Research Article

Determination of A CT Scan Scoring System As A Predictor Of Malignancy in Mucinous Ovarian Tumors With Histopathological Correlation

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Abstract

Background: Mucinous ovarian tumors have diverse radiological characteristics and can make it difficult to differentiate benign, borderline, and malignant tumors preoperatively. CT Scan is one of the main modalities in the evaluation of ovarian masses, but its interpretation can be subjective. Therefore, a scoring system based on CT Scan characteristics is needed to help predict the degree of malignancy of mucinous ovarian tumors.

Objective: To determine a scoring system based on CT Scan characteristics as a preoperative diagnostic aid to differentiate mucinous ovarian tumors into benign, borderline, and malignant categories based on correlation with histopathology results.

Methods: This was an observational analytic study with a retrospective cross-sectional design and a diagnostic test. The study involved 120 patients with mucinous ovarian tumors who underwent contrast-enhanced abdominal CT Scan and were confirmed by histopathological examination at RSUD Dr. Soetomo Surabaya from January 2020 to March 2026. The CT Scan characteristics analyzed included morphology, wall thickness, septa, solid component, enhancement pattern, and tumor margin. Analysis was performed using bivariate tests and ordinal logistic regression, and the performance of the scoring system was then evaluated using the Receiver Operating Characteristic (ROC) curve, Area Under the Curve (AUC), sensitivity, and specificity.

Results: Multivariate analysis showed that solid component, enhancement pattern, and tumor margin were predictors significantly associated with the degree of malignancy based on histopathology. The scoring system assigns 2 points for the presence of a solid component, 1 point for mild, 3 points for moderate and strong enhancement, and 2 points for an irregular tumor margin, with a score range of 0-8. To differentiate malignant from non-malignant tumors, an AUC of 0.933 (95% CI: 0.885-0.982; $p < 0.001$) was obtained with a cut-off of ≥4 (sensitivity 90.7%, specificity 89.4%). To differentiate borderline from benign tumors, an AUC of 0.908 (95% CI: 0.858-0.959; $p < 0.001$) was obtained with a cut-off of ≥2 (specificity 100%).

Conclusion: A scoring system based on CT Scan characteristics, comprising solid component, enhancement pattern, and tumor margin, can be used as an aid for stratifying the malignancy of mucinous ovarian tumors in preoperative evaluation. External validation in larger, multicenter cohorts is needed before wider clinical use of the scoring system.

Keywords: Mucinous Ovarian Tumors, CT Scan, Malignancy Scoring System, Histopathology, Diagnostic Performance.

1 Introduction

Ovarian tumors are a gynecological problem with high incidence and complexity and a high mortality rate. According to Global Cancer Incidence, Mortality and Prevalence data, the number of ovarian tumor cases in Indonesia was 14,896, with up to 9,581 deaths. Ovarian carcinoma is the 7th most common malignancy in women, the 2nd most common gynecological malignancy, accounts for 5% of all carcinoma cases in women, and is the 5th leading cause of carcinoma-related death in women [1], [2], [3]. This is because the ovary is prone to tumor formation due to endocrine disturbances and the ovulation cycle that occurs every month [2].

The WHO classifies ovarian tumors by tissue of origin: surface epithelial (65%), germ cells (15%), sex cord-stromal (10%), and metastasis (5%) [1]. Surface epithelial tumors are the most common type of ovarian tumor. Based on cell type, surface epithelial tumors are classified into serous (46% of all epithelial ovarian tumors), mucinous (36%), endometrioid (8%), clear cell (3%), undifferentiated (2%), and mixed (3%) [4], [5]. Based on histological features, epithelial ovarian tumors can be divided into benign, borderline, and malignant subclasses, accounting for 60%, 5%, and 35% of all epithelial tumors, respectively, and approximately 80%, 16-17%, and 3-4% of primary mucinous tumors [1], [5].

Mucinous epithelial ovarian tumors have unique characteristics because they tend to be large and filled with mucous fluid, and may sometimes also contain solid components and calcifications [5]. These tumors are characterized by epithelial cells that resemble gastrointestinal cells and include three distinct groups, namely mucinous cystadenoma, mucinous borderline tumor, and mucinous carcinoma [4]. Among the 3,226 ovarian tumor cases reviewed in the French Network for Ovarian Rare Tumors by Specialist Gynecological Pathologists, disagreement was most frequent when diagnosing mucinous tumors, with 49 of 175 discordant diagnoses. This high degree of variability may be due to the lack of analysis and studies on histological criteria and the absence of alternative tools to aid classification, including molecular markers [5].

Mucinous borderline tumor (MBT) itself poses a distinct diagnostic challenge because its histological characteristics lie between those of benign and malignant tumors [4]. One important concern regarding the misdiagnosis of mucinous ovarian carcinoma (MOC) as mucinous borderline tumor (MBT) is its impact on patient prognosis. When MOC is underdiagnosed as MBT, patients receive undertreatment, which reduces treatment success. Conversely, when MBT is overdiagnosed as MOC, patients receive unnecessary additional management. Determining malignancy status preoperatively strongly influences the surgical strategy. This shows the importance of making an accurate radiological diagnosis between these two entities.

Computed tomography (CT) is currently the main modality for evaluating adnexal masses [6]. However, CT interpretation is often subjective and depends on the radiologist's experience, and without standardization, interobserver variability can be substantial [7]. Features that may suggest malignancy and warrant further evaluation include a cyst larger than 10 cm, multiloculation, wall or septal thickness greater than 3 mm, a solid component with necrosis, irregularity, ascites, and increased vascularization [8], [9], [10]. In addition, a previous study of CT features in mucinous ovarian tumors reported that morphology, tumor wall, septa, presence of a solid component, and contrast enhancement pattern can aid preoperative diagnosis of benign, borderline, or malignant tumors. In contrast, site (laterality), tumor size, and intramural calcification did not provide distinctive features in that study [11].

A study on a Modified Computed Tomography Scoring System for Ovarian Tumors explained that masses with a cystic component mixed with fat are more often found in benign tumors, whereas cystic masses with a solid admixture are more often found in malignant tumors. Thin septa tend to be found in benign tumors, and thick septa are more often found in malignant tumors [6]. In the multivariate logistic regression analysis of that study, it was explained that the presence of a solid component and metastasis were significant independent factors for differentiating benign from malignant ovarian tumors in general.

This study continues the research conducted by Handayani et al. [11] to create a scoring system based on CT Scan characteristics in mucinous ovarian tumors. By assigning points to each CT characteristic and determining the degree of malignancy based on cut-off values, radiologists can draw more accurate conclusions about the probability of tumor malignancy, and the system can become a reliable diagnostic aid to improve the accuracy of preoperative staging. This study aims to determine a CT scan-based scoring system as a preoperative diagnostic aid to differentiate mucinous ovarian tumors into benign, borderline, and malignant categories with histopathological correlation.

Methods

2.1 Research Design

This was an observational analytic study with a cross-sectional design conducted retrospectively. It was a diagnostic test to evaluate the reliability of the CT Scan scoring system in predicting the degree of malignancy of mucinous ovarian tumors, divided into benign, borderline, and malignant, with histopathological examination as the gold standard.

2.2 Study Population and Sample

Female patients with suspected ovarian tumors who underwent contrast-enhanced abdominal CT Scan at RSUD dr. Soetomo. Patients with mucinous-type ovarian tumors who underwent contrast-enhanced abdominal CT Scan and histopathological examination at RSUD dr. Soetomo. The study sample was taken from the accessible population that met the inclusion criteria. The sample size was determined using the Lemeshow formula for studies with an unknown population size. Based on the calculation with a significance level of 5%, a population proportion of 0.45283, and a tolerable error of 10%, a minimum sample size of 95.158 subjects was obtained, which was rounded to 95 subjects. Study subjects were determined based on inclusion and exclusion criteria. The inclusion criteria were patients with ovarian tumors at RSUD dr. Soetomo, who had undergone contrast-enhanced abdominal CT Scan at RSUD dr. Soetomo, had undergone surgery, had undergone histopathological examination, and were histopathologically confirmed as having a mucinous-type ovarian tumor. Meanwhile, the exclusion criteria were patients after chemotherapy or radiotherapy evaluation and patients with histopathologically confirmed ovarian metastasis.

2.3 Study Location and Time

The study was conducted at the Radiology Installation of RSUD Dr. Soetomo Surabaya from 1 January 2020 to 30 March 2026.

2.4 Variable Identification

The independent variables (X) in this study were the significant abdominal CT Scan characteristics in patients with mucinous-type ovarian tumors, which include morphology, wall thickness, septa, presence of a solid component,

enhancement pattern, and tumor margin. The dependent variable (Y) was the classification of mucinous-type ovarian tumors, consisting of benign (mucinous ovarian cystadenoma), borderline (mucinous borderline tumor), and malignant (mucinous ovarian carcinoma).

2.5 Operational Definitions

The operational definition of each variable studied was delimited according to the study objectives. Morphology is the shape of the tumor, categorized as unilocular and multilocular. Tumor wall thickness is the thickness of the outermost tumor wall measured at its thickest part in millimeters (mm), categorized as thin if <3 mm and thick if ≥3 mm.

Septa are thin tissue that crosses the lesion cavity from one internal surface to the contralateral side. The presence of septa is categorized as present or absent. If septa are present, the greatest thickness (height) is measured in millimeters (mm), categorized as thin if <3 mm and thick if ≥3 mm.

A solid component is a hyperdense lesion with a value of 30-60 HU measured in the non-contrast phase. The presence of a solid component is categorized as present or absent. If a solid component is present, the thickness (height) of the largest solid component on the tumor wall is measured in millimeters (mm) and expressed on a numerical scale.

Enhancement pattern is the increase in Hounsfield Unit value after contrast injection in the solid component, wall, or septa of the tumor, measured in the venous phase. The enhancement pattern is categorized as present or absent. If enhancement is present in the venous phase, the density is compared with the myometrium and categorized as mild if lower than the myometrium, moderate if equal to the myometrium, and strong if higher than the myometrium.

Tumor margin is the boundary of the tumor with the surrounding tissue, categorized as regular and irregular. Overall, these abdominal CT Scan characteristic variables were used to analyze their association with the classification of mucinous-type ovarian tumors, namely mucinous ovarian cystadenoma, mucinous borderline tumor, and mucinous ovarian carcinoma.

2.6 Research Instruments

Medical records of patients diagnosed with ovarian cyst who had undergone histopathological examination with a result of mucinous-type ovarian tumor (cystadenoma/benign, borderline, or carcinoma/malignant).

CT scan machines: Philips Ingenuity 128 Slice, Philips Incisive CT 128 Slice, Toshiba Aquilion CX TSX-101A 128 Slice, Siemens Somatom go.Now 32 Slice, Philips Ingenuity CT Pro 500 128 Slice

DICOM files of patients with mucinous-type ovarian tumors at RSUD dr. Soetomo who had undergone surgery and were histopathologically confirmed as having a primary mucinous ovarian tumor, categorized as mucinous cystadenoma, mucinous borderline, or mucinous carcinoma. Data collection table for abdominal CT Scan characteristics of mucinous-type ovarian tumors.

2.7 Data Processing Method

The researchers identified subjects who met the inclusion criteria over a 6-year period, from 1 January 2020 to 30 March 2026. Medical record data of patients who met the inclusion criteria were taken as the study sample. The standard used to determine mucinous ovarian tumors was the histopathology result. The abdominal CT Scans of patients histopathologically confirmed as having mucinous ovarian tumors were re-read, blinded, by two Consultant Radiologists specializing in Breast and Female Reproductive Imaging with more than 10 years of experience. The independent variable data collected from the abdominal CT Scan results were compiled into a data collection sheet, which was then analyzed and presented as the study results.

2.8 Data Analysis

The researchers identified subjects who met the inclusion criteria and who underwent non-contrast and contrast abdominal CT Scan at RSUD dr. Soetomo, had undergone histopathological examination, and were confirmed as having a mucinous ovarian tumor. The raw data were re-read by two Consultant Radiologists specializing in Breast and Female Reproductive Imaging with more than 10 years of experience, blinded to patient data. The researchers then summarized the study data in a prepared worksheet, followed by univariate analysis, with categorical data presented as (n) and percentage, and numerical data presented as Mean ± Standard Deviation if normally distributed or Median (Minimum-Maximum) if not normally distributed. Bivariate analysis was then performed using the Chi-square test for categorical independent variables, and the Spearman Rank correlation test and the Kruskal-Wallis differentiation test for numerical independent variables, to determine whether there was a significant association between the scores created and the PA result.

Multivariate analysis was then performed using ordinal regression because the dependent variable (Y) is ordinal (Benign, Borderline, Malignant). The analysis yields the coefficient (β) and odds ratio (OR) for each independent variable (X). A Receiver Operating Characteristic (ROC) curve was then created to determine the cut-off point,

followed by calculation of sensitivity and specificity. The ordinal regression output produces multiple cut-offs: the first score card determines the cut-off for malignant versus non-malignant (benign and borderline), and the second score card determines the cut-off for benign versus non-benign. Thus, values between the 2 cut-offs for benign and malignant will be obtained, which become the values for borderline.

2.9 Research Ethics

The researchers submitted a research approval request to the Ethics Committee of RSUD Dr. Soetomo Surabaya.

3 Results

3.1 Characteristics of Study Subjects

This study evaluated 120 subjects with mucinous-type ovarian tumors who had undergone contrast-enhanced abdominal CT Scan and were confirmed by histopathological examination at RSUD Dr. Soetomo.

Table 1: Frequency Distribution of Study Subject Characteristics

Variable	Category	Frequency (n)	Percentage (%)	Cumulative (%)
Age	1-20 years	11	9.2%	9.2%
	21-40 years	34	28.3%	37.5%
	41-60 years	62	51.7%	89.2%
	61-80 years	13	10.8%	100.0%
Morphology	Unilocular	2	1.7%	1.7%
	Multilocular	118	98.3%	100.0%
Diameter	< 10 cm	2	1.7%	1.7%
	> 10 cm	118	98.3%	100.0%
Tumor Wall Thickness	< 3 mm	59	49.2%	49.2%
	>= 3 mm	61	50.8%	100.0%
Septa	< 3 mm	67	55.8%	55.8%
	>= 3 mm	53	44.2%	100.0%
Solid Component	Negative	40	33.3%	33.3%
	Positive	80	66.7%	100.0%
Enhancement Pattern	Non enhance	20	16.7%	16.7%
	Mild enhancement	47	39.2%	55.8%
	Moderate enhancement	39	32.5%	88.3%
	Strong enhancement	14	11.7%	100.0%
Tumor Margin	Regular	97	80.8%	80.8%
	Irregular	23	19.2%	100.0%
PA Result	Benign	24	20.0%	20.0%
	Borderline	42	35.0%	55.0%
	Malignant	54	45.0%	100.0%

Table 1 presents the general overview or frequency distribution characteristics of the total 120 study subjects based on various radiological variables. By age group, most patients were in the 41-60 year range, namely 62 people (51.7%), followed by the 21-40 year group with 34 people (28.3%). The older age group (61-80 years) comprised 13 people (10.8%), and the youngest age group (1-20 years) comprised 11 people (9.2%). This shows that these cases are most often found in adulthood through middle age.

Almost all study samples had multilocular morphology, namely 118 cases (98.3%), while unilocular morphology was found in only 2 cases (1.7%). Most tumors were > 10 cm in size, namely 118 cases (98.3%), while a size < 10 cm was found in only 2 cases (1.7%), with a mean tumor diameter of 24.77 ± 6.87 and a median of 25.45 cm (range 6.7-40.1 cm). The distribution of wall thickness was fairly balanced between thin walls < 3 mm in 59 cases (49.2%) and thick walls ≥ 3 mm in 61 cases (50.8%), with a mean wall thickness of 3.46 ± 1.64 mm. Septa with a thickness < 3 mm were found in 67 cases (55.8%), and the remaining ≥ 3 mm in 53 cases (44.2%), with a mean septal thickness of 3.05 ± 1.39 mm. Most cases showed a positive solid component, namely 80 cases (66.7%), while the remainder were negative (without a solid component) in 40 cases (33.3%).

Based on the degree of contrast enhancement, the most common category was mild enhancement in 47 cases (39.2%), followed by moderate enhancement in 39 cases (32.5%), non-enhance in 20 cases (16.7%), and strong enhancement in 14 cases (11.7%). The majority of tumor margins were regular in 97 cases (80.8%), while irregular margins were found in 23 cases (19.2%). For the histopathological examination results, of the total 120 samples, the largest group was the malignant category with 54 cases (45.0%), followed by the borderline category with 42 cases (35.0%), and the benign category with 24 cases (20.0%).

3.2 Bivariate Analysis of CT Scan Variables with Histopathology Results

Table 2: Summary Table of Bivariate Analysis with Histopathology Results

Predictor Variable	Statistical Test	p Value	Conclusion
Age	Linear-by-Linear / Pearson	p = 0.028 (L-by-L)	Significant (Linear trend)
Morphology	Fisher's Exact Test	p = 0.300	Not Significant
Diameter	Fisher's Exact Test	p = 1.000	Not Significant
Tumor Wall Thickness	Pearson Chi-Square	p < 0.001	Highly Significant
Septa	Pearson Chi-Square	p < 0.001	Highly Significant
Solid Component	Pearson Chi-Square	p < 0.001	Highly Significant
Enhancement Pattern	Pearson Chi-Square	p < 0.001	Highly Significant
Tumor Margin	Pearson Chi-Square	p < 0.001	Highly Significant

Regarding the association between age and malignancy, the overall Pearson Chi-Square test was not significant (p = 0.065 at α = 0.05). However, the Linear-by-Linear Association test was significant (p = 0.028), indicating a significant linear trend in which the proportion of malignancy increases with older age groups (76.9% in the 61–80 year group vs. 18.2% in the 1–20 year group).

For tumor morphology (unilocular vs. multilocular), Fisher's Exact Test showed no significant association with the degree of malignancy (p = 0.300). This may be because 98.3% of the samples were multilocular. Tumor diameter (<10 cm vs. >10 cm) also showed no significant association with the PA result (Fisher's Exact Test, p = 1.000).

In contrast, tumor wall thickness was highly significantly associated with the PA result (Pearson Chi-Square = 55.874, p < 0.001). Tumor walls ≥ 3 mm predominated in the malignant group (77.0%), whereas tumor walls < 3 mm predominated in the benign (39.0%) and borderline (49.2%) groups.

Tumor septal thickness was likewise highly significantly associated with the PA result (Pearson Chi-Square = 51.917, p < 0.001). Thick septa were found in 81.1% of malignant cases, while thin septa predominated in benign (34.3%) and borderline (49.3%) cases.

The presence of a solid component was also highly significantly associated with the PA result (Pearson Chi-Square = 58.512, p < 0.001). A solid component was found in 96.3% of malignant cases, whereas the absence of a solid component predominated in benign (55.0%) and borderline (40.0%) cases.

Enhancement pattern was highly significantly associated with the PA result as well (Pearson Chi-Square = 65.591, p < 0.001). Strong (92.9%) and moderate (82.1%) enhancement patterns were strongly associated with malignant cases, whereas non-enhancement and mild enhancement tended toward benign and borderline cases.

Finally, tumor margin was significantly associated with the PA result (Pearson Chi-Square = 20.741, p < 0.001). Irregular tumor margins had a malignant proportion of up to 87.0%, whereas regular margins were found in benign (24.7%), borderline (40.2%), and malignant (35.1%) cases.

3.3 Final Parameters of Ordinal Logistic Regression

The final model retained 3 main independent variables, consisting of solid component, enhancement pattern, and tumor margin. All final variables had p values < 0.05.

Table 3: Parameter Estimates of the Final Ordinal Logistic Regression Model

Variable	Regression Coefficient (B)	Standard Error	Wald	Sig. (p)	95% CI
Solid Component = Positive	3.147	0.673	21.881	< 0.001	1.828 - 4.466
Solid Component = Negative	0 (ref)	-	-	-	-
Enhancement = Strong	4.732	1.300	13.248	< 0.001	2.184 - 7.281
Enhancement = Moderate	4.697	0.915	26.324	< 0.001	2.903 - 6.491
Enhancement = Mild	1.376	0.699	3.876	0.049	0.006 - 2.747

Enhancement = Non	0 (ref)	-	-	-	-
Tumor Margin = Irregular	2.502	0.917	7.441	0.006	0.704 - 4.299
Tumor Margin = Regular	0 (ref)	-	-	-	-

The estimate (B) shown in Table 3 indicates the magnitude and direction of the effect of a variable category on the dependent variable. A positive value (as with existence of solid component or tumor margin irregular) means that the presence of that factor increases the tendency or probability of an outcome in a higher category (for example, toward malignancy) compared with the comparison/reference group. Std. Error measures the degree of uncertainty of the estimated B coefficient. The smaller the Std. Error relative to the B value, the more precise and accurate the model is in estimating that parameter. Wald statistic is a test statistic calculated to test the significance of each regression coefficient partially. The Wald value is obtained from the square of the ratio of B to Std. Error, where a larger Wald value generally reflects a stronger predictor contribution. Sig. (p-value) is the probability value used to test the statistical hypothesis. If the Sig. value is below the standard significance threshold ($p < 0.05$), this demonstrates that the variable has a statistically significant influence on the histopathology result.

Based on the ordinal logistic regression results in Table 3, the existence of solid component showed a significant increase in log-odds of 3.147 (with coefficient B = 3.147, Wald = 21.881, $p < 0.001$, and 95% CI: 1.828-4.466) of being in a higher malignancy category if compared with no solid component. For the enhancement pattern variable, strong enhancement (B = 4.732, $p < 0.001$, 95% CI: 2.184-7.281) and moderate enhancement (B = 4.697, $p < 0.001$, 95% CI: 2.903-6.491) gave the highest parameter estimates of increased malignancy risk, followed by the mild enhancement (B = 1.376, p = 0.049, 95% CI: 0.006-2.747) when compared with the non-enhance group. In addition, irregular tumor margin characteristic also significantly increased the tendency toward malignancy by 2.502 times (with B = 2.502, Wald = 7.441, p = 0.006, and 95% CI: 0.704-4.299) compared with a regular tumor margin.

3.4 Evaluation of Scoring Model Performance with ROC Curve and AUC

Evaluation of scoring model performance using the ROC (Receiver Operating Characteristic) curve and AUC (Area Under the Curve) serves to measure the diagnostic discrimination ability of a scoring system in accurately differentiating between different clinical condition groups, such as separating malignant from non-malignant cases. Through the graph and the AUC value, this analysis assesses how reliable the model is overall in predicting pathological status, where values closer to 1.0 indicate increasingly outstanding diagnostic performance. In addition, a crucial function of this evaluation is to determine the most optimal score cut-off point in clinical practice, so that clinicians can set an appropriate risk threshold to balance sensitivity and specificity as much as possible.

3.4.1. ROC Analysis for Determining the Non-Malignant and Malignant Cut-Off.

The accuracy and discrimination of the scoring system were tested using the Receiver Operating Characteristic (ROC) in two different clinical conditions. This test evaluates the ability of the score to identify malignant cases.

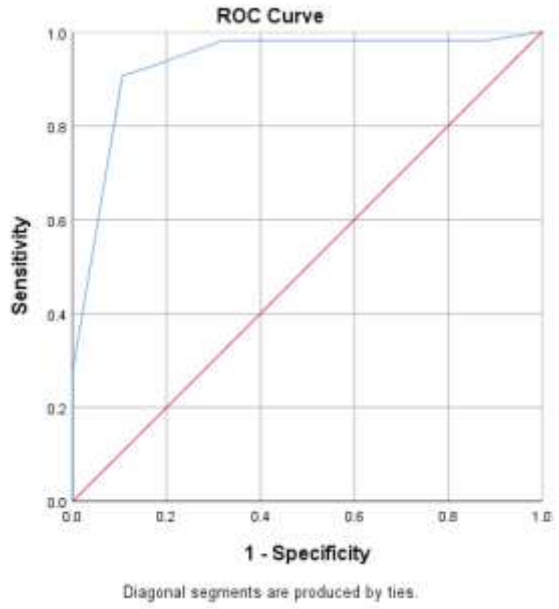


Figure 1: ROC Curve for Non-Malignant and Malignant Tumors

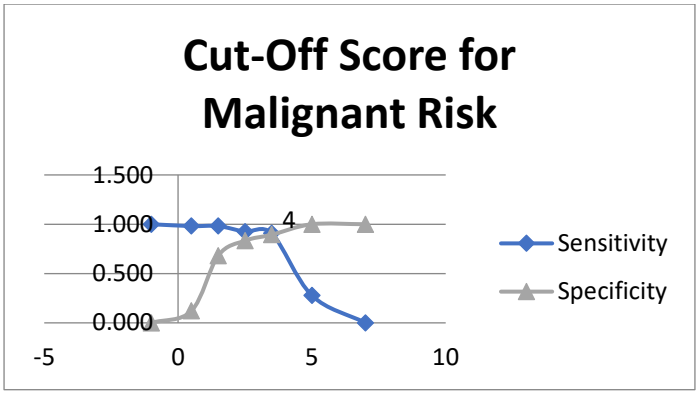


Figure 2: Malignancy Risk Score Cut-Off

An Area Under the Curve (AUC) of 0.933 was obtained with a standard error (Std. Error) of 0.025, $p < 0.001$, and a 95% Confidence Interval (CI) range of 0.885 to 0.982. This very high AUC value confirms that the developed scoring system has excellent discrimination performance in detecting and identifying malignant cases.

Based on evaluation of the cut-off coordinates, a score of 3.50 (equivalent to a rounded score of 4) was set as the optimal cut-off point in clinical practice because it provides a very good balance of diagnostic performance, with a sensitivity of 90.7% and a specificity of 89.4% (1 - Specificity = 10.6%). For comparison, using a threshold at a score of 1.50 gives a very high sensitivity of 98.1% but a lower specificity (68.2%). Conversely, a threshold at a score of 5.00 yields a perfect specificity of 100.0% but a drastic decrease in sensitivity to 27.8%.

3.4.2. ROC Analysis for Determining the Benign and Borderline Cut-Off.

This test aims to evaluate the ability of the score to separate borderline patients from the benign group, because a cut-off for borderline cases is needed among the patient categories already separated from the malignant category.

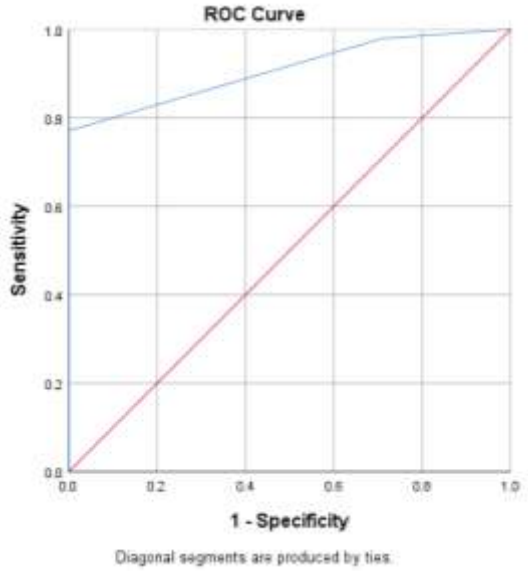


Figure 3: ROC Curve for Benign and Borderline Tumors

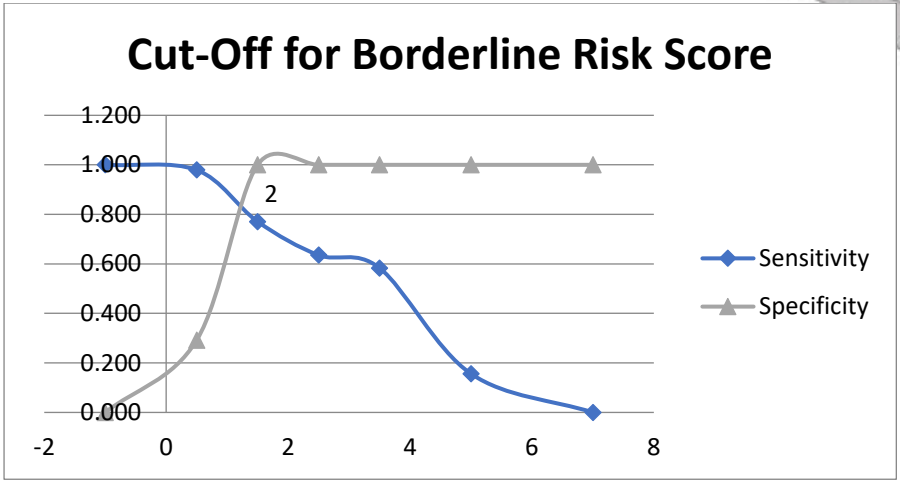


Figure 4: Cut-Off for Borderline Risk Score

An Area Under the Curve (AUC) of 0.908 was obtained with a Std. Error of 0.026, $p < 0.001$, and a 95% Confidence Interval (CI) range of 0.858 to 0.959. This high AUC value indicates that the scoring model has very good discrimination performance in identifying borderline patients among non-malignant patients.
Based on evaluation of the cut-off coordinates, a score of 1.50 (equivalent to a rounded score of 2) was set as the optimal cut-off point because it provides a Sensitivity of 77.1% with a perfect Specificity of 100.0% (1 - 0.000 = 1.000), meaning that no Benign patients were misclassified into the intermediate or high risk group at that threshold.

3.4.3. Test of Cut-Off Scores with Histopathology Results

Table 4: Analysis Table of Risk Score with Histopathology Results

Risk Score Category	Benign (n=24)	Borderline (n=42)	Malignant (n=54)	Total
Score < 2 (Benign)	24 (52.2%) / [100%]	21 (45.7%) / [50.0%]	1 (2.2%) / [1.9%]	46 (100%)
Score 2 - 3 (Borderline)	0 (0.0%) / [0.0%]	14 (77.8%) / [33.3%]	4 (22.2%) / [7.4%]	18 (100%)
Score >= 4 (Malignant)	0 (0.0%) / [0.0%]	7 (12.5%) / [16.7%]	49 (87.5%) / [90.7%]	56 (100%)
Total Cases	24 (20.0%)	42 (35.0%)	54 (45.0%)	120 (100%)

Table 4 presents the analysis of the risk score cut-off test against the histopathology results of the 120 samples. The stratification into three clinical risk groups shows a very specific and meaningful distribution. In the benign group (score < 2 or 0 - 1 points), which comprised 46 cases, all benign cases (100% or 24 of 24 benign cases) fell into this category, while only 1 case (2.2%) was malignant. The borderline group (score 2 - 3 points), comprising 18 cases, was dominated by borderline cases at 77.8% (14 cases) with none benign case (0.0%). Finally, the malignant group (score ≥ 4 points), consisting of 56 cases, was strongly dominated by malignant cases at 87.5% (comprising 49 of the total 54 malignant cases, equivalent to 90.7% of all malignant cases), and it was confirmed that not a single benign case entered this high risk group.

3.4.4. Validation of Agreement and Correlation.

The test results show validation of agreement and correlation (Symmetric Measures). The analysis shows a very good association and agreement between the risk score system created and the definitive diagnosis from anatomical pathology. Based on the Spearman Correlation Test, a correlation coefficient of $r = 0.834$ with significance $p < 0.001$ was obtained, indicating a very strong and statistically significant positive relationship between the risk score group division and the degree of malignancy from anatomical pathology results.
In addition, based on the Cohen's Kappa Agreement Test, an agreement value of $k = 0.584$ with significance $p < 0.001$ was obtained, indicating a moderate to substantial level of agreement between the predicted risk score grouping and the definitive diagnosis from anatomical pathology.

3.5 Risk Category Score and Clinical Stratification

Based on the entire series of analyses performed, this study successfully identified that the variables solid component, enhancement pattern, and tumor margin are the 3 main radiological parameters most significant in predicting the degree of malignancy of mucinous ovarian tumors.

Table 5: Point Weighting of CT Scan Characteristics in the Risk Scoring System

Risk Category	Points
Solid Component = Positive	2
Solid Component = Negative	0
Enhancement Pattern = Strong	3
Enhancement Pattern = Moderate	3
Enhancement Pattern = Mild	1
Enhancement Pattern = Non	0
Tumor Margin = Irregular	2
Tumor Margin = Regular	0

Table 6: Clinical Risk Group Stratification Based on Total Score

Clinical Risk Group Stratification	Score
Benign	< 2 (0 - 1 points)
Borderline	2 - 3 points
Malignant	≥ 4 points

Based on the regression coefficients of these parameters, a practical and structured clinical risk scoring system was successfully developed with a total score range of 0 - 8 points, with point weights set as follows: existence of solid component is worth 2 points, enhancement pattern is worth 1 point for the mild category and 3 points for the moderate and strong categories, and irregular margin is worth 2 points.

Evaluation of diagnostic performance using the ROC curve showed outstanding results, with an AUC of 0.933 for differentiating malignant cases and an AUC of 0.908 for screening cases requiring further intervention (non-benign). Through clinical risk stratification, this system divides patients into three highly accurate operational groups, benign (score < 2), which includes all benign cases, borderline (score 2 - 3), which is dominated by borderline cases, and malignant (score ≥ 4), in which more than 90% of malignant cases are effectively detected.

4 Discussion

4.1 Demographic Characteristics and Sample Distribution

The results showed that most patients with mucinous-type ovarian tumors were in the 41-60 year age group (51.7%), with a mean subject age of 43.84 ± 14.68 years. This finding is in line with the epidemiology stating that the incidence of mucinous cystadenoma (benign) typically occurs in women aged 20-40 years, mucinous borderline tumor has a mean age range of 40-49 years, and mucinous carcinoma 45 years [12].

Bivariate analysis using the Linear-by-Linear Association test showed a statistically significant linear trend ($p = 0.028$), in which the proportion of malignancy increased with advancing age (reaching 76.9% in the 61-80 year age group). This strengthens the evidence that age is one of the important independent risk factors for increased susceptibility to ovarian malignancy, with incidence rising drastically after the age of 50 years [13], [14].

4.2 Association of CT Scan Characteristics with Histopathology Results

Of the seven CT scan variables evaluated, five variables were shown to have a highly statistically significant association with the histopathology result, namely tumor wall thickness ($p < 0.001$), septal thickness ($p < 0.001$), presence of a solid component ($p < 0.001$), enhancement pattern ($p < 0.001$), and tumor margin ($p < 0.001$).

Tumor walls and septa with a thickness ≥ 3 mm predominated in the malignant group, at 87.0% and 79.6%, respectively. Pathophysiologically, aggressive tumor cell growth triggers neoangiogenesis and the formation of thick stromal tissue, which appears visually as thickening of the walls and septa on contrast-enhanced abdominal CT scan. This is because epithelial ovarian cancer is characterized by genetic changes that trigger abnormal signaling to stimulate proliferation, inhibit apoptosis, inhibit anoikis, increase motility, adhesion, and cell invasion, and recruit stromal components including mesenchymal stem cells and new blood vessels [15]. This is consistent with the study

by Bourgioti, C., et al, 2025, which stated that the presence of a solid component, thick walls and septa with irregular edges, and contrast enhancement on CT point to suspicion of borderline or malignant tumors. Additional findings such as invasion into pelvic organs or the pelvic sidewall, ascites, peritoneal metastasis, and lymphadenopathy strengthen the diagnosis of malignancy [16].

A solid component was identified in 66.7% of the total sample and showed a very strong association with malignancy ($p < 0.001$), with 96.3% of malignant cases in this study having a solid component. This is consistent with the study by Handayani et al. [11], whose analysis found that a solid component reached a high percentage in the malignant mucinous tumor group. The presence of solid tissue within a cystic mass reflects active epithelial proliferation and areas of micronecrosis, which are hallmarks of epithelial ovarian malignancy [17].

Enhancement patterns of the moderate enhancement (82.1%) and strong enhancement (92.9%) categories, measured in the venous phase and compared with the myometrium, showed a very close association with malignancy [18]. High vascularization in the solid component and septa indicates high tumor vascular activity resulting from the malignant angiogenesis process [19].

Irregular tumor margins were shown to significantly increase the risk of malignancy, with 87.0% of cases with irregular margins confirmed as malignant. Irregular tumor margins reflect an infiltrative or destructive growth pattern that penetrates the tumor capsule into the surrounding tissue. This is consistent with the study by Zheng et al., which evaluated imaging variables for differentiating mucinous ovarian tumors, in which margin shape and internal structure were shown to have very strong statistical significance ($p < 0.001$) for malignancy risk [20].

Tumor morphology (unilocular or multilocular) did not show a significant value ($p = 0.300$; Fisher's Exact Test). Because $p > 0.05$, there was no significant association between morphology type and degree of malignancy. This is because 98.3% of the samples were multilocular. Theoretically, mucinous ovarian tumors have a broad histopathological spectrum, ranging from benign (cystadenoma) and borderline to malignant (carcinoma), in which complex multilocular morphology and large tumor size are often associated with increased suspicion of malignancy. However, in this study, the variables morphology (unilocular and multilocular) and tumor diameter were not statistically shown to be significantly associated with malignancy risk. This lack of statistical significance can be explained by the homogeneous characteristics of the sample, in which most lesions were of the multilocular type (reaching 98.3%) and large (> 10 cm). Mucinous tumors physiologically tend to grow into large multilocular cystic masses (multiloculated cystic mass) in both benign and malignant categories, so the clustered data distribution (class imbalance) in one particular morphology category caused the statistical test to not detect a significant variation in proportions between malignancy groups [8].

Tumor diameter was also not statistically shown in this study to be associated with malignancy risk ($p = 1.000$; Fisher's Exact Test), consistent with the study by Handayani et al. [11], which stated that tumor size does not provide a distinctive feature for differentiating the degree of malignancy. In this study there was also no correlation because the majority of the sample was dominated by multilocular lesions measuring > 10 cm.

4.3 Performance of the Risk Scoring System and ROC (AUC) Analysis

This study successfully formulated a practical clinical risk scoring system with a score range of 0 - 8 points based on weighting of the ordinal logistic regression coefficients (B). Evaluation of diagnostic performance using the Receiver Operating Characteristic (ROC) curve proved that this scoring model has very good discrimination ability.

The ROC analysis created to differentiate non-malignant from malignant produced an Area Under the Curve (AUC) of 0.933 ($p < 0.001$). This value confirms excellent performance. A score cut-off of ≥ 3.5 (equivalent to a score of ≥ 4) was set as the optimal threshold for detecting malignancy, with a sensitivity of 90.7% and a specificity of 89.4%.

ROC analysis 2 aims to screen non-malignant cases requiring further evaluation, namely to separate borderline from purely benign. This analysis produced an AUC of 0.908 ($p < 0.001$) with an optimal cut-off at a score of ≥ 1.5 (score ≥ 2), which gave a perfect specificity of 100.0%. This means that not a single benign patient was misclassified into the moderate or high risk group, so it is very safe for avoiding overtreatment in benign cases.

4.4 Clinical Risk Stratification and Model Validation

Through stratification of clinical risk groups based on accumulated scores, patients were grouped into three operational categories:

A. Benign (Score < 2): includes all purely benign patients (100% of benign cases), so clinicians can consider a conservative approach or lighter clinical monitoring.
B. Borderline (Score 2 - 3): dominated by borderline cases (77.8%), which separates the gray area between benign and malignant.
C. Malignant (Score ≥ 4): strongly dominated by malignant cases (87.5% of which were proven to be truly malignant), which indicates the need for radical surgical intervention.

The agreement validation test using Spearman Correlation showed r = 0.834 (p < 0.001), indicating a very strong positive association between increasing score and the degree of histopathological malignancy. Meanwhile, the Cohen's Kappa test yielded k = 0.584 (p < 0.001), indicating a moderate to substantial level of agreement between the scoring model's predictions and the definitive histopathological diagnosis.

Overall, this scoring system based on CT scan characteristics proved to be valid, objective, and reliable for application as a preoperative diagnostic aid in healthcare facilities to improve the accuracy of management of patients with mucinous ovarian tumors.

Conclusion

In 120 subjects with mucinous ovarian tumors, solid component, enhancement pattern, and tumor margin are CT scan characteristics that can be used in a scoring system to predict malignancy based on histopathological correlation. The scoring system assigns a weight of 2 for solid component, 1-3 for enhancement pattern, and 0-2 for tumor margin, with a cut-off of ≥2 to differentiate benign from borderline tumors with 100% specificity, and a cut-off of ≥4 for the malignant category with 90.7% sensitivity, 89.4% specificity, and an AUC of 0.933. These findings indicate that a scoring system based on CT scan characteristics can help stratify the malignancy of mucinous ovarian tumors in preoperative evaluation, although validation in a larger, multicenter sample is still needed.

This scoring system can be considered as additional guidance in the preoperative evaluation of mucinous ovarian tumors, especially in assessing solid component, enhancement pattern, and tumor margin. Further studies with a larger, multicenter sample, as well as integration of MRI or immunohistochemical examination, are needed to evaluate and improve the validity and diagnostic accuracy of the scoring system.

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