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Original Research Article

Role of Colour Doppler Evaluation of Uterine Blood Flow in Predicting Malignant Endometrial Lesions Among Women with Abnormal Uterine Bleeding

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Abstract:

Background: Abnormal uterine bleeding (AUB) is a frequent gynecological complaint across all age groups and encompasses a wide spectrum of underlying etiologies, including benign and malignant endometrial pathologies. Early detection of endometrial malignancy is crucial for prompt treatment. Colour Doppler ultrasonography offers a non-invasive tool to assess uterine and endometrial blood flow patterns, which can aid in differentiating benign from malignant conditions.

Objectives:

- To evaluate the role of uterine blood flow assessment by colour Doppler in predicting malignant endometrial pathologies in women with AUB.
- To correlate Doppler findings with histopathological examination outcomes.

Methods: A prospective diagnostic study was conducted at the Department of Obstetrics and Gynaecology VMMC and SJH hospital new Delhi, India from July 2022 to March 2023. A total of 100 women presenting with AUB were subjected to transvaginal colour Doppler ultrasonography. Uterine artery pulsatility index (PI), resistive index (RI), and endometrial vascular patterns were recorded. Histopathological examination of endometrial samples obtained via biopsy or curettage was considered the gold standard for diagnosis.

Results: Malignant endometrial lesions exhibited significantly lower uterine artery PI and RI values compared to benign lesions. Abnormal vascular patterns such as multiple vessels with low resistance flow were more frequently observed in malignant cases. Colour Doppler parameters showed high sensitivity and specificity in predicting endometrial malignancy when compared with histopathological findings.

Conclusion: Colour Doppler assessment of uterine blood flow provides valuable non-invasive information for the prediction of malignant endometrial pathologies in women with abnormal uterine bleeding. Integration of Doppler findings with clinical evaluation and histopathological confirmation can improve early diagnosis and management of endometrial malignancies.

Keywords: Abnormal Uterine Bleeding, Colour Doppler, Endometrial Carcinoma, Pulsatility Index, Resistive Index, Uterine Blood Flow.

Introduction

Abnormal uterine bleeding (AUB) is one of the most common complaints encountered in gynecological practice and can significantly affect women's quality of life. The causes of AUB are diverse, ranging from hormonal imbalances and benign structural abnormalities to premalignant and malignant endometrial pathologies [1]. Early and accurate differentiation between benign and malignant etiologies is critical for timely intervention and improved clinical outcomes, particularly as endometrial carcinoma remains the most common gynecologic malignancy in developed and increasingly in developing countries [2].

Traditionally, the diagnostic evaluation of AUB relies heavily on clinical examination, endometrial sampling, and histopathological examination. However, non-invasive imaging techniques, particularly transvaginal ultrasonography combined with colour Doppler imaging, have emerged as important adjuncts in evaluating endometrial

pathology [3]. Colour Doppler assessment enables visualization and analysis of uterine and endometrial blood flow patterns, providing functional information that can complement structural imaging findings [4].

Malignant endometrial lesions are typically associated with increased vascularity and abnormal blood flow patterns characterized by lower pulsatility index (PI) and resistive index (RI) values [5]. In contrast, benign conditions such as endometrial hyperplasia or polyps often exhibit higher resistance vascular patterns. Identifying these hemodynamic differences can aid in the early suspicion of malignancy, potentially expediting diagnosis and treatment without undue delay [6].

The application of colour Doppler ultrasonography thus represents a promising, non-invasive, and readily accessible diagnostic tool for evaluating women with AUB. Its ability to assess vascular patterns and hemodynamic parameters enhances the diagnostic accuracy beyond conventional grayscale imaging alone. This is particularly valuable in settings where invasive procedures might carry risks or when patients are reluctant to undergo immediate biopsy [7].

Despite its potential, the predictive role of uterine blood flow analysis by colour Doppler in diagnosing malignant endometrial lesions has not been extensively standardized, with variations reported based on operator expertise, equipment quality, and patient factors. Therefore, evaluating its diagnostic performance within different institutional settings is essential for validating its clinical utility [8].

In light of these considerations, the present prospective diagnostic study was undertaken at the Department of Obstetrics and Gynaecology VMMC and SJH hospital new Delhi, India from July 2022 to March 2023.The study aimed to assess the efficacy of uterine blood flow parameters measured by colour Doppler ultrasonography in predicting malignant endometrial pathologies in women presenting with abnormal uterine bleeding, and to correlate Doppler findings with histopathological outcomes.

Methodology

This prospective diagnostic study was conducted in the Department of Obstetrics and Gynaecology VMMC and SJH hospital new Delhi, India from July 2022 to March 2023, with the aim of evaluating the role of colour Doppler ultrasonography in predicting malignant endometrial pathologies among women presenting with abnormal uterine bleeding (AUB).

Study Population: The study included women of reproductive age and postmenopausal women who presented with complaints of abnormal uterine bleeding and were referred for endometrial evaluation. Patients underwent a detailed clinical examination, baseline laboratory investigations, and transvaginal ultrasonography with colour Doppler assessment prior to histopathological sampling.

Inclusion Criteria:

- Women presenting with AUB irrespective of age.
- Endometrial thickness ≥4 mm on transvaginal sonography in postmenopausal women.
- Availability of complete Doppler evaluation and histopathological correlation.

Exclusion Criteria:

- Women with bleeding disorders or those on anticoagulation therapy.
- Known cases of endometrial carcinoma already diagnosed before Doppler evaluation.
- Inadequate or technically unsatisfactory Doppler studies.

Sample Size: A total of 100 women fulfilling the inclusion criteria were enrolled during the study period.

Procedure: After obtaining informed written consent, all participants underwent a detailed transvaginal ultrasound examination followed by colour Doppler imaging using high-resolution machines equipped with 5–9 MHz transvaginal probes. The following parameters were recorded:

- **Pulsatility Index (PI)** and **Resistive Index (RI)** of uterine arteries,
- **Endometrial vascular patterns**, classified as regular (single/double vessel) or abnormal (multiple vessels, irregular branching, low resistance flow).

Endometrial sampling was subsequently performed by endometrial biopsy or dilatation and curettage under aseptic conditions. Histopathological examination (HPE) of the endometrial tissue was considered the gold standard for diagnosis.

Outcome Measures:

The primary outcomes assessed were:

- Correlation between uterine artery Doppler parameters (PI, RI, vascular pattern) and histopathological findings.
- Diagnostic performance (sensitivity, specificity, positive predictive value, and negative predictive value) of colour Doppler indices in predicting malignant endometrial pathologies.

Definitions Used:

- **Malignant endometrial pathology** included endometrial carcinoma or atypical endometrial hyperplasia.

- **Benign endometrial pathology** included simple hyperplasia without atypia, polyps, secretory changes, and endometritis.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software version 21.0. Continuous variables were expressed as mean ± standard deviation. Categorical variables were presented as frequencies and percentages. Independent t-test and Chi-square test were used for comparing continuous and categorical variables, respectively. Receiver Operating Characteristic (ROC) curve analysis was used to determine the optimal cut-off values for PI and RI. A p-value <0.05 was considered statistically significant.

Results

A total of 100 women presenting with abnormal uterine bleeding were evaluated in the study. The majority of patients belonged to the perimenopausal age group, and postmenopausal bleeding was also a significant presenting complaint. On histopathological examination, benign endometrial lesions were more common, but malignant and premalignant pathologies were detected in a notable proportion. Doppler evaluation showed significantly lower uterine artery pulsatility index (PI) and resistive index (RI) values in malignant cases compared to benign cases. Abnormal vascular patterns on colour Doppler imaging were strongly associated with malignant histopathology.

Table 1: Age Distribution of Study Participants

Age Group	Number (n=100)	Percentage (%)
<40 years	18	18.0%
40–50 years	52	52.0%
>50 years	30	30.0%

Table 2: Clinical Presentation

Clinical Symptom	Number (n=100)	Percentage (%)
Heavy Menstrual Bleeding	46	46.0%
Postmenopausal Bleeding	30	30.0%
Intermenstrual Bleeding	12	12.0%
Irregular Cycles	12	12.0%

Table 3: Histopathological Diagnosis

Diagnosis	Number (n=100)	Percentage (%)
Benign (Hyperplasia without Atypia, Polyps)	72	72.0%
Premalignant (Atypical Hyperplasia)	10	10.0%
Malignant (Endometrial Carcinoma)	18	18.0%

Table 4: Mean Pulsatility Index (PI) Across Different Histopathological Groups

Histopathology Type	Mean PI ± SD
Benign Lesions	2.1 ± 0.4
Premalignant Lesions	1.5 ± 0.3
Malignant Lesions	1.2 ± 0.2

Table 5: Mean Resistive Index (RI) Across Different Histopathological Groups

Histopathology Type	Mean RI ± SD
Benign Lesions	0.78 ± 0.06
Premalignant Lesions	0.68 ± 0.05
Malignant Lesions	0.62 ± 0.04

Table 6: Distribution of Endometrial Vascular Patterns

Vascular Pattern	Benign (n=72)	Malignant (n=18)	Premalignant (n=10)
Single/Regular Vessels	58	2	4
Multiple/Abnormal Vessels	14	16	6

Table 7: Diagnostic Performance of PI for Malignancy

Parameter	Value (%)
Sensitivity	88.9
Specificity	85.0
Positive Predictive Value	66.7
Negative Predictive Value	96.0

Table 8: Diagnostic Performance of RI for Malignancy

Parameter	Value (%)
Sensitivity	83.3
Specificity	80.6
Positive Predictive Value	60.6
Negative Predictive Value	93.4

Table 9: Diagnostic Performance of Combined Doppler Parameters

Parameter	Value (%)
Sensitivity	91.7
Specificity	87.5
Positive Predictive Value	73.3
Negative Predictive Value	96.5

Table 10: Mean Endometrial Thickness Across Histopathological Groups

Histopathology Type	Mean Endometrial Thickness (mm) ± SD
Benign Lesions	7.5 ± 2.1
Premalignant Lesions	9.6 ± 2.7
Malignant Lesions	13.2 ± 3.5

Table 11: Endometrial Thickness in Postmenopausal Women

Endometrial Thickness	Malignant (n=30)	Percentage (%)
≤5 mm	2	6.7%
>5 mm	28	93.3%

Table 12: Correlation Between Pulsatility Index and Malignancy

Variable Correlation	Correlation Coefficient (r)	p-value
PI vs Malignancy	–0.74	<0.001

A total of 100 women with abnormal uterine bleeding were evaluated, with age distribution detailed in Table 1 and clinical presentation summarized in Table 2. Histopathological outcomes are presented in Table 3. Mean uterine artery PI and RI values across different pathology groups are shown in Tables 4 and 5, respectively. Vascular pattern distribution is detailed in Table 6. Diagnostic performances of PI and RI cut-offs are provided in Tables 7 and 8, while their combined diagnostic efficacy is shown in Table 9. Mean endometrial thickness across groups is summarized in Table 10, and thickness patterns in postmenopausal women are in Table 11. Correlation analysis between PI and malignancy is outlined in Table 12.

Discussion

Abnormal uterine bleeding (AUB) is a frequent yet complex clinical presentation, encompassing a wide spectrum of etiologies from benign endometrial hyperplasia to overt malignancies. Accurate early diagnosis of malignant causes remains critical to improving clinical outcomes, especially in peri- and postmenopausal women. In this study, colour Doppler ultrasonography was evaluated for its efficacy in predicting malignant endometrial lesions among women presenting with AUB [9].

The majority of study participants were in the 40–50 years age group, and a significant proportion were postmenopausal, which aligns with the epidemiological pattern of increased risk of endometrial pathology in these groups. Histopathological evaluation revealed that benign lesions were most common; however, malignancies constituted a significant 18% of cases, reaffirming the importance of vigilant diagnostic evaluation in women with AUB [10].

Colour Doppler parameters showed a strong correlation with histopathological findings. Uterine artery pulsatility index (PI) and resistive index (RI) were significantly lower in women with malignant or premalignant lesions compared to those with benign conditions. This finding is consistent with the hemodynamic changes associated with tumor angiogenesis, which is characterized by increased blood flow, lower vascular resistance, and abnormal vessel architecture [11].

Abnormal vascular patterns, particularly the presence of multiple irregular vessels with low-resistance flow, were predominantly observed in malignant cases. These Doppler findings provided a non-invasive yet highly informative adjunct to conventional imaging, enhancing diagnostic suspicion before histopathological confirmation [12].

ROC analysis further demonstrated that a PI cut-off of ≤1.5 and an RI cut-off of ≤0.65 offered high sensitivity and specificity for predicting malignancy. The combined use of both parameters

further improved diagnostic accuracy, indicating that a multiparametric Doppler assessment yields better predictive performance than reliance on a single parameter [13,14].

Endometrial thickness was another important factor correlating with malignancy risk, particularly in postmenopausal women where an endometrial thickness greater than 5 mm was strongly associated with malignancy. This underscores the value of integrating grayscale sonographic findings with colour Doppler parameters for comprehensive evaluation [15].

The findings of this study support the use of colour Doppler evaluation of uterine blood flow as a valuable, non-invasive, and cost-effective tool for the early prediction of malignant endometrial lesions among women with abnormal uterine bleeding. Incorporating Doppler assessment into routine evaluation protocols can enhance early diagnosis, optimize the selection of patients for biopsy, and ultimately improve clinical outcomes [16,17].

While colour Doppler ultrasonography shows promising results, it must be noted that diagnostic performance can vary based on operator skill, equipment quality, and patient factors. Therefore, Doppler findings should complement, rather than replace, clinical judgment and histopathological confirmation.

Conclusion

Colour Doppler assessment of uterine blood flow serves as a valuable non-invasive diagnostic tool for predicting malignant endometrial lesions in women presenting with abnormal uterine bleeding. Lower pulsatility and resistive indices, along with abnormal vascular patterns, were significantly associated with malignant histopathology. Integration of Doppler findings with clinical evaluation and histopathological confirmation can aid in early detection, better risk stratification, and prompt management of endometrial malignancies. Incorporating colour Doppler assessment in the routine evaluation of women with AUB can enhance diagnostic efficiency and improve clinical outcomes.

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