Development of an automated diagnosis of complications after operation on mitral valve

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Abstract - There is always a risk of postoperative complications after heart surgery. Doctors need carry out comprehensive analysis of many data in order to detect and to foresee this aftereffect. This analysis takes a lot of time and effort. Automated identification of postoperative complications in the patient's mitral valve was developed for avoiding this problem. Statistical models of post-operative complications of the patient were engineered based on discriminant analysis and logistic regression models with use cluster analysis. The results of calculations at this stage of the study showed a high diagnostic performance of logistic regression with clustering.

Key words – heart surgery, mitral valve, cluster analysis, discriminant analysis, logistic regression.

I. Introduction

Nowadays, many people are suffering various diseases, one such disease is dysfunction of valvular heart disease (VHD). VHD is any disease process involving one or more of the valves of the heart (the aortic and mitral valves on the left and the pulmonary and tricuspid valves on the right). These disorders may be congenital (inborn) or acquired (due to another cause later in life). Treatment may be with medication but often (depending on the severity) involves valve repair or replacement (insertion of an artificial heart valve) [1-2].

In most cases, valve replacement surgery is successful, but there are postoperative complications that can be fatal to humans if they are not predicted in advance. Postoperative complications were difficult to see therefore patients were conducted prevention, but it does not always help. Professor E.A. Nastenko and others researched some of postoperative complications [3]. One of them is a postoperative complication after mitral valve.

In this work, the automated probabilistic prediction of postoperative complications by using static patient data was considered. Relevance of the work is the ability to predict the type of postoperative complications. This will ensure rapid rehabilitation of the patient, thereby save his life. Result of the work is determination specific patient parameters, which will be further developed software that detects type of postoperative complications.

II. Overview of the experimental material

Studies based on the initial data from the National M.M. Amosov Institute of Cardiovascular Surgery of the Medical Sciences of Ukraine were conducted. The input clinical data for this research were resulted on the patient data with coronary heart disease and acquired heart disease. Observational data were got in patients in the first, second and third day after mitral valve replacement, operation was performed under extracorporeal circulation. Data from 330 patients on 69 parameters were collected. Classification of postoperative complications has been established as follows: normal, severe impairment of cerebral circulation, acute heart failure and joint complications.

Basic methods of controlling and recording parameters patients: ultrasound diagnosis, electrocardiography and software for evaluation of the patient after operation on mitral valve. Using echocardiography was to determine the ratio of volume indices of cardiac contraction: end-diastolic (EDV), end-systolic (ESV) and stroke (SV) volumes of the left ventricle (LV) in patients with valvular heart intact. A survey conducted in calm conditions and age of the patients was 13 to 63 years. Measured only diastolic and systolic volumes of the heart, the estimated values calculated immediately across the data set [3].

In this work used the following groups of indicators that describe the various characteristics of circulation:

a) delivery indicators and myocardial oxygen consumption;
b) indicators of systemic oxygen transport;
c) hemodynamic parameters;
d) performance indicators delivery and myocardial oxygen consumption;
e) blood counts and etc.

III. Research methods

IBM SPSS Statistics 21.0 was used in this work. The method of discriminant analysis (DA) and logistic regression were used to identify these appliances to certain complications. For each method was found most effective factors. That is for the DA (Fig.1) used the Mahalanobis distance, applied F-test to include 2,2 and 2,1 exception. Also scripting option on intra group covariance matrix (classification is the assumption of equality of covariance matrices in classes and calculate the matrix (for the reference to the class object by the Mahalanobis distance) for all data sample).

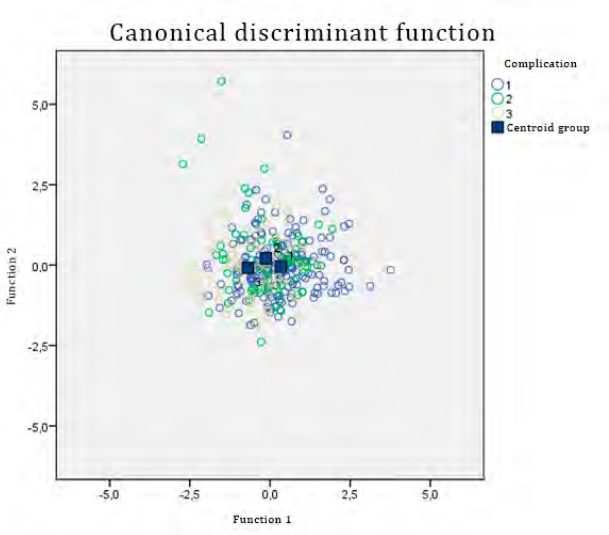


Fig. 1. Canonical discriminant function

The results of DA classification are shown in Table 1. Canonical discriminant function shows that our data had not very good classification.

TABLE 1

THE CLASSIFICATION RESULTS

	Sequela	Predicting group membership			Итого
		1	2	3	
Frequency	1	167	0	15	182
	2	51	6	12	69
	3	49	1	29	79
%	1	91,8	,0	8,2	100,0
	2	73,9	8,7	17,4	100,0
	3	62,0	1,3	36,7	100,0
61.2% of the original grouped observations classified correctly.					

Cross validation test (the method of evaluation of the model and its behavior on independent data) to evaluate the sensitivity and specificity of the developed models were used. The initial array of observations was randomly broken down a training group and a test to assess the predictive performance of the obtained models. The predictive model was constructed the first model, the checking was carried out on the effectiveness of the test model. Logistic regression showed a better data: recognition result was 75.8% (Table 2).

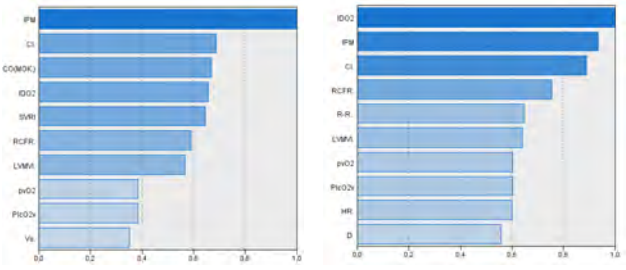
TABLE 2

THE CLASSIFICATION RESULTS

	Observed		Predicted		
			Sequela		Percentage of correct
			1	2	
Step 1	Sequela	1	144	38	79,1
		2	42	106	71,6
	The total percentage				75,8
The separation value = ,500					

These methods do not give good recognition results, as has been implemented method of cluster analysis. Based on clustering, the input clinical data were divided into clusters with the classification of postoperative complications: normal, heart failure, cerebral circulatory insufficiency. These groups were disunited into subgroups to improve results.

Each complication was divided into two clusters using two-stage cluster analysis. This analysis showed the importance predictor: variables that affect the distribution of variables. All complications were separated into two clusters.



a) b)

Fig. 2. Important predictor

The variables that most influence the formation of clusters were separated from all the data and were entered into the cell classification. The results slightly improved, particularly through binary logistic regression (Table 3).

TABLE 3

THE CLASSIFICATION RESULTS

	Observed		Predicted		
			Sequela		Percentage of correct
			1	2	
Step 1	Sequela	1	220	19	92,4
		2	48	43	47,3
	The total percentage				80,4
The separation value = ,500					

The distribution of the second group on the contrary decreased, which indicates that the variables linking this group were incorrectly eliminated.

Conclusion

These methods of analysis can identify the factors that lead to the development of congestive heart failure. The comparative analysis of statistical methods revealed that the binary logistic regression gives a higher percentage of correct data of that testifies to the high quality of the resulting model.

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