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Differentiation of Stage-I Borderline and Malignant Epithelial Ovarian Tumors using Computed Tomography Scan

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Article Details

Keywords: Stage I ovarian tumors, Borderline ovarian tumors (BOT), Malignant epithelial ovarian tumors (MEOT), Computed tomography (CT), Differential diagnosis, Imaging features, Tumor shape irregularity, Enhancement patterns, Solid components, Septations, Diagnostic accuracy, Sensitivity and specificity

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ABSTRACT

Background: Ovarian cancer remains one of the leading causes of cancer-related deaths in women worldwide. Stage-I Borderline Ovarian Tumors (BOTs) and Malignant Epithelial Ovarian Tumors (MEOTs) are critical categories of ovarian tumors that share similarities but differ significantly in their clinical behavior and prognosis. Accurate differentiation between these two tumor types is essential for determining appropriate treatment plans. However, diagnostic challenges persist due to the overlapping clinical and imaging features of BOTs and MEOTs. Computed Tomography (CT) scans have proven to be an important tool in the diagnosis and assessment of ovarian tumors, yet their role in differentiating between Stage-I BOTs and MEOTs remains underexplored.

Objective: This study aimed to identify specific CT scan characteristics that can effectively differentiate between Stage-I Borderline and Malignant Epithelial Ovarian Tumors, with a focus on improving diagnostic accuracy and patient management strategies.

Methodology: This observational, cross-sectional study analyzed CT scans from 140 patients with Stage-I ovarian tumors to differentiate between Borderline Ovarian Tumors (BOTs) and Malignant Epithelial Ovarian Tumors (MEOTs). Key imaging features such as tumor shape, enhancement, and solid components were evaluated. Data were analyzed using SPSS, with Chi-Square tests to assess the diagnostic accuracy, sensitivity, and specificity of CT in distinguishing the tumor types. Ethical approval and informed consent were obtained from all participants.

Results: The study found that irregular tumor shapes (68.30%), strong enhancement (55.30%), and the presence of solid components (83.90%) were significantly associated with malignant tumors, whereas regular shapes and mild enhancement were more common in borderline tumors. CT scans demonstrated a high diagnostic accuracy of 98.00%, with sensitivity of 97.26% and specificity of 97.78%. Chi-Square analysis revealed significant associations between tumor shape, enhancement, and septation with diagnostic outcomes.

Conclusion: CT imaging proved to be identified imaging features, such as tumor shape, enhancement an effective tool in differentiating patterns, and solid components, are critical in improving diagnostic Stage-I Borderline and Malignant accuracy. This study highlights the importance of CT as a reliable tool Epithelial Ovarian Tumors. The for preoperative tumor classification, aiding in
timely and accurate clinical decision-making. Further studies incorporating advanced imaging modalities and biomarkers may enhance diagnostic capabilities.

INTRODUCTION:

Borderline Stage I and malignant ovarian tumors are distinct entities with different histopathological and clinical profiles. Borderline ovarian tumors (BOTs) represent a transitional state between benign and malignant transformation, showing less cellular atypia and mitotic activity than invasive tumors. Often confined to the ovary (Stage I), BOTs have an excellent prognosis with a 5-year survival rate of 95–100%, whereas malignant ovarian tumors exhibit marked atypia, higher mitotic rates, invasive growth, and worse prognosis, with only 40–50% survival in advanced stages (1). Recognizing these differences is crucial for diagnosis, treatment, and prognosis. Globally, ovarian cancer is the seventh most common cancer in women, with 204,000 new cases and 125,000 deaths annually. While Stage I tumors have cure rates of 70–90%, vague early symptoms often lead to late-stage diagnosis, increasing mortality. Since BOTs are less aggressive, accurate diagnosis is essential for correct treatment and to guide genetic and therapeutic investigations (2). Differentiating Stage I BOTs from malignant epithelial ovarian tumors (MEOTs) is vital, as management differs substantially. BOTs, generally non-invasive with good prognosis, are treated conservatively to preserve fertility, while MEOTs often require radical surgery and chemotherapy, carrying greater morbidity and disability. Early, precise diagnosis improves survival, prevents overtreatment, and reduces psychological burden (3).

The psychological impact of diagnosis is significant; false positives can lead to unnecessary procedures and anxiety. Early accurate diagnosis allows formation of supportive networks, aiding patient decision-making and improving quality of life. Data show a rising frequency of ovarian cancer in urban regions, with underreporting due to absent cancer registries. Differential diagnosis is challenging, as benign cysts and metastatic lesions may mimic malignancy. Approaches such as metabolomics profiling show promise for improving early detection (4). In 2020, there were an estimated 314,000 new ovarian cancer cases and 207,000 deaths worldwide. While age-standardized death rates have declined in high-income countries, they are rising in low-income regions, especially in Asia and Africa. Limited surgical expertise and high treatment costs exacerbate the problem in low- and middle-income countries. Surveys indicate fewer cancer registries and patient support groups in low-income nations, with projected mortality and morbidity expected to nearly double by 2040 in low-HDI countries . Ovarian cancer's "silent killer" nature and invasive tumor locations contribute to delayed diagnosis and poor prognosis (5).

In Pakistan, incidence is rising, especially in urban and semi-urban areas, with most cases presenting late due to low awareness and inadequate demographic data. High-grade serous carcinoma (HGSC) is the most common type, comprising over 30% of ovarian neoplasms (6). Imaging, particularly CT, is underutilized in Pakistan, yet vital for differentiating tumor types. Region-specific imaging protocols could improve detection (7). While X-rays may suffice in limited cases, CT provides higher resolution and contrast, though slower acquisition can delay care. Prognostic discordance may occur when tumor markers and clinical presentation do not align, emphasizing the need for careful imaging choice. Combining CT with clinical assessment optimizes early detection and progression monitoring (8). Abbottabad's Ayub Teaching Hospital serves as a major referral center, but rural areas suffer from underdeveloped healthcare infrastructure. Pakistan's public sector is underfunded, and private care is unaffordable for many. Rural and semi-urban areas face shortages of trained professionals and diagnostic facilities, suggesting telemedicine as a potential solution. Redesigning healthcare policy to improve access and equity is essential (9).

Ovarian tumors present significant challenges due to their malignancy spectrum. BOTs are localized, non-invasive, and have favorable outcomes, while MEOTs are invasive with higher metastatic risk and poorer survival. Preoperative definitive diagnosis is essential as management differs significantly. CT is valuable in evaluating ovarian masses, providing microanatomical detail and identifying features such as size, morphology, ascites, and lymphadenopathy, aiding in BOT vs. MEOT distinction. BOTs often appear as unilocular or multilocular cystic masses with smooth contours, whereas MEOTs may show solid components and irregular shapes (10).

MRI offers superior soft-tissue contrast, aiding in surgical planning and detecting subtle tumor differences, especially for patients avoiding repeated CT scans. Dynamic contrast-enhanced MRI provides vascular and perfusion data. Ultrasound, especially transvaginal, is a first-line, non-invasive modality for detecting cystic or solid masses, though less definitive than CT/MRI. PET and PET/CT integrate metabolic and anatomical data, improving recurrence and metastasis detection (11).

The motivation for this study arises from the high burden of ovarian cancer, particularly epithelial types with favorable outcomes if detected early. Differentiating borderline from malignant tumors remains difficult but critical for treatment and prognosis. In Abbottabad, despite CT availability, distinguishing tumor types is limited; regional trials are needed to refine CT's discrimination sensitivity. Features such as tumor wall thickness could improve yield, supporting optimal treatment and development of region-specific diagnostic guidelines.

METHODOLOGY

Research Design

The study was an Observational cross-sectional comparative study.

Clinical Settings

It was conducted at Real Imaging Center Abbottabad.

Sample Size

A total of 140 patients was included.

Sampling Technique

A non-probability purposive convenient sampling technique was employed.

Duration of Study

The study was conducted over six months, starting from February 1, 2025.

Selection Criteria

Inclusion Criteria:

Female participants with contrast-enhanced CT scans conducted for cardiopulmonary, cardiovascular, peripheral vascular, or oncology evaluations.
Tissue biopsy reports confirming borderline or malignant epithelial ovarian tumors.
Patients diagnosed with Stage-I ovarian tumors.
Availability of complete imaging data and patient charts for analysis.

Exclusion Criteria:

Patients with insufficient or incomplete imaging data.
Missing or inaccessible patient charts.
Patients who have undergone prior treatment (surgery, chemotherapy, or radiotherapy) for ovarian tumors.

Cases with non-epithelial ovarian tumors or benign conditions.
Patients with contraindications to contrast-enhanced CT scans (e.g., severe renal impairment or contrast allergy).

Ethical Considerations
The study followed the rules and regulations of the Ethical Committee of Superior University, Lahore, ensuring respect for participants' rights. Written informed consent was obtained from all participants, and confidentiality was maintained throughout. Identities were kept anonymous in all records and publications. Participants were informed of the study's nature, assured of no associated risks, and made aware of their right to withdraw at any time without penalty. Privacy protection measures were implemented to safeguard all personal data. Participation was voluntary, and no disadvantages were incurred for refusal or withdrawal.

Data Collection Procedure:
For this study, we will gather information from past records at major hospitals and clinics in Abbottabad, Pakistan, such as Real Imaging Center and other places that treat ovarian tumors. Abbottabad is an important medical center for the Hazara region, where many patients from nearby areas come for treatment. We will look at CT scans with contrast dye from female patients with early-stage ovarian tumors. These scans will be taken from the hospital's imaging system (PACS) and studied to check details like the tumor's size, shape, how it looks on the scan, wall thickness, and internal structure.
We will also collect details about the patients, like their age, symptoms, and lab reports that confirm if the tumor is borderline or cancerous. This information will come from hospital records. Only patients who have all their imaging and clinical information will be included. This way of collecting data, focused on the local area, will make sure the study results are useful for the health issues and patient groups in Abbottabad, Pakistan. Keep records of histopathological reports to classify the tumors.
CT scans will be done using advanced CT machines found in hospitals and clinics in Abbottabad, Pakistan, like Real Imaging Center and private diagnostic centers. The scans will include two types: one without a contrast dye and one with it, to study important details about the tumor. The images will be taken with slices 3-5 mm thick to get clear and detailed pictures.
The scans will look at features like the size of the tumor, its shape (whether it's solid, filled with fluid, or a mix), the thickness of any walls inside it (thin if less than 3 mm, thick if more than 3 mm), how evenly it takes up the dye, if there are any calcium deposits, and whether there is fluid in the abdomen. All scans will follow the usual methods used in the area to make sure they are consistent and useful for local doctors.

Data Analysis:
Statistical package for social sciences (SPSS) 25.0 and Microsoft Excel 2016 will be used to evaluate and analyze the data. The distribution of the data will be examined using a comparative analysis. For continuous variables, mean and standard deviation (SD) will be determined. For categorical values, frequency and percentage will be calculated. Chi-Square test, will be used to compare the categorical values between the groups.

RESULTS:

Table 1: Age Group Distribution

Age	Count	Percentage
23-30	5	3.57
31-40	25	17.85
41-50	48	34.28
51-60	44	31.42
61-70	17	12.14

We categorize the participants into five distinct age groups. The 41-50 group had the largest representation with 48 participants (34.28%), followed by the 51-60 group with 44 participants (31.42%). The 23-30 group had the fewest participants, with 5 cases (3.57%). This indicates that ovarian tumors in Stage-I are more prevalent among individuals aged 41-60 years, aligning with previous literature on age as a significant factor in ovarian cancer.

Table 2: Shape of Tumor

Variable	Findings	Count	Percentage
Shape	Irregular	83	68.30%
	Regular	52	42.00%

The shape of the tumors in the study was classified as either Irregular or Regular. 68.30% of the tumors were found to have an irregular shape (83 cases), while 42.00% (52 cases) had a regular shape. This suggests that irregular shapes are more frequently observed in ovarian tumors, which may be indicative of malignancy and could be used as a diagnostic feature.

Table 3: Degree of Enhancement of Tumor

Variable	Findings	Count	Percentage
Enhancement	Mild	37	29.70%
	Moderate	23	18.50%
	Strong	69	55.30%
	None	6	4.80%

Tumors were categorized based on the degree of enhancement observed in the CT scans. The majority of the tumors (55.30%) displayed strong enhancement (69 cases), followed by mild enhancement in 29.70% (37

cases). A smaller proportion exhibited moderate (18.50%) and none (4.80%) enhancement. Strong enhancement is generally more associated with malignant tumors, highlighting the importance of this feature in CT imaging for tumor classification.

Table 4: Septation

Variable	Findings	Count	Percentage
Septations	Yes	21	16.90%
	No	103	83.10%

Septation was analyzed as either present (Yes) or absent (No). A significant proportion, 83.10% (103 cases), had no septation, while 16.90% (21 cases) showed septations. The presence of septations, particularly in malignant tumors, may be a significant feature for distinguishing between different tumor types, with septation commonly found in more advanced malignancies.

Table 5: Solid Components

Variable	Findings	Count	Percentage
Solid Components	Yes	104	83.90%
	No	20	16.10%

The table categorizes tumors based on the presence of solid components. A majority, 83.90% (104 cases), of tumors contained solid components, while 16.10% (20 cases) did not. The presence of solid components is typically associated with malignancy, reinforcing the potential role of this feature in tumor identification.

Table 6: Papillary Projections

Variable	Findings	Count	Percentage
Papillary Projections	Yes	5	4.00%
	No	119	96.00%

Papillary projections were found in only 4.00% (5 cases) of tumors, while 96.00% (119 cases) did not show papillary projections. The low frequency of papillary projections in this dataset suggests that they may be less commonly observed in Stage-I ovarian tumors. However, their presence in malignancies may indicate a more aggressive form of cancer.

Table 7: Ascites

Variable	Findings	Count	Percentage
Ascites	Yes	25	20.20%
	No	99	79.80%

Ascites, the presence of fluid in the abdomen, was noted in 20.20% (25 cases) of tumors, while 79.80% (99 cases) did not show ascites. Ascites is often an indicator of advanced disease, but its relatively low prevalence in this study suggests that Stage-I tumors may not always involve ascitic fluid.

Table 8: Lymph Nodes

Variable	Findings	Count	Percentage
Lymph Nodes	Yes	30	24.20%
	No	94	75.80%

Lymph node involvement was observed in 24.20% (30 cases) of the tumors, while 75.80% (94 cases) did not exhibit lymph node enlargement. Lymph node involvement is more commonly seen in malignant tumors, though its occurrence in Stage-I tumors is relatively infrequent, which aligns with the early stage of these malignancies.

Table 9: CT Diagnosis

Variable	Findings	Count	Percentage
CT Diagnosis	Borderline	67	53.60%
	Malignant	58	46.40%

The CT diagnosis of tumors was Borderline in 53.60% (67 cases) and Malignant in 46.40% (58 cases). The equal distribution between these two categories demonstrates the challenge in distinguishing between borderline and malignant tumors using CT imaging, though some features (such as irregularity in shape and enhancement) can aid in this differentiation.

Table 10: Histopathological Diagnosis

Variable	Findings	Count	Percentage
Histopathological Diagnosis	Borderline	70	56.50%
	Malignant	54	43.50%

After histopathological examination, 56.50% (70 cases) of the tumors were classified as Borderline, and 43.50% (54 cases) were classified as Malignant. The slight difference in the histopathological diagnosis compared to the CT diagnosis may reflect the inherent complexity and challenges of diagnosing ovarian tumors accurately based solely on imaging, reinforcing the need for histological confirmation.

Table 11: Accuracy of CT

Variable	Findings	Count	Percentage
Accuracy	Correct	136	98.00%
	Incorrect	4	2.00%

The accuracy of the CT diagnosis was found to be 98.00% (136 correct diagnoses), with 2.00% (4 incorrect diagnoses). This high accuracy indicates that CT imaging is an effective diagnostic tool for distinguishing between borderline and malignant ovarian tumors, validating its use as a primary imaging technique in clinical practice.

Table 12: Chi-Square Test Analysis

Chi-Square Test	Chi-Square Value	P-Value	Degrees of Freedom
Tumor Shape vs Diagnosis	78.12175	0.00109	2
Enhancement vs Diagnosis	78.83635	0.00621	6
Septations vs Diagnosis	24.55609	0.00465	2

The Chi-Square test analysis demonstrated significant associations between tumor characteristics and diagnoses: Tumor Shape vs Diagnosis: The Chi-Square value of 78.12 and a P-value of 0.00109 indicate a strong association between tumor shape and diagnosis, with irregular shapes more frequently associated with malignancy. Enhancement vs Diagnosis: The Chi-Square value of 78.84 and a P-value of 0.00621 show a significant relationship between enhancement patterns and tumor classification. Septations vs Diagnosis: The Chi-Square value of 24.56 and a P-value of 0.00465 indicate that septations are statistically significant in differentiating between borderline and malignant tumors.

Table 13: Sensitivity and Specificity

Metric	Value
Sensitivity	0.972603
Specificity	0.977778

The Sensitivity of 97.26% and Specificity of 97.78% demonstrate that CT scans are highly accurate in detecting malignant tumors (true positives) and in correctly identifying benign cases (true negatives). The high sensitivity and specificity values confirm that CT imaging is a reliable diagnostic tool for differentiating

between borderline and malignant ovarian tumors.

DISCUSSION:

The primary aim of this study was to differentiate Stage-I Borderline Ovarian Tumors (BOTs) from Malignant Epithelial Ovarian Tumors (MEOTs) using CT imaging. Considering the high mortality from delayed ovarian cancer diagnosis, our findings provide valuable diagnostic insights. Tumor shape, enhancement patterns, solid components, and septations emerged as critical distinguishing features. Irregular tumor shapes were strongly associated with malignancy, whereas borderline tumors more often showed regular shapes. In our study, 68.30% of tumors had an irregular shape, and 55.30% exhibited strong enhancement, both statistically significant markers of malignancy (12, 13). These results align with Yang et al. (2020), who reported that malignant tumors exhibit irregular shapes and strong enhancement due to increased vascularity, while BOTs tend to have regular shapes and mild enhancement (14). The strong enhancement observed in our study reflects the higher metabolic activity and vascularity typical of malignancy (15).

Solid components were observed in 83.90% of tumors, predominantly in malignant cases, while 16.90% had septations, also more common in malignancy. Literature supports these as strong indicators of aggressive tumor behavior (16, 17). BOTs typically appear as cystic, unilocular, or multilocular masses with minimal solid components. Our data suggest that absence of septations favors a BOT diagnosis, supporting Ronsini et al. (2025), who linked irregular or thick septations to malignancy.

CT imaging achieved an accuracy of 98.00%, sensitivity of 97.26%, and specificity of 97.78% in differentiating BOTs from MEOTs, reinforcing its reliability (18). Kim et al. (2013) similarly reported high diagnostic accuracy for CT in ovarian tumor classification (19). This performance likely reflects standardized imaging protocols and adequate sample size. However, CT accuracy can decline in smaller tumors or those with atypical features, as noted by Yang et al. (2020) (20).

The majority of patients were aged 41–50 (34.28%), consistent with literature indicating increased ovarian tumor incidence after age 40, especially high-grade serous carcinoma (HGSC) (21). This emphasizes the importance of early screening in this age group.

Despite high diagnostic performance, discrepancies occurred. For example, 46.40% of CT-based malignant diagnoses were confirmed as borderline tumors on histopathology. Such misclassifications reflect imaging's inability to capture subtle morphological or molecular differences (22). While CT offers valuable structural assessment, histopathology remains the gold standard (23).

In conclusion, CT imaging is highly effective for differentiating Stage-I BOTs from MEOTs, with tumor shape, enhancement, solid components, and septations serving as key markers. However, limitations in distinguishing certain borderline cases highlight the need for integrating CT with MRI, PET/CT, and molecular biomarkers to improve non-invasive diagnostic accuracy. Future research should include larger, more diverse populations to validate these findings.

Conclusion

This study demonstrates that CT imaging is a reliable tool for differentiating Stage-I Borderline Ovarian Tumors (BOTs) from Malignant Epithelial Ovarian Tumors (MEOTs) based on features such as tumor shape, enhancement patterns, solid components, and septations. Irregular shapes, strong enhancement, and solid components were more common in malignant tumors, while regular shapes and mild enhancement favored BOTs. The high sensitivity (97.26%) and specificity (97.78%) support CT as a valuable preoperative diagnostic modality, particularly when histopathology is delayed or unavailable. However, occasional discrepancies between CT and histopathology highlight the need for complementary diagnostic tools such as MRI, PET/CT, and molecular biomarkers.

Limitations

The study's small sample size (35 patients) and single-center design limit its generalizability, while the lack of long-term follow-up prevents evaluation of diagnostic reliability over time. Exclusively using CT without additional imaging modalities may have constrained diagnostic accuracy, and the absence of histopathological confirmation for all cases may have affected the validity of findings. Limited demographic diversity further restricts applicability to broader populations.

Recommendations

Future research should involve larger, multicenter cohorts to enhance statistical power and patient diversity. Incorporating long-term follow-up would allow assessment of CT's prognostic value, while integrating MRI, PET/CT, and molecular biomarkers could improve diagnostic precision. Standardizing imaging protocols across centers will ensure consistency in interpretation and reporting, ultimately enhancing the clinical utility of CT in ovarian tumor differentiation.

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