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ORIGINAL ARTICLE

Evaluation of pelvic floor muscle by transperineal elastography in patients with deep infiltrating endometriosis: preliminary observation

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Abstract

Purpose To assess the elasticity of the pelvic floor muscle (PFM) affected by deep infiltrating endometriosis (DIE) with transperineal elastography.

Methods This prospective observational study included 88 patients who were diagnosed with DIE, ovarian endometrioid cyst, or ovarian teratoma. All the patients were assigned to one of the three groups and underwent transperineal elastography. The scoring system and strain ratio (SR) values were recorded and analyzed. Assessments were conducted at maximal Valsalva and under quiescent condition, respectively.

Results The mean elastography score was statistically significantly higher for the levator ani of group I than groups II and III under quiescent condition. In addition, SR of the levator ani in group I was higher than that in groups II and III. However, at maximal Valsalva, the mean elastography score of group I was lower than that of groups II and III. In addition, SR of group I was lower than that of groups II and III.

Conclusion The elasticity of the PFM in DIE patients could be qualitatively evaluated by transperineal elastography. The coordination of the PFM was injured and decreased elasticity appeared in DIE patients.

Keywords Transperineal elastography · Deep infiltrating endometriosis · Pelvic floor muscle

Introduction

Endometriosis is one of the most frequently encountered benign gynecological diseases, known to affect from 7 to 10% of women of reproductive age. It is associated with significant morbidity and comprises a major public health concern [1]. Defined as an endometriotic lesion penetrating to a depth of at least 5 mm, deep infiltrating endometriosis (DIE) influenced between 4 and 37% of patients with pelvic endometriosis [2]. DIE usually causes pelvic pain, dysmenorrhea, dyspareunia, dyschezia, urinary symptoms, and infertility [3].

It was reported that musculoskeletal changes due to the chronic antalgic posture adopted by DIE patients may occur besides the classical signs of the disease. The overload of the pelvic floor muscle (PFM) resulting from the relief of postural deviation adaptation ultimately led to structural and functional changes of the PFM [4, 5]. The damage to the PFM, especially muscle spasms and trigger points, was associated with exacerbation of dyspareunia and pelvic pain [6].

It was revealed that compared with women without endometriosis, women with DIE had an increased prevalence of PFM spasms [7]. It was thus significant to investigate the methods for evaluating the PFM in DIE patients. Raimondo et al. [8] applied 3D and 4D transperineal ultrasound to research the PFM in DIE patients. However, it only detected the morphology of the PFM. In this preliminary study, we

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aimed to assess the elasticity of the PFM affected by DIE with transperineal elastography.

Methods

This was a prospective observational study. The study design and protocol were approved by the Institutional Review Board, and all patients gave written informed consent after the procedure was explained fully. Patients diagnosed with colorectal DIE in the Obstetrics and Gynecology Hospital of Fudan University, Shanghai, P. R. China during the period from July 2016 to December 2017 were included. Twenty-eight consecutive women with a diagnosis of DIE were included in the study group.

Diagnosis of colorectal DIE in our hospital was based on clinical examinations and pelvic magnetic resonance imaging (MRI). Laparoscopic excision of the DIE was performed in all patients in the study group (group I). Diagnosis of DIE was based on the laparoscopic appearance and histological examination of the surgical specimens. The criteria for exclusion were: postmenopausal status, previous non-surgical treatment for endometriosis, such as high-intensity focused ultrasound (HIFU), hormonal therapy within 6 months before surgery, such as GnRH-a, use of oral contraceptive agents, and pelvic organ prolapse.

Thirty age-matched patients with ovarian endometrioid cyst and without sonographic (MRI) signs of DIE were enrolled as group II. Thirty age-matched patients with ovarian teratoma and without sonographic (MRI) signs of DIE were enrolled as a control group (group III). All patients in groups II and III underwent oophorocystectomy and the diagnoses were confirmed by histological examination.

Clinical data were obtained, including age, parity, body mass index (BMI), and pain symptoms. The level of the patient's discomfort and pain was evaluated by the visual analogue scale system using a ten-point line, with the extreme points 0 and 10 corresponding to ''no pain'' and ''maximum pain'', respectively.

All the patients underwent transperineal elastography preoperatively. With an empty bladder, the patients were in the lithotomy position. Assessments were conducted at maximal Valsalva and under quiescent condition, respectively. All patients underwent imaging on the system Hitachi ARIETTA 60 (Hitachi Medical, Tokyo, Japan) using a transperineal 3.5 MHz probe. In addition, transperineal elastography was performed by a radiologist (M.X.) with 7 years of experience in sonography and who has specialized in elastography for the last 3 years. The radiologist was blind to clinical examinations and MRI before elastographic procedures.

The procedures were as follows. First, the levator ani was located by conventional transperineal ultrasound. Transperineal elastography was carried out instantly after the conventional gray-scale ultrasound image was acquired. Therefore, gray-scale ultrasound and elastogram images were shown simultaneously. Images were obtained by applying repetitive light pressure on the skin of the perineum two or three times per second, with the probe positioned perpendicular to the skin when applying pressure. The region of interest (ROI) extended from the levator ani to the adjacent anal canal. The mean values of three successive measurements were noted.

All records were recorded in a separate folder and added to the database for subsequent evaluation. The tissue elasticity information was displayed in color, with blue indicating hard tissue, green indicating medium tissue stiffness, and red indicating soft tissue.

Calculation of the strain ratio (SR) was based on comparison of the strains measured in the levator ani and the adjacent anal canal at the same depth. The operator manually drew the contours. First, the levator ani was selected and labeled as A, and then, the adjacent anal canal at the same depth was selected and labeled as B. The stiffness of the tissues was represented by strain ratio (B/A), which was calculated by the sonographic equipment.

To enhance reproducibility, all measurements were performed three times, and the mean values were calculated to achieve data that are more reliable. Elastic parameters included elasticity scores and SR values. For ease of image

Table 1 Elastography scoring system (ES 1–4) (the color which indicated stiffness was different in our study, red for soft and blue for hard)

Elastographic score	Overall impression	Elastographic appearance
ES 1	Soft	Predominantly purple, green or yellow with less than 10% displaying red. The node is indistinguishable from surrounding tissues
ES 2	Moderately soft	Predominantly yellow or green and with red areas comprising between 10 and 50%. The node is partially delineated from surrounding tissues
ES 3	Moderately stiff	Predominantly red and with yellow or green areas comprising between 10 and 50%. The node is partially delineated from surrounding tissues
ES 4	Stiff	Predominantly red and with less than 10% appearing yellow or green. The node is distinguishable from surrounding tissues

Table 2 Baseline characteristics of groups I, II, and III

	Group 1 ($n=28$)	Group 2 ($n=30$) (Group 1 vs group 2)	p	Group 3 ($n=30$) (Group 1 vs group 3)	p
Age (years)	38.4 ± 5.7	42.1 ± 7.6	0.82	40.8 ± 6.1	0.68
Parity (n)					
0	5	8		10	
1	20	17		16	
≥ 2	3	5		4	
Body mass index (BMI)	24.5 ± 3.7	23.1 ± 4.3	0.92	24.1 ± 2.2	0.80
CA125	176.4 ± 42.5	158.8 ± 36.1	0.79	7.8 ± 1.9	< 0.001
VAS of					
Dysmenorrhea	8.7 ± 1.2	5.2 ± 3.1	0.027	2.8 ± 1.6	0.002
Algopareunia	7.3 ± 3.2	3.6 ± 2.1	0.015	1.5 ± 0.3	< 0.001

analysis, the elasticity images were evaluated by a four-point scoring system that was used in a study of neck masses (Table 1) [9]. SR values of the levator ani were measured as the ratio of stiffness of lesions to stiffness of the surrounding tissue.

The SPSS version 11.0 for Windows software package (SPSS Inc., Chicago, IL) was used for statistical data analysis. Data were expressed as mean ± standard deviation. A Mann–Whitney U test was performed to determine whether the elasticity scores and SR were different at maximal Valsalva and under quiescent condition, respectively.

Results

Baseline characteristics and pain symptoms are listed in Table 2. All 88 patients in the three groups completed the study. In the DIE group, 16 patients underwent laparoscopic rectal shaving, three patients underwent laparoscopic disc excision, and others underwent laparoscopic bowel resection. Diagnosis of endometriosis was confirmed by histological examination postoperatively. Thirty patients in groups II and III underwent oophorocystectomy. Ovarian endometrioid cyst and ovarian teratoma were confirmed by histological examination, respectively. During the operations in groups II and III, no DIE was found in these cases after carefully exploring the pelvic cavity.

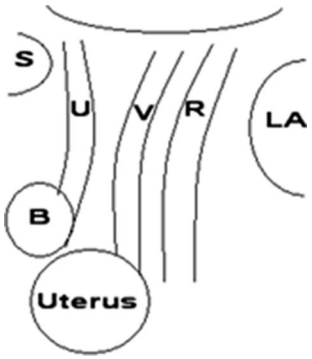

Fig. 1 Schema of the organs detected by transperineal ultrasound. *LA* levator ani, *R* rectum, *V* vagina, *U* urethra, *S* symphysis pubis, *B* bladder

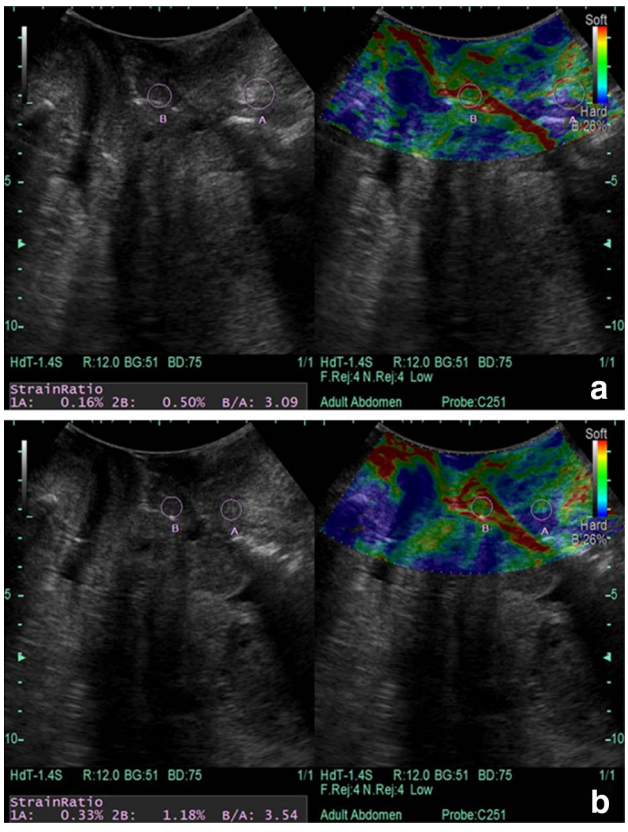

Fig. 2 Conventional transperineal ultrasound and elastography of a patient with DIE (group I) at maximal Valsalva (**a**) and quiescent condition (**b**). Elasticity score was ES 2 and 3, respectively. SR was 3.09 and 3.54, respectively

Transperineal elastography was successfully performed in all cases preoperatively. The mean elastography score was statistically significantly higher for the levator ani of group I than groups II and III under quiescent condition (3.2 ± 0.5 vs 2.3 ± 0.4, 3.2 ± 0.5 vs 2.4 ± 0.3, $p = 0.018$ and 0.011), respectively. In addition, SR of the levator ani in group I was higher than that in groups II and III (3.25 ± 0.31 vs 1.68 ± 0.25, 3.25 ± 0.31 vs 1.75 ± 0.14, $p = 0.006$ and 0.008), respectively. However, at maximal Valsalva, the mean elastography score of group I was lower than that of groups II and III (2.5 ± 0.3 vs 3.5 ± 0.2, 2.5 ± 0.3 vs 3.6 ± 0.4, $p = 0.016$ and 0.009), respectively. In addition, SR of group I was lower than that of groups II and III (3.17 ± 0.24 vs 4.69 ± 0.47, 3.17 ± 0.24 vs 4.85 ± 0.62, $p = 0.007$, 0.005), respectively (Figs. 1, 2, 3, 4). The stiffness of the PFM in group I was similar between quiescent condition and maximal Valsalva. There was no difference in the mean elastography score and SR for the levator ani between groups II and III at maximal Valsalva and under quiescent condition, respectively (Table 3).

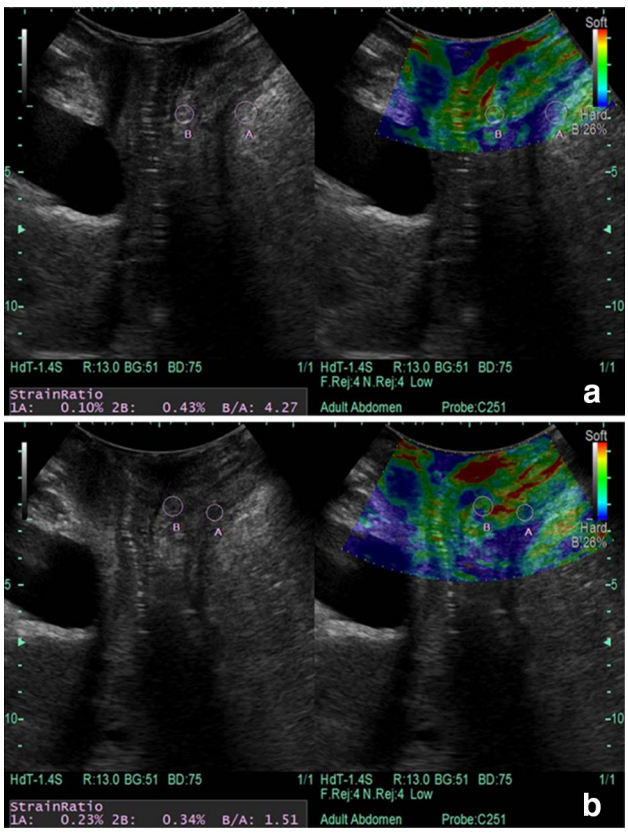

Fig. 3 Conventional transperineal ultrasound and elastography of a patient in group II at maximal Valsalva (**a**) and quiescent condition (**b**). Elasticity score was ES 4 and 2, respectively. SR was 4.27 and 1.51, respectively

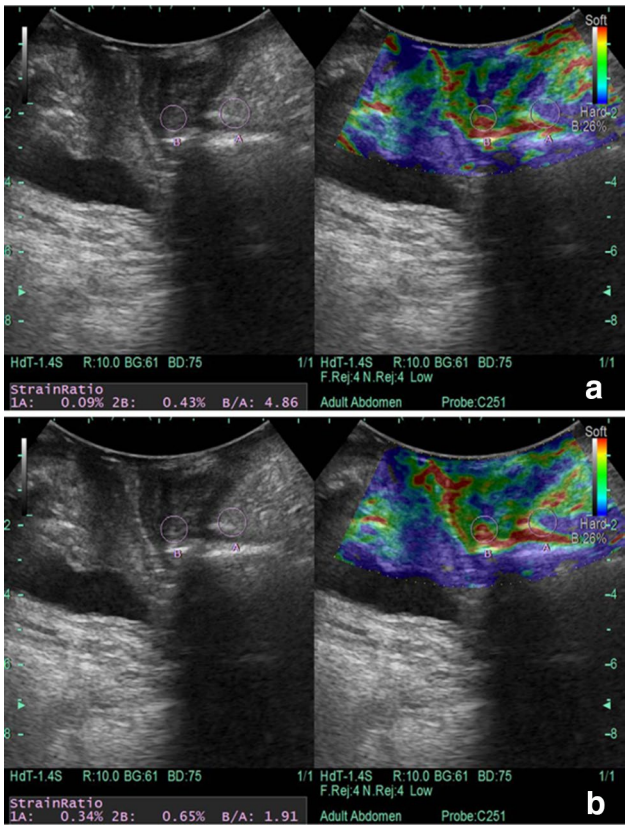

Fig. 4 Conventional transperineal ultrasound and elastography of a patient in group III at maximal Valsalva (**a**) and quiescent condition (**b**). Elasticity score was ES 4 and 3, respectively. SR was 4.86 and 1.91, respectively

Discussion

In this study, we investigated assessment of the PFM affected by DIE with transperineal elastography. It was proved that the coordination of the PFM was injured and decreased elasticity appeared in DIE patients. To our knowledge, it was the first report about evaluation of the PFM in DIE patients by elastography.

The elasticity of the PFM decreased due to muscle spasms and trigger points, which caused deep dyspareunia [10]. In other words, the PFM became shortened, weak, and fast fatigable [11]. The definite mechanism of the muscle spasms was not clear. Perhaps, they were involuntary motor responses that activated the pain receptors constantly and resulted in local ischemia. Furthermore, the spasm may be a muscle reaction due to viral infection, cold, long periods of immobilization, emotional distress, or direct muscle trauma [12].

It has been difficult to evaluate the PFM with atraumatic examination. Raimondo et al. [8] found that women with DIE had a smaller levator hiatal area at rest and during the Valsalva maneuver compared with the control group on

Table 3 Elasticity scores and SR of the levator ani in groups I, II, and III ($n=88$)

	Group 1 ($n=28$)	Group 2 ($n=30$) (Group 1 vs group 2)	p	Group 3 ($n=30$) (Group 1 vs group 3)	p
Elasticity score					
Quiescent condition	3.2 ± 0.5	2.3 ± 0.4	0.018	2.4 ± 0.3	0.011
Maximal Valsalva	2.5 ± 0.3	3.5 ± 0.2	0.016	3.6 ± 0.4	0.009
Strain ratio					
Quiescent condition	3.25 ± 0.31	1.68 ± 0.25	0.006	1.75 ± 0.14	0.008
Maximal Valsalva	3.17 ± 0.24	4.69 ± 0.47	0.007	4.85 ± 0.62	0.005

transperineal 3D and 4D ultrasound. In addition, women with DIE showed a higher frequency of levator ani muscle coactivation during the Valsalva maneuver. In addition, they also found that women in the DIE group showed a smaller levator hiatal area at rest, during contraction, and during the Valsalva manoeuver, and a smaller change in levator hiatal area narrowing during PFM contraction, compared to women in the ovarian endometriosis group [13].

However, the above studies of evaluation of the PFM all paid close attention to morphology. In recent years, we investigated the application of elastography in evaluation of the PFM and identified the elasticity of the PFM. We previously confirmed that the change in the elasticity of the levator ani was earlier than a structural abnormity in patients with pelvic organ prolapse (POP). In addition, immunohistochemistry confirmed it [14]. We also performed transperineal elastography to measure the levator ani in patients with stage I/II POP before and after Kegel exercises. The mean elastography score was statistically significantly higher for the levator ani after Kegel exercise than for the baseline score [15]. These results indicated that elastography could assess the elasticity of the PFM. However, the studies were qualitative and only the score grade was used. In the present preliminary study, SR value examination research was applied.

In general, under quiescent condition, the PFM is relaxed and the stiffness should be soft. In addition, at maximal Valsalva, the PFM is hypertonic and the stiffness should be hard. In this study, we revealed that the mean elastography score and SR were higher for the levator ani of group I than those of groups II and III under quiescent condition. In addition, at maximal Valsalva, the mean elastography score and SR of group I were lower than those of groups II and III. The stiffness of the PFM in group I was similar between the quiescent condition and maximal Valsalva. The results suggested that the coordination of the PFM was injured and decreased elasticity appeared in DIE patients.

Conclusion

Though it was unclear whether the impairment and the decreased elasticity of the PFM were the cause or the result of DIE, the methods of evaluation deserved to be investigated. In the future, we will continue to study the treatment of DIE and its effect on the PFM by elastography. In addition, intra-observer differences should be examined in the next step.

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Compliance with ethical standards

Conflict of interest We declare that we have no conflicts of interest.

Ethical approval The study design and protocol were approved by the Institutional Review Board of the Obstetrics and Gynecology Hospital of Fudan University, Shanghai, P. R. China. In addition, all patients gave written informed consent after the procedure was explained fully.

References

1. Giudice LC. Clinical practice. Endometriosis. N Engl J Med. 2010;362:2389–98.
2. Koninckx PR, Meuleman C, Demeyere S, et al. Suggestive evidence that pelvic endometriosis is a progressive disease, whereas deeply infiltrating endometriosis is associated with pelvic pain. Fertil Steril. 1991;55:759–65.
3. Koninckx PR, Ussia A, Adamyan L, et al. Deep endometriosis: definition, diagnosis, and treatment. Fertil Steril. 2012;98:564–71.
4. Baker PK. Musculoskeletal origins of chronic pelvic pain—diagnosis and treatment. Obstet Ginecol Clin North Am. 1993;20:719–43.
5. FitzGerald MP, Kotarinos R. Rehabilitation of the short pelvic floor I: background and patient evaluation. Int Urogynecol J. 2003;14:261–8.
6. Dos Bispo AP, Ploger C, Loureiro AF, et al. Assessment of pelvic floor muscles in women with deep endometriosis. Arch Gynecol Obstet. 2016;294:519–23.

7. Butrick CW. Pelvic floor hypertonic disorders: identification and management. Obstet Gynecol Clin North Am. 2009;36:707–22.
8. Raimondo D, Youssef A, Mabrouk M, et al. Pelvic floor muscle dysfunction on D/4D transperineal ultrasound in patients with deepinfiltrating endometriosis: a pilot study. Ultrasound Obstet Gynecol. 2017;50:527–32.
9. Lyshchik A, Higashi T, Asato R, et al. Thyroid gland tumor diagnosis at US elastography. Radiology. 2005;237:202–11.
10. Heim LJ. Evaluation and differential diagnosis of dyspareunia. Am Fam Physician. 2001;63:1535–44.
11. Butrick CW. Pathophysiology of pelvic floor hypertonic disorders. Obstet Gynecol Clin North Am. 2009;36:699–705.
12. Yap EC. Myofascial pain—an overview. Ann Acad Med Singap. 2007;36:43–8.
13. Mabrouk M, Raimondo D, Del Forno S, et al. Pelvic floor muscle assessment at -and 4-dimensional transperineal ultrasound in women with endometriosis, with or without retroperitoneal infiltration: a step towards complete functional assessment. Ultrasound Obstet Gynecol. 2018;52:265–8 (**Epub ahead of print**).
14. Xie M, Zhang X, Liu J, et al. Evaluation of levator ani with no defect on elastography in women with POP. Int J Clin Exp Med. 2015;8:10204–12.
15. Xie M, Zhang X, Zhang X, et al. Can we evaluate the levator ani after Kegel exercise in women with pelvic organ prolapse by transperineal elastography? A preliminary study. J Med Ultrasonics. 2018;45:437–41.