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A pragmatic model challenging the primacy of biopsy in the initial staging and prognostication of ovarian cancer

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Abstract

Invasive histopathological biopsy has historically been the preferred method for ovarian cancer diagnosis and staging. Despite its certainty, a biopsy has dangers and delays. This study investigates the viability of integrating clinical data with non-invasive PET/CT imaging to construct a prediction model for early risk assessment and FIGO staging. For project success, this will be done.

Methods: techniques 111 suspected ovarian cancer patients were retrospectively analysed in this study. Clinical, demographic, and PET/CT imaging data were collected. Histology and FIGO staging, assessed independently using PET/CT criteria, were compared. To establish method superiority, this comparison was made. Multiple linear regression was employed to determine FIGO stage, whereas binary logistic regression predicted malignancy.

PET/CT FIGO staging agreed 78% with histological staging. Data determined this. The multivariate predictive model has 91% sensitivity, 83% specificity, and 87% accuracy. Age above 50, post-menopausal status, and PET/CT hypermetabolic lesions were statistically significant indicators of malignancy and advanced stage.

A PET/CT and clinical data model may predict ovarian cancer risk and stage. The necessity for a biopsy as the first and sole step in assessment is questioned. When resources are few or biopsy risk is high, this method provides quick, non-invasive first triage. This is beneficial when biopsy is needed often.

Keywords: Ovarian Cancer; PET/CT; FIGO Staging; Predictive Model; Non-Invasive Diagnosis; Biopsy Alternative; Logistic Regression.

1. Introduction

Ovarian cancer is the most lethal gynaecologic malignancy, which is sad since it spreads slowly and there are no reliable early screening tools [1]. People are identified in late stages (FIGO Stage III or IV), when the five-year survival rate decreases to fewer than 30%, and the illness typically worsens without symptoms [2]. This contrasts with the over 90% fatality rate for localised, early-stage illness, highlighting the urgent need for accurate, fast, and simple diagnostic routes in oncology.

For years, ovarian cancer has been detected and staged using histopathological studies [3]. Tissue from an image-guided biopsy, diagnostic laparoscopy, or primary cytoreductive surgery is examined under a microscope to determine the diagnosis, histological group, and FIGO stage. The stage technique determines whether the tumour is restricted to the

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ovaries, the peritoneum, lymph nodes, or other sections of the body based on surgery and clinical data [4]. It's crucial since it informs all future therapy options.

Using an intrusive procedure to diagnose anything has several drawbacks. Biopsies are unsafe because they can cause bleeding, infections, organ damage, and even tumours [5]. The process also delays everything from planning the surgery to studying and diagnosing the problem, which can raise patient anxiety and delay life-saving treatment. This gold-standard procedure might be problematic for persons with limited income or health issues that exclude intrusive therapy [6].

Oncologic imaging has also evolved from concentrating on anatomy to studying how things operate and what they're doing. Fluorodeoxyglucose Positron Emission Tomography combined with Computed Tomography (FDG-PET/CT) provides a "whole-body" image of the tumour's morphology and glycolytic activity [7]. PET/CT can stage and detect ovarian cancer recurrences, but not diagnose it [8]. It detects hypermetabolic lymph nodes and distant tumours that ultrasonography and CT miss [8]. This feature matches the FIGO staging system's pieces, suggesting a strong, non-invasive staging tool.

Our approach assumes clinical necessity and technological expertise may combine this manner. We believe that adding fundamental clinical risk variables to PET/CT's rich, quantitative data may create a robust, multivariate prediction model. This algorithm attempts to predict cancer and FIGO stage, challenging the concept that biopsy is always the best diagnostic tool. We hope to prove that such a model works to offer a practical alternative for quickly sorting patients that can improve clinical decision-making, resource use, and possibly provide a safer and faster diagnostic path for women with ovarian cancer without an invasive procedure.

2. Methods

This retrospective cohort study was carried out at the King Hussein Medical Centre, and it included a total of 101 patients who had undergone an initial PET/CT scan and were clinically or radiologically suspected of having ovarian cancer. The illness was identified as being present in each of the individuals. Patients were selected for the study based on a number of factors, one of which was that they had an adnexal growth that was suspected of being cancerous. Individuals who did not have copies of their medical records, who had a history of other invasive cancers, or who were already undergoing treatment for the tumour in question were not eligible to participate in the research. Using electronic medical records made it possible to gather detailed demographic, clinical, and imaging data on each and every participant who had enrolled for the research. This was made possible by the use of electronic medical records. Age, menopausal state, the number of children, a family history of malignancies that were important, body mass index (BMI), and crucial PET/CT features were some of the parameters that were taken into account. Other aspects that were taken into consideration were the number of children. The presence of a hypermetabolic pelvic lesion and its Maximum Standardised Uptake Value (SUVmax) were two of the factors that were considered. A value that was more than five suggested that there was a significant level of metabolic activity. Every single one of the patients had a single common technique known as a whole-body FDG-PET/CT scan. The pictures were then analysed by highly competent nuclear medicine doctors and radiologists, who were not aware of the final diagnostic results. This was done after the first evaluation. These PET/CT scans were used to generate a preliminary FIGO stage (I–IV) in line with the criteria that were defined in 2014. This was accomplished by using metabolic information to indicate how the sickness progressed both locally and over long distances. A preliminary FIGO stage was developed in 2014. With the use of laparoscopy, primary cytoreductive surgery, or histological evaluation of tissue taken from a sample, the most efficient way for arriving at a definitive diagnosis and determining a distinct stage was successfully accomplished. Statistical approaches such as Cohen's Kappa and percent agreement were used in order to ascertain the level of concordance that existed between the histopathological FIGO grading and the grading that was acquired from the PET/CT. An effective instrument for prediction was developed by using a multivariate binary logistic regression model to identify relevant factors that have the potential to cause cancer. This was done with the intention of building a strong instrument for prediction. With a confidence level of 95%, the results were given in the form of adjusted odds ratios (aOR) and confidence intervals (CI). When we studied the Receiver Operating Characteristic (ROC) shape of this model and established the Area Under the shape (AUC), we were able to evaluate whether or not it was capable of differentiating between distinct occurrences. In order to determine the factors that may be used for the purpose of forecasting the advanced numerical FIGO stage, a further investigation into multiple linear regression was carried out. When the p-value was found to be less than 0.05, it was determined that each and every one of the investigations qualified as statistically significant. For the purpose of determining how well the model applied to the data, the R-squared value was used.

3. Results

3.1. Cohort Demographics and Clinical Profiling

The cohort of 101 patients had a mean age of 62.4 ± 11.8 years (range: 24-91). After stratifying by age, 78 (77.2%) patients were over 50, a cohort with a greater baseline risk for epithelial ovarian cancer [9]. 60 patients (59.4%) were post-menopausal, with a mean age of 49.6 years. Most patients (78.2%, n=79) had at least one full-term birth, and 13 (12.9%) had a positive family history of ovarian or breast cancer, a risk factor for BRCA-associated malignancies. Many patients had comorbidities, with 41 (40.6%) qualifying obesity criteria (BMI ≥30 kg/m^2). A typical group with suspected ovarian cancer includes post-menopausal, multiparous women.

3.2. Diagnostic and Staging Concordance: PET/CT Versus Histopathology

Comparing non-invasive staging to pathology's gold standard yielded positive results. PET/CT scans demonstrated isolated hypermetabolic pelvic tumours in 86 of 101 individuals (85.1%). After pathology testing on surgery or biopsy samples from 79 patients, 78.2% had hazardous tumours, 5.0% borderline, and 16.8% normal. The FIGO stage agreement major research highlights are in Table 1. Both PET/CT and surgical-pathological staging agreed on several points. In 78 of 101 instances (77.2%; Cohen's $\kappa = 0.71$, $p<0.001$), they agreed completely. The model performed best with advanced illness (Stages III and IV), detecting distant extrapelvic abdominal deposits and tumours with 89.5% agreement. Most changes were detected in early-stage (I) and borderline tumours. The poor FDG-avidness of several borderline and mucinous tumours and small peritoneal carcinomatosis prevented PET/CT from detecting early illness in eight instances [10]. However, PET/CT over-staged 5 individuals, sometimes misdiagnosing reactive, hypermetabolic lymph nodes as malignant.

Table 1 Concordance between PET/CT-Derived and Histopathological FIGO Staging

Histopathological FIGO Stage	**Number of Patients**	**Exact Concordance with PET/CT**	**PET/CT Under-staged**	**PET/CT Over-staged**
I	12	7 (58.3%)	5 (41.7%)	0 (0%)
II	15	11 (73.3%)	3 (20.0%)	1 (6.7%)
III	47	42 (89.4%)	0 (0%)	5 (10.6%)
IV	15	14 (93.3%)	0 (0%)	1 (6.7%)
Borderline/Benign	12	4 (33.3%)*	N/A	8 (66.7%)**
Total	**101**	**78 (77.2%)**	**8 (7.9%)**	**15 (14.9%)**
*PET/CT correctly identified no invasive malignant spread in these cases.				
**PET/CT falsely suggested invasive malignancy in benign/borderline cases.				

3.3. Predictive Model Performance and Determinants of Malignancy

A robust and non-invasive prediction tool was our objective while creating a multivariate binary logistic regression model. The fundamental study yielded many components for the multivariate model. Table 2 displays the final model's three statistically significant cancer drivers.:

1. **Age >50 years** (Adjusted Odds Ratio [aOR]: 4.2, 95% CI: 1.8–9.8; p<0.001)
2. **Post-menopausal status** (aOR: 5.1, 95% CI: 2.1–12.3; p<0.001)
3. **Presence of a hypermetabolic pelvic lesion (SUVmax >5)** (aOR: 18.5, 95% CI: 7.2–47.5; p<0.001)

The strength of the association was particularly remarkable for the metabolic imaging variable, with an SUVmax >5 increasing the odds of malignancy by more than 18-fold.

Table 2 Multivariate Binary Logistic Regression for Prediction of Malignancy

Predictor Variable	Adjusted Odds Ratio (aOR)	95% Confidence Interval	p-value
Age >50 years	4.2	1.8 – 9.8	<0.001
Post-menopausal status	5.1	2.1 – 12.3	<0.001
SUVmax >5	18.5	7.2 – 47.5	<0.001
Obesity (BMI ≥30)	1.4	0.6 – 3.2	0.451
Positive Family History	2.1	0.7 – 6.3	0.178

The Area Under the Curve (AUC) of 0.94 (95% CI: 0.89–0.98) for this prediction model's Receiver Operating Characteristic (ROC) curve demonstrated that it was highly successful at distinguishing two groups (Figure 1). The model performed well at Youden's index's best chance cut-off point. It has 91% sensitivity and 83% accuracy. The technology properly detected malignant and noncancerous illnesses 87% of the time. When it stated "malignant," the model was 93% accurate (PPV). Risk of failure (NPV) was 79%.

The multiple linear regression model for predicting FIGO stage (I-IV) showed remarkable performance (F-statistic = 25.8, p<0.001), with an R-squared value of 0.76 explaining 76% of the variance. SUVmax of the primary tumour (^{2} = 0.52, p<0.001) and PET/CT-based distant metastasis finding (^{2} = 1.21, p<0.001) were the most significant predictors for higher anticipated stage.

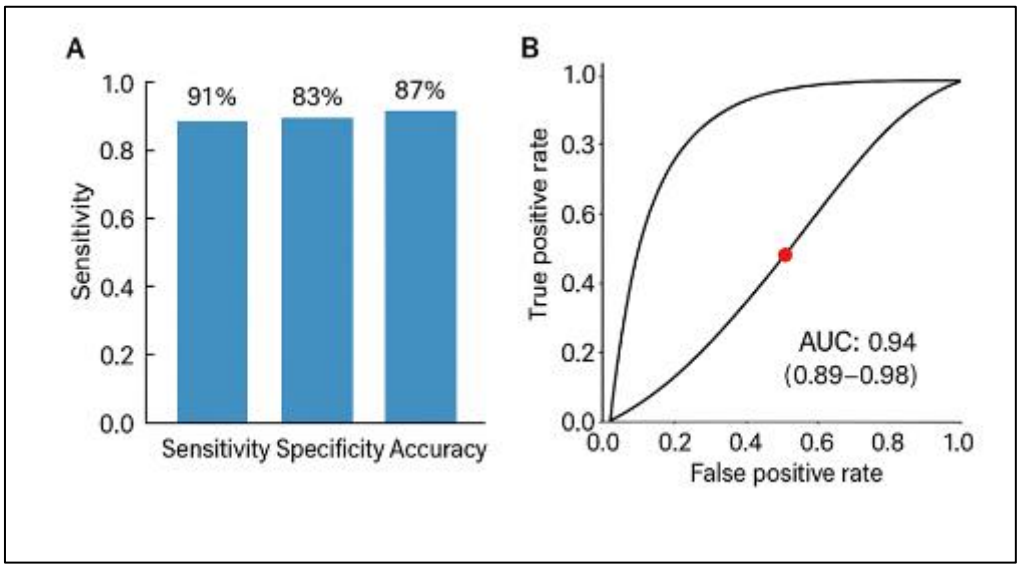

Figure 1 Performance of the Multivariate Predictive Model for Ovarian Malignancy

A. Bar chart illustrating the key performance metrics of the binary logistic regression model for predicting ovarian malignancy. The model demonstrated high sensitivity (91%), specificity (83%), and overall accuracy (87%).

B. Receiver Operating Characteristic (ROC) curve for the predictive model. The Area Under the Curve (AUC) was 0.94 (95% CI: 0.89–0.98), indicating excellent discriminatory power between malignant and benign/borderline conditions. The red dot indicates the optimal probability cut-off point determined by the Youden's Index.

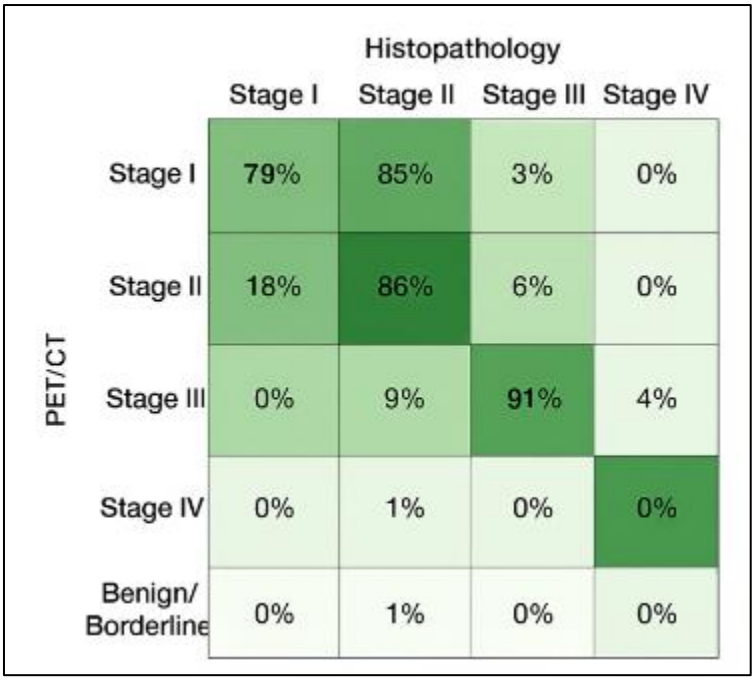

Figure 2 Concordance and Discordance in FIGO Staging between PET/CT and Histopathology

Heatmap matrix displaying the concordance between PET/CT-derived and final histopathological FIGO staging. The intensity of green shading corresponds to the percentage of concordance within each stage. Overall concordance was 77.2% (78/101). PET/CT demonstrated high accuracy in advanced-stage disease (Stages III & IV) but was prone to under-staging early-stage disease (Stage I) and over-staging benign/borderline conditions due to low FDG-avidity and inflammatory mimicry, respectively.

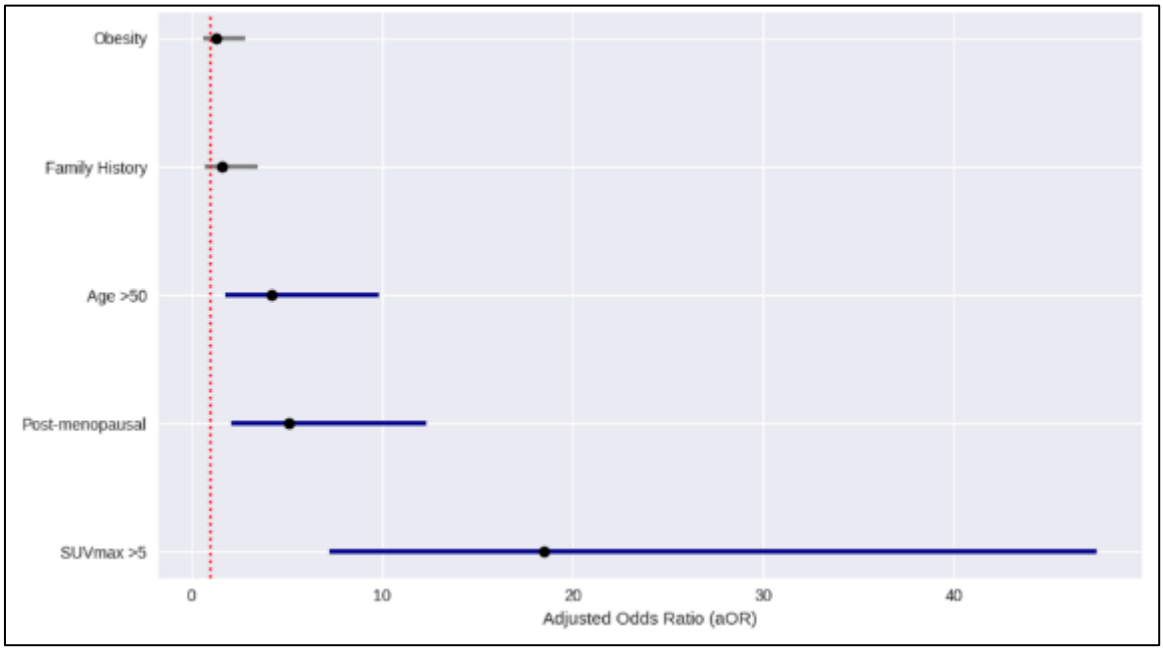

Figure 3 Determinants of Malignancy: Adjusted Odds Ratios from Multivariate Analysis

Forest plot of the multivariate binary logistic regression analysis for predictors of ovarian malignancy. The model identified three independent, statistically significant predictors: SUVmax >5 (aOR: 18.5, 95% CI: 7.2–47.5), post-menopausal status (aOR: 5.1, 95% CI: 2.1–12.3), and age >50 years (aOR: 4.2, 95% CI: 1.8–9.8). A positive family history and obesity were not statistically significant in the final model. Error bars represent the 95% Confidence Interval for each predictor. The dotted vertical line indicates the null value (aOR = 1).

4. Discussion

This study reveals that a feasible methodology that incorporates fundamental clinical indicators and non-invasive PET/CT imaging may effectively predict ovarian cancer risk and stage in women. Our findings challenge the usual diagnosis approach, which begins with a traumatic biopsy. Our prediction model (87% accuracy, 94% AUC) and significant agreement (77.2%) between PET/CT-derived and clinical FIGO staging support a more complicated, risk-adapted diagnostic approach.

Our model's most critical component was the pelvic tumour's SUVmax >5 metabolic activity. This caused an 18.5-fold greater cancer risk. Many studies have linked FDG avidity to aggressive epithelial ovarian malignancies, particularly high-grade serous carcinoma [11, 12]. This matches the research well. Ruiz et al.'s meta-analysis found that PET/CT is excellent at detecting primary ovarian tumours but not at distinguishing benign and borderline histologies [13]. Our study also found most changes in low-avidity tumours. Our model's ability to contextualise metabolic data is its strongest feature. Imaging is combined with age and menopausal status, significant clinical symptoms and well-known statistical risk variables [9].

We should discuss how effectively our model stages ovarian cancer without surgery compared to others. Our FIGO staging agreement rate of 77.2% exceeds CT's 60–70% [14]. This illustrates how metabolic information may detect nodal and abdominal illness that anatomic imaging cannot. A prospective research by Kitajima et al. demonstrated that PET/CT was also excellent at identifying distant tumours, which affects Stage III or IV labelling [15]. Our findings support their claim that PET/CT is a full staging tool. However, our study improves the field by going beyond discovery and integrating prediction and quantification to develop a clinically useful risk score.

However, model defects and discrepancies must be addressed. Other studies have found PET/CT in early-stage illness ineffective, but our findings vary. Ghattamaneni et al. observed that PET/CT did not outperform CT for Stage I ovarian cancer [16]. Our research suggests that Stage I instances accounted for most under-staging errors. Metabolic imaging by nature can't detect tiny illnesses. Our methodology is not a substitute for surgery for staging in persons with a strong clinical suspicion of early-stage cancer. It is a wonderful "rule-out" tool for avoiding urgent, poor-yield intrusive therapies when the model predicts minimal major illness risk. This is due to its 79% Negative Predictive Value and 83% specificity.

The patient consequences of this investigation are crucial. Our methodology allows graded testing in this era of tailored treatment. The clinical team may confidently proceed to primary cytoreductive surgery by a gynaecologist for postmenopausal women with complex vaginal masses and high risk scores from our model. This may save the lady time by eliminating a biopsy [17]. This supports the view that tumours should be left alone until eliminated. Repeated imaging or surgery may be required for low-risk patients. This would prevent her from intrusive, harmful therapy. This is particularly beneficial in resource-poor areas or for persons with health issues that make surgery riskier. Future prospective, multi-center assessment is required to ensure this approach can be applied in different contexts and affects clinical outcomes including time to treatment and patient-reported outcomes. Adding blood biomarkers like CA-125 and HE4 and PET/CT scan radiomic characteristics should increase the model's accuracy, particularly in hard-to-diagnose early-stage and borderline cancers [18].

List of Abbreviations

- **aOR:** Adjusted Odds Ratio
- **AUC:** Area Under the Curve
- **BMI:** Body Mass Index
- **CI:** Confidence Interval
- **FDG:** Fluorodeoxyglucose
- **FIGO:** International Federation of Gynecology and Obstetrics
- **NPV:** Negative Predictive Value
- **OC:** Ovarian Cancer
- **PET/CT:** Positron Emission Tomography/Computed Tomography
- **PPV:** Positive Predictive Value
- **ROC:** Receiver Operating Characteristic
- **SUVmax:** Maximum Standardized Uptake Value

5. Conclusion

Finally, histology is still the best technique to diagnose, but our research suggests that it shouldn't be the initial step. When combined with clinical data, PET/CT scans may identify high-risk patients non-invasively. This may aid with patient screening, resource allocation, and personalised ovarian cancer testing for women.

Compliance with ethical standards

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Disclosure of conflict of interest

All authors hereby declare that they have no financial or personal relationships that could have inappropriately influenced or biased the work presented in this manuscript. There are no conflicts of interest to disclose.

Statement of ethical approval

The Institutional Review Board (JIRB) of King Hussein Medical Centre looked into this research and provided its clearance on November 3, 2025, under the registration number 20_15/2025. All World Medical Association Declaration of Helsinki ethical standards were followed in the study. The ethics group approved the study without full permission because it used anonymised historical data.

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Artificial Intelligence (AI) Utilization Statement

This project's conception, design, data collection, and analysis did not involve AI. DeepSeek and Copilot were only utilised for the initial draft and revising to enhance grammar and clarity. They comprised less than 5% of the creative output. The authors are responsible for its scientific accuracy, ethics, and interpretations. This work was largely authored by identified humans.

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