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ORIGINAL ARTICLE

The accuracy of transvaginal ultrasound and uterine artery Doppler in the prediction of adenomyosis

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KEYWORDS

Ultrasound;
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Abstract *Objective:* To measure the accuracy of the ultrasonographic features in predicting adenomyosis and to determine if there is a role for uterine artery Doppler in adenomyosis prediction.
Study design: A prospective comparative study.
Setting: Cairo University hospital.
Materials and methods: Three hundred and fifty-two women who were scheduled for hysterectomy for various indications underwent preoperative transvaginal ultrasound scan (TVS) and uterine artery Doppler velocimetry in an attempt to diagnose adenomyosis. All the results were then correlated with histopathological results after hysterectomy.
Results: Forty-eight participants were ultrasonographically diagnosed as having adenomyosis from which 37 patients were histologically confirmed. Both groups were comparable in age, but adenomyosis tend to occur in multiparas. We found that subendometrial linear striations, myometrial cysts' number and poor endometrial delineation were significantly associated with adenomyosis. Sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of TVS for diagnosing adenomyosis were: 75.68%, 90.79%, 49.12%, 96.95% and 89.20%, respectively. Heterogenous myometrial echotexture was the most common ultrasonographic feature in adenomyotic cases. Neither uterine artery resistance index nor pulsatility index showed significant association with adenomyosis.
Conclusion: TVS is a potentially valuable tool in predicting adenomyosis especially when subendometrial linear echogenic striations, myometrial cysts, and poor endometrial delineations were found. However, uterine artery Doppler has no diagnostic values.

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1. Introduction

Adenomyosis refers to the presence of intramyometrial endometrial mucosa (glands and stroma) surrounded by hypertrophic myometrium. It is a common disorder; however its exact prevalence is difficult to determine. It varies in both autopsy (20–67%) (1) and clinical studies (10–88%) (2–6). This is likely due to the inconsistent pathological definition of adenomyosis, different uterine specimen processing and varied patient inclusion criteria. The classic clinical scenario is that of a patient who presents with menorrhagia, dysmenorrhea and

metrorrhagia accompanied by an enlarged, soft uterus which is tender on examination. It is important to note that the frequency and severity of symptoms appear to correlate with the extent and depth of adenomyosis (1,6,7).

Although the typical clinical presentation may strongly suggest adenomyosis, the clinical diagnosis is not accurate and imaging is often used prior to treatment selected.

Transvaginal ultrasound is probably the first choice of imaging modality in the patient with adenomyosis. It is widely available and has both low cost and good accuracy similar to that reported to MRI. Transvaginal ultrasound sensitivity ranges from 57% to 89% whereas its specificity ranges from 65% to 98% (8–13). However, it is a technique that is operator dependent. In addition, the accuracy of this method decreases in the patient who present with large uteri and also if adenomyosis is associated with leiomyomas. The reported sensitivity and specificity of MRI range from 70% to 86% and 86% to 93%, respectively (8–10). MRI is generally used if the ultrasound results are equivocal or when additional information is needed.

The imaging appearance of adenomyosis is based on the ectopic glands which are surrounded by a stromal reaction of densely packed smooth muscle cells. This process often leads to the globular appearance of the uterus. The disease can also be predicted by heterogenous myometrial echotexture, indistinct endometrial strip, asymmetric thickening of the anterior or posterior uterine wall or myometrial cysts. Myometrial cysts are small anechoic lakes of 2–6 mm in diameter. They may represent cystic endometrial implants or focal myometrial haemorrhage. Colour Doppler can be used to differentiate it from myometrial vessels. The aim of this study was to detect the accuracy of different ultrasonographic features in diagnosing adenomyosis and to detect if there is a role of uterine artery Doppler study in its diagnosis.

2. Patients and methods

2.1. Study design

Three hundred and fifty-two patients who were scheduled for hysterectomy, were subjected to transvaginal ultrasound and uterine artery Doppler study. Ultrasonographic features suggestive of adenomyosis were documented as well as the uterine artery Doppler indices. The ultrasonographic findings were compared with histopathological diagnosis. The study has been approved by the internal ethics committee.

2.2. Study population

This study included 363 patients who were scheduled for hysterectomy either abdominal, vaginal or laparoscopic with or without salpingoophorectomy in Kasr El-Aini hospital during the period from August 2007 to October 2008. Eleven patients were excluded from the study either because that they refused hysterectomy or being unfit for surgery. Therefore, the study population consisted of 352 patients. One hundred and ninety-eight patients were premenopausal (56.3%) while 154 were postmenopausal (43.8%).

The demographics and clinical data were collected by means of retrospective chart review. The patients' age ranged from 38 to 70 years with a mean ± SD 48.7 ± 5.2 years.

The indications for hysterectomy were leiomyomata (the most common) in 147/352 (41.7%) followed by abnormal uterine bleeding (110/352, 31.25%), endometrial hyperplasia (33/352, 9.3%), prolapse (30/352, 8.5%), adnexal masses (27/352, 7.7%), and cervical masses (5/352, 1.4%).

2.3. Ultrasound examination

Ultrasound scanning was performed with Accuvix (Medison, Seoul, Korea) scanner using 4–7 MHZ endovaginal probe. Three trained sonographers were responsible for the scanning process. They were blinded to the histological results and clinical history. Before the ultrasound scanning, the women were asked to empty the bladder and to get rest for at least 15 min. Scanning was done in early morning to avoid fluctuations due to circadian rhythm of uterine artery blood flow.

The following US criteria were evaluated: uterine diameters, outline, myometrial echotexture, myometrial linear striation, myometrial cysts (its number if present), endometrial–myometrial junction, uterine wall asymmetry and if there was any associated gynecological pathology. Myometrial cysts were defined as rounded anechoic area of 2–6 mm in diameter (8,14). Colour Doppler was used to differentiate the myometrial cysts from myometrial blood vessels.

Heterogenous myometrium was defined by the presence of an indistinctly marginated myometrial area with decreased or increased echogenicity (8,15). Furthermore, heterotopic endometrium extending into the inner myometrium can appear as echogenic linear striations. When these lines are small or indistinct, pseudo-widening of the endometrium or poor delineation of the endomyometrial junctional zone is seen. Globular and/or asymmetric uterus was defined as a regular enlarged uterus with possible myometrial asymmetry unrelated to leiomyoma.

Uterine artery Doppler was done for all patients. Each uterine vessel was demonstrated by colour Doppler as it crossed over the hypogastric artery and vein just before it entered the uterus at the uterine-cervical junction. Pulsed Doppler velocimetry of the uterine artery was obtained immediately after the crossing of the hypogastric artery and before it divided into the uterine and cervical branches. For examining the uterine arteries, the gate of the Doppler was positioned when good colour signal were identified on the screen. The resistance index (RI) and the pulsatility index (PI) of uterine arteries were calculated when three similar consecutive waves were obtained. The average value of the bilateral uterine arteries of each index was calculated.

2.4. Histopathological examination

Histopathological examination was performed to hysterectomy specimen. The pathologists were blinded to the ultrasonographic and clinical findings. Histologically, adenomyosis was diagnosed by migration of the endometrial glands from the stratum basale into the myometrium. The ectopic glands tend to be at least 2–3 mm below the endometrial–myometrial junction. This often occurs with reactive hyperplasia of the smooth muscle.

2.5. Statistical analysis

Data were statistically described in terms of range, mean ± SD, frequencies (number of cases) and relative

frequencies (percentages) when appropriate. Comparison of quantitative variables between cases with adenomyosis and those with no adenomyosis was done using Student's *t*-test for independent samples in when normally distributed and Mann–Whitney *U*-test for independent samples in comparing non-normally distributed data. For comparing categorical data, Chi square (χ^2) test was performed. Exact test was used instead when the expected frequency is less than 5. Accuracy was represented using the terms sensitivity, specificity, +ve predictive value, −ve predictive value and the overall accuracy. A probability value (*p* value) less than 0.05 was considered statistically significant and <0.001 is considered highly significant. All statistical calculations were done using computer programs Microsoft Excel version 7 (Microsoft Corporation, NY, USA) and SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 13 for Microsoft windows.

3. Results

Adenomyosis was found in 37/352 (10.5%) patients at the histopathological examination. Other pelvic pathology was associated in 10/37 of the adenomyotic cases (27.77%). Leiomyomas were the most commonly associated gynecological pathology with adenomyosis (6/37, 16.2%) then endometrial hyperplasia (3/37, 8.3%) and ovarian cyst (1/37, 2.7%).

Transvaginal ultrasound diagnosed adenomyosis in 48 cases out of 352 cases scheduled for hysterectomy, of whom, only 37 cases had a histopathological diagnosis of adenomyosis. The sensitivity, specificity, negative predictive value, positive predictive value and accuracy of transvaginal ultrasound in the diagnosis of adenomyosis were: 75.68%, 90.79%, 49.12%, 96.95% and 89.20%, respectively.

As regard each ultrasonographic criteria for the diagnosis of adenomyosis, heterogenous myometrial echotexture, poor endometrial delineation, myometrial linear striation, myometrial cysts (Fig. 1) and the number and site of these cysts (>2 cysts and near the endometrial lining) were found to have the highest statistical significant ($p < 0.05$) than globular uterine outline or asymmetrical myometrial walls. Each ultrasonographic criteria for the diagnosis of adenomyosis had its own sensitivity, specificity, positive predictive value and accuracy (Tables 1 and 2).

Myometrial heterogenicity was the most common ultrasonographic finding 35/37 (94.6%). The myometrial linear striation was the most specific ultrasonographic finding (90.79%) with the highest positive predictive value (38.3%) and it was the most accurate (86.36%) but with the lowest sensitivity (48.65%). Poor endometrial delineation showed the highest sensitivity (75.68%) and its specificity, positive predictive value, negative predictive value and accuracy were 54.29%, 16.28%, 95% and 56.53%, respectively. In those with myometrial cysts, the number of them was noted and it was observed that the myometrial cyst number was more than 2 in 25/37 of adenomyosis cases (96.2%) whereas in non-adenomyotic cases the number was 2 or less in 144/352 (41%). It showed a significant statistical difference ($p < 0.001$). The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of a number of myometrial cysts more than 2 were 96.15%, 100%, 100%, 99.3% and 99.4%, respectively (Table 2).

As regard to the uterine artery Doppler indices (Fig. 2), the resistance index (RI) in cases diagnosed with adenomyosis ranged from 0.75 to 0.94 with a mean 0.86 and SD ± 0.05. In non-adenomyosis cases the RI ranged from 0.72 to 0.93 with a mean of 0.84 and SD ± 0.06. Pulsatility index (PI) in cases diagnosed with adenomyosis ranged from 1.35 to 3.1 with a mean 2.47 and SD ± 0.47. In non-adenomyosis cases the PI ranged from 1.65 to 3.01 with a mean of 2.3 and SD ± 0.539. There was no statistical difference between both

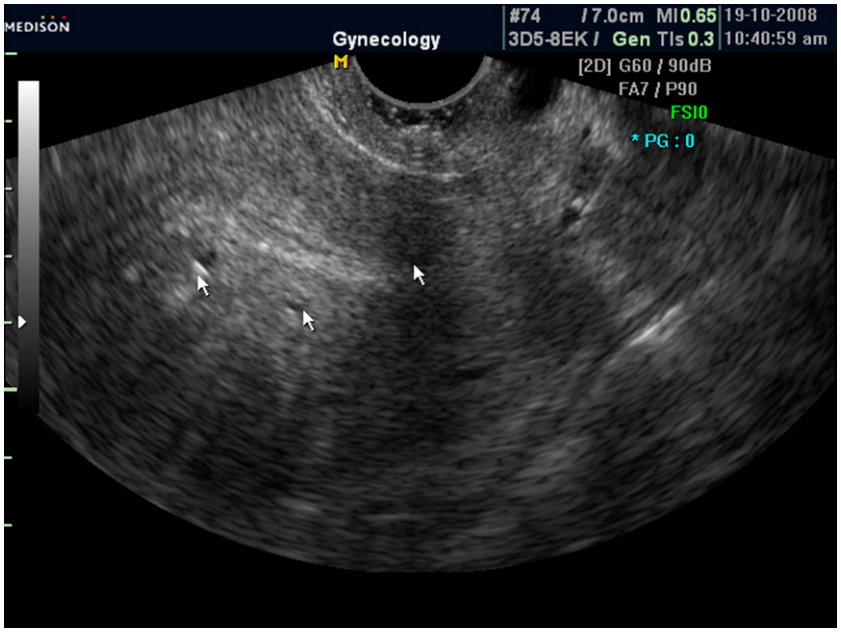

Figure 1 An ultrasound picture of an adenomyotic uterus shows the characteristic ultrasonographic features myometrial cyst (arrow) and linear striations and indistinct endometrial lining.

Table 1 Comparison of ultrasonographic features between cases with histopathologically proved adenomyosis and those without adenomyosis.

	Adenomyosis ($n = 37$)	No adenomyosis ($n = 315$)	p
Globular uterus			
Yes	25 (67.6)	228 (72.4)	0.538
No	12 (32.4)	87 (27.6)	
Asymmetrical anterior–posterior uterine wall			
Yes	12 (32.4)	86 (27.3)	0.510
No	25 (67.6)	229 (72.7)	
Heterogeneous myometrial echotexture			
Yes	35 (94.6)	175 (55.6)	<0.001
No	2 (5.4)	140 (44.4)	
Poor endometrial delineation			
Yes	28 (75.7)	144 (45.7)	<0.001
No	9 (24.3)	171 (54.3)	
Linear myometrial striation			
Yes	18 (48.6)	29 (9.2)	<0.001
No	19 (51.4)	286 (90.8)	
The presence of myometrial cysts			
Yes	26 (70.3)	144 (45.7)	0.005
No	11 (29.7)	171 (54.3)	

adenomyotic cases and non-adenomyotic ones as regard uterine artery RI ($p = 0.1$) and PI ($p = 0.09$) (Table 3).

4. Discussion

Adenomyosis is a common condition. Although it is often overlooked, it is usually found in 70% of hysterectomy specimen. Transvaginal ultrasound has been used for the diagnosis of adenomyosis (16,17). The reported incidence varies widely from 5% to 70% (18). Meredith et al. (19), studied the ability of transvaginal ultrasound in prediction of adenomyosis and they found that transvaginal sonography was an accurate diagnostic test for adenomyosis.

Transvaginal ultrasound was suggested to be the first diagnostic tool in adenomyosis diagnosis being non-invasive but it is operator dependent so many studies compare the accuracy of transvaginal ultrasonographic diagnosis of adenomyosis. Bazot et al. (11) compare transabdominal ultrasound (TAS) and transvaginal ultrasound (TVS) in the detection of myometrial and endometrial disorders. They found that sensitivity, specificity, positive predictive value, negative predictive value and accuracy of transvaginal ultrasound were 65%, 97.5%, 92.8% and 88.8% whereas, Reinhold et al. (8) reported a specificity of 86% for transvaginal ultrasound.

Kepkepk et al. in their study, mentioned that the sensitivity, specificity, positive (PPV) and negative (NPV) predictive values and accuracy of transvaginal ultrasound for the diagnosis of adenomyosis were 80.8%, 61.4%, 55.3%, 84.4% and 68.6%, respectively. As regard our study, the sensitivity, specificity, positive (PPV) and negative (NPV) predictive values and accuracy of transvaginal ultrasound for the diagnosis of adenomyosis were 75.68%, 90.79%, 49.12%, 96.95% and 89.20%, respectively.

There are different ultrasonographic features which were suggested by many studies in order to reach a diagnosis of adenomyosis. This led to different accuracy in transvaginal detection of adenomyosis. In most studies, heterogenous myometrial echotexture was the most common criteria for adenomyosis diagnosis and this matched with our study results. Bromley et al. (18) in their study, found that all patients with adenomyosis had a mottled heterogeneous appearing uterus, 95% had a globular uterus, 82% had small myometrial lucent areas, and 82% had an indistinct endometrial stripe. Kepkepk et al. (20) noted that that a regularly enlarged uterus with a globular appearance, subendometrial echogenic linear striations and myometrial cysts had the highest accuracy for the diagnosis of adenomyosis. Of all findings evaluated, heterogeneous myometrium was the most common in patients with adenomyosis (21/26 patients), but it had a poor specificity, the presence of subendometrial linear striations was the most specific sonographic feature (95.5%) and it had the highest PPV (80.0%) for the diagnosis of adenomyosis. In our study we found that the poor endometrial delineation, myometrial striation and myometrial cysts were the only ultrasonographic criteria which were of statistical significance. The most specific ultrasonographic feature was the myometrial linear striation (90.79%) with the highest negative predictive value (93.7%) and with accuracy (86.36%). It was followed by the poor endometrial delineation whose accuracy in predicting adenomyosis was (56.53%).

In extensive disease, small anechoic lakes of 2–6 mm diameter are sometimes detected (myometrial cysts). Lakes of this size are at the limit of ultrasonographic resolution and may represent larger cystic implants or, more likely, focal myometrial haemorrhage. Detecting such areas of heterogeneous echogenicity within the myometrium is often complicated by the presence of various artefactual echogenic shadows and the confusion is compounded by the presence of leiomyomata and vascular calcifications (18). Fedele et al. (14) were the first to document the value of these myometrial cysts in the diagnosis of adenomyosis. This was followed by Bazot et al. (11) who observed that the number and distribution of myometrial cysts correlates with the grade of adenomyosis. This agreed with our study results which showed a significant statistical difference between adenomyotic and non-adenomyotic cases as regard to the presence of myometrial cysts per say and when the

Table 2 Accuracy of different ultrasonographic features for diagnosing adenomyosis.

	Sensitivity	Specificity	PPV	NPV	Accuracy
Heterogeneous myometrial echotexture	94.59	44.44	16.67	98.59	49.72
Poor endometrial delineation	75.68	54.29	16.28	95.00	56.53
Linear myometrial striation	48.65	90.79	38.30	93.77	86.36
The presence of myometrial cysts	70.27	54.29	15.29	93.96	55.97
Myometrial cysts >2	96.15	100.00	100.00	99.31	99.41

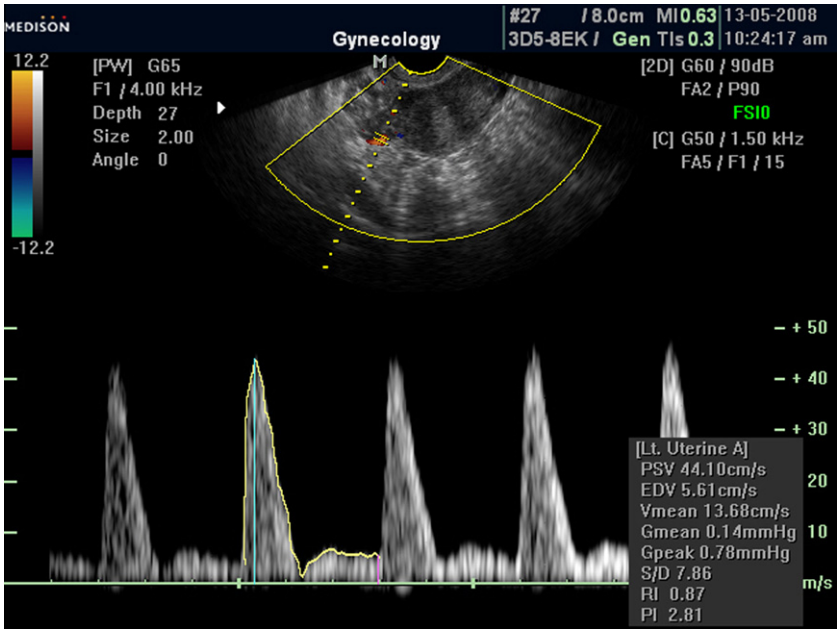

Figure 2 Doppler study of the uterine artery (left) in a case documented to have adenomyosis.

Table 3 Comparison of uterine artery Doppler indices (RI and PI) between adenomyotic and non-adenomyotic participants.

	Adenomyotic cases (n = 37)	Non-adenomyotic cases (n = 315)	p value
Uterine artery RI			
Min	0.72	0.75	0.107
Max	0.93	0.94	
Mean	0.865	0.847	
SD	0.051	0.063	
Uterine artery PI			
Min	1.35	1.65	0.093
Max	3.10	3.01	
Mean	2.473	2.317	
SD	0.472	0.539	

number of them is more than 2 (p = 0.005 and 0.000), respectively. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of a number of myometrial cysts more than 2 were 96.15%, 100%, 100%, 99.3% and 99.4%, respectively.

As increased myometrial perfusion was postulated as a cause of adenomyosis. We tried to find if there is more increase in the uterine artery blood flow in adenomyotic uteri so that we can add uterine artery Doppler in the ultrasound features for adenomyosis but there was no statistical difference in either uterine artery Doppler indices (RI,PI) in both adenomyotic cases and non-adenomyotic ones.

The main limitation of our study is that different pathologists examine the hysterectomy specimens and that there may be a false prevalence especially in cases where there is focal adenomyosis which may need further blocks also the inclusion of only hysterectomized cases.

Our study included both the ultrasonographic features of patients suspecting to have adenomyosis and compare them with the histopathological results. This study had the privilege of including a large sample volume but still there may be a need of further studies with larger sample volume to put a scoring system including both the clinical and ultrasonographic criteria for diagnosis of adenomyosis with a high accuracy.

In conclusion, by transvaginal ultrasound: subendometrial linear echogenic striations showed the highest specificity and accuracy. The myometrial cysts show a high negative predictive value and their number (if more than 2) represent the highest accuracy. Poor endometrial delineations represent the most sensitive criteria, but with low specificity and with the least positive predictive value. Uterine artery Doppler study cannot be used in our way to predict adenomyosis.

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