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"MODERN METHODOLOGIES OF SCORING SYSTEMS FOR ULTRASOUND DIAGNOSIS OF OVARIAN CANCER: DIFFERENTIATION AND PROGNOSIS"

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Abstract: Ovarian cancer remains a significant public health concern, owing to its high mortality rate and propensity for recurrence. Although improvements in screening and diagnostic methods have been made, the disease frequently goes undetected until advanced stages, where the prognosis is unfavorable. This study aims to improve the differentiation of ovarian masses through ultrasound imaging and advanced assessment techniques. The study analyzed data from 121 patients with histologically confirmed ovarian tumors, using both transvaginal and transabdominal ultrasound techniques. Logistic regression models and machine learning algorithms were utilized to analyze the multidimensional ultrasound data with the aim of enhancing the accuracy of differentiating between benign and malignant tumors.

Results: The implementation of a scoring system to evaluate ultrasound findings in conjunction with logistic regression modeling significantly improved diagnostic accuracy. The predictive model developed utilizes morphological characteristics such as size, shape, echogenicity, and vascularization to accurately predict malignancy risk with a high degree of accuracy. Analysis of the ROC curve confirmed the effectiveness of the model with sensitivity, specificity, and accuracy exceeding 92%.

Conclusion: This study emphasizes the importance of incorporating machine learning techniques into ultrasound imaging to improve the diagnosis of ovarian tumors. Despite ongoing difficulties in early cancer detection, using advanced assessment and predictive models is a significant advance in the field of ultrasound imaging for ovarian neoplasia. This could lead to better outcomes for patients by providing earlier and more accurate diagnoses.

Keywords: Ovarian neoplasm assessment, ultrasound imaging, diagnostic criteria, logistic regression analysis, medical imaging machine learning.

Ovarian cancer continues to be one of the most significant challenges in public health due to its high mortality rate and frequent recurrence. Over the last three decades, researchers have made numerous attempts to develop an ultrasound-based predictive model for assessing tumor progression, sensitivity to treatment, and overall survival.

However, the lack of awareness among general practitioners and gynecologists about ovarian cancer leads to its frequent diagnosis in late stages, with a 5-year survival rate of only 17%. Although screening programs exist, they have not significantly increased the frequency of early

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ovarian cancer detection. Therefore, the development of an accurate and convenient algorithm for identifying the risk of ovarian cancer is a crucial task.
Due to the rapid progression of ovarian tumors in stages III and IV, approximately 60-70% of patients are diagnosed at the initial stage of treatment. One way to combat this issue is to improve ultrasound diagnostic methods. Accurate ultrasound imaging of the ovaries is crucial because most tumors are detected through ultrasound. Therefore, it is essential to develop strategies to minimize discrepancies between ultrasound findings and histological results, as well as reduce the number of false positives and false negatives. To prevent errors, scoring protocols based on morphological features have been developed. Improving the accuracy and efficiency of ultrasound scoring can reduce the need for further studies and provide more precise diagnostic results.
In recent years, scientists have been working hard to develop effective screening programs for detecting ovarian tumors. These programs are designed for ultrasound diagnostic specialists of different levels of experience. Ultrasound systems used to evaluate ovarian tumors play an important role in the diagnosis and treatment of this condition, allowing doctors to categorize tumors as benign, malignant, or of medium risk based on their ultrasound features. The main assessment systems used are presented below.
IOTA System (International Ovarian Tumor Analysis):
IOTA uses a simple set of rules to classify tumors based on specific ultrasound features, such as the presence of solid masses, multiple internal partitions, fluid accumulation, and abnormal blood flow patterns.
The ADNEX model helps distinguish between benign and malignant tumors, as well as between epithelial and non-epithelial tumors, by analyzing ultrasound images and clinical data such as age and CA-125 levels.
RMI (Malignancy Risk Index) System:
This system evaluates the risk of ovarian cancer based on ultrasound findings, CA-125 levels, and menopausal status. High RMI values indicate a higher risk of malignancy.
O-RADS (Ovarian-Appendage Health Reporting and Data Standardization):
Developed by the American College of Radiology, O-RADS standardizes the reporting and interpretation of ovarian and appendage ultrasound findings on a scale of 0-5, with each level indicating a different level of risk for ovarian cancer. These techniques significantly improve the accuracy of diagnosing ovarian tumors and help doctors make informed decisions about whether further examination, surgery, or follow-up is needed. However, despite these advances, the mortality rate for ovarian cancer remains high. This emphasizes the importance of ongoing research into this disease.
Objective: To improve the accuracy of ovarian tumor diagnosis using logistic regression analysis and optimize the scoring system for evaluating multiparameter ultrasound data.
Materials and methods: The present study is based on the results of ultrasonography performed in 121 women with histologically verified ovarian tumors, including 70 patients with benign tumors and 51 with malignant neoplasms, aged 16 to 74 years, 68 women were in reproductive status, 53 in the postmenopausal period. Comprehensive ultrasound examination included seroscale echography, pulse-wave Doplerography and energy Doppler mapping.
The use of a transvaginal sensor makes it possible to more accurately visualize the presence, localization and structure of ovarian neoplasms in 60-85% of cases. However, this method has limitations when evaluating large tumors or ovarian formations located above the uterus, since its maximum penetration depth is 8-9 cm.

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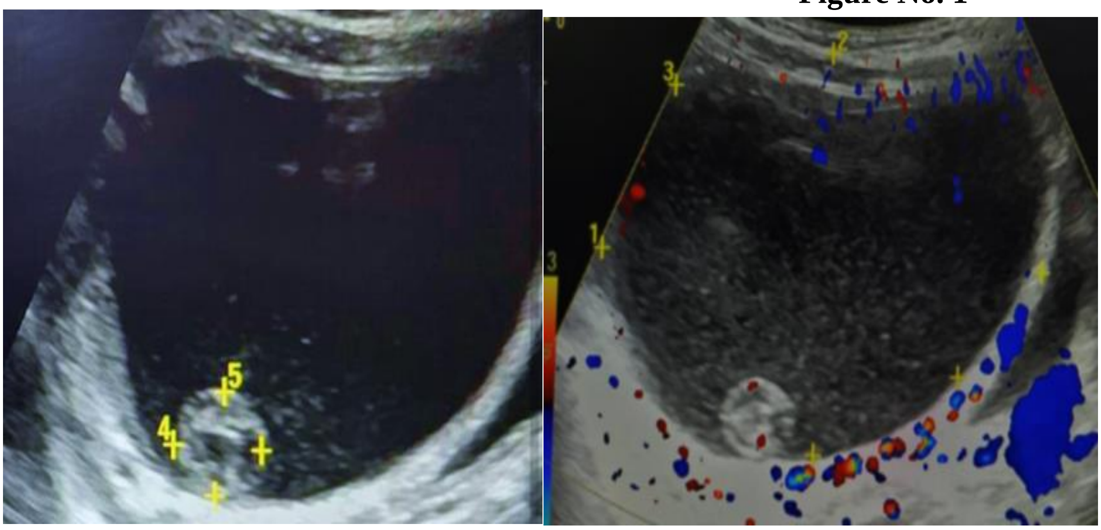
In this regard, ultrasound examinations were performed on the Aplio 500 device using an intracavitary sensor with a frequency of 6.0 MHz for transvaginal examination of the pelvis and a convex sensor with a frequency of 3.75 MHz for transabdominal examination of the abdominal cavity. A standard diagnosis of the abdominal cavity was performed. Before the examination, the bladder of the patients was moderately filled. For full access to the lower abdomen, the patients were placed on their backs, and, if necessary, a thorough scan of the pelvic organs and abdominal cavity was performed. During the examination, the size of the uterus and both ovaries were recorded, as well as any neoplasms in the ovaries or other pelvic organs were detected. The size, shape, boundaries of neoplasms, their relation to surrounding tissues, internal echo structure and blood supply to the tumor were also recorded.
In the analysis of echography data, along with traditional visual image recognition, an improved method of scoring (rating) evaluation of echo signs was used. To classify the risk inherent in various formations, we performed an analysis of prospectively collected patient data using Kruskal-Wallace statistics, a multicollinearity test, a matrix (heat map) of Pearson pair correlation coefficients, as well as multiple logistic regression with the selection of significant, but not multicollinear echo signs. Hypothesis testing, evaluation of the parameters of probabilistic models obtained on the basis of sample data was carried out using the Valda statistical test.
The reference method was a pathohistological examination of tumor tissue samples taken during surgery. Pathohistological examination of tumor tissue samples was carried out in the pathomorphological department of the Republican oncological scientific center of the Republic of Uzbekistan

Figure No. 1



During the ultrasound examination, a unilocular, anechoic, rounded formation with a solid component was visualized in the left ovary. The formation had a diameter of 3 mm and measured 6.7 x 3.2 cm with a wall thickness of 3.4 mm. Doplerography showed an increase in vascularization along the periphery and a single locus in the solid component. IR with pulse-wave Doppler was 0.58. A histologic examination confirmed the diagnosis of serous cystadenocarcinoma.

Table No. 1
Scoring ultrasound scale of ovarian neoplasms

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N	Features	Score
1	Localization	
	One-sided	0
	Double-sided	1
2	**Shape**	
	outlined shape	0
	Irregular	1
3	Size	
	≤ 50 мм	0
	>50мм≤100 мм	1
	>100 мм	2
4	**Echostucture**	
	1.Single or multilocular cystic formation without a solid component	0
	2. Single or multilocular cystic formation with a solid component	1
	3.Single or multilocular cystic formation with a predominance of solid component or an entirely solid tumor	2
5	Echogenicity	
	Anechoic	0
	Hypoechoic	1
	Mixed	2
6	**Structure of the inner wall**	
	Absence of papillary growths	0
	Papillary <3mm	1
	Papillary > 3mm	2
7	Wall thickness	
	Less than ≤ 3 mm	0
	More than >3 mm	1
	Not applicable (more often in solid lesions)	2
8	Septations	

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	None	0
	Thinner≤ 3mm	1
	Thicker >3 mm	2
9	Ascites	
	Absent	0
	Availability	1
	IR	
	>0.6	0
10	<0.6 >0.4	1
	≤ 0.4	
	PI	
11	Above 1.0	0
	Below 1.0	1
12	Color rating	
	Lack of blood flow	0
	Blood flow only in the periphery	1
	Blood flow in the center is single	2
	The blood flow in the center is massive	3

Results: It was found that the ultrasound images of ovarian tumors often overlap in terms of echo graphic signs, making it difficult to predict the morphological class of a visualized formation based on visual analysis alone. This limits the accuracy of predicting the nature of ovarian tumors.
In this regard, we have developed a logistic model for predicting the benign or malignant nature of ovarian formations using a multiparametric regression analysis of echo signs, pre-graded by a semi-quantitative method on a point scale .
Correlation matrix of ultrasonographic signs and parameters of nature-dependent ovarian formations (n=121)
The model is constructed using machine learning, a prerequisite for which is the selection of the most significant (relevant), but less interdependent (non-collinear) echo signs from the entire analyzed list of echo signs as predictors of the constructed model. To select such echo signatures, the Wrapper backward selection features, the most commonly used wrapping method in machine learning, is used.

Figure No. 2

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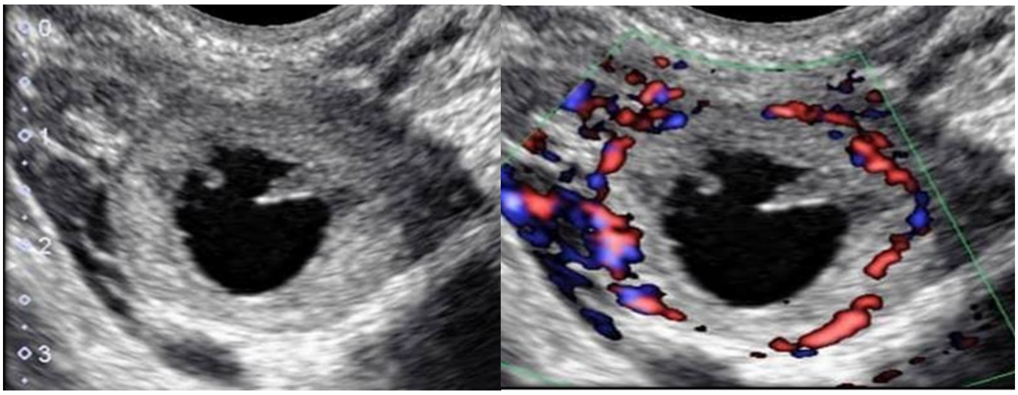
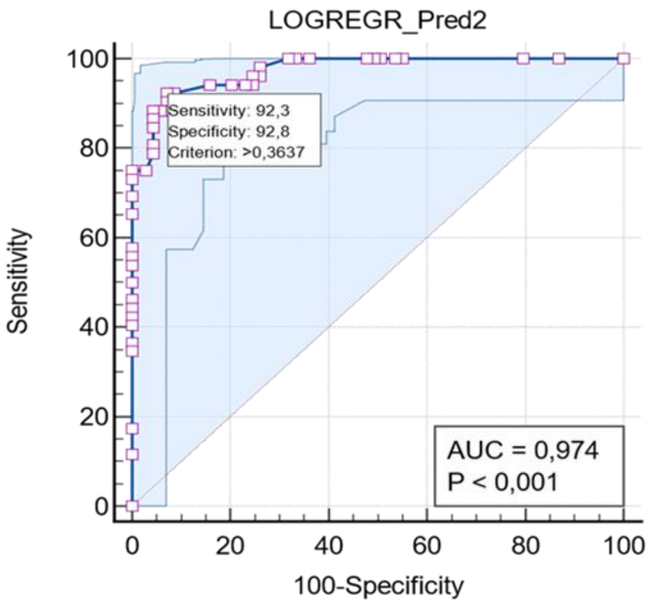


During ultrasound examination in B mode, a unilocular anechoic rounded formation with papillary outgrowths 3.5 mm in diameter is visualized in the left ovary, the size of the formation is 4.7 x 3.2 cm, with a wall thickness of 5.5 mm, increased peripheral vascularization is noted during doplerography, and the pulse-wave Doppler is 0.6. Histologically, a cyst of the corpus luteum was verified.

As a result, four echo signs were selected as predictors of the model: size, shape of formation, presence and thickness of papillary outgrowths, degree of vascularization according to energy Doppler mapping. The adequacy of the selected predictors was c RH-curves predicting the benign or malignant nature of ovarian formations by non-collinear echographic signsonfirmed by the Wald method and the correlation matrix.

Figure No. 3

RH-curves predicting the benign or malignant nature of ovarian formations by non-collinear echographic signs



y= 1/ (1+ exp (- (-7.4+ 1.8 * x1 + 1.2* x2+2.5*x3+2.2*x4)))

where: y is the malignancy index of the formation (derived model);

x1 is the size of the education;

x2 – the presence and thickness of papillary outgrowths;

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x3 is a form of education;
x4 is the degree of vascularization (EDC).

The effectiveness of the constructed model was evaluated by ROC analysis with the construction of a curve of dependence of true-positive and false-negative results, which showed high sensitivity (92.3%), specificity (92.8%) and accuracy (92.6%), with AUC=0.974±0.011(P <0.0001).The threshold value of the malignancy index in the discrimination of malignant from benign tumors was determined, which was >0.364 (with a range of malignancy index from 0 to 1)

Discussion

The present study highlights significant improvements in the field of ultrasound differential diagnosis of ovarian tumors, provided by the use of modern scoring systems and statistical analysis. Despite significant advances in ultrasound diagnostics, it is important to emphasize that early detection and accurate classification of tumors remain critical aspects for improving the prognosis and treatment planning of ovarian cancer.

The integration of machine learning into ultrasound diagnostics has allowed the development of predictive models that significantly increase the accuracy of the identification of malignant neoplasms. These models, based on the analysis of a variety of parameters such as shape, size, echogenicity and vascularization, help doctors make more informed clinical decisions.

Assessment systems such as IOTA and RMI demonstrate their effectiveness in classifying and assessing the risk of tumors. However, the results of our study also indicate the need for further improvement of these systems in order to minimize the number of false positive and false negative diagnoses, which is critically important for optimizing therapeutic approaches.

The limitations of existing diagnostic techniques, especially in the assessment of large tumors or tumors located in areas difficult to scan, emphasize the need for continuous technological development and adaptation of clinical protocols.

The development of new ultrasound technologies and techniques should focus on improving the visualization and quantification of tumor formations, which will contribute to earlier detection of the disease and, as a result, better treatment results. In addition, it is important to continue research in the field of machine learning in order to further refine the criteria and parameters used to train predictive models, taking into account the variety of clinical manifestations and characteristics of ovarian tumors.

The conclusion of this study shows that ultrasound in combination with advanced analytical methods can significantly improve the accuracy of diagnosis of ovarian tumors. However, it should be recognized that in order to achieve optimal accuracy and specificity, further study and development of techniques are necessary, which will be the subject of future research in this area.

Conclusions:

1. The use of reverse wrapping (backward or forward) predictor selection technology ensures the adequacy of the ultrasound scoring model of differentiation of benign and malignant ovarian tumors constructed by machine learning;

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2. The developed ultrasonic scoring model allows predicting the probability of a benign or malignant nature of the formation with a sensitivity of 92.3%, a specificity of 93.8% and an accuracy of 92.5%;

3. In addition to the visual assessment of echograms, the malignancy index calculated using the scoring model equation makes it possible, focusing on the established discriminatory threshold, to determine the nature of the formation with high accuracy (92.6%), thereby predetermining therapeutic tactics.

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