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Risk Factors for Cardiopulmonary Complications in Surgeries for Benign Ovarian Tumors

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Abstract

Background: In recent years, advances in medical care have improved surgical outcomes in elderly patients with comorbidities, particularly in elective surgeries for non-malignant conditions. Assessing risk factors is crucial for enhancing safety in older patients undergoing surgery for benign ovarian cysts (BOC), given the increased potential for postoperative complications. This study aimed to identify key predictors of postoperative non-surgical complications in patients over 65 and to assess the incidence of these predictors, focusing on cardiorespiratory events.

Methods and Results: This retrospective study included 288 female patients aged ≥65 and under 65 who underwent elective surgery for benign ovarian cyst removal at a single clinical center. The primary outcome was the incidence of cardiorespiratory complications (CRC), with predictive factors such as obesity, hypertension, and age analyzed through univariate and multivariate models. The study utilized a Random Forest model to assess the predictive value of these risk factors and compared the predicted risk with observed complication rates to evaluate model accuracy. Calibration and complication odds ratios were computed to establish the significance of predictive variables.

Among the studied patients, obesity and hypertension emerged as significant independent predictors of postoperative CRC, while age alone did not contribute significantly to risk. Cardiorespiratory complications, including pneumonia, respiratory failure, arrhythmias, and hypertensive crises, were recorded in 8.7% of patients. The Random Forest model confirmed obesity and hypertension had a greater influence than age as determinants of complication risk, suggesting that comorbid conditions substantially increase postoperative risks.

Conclusion: This study highlights the importance of comorbidities, particularly obesity and hypertension, as primary predictors of postoperative complications in elderly patients undergoing surgery for BOC. Age alone was not a significant risk factor, indicating that tailored management of comorbid conditions may better mitigate postoperative risks than focusing on age as an isolated factor.(**International Journal of Biomedicine. 2024;15(1):150-154.**)

Keywords: benign ovarian cysts • cardiorespiratory complications • risk assessment • comorbidities

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Abbreviations

ACS, acute coronary syndrome; **ARDS**, acute respiratory distress syndrome; **CRC**, cardiorespiratory complications; **BOC**, benign ovarian cysts; **PE**, pulmonary embolism.

Introduction

Ovarian neoplasms are among the most prevalent gynecological conditions and are considered one of the most common pathologies affecting the female reproductive system. The structure of ovarian tumors varies depending on the age group of the patients. In women of reproductive age, benign neoplasms are predominant, whereas in the postmenopausal period, there is a significant increase in the proportion of malignant tumors.[1] Benign neoplasms

constitute 75%-80% of ovarian tumors.[2] These neoplasms often develop asymptomatically and remain undetected in the early stages. However, some may present complications requiring emergency surgical intervention, underscoring the importance of timely diagnosis and surgical treatment when clinical indications are present. In certain cases, non-surgical complications may develop in patients after cyst removal, most frequently involving the cardiovascular and respiratory systems. The most common complications include arrhythmias, angina attacks, hypertensive crisis, pneumonia, and respiratory distress syndrome.[3] The occurrence of these complications increases the burden on the healthcare system, prolongs hospitalization, and, in certain cases, may lead to fatal outcomes. This underscores the need to identify significant factors influencing the development of this group of complications. This study aimed to assess the incidence and structure of postoperative non-surgical complications in patients over 65 years of age who underwent elective surgery for ovarian cysts.

Materials and Methods

This study is a retrospective data analysis from 288 female patients with benign cystic ovarian neoplasms who underwent surgical treatment in the Gynecology Department from January 1, 2022, to January 1, 2023.

Non-surgical complications were categorized as respiratory complications and cardiovascular complications.

Respiratory complications were stratified as follows:

- Atelectasis of pulmonary parenchyma, identified via radiographic findings.

- Pneumonia, defined by criteria that include a new or progressive and persistent infiltrate, consolidation, or cavitation detected on chest radiographs, with at least one of the following: fever (>38°C) without other recognized causes; leukopenia (WBC count of less than 4×10^9/L) or leukocytosis (WBC count of more than 12×10^9/L); for patients over 70, altered mental status along with purulent sputum or changes in sputum characteristics, increased respiratory secretions or need for suctioning; new or worsening symptoms (dyspnea, tachypnea, etc.) or clinical signs (rales, bronchial breath sounds, etc.).

- Acute respiratory distress syndrome (ARDS).

- Prolonged mechanical ventilation for more than 48 hours.

- Pleural effusion requiring pleural puncture.

Cardiovascular complications were stratified as follows:

-Clinically significant arrhythmias requiring pharmacologic cardioversion or electrical cardioversion.

- Acute coronary syndrome (ACS), identified by ECG findings and confirmed by biochemical tests.

- Hypertensive crisis, defined by a significant elevation in blood pressure (SBP ≥180 mmHg and/or DBP ≥120 mmHg) accompanied by acute symptoms of target organ (heart, brain, kidneys) damage or general deterioration.

- Pulmonary embolism, diagnosed based on clinical presentation (acute onset of dyspnea, chest pain, tachycardia), a high Wells score, and confirmation of pulmonary embolism through instrumental methods.

Inclusion criteria included BOC patients of any age who underwent elective surgical treatment without concomitant infectious pathology.

Exclusion criteria included emergency interventions, confirmed ovarian cancer, and incomplete clinical data in medical records.

Patients were divided into two age groups to ensure accurate assessment: those aged 65 and older and those under 65. Data were collected according to a developed protocol, encompassing various patient variables. Clinical, laboratory, and surgical parameters of the women under study were evaluated.

Statistical analysis

Statistical analysis was conducted using StatTech v. 4.5.0 (StatTech LLC, Russia). Baseline characteristics were summarized as frequencies and percentages. For descriptive analysis, results are presented as median (Me), first quartile (Q1), and third quartile (Q3). The 95% confidence intervals (CI) for percentages were calculated using the Clopper-Pearson method. Group comparisons with respect to categorical variables are performed using chi-square tests or, alternatively, Fisher's exact test when expected cell counts were less than 10. A P-value of <0.05 was considered statistically significant.

A predictive model for the probability of specific outcomes was developed using logistic regression. Nagelkerke's R^2 coefficient served as a measure of certainty, indicating the portion of variance explained by the logistic regression model.

Data Splitting and Machine Learning Model: Machine learning methods were employed to build the predictive model. The dataset was divided into training and test sets in an 80/20 ratio. The training set was used to train the model, while the test set was used to evaluate its predictive accuracy. The Random Forest model was chosen for data analysis.

The model was trained on the training dataset using the following hyperparameters:

- Number of trees (n_estimators)

- Maximum tree depth (max_depth)

- Minimum samples required to split a node (min_samples_split)

- Minimum samples required in a leaf node (min_samples_leaf)

- Class weight balancing (class_weight) — to address the imbalance between the number of patients with and without complications.

The model was trained on the training data and then tested on the test set to evaluate prediction accuracy. Metrics used to assess the model included accuracy, recall, precision, and F1-score.

Feature Importance Evaluation: After training, the importance of each feature was assessed to determine the contribution of each factor to outcome predictions. Feature importance was calculated based on each parameter's contribution to reducing model error, providing insights into which variables are most significant for predicting complications.

Data analysis and construction of the machine learning model were performed in the Python programming

environment within Jupyter Notebook. The Random Forest model was implemented using the scikit-learn library, data processing was handled with pandas, and visualizations were created using matplotlib.

Results

A univariate analysis was conducted to assess the frequency of non-surgical complications based on clinical and laboratory data. Additionally, the impact of surgical parameters, such as operation time, blood loss volume, and type of surgical access, was analyzed. The results of this analysis are presented in Tables 1 and 2.

Table 1.

Frequency of CRC by the clinical and laboratory data of patients.

Indicators	Cardiorespiratory complications		*P*-value
	CRC-	CRC+	
Age,years, Me [IQR]	43.00[32.00;57.00]	57.00[52.00;64.00]	<0.001
Under 65 years	234(93.2%)	17(6.8%)	0.048
Over 65 years	31(83.8%)	6(16.2%)	
BMI, Me [IQR]	25.95[22.86;30.22]	32.46[27.11;34.44]	<0.001
MD,years, Me [IQR]	0.00[0.00;7.00]	6.00[1.00;16.00]	<0.001
TLI, Me [IQR]	127.60[113.87;138.86]	131.38[123.35;145.04]	0.124
NLI, Me [IQR]	3.98[3.36;4.47]	3.84[3.29;4.17]	0.279
LII, Me [IQR]	1.51[1.21;1.76]	1.62[1.27;1.81]	0.480
SD,min, Me [IQR]	35.00[25.00;45.00]	35.00[30.00;37.50]	0.947
BL,mL, Me [IQR]	20.00[15.00;40.00]	25.00[20.00;50.00]	0.198
LOS,days, Me [IQR]	6.00[4.00;7.00]	6.00[5.00;7.00]	0.074
Laparoscopy	236(92.5%)	29(87.9%)	0.352
Laparotomy	19(7.5%)	4(12.1%)	

BMI, body mass index; MD, menopause duration; TLI, Thrombocyte-Leukocyte Index; NLI, Neutrophil-Lymphocyte Index; LII, Leukocyte Intoxication Index; SD, surgery duration; BL, blood loss; LOS, length of hospital stay.

Table 2.

Frequency of CRC based on comorbid conditions.

Indicators	Categories	Cardiorespiratory complications		*P*-value
		CRC-	CRC+	
Hypertension	Absence of Hypertension	189(71.3%)	6(26%)	<0.001
	Presence of Hypertension	76(28.7%)	17(74%)	
Diabetes	Absence of Diabetes	251(94.7%)	21(91.3%)	0.493
	Presence of Diabetes	14 (5.3%)	2(8.7%)	
Obesity	Absence of Obesity	198(74.7%)	8(34.8%)	<0.001
	Presence of Obesity	67(25.3%)	15(65.2%)	

Univariate analysis found that patients' surgical parameters did not influence the occurrence of non-surgical complications. The patients' age had a statistically significant impact on the frequency of non-surgical complications (*P*=0.048), OR=2.664; (95% CI: 0.977–7.266).

Hypertension and obesity had a statistically significant impact on the occurrence of non-surgical complications (*P*<0.001), with OR=7.046 (95% CI: 2.676 – 18.551) and OR=5.541 (95% CI: 2.249 – 13.652), respectively. In contrast, the presence of diabetes mellitus was not statistically significant (*P*=0.493), with OR=1.707 (95% CI: 0.363 – 8.021).

Cardiorespiratory complications were stratified according to the Clavien-Dindo classification. Type I complications were not recorded due to their low clinical significance and were excluded from the analysis. The stratification results are presented in Table 3.

Table 3.

Structure of cardiorespiratory complications.

Type of Complication		n	(%)
Minor Complications			
Grade II	Pneumonia	3	13.0
	Arrhythmia requiring pharmacologic correction	4	17.5
	Angina attack requiring pharmacologic correction	3	13.0
Major Complications			
Grade IIIA	Pleural effusion (requiring pleural puncture)	3	13.0
Grade IIIB	Cardiac arrhythmia requiring cardioversion by electrical stimulation	2	8.7
	ACS without hemodynamic instability requiring invasive treatment	1	4.35
Grade IVA	ACS with hemodynamic instability	2	8.7
	Acute respiratory failure managed with oxygen therapy	1	4.35
	ARDS	1	4.35
Grade IVB	Severe pneumonia requiring mechanical ventilation	1	4.35
	Respiratory failure with heart failure	1	4.35
Grade V	PE	1	4.35
Total		23	100

It is known that univariate analysis does not account for interactions between variables and their combined influence on outcomes. This limitation can lead to an incomplete assessment of study results and may mask complex interrelationships among patient-related factors. Therefore, multivariate analysis methods are necessary to make accurate predictions. Machine learning methods were employed to address complex dependencies between variables and improve outcome prediction. The Random Forest model was selected for its ability to handle nonlinear dependencies and account for variable interactions.

This model was used to predict the development of non-surgical complications, considering factors such as operation time, blood loss volume, age, presence of obesity, diabetes mellitus, and hypertension. One key step was splitting the data

into training and test sets to train the model on a portion of the data and assess its accuracy on independent observations.

The following table presents the results of the multivariate logistic regression, analyzing the influence of various factors on the probability of developing non-surgical complications. Table 4 provides the regression coefficients for each factor, confidence intervals (95% CI), and *P*-values, enabling the assessment of the significance of these factors.

Table 4.

Results of multivariate logistic regression.

Variable	Coefficient	95% CI	*P*-value
Over 65 years	0.404	-0.722 - 1.530	0,481
Diabetes	-0.427	-2.119 - 1.263	0.619
Obesity	1.339	0.360 - 2.317	0.007
Hypertension	1.456	0.382 - 2.530	0.007
Duration of surgery	-0.002	-0.0393 - 0.035	0.912
Surgical access	0.183	-1.255 - 1.622	0.802
Blood loss	-0.0008	-0.017 - 0.015	0.916

The most significant factors influencing the development of complications were obesity and hypertension, as indicated by their positive coefficients and *P*-values <0.05. Other factors, such as age, diabetes mellitus, operation duration, type of access, and blood loss volume, did not significantly impact complications, as evidenced by high p-values and coefficients close to zero.

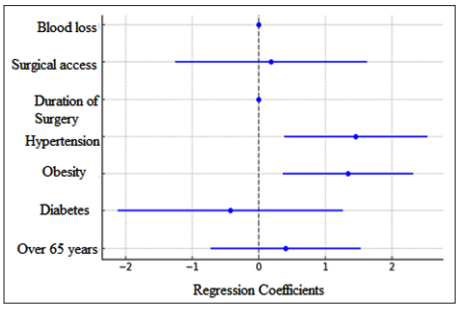

Fig. 1. *Regression Coefficients and Confidence Intervals (Forest Plot).*

The Forest Plot visually illustrates the influence of various factors on the likelihood of developing non-surgical complications. Significant variables include obesity and hypertension, both of which display positive regression coefficients, indicating an increased risk of complications for patients with these factors. In contrast, age over 65, diabetes mellitus, operation duration, and blood loss volume did not demonstrate statistically significant effects on the risk of complications, as their confidence intervals cross zero. This suggests that, despite the statistically significant impact of age on complications in univariate analysis, this parameter is not a key risk factor.

The power analysis shows that with a sample size of 288 patients, standard statistical power exceeding 0.8 is achieved, confirming that the data are sufficient to detect significant effects in the risk factor analysis for non-surgical complications. For smaller effect sizes (around 0.2), an optimal sample size would be between 150 and 200 patients, indicating the reliability of the findings for this patient group.

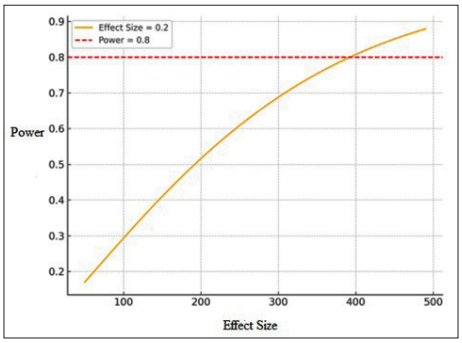

Fig. 2. *Power Analysis Results for Multivariate Logistic Regression.*

Thus, the current sample size allows for multivariate analysis with a high confidence level and enables accurate interpretation of its results. The likelihood of missing important factors (Type II error) is minimal, strengthening the scientific validity of the conclusions regarding the impact of factors such as obesity and hypertension on the risk of developing cardiorespiratory complications.

Discussion

In our study, a retrospective assessment of the risk of developing non-surgical, specifically cardiorespiratory, postoperative complications was conducted based on an analysis of the postoperative period in patients who underwent surgical treatment for benign cystic ovarian neoplasms. These complications were categorized as follows: pneumonia, respiratory failure, arrhythmias, angina attacks, and hypertensive crises. This study demonstrated that the overall incidence of cardiorespiratory postoperative complications was 8.7%, comparable with WHO data and the results of numerous previous studies.[3,4] Patients in the older age group generally have a higher number of comorbidities, primarily cardiovascular diseases, diabetes mellitus, and obesity. These factors can significantly influence surgical outcomes. Therefore, it is essential to identify significant factors that may affect the development of non-surgical complications in the postoperative period. Univariate analysis identified the following significant risk factors: older age, higher BMI, diabetes mellitus, and hypertension.

Since univariate analysis does not account for interactions between variables and their combined effects on outcomes, machine learning methods were applied in our study. Univariate analysis indicated that age over 65 impacts the development of postoperative complications. However, further application of more complex statistical methods revealed that this relationship is not so straightforward. Multivariate analysis demonstrated that the occurrence of CRC in the postoperative period among elderly patients is more closely associated with the presence of comorbidities, such

as hypertension and obesity. Numerous studies confirm that univariate analysis alone is insufficient to fully identify risk factors for the development of postoperative complications.[5-7]

Therefore, it is not advisable to consider advanced age as an independent predictor of complications, as the key risk factor is the presence of comorbidities in combination with other factors. Our study identified hypertension in 32.3% of the operative patients. In earlier studies by other authors, this figure was 30.1%. In 2020, the International Society of Hypertension introduced its own proposal for stratifying patients according to the risk level associated with hypertension.[8] This study noted that high-risk patients have a reduced ability to cope with significant stressors, including surgical procedures. In our research, hypertension was found to increase substantially the incidence of postoperative CRC. Therefore, when hypertension is identified during the preoperative assessment, patients should be prescribed appropriate medication to reduce the risk of CRC in the postoperative period.

Morbid obesity significantly increases the development of postoperative complications, as confirmed by numerous studies.[9] Research has shown that obese patients experience disruptions in both innate and adaptive immune responses associated with chronic low-grade inflammation, characterizing obesity as a metabolic disease.[10]This condition is known to cause a metabolic imbalance in the homeostasis system, often leading to a systemic inflammatory response that manifests postoperatively as exacerbations of chronic infection sites, including in the upper respiratory tract and lungs. Thus, obesity may be an indirect cause of postoperative pneumonia and respiratory failure.[11] Numerous studies confirm that obesity is an independent risk factor for non-surgical complications, likely due to increased production of pro-inflammatory cytokines, such as IL-6 and TNF-alpha. These substances increase the permeability of the alveolar-capillary membrane, creating conditions for the development of respiratory failure.[12] Supporting this, a study conducted by McMahon et al.[13] demonstrated that among women who had a hysterectomy, obese women had a higher rate of complications than nonobese women. In a large study by Tyan et al., [11] involving an analysis of 159,025 patients who underwent various types of hysterectomy, it was conclusively demonstrated that Grade 3 obesity increases the risk of postoperative complications by 31% compared to patients without obesity.

Thus, the findings highlight the role of hypertension and obesity as significant risk factors for the development of CRC in patients after surgical treatment for BOC. Our study supports the need to develop individualized management protocols for patients with these conditions to reduce the incidence of these complications. The influence of age over 65 in operative patients did not negatively impact the development of CRC in multivariate analysis.

In conclusion, in our study the incidence of postoperative CRC was 8.7%. Significant factors contributing to the development of CRC in patients after surgery for BOC include hypertension and obesity.

Competing Interests

The authors declare that they have no competing interests.

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