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Original Article

Efficacy of 3D ultrasound on diagnosis of women pelvic flour dysfunction

Aifang Chen[1*], Yingzi Zhang[2*], Chunju Lv[1], Jiajun Zhang[1], Hongzhen Liu[2]

Departments of [1]Ultrasonography, [2]Obstetrics, Affiliated Hospital of Taishan Medical College, Tai'an, China. [*]Equal contributors.

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Abstract: Pelvic flour dysfunction (PFD) is one common disease in females and severely affects health and life quality. 3D ultrasound is applied due to its high accuracy and consistency, and can better reveal anatomical structure and functional alternation of body tissues and organs. This study thus investigated the morphological feature of female PFD patients using 3D ultrasound with its clinical significance. A total of 40 PFD patients admitted were enrolled in this study, in parallel with 20 cases with benign diseases as the control group. 3D ultrasound examination revealed sonogram of all patients to check the prolapse of pelvic organs. In specific, the size and area of pelvic diaphragm, and thickness of puborectalis were observed. Control patients had symmetric bilateral puborectalis, rhombic diaphragm with complete structure. PFD patients, including both natural labor and caesarean birth, had organ prolapse to different extents, as shown by higher downward of bladder neck, rotation angle of urinary tract, gall bladder bulge, incidence and distance of uterus or rectal prolapse compared to control ones ($P<0.05$). The diameter and area of diaphragm were higher than control group during all phases, while thickness of musculi levator ani was lower than control group ($P<0.05$). Those indexes were better in natural delivery over caesarean birth ($P<0.05$). 3D ultrasound to observe female PFD can better illustrated structure morphology, as it can measure the diameter and size of pelvic diaphragm, all of those provide evidence of PFD diagnosis.

Keywords: 3D ultrasound, pelvic flour dysfunction, natural deliver, caesarean birth

Introduction

Pelvic flour dysfunction (PFD) is one common disease in females and severely affects health and life quality. The incidence of PFD is over 40% in middle age to elder women, and has become one major public health issue [1]. Features of PFD include prolapse of pelvic organs and urinary incontinence. PFD patients are often manifested with vaginal wall prolapse, urinary incontinence, and uterine prolapse. Those symptoms are due to the weakening of supporting force at pelvic floor, causing abnormal localization of pelvic organs, whose functions were thus disrupted [2]. 3D ultrasound has now been widely applied in clinics with advantages including precise location, less radiation, and satisfactory consistency, providing dynamic images reflecting anatomical structure and functions of pelvic organs [3]. Previous study has shown that 3D ultrasound could effectively observe the anatomical structure and functional alternation of musculus levator anita and reproductive hole, whose diameter line length can be precisely measured [4]. This study selected PFD patients admitted in our hospital, and observed the morphological changes at acute stage by 3D ultrasound, in an attempt to provide complete evidences for diagnosing PFD.

Materials and methods

General information

A total of 40 PFD patients admitted in Affiliated Hospital of Taishan Medical College from January 2014 to January 2015 were recruited in this study. Patients were aging between 35 and 75 years old, with average age at (51.2±4.6) years old. All participants were primipara, including 22 cases of natural delivery and 18 cases of caesarean birth. All patients had no history of PFD or pregnancy complications. The

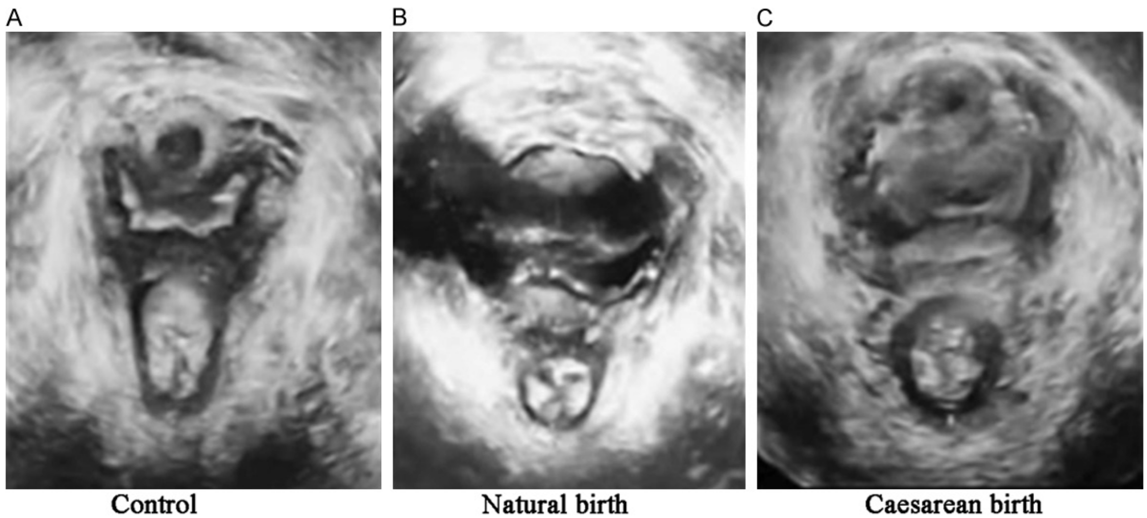

Figure 1. 3D ultrasound images of all patients.

recovery of uterine after surgery was satisfactory. Another cohort of 20 females with benign gynecologic disease in our hospital were recruited as the control group. They were aging between 30 and 70 years old, with average age at (49.7±4.8) years old. No significant difference can be observed regarding sex or age between two groups (P>0.05), which were therefore comparable.

The study protocol was approved by the Research Ethics Committee of Affiliated Hospital of Tashan Medical College, and all patients gave their informed consent before study commencement.

Exclusive criteria: Patients with: (1) Pelvic organ disease; (2) Urine incontinence; (3) Neural disease; (4) Pelvic surgery or lesion; (5) Inflammation of urinary-reproductive tract.

Equipment

3D ultrasound equipment (Voluson) was produced by GE Healthcare (US), and was equipped with 3D volume probe (model RIC5-9-D and RAB4-8-D) at 4~8 MHz with 2D emission angle at 146° or 70°, and swig angle at 135° or 85° (5° stepwise).

Experiment protocol

All patients had emptied bladder and rectum before examination, and were placed in lithotomy position. Couplant was applied on the surface of the probe, which was placed between urethral orifice and vaginal orifice to reveal pubic symphysis, the connection part of rectal and anal canal and sagittal section of urinary tract. 2D ultrasound was use to observe the prolapse of pelvic organs at still or motion. 3D imaging system was then initiated to reveal pubic symphysis, internal muscles of bilateral pubis, urinary tract, vaginal and rectum, for measurement at the plane.

Observable indexes

3D ultrasound images of natural birth, caesarean birth and control patients were obtained to include bilateral pubis, rectal muscles, vagina and pelvic diaphragm hiatus.

The prolapse condition of pelvic organs in all patients was tested, including the downward distance of bladder neck in anterior pelvic cavity, the turning angle of urinary tract, expansion distance of bladder, incidence and distance of uterine prolapse in middle pelvic cavity, and incidence of prolapse and distance of rectum in posterior pelvic cavity.

The anterior/posterior diameter, transverse diameter, area and thickness of levator ani muscle were also observed and compared between groups.

Statistical analysis

SPSS17.0 software was used to process all collected data, which were presented as mean ±

Table 1. Prolapse of pelvic organs

Index	Experimental group		Control
	Natural birth	Caesarean birth	
Prolapse of anterior pelvic organs			
Downward distance of bladder neck (mm)	33.27±12.21*,#	28.78±9.82#	3.26±1.12
Turning angle of uterine tract (°)	61.47±22.24*,#	46.25±16.12#	2.89±1.44
Expansion distance (mm)	23.13±15.26*,#	11.02±5.67#	2.92±1.31
Middle pelvic cavity (uterine prolapse)			
With prolapse/expansion (N)	6*,#	12#	18
Without prolapse/expansion (N)	16*,#	6#	2
Expansion distance (mm)	16.24±9.05*,#	7.64±3.35#	2.02±1.26
Posterior pelvic cavity (rectal expansion)			
With prolapse/expansion (N)	8*,#	11#	19
Without prolapse/expansion (N)	14*,#	7#	1
Expansion distance (mm)	15.54±4.78*,#	13.28±3.89#	1.97±0.78

Note: *, P<0.05 compared to caesarean birth group; #, P<0.05 compare to control group.

standard deviation. Measurement data were analyzed by analysis of variance (ANOVA) and were compared by LSD test. Enumeration data were compared by chi-square test. A statistical significance was defined when P<0.05.

Results

3D ultrasound images of patients

Control people had an "H"-shape vagina, with symmetric and continuous bilateral puborectal muscle to form bilateral and posterior edge of pelvic diaphragm hiatus in a "U"-shape. The area of pelvic diaphragm hiatus was small and in complete structure rhombus shape (**Figure 1A**).

Patients with natural birth had curved bilateral puborectal muscles with large arch. Asymmetric puborectal muscles had interruption, with collapse of vagina in some patients. The area of pelvic diaphragm hiatus was large, with loose structure and atypical morphology. Severe patients may develop the absence or abnormal morphology of pelvic diaphragm hiatus (**Figure 1B**).

Patients undergone caesarean birth had symmetric and continuous bilateral puborectal muscle, with collapse of vagina in some patients. The lack of "H"-shape structure was accompanied with small pelvic diaphragm hiatus, which had relatively complete structure and rhombus-like shape (**Figure 1C**).

Prolapse of pelvic organs

We further compared to condition of pelvic organ prolapse in all groups. Results found the occurrence of pelvic organ prolapse in both natural birth and caesarean birth group. Compared to caesarean birth group, natural birth patients had higher downward distance of bladder neck, the turning angle of urinary tract, expansion distance of bladder, incidence and distance of uterine prolapse, and incidence of prolapse and distance of rectum (P<0.05 in all cases). Both experimental groups had elevated indexes compared to control group (P<0.05, **Table 1**).

Comparison of diameters of pelvic diaphragm hiatus and thickness of musculus levator anita

We further compared anterior/posterior diameter, transverse diameter, area of musculus levator anita and thickness of levator ani muscle. Results showed that during quiescent stage, tension period and rectal shrinkage stage, the anterior/posterior diameter, transverse diameter, area of musculus levator anita in both natural and caesarean birth groups were all larger than control group, while the thickness of musculus levator anita was smaller than control group (P<0.05 in all cases). Those indexes were better in natural birth group compared to those in caesarean birth group (P<0.05 in all cases, **Table 2**).

Table 2. Comparison of diameters of pelvic diaphragm hiatus and thickness of musculus levator anita in all patients

Group	N	Longitudinal diameter (cm)	Transverse diameter (cm)	Area (cm^2)	Thickness of musculus levator anita (cm)
Natural birth	22				
Quiescent		5.38±0.63*,#	4.52±0.76*,#	15.74±1.79*,#	0.56±0.12*,#
Tension		5.71±0.82*,#	4.78±0.94*,#	17.13±1.67*,#	0.59±0.13*,#
Shrinkage		4.73±0.87*,#	4.36±0.71*,#	14.82±1.73*,#	0.67±0.11*,#
Caesarean birth	18				
Quiescent		5.01±0.52#	4.21±0.61#	14.23±1.68#	0.72±0.15#
Tension		5.24±0.53#	4.32±0.72#	14.84±1.57#	0.73±0.14#
Shrinkage		4.43±0.62#	4.06±0.45#	12.84±1.76#	0.82±0.16#
Control	20				
Quiescent		4.56±0.54	4.03±0.27	14.08±1.25	0.79±0.11
Tension		5.01±0.52	4.11±0.32	13.07±1.36	0.81±0.13
Shrinkage		4.12±0.45	4.01±0.13	12.25±1.12	0.89±0.17

Note: *, $P<0.05$ compared to caesarean birth group; #, $P<0.05$ compare to control group.

Discussion

PFD including prolapse of pelvic organs, urine incontinence and sexual dysfunction, is caused by the defects, degeneration, injury and dysfunction of supporting structure of pelvic cavity [5, 6]. The floor pelvic of females can be divided into outer muscular layer, middle urogenital diaphragm and inner pelvic diaphragm. Under normal conditions, the full supporting system maintains complete structure and functions of floor pelvic and most importantly, the supporting by musculi levator ani [7, 8]. The pelvic diaphragm hiatus locates in the center of pelvic floor muscles, and is surrounded by pubic symphysis and inner edge of musculi levator ani. As urinary tract, vagina and rectum all cross this opening, whose anatomical structure is thus weak and susceptible to PFD [9]. As previously indicated, ultrasound can help to evaluate the risk of pelvic organ prolapse, thus providing reference for clinics, suggesting the value of prelabor pelvic floor ultrasound to evaluate the risk of perineal tear during delivery and pelvic floor injury [10].

This study selected PFD patients, who received 3D ultrasound examination in our hospital. Control people had symmetric and continuous bilateral puborectal muscle. The area of pelvic diaphragm hiatus was small and in complete structure. Patients with natural birth had symmetric bilateral puborectal muscles with large area of pelvic diaphragm hiatus and atypical morphology. Patients in caesarean birth had symmetric bilateral puborectal muscle, with small pelvic diaphragm hiatus and complete structure. 3D ultrasound can completely observe bladder neck, urinary tract, vagina, cervix and pelvic floor supporting structures, and can clearly reflect the occurrence site of pelvic floor disease and connections with adjacent tissues, for accurate and consistent evaluation of bladder, urinary tract and pelvic floor structure/function [11, 12].

This study compared the prolapse of pelvic cavity organs in all patients and found different grades of prolapse in both natural and caesarean birth groups. Downward distance of bladder neck, the turning angle of urinary tract, expansion distance of bladder, incidence and distance of uterine prolapse, and incidence and distance of prolapse of rectum were all higher in natural birth group than caesarean birth group. Both groups in patients had higher indexes than control group, suggesting that natural birth females are more susceptible to pelvic organ prolapse after PFD. Previous study also found that about 20% primipara women had injury of stretching muscles, with pelvic floor structure damage at different degrees, which may cause PFD [13].

We further compared to longitudinal diameter, transverse diameter, area of pelvic diaphragm hiatus and thickness of musculus levator ani. Results showed that both natural and caesarean birth groups had larger longitudinal diameter, transverse diameter, area of pelvic diaphragm hiatus, and smaller thickness of musculus levator anita compared to control group. Longitudinal diameter, transverse diameter, and area of pelvic diaphragm hiatus were larger in natural birth group compared to those in caesarean birth group, while the thickness of musculus levator anita was smaller. As previously recorded, the elasticity of musculus levator ani determines its function, while the size of pelvic diaphragm hiatus is one important indicator reflecting the elasticity of musculus levator anita. 3D ultrasound for observing musculus levator anita and pelvic diaphragm hiatus can effectively evaluate the structure/morphology and function of pelvic floor structure [14]. One study using 3D ultrasound to analyze the pelvic floor index of late pregnant women demonstrated the effect of pregnancy on pelvic floor structure [15]. 3D ultrasound can observe larger pelvic diaphragm hiatus in natural birth women compared to those with caesarean birth, with the damage of completeness of musculus levator anita [16]. The longitudinal diameter and area of pelvic diaphragm hiatus can be affected by multiple factors including pregnancy, delivery and age [17]. With pregnancy, the abdominal pressure of patients may elevate to exert certain effects on the pelvic floor structure, especially in those natural birth women, whose pelvic floor structure is more susceptible to damage with aging and change of hormonal levels [18, 19]. 3D ultrasound, in principle, used the 2D plane composing of pubic symphysis, the connection part of rectal and anal canal, and urinary tract as the basis to rebuild 3D images, on which all anatomical structures of female pelvic floor was measured precisely to identify the structural images and functions in a more standardized pattern [20].

In summary, 3D ultrasound observation on female PFD patients can better reveal the structure of pelvic floor, and can accurately measure the size and area of pelvic diaphragm hiatus and thickness of musculus levator anita, to provide better anatomical and functional evidences for diagnosis female PFD, and is thus worth for widely promotion.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Hongzhen Liu, Department of Obstetrics, Affiliated Hospital of Taishan Medical College, 706 Taishan Street, Tai'an 271000, China. Tel: +86-538-8299791; Fax: +86-538-8299791; E-mail: liuhongzhenfas@163.com

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