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Mortality Prediction Based on Echocardiographic Data and Machine Learning: CHF, CHD, Aneurism, ACS Cases

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Abstract

This paper represents the research results of echocardiographic study for early prediction of mortality. The classification task is solved by analyzing the echocardiographic data from medical information system. Echocardiographic data of 90000 hearts condition extracted directly from medical information system were analyzed. The considered echocardiographic studies were conducted for patients with CHF, CHD, hypertension, heart arrhythmia, valvular heart disease, autoimmune disease, congenital heart defect, cardiomyopathy, endocrine disease, heart failure, mixed connective tissue disease, cancer, aneurism. Using machine learning methods and neural networks it is possible to make an early prediction of mortality based on instrumental echocardiographic study. It can be offered to clinicians as support for accurate, reasonable saving clinical decisions with minimization risks for patient's health. The classification task mortality prediction is solved by machine learning methods with 97% ROC curve. The simple echocardiographic test results like FV Simpson, systolic volume, the valves condition, the condition of the ascending aorta and other echocardiographic data are used as predictors. Such a simple approach to solving critical tasks can make the method widely used in clinical practice.

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Keywords: mortality, prediction, CHD, hypertension, heart arrhythmia, valvular heart disease, autoimmune disease, congenital heart defect, cardiomyopathy, endocrine disease, heart failure, mixed connective tissue disease, cancer, aneurism

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1. Introduction

Echocardiography studies can identify a number of factors with independent prognostic value in overall mortality for patients with cardiovascular disease [1]. Early detection of the risks mortality and "point" appointment of procedures makes a significant contribution to value-based medicine. Calculation of personal risks on the basis of empirical retrospective data contributes to the detection of the disease in the early stages, the treatment decision can significantly improve the quality of treatment, optimize costs and improve the quality of life of the patients. The second chapter of this paper describes related work on the research topic. The third chapter describes the stages of data pre-processing, patient characteristics, data analysis, configuration of machine learning models and neural networks.

The study of echocardiographic tests for the diagnosis of patients was conducted in a group of 92357 patients admitted to the Almazov center from 2010 to 2019. Most patients of the medical center underwent echocardiographic examination of the heart with the determination of the main structural and hemodynamic parameters. Decision trees, random forest method, naive Bayesian classifier, multilayer perceptron were used as classifiers in the study. Machine learning methods shows 97 % ROC curve.

Further, the fourth Chapter provides a clinical interpretation of the results of data analysis and decision trees. Thus, it was possible to extract the types of patients and prognosis markers that work in combination. It was possible to identify clinical and prognostic groups of patients with CHF by decision tree methods based on the analysis of large EHR data..

2. Related works

There are research papers describing some general statistics on emergency mortality patients who underwent echocardiography. Such studies cover patients of a small number of groups of a certain age or nosological groups. These studies describes the adverse results after echocardiography [2]. Adverse effects may be associated with the procedure itself. Laboratory results are used as predictors of mortality in patients with acute coronary syndrome (ACS) [3] [4] [5]. The approach of predicting the results of treatment on the basis of hemodynamic parameters, physical activity tolerance, quality of life before treatment is widespread. To solve such problems, machine learning methods are used, in particular decision trees [6]. The results of classification using machine learning methods are unstable and depend on the algorithm parameters, the balance of class sizes and the size of the training sample [7]. The using these methods can lead to a problem of retraining the number of features comparable or greater than the number of observations. To solve the above problems and improve the accuracy and stability of the classification are widely used ensemble decision trees based on the technology of boosting and bagging [8]. Neural networks are often used to predict treatment outcomes[9].

3. Machine learning method for mortality prediction

Machine learning methods and neural networks were used to predict the lethal outcome. The settings of optimal parameters, predictor analysis, data analysis, search of options for filling in gaps were performed.

3.1. Clinical data

For the analysis, the data of the current Almazov medical center were used*. The data retrospective was from 2010 to 2019. The causes of the diagnoses for which echocardiographic examination was carried out are presented in the table 1.

* <http://www.almazovcentre.ru/?lang=en>

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