# Ultrasound features and role of O-RADS classification in the diagnosis of ovarian tumors

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**Abstract**

**Background:** Ovarian tumors are a common condition in women, with 5% - 30% cases being malignant. Clinical symptoms are often nonspecific, causing difficulties in early diagnosis and detection. The O-RADS classification system provides a consistent way to interpret ovarian masses on ultrasound. **Aim:** The aim of this study is to (1) Describe the ultrasound characteristics of ovarian tumors according to the O-RADS classification. (2) Investigate the signs predicting malignancy in the O-RADS 3, 4, and 5 categories. **Materials and Method:** This cross-sectional study involved 188 patients who were examined and treated at the Hospital of Hue University of Medicine and Pharmacy, diagnosed with ovarian tumors, from April 2022 to September 2023. **Results:** 88.8% of ovarian tumors were found to be benign (88.8%), with serous tumors being the most common type in both benign and malignant groups. The distribution of ovarian tumors based on the O-RADS classification was as follows: O-RADS 1 (1.6%), O-RADS 2 (52.1%), O-RADS 3 (22.9%), O-RADS 4 (17.6%), O-RADS 5 (5.9%). Most ovarian tumors were monocystic masses, without solid components (65.4%), with diameters ranging from 50 - 100 mm (58.0%), and had smooth inner borders (79.3%). Papillary growth in inner borders and increased vascularity in Doppler ultrasound (color score: CS = 2 - 4) were found to be predictive factors for malignant ovarian tumors, with adjusted odds ratios (aOR) of 8.5 and 5.5, respectively. **Conclusions:** Monocystic mass with solid components, multicystic mass with solid components, mass with solid components, irregular inner borders, papillary growth in inner borders, and increased vascularity in Doppler ultrasound (CS = 2 - 4) were identified as predictive factors for malignant ovarian tumors.

**Keywords:** *ovary tumors, O-RADS classification, ultrasound.*

## 1. BACKGROUND

Ovarian tumors are the most common disease of the ovaries with a prevalence of 5% - 30% being malignant of cases being malignant lesions. They often present with nonspecific clinical symptoms, leading to challenges in early diagnosis and detection. The disease is often detected in a late stage [1].

There have been many scores and classification systems introduced to improve the effect of early diagnosis of ovarian cancer such as Schillinger, IOTA, or GI-RADS. In 2018, the American College of Radiology issued a consensus on using the O-RADS classification system in the diagnosis of ovarian tumors, providing a consistent way to interpret ultrasound characteristics and restrict ambiguous pictures and errors, especially in cases with potential for malignancy, as well as proposed guidelines for the management of risk groups. The O-RADS classification system offers a standardized approach to interpreting ovarian masses using ultrasound [2].

In Vietnam, there have been studies evaluating the application of classifications and scores in diagnosing as well as describing pathological characteristics of ovarian tumors [3]. However, there are still quite a few studies that fully investigate the ultrasound image characteristics and signs for the prediction of malignant ovarian tumors based on the O-RADS classification when compared with postsurgical pathological results. Therefore, we carry out this study with 2 aims:

*1. To describe the ultrasound characteristics of ovarian tumors according to the O-RADS classification.*

*2. To investigate the signs predicting malignancy in the O-RADS 3, 4, and 5 categories.*

## 2. MATERIALS AND METHODS

### 2.1. Participants

- A cross-sectional study was conducted on 188 patients who sought examination and treatment at the Hospital of Hue University of Medicine and Pharmacy. These patients were diagnosed with ovarian tumors between April 2022 and September 2023.

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***2.1.1. Sample selection criteria***

- Patient has ovarian tumor on gynecological ultrasound;
- Patient has postsurgerial histopathological results.

***2.1.2. Exclusion criteria***

- Patient has previously been treated for ovarian tumors;
- Patient has cancer from other organs metastasizes to the ovaries;
- Patient does not agree to participate in the study.

***2.1.3. Sampling method***

- 188 patients satisfied the selection criteria based on the convenience sampling method.

**2.2. Study methods**

***2.2.1. Study design:*** A descriptive cross-sectional method was applied.

***2.2.2. Place and time***

- The study was conducted in the Obstetrics and Gynecology Department, Pathology Department, and Department of Diagnostic Imaging, at Hue University of Medicine and Pharmacy Hospital from April 2022 to September 2023.

***2.2.3. Study techniques***

*2.2.3.1. 2D ultrasound, Doppler ultrasound, and histopathological techniques*

- According to the instructions of the Vietnam Ministry of Health.

*2.2.3.2. Signs that need to be recorded according to the O-RADS classification system*

- Lesion category: unilocular/multilocular, solid/ without solid component
- Cystic lesions: inner margin or walls including solid component (papillary projection or nodule, smooth, irregular); internal content, cystic component (anechoic fluid, hyperechoic components)
- Solid or solid-appearing lesions: external contour (smooth, irregular); internal contents (acoustic shadowing)
- Maximum diameter
- Vascularity: CS = 1, CS = 2, CS = 3, CS = 4
- General and extra-ovarian findings: paraovarian cyst, peritoneal inclusion cyst, fluid distended in Fallopian tube, cul-de-sac fluid, ascites, peritoneal thickening or nodules.

*2.2.3.3. Histopathological classification of ovarian tumors*

- According to the classification of ovarian tumors of World Health Organization [4].

**2.2.4. Data processing and analysis**

The collected data were processed according to medical statistical algorithms, using SPSS 22.0 software. Descriptive data were shown in numbers, percentages, mean, and standard deviation. Algorithms were used including:

- Chi-squared test ($\chi 2$);
- Independent-samples t-test, the Wilcoxon test;
- Significance was set at $p \leq 0.05$ for all tests;
- Simple linear regression and multiple linear regression.

**3. RESULTS**

**3.1. General characteristics**

The patients were quite evenly distributed geographically with 53.2% living in urban areas. The group with malignant histology had an average age of 50.62 ± 14.3, higher than the benign group with 41.01 ± 16.5 ($p = 0.012$). The incidence of general ovarian tumors and benign ovarian tumors in premenopausal women was 2.5 times higher than in postmenopausal women, while malignant ovarian tumors were more common in postmenopausal women than the premenopausal group ($p < 0.05$).

**3.2. Ultrasound characteristics compared with pathological results**

***3.2.1. Postsurgical pathological results***

The study found that the majority of ovarian tumors were benign, accounting for 88.8% of cases, with the highest proportion being serous cystadenoma, followed by dermoid cysts, mature teratomas, and endometriosis. Malignant tumors accounted for 11.2% with serous carcinoma being the most common, followed by mucinous carcinoma.

***3.2.2. Distribution of ovarian tumors according to O-RADS classification compared with pathology results***

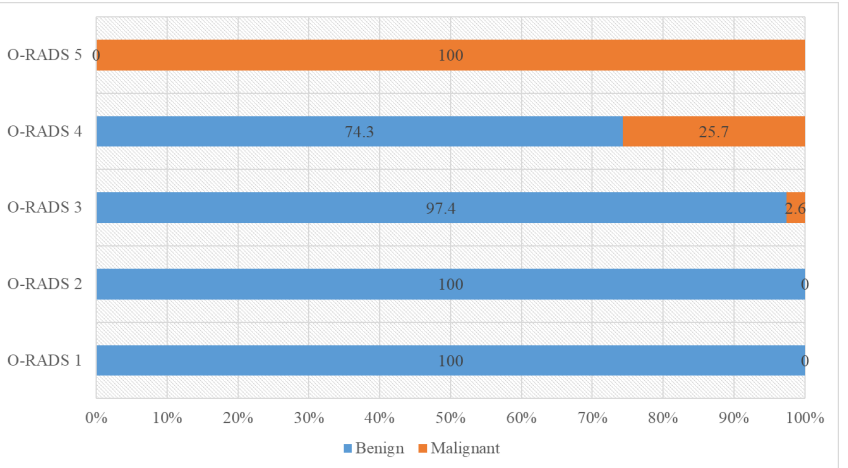


**Chart 1.** Distribution of ovarian tumors according to O-RADS classification compared with pathology results

Based on the O-RADS classification, the distribution of ovarian tumors is as follows: O-RADS 1 (1.6%), O-RADS 2 (52.1%), O-RADS 3 (22.9%), O-RADS 4 (17.6%), O-RADS 5 (5.9%). 100% O-RADS 1 and O-RADS 2 ovarian tumors were benign. All tumors classified as O-RADS 5 were malignant.

***3.2.3. Major ultrasound features of ovarian tumors***

66.0% of ovarian tumors were unilocular without solid components and the majority of these tumors were benign (123/124 patients). Solid or solid-appearing tumors were only found in 5.9% of cases but the malignant rate was 2 times higher than benign tumors in this group.

The average diameter was 84.4 ± 46.2 mm. In particular, the malignant group was 129.5 ± 68.6 mm higher than the benign group was 78.8 ± 39.4 mm. Most ovarian tumors in general and benign tumors had a diameter of 5 - 10 cm, 56.4%, and 58.7% respectively. While malignant tumors were mainly ≥ 10 cm (57.1%). This difference is statistically significant ($p < 0.05$).

86.2% of tumors without solid components are benign, and only 4/148 cases are malignant. In contrast, tumors with solid components are up to 81% malignant. The difference was statistically significant with $p < 0.005$.

The majority of ovarian tumors in general and benign tumors in particular had regular internal margins with 81.4%. 100% of solid tumors with irregular outer margins were malignant tumors. 100% of malignant tumors didn't have acoustic shadowing.

46.8% of ovarian tumors was an anechoic fluid and/or with little echogenicity inside. Hypoechoic ovarian tumors accounted for the lowest rate of 4.3%.

The majority of benign tumors didn't have vascular proliferation (84%). Ovarian tumors with increased vascularity (CS = 2 - 4) had a significantly higher malignant risk than those without increased vascularity ($p < 0.001$).

***3.2.4. Extra-ovarian findings***

In most cases, no cul-de-sac fluid, peritoneal thickening, or nodules was present. 87.5% of tumors accompanied by peritoneal fluid were malignant, and 4/4 of cases with thickened peritoneal or nodules were malignant. This difference was statistically significant $p < 0.05$.

**3.3. Signs predicting malignancy in the O-RADS 3, 4, and 5 categories**

We conducted data selection for patients in O-RADS 3,4,5 groups and regression analysis based on 84 patients in O-RADS 3,4,5 groups.

***3.3.1. Simple linear regression of signs predicting malignancy***

**Table 1.** Simple linear regression of signs predicting malignancy

| Ultrasound characteristics | OR (CI 95%) | p |
|---|---|---|
| Multilocular | 0.6 (0.2 - 1.6) | 0.3 |
| Unilocular cyst with solid component(s) | **12 (1.2 - 133.7)** | **0.03** |
| Multilocular cyst without solid component(s) | 2.7 (0.2 - 28.4) | 0.4 |
| Multilocular cyst with solid component(s) | **11.4 (1.8 - 120.3)** | **0.04** |
| Solid tumor | **35 (3.3 - 368.6)** | **0.03** |
| Solid appearing | **8.5 (2.5 - 28.4)** | **0.001** |
| Maximum diameter 5 - 10 cm | 1.4 (0.1 - 14.3) | 0.7 |
| Maximum diameter ≥ 10 cm | 1.3 (0.1 - 13.1) | 0.8 |
| Papillary projection of the inner margin | **16.3 (3.1 - 87.1)** | **0.001** |
| Irregular inner margin | **7.5 (1.1 - 52.4)** | **0.04** |
| Vascularity CS = 2 - 4 | **20.1 (5.6 - 71.4)** | **< 0.001** |
| Cul-de-sac fluid | N/A | P > 0.05 |
| Peritoneal thickening, or nodules | N/A | P > 0.05 |

Unilocular cyst with solid component(s), multilocular cyst with solid component(s), solid tumor, solid appearance, papillary projection of the inner margin, irregular inner margin, and vascularity CS=2-4 were independent risk factors of malignant ovarian tumors.

***3.3.2. Multiple linear regression of signs predicting malignancy***

We conducted multiple linear regression analyses based on characteristics with OR > 1 and p < 0.05. Including solid appearance, papillary projection of the inner margin, irregular inner margin, and vascularity CS = 2 - 4.

**Table 2.** Multiple linear regression of signs predicting malignancy

| Ultrasound characteristics | OR | CI 95% | p |
|---|---|---|---|
| Solid appearing | 0.9 | 0.1 - 6.9 | 0.7 |
| Papillary projection of the inner margin | **8.5** | **1.2 - 60.4** | **0.03** |
| Irregular inner margin | 3.5 | 0.3 - 42.8 | 0.3 |
| Vascularity CS=2-4 | **5.5** | **1 - 29.2** | **0.04** |

There was a statistically significant association between findings: papillary projection of the inner margin and vascularity CS=2-4 with the risk of malignant ovarian tumors.

***3.3.3. The value of signs predicting malignancy***

**Table 3.** The value of signs predicting malignancy

| Ultrasound characteristics | Sensitivity (%) | Specificity (%) | Positive predictive value | Negative predictive value |
|---|---|---|---|---|
| Papillary projection of inner margin | 64.3 | 81.4 | 45.0 | 90.6 |
| Vascularity CS=2-4 | 80.9 | 82.5 | 60.2 | 92.8 |

Vascularity CS=2-4 had quite high sensitivity and specificity, while papillary projection of the inner margin hadn't high sensitivity in predicting malignant ovarian tumors.

## 4. DISCUSSION

### 4.1. General characteristics

Our study is similar to some other studies that found that the average age of the malignant group was higher than those of the benign group [5, 6, 7]. The incidence of ovarian tumors in general and benign tumors in premenopausal women was 2.5 times higher than in postmenopausal women, while malignant tumors were more common in postmenopausal women (p < 0.05). Other authors

also have similar results [3, 5]. It can be explained since the symptoms of ovarian tumors in the early stages are often vague and difficult to detect. It is not until the late stages of the disease that the clinical symptoms are clear and easy to detect [8].

**4.2. Ultrasound characteristics compared with pathological results**

***4.2.1. Postsurgical pathological results***

In our study, 88.8% of cases were benign tumors, with the highest proportion being serous cystadenoma (40.4%), followed by dermoid cysts, mature teratomas, and endometriosis. Malignant tumors accounted for 11.2% with serous carcinoma being the most common, followed by mucinous carcinoma. Studies by Vo Thi Quynh Nhu (2022) and Xie T (2022) also showed similar results. We saw that there is diversity in the histopathological results of ovarian tumors; the difference in rates may be due to the location of each study [6, 9].

***4.2.2. O-RADS classification***

In general, the results of our study and those of the authors were different due to many reasons such as sample size or study location, but there was a tendency for a malignancy rate of > 75% in the O-RADS 5 group; 20 - 79% in O-RADS 4 group; 1 - 16% in O-RADS 3 and 0 - 1% in O-RADS 2 group. According to a publication by the US, the O-RADS 2 group was almost certainly benign (< 1% risk of malignancy); O-RADS 3, low risk of malignancy (1% to < 10%); O-RADS 4, intermediate risk of malignancy (10% to < 50%); O-RADS 5, high risk of malignancy (≥ 50%). Therefore, our results were appropriate [2].

***4.2.3. Major ultrasound features of ovarian tumors***

In our study, the majority of benign ovarian tumors were unilocular without solid components (73.7%), solid or nearly solid tumors accounted for a high proportion in the malignant group (33.3%). The percentage of malignant tumors containing solid components was 81.0% while most benign tumors did not contain solid components with 86.2% ($p < 0.001$). Other studies also agreed that the tumors without solid components tended to be benign, and tumors with solid components tended to be malignant [3, 7].

The average diameter of malignant tumors was 129.5 ± 68.6 mm, higher than that of benign tumors, which was 78.8 ± 39.4 mm. Our study had a higher rate of unilocular tumors than multilocular tumors in both benign and malignant groups. The difference was not statistically significant ($p > 0.05$), similar to Tran Doan Tu (2020) [5]. However, Vo Thi Quynh Nhu found that 75.4% of malignant tumors were multilocular lesions [6].

Most benign tumors had regular inner margins (87.1%). While the majority of malignant tumors had a papillary projection (64.3%) or irregular inner margins (21.4%). There were 11 solid lesions we recorded, 4/11 had regular outer margins and all of them were benign tumors, 7/11 cases had irregular outer margins and all of them were malignant. This difference was statistically significant with $p < 0.05$. The papillary projection or irregular inner margins had a higher risk of being malignant than the regular inner margins without papillary [10].

Acoustic shadowings were not recorded in malignant lesions and were recorded in 35/188 benign lesions. Some authors have observed that adding acoustic shadowing to the O-RADS system improved the area under the curve (AUC) to 0.94 ($p = 0.01$), similar to the assessment of other neoplasms in the ANDEX model (AUC = 0.95, $p = 0.35$) [11].

Since 1989, T. Bourne has begun to describe perfusion imaging and concluded that vascular flow imaging on transvaginal ultrasound can be used for screening purposes. Avoid missing potentially malignant ovarian masses in the early stages [12]. In our study, 92.2% of benign ovarian tumors did not have increased vascularity, and 81% of malignant ovarian tumors had mild, moderate to strong vascular proliferation. The difference is statistically significant $p < 0.001$.

***4.2.4. Extra-ovarian findings***

Recording extra-ovarian lesions such as fluid retention and peritoneal inclusion cysts didn't increase the risk score for O-RADS, but other features such as free peritoneal fluid, peritoneal thickening, or nodules might increase the category to O-RADS 5, so they play an important role in detecting malignant ovarian tumors [2]. In our study, 100% of patients with peritoneal thickening or nodules were malignant and 33.3% of malignant tumors had the presence of peritoneal fluid. This rate is equivalent to Vo Thi Quynh Nhu's study (2022) [6].

**4.3. Signs predicting malignancy in the O-RADS 3, 4, and 5 categories**

Simple linear regression analysis of ultrasound characteristics in 84 patients in the O-RADS 3,4,5 group, we found an association between some factors and the risk of malignant ovarian tumors.

***4.3.1. Lesion category***

In our study, unilocular cysts with solid component (OR = 12.0; CI 1.2 - 133.7; $p < 0.001$),

multilocular cysts with solid component (OR = 11.4; CI = 1.8 - 120.3; p < 0.05), solid or nearly solid tumors (OR = 35; CI 3.3 - 368.6; p < 0.05) were factors predicting malignant tumors. Among them, the solid or near-solid tumors group had the greatest relevance with the largest OR. When compared with other authors, our study had a similarity: the group of solid or nearly solid tumors had the largest OR, followed by single-lobed tumors with solid components [6, 7].

***4.3.2. Solid appearing***

The solid component in the tumor has been evaluated as a factor predicting malignancy from many previous publications and consensuses such as IOTA, GI-RADS, ... and some other studies [13]. For our study, the solid component had OR = 8.5, CI 2.5 - 28.4; p < 0.05, but after multiple linear regression analyses, this had p > 0.05. The difference may be due to the low number of malignant solid tumors in our study. It needs to be expanded in the future to further analyze and clarify.

***4.3.3. Papillary projection of inner margin and irregular inner margin***

In our study, papillary projection and irregular inner margins were two features related to malignant ovarian tumors with p < 0.05. Multiple linear regression analysis showed that the papillary projection with OR = 8.5, CI = 1.2 - 60.4, p < 0.03. Based on the characteristics of the inner margin to diagnose malignant ovarian tumors had the sensitivity Se = 64.3%, and specificity Sp = 81.4%, but the positive predictive value is low at only 45.0%. The irregular inner margins or papillae > 3 mm have been studied by many authors and confirmed as a factor predicting early malignancy, as researched by D. Timmerman in 2008 [7]. Our research also supports this judgment.

***4.3.4. Vascularity of the tumors***

There was a small proportion of tumors in our study with increased vascularity. Conducting logistic regression analysis, we found that low to moderate proliferation had OR > 1 and p < 0.05, while strong proliferation (CS = 4) had p > 0.05. Some other studies also performed simple linear regression analysis and concluded that all levels of vascular proliferation are predictive factors for malignancy [7, 13].

Such a difference may be due to our sample size being much smaller than the author's, the number of tumors with a vascular proliferation level of CS=4 is still low, and the evaluation of ultrasound images has demonstrated that there is a difference between experts and non-experts [13]. Therefore, we performed a multivariable regression model with the level of perfusion divided into two levels: without increased perfusion (CS = 1) and with increased perfusion (CS = 2-4). The result is OR index > 1, p < 0.05, sensitivity 80.9%, and specificity 82.5% in the increased group. Thus, in general, studies agree that increased blood perfusion is a factor predicting the malignancy of ovarian tumors.

## 5. CONCLUSIONS

Based on the O-RADS classification, the distribution of ovarian tumors is as follows: O-RADS 1 (1.6%), O-RADS 2 (52.1%), O-RADS 3 (22.9%), O-RADS 4 (17.6%), O-RADS 5 (5.9%). The majority of ovarian tumors are unilocular cysts without solid components (65.4%), 50-100cm in diameter (58.0%), with regular inner margins (79.3%), 13.8% have irregular internal margins and 6.9% have papillae. 20.2% of tumors contained solid components. The most common reverb characteristics were drum (44.7%) and mixed reverb (34.6%). The majority of ovarian tumors do not have an acoustic shadowing at 84.0% and do not have vascular proliferation on ultrasound at 84.6%.

This study highlights several ultrasound characteristics associated with malignant ovarian tumors. Monocystic masses with solid components, multicystic masses with solid components, masses with solid components, irregular inner borders, papillary growth in inner borders, and increased vascularity in doppler ultrasound (CS = 2 - 4) were identified as predictive factors for malignancy.

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