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The Model for Predicting the Risk of Development of Complications in Pregnancy with Supravesical Obstruction

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Abstract This research describes the factors that cause the development of complicated supravesical obstruction in pregnant women. Each factor has been analyzed by step-by-step regression analysis; odds ratios and relative risk have been calculated against the outcome of this condition for each pregnant woman. High-risk factors and odds ratios have been selected as the classifier of outcomes for discriminant analysis. Based on the discriminant function, a model has been developed for predicting the risk of developing a complicated course of supravesical obstruction in pregnant women. The results of the self-test showed high sensitivity and specificity of this model.

Keywords Complicated supravesical obstruction, Pregnancy, Predicting model

1. Introduction

Complicated supravesical obstruction (SVO) is quite common during pregnancy. The frequency of this condition around the world is reported to range from 0.3 to 1.9 cases per thousand pregnant women [1-3], making up an average of 0.8 cases per thousand pregnant women [1]. Complications arising out of this condition are dangerous both for a pregnant woman and for the fetus [4-6], which increases the material expenditures for elimination of complications [7], thus significantly deteriorating the quality of life of pregnant women [8]. Currently, prevention of complicated supravesical obstruction is viewed as a crucial public health problem.

Recently, most research has focused on identification of SVO risk factors. Many epidemiological studies have confirmed association between SVO and such factors as maternal age [9,10], the side damaged by urinary tract disorder [11], occurrence of abnormalities during the pregnancy [12,13], urinary tract infection during pregnancy [1,14], use of drugs during pregnancy [15,16]. For the aims of diagnosing SVO, such research methods as U/S [17,18], X-ray study [17,19], urine analyses [2,4,6,14] and blood tests [7] are widely used. However, no perfect risk prediction tool for SVO has yet been developed, but it is important to take an individual approach in each case. Individual risk prognosis is based on a number of key factors that can provide supplementary data for diagnosing SVO and prevent the development of SVO complications.

Nevertheless, there are a number of studies on prediction of individual SVO risk. In our previous study, we used a decision algorithm to project the risks of SVO complications. There is currently no generalized SVO risk prediction reporting system. In order to solve this problem, we attempted to develop an SVO risk prediction model through discriminant analysis based on risk factors.

2. Materials and Methods

We conducted a case-control study, which included an analysis of the case histories of 405 pregnant women with SVO dated from January 2017 to December 2018, who applied to the Republican Specialized Scientific and Practical Medical Center of Urology. Pregnant women with supravesical obstruction and clinical laboratory findings within normal limits were selected to the control group. Pregnant women with SVO and confirmed clinical and laboratory data made up a case group.

In this clinical study, the case-control ratio was 1: 4 due to the relatively small number of controls and a large number of potential cases. In some cases, the use of a 1: 4 case-control ratio can provide the necessary statistical power to determine important predictors.

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2.1. Data Collection

Research data was compiled of all the clinical, instrumental and laboratory findings of patients obtained using an automated information system.

2.2. Quality Control

Patients were strictly selected according to the eligibility criteria and diagnostic criteria. Five percent of all patients were considered at random, and the cases with missing data > 10% and / or logic errors> 10% were excluded from the study. Double input was used to ensure the quality of data input, and a logical check was performed for the input data.

2.3. Statistic Analysis

A large number of variables (35) were analyzed in this study. We used a one-dimensional logistic regression to identify significant risk factors associated with SVO, and then used Fisher's discriminant analysis to develop a simple and useful prediction model based on significant predictors. Univariate analysis cannot control the influence of other variables or avoid the collinearity of some variables. Thus, in the Fishers' discriminant analysis, we used a stepwise approach to determine the final prediction that could control the mixing effect and overcome the collinearity between variables.

Fishers' discriminant was supposed to find a linear combination for categorical groups, as discriminant estimates (Z) were calculated to maximize between-group variance and minimize intragroup variations. The linear combination was known as the Fishers' discriminant function as follows:

$$Z = C_1 X_1 + C_2 X_2 + C_3 X_3 + \cdots + C_m X_m$$

where Z is: discriminant scores between two groups; X_1, X_2, X_3, $\cdots$, X_m: discriminant variables; C_1, C_2, C_3, $\cdots$, C_m: discriminant coefficients for each discriminant variable. Discriminant variables can be selected in two ways: "input he variables together" and "input the variables step by step". The stepwise method selected discriminant variables based on Wilks' lambda statistics, and in common case, the value of F was set to $F_{Entry} = 4{,}95$ и $F_{Removal} = 2{,}19$. The discriminant function defined by the stepwise discriminant was simpler and more efficient. Assuming that the average discriminant score of controls was $\overline{Z}_A$, $\overline{Z}_B$ for cases and $\overline{Z}$ for total number, $\overline{Z} = \overline{Z}_A + \overline{Z}_{B2}$. In accordance with the discriminant function, we calculate the discriminant assessment Z_x for each subject; if $Z_x > \overline{Z}$, the subject is considered highly probable and if $Z_x \leq \overline{Z}$, subject is regarded as control.

Using MS Excel software, we developed a database and then entered data. The data obtained were analysed using the SPSS 22.0. software. Results were considered significant if P <0,05.

3. Results

3.1. Socio-demographic Characteristics of the Patients

Of total number of 405 patients who have been examined and treated from January 2017 to December 2018, the data of 258 patients were analysed (228 cases and 30 controls), and 147 patients were excluded from the study because the data collected on them was insufficient. Table 1 shows the distribution of the socio-demographic characteristics in two groups. Except for week of gestation, there are no statistically significant differences, which is also characteristic for other parameters. Cases and controls were comparable, with due proportionality.

3.2. Predictors Screening

Using a one-dimensional logistic regression analysis, 35 variables related to SVO were sequentially analyzed.

According to one-dimensional logistic regression analysis, SVO was significantly associated with the following 12 variables: (see table 2): affected side, maximum anteroposterior diameter of kidney pelvis, stones in kidney, stones in ureter, disease duration, body temperature, urine WBC count, bacteriuria, blood WBC count, leukocytal intoxication index, erythrocyte sedimentation rate, serum urea level and serum creatinine level.

3.3. Development of Prediction Model

Using the results of a one-dimensional logistic regression analysis, the SVO risk prediction model was developed using Fisher's stepwise discriminant analysis (F Entry = 4,95, F Removal = 2,19) based on the 10 selected variables, which were statistically significant. A stepwise discriminant analysis showed that Wilks' lambda, as a test of the discriminant function, was significant (lambda = 0.771, chi-square test = 86.044, DF = 8, p <0.001), and 12 variables were selected as follows: affected side (x1), disease duration (x2), body temperature (x3), urine WBC count (x4), bacteriuria, blood WBC count (x5), leukocytal intoxication index (x6), ESR (x7), maximum anteroposterior diameter of kidney pelvis (x8), kidney stones (x9), ureter stones (x10) serum urea level (x11) and serum creatinine level (x12).

The final standardized discriminant function was calculated by the following equation:

Z = 0,287 X 1 + 0,283 X 2 + 0,255 X 3 + 0,464 X 4 + 0,338 X 5 + 0,309 X 6 + 0,236 X 7 + 0,422 X 8 + 0,319 X 9 + 0,2 87 X 10 + 0,315 X 11 + 0,364 X 12

Then we calculated the discriminant function Z i for each subject; if Z i > 0,235, the subject was considered highly likely to suffer from SVO and if Z i ≤ 0,235, the subject was considered normal.

Table 1. Socio-Demographic Characteristics of Cases and Controls

Characteristics	Control (n = 30)	Main (n = 228)	$\chi 2$	P	OR	95% CI (OR)	
Maternal age (years), n (%)			0,983	0,805			
20-24	10 (32,7)	87 (38,1)			1		
25-29	1 3 (42,5)	91 (39,8)			0,807	0,481	1,352
30-34	6 (22,6)	46 (20,4)			0,776	0,418	1,442
≥ 35	1 (2.2)	4 (1,8)			0,688	0,128	3,702
Week of gestation	18 (4.4)	29 (11,5)			1,650	0,760	3,582
Past surgical interventions, n (%)	3 (10,0)	12 (5,3)			4,673	1,476	14,795
Disease duration (days)	35 (24,8)	48 (18,6)			1		

OR stands for odds ratio; b CI stands for confidence interval; * P <0,05

Table 2. The results of one-dimensional logistic regression analysis of SVO factors impact

Screened factors	Control (n = 30)	Main (n = 228)	B	P	OR	95% CI	
Affected side, n (%)				0,003 *			
Right	22 (9,7)	6 (5,3)			1		
Left	10 (4,4)	1 (0,9)	-1,003	0,381	0,367	0,039	3,462
Both kidneys	107 (47,3)	39 (34,5)	0,290	0,056	1,336	0,504	3,541
Disease duration	56 (24,8)	13 (11,5)	-0,930	0,005 *	0,395	0,206	0,757
Body temperature	75 (33,2)	55 (48,7)	0,647	0,006 *	1,909	1,204	3,028
Urine WBC	6 (2,7)	9 (8,0)	1,155	0,033 *	3,173	1,100	9,149
Bacteriuria, n (%)	2 (0,9)	6 (5.3)	1,837	0,026 *	6,280	1,247	31,634
Blood WBC	5 (2,2)	16 (14,2)	1,987	0,000 *	7,291	2,597	20,466
Leukocytal intoxication index	11 (4.9)	21 (18,6)	1,495	0,000 *	4,461	2,067	9,629
Erythrocyte sedimentation rate, n (%)				0,033 *			
Maximum anteroposterior diameter of kidney pelvis	16 (7.1)	15 (13,3)			1		
Urea level	79 (35,0)	48 (42,5)	-0,434	0,282	0,648	0,294	1,429
Creatinine level	131 (58,0)	50 (44,2)	-0,899	0,023 *	0,407	0,187	0,885

OR denotes odds ratio; CI denotes confidence interval; b stands for partial regression coefficient; * P <0,05

3.4. Forecasting of Discriminant Analysis of Predictive Impact. Prediction Accuracy

The forecast of accuracy of the prediction model was carried out by self-testing. Table 3 shows the classification of the self-test results. 83.8% of subjects were correctly classified as SVO main or control, correct prediction indicators were 74.3% for SVO cases (sensitivity) and 88.5% for control (specificity), while positive and negative prognostic values were 76.4 and 87.3% respectively.

Table 3. Classification of the self-test results. Predicted group membership

	Main	Control	Total
Control	20	10	30
Main	208	20	228
Total	228	30	258

3.5. Analysis of the ROC Curve for Predicting Discriminant Analysis

The receiver operating characteristic curve is an important indicator of the prediction model accuracy. The area under the ROC curve (AUC - area under curve) usually varies from 0.5 to 1.0. When AUC ranges from 0.5 to 0.7, the diagnostic value of the test is low; when it is between 0.7 and 0.9, it has an average diagnostic value; and when it exceeds 0.9, it has a high diagnostic value.

The AUC model for predicting discriminant analysis is shown in Fig. 1. AUC has demonstrated statistical significance (AUC = 0.846, SE = 0.027, P <0.001, 95% CI: 0.794 ~ 0.898). The diagnostic value of the model was average.

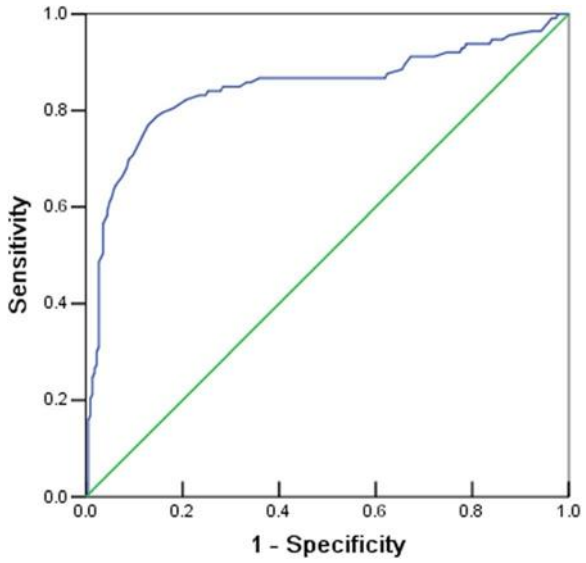


Figure 1. ROC curve for discriminant analysis of the prediction model

4. Conclusions

Discriminant prediction model based on affected side, maximal anteroposterior diameter of kidney pelvis, stones in kidneys and ureter, disease duration, body temperature, urine WBC count, bacteriuria, blood WBC count, leucocytal intoxication index, erythrocytes sedimentation rate, serum urea level and serum creatinine level might be helpful in estimating the risk of SVO complications. Further research is needed to improve and simplify the model and confirm its authenticity and reliability.

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