestational week at delivery was 37-40, with an average gestational week of (38.87±1.32). The newborn weight was 2832-4763 g, and the average weight was (3785.23±145.86) g. In addition, 328 patients without PFD who underwent postpartum physical examination in our hospital during the same period were selected as the control group, aged 21-40 years old, with an average age of (28.68±2.76) years. The gestational week at delivery was 37-41, and the average gestational week was (38.72±1.36). The weight of the newborn is 2794-4599g, and the average weight is (3691.77±141.32) g, this study was approved by the ethics committee. There was no statistically significant difference in general data between the two groups (P>0.05).

2.2 Inclusion criteria

Patients who were compliant to fill out with vaginal delivery firstly, and single pregnancy in head position

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were included to the study. Besides, in addition to the originally described that the 42-70d postpartum lochia has been drained, with no urinary system and vaginal inflammation, and signed informed consent. Exclusion criteria were determined with liver, kidney, heart, lung dysfunction. In addition, the multiple births, history of induction of labor in the middle and late pregnancy, PFD occurred before pregnancy, lack of case data, mental disorders, and who could not complete the study also excluded.

2.3 Methods

All participants underwent perineal 4D-US examination, using the Voluson E8 color Doppler ultrasound system produced by GE in the United States to examine the patients. On the 42nd day after delivery (non-menstrual period), the pelvic floor tissues of all participants were examined and measured. Before the examination, the participants were asked to empty their bladder, take the bladder lithotomy position, and put a disposable condom on the outside of the volume probe, both inside and outside. The layers are fully coated with a sufficient amount of couplant and placed on the vulva of the participant. Two-dimensional and 4D-US images were collected and saved at rest and breath-holding, all image data were exported to the ultrasound imaging workstation, and the 4D View off-machine analysis software was used to reconstruct the relevant data. In addition, evaluate the distance between the cervix and the bladder neck and the movement of the bladder neck during resting and breath-holding force, and measure the left and right diameters of the pelvic diaphragmatic hiatus (LHLR), anteroposterior diameter (LHAP), area (LHA), and left and right levator ani muscle thickness (LAT). And so on, take the average after measuring 3 times.

2.4 Observation indicators

(1) Analyze the characteristics of the two groups of transperineal 4D-US ultrasound images. (2) Compare the two groups at rest and hold the breath during LHLR, LHAP, LHA, left and right LAT, etc. (3) Compare the two groups, the distance from the cervix to the lower edge of the symphysis pubis, the degree of urethral rotation, the distance from the bladder to the lower edge of the symphysis pubis, the distance from the ampulla of the rectum to the lower edge of the symphysis pubis.

2.5 Statistical methods

Statistical software SPSS22.0 was used for the analysis. The count data (results of ultrasonic contrast and endoscopic ultrasonography) were expressed by "$\overline{x}$ ±s" and tested by t test, P<0.05 means that the difference is statistically significant.

3 Results

3.1 Ultrasound imaging characteristics

The PFD group can be seen by perineal 2D-US. In the resting state, it clearly shows that the pelvic diaphragm hiatus is irregular rhombus, and the structure of the rectum and vagina can be seen, but the arrangement is loose and scattered, and the echoes of the left and right puborectalis are asymmetric. The above characteristics are more obvious when holding your breath and exerting force. In the control group, 2D-US examination of the perineum showed that the pelvic diaphragm hiatus was rhomboid in the resting state, and the rectum and vagina were compact and neatly arranged. The left and right sides of the puborectum and echo were continuous and symmetric. The structure of the vagina, rectum, and urethra when the breath was held. The display is clearer, the arrangement is loose, the left and right puborectalis muscles bulge outwards, and there are more echoes in the levator ani hiatus.

Before the observation of resting state and valsva state in the control group (Fig.1), the posterior chamber of bladder neck was in the normal range, the posterior angle of bladder was intact, there was no voice image of bladder bulge and no uterine prolapse. Before and after the observation of resting and valsva state in the PFD group, the bladder neck movement was increased, the small funnel formed in the urethral orifice, the bladder was obviously dilated, and the uterus was obviously prolapsed (Fig.2).

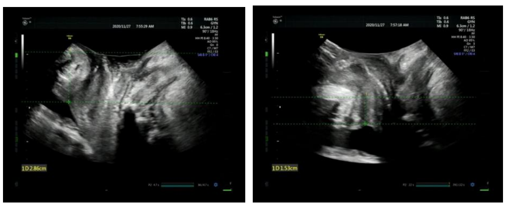

Fig. 1 The resting state and valsva state of control group

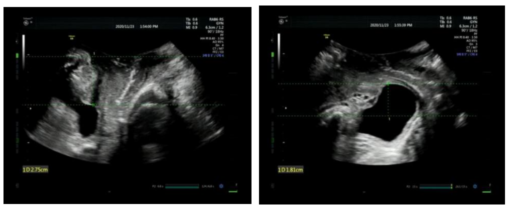

Fig. 2 The resting state and valsva state of PFD group

3.2 Comparison of the levels of indicators in resting state and breath-holding force

In PFD group, the resting state and breath-holding force LHLR, LHAP, LHA, left LAT, and right LAT were all greater than those of the control group, and the difference was statistically significant (P<0.05). Specific results were shown in Table 1.

Tab.1 Comparison of each index level in resting state and breath holding force between the two groups（ $\bar{x}$ ±s）

Condition	Group	LHLR（cm）	LHAP（cm）	LHA（cm^2）	LAT/Left（mm）	LAT/Right（mm）
Resting state	PFD（n=328）	4.15±0.36	5.31±0.46	17.55±2.34	6.13±0.34	6.26±0.41
	Control（n=328）	3.42±0.32	4.77±0.39	15.05±1.97	5.88±0.32	5.88±0.29
	t	8.666	10.373	7.352	4.851	5.823
	P	0.000	0.000	0.000	0.000	0.000
Breath holding	PFD（n=328）	4.87±0.47	5.85±0.70	22.36±3.31	7.45±0.52	7.68±0.46
	Control（n=328）	4.26±0.41	5.22±0.33	18.34±2.67	6.51±0.43	6.67±0.39
	t	8.915	8.166	8.312	12.136	13.372
	P	0.000	0.000	0.000	0.000	0.000

3.3 Comparison of clinical index levels

In the PFD group, the distance from the bladder neck to the lower edge of the pubic symphysis ($\triangle D_1$), the distance from the lower edge of the cervix to the pubic symphysis ($\triangle D_2$), and the distance from the rectal ampulla to the lower edge of the pubic symphysis ($\triangle D_3$) were larger than those of the control group, and the urethral rotation was smaller than that of the control group. P<0.05). Specific results were shown in Table 2.

Tab. 2 Comparison of clinical indexes between the two groups（ $\bar{x}$ ±s）

Group	Urethral rotation (°)	$\triangle D_1$ (mm)	$\triangle D_2$ (mm)	$\triangle D_3$ (mm)
PFD（n=328）	34.66±4.16	26.72±3.25	28.85±4.32	15.51±3.37
Control（n=328）	47.99±3.67	13.37±3.11	7.43±1.27	6.52±2.19
t	19.915	21.382	40.516	18.863
P	0.000	0.000	0.000	0.000

3.4 4D-US imaging of perineum

4D-US imaging of perineum were shown in Fig.1, which can be observed that foramen area of levator ani muscle was normal in VALSVA group without pelvic floor dysfunction, the structure of urethra, vagina and rectum was clear and compact (Fig.3A). During the pelvic floor dysfunction group, the area of the foramen of the levator ani muscle increased VALSVA the movement, and the structure of urethra, vagina and rectum was clear and loosely arranged (Fig.3B).

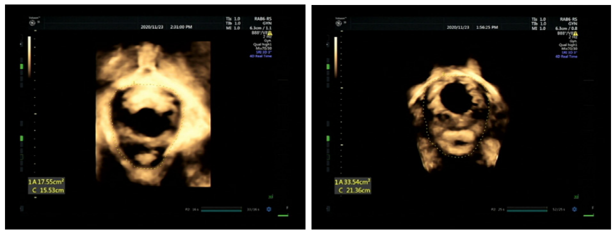

Fig. 3 4D-US imaging of control group(A) and PFD group(B)

With 4D-US, it is also possible to obtain tomographic ultrasound imaging (TUI), through the TUI technique that reproduces pelvic floor "slices". Fig. 4 shows an image of the anal sphincter in a 20-year-old patient with mild pelvic floor dysfunction. The image in the upper left corner is the reference slice in the coronal plane. The other eight images represent axial planar slices obtained at 2.5 mm intervals. Fig. 5 shows the levator ani muscle in a patient with severe basin dysfunction.

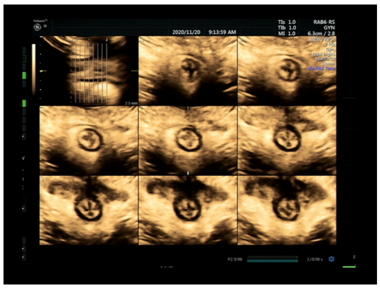

Fig. 4 Tomographic ultrasound imaging of the anal sphincter obtained by 4D-US.

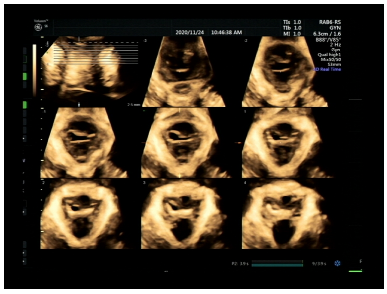

Fig. 5 Tomographic ultrasound imaging of the levator ani muscle obtained by 4D-US.

4 Discussion

The support system of the female pelvic floor structure is pelvic connective tissue and pelvic floor muscles. During vaginal delivery, mechanical degeneration of the pelvic floor tissue will affect the pelvic floor connecting tissue and muscle support structure. In severe cases, the pelvic floor support tissue will occur. Different degrees of damage make the pelvic floor support system function decline, and PFD eventually occurs. Although magnetic resonance imaging can obtain definite clinical effects in the diagnosis of pelvic floor diseases, the examination cost is relatively high and it is not suitable for postpartum use [5-6]. Studies have shown [7-8] that 4D-US imaging is a brand-new ultrasound examination technology. Real-time volume data can be obtained through ultrasound examination, which can comprehensively observe human tissues and organs, and observe the image information of resting and breathing force. The evaluation of the bottom function has been gradually applied to the diagnosis of clinical diseases.

The results of this study showed that the LHLR, LHAP, LHA, the left LAT and the right LAT in the resting state and breath-holding force in the PFD group were greater than those in the control group. The distance from the lower edge and the distance from the rectal ampulla to the lower edge of the symphysis pubis are larger than those of the control group, and the degree of urethral rotation is smaller than that of the control group, indicating that there is a close relationship between the morphological changes of the pelvic diaphragm and levator ani muscle and PFD, and for PFD patients, abnormal function of bladder neck and urethra supporting structure can be used as an important basis for clinical diagnosis of PFD. Analysis of the reasons shows that LHLR, LHAP, LHA, the left and right LAT are the main morphological features of the levator ani muscle and pelvic diaphragm hiatus, which can fully reflect the changes in the pelvic floor structure of the patient. During vaginal delivery, the fetus is delivered through the pelvic diaphragm hiatus, which causes excessive stretching and expansion of the pelvic floor muscles, which destroys the integrity of the pelvic diaphragm hiatus, showing large LHLR, LHAP, and LHA [9-11]. In addition, due to the damage of the pelvic floor muscles, the body's defensive repair and reflex, the left and right LAT increases. Therefore, the use of transperineal 4D-US can reconstruct the plane of the levator ani muscle hiatus, present the complex pelvic floor structure in a more intuitive and three-dimensional manner, and measure the scope of the puborectal muscle tear, which is beneficial to assess the severity of pelvic floor dysfunction and improve it. Diagnostic value [12-13].

Of course, it should be pointed out that this study has some following limitations. First, the small sample size of the control and PFD groups may lead to insufficient accuracy of diagnostic criteria. Second, we did not monitor the weight gain or abdominal circumference changes during pregnancy in the two groups. Furthermore, the number of subjects in different groups with different ultrasound PFD results did not exactly match, this will lead to unreliable results to some extent [14]. In the future, we hope to obtain more clinical samples and use univariate and multivariate linear regression models for association analysis to find key indicators.

5 Conclusion

According to the description above, 4D-US has major potential advantages when it comes to describing prolapse, especially when associated with fascial or muscular defects, and in terms of defining functional anatomy. The ability to perform a real-time 4D assessment of pelvic floor structures makes pelvic floor ultrasound superior to Magnetic Resonance Imaging (MRI) for this application. 4D-US is clinically valuable, reasonable, allows morphological and dynamic evaluation of function of PFD in women with pelvic floor dysfunction symptoms, it can provide visual biofeedback for teaching patients how to contract pelvic floor muscles, for teaching and training healthcare providers in palpation, and improvement of a clinically applicable scale for pelvic floor muscle contraction. The 4D-US is noninvasive, and which is the simplest, cheapest and most widely used imaging. 2D-US can detect the discontinuity between the high echo fiber of puborectalis muscle and the pelvic lateral wall to diagnose levator ani avulsion. However, the reproducibility of these findings is not as good as that of 4D-US.

In summary, transperineal 4D-US has a high clinical application value in the diagnosis of PFD diseases. In addition, 4D-US can be used for early diagnosis of PFD patients and give corresponding training intervention, which provides reference for clinical diagnosis and intervention, and is worthy of popularization and application.

Acknowledgments

Thanks for the financial support of the Science & Technology Planning Projects of Zhanjiang City, China (Grant No. 2020B01052). Acknowledgement to Dr. Xinghao Tu in HistoIndex for proof reading and editing.

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