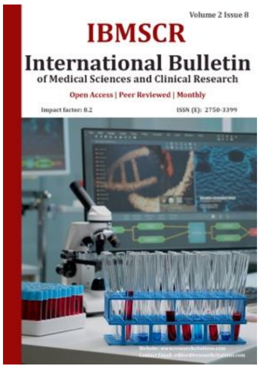

DIAGNOSTIC PERFORMANCE OF RADIOMICS-BASED ULTRASOUND ANALYSIS IN WOMEN WITH OVULATORY DYSFUNCTION–RELATED ABNORMAL UTERINE BLEEDING

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Abstract. Abnormal uterine bleeding associated with ovulatory dysfunction (AUB-O) is a common gynecological condition among women of reproductive age. Radiomics enables quantitative analysis of medical images and allows detection of subtle microstructural tissue characteristics. Objective: To evaluate the diagnostic performance of radiomics-based ultrasound analysis for risk stratification of ovarian changes in patients with ovulatory dysfunction–related abnormal uterine bleeding. Methods: A prospective study included 23 women aged 18–45 years with clinically confirmed ovulatory dysfunction. All participants underwent transvaginal ultrasound examination. Images were stored in DICOM format and processed for radiomics analysis. Results: The mean age of patients was 29.6±4.8 years, and the mean body mass index was 24.3±2.9 kg/m^2. Ultrasound examination identified follicular cysts in 11 cases, lutein cysts in 3 cases, persistent follicles in 5 cases, and suspicious ovarian morphology in 4 cases. Conventional ultrasound classified 16 cases as benign and 7 as suspicious, while clinical follow-up confirmed 14 benign and 9 high-risk cases. A total of 132 radiomic features were extracted; after feature selection, 8 key parameters were included in the model. Significant predictors included entropy (p=0.004), GLCM contrast (p=0.008), homogeneity (p=0.012), and shape irregularity index (p=0.015). Radiomics-based analysis demonstrated higher diagnostic accuracy compared with conventional ultrasound (p<0.01). Conclusion: Radiomics-based ultrasound analysis improves the diagnostic evaluation of ovarian changes in women with AUB-O and may provide an objective tool for risk stratification and clinical decision-making.

Keywords: abnormal uterine bleeding; radiomics; ultrasound imaging; ovarian morphology; texture analysis.

Introduction. Abnormal uterine bleeding (AUB) is one of the most common gynecological disorders affecting women of reproductive age and represents a significant clinical and public health concern. It is associated with substantial negative effects on quality of life, work productivity, and overall well-being, and it often requires repeated medical consultations and diagnostic procedures [6]. According to the classification proposed by the International Federation of Gynecology and Obstetrics (FIGO), the causes of AUB are categorized using the PALM–COEIN system, which distinguishes structural and non-structural etiologies, including ovulatory dysfunction as a major non-structural cause [10]. Ovulatory dysfunction–related abnormal uterine bleeding (AUB-O) is particularly common in reproductive-age women and is frequently associated with hormonal imbalance and functional ovarian alterations [3,13].

Transvaginal ultrasound remains the primary imaging modality for the evaluation of pelvic organs and ovarian morphology in patients with abnormal uterine bleeding. Ultrasound examination allows assessment of ovarian size, follicular development, and internal structural characteristics. Standardized ultrasound-based risk stratification systems, such as the Ovarian-Adnexal Reporting and Data System (O-RADS), have been developed to improve diagnostic consistency and facilitate clinical decision-making when evaluating adnexal lesions [2]. In addition, ultrasound plays an important role in distinguishing benign ovarian changes from potentially malignant lesions and guiding further diagnostic management [14].

Despite these advances, conventional ultrasound interpretation often relies on subjective visual assessment by the examiner, which may lead to variability in diagnostic accuracy. In many cases, subtle microstructural changes within ovarian tissue cannot be easily detected using standard morphological evaluation alone. For this reason, there is growing interest in advanced quantitative imaging techniques that can provide more objective and reproducible diagnostic information.

Radiomics has emerged as a promising approach in modern medical imaging. This technique involves the extraction of large numbers of quantitative features from medical images, allowing imaging data to be transformed into high-dimensional information that reflects tissue heterogeneity and structural characteristics [8]. Radiomic features capture subtle patterns within images that may not be visible during routine visual assessment, thereby enabling more detailed characterization of pathological processes [7]. Previous studies have demonstrated that radiomics can be used to decode tumor phenotype through noninvasive imaging analysis, providing valuable information about tissue microstructure and biological behavior [1].

The integration of radiomics with machine learning techniques further expands the diagnostic potential of imaging analysis by enabling the development of predictive models capable of distinguishing different pathological conditions [5]. Texture analysis methods, including parameters derived from gray-level matrices, are particularly sensitive to variations in tissue heterogeneity and have been successfully applied in oncological imaging studies [9]. Recent investigations have also explored the application of radiomics in gynecological imaging, where radiomic signatures derived from ultrasound images have shown promise in differentiating types of ovarian tumors and improving diagnostic performance [11].

In addition to imaging-based assessment, clinical and laboratory parameters such as tumor markers may contribute to risk stratification of ovarian pathology. For example, biomarkers such as CA-125 are frequently used in the evaluation of ovarian tumors and may complement imaging findings in diagnostic algorithms [4]. Integrating imaging data with clinical parameters and advanced analytical approaches may therefore improve the overall accuracy of ovarian lesion assessment and prognostic modeling [12].

Given the increasing interest in quantitative imaging techniques, radiomics-based analysis of ultrasound images may provide new opportunities for improving the evaluation of ovarian morphological changes in women with ovulatory dysfunction–related abnormal uterine bleeding. By identifying subtle imaging biomarkers associated with tissue heterogeneity, radiomics may enhance diagnostic precision and support more objective clinical decision-making.

Therefore, the aim of the present study was to evaluate the diagnostic performance of radiomics-based ultrasound analysis in assessing ovarian morphological changes in women with ovulatory dysfunction–related abnormal uterine bleeding (AUB-O).

Materials and methods. A prospective study included 23 women aged 18–45 years with clinically confirmed ovulatory dysfunction. Diagnosis was established based on clinical and laboratory findings, including progesterone levels in the luteal phase below 10 ng/ml. All patients underwent transvaginal ultrasound examination using a 5–9 MHz probe. Ultrasound images were stored in DICOM format and processed for radiomics analysis. Regions of interest (ROI) were manually segmented in areas corresponding to ovarian structural changes. Radiomic features were extracted using the PyRadiomics platform. Extracted parameters included: first-order statistical features, GLCM texture features, shape descriptors, wavelet features. Feature selection was performed using LASSO regression. Diagnostic performance was evaluated using ROC curve analysis. Sensitivity, specificity, and AUC values were calculated. Statistical significance was set at $p<0.05$.

Results. A total of 23 women with ovulatory dysfunction–related abnormal uterine bleeding (AUB-O) were included in the study. The mean age of the participants was 29.6 ± 4.8 years, and the mean body mass index (BMI) was 24.3 ± 2.9 kg/m^2. Ovulatory dysfunction was confirmed in all patients based on laboratory findings, with serum progesterone levels in the luteal phase below 10 ng/ml.

The clinical and ultrasound characteristics of the study population are summarized in Table 1. Follicular cysts represented the most common ovarian alteration and were identified in 11 cases (47.8%). Persistent follicles were detected in 5 cases (21.7%), while lutein cysts were observed in 3 patients (13.0%). Suspicious ovarian morphology characterized by irregular borders or internal echogenic structures was identified in 4 cases (17.4%).

Based on conventional ultrasound evaluation, 16 patients (69.6%) were classified as having benign ovarian changes, whereas 7 patients (30.4%) were considered to have suspicious lesions requiring further clinical monitoring. However, clinical follow-up revealed that 14 cases (60.9%) were ultimately confirmed as benign, while 9 cases (39.1%) demonstrated high-risk morphological characteristics.

Table 1. Clinical and ultrasound characteristics of patients with AUB-O (n = 23)

Parameter	**Value**
Age (years), mean ± SD	29.6 ± 4.8
BMI (kg/m^2), mean ± SD	24.3 ± 2.9
Progesterone level (luteal phase)	<10 ng/ml
Follicular cysts	11 (47.8%)
Persistent follicles	5 (21.7%)
Lutein cysts	3 (13.0%)
Suspicious ovarian morphology	4 (17.4%)
Benign lesions (conventional ultrasound)	16 (69.6%)
Suspicious lesions (conventional ultrasound)	7 (30.4%)
Final benign diagnosis	14 (60.9%)
High-risk morphology	9 (39.1%)

Radiomics analysis of ultrasound images produced 132 quantitative imaging features, including first-order statistical parameters, texture features derived from the Gray Level Co-occurrence Matrix (GLCM), shape descriptors, and wavelet-based parameters. After feature reduction using LASSO regression, eight key radiomic features were selected for inclusion in the predictive model.

Among these features, several parameters demonstrated statistically significant differences between benign and suspicious ovarian lesions. In particular, entropy, GLCM contrast, homogeneity, and shape irregularity index were identified as significant predictors of suspicious ovarian morphology. These results are summarized in Table 2.

Higher values of entropy and GLCM contrast were observed in suspicious lesions, indicating increased microstructural heterogeneity within the ovarian tissue. Conversely, homogeneity values were significantly lower, reflecting irregular internal texture patterns.

Table 2. Significant radiomics features associated with suspicious ovarian morphology

Radiomic feature	Benign lesions	Suspicious lesions	p-value
Entropy	Lower	Higher	0.004
GLCM contrast	Lower	Higher	0.008
Homogeneity	Higher	Lower	0.012
Shape irregularity index	Lower	Higher	0.015

The diagnostic performance of conventional ultrasound and the radiomics-based predictive model was further evaluated using receiver operating characteristic (ROC) analysis. The results demonstrated that the radiomics model provided improved diagnostic accuracy in identifying suspicious ovarian changes compared with conventional ultrasound assessment.

Specifically, the radiomics model demonstrated higher sensitivity (88.9%) and specificity (85.7%), whereas conventional ultrasound showed lower sensitivity (72.7%) and specificity (78.6%). The area under the ROC curve (AUC) for the radiomics model reached 0.89, indicating strong diagnostic discrimination. These findings are presented in Table 3.

Table 3. Diagnostic performance of conventional ultrasound and radiomics-based model

Diagnostic method	Sensitivity (%)	Specificity (%)	Accuracy (%)	AUC
Conventional ultrasound	72.7	78.6	76.1	0.74
Radiomics-based model	88.9	85.7	87.0	0.89

Overall, the radiomics-based predictive model demonstrated superior diagnostic performance compared with conventional ultrasound evaluation, reducing both false-negative and false-positive classifications. These findings suggest that quantitative radiomics analysis can significantly improve risk stratification of ovarian morphological changes in women with AUB-O.

Discussion. The present study demonstrates the potential diagnostic value of radiomics-based ultrasound analysis in evaluating ovarian morphological changes in women with ovulatory dysfunction–related abnormal uterine bleeding (AUB-O). Although conventional transvaginal ultrasound remains the primary imaging modality for assessing ovarian structures, its interpretation often relies on subjective visual evaluation. Radiomics offers a quantitative approach that enables extraction of subtle imaging features reflecting the internal microstructure of tissues, thereby improving diagnostic objectivity.

In this study, conventional ultrasound examination identified benign ovarian changes in the majority of patients; however, discrepancies were observed between initial ultrasound assessment and clinical follow-up results. While conventional ultrasound classified 16 cases as benign and 7 as suspicious, follow-up data revealed that 9 cases demonstrated high-risk morphological characteristics. This finding highlights the limitations of traditional ultrasound evaluation, particularly when subtle structural abnormalities are present.

Radiomics analysis enabled the extraction of a large number of quantitative imaging features from ultrasound images. Among these, entropy, GLCM contrast, homogeneity, and shape irregularity index were identified as significant predictors of suspicious ovarian morphology. Higher entropy and contrast values observed in suspicious lesions indicate increased tissue heterogeneity, which may reflect underlying microstructural alterations. Conversely, lower homogeneity values suggest irregular internal architecture of ovarian tissue. These findings are consistent with previous radiomics studies demonstrating that texture features derived from gray-level matrices are highly sensitive to tissue heterogeneity.

Another important observation of the present study is the improved diagnostic performance of the radiomics-based predictive model compared with conventional ultrasound evaluation. The radiomics model demonstrated higher sensitivity, specificity, and overall diagnostic accuracy. In particular, the reduction in false-negative cases suggests that radiomics may help detect suspicious ovarian alterations that might otherwise be overlooked during routine ultrasound examination.

The clinical implications of these findings are significant. Early identification of suspicious ovarian morphological changes is crucial for appropriate patient management and risk stratification. Radiomics-based ultrasound analysis may serve as an additional decision-support tool, assisting clinicians in distinguishing benign functional ovarian changes from potentially high-risk lesions. By providing objective quantitative parameters, radiomics may reduce diagnostic uncertainty and improve confidence in clinical decision-making.

Furthermore, the application of radiomics in ultrasound imaging is particularly valuable in resource-limited settings where access to advanced imaging modalities such as MRI may be restricted. Since radiomics analysis can be performed using standard ultrasound images, its integration into routine gynecological practice may enhance diagnostic precision without substantially increasing healthcare costs.

Despite these promising findings, several limitations should be considered. First, the relatively small sample size of the present study may limit the generalizability of the results. Second, manual segmentation of the region of interest may introduce variability in radiomic feature extraction. Future studies with larger patient cohorts and automated segmentation techniques are needed to validate these findings and improve reproducibility.

Overall, the results of this study support the growing evidence that radiomics-based ultrasound analysis can enhance the diagnostic evaluation of ovarian morphological changes in women with ovulatory dysfunction–related abnormal uterine bleeding. Further research integrating radiomics with clinical and laboratory parameters may contribute to the development of more accurate predictive models for gynecological disorders.

Conclusion. This study demonstrated that radiomics-based ultrasound analysis provides improved diagnostic performance in evaluating ovarian morphological changes in women with ovulatory dysfunction–related abnormal uterine bleeding (AUB-O). Conventional ultrasound assessment, although widely used in clinical practice, relies primarily on visual interpretation and may fail to detect subtle microstructural abnormalities within ovarian tissue.

The results of the present study showed that radiomic features, particularly entropy, GLCM contrast, homogeneity, and shape irregularity index, were significantly associated with suspicious ovarian morphology. These parameters reflect tissue heterogeneity and internal structural irregularities that are not always visible during routine ultrasound examination.

In comparison with conventional ultrasound evaluation, the radiomics-based predictive model demonstrated higher sensitivity, specificity, and overall diagnostic accuracy, indicating its potential value as an additional tool for risk stratification of ovarian changes in patients with AUB-O. The use of quantitative imaging biomarkers may therefore contribute to more objective assessment and improved clinical decision-making.

Overall, the integration of radiomics into ultrasound imaging may enhance the early identification of suspicious ovarian alterations, reduce diagnostic uncertainty, and help optimize patient management strategies. Further studies with larger patient populations and multicenter validation are required to confirm the clinical applicability and reproducibility of radiomics-based diagnostic models in gynecological imaging.

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References:

1.Aerts HJWL, Velazquez ER, Leijenaar RTH, Parmar C, Grossmann P, Carvalho S, et al. Decoding tumour phenotype by noninvasive imaging using a radiomics approach. Nat Commun. 2014;5:4006.

2.Andreotti RF, Timmerman D, Strachowski LM, Froyman W, Benacerraf B, Bennett GL, et al. Ovarian-Adnexal Reporting and Data System (O-RADS): ultrasound risk stratification and management system. Radiology. 2020;294(1):168–185.

3.Bahamondes L, Ali M. Recent advances in managing and understanding abnormal uterine bleeding. F1000Res. 2018;7:F1000 Faculty Rev-684.

4.Dwivedi K, Sharipov A, Ramseela S, Powrnamy P, Mandal A, Waqar D, et al. Evaluating CA-125 for ovarian cancer detection: a review of diagnostic performance. Int J Med Sci. 2025;1(3):116–120.

5.Erickson BJ, Korfiatis P, Akkus Z, Kline TL. Machine learning for medical imaging. Radiographics. 2017;37(2):505–515.

6.Fraser IS, Langham S, Uhl-Hochgraeber K. Health-related quality of life and economic burden of abnormal uterine bleeding. Expert Rev Obstet Gynecol. 2009;4(2):179–189.

7.Gillies RJ, Kinahan PE, Hricak H. Radiomics: images are more than pictures, they are data. Radiology. 2016;278(2):563–577.

8.Lambin P, Rios-Velazquez E, Leijenaar R, Carvalho S, van Stiphout RGPM, Granton P, et al. Radiomics: extracting more information from medical images using advanced feature analysis. Eur J Cancer. 2012;48(4):441–446.

9.Lubner MG, Smith AD, Sandrasegaran K, Sahani DV, Pickhardt PJ. CT texture analysis: definitions, applications, biologic correlates, and challenges. Radiographics. 2017;37(5):1483–1503.

10.Munro MG, Critchley HOD, Fraser IS. The FIGO classification of causes of abnormal uterine bleeding in the reproductive years. Fertil Steril. 2011;95(7):2204–2208.
11.Park HJ, Lee SM, Kim HJ, et al. Radiomics signature for predicting ovarian tumor type using ultrasound imaging. Ultrasound Med Biol. 2021;47(6):1481–1490.
12.Ravshanovna XM, Dwivedi K. Integration of a comprehensive ultrasound assessment in the prognostic modeling of benign and malignant ovarian tumors. Int J Contemp Pathol. 2024;10(2).
13.Singh S, Best C, Dunn S, Leyland N, Wolfman WL. Abnormal uterine bleeding in pre-menopausal women. J Obstet Gynaecol Can. 2013;35(5):473–475.
14.Valentin L. Imaging in gynecology: best practice in the diagnosis of ovarian masses. Best Pract Res Clin Obstet Gynaecol. 2014;28(5):683–695.