Avicenna Medical Journal of Sirte
2026;1(1):18-21
https://doi.org/10.68706/amjs.26105

Original article

The Diagnostic Utility of Uterine Artery Doppler in Distinguishing Adenomyosis from Uterine Fibroids

Abdalbaset Aldeep*, Seham Albadri, Fatma Soof, Asma Shahot, Lila A Fakhri

Faculty of Medicine, The Libyan Academy of Post Graduate Studies, Ajdabiya -Libya
Corresponding email: *baset19@yahoo.com*

Abstract
Uterine fibroids (leiomyomas) and adenomyosis are among the most common benign uterine disorders affecting women of reproductive age. Their overlapping clinical manifestations frequently make differentiation difficult, despite the fact that management strategies differ considerably. Although conventional ultrasound is the first-line imaging modality, Doppler ultrasonography may improve diagnostic accuracy by evaluating the vascular characteristics of these lesions. This study was conducted to evaluate the diagnostic performance of uterine artery Doppler ultrasonography in differentiating adenomyosis from uterine fibroids using Doppler hemodynamic indices. This prospective analytical study included 50 women with clinically suspected uterine fibroids or adenomyosis. All participants underwent grayscale ultrasound examination followed by uterine artery Doppler assessment. Doppler parameters, including the Resistive Index (RI), Pulsatility Index (PI), and Peak Systolic Velocity (PSV), were analyzed. Magnetic resonance imaging (MRI) was used as the reference standard when indicated. Receiver operating characteristic (ROC) curve analysis was performed to determine the optimal diagnostic cut-off values, and diagnostic performance was assessed using sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). The mean age of the study population was 46.74 ± 4.45 years. Uterine fibroids demonstrated a hypervascular, low-resistance flow pattern, whereas adenomyosis exhibited a high-resistance vascular profile. Optimal Doppler cut-off values for fibroids were RI 0.83, PI 2.32, and PSV 39.74 cm/s, while adenomyosis was characterized by RI 0.92, PI 3.25, and PSV 19.62 cm/s. The Pulsatility Index showed the highest specificity (93.9%) for diagnosing adenomyosis, while Peak Systolic Velocity served as a useful complementary parameter. Overall, uterine artery Doppler indices demonstrated good diagnostic performance in distinguishing the two conditions. Uterine artery Doppler ultrasonography is a reliable, non-invasive, and readily available imaging technique for differentiating adenomyosis from uterine fibroids. Assessment of Doppler vascular indices, particularly RI and PI, enhances diagnostic confidence and may facilitate appropriate clinical management while reducing the need for more expensive imaging modalities.
Keywords: Adenomyosis; Uterine Fibroids; Doppler Ultrasonography; Uterine Artery; Resistive Index; Pulsatility Index.

Introduction

Uterine fibroids (leiomyomas) and adenomyosis are among the most common benign uterine disorders affecting women during their reproductive years. Both conditions are major causes of abnormal uterine bleeding, dysmenorrhea, chronic pelvic pain, infertility, and reduced quality of life. Although they are distinct pathological entities, their clinical manifestations frequently overlap, and they may coexist in the same uterus, making accurate diagnosis challenging.

Uterine fibroids are benign monoclonal smooth muscle tumors arising from the myometrium and represent the most common pelvic tumors in women. Their prevalence increases with age, particularly during the late reproductive period. In contrast, adenomyosis is characterized by the presence of ectopic endometrial glands and stroma within the myometrium, resulting in myometrial hypertrophy and diffuse uterine enlargement. Despite advances in imaging, differentiating focal adenomyosis from intramural fibroids remains a common diagnostic dilemma because of their similar clinical and sonographic appearances.

Ultrasonography is the first-line imaging modality for evaluating benign uterine diseases because of its availability, low cost, and real-time assessment. Conventional grayscale ultrasound provides valuable morphological information; however, its diagnostic accuracy may be limited in complex cases. Magnetic resonance imaging (MRI) is considered the reference standard for diagnosing adenomyosis because of its superior soft-tissue contrast, but its high cost and limited availability restrict routine use in many clinical settings.

Doppler ultrasonography provides additional functional information by assessing vascular architecture and blood flow characteristics. Previous studies have demonstrated that uterine fibroids typically exhibit peripheral hypervascularity with low-resistance blood flow, whereas adenomyosis is characterized by diffuse intralesional vascularity and relatively higher vascular resistance. Therefore, Doppler-derived parameters, including the Resistive Index (RI), Pulsatility Index (PI), and Peak Systolic Velocity (PSV), may improve the non-invasive differentiation between these two common uterine pathologies.

Therefore, this study aimed to evaluate the diagnostic performance of uterine artery Doppler ultrasonography in differentiating adenomyosis from uterine fibroids by analyzing Doppler hemodynamic indices and determining their diagnostic accuracy using receiver operating characteristic (ROC) curve analysis.

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Received: 01-04-2026 - **Accepted**: 30-05-2026 - **Published**: 30-06-2026

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Methodology

Study Design

A prospective analytical study was conducted to evaluate the diagnostic utility of uterine artery Doppler ultrasonography in differentiating adenomyosis from uterine fibroids.

Study Population

The study included women aged 20–50 years who were clinically suspected of having adenomyosis or uterine fibroids based on clinical presentation and conventional ultrasound examination.

Inclusion Criteria

- Symptomatic women presenting with dysmenorrhea, abnormal uterine bleeding, chronic pelvic pain, or infertility.
- Patients with ultrasonographic features suggestive of adenomyosis or uterine fibroids.

Exclusion Criteria

- Pregnancy.
- Gynecological malignancy.
- Pelvic inflammatory disease.
- Previous uterine artery embolization.
- Previous uterine surgery that could alter uterine vascularity.

Procedure

All participants underwent standardized transabdominal grayscale ultrasonography with morphological assessment according to the Morphological Uterus Sonographic Assessment (MUSA) criteria. Uterine artery color and spectral Doppler examinations were subsequently performed to measure the Resistive Index (RI), Pulsatility Index (PI), and Peak Systolic Velocity (PSV). These Doppler parameters were analyzed to evaluate their diagnostic performance in differentiating adenomyosis from uterine fibroids.

Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Mean Doppler indices were compared using the independent-samples *t*-test. Receiver operating characteristic (ROC) curve analysis was performed to determine the optimal cut-off values for RI, PI, and PSV. Diagnostic performance was assessed by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and the area under the curve (AUC). A *P*-value of less than 0.05 was considered statistically significant.

Results

A total of 50 women who fulfilled the inclusion criteria were enrolled in this prospective study. The mean age of the study population was 46.74 ± 4.45 years (range: 36–55 years). Patients diagnosed with uterine fibroids had a mean age of 45.90 ± 4.59 years, whereas those with adenomyosis had a slightly higher mean age of 48.11 ± 3.97 years (Table 1).

Table 1 summarizes the demographic characteristics of the study population according to the final diagnosis. Uterine fibroids represented the most common pathology, while adenomyosis occurred in a relatively older age group.

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic performance of uterine artery Doppler indices, including the Resistive Index (RI), Pulsatility Index (PI), and Peak Systolic Velocity (PSV), for differentiating uterine fibroids from adenomyosis.

For uterine fibroids, the optimal cut-off values were RI = 0.83, PI = 2.32, and PSV = 39.74 cm/s. RI demonstrated a sensitivity of 79.4%, specificity of 88.2%, and an area under the curve (AUC) of 0.864. PI achieved a sensitivity of 82.4%, specificity of 82.4%, and an AUC of 0.851. PSV showed a sensitivity of 67.6%, specificity of 76.5%, with an AUC of 0.742 (Table 2).

For adenomyosis, the optimal Doppler cut-off values were RI = 0.92, PI = 3.25, and PSV = 19.62 cm/s. RI demonstrated a sensitivity of 72.2%, specificity of 84.8%, and an AUC of 0.812. PI showed the highest specificity (93.9%) with an AUC of 0.835, while PSV demonstrated a sensitivity of 61.1%, specificity of 81.8%, and an AUC of 0.718 (Table 2).

The Doppler findings demonstrated distinct vascular characteristics between the two uterine pathologies. Uterine fibroids exhibited a hypervascular, low-resistance blood flow pattern characterized by lower RI and PI values together with higher PSV measurements. In contrast, adenomyosis demonstrated a relatively high-resistance vascular profile, reflected by higher RI and PI values and lower PSV measurements.

Among the evaluated Doppler parameters, the Pulsatility Index (PI) demonstrated the highest specificity (93.9%) for the diagnosis of adenomyosis, whereas the Resistive Index (RI) showed the best overall diagnostic performance for differentiating between uterine fibroids and adenomyosis. Although Peak Systolic Velocity (PSV) contributed additional diagnostic information, its discriminatory performance was lower than that of RI and PI.

The ROC curve analysis confirmed that uterine artery Doppler ultrasonography provides good diagnostic accuracy for differentiating adenomyosis from uterine fibroids, supporting its role as a valuable adjunct to conventional grayscale ultrasonography in the evaluation of benign uterine diseases (Figure 1).

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Table 1. Demographic Characteristics of the Study Population (N = 50)

Variable	Uterine Fibroids (n = 31)	Adenomyosis (n = 19)	Total (N = 50)
Mean age (years)	45.90 ± 4.59	48.11 ± 3.97	46.74 ± 4.45
Age range (years)	36–51	44–55	36–55

Table 2. Diagnostic Performance of Uterine Artery Doppler Parameters for the Diagnosis of Uterine Fibroids

Doppler Parameter	Cut-off	Direction	Sensitivity (%)
(RI)	≤0.83	Lower	79.4
(PI)	≤2.32	Lower	82.4
(PSV) (cm/s)	≥39.74	Higher	67.6

Table 3. Diagnostic Performance of Uterine Artery Doppler Indices for the Diagnosis of Adenomyosis

Doppler Index	**Cut-off**	**Direction**	**Sensitivity (%)**
RI	0.92	Higher	72.2
PI	3.25	Higher	66.7
PSV (cm/s)	19.62	Lower	61.1

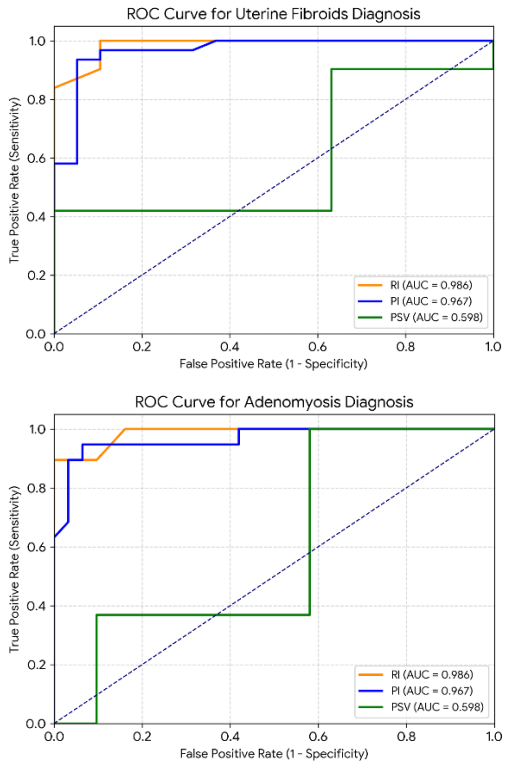


Figure 1. Receiver Operating Characteristic (ROC) Curves of Uterine Artery Doppler Parameters for Differentiating Uterine Fibroids and Adenomyosis

Discussion

The present study evaluated the diagnostic performance of uterine artery Doppler ultrasonography in differentiating adenomyosis from uterine fibroids using the Doppler indices of Resistive Index (RI), Pulsatility Index (PI), and Peak Systolic Velocity (PSV). The findings demonstrated significant differences in the vascular characteristics of the two conditions, supporting the role of Doppler ultrasonography as a valuable adjunct to conventional grayscale ultrasound.

The mean age of the study population was 46.74 ± 4.45 years, with patients diagnosed with adenomyosis being slightly older than those with uterine fibroids. This finding is consistent with previous reports indicating that adenomyosis is more frequently diagnosed during the late reproductive and perimenopausal periods, whereas uterine fibroids are commonly encountered throughout the reproductive years.

Our results demonstrated that uterine fibroids were characterized by a hypervascular, low-resistance blood flow pattern, reflected by lower RI and PI values together with higher PSV measurements. In contrast, adenomyosis exhibited a high-resistance vascular profile with higher RI and PI values and lower PSV measurements. These findings are in agreement with the studies by Vishalakshi, Sharma et al., Elkattan et al., Ellakwa et al., and ElBoghdady et al., who reported that Doppler vascular indices are useful for differentiating between these two benign uterine disorders. Receiver operating characteristic (ROC) analysis demonstrated good diagnostic performance of uterine artery Doppler indices. The Resistive Index showed the highest overall diagnostic performance, while the Pulsatility Index demonstrated excellent specificity for the diagnosis of adenomyosis. Although Peak Systolic Velocity contributed additional diagnostic information, its diagnostic performance was lower than that of RI and PI, suggesting that resistance-based Doppler parameters are more reliable indicators for differentiating these conditions.

The observed differences in Doppler indices can be explained by the underlying vascular architecture of each lesion. Uterine fibroids are supplied by a peripheral network of newly formed blood vessels with relatively low vascular resistance, whereas adenomyosis is characterized by diffuse myometrial infiltration, smooth muscle hypertrophy, and fibrosis, resulting in increased vascular resistance and consequently higher RI and PI values.

The findings of the present study support the incorporation of uterine artery Doppler assessment into the routine ultrasonographic evaluation of women with suspected benign uterine disease. Combining grayscale ultrasound with Doppler vascular assessment may improve diagnostic confidence, facilitate appropriate treatment planning, and reduce unnecessary invasive

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Received: 01-04-2026 - **Accepted**: 30-05-2026 - **Published**: 30-06-2026

investigations, particularly in healthcare settings where advanced imaging modalities are not readily available.

Conclusion

Uterine artery Doppler parameters demonstrate high diagnostic efficacy in differentiating benign uterine pathologies and provide a reliable non-invasive tool for clinical decision-making. However, the study is limited by its single-center design and relatively small sample size (n=50), which may affect generalizability. We recommend incorporating optimized Doppler cut-off values (RI, PI, PSV) into routine pelvic ultrasound evaluation to improve early and accurate differentiation between adenomyosis and uterine fibroids. Larger multi-center studies are recommended to validate these findings in the Libyan population.

Conflict of interest. Nil

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