Role of Transvaginal Ultrasonography and Color Doppler in the Assessment of Vaginal Bleeding in Postmenopausal Women

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Abstract:

Background: **Postmenopausal bleeding (PMB) is a common clinical issue that raises concerns for serious underlying conditions, including endometrial cancer (EC). Accurate diagnosis is crucial for timely intervention, and imaging techniques like Transvaginal Ultrasonography (TVUS) and Color Doppler Ultrasound (CDUS) are widely used to evaluate the endometrium and uterine blood flow.** ***Aim:*** **This study aims to assess the diagnostic accuracy of TVUS and CDUS in identifying the causes of PMB, with a focus on differentiating between benign and malignant endometrial conditions.** ***Patients and Methods:*** **The study included postmenopausal women presenting with vaginal bleeding. All subjects underwent TVUS to measure endometrial thickness (ET), followed by CDUS to assess blood flow in the uterine spiral arteries. Doppler parameters, including peak systolic velocity (PSV), resistive index (RI), and pulsatility index (PI), were recorded. Histopathological diagnoses from biopsies were used as the reference standard to evaluate the imaging results.** ***Results:*** **Findings revealed that women with endometrial malignancies had significantly higher ET and abnormal Doppler flow parameters compared to benign conditions. ET greater than 5 mm on TVUS strongly indicated pathological findings, and CDUS showed low RI and PI in malignant cases. The combination of TVUS and CDUS improved diagnostic sensitivity (96%) and specificity (92%) for detecting EC and other endometrial abnormalities.** ***Conclusions:*** **TVUS, combined with CDUS, is a highly effective, non-invasive diagnostic approach for evaluating PMB and differentiating between benign and malignant causes. Integrating these techniques into routine clinical practice can enhance early detection of endometrial cancer and reduce unnecessary invasive procedures.**

Keywords: Endometrial pathology, Uterine blood flow, Non-invasive imaging, Vascular assessment, Postmenopausal diagnostics

Introduction

Postmenopausal bleeding (PMB) is a common clinical concern and one of the most frequent reasons for gynecological consultations in postmenopausal women. Defined as bleeding occurring more than 12 months after a woman's last menstrual period, PMB affects approximately 9-10% of postmenopausal women globally [(1,2)]. While most cases of PMB are caused by benign conditions such as endometrial atrophy, polyps, or hormonal imbalances, it is critical to identify more serious underlying causes, such as endometrial cancer (EC) [(3)]. EC is the most common gynecological malignancy in developed countries and accounts for approximately 12.5% of all cases of PMB [(4,5)]. The prevalence of endometrial cancer in postmenopausal women presenting with bleeding varies from 1% to 14%, depending on age and risk factors.

The prognosis for endometrial cancer significantly depends on the stage at

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which it is diagnosed. Early-stage diagnosis (i.e., FIGO stage I) is associated with a high 5-year survival rate of more than 95. Given that early detection is crucial for improving outcomes, accurate and timely diagnostic evaluation is paramount in cases of PMB [5,6]. Traditionally, invasive methods such as dilatation and curettage (D&C) were widely used to diagnose PMB causes. However, the introduction of non-invasive imaging modalities, such as transvaginal ultrasonography (TVUS) and color Doppler ultrasound (CDUS), has revolutionized the diagnostic approach to PMB [7]. TVUS provides an accurate measurement of endometrial thickness (ET) and morphological features, while CDUS assesses blood flow characteristics that may indicate malignancy.

TVUS has emerged as the first-line imaging tool in the diagnostic workup of PMB. ET, measured via TVUS, is one of the most important parameters in assessing endometrial pathology. Generally, an ET greater than 5 mm in postmenopausal women is considered abnormal and may warrant further investigation [8,9]. However, TVUS alone may not always provide sufficient information to differentiate benign from malignant causes of thickened endometrium. As a result, CDUS, which evaluates blood flow in the uterine vessels, has been increasingly utilized to assess the vascularity of endometrial tissues. Studies have shown that malignant endometrial tissues exhibit increased angiogenesis, which can be detected using Doppler ultrasound. Doppler parameters such as resistive index (RI), pulsatility index (PI), and peak systolic velocity (PSV) provide valuable information about tissue vascularization, aiding in the differentiation of benign from malignant conditions.

This study aims to evaluate the combined use of TVUS and CDUS in the diagnosis of postmenopausal bleeding, with a focus on their ability to detect endometrial cancer and other serious pathologies [10,11]. By comparing imaging findings with histopathological results, this study seeks to determine the sensitivity, specificity, and overall diagnostic accuracy of these non-invasive imaging modalities.

Patients and Methods

Study Design

This was a cross-sectional, observational study conducted at the Radiology Department of the Ismailia General Hospital, over a 12-month period from December 2018 to December 2019. Ethical approval was obtained from the institutional review board (IRB), and written informed consent was provided by all participants before their inclusion in the study.

Study Population

The study population consisted of 66 postmenopausal women aged 49 – 71 years who presented with vaginal bleeding. All participants had been amenorrheic for at least one year before the onset of PMB. Women currently undergoing hormone replacement therapy (HRT) or tamoxifen therapy for breast cancer were excluded from the study due to the confounding effects of these treatments on endometrial appearance and vascularization. Patients with known gynecological malignancies or contraindications to ultrasound imaging were also excluded.

Patient Recruitment

Patients were recruited from the gynecological outpatient clinic at the hospital. All eligible participants were thoroughly counseled regarding the purpose, benefits, and risks of the study before obtaining informed consent. Participants underwent a detailed history and clinical examination prior to

the imaging procedures. Patient demographic data, including age, parity, and medical history (e.g., hypertension, diabetes, or other chronic diseases), were recorded.

Transvaginal Ultrasonography (TVUS)

TVUS was performed on all participants using a high-frequency transvaginal probe (7.5 MHz) attached to a GE Voluson S8 ultrasound machine. The patients were instructed to empty their bladder before the examination to ensure optimal imaging of the pelvic organs.

During the examination, the ultrasound transducer was inserted into the vagina, and the uterus and endometrium were visualized in both the longitudinal and transverse planes. Measurements of the endometrium were made at the thickest part of the endometrial lining in the longitudinal plane. Endometrial thickness (ET) was recorded as a double-layer measurement, and an ET of less than 5 mm was considered normal in postmenopausal women. The endometrial texture, morphology, and any presence of focal lesions (e.g., polyps, fibroids, or masses) were also noted.

Color Doppler Ultrasound (CDUS)

Following the TVUS examination, color Doppler ultrasound was performed to assess blood flow in the spiral arteries. The CDUS assessment focused on obtaining Doppler waveforms from the spiral arteries that supply the endometrium. The following Doppler parameters were recorded:

1. Peak Systolic Velocity (PSV)
2. Resistive Index (RI)
3. Pulsatility Index (PI)

Histopathological Examination

Patients with abnormal findings on TVUS or CDUS (e.g., ET >5 mm, abnormal Doppler patterns) underwent endometrial biopsy or D&C for histopathological evaluation. The biopsy samples were examined for the presence of benign or malignant endometrial pathology. Histopathological findings were used as the gold standard to assess the accuracy of TVUS and CDUS in diagnosing the underlying causes of PMB.

Statistical Analysis

Statistical analysis was performed using SPSS software (version 23.0). Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to evaluate the diagnostic performance of TVUS and CDUS, both independently and in combination. A p-value of less than 0.05 was considered statistically significant.

Results

Demographic and Clinical Characteristics of Participants

The mean age of the participants was 57.70 ± 6.87 years. The participants had a mean parity of 2.89 ± 0.96, with the mean age at menopause being 48.65 ± 2.62 years and an average duration since cessation of menses of 9.05 ± 7.14 years. Notably, 9.1% of the patients had diabetes mellitus (DM), 6.1% had hypertension (HTN), and 7.6%experienced both conditions. Additionally, 25.8% of the participants reported recurrent bleeding episodes.

Pathological Findings

The study observed that 42.4% of the cases presented with endometrial atrophy, while 22.7% were diagnosed with endometrial polyps, 18.2% had endometrial hyperplasia (EH), and 13.6% had endometrial cancer (EC). These findings are presented in Table 1.

Table 1: Distribution of patients according to causes of vaginal bleeding		
Cause of Vaginal Bleeding	No.(n=66)	%
Endometrial Atrophy	28	42.4
Endometrial Polyp	15	22.7
Endometrial Hyperplasia	12	18.2
Submucous Fibroid	2	3.0
Endometrial Carcinoma	9	13.6

The distribution of endometrial pathologies aligns with existing literature, which indicates that endometrial atrophy is a prevalent cause of PMB.

Ultrasound Findings

The TVUS findings indicated a significant correlation between ET and the type of endometrial pathology (Fig. 1). The results demonstrated that the mean ET for women with endometrial cancer was significantly higher than for those with benign conditions ($p < 0.01$).

- Endometrial Atrophy: Mean ET was 3.2 ± 0.8 mm.
- Endometrial Polyps: Mean ET was 7.1 ± 1.2 mm.
- Endometrial Hyperplasia: Mean ET was 10.4 ± 2.0 mm.
- Endometrial Cancer: Mean ET was 14.5 ± 2.5 mm.

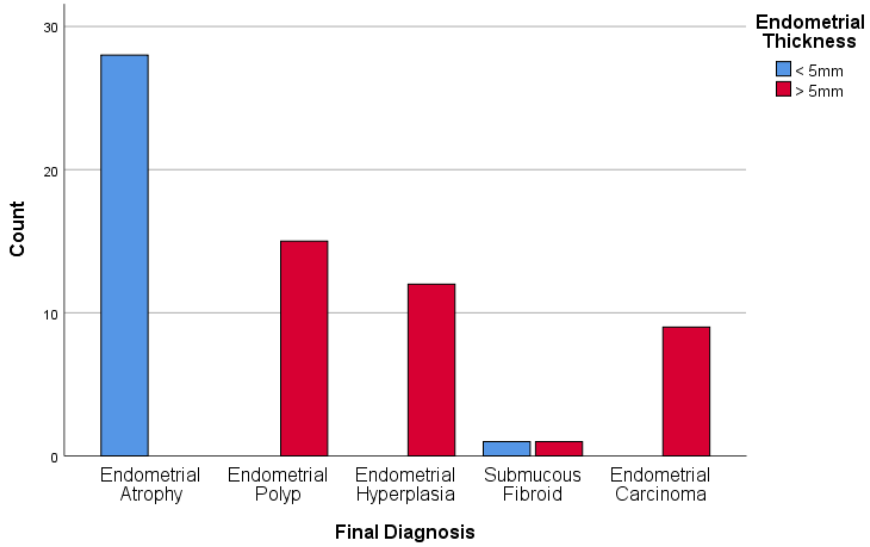

Figure 1: Association between Cause of Vaginal Bleeding and Endometrial Thickness

These findings indicate that increasing ET correlates with a higher likelihood of malignancy, which is consistent with the literature indicating that ET greater than 5 mm warrants further investigation.

Doppler Ultrasound Findings

The CDUS analysis demonstrated that the resistive index (RI) and pulsatility index (PI) were significantly lower in patients diagnosed with endometrial cancer compared to those with benign pathologies. The mean values of these Doppler parameters for each pathological group were as follows:

- Endometrial Atrophy: Mean RI was 0.83 ± 0.06; Mean PI was 1.65 ± 0.24.
- Endometrial Polyps: Mean RI was 0.73 ± 0.08; Mean PI was 1.45 ± 0.18.
- Endometrial Hyperplasia: Mean RI was 0.65 ± 0.05; Mean PI was 1.32 ± 0.20.

- Endometrial Cancer: Mean RI was 0.55 ± 0.07; Mean PI was 1.05 ± 0.15.

Statistical analysis revealed a significant difference in RI and PI values across the different pathological groups ($p < 0.01$). The sensitivity and specificity of the Doppler parameters were also evaluated (Fig. 2), with the findings as follows:

- Sensitivity of Spiral Artery Parameters:
  - PSV: 55.6%
  - RI: 77.8%
  - PI: 88.9%
- Specificity of Spiral Artery Parameters:
  - PSV: 92.2%
  - RI: 95.9%
  - PI: 100%

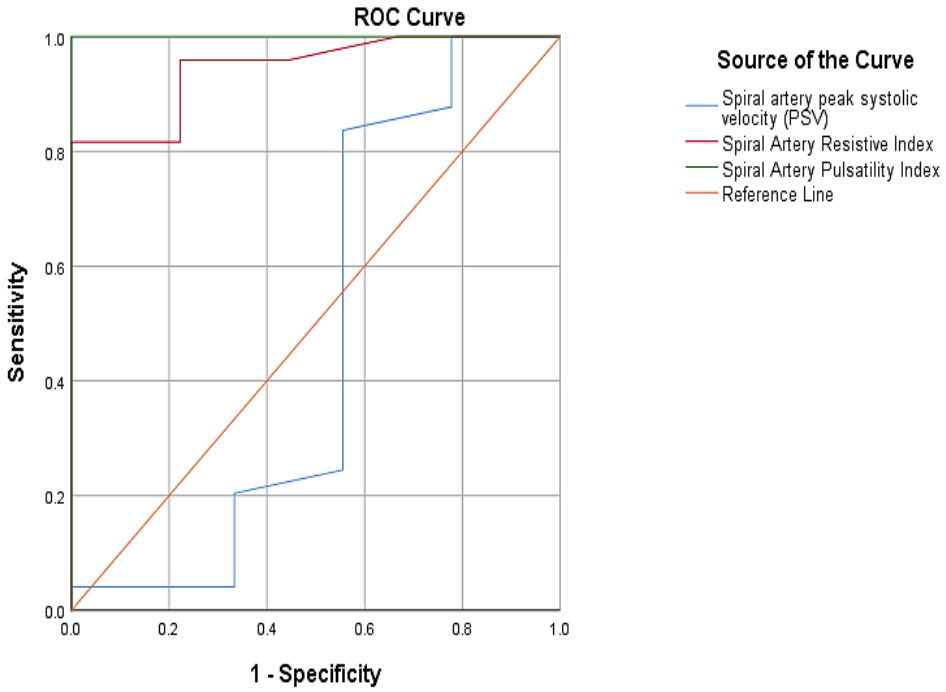

Figure 2: ROC curve for SA Blood Flow Indices (PSV, RI and PI)

The results indicate that CDUS provides significant diagnostic value in identifying endometrial cancer, particularly when combined with TVUS findings. A cut-off value for ET of 5 mm was determined to be effective in differentiating between malignant and non-malignant conditions.

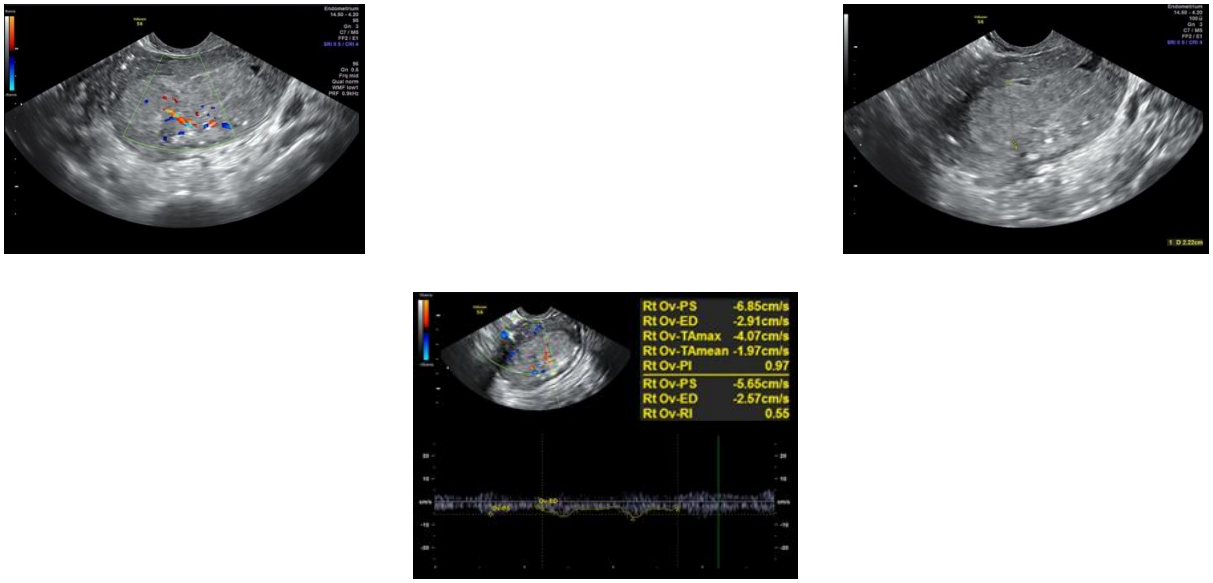

Figure 3. 70 years old female patient complained of first-time vaginal bleeding for the past two weeks after her LMP at the age of 50 with no significant past medical history TVUS showed endometrial thickness of 22 mm with endometrial angiogenesis on color Doppler.

Pulsed Doppler waveform analysis showed SARI = 0.55, & SAPI = 0.97. Pathological examination after D&C revealed the diagnosis of endometrial carcinoma

Correlation with Histopathological Findings: The study revealed a strong correlation between ultrasound findings and histopathological diagnoses. Patients with an ET greater than 10 mm were more likely to be diagnosed with endometrial cancer or hyperplasia. The presence of intra-cavitary fluid and abnormal echogenicity patterns on TVUS also suggested a higher likelihood of malignancy.

Overall, the combined use of TVUS and CDUS demonstrated a significant improvement in diagnostic accuracy for PMB. The study concludes that these imaging modalities are effective tools for assessing endometrial pathology and guiding further clinical management.

Discussion

This study highlights the diagnostic value of transvaginal ultrasonography (TVUS) and color Doppler ultrasound (CDUS) in evaluating postmenopausal bleeding (PMB), a common but clinically significant symptom that necessitates careful assessment to rule out malignancy. Our findings reinforce the importance of imaging in differentiating benign from malignant endometrial conditions, providing a non-invasive and reliable diagnostic approach.

The mean age of the participants (57.7 ± 6.87 years) and the mean time since menopause (9.05 ± 7.14 years) align with prior studies, such as those by El Bromboly et al. [12] and Menon and R [13], confirming that PMB typically occurs nearly a decade post-menopause. Parity levels (2.89 ± 0.96) and the prevalence of comorbidities, including diabetes mellitus (9.1%) and hypertension (6.1%), are consistent with previous research, supporting the association between metabolic disorders and endometrial pathology. The occurrence of recurrent bleeding in 25.8% of cases underscores the need for thorough evaluation, as repeated episodes may indicate underlying pathology.

The distribution of endometrial pathologies in our study—atrophy

(42.4%), polyps (22.7%), hyperplasia (18.2%), and endometrial cancer (13.6%)—is comparable to findings by El Bromboly et al. [12] and Menon and R [13], reinforcing the predominance of atrophic endometrium as a leading cause of PMB. However, studies such as those by Khazaali et al. [17] and Abdel-Razik et al. [14] reported higher incidences of endometrial hyperplasia, which may be attributed to differences in study populations, inclusion criteria, and variations in the diagnostic threshold for hyperplasia.

TVUS demonstrated a significant association between endometrial thickness (ET) and pathology, with the highest mean ET observed in endometrial cancer cases (14.5 ± 2.5 mm) and the lowest in atrophic endometrium (3.2 ± 0.8 mm). This aligns with studies by Abdel-Razik et al. [14] and El Bromboly et al. [12], which found that ET >10 mm strongly correlated with malignancy. Various studies, including Aboul-Fotouh et al. [15] and Menon and R [13], have proposed different ET cut-off values for malignancy detection, ranging from 4 mm to 10.8 mm. While a 5 mm cut-off remains widely accepted as a threshold for further investigation, our findings support the need for additional diagnostic markers, particularly when ET is in an intermediate range.

CDUS findings showed a significant difference in vascular parameters between malignant and benign cases. Endometrial cancer was associated with the lowest resistive index (RI = 0.55 ± 0.07) and pulsatility index (PI = 1.05 ± 0.15), indicating increased vascularity and lower impedance, features characteristic of malignant neovascularization. These findings are consistent with those reported by Abd elMaboud and Elsaid (20) and Kucur et al. [21], who observed a significant decrease in RI and PI values in endometrial cancer cases.

The diagnostic accuracy of CDUS was further highlighted by the sensitivity and specificity of Doppler parameters. The PI demonstrated the highest diagnostic performance, with a sensitivity of 88.9% and specificity of 100%, followed by RI (77.8% sensitivity, 95.9% specificity). These findings reinforce previous studies by Appleton and Plavsic [22], who demonstrated that CDUS effectively differentiates benign from malignant angiogenesis by assessing vascular resistance. However, some studies, such as that by Joseph and Neelakandan [23], found no statistically significant difference in RI values between malignant and benign cases. These discrepancies could be attributed to differences in ultrasound equipment, Doppler settings, operator expertise, and the absence of standardized criteria for assessing endometrial vascularity.

The findings of this study emphasize the role of TVUS and CDUS as non-invasive, first-line diagnostic tools for PMB evaluation. The combination of ET measurement and Doppler parameters significantly improves diagnostic accuracy, reducing the need for unnecessary invasive procedures, such as endometrial biopsy, particularly in cases where malignancy is unlikely. Given the variability in ET cut-off values across studies, integrating Doppler indices can enhance diagnostic precision, particularly for patients with intermediate ET values.

The results also highlight the importance of a multimodal approach in clinical decision-making. While TVUS alone provides valuable morphological insights, its specificity is limited when assessing borderline ET cases. CDUS enhances diagnostic accuracy by providing functional information on vascularity, which is particularly useful in

differentiating hyperplasia from malignancy. Clinicians should consider both modalities when evaluating PMB to optimize patient management and avoid overuse of invasive procedures.

Limitations of the study

This study has several limitations. The relatively small sample size (66 patients) may limit the generalizability of the findings, and larger, multicenter studies are needed to validate the results. Additionally, ultrasound assessments are inherently operator-dependent, which may introduce variability. Differences in ultrasound machine settings, Doppler parameters, and a lack of standardized vascularity criteria could contribute to discrepancies between studies. Further research should aim to establish standardized CDUS criteria for endometrial pathology assessment.

Conclusion

TVUS and CDUS are essential non-invasive diagnostic tools for PMB. The integration of Doppler parameters significantly enhances malignancy detection, reinforcing their role in clinical decision-making and early intervention strategies.

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