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Research Article

Logistic Regression as a Prognostic Tool for Estimating Development of Postpartum Endometritis and Lactostasis

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Abstract

Introduction: During our investigation of postpartum purulent-inflammatory diseases we implied both standardised set of diagnostic tools as well as fluorescent spectroscopy. ROC-analysis and logistic regression were implied to perform a prognostic assessment of the development of postpartum endometritis and lactostasis.

Objectives: We aim to assess prognosis of development of postpartum endometritis and lactostasis among postpartum women.

Methods: General clinical assessment methods, biochemical and instrumental analysis, including fluorescent spectroscopy and statistical assessment (logistic regression). The main cohort of participants consisted of 30 postpartum women with postpartum endometritis and lactostasis. The control group was formed from 40 postpartum women with uncomplicated post labour period.

Results: We performed and implemented a stepwise logistic regression (with forward selection) aimed to separate the factors, whose cumulative effect would have a significant effect on development of postpartum endometritis and lactostasis.

Through statistical analysis, we were able to determine 6 clinically significant factors (indication of colpitis, TORCH-infections, labour duration >12 hrs, number of bed days and the maximum value of the wavelength in fluorescence intensity of blood serum derived from fluorescent spectroscopy) which cumulatively have an impact on occurrence of postpartum endometritis and lactostasis. Optimal threshold of decision making (cut-off point) which allows a maximum balance between sensitivity and specificity for this model was 0.47. Therefore, when either of these variables has a value of 0.47≤, we can conclude that the patient has a high risk of developing postpartum endometritis and lactostasis. Consequently, if the 0.47≥, we can confirm the absence of risk of postpartum endometritis and lactostasis development.

Among 93.33% patients of the main cohort this indicator exceeded the optimal threshold value of 0.47. On the other hand, only 7.5% of patients from control group had an indicator of more than 0.47.

Conclusion: As a result of our study, we proposed a prognostic model which allowed prognosis of development of postpartum endometritis and lactostasis. The resulting model is correct with a probability of >99% ($p<0.001$; $\chi^2 = 64.88$; $df = 6$).

Keywords: Postpartum Endometritis; Lactostasis; Logistic Regression; ROC-Analysis

Abbreviation

PPE: Postpartum Endometritis.

Currently, it is key to emphasize development of new methods required for early identification and treatment of postpartum pu-

rulent-inflammatory diseases, especially postpartum endometritis which is becoming more common across the population. In order for the treatment to be highly effective, it is crucial to evaluate its prognosis and diagnostic methods involved. During our investigation we implied fluorescent spectroscopy in sepsis diagnosis (the patent of Ukraine №76953) [1] as well as in postpartum purulent-inflammatory diseases (patent of Ukraine №133472) [2]. In the framework of this method, the pathogenetic mechanism of alteration of albumin molecules at endogenous intoxication was established [3,4]. Therefore, the pathogenetic components of the treatment of sepsis and purulent-inflammatory diseases are antibiotic therapy and infusion therapy with albumin solutions to replenish the amount of complete albumin in blood serum [5]. The use of probiotics for lactostasis is an important component of treatment that reduces the risk of mastitis [6]. A thorough evaluation is also very important for the effectiveness of antibiotic therapy in connection with the significant spread of antibiotic resistance [7,8].

In our methodology we used logistic regression to perform prognostic evaluation of postpartum endometritis and lactostasis development. This method enabled us to forecast the relationship between the investigated dependant variable (probability of postpartum endometritis development) and a couple of independent variables that have the biggest impact.

Aim

To carry out evaluation of prognosis of postpartum endometritis and lactostasis among postpartum women.

Methodology

The clinical research centre for this particular investigation was the Department of Gynecology №2 of Vinnytsia Council Clinical Hospital №2. The luminescent laboratory of the Department of Experimental Physics, Ivan Franko Lviv National University was an experimental research centre. The main cohort consisted of 30 postpartum women with postpartum endometritis and lactostasis. Control cohort consisted of 40 postpartum women who had uneventful post-pregnancy period. The research methods used in diagnosis of postpartum endometritis included clinical, laboratory, biochemical, instrumental and statistical.

Results

In this study, we performed and implemented a stepwise logistic regression (with forward selection) aimed to separate the factors, whose cumulative effect would have a significant effect on development of postpartum endometritis and lactostasis.

A probability of PPE taking place (Q), depending on the selected factors was calculated using the following formula:

$$Q = \frac{1}{1+e-R} \times 100 \quad \text{.....(1.1)}$$

Where e = 2.72… - is the base of a natural logarithm

R = is the quantity calculated according to the formula 1.2, mentioned below:

$$R = K + \beta_{1x1} + \beta_{2x2} + \ldots + \beta_{nxn}, \quad \text{.....(1.2)}$$

K = is a constant

n = the number of factors which are included in prognostic model

β_i = coefficients that correspond to a number of calculated factors

x_i = corresponding numerical values of the factors

Theoretically, Q can hold a value ranging from 0% (an impossible event) to 100% (a constantly occurring event). The meaning of β_i coefficients are calculated by the software and are represented by the natural log of the correlation of the probabilities of corresponding variables. Increasing the value of the independent variable by a unit of measurement would increase the chances of developing complications in EXP (β) times.

Via completion of statistical analysis, we were able to determine 6 clinically significant factors, which cumulatively have an impact on occurrence of postpartum endometritis and lactostasis; they are demonstrated in table 1.

Factor	Coefficient	Exp(β)	Annotations	z
Constant	-227.9788			-1.91
TORCH	2.8806	17.82	X1	1.96
Colpitis	4.9221	137.29	X2	3.28
Labour duration >12 hrs	3.5649	35.33	X3	1.75
Abnormal labour	3.4808	32.48	X4	2.30
Lambda (λ) max of blood serum	0.6568	1.93	X5	1.84
Bed days	0.8049	2.24	X6	2.11

Table 1: The results of regression coefficients related to the occurrence of postpartum endometritis and lactostasis among postpartum women (n = 30) using logistic regression.

The resulting model is correct with a probability of 99% ($p<0.001$, $\chi^2 = 64.88$, df = 6).

By substituting derived coefficient β into the equation 1.2 we can determine the R and hence predict the probability of postpartum endometritis and lactostasis occurrence in main cohort.

$$R = - 227.9788 + 2.8806 * X1 + 4.9221 * X2 + 3.5649 * X3 + + 3.4808 * X4 + 0.6568 * X5 + 0.8049 * X6 \quad (1.3)$$

Furthermore, ROC-analysis was used in order to determine a mathematical credibility of the model and calculate an optimal threshold of decision making (cut-off point). As a result, a ROC-curve was implied in order to demonstrate correlation between specificity and sensitivity. The area under the curve (AUC) was calculated to characterise the model's quality, where the scale varied between 0.5 (method is unacceptable) to 1-100% which is an indication of the congruence in prognosis based on the model.

The equation was evaluated according to Akaike information criterion (AIC) [9], verification using χ^2 for the likelihood ratio test and by Nagelkerke's R^2 (Pseudo R^2) [10,11]. Nagelkerke's coefficient of determination (Pseudo R^2) of this model equals 0.8112 (i.e. the set of variables in this model explains almost 81% of dispersion of the dependent variable). The area under curve (AUC) = 0.97.

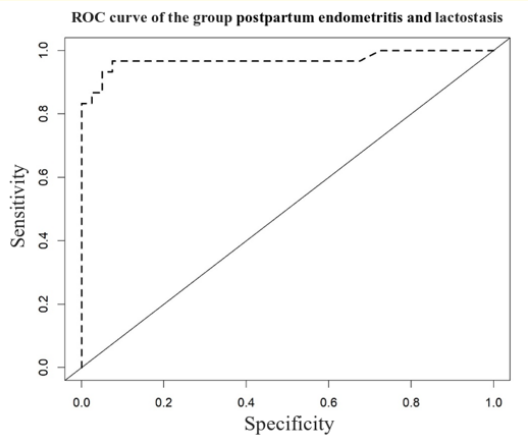

Figure 1: ROC curve of the group postpartum endometritis and lactostasis.

Optimal threshold of decision making (cut-off point) which allows a maximum balance between sensitivity and specificity for this model was 0.47. Therefore, when either of these variables has a value of 0.47≤, we can conclude that the patient has a high risk of developing postpartum endometritis and lactostasis. Consequently, if the 0.47≥, we can confirm the absence of risk of postpartum endometritis and lactostasis development.

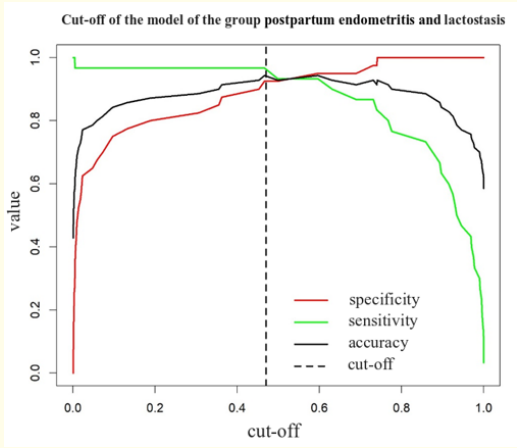

Figure 2: Threshold of decision making (cut-off point) correlated to specificity, sensitivity and accuracy of the mathematical model for the group – postpartum endometritis and lactostasis.

When the threshold of decision making (cut-off point) is 0.47, the values for the parameters are as follows: sensitivity is 93.33%, specificity is 92,50%, the likelihood ratio of the positive result (LR+) is 12.44, the likelihood ratio of the negative result (LR-) is 0.07, positive prognostic value (PPV) is 90.32%, negative prognostic value (NPV) is 94.87%. The data used in the aforementioned prognosis using threshold of decision making of 0.47 are outlined in table 2.

	Uncomplicated course of postpartum period (n=40)	**Diagnosed postpartum endometritis and lactostasis (n=30)**	**Total**
Calculated value ≤0.47	37 (92.5%)	2 (6.67%)	39
Calculated value ≥ 0.47	3 (7.5%)	28 (93.33%)	31
Total	40	30	70

Table 2: Diagnostic value of the mathematical model implied in prognosis of postpartum endometritis among postpartum women with endometritis and lactostasis.

Conclusion

As a part of our investigation we proposed a prognostic model of development of postpartum endometritis and lactostasis. A resulting model is correct with a probability of >99% ($p<0.001$; $\chi^2 = 64.88$; $df = 6$).

This model included the following core factors: colpitis, TORCH-infection, labour duration >12 hours, a number of bed days and the maximum value of the wavelength in fluorescence intensity of blood serum derived from fluorescent spectroscopy. Subsequently, logistic regression enabled correct assessment of the risk of development of postpartum endometritis based on the following methods: serological (TORCH), bacterioscopic (colpitis) and fluorescent spectroscopy.

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Volume 1 Issue 7 December 2019