

Original Research Article

Diagnostic validity of transvaginal sonography and Doppler in women with abnormal uterine bleeding: predicting diagnosis of adenomyosis and leiomyoma – an observational design

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ABSTRACT

Background: Adenomyosis and leiomyoma are common structural causes of abnormal uterine bleeding. Conservative or definitive management depends on accurate evaluation. Purpose of the study is to define validity of Morphological Uterus Sonographic Assessment features along with doppler to prognosticate the etiology in a cohort presenting with Abnormal Uterine Bleeding.

Methods: In an observational study carried out in Teaching Hospital 140 women having AUB were enrolled consecutively. All participants underwent Trans-vaginal sonography and Doppler. Histopathology of operated specimens was the reference standard for diagnosis. TVS signs; asymmetrical thickening of myometrium, myometrial cyst, venetian blind shadowing, well-defined hypoechoic mass and edge shadowing were noted. In Doppler, scattered intramural vascularity and peripheral outer feeding vessels were our target features. Diagnostic indices noted and compared using chi-square or Fisher exact test.

Results: 94 women underwent surgery; histopathology confirmed leiomyoma in 54.3%, adenomyosis in 26.6%, combined pathology 14.9% and normal findings in 4.2%. Age and parity were significantly associated, adenomyosis more in older and multiparous women and leiomyoma in younger and nullipara, ($p=0.001$ and $p=0.014$, respectively). TVS demonstrated accuracy of 97.8%, 97.8%, 78.5% in asymmetrical thickening, myometrial cyst and venetian blind shadowing respectively in adenomyosis and 99.2% and 93.5% accuracy in well-defined hypoechoic mass and edge-shadowing for leiomyoma. Doppler vascularity showed sensitivity of 85% in scattered intramural vascularity for adenomyosis and 92.2% peripheral feeding vascularity for leiomyoma.

Conclusions: Near to accurate clinical diagnosis of uterine pathology by MUSA features in TVS and a complemented color Doppler for AUB is the main outcome of this study.

Keywords: Abnormal uterine bleeding, Adenomyosis, Doppler ultrasound, Leiomyoma, Trans-vaginal sonography

INTRODUCTION

Abnormal uterine bleeding (AUB) is one of the most frequent gynecological complaints in women of reproductive age with prevalence estimates of 20.48% in a population-based Indian study.¹ The FIGO PALM-COEIN system provides a standardized approach for classifying

AUB into structural causes - polyp, adenomyosis, leiomyoma, and malignancy and non-structural causes, thereby improving diagnostic consistency and management planning.²

Among the structural causes of abnormal uterine bleeding, adenomyosis and leiomyoma emerge as two of the most

significant and commonly encountered conditions. In India PALM component predominates, and is as high as 63.98%.³ Adenomyosis affects an estimated 20-45% of women of reproductive age, with recent studies indicating prevalence rates as high as 45% in adolescents and young women experiencing dysmenorrhea. The condition has demonstrated an increasing diagnostic challenge, with South Korean population-based data showing prevalence rising from 1.42 per 1000 individuals in 2002 to 7.50 per 1000 individuals in 2016.⁴ Uterine leiomyoma, represents the most frequent benign tumours in gynaecology, with prevalence estimates of 50% in women up to menopause.⁵

The clinical similarity between two conditions causes diagnostic challenge in all AUB women.⁶ Trans-vaginal sonography (TVS) is widely used as the first-line imaging modality for myometrial pathology because it is accessible, inexpensive, and capable of high-resolution assessment of uterine morphology. Prior studies and meta-analyses support its role in adenomyosis diagnosis too, while three-dimensional ultrasound and Doppler techniques provide additional information about lesion morphology and vascular distribution.⁷⁻⁹ Standardized sonographic descriptors, including revised Morphological Uterus Sonographic Assessment (MUSA) features, have further improved reporting of adenomyosis-related findings such as myometrial cysts, asymmetrical thickening, fan-shaped or venetian blind shadowing, and abnormal junctional-zone features.¹⁰⁻¹²

The diagnostic challenge is especially relevant in resource-constraint settings, where magnetic resonance imaging may not be feasible for every patient and histopathology is often available only after surgery. A precise diagnosis of adenomyosis helps young women for conservative and fertility preserving approach. This study was therefore undertaken to compare the diagnostic performance of TVS with Doppler in differentiating adenomyosis from leiomyoma among women presenting with AUB, chronic pelvic pain using postoperative histopathology as the reference standard in operated cases.

METHODS

This observational study was carried out in Department of Obstetrics and Gynecology in a Rural Teaching Hospital in Central India, from 01st January 2024 to 31st December 2024. Women attending the gynecology outpatient department with cyclical abnormal uterine bleeding, dysmenorrhea were recruited and consecutively. Informed written consent was obtained. Patients who did not consent and those with AUB attributable to other non-target causes such as polyp, ovarian mass or disturbed rhythmic presentation of menstrual cycle and coagulopathy were excluded.

The sample size was calculated using $n = Z^2 \times p \times q / d^2$ for estimation of a proportion at 95% confidence level. Using an estimated AUB prevalence of 10% and 5% absolute precision, the calculated sample size was 138.3 and was

rounded to 140. Eligible participants were enrolled consecutively during the study period. Data were entered into statistical software SPSS by IBM v26 for analysis. Baseline characteristics were summarised with means $\pm$ SD or percentages. Comparative testing between groups used the χ^2 test for categorical data and the independent-samples t-test for continuous variables; $p < 0.05$ was considered statistically significant.

Demographic data, age, location, parity, length of marital life, duration of symptoms and severity of AUB was noted. Out of routine investigations hemoglobin gm/dl was observed. All participants underwent TVS with Doppler at presentation according to departmental protocol. A senior and experienced sonologist carried out the study. Imaging was carried out by trans-vaginal probe using MUSA features and to provisionally classify cases as adenomyosis, leiomyoma, combined adenomyosis with leiomyoma, or normal/other.

Grayscale features assessed included asymmetrical myometrial thickening, myometrial cysts or lacunae, venetian blind shadowing, well-defined hypoechoic mass, and edge shadowing. Doppler vascularity was also done and categorized as scattered/intramural, peripheral/outer feeding, mixed, or normal.

Patients requiring surgery underwent operative management, and the specimen was submitted for histopathological examination. Postoperative histopathology was considered the gold standard for diagnostic validity calculations in the operated subgroup. MRI findings, when available, were noted but were not used as the primary comparator.

The primary outcome was the diagnostic performance of TVS with Doppler in differentiating adenomyosis from leiomyoma, expressed as sensitivity, specificity, positive predictive value, negative predictive value, and accuracy. Bivariate logistic regression applied for various MUSA and Doppler features. Secondary outcomes included PALM-COEIN categorization and management patterns guided by imaging. The study was conducted after approval from the Institutional Ethics Committee of Medical College (IEC Ref. No. PG/OBSTETRICS & GYNAECOLOGY 51/2024).

RESULTS

A total of 140 women fulfilling the eligibility criteria were enrolled. The mean age was 38.5 ± 6.2 years; the largest age groups were 31-40 years and 41-50 years, with 55 women (39.3%) in each group.

Multiparity was common, and symptoms were usually prolonged, with 116 women (82.9%) reporting symptoms for more than 6 months. The most frequent clinical manifestations were heavy bleeding and heavy bleeding with pain. Baseline demographic and clinical characteristics are summarized in Table 1.

Table 1: Demographic and clinical profile of women recruited and with abnormal uterine bleeding (n=140).

Demographic and clinical parameters	Category	N (%)
Age group (years)	<30	25 (17.8)
	31-40	55 (39.3)
	41-50	55 (39.3)
	>50	5 (3.6)
Parity	Nulliparous	26 (18.6)
	Para 1-2	64 (45.7)
	Para ≥3	50 (35.7)
Primary symptom	Heavy bleeding	58 (41.4)
	Heavy bleeding with pain	52 (37.1)
	Abdominal mass	22 (15.7)
	Irregular bleeding	8 (5.7)
Duration of symptoms	<6 months	24 (17.1)
	6-12 months	54 (38.6)
	>12 months	62 (44.3)
Hemoglobin	Severe anemia (Hemoglobin <7 g/dl)	8 (5.7)
	Moderate anemia (Hemoglobin 7-9.9 g/dl)	64 (45.7)
	Mild anemia (Hemoglobin 10-10.9 g/dl)	42 (30.0)
	Normal (Hemoglobin ≥11 g/dl)	26 (18.6)

Of the 140 women, 94 (67.1%) underwent surgical management and 46 (32.9%) were managed medically. Total abdominal hysterectomy was performed in 51 cases (36.4%), vaginal hysterectomy (VH) in 40 (28.6%), and myomectomy in 3 (2.1%). The preoperative radiological diagnosis showed the distribution as, leiomyoma in 68

cases (48.6%), adenomyosis in 38 (27.1%), both leiomyoma and adenomyosis in 26 (18.6%), and normal/other findings in 8 (5.7%). Among operated cases, histopathologically confirmed leiomyoma was in 51 (54.3%), adenomyosis in 25 (26.6%), combined leiomyoma and adenomyosis in 14 (14.9%), and normal/other findings in 4 (4.2%).

Table 2: Association of age and parity with final histopathological diagnosis among operated cases (n=94).

Variables	Category	Adenomyosis (n=25)	Leiomyoma (n=51)	Both (n=14)	Normal/other (n=4)	P value
Age group (years)	<30	0	16	0	1	0.001
	31-40	10	16	11	2	
	41-50	12	19	3	1	
	>50	3	0	0	0	
Parity	Nulliparous	0	9	0	2	0.014
	P1-2	14	31	10	2	
	P≥3	11	11	4	0	

Age and parity were significantly associated with final histopathological diagnosis among operated cases ($p=0.001$ and $p=0.014$, respectively). Adenomyosis clustered more frequently in older and multiparous women, whereas leiomyoma was more common in younger women and was also observed among nulliparous women. Feature-level bivariate analysis showed that TVS signs and Doppler vascularity patterns were significantly associated with the diagnostic category (Table 3). Asymmetrical thickening and myometrial cysts/lacunae favored adenomyosis and combined pathology, whereas a

well-defined hypoechoic mass and edge shadowing favored leiomyoma and combined pathology. Doppler mapping showed a complementary pattern: scattered/intramural vascularity predominated in adenomyosis, peripheral/outer feeding vascularity in leiomyoma, mixed vascularity in combined disease, and normal flow in normal/other histopathology. Asymmetrical thickening of myometrium, myometrial cysts, venetian blind shadowing, well defined hypoechoic mass, edge shadowing, scattered intramural vascularity,

Peripheral outer feeding vessels is statistically significantly different in adenomyosis and leiomyoma;

meaning this can be a diagnostic finding to differentiate these two conditions.

Table 3: Bivariate analysis of histopathology, TVS findings, and doppler vascularity patterns in 94 subjects.

Assessment	Finding / pattern	Adenomyosis N (%)	Leiomyoma N (%)	Both pathology N (%)	No pathology / other N (%)	P value
Diagnostic signs (n=94)	Final diagnosis	25 (26.6)	51 (54.3)	14 (14.9)	4 (4.2)	-
TVS signs (n=94)	Asymmetrical thickening of myometrium present	32 (78.0)	5 (7.7)	21 (80.8)	0 (0.0)	<0.001
	Myometrial cysts/lacunae present	32 (78.0)	5 (7.7)	21 (80.8)	0 (0.0)	<0.001
	Venetian blind shadowing present	26 (63.4)	5 (7.7)	0 (0.0)	0 (0.0)	<0.001
	Well-defined hypoechoic mass present	7 (17.1)	58 (89.2)	26 (100.0)	0 (0.0)	<0.001
	Edge shadowing present	7 (17.1)	50 (76.9)	26	0 (0.0)	<0.001
Doppler vascularity (n=94)	Scattered intramural vascularity	22 (88.0)	4 (7.8)	1	0 (0.0)	<0.001
	Peripheral outer feeding vessels	3 (12.0)	47 (92.2)	3	0 (0.0)	
	Mixed pattern	0 (0.0)	0 (0.0)	10	0 (0.0)	
	Normal pattern	0 (0.0)	0 (0.0)	0	4 (100.0)	

Values are n (%). TVS: transvaginal sonography; HPE: histopathological examination. The TVS signs and Doppler-HPE cross-tabulation is reported for operated histopathology-confirmed cases. Statistical significance was assessed using chi-square or Fisher exact test, as appropriate.

Table 4: Diagnostic accuracy of TVS signs for adenomyosis and leiomyoma in 94 women.

TVS sign		Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Asymmetrical thickening	Adenomyosis	95.08*	100	100	96.34	97.86 [‡]
	Leiomyoma	22.83 [^]	22.92	36.21	13.41	22.86
Myometrial cysts/lacunae	Adenomyosis	95.08*	100	100	96.34	97.86 [‡]
	Leiomyoma	22.83 [^]	22.92	36.21	13.41	22.86
Venetian blind shadowing	Adenomyosis	50.82*	100	100	72.48	78.57 [‡]
	Leiomyoma	0 [^]	35.42	0	15.59	12.14
Well-defined hypoechoic mass	Adenomyosis	34.43 [!]	11.39	23.08	18.37	21.43
	Leiomyoma	98.91 [#]	100	100	97.96	99.29 [‡]
Edge shadowing	Adenomyosis	34.43 [!]	21.52	25.3	29.82	27.14
	Leiomyoma	90.22 [#]	100	100	84.21	93.57 [‡]

* = highlights high sensitivity in adenomyosis! = Low sensitivity in adenomyosis { = high accuracy # = high sensitivity in leiomyoma [^] = low sensitivity in leiomyoma

Table 5: Diagnostic validity of doppler vascularity patterns among histopathologically confirmed cases (n=94).

Doppler vascularity pattern	Target condition	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Scattered/intramural vascularity	Adenomyosis	85.0	92.5	89.5	89.1
Peripheral/outer feeding vascularity	Leiomyoma	92.2	89.7	95.2	83.9

PPV: positive predictive value; NPV: negative predictive value.

Separated diagnostic validity analysis confirmed high performance for both imaging components. Overall TVS

diagnosis showed sensitivity, specificity, PPV, and NPV of 85.0%, 92.5%, 89.5%, and 89.1% for adenomyosis, and

92.2%, 89.7%, 95.2%, and 83.9% for leiomyoma. Among grayscale markers, myometrial cysts/lacunae had the highest specificity for adenomyosis (94.3%), whereas a well-defined hypoechoic mass had the strongest overall performance for leiomyoma. Doppler validity was comparable: scattered/intramural vascularity supported adenomyosis, while peripheral/outer feeding vascularity supported leiomyoma.

DISCUSSION

This study showed that feature-based TVS with Doppler can distinguish adenomyosis from leiomyoma with useful preoperative accuracy in women with AUB. Among the 94 operated women, histopathology identified leiomyoma in 54.3%, adenomyosis in 26.6%, and combined disease in 14.9%. TVS sensitivity and specificity were 85.0% and 92.5% for adenomyosis and 92.2% and 89.7% for leiomyoma. Coexisting disease was clinically important from management point of view. Combined Adenomyosis and Leiomyoma was recorded in 18.6% of the full imaging cohort and in 14.9% of the operated subgroup. These percentages are not directly comparable because their denominators differ, but both support a deliberate search for diffuse myometrial disease even when a discrete fibroid is evident, as also emphasized in hysterectomy-based studies of AUB associated with leiomyoma.⁶ It reflects the biological behaviour of these disorders and the care seeking pattern in a tertiary gynaecological setting. Leiomyoma enlarge during hormonally active years and commonly cause pressure symptoms and heavy bleeding; frequently coming to clinical attention because of bleeding-related quality-of-life impairment, whereas adenomyosis is more strongly linked with dysmenorrhea, multiparity, and chronic inflammatory change within the myometrium.¹³ Women with AUB and clinically diagnosed leiomyoma needs multidimensional approach for diagnosis and further management. The advanced MRI imaging is not feasible in resource constraint setting like ours. That is why we want a clinically summed up guideline for fertility preserving management protocol in AUB women. Potential benefits and risks with myomectomy will be guided by a tailored approach for managing such women.¹⁴ As adenomyosis has a heterogeneous symptom profile, not only heavy bleeding and dysmenorrhea but it influences fertility and remains a challenge to gynaecologist requiring a definitive diagnostic and management approach.¹⁵ The high prevalence of anemia and prolonged symptom duration in this study also suggests that many women reached tertiary care only after sustained morbidity, which strengthens the practical relevance of early imaging-based differentiation (Table 1).

The finding that age and parity were significantly associated with final diagnosis is clinically relevant. Adenomyosis was concentrated among older and multiparous women, whereas leiomyoma was more frequent in younger women and was also seen among nulliparous patients (Table 2). Our results are clinically

important because they move diagnosis beyond a binary “fibroid versus adenomyosis” impression. In practice, direct adenomyosis markers such as myometrial cysts and asymmetrical wall thickening increase diagnostic confidence, while a sharply marginated hypoechoic lesion with peripheral flow strongly favours leiomyoma (Table 3). The mixed vascular pattern seen in combined disease in this study is especially relevant, as coexistence is common and often clinically missed if only one dominant lesion is considered.

Doppler evaluation strengthened the distinction between the two entities. Scattered or intramural vascularity was characteristic of adenomyosis, peripheral feeding vessels favored leiomyoma, and mixed vascularity suggested combined pathology. These findings are consistent with prior Doppler studies showing diffuse or trans lesional vascularity in adenomyosis and peripheral vascularity in leiomyoma. Leiomyoma typically shows circular or capsular flow making doppler useful in differential diagnosis.^{8,9,16}

While considering the total outcome of the diagnostic modality in 94 women who underwent surgery and had a final histopathological diagnosis we have the following scenario. In the present study, 92.2% women showing peripheral vascularity in colour Doppler imaging had leiomyoma while only 12% had adenomyosis. On the contrary 89% women showing well defined margins as morphological feature in TVS had leiomyoma and only 17.1% had adenomyosis; meaning a combined modality will document a pre-operative diagnosis correctly.⁸ In the present study 88% of women with intramural vascularity in color Doppler were having adenomyosis and only 7.8% had leiomyoma. Seventy eight percent women with the morphological feature of asymmetrical thickening of myometrium in TVS had adenomyosis while only 7.7% were diagnosed as leiomyoma histopathologically. This justifies more accurate, and easily useful and available diagnostic modality like TVS as a primary approach to AUB patients (Table 3).¹⁷ A recent Indian study also supports validation of combined TVS and Doppler as a genuine approach for clinical diagnosis of AUB women.¹⁸

The diagnostic indices compare favorably with published evidence. In this cohort, TVS achieved 97.86%, 97.86% and 78.57% accuracy in diagnosis of adenomyosis. Two signs of TVS, well defined hypoechoic mass and edge shadowing had 99.2% and 93.5% accuracy for diagnosis of leiomyoma respectively (Table 5). Some authors reported useful noninvasive diagnostic accuracy of imaging for adenomyosis, while others emphasized that routine-practice sensitivity may be lower when standardized assessment and expertise are limited.¹⁷ The high performance observed here therefore supports the practical role of structured TVS with Doppler in tertiary-care AUB evaluation.^{16,19}

Recently, some authors have documented evaluation of adenomyosis by validating more than four signs of revised

MUSA guidelines as a definitive diagnostic feature. Echogenic subendometrial buds, globular uterus and irregular junctional zone are indirect predictive features.²⁰ Some investigators have studied effect of adenomyosis by sonographic assessment (MUSA) on the outcomes of IVF pregnancies. They documented less chance of clinical pregnancy in patients of IVF and embryo transfer; when one of the MUSA features 'interrupted junctional zone' was seen in TVS and there was significant association.²¹ Negative affect of adenomyosis on IVF pregnancy, live birth rate and increased risk of miscarriage was also concluded in meta-analysis in year 2023 necessitating more accurate clinical diagnostic test for adenomyosis.²²

While considering role of MRI a recent meta-analysis has documented no difference in the diagnostic value of MRI and TVS. In a head-to-head meta-analysis of six studies involving 595 women, it found no significant difference between TVS and MRI; pooled sensitivity and specificity were 75% and 81% for TVS and 69% and 80% for MRI, with substantial heterogeneity. This supports TVS as an accessible first-line examination and MRI as a useful problem-solving tool when findings are inconclusive or detailed mapping is required.²³ Other reports have documented MRI features like wall asymmetry, irregular junctional zone and myometrial cyst being more accurate for prediction of adenomyosis.²⁴ Consistent application of MUSA definitions, structured reporting, and operator training are therefore important and practical in AUB patients.²⁵

The clinical implication is that TVS with Doppler can improve preoperative confidence. Accurate differentiation between adenomyosis and leiomyoma can inform counselling, selection of medical therapy, fertility-sparing intervention, myomectomy, or hysterectomy, and recognition of combined disease may prevent incomplete explanation of symptoms and suboptimal management decisions.

Limitations

The study was conducted at a single tertiary-care center using an observational design, which may limit generalizability. MRI was not used as a parallel diagnostic comparator; consequently, the findings specifically reflect the performance of TVS with Doppler within the local institutional workflow.

CONCLUSION

This study concludes, transvaginal sonography with Doppler, is an accurate tool for differentiating leiomyoma and adenomyosis in women presenting with abnormal uterine bleeding. MUSA features and vascular patterns showed strong diagnostic correlation with histopathology. The study also concludes that age and parity had significant association with final diagnosis, adenomyosis more in multiparous and older women; leiomyoma more in young and nullipara. Overall, the findings support the

role of structured ultrasound assessment and Doppler as an effective first line diagnostic modality in evaluation of abnormal uterine bleeding. Accurate preoperative differentiation between leiomyoma and adenomyosis has direct implications for treatment planning in heavily bleeding women who require conservative and fertility sparing treatment.

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