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Predictive Modeling of Comorbid Anxiety in Young Hypertensive Patients Based on a Machine Learning Approach

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Abstract: *Objective:* To analyze the risk factors of anxiety in young hypertensive patients and build a prediction model to provide a scientific basis for clinical diagnosis and treatment. *Methods*: According to the research content, young hypertensive patients admitted to the hospital from January 2022 to December 2024 were selected as the research object and at least 950 patients were included according to the sample size calculation. According to the existence of anxiety, 950 patients were divided into control group (n = 650) and observation group (n = 300), and the clinical data of all patients were collected for univariate analysis and multivariate Logistic regression analysis to get the risk factors of hypertension patients complicated with anxiety in. All patients were randomly divided into a training set (n = 665) and a test set (n = 285) according to the ratio of 7:3, and the evaluation efficiency of different prediction models was obtained by using machine learning algorithm. To evaluate the clinical application effect of the prediction model. *Results:* (1) Univariate analysis showed that age, BMI, education background, marital status, smoking, drinking, sleep disorder, family history of hypertension, history of diabetes, history of hyperlipidemia, history of cerebral infarction, and TC were important risk factors for young hypertensive patients complicated with anxiety. (2) Multivariate Logistic regression analysis showed that hypertension history, drinking history, coronary heart disease history, diabetes history, BMI, TC, and TG are important independent risk factors for young hypertensive patients complicated with anxiety. (3) Extra Trees has the highest predictive power for young people with hypertension complicated with anxiety, while Decision-Tree has the lowest predictive power. *Conclusion:* Hypertension history, drinking history, coronary heart disease history, diabetes history, BMI, TC, and TG are important independent risk factors that affect the anxiety of young hypertensive patients. Extra Trees model has the best prediction efficiency among different groups of models.

Keywords: Machine learning method; Youth hypertension; Anxiety; Prediction model

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1. Introduction

Hypertension is a common chronic disease, which means that blood pressure is measured three times on different days without using antihypertensive drugs, with systolic blood pressure ≥ 140mmHg and/or diastolic blood pressure ≥ 90mmHg [1]. Studies have shown that in recent years, the incidence of hypertension is younger [2]. According to statistics, the incidence of hypertension among young people in the world is on the rise [3, 4]. In some developed countries, the incidence of hypertension among young people is about 5%–10%, while in developing countries, the proportion is gradually increasing. The occurrence of hypertension in young people is closely related to heredity and lifestyle. If there are hypertensive patients in the family, the probability of genetic related genes in young people is high, which may lead to abnormal vascular wall structure and function and lead to hypertension [5]. In addition, a long-term high-salt diet will increase sodium ions in the body, lead to water and sodium retention, increase blood volume, and then raise blood pressure [6].

At the same time, long-term heavy drinking will damage vascular endothelial cells, affect the normal function of blood vessels, trigger blood pressure fluctuations, and lack of exercise will easily cause body fat accumulation, leading to obesity, which is an important risk factor for hypertension [7]. If not treated in time, long-term hypertension will increase the burden on the heart and cause left ventricular hypertrophy, which may further develop into heart failure [8]. At the same time, hypertension is also an important risk factor for cardiovascular and cerebrovascular diseases such as coronary heart disease and stroke, which increases the risk of myocardial infarction, cerebral hemorrhage, and cerebral infarction [9]. At present, the pathogenesis of hypertension in young people is not clear, but some scholars point out that anxiety is one of the important causes of hypertension. Therefore, early screening of influencing factors of anxiety in young hypertensive patients can provide scientific basis for clinical diagnosis and treatment.

In the era of rapid development of science and technology, machine learning algorithm, as the core technology in the field of artificial intelligence, is deeply affecting many industries, especially in the medical field, bringing a new perspective and method for disease prediction [10, 11]. Machine learning algorithm is a technology that allows computers to learn from data and make predictions or decisions. Traditional programming is based on predefined rules and instructions, while machine learning is different [12]. Based on a large number of data, it allows computer models to automatically find patterns, laws, and characteristics in the data. The learning process of algorithm is similar to that of human learning knowledge from experience, except that it is realized by mathematical model and complicated calculation, and it has a very wide and important application in predicting the occurrence of diseases [13, 14].

Many studies have shown that in the prediction of cardiovascular diseases, multi-dimensional data such as patients' age, gender, blood pressure, blood lipid, and family history can be intergrated, using logistic regression, decision tree and other algorithms to build a prediction model [15, 16]. Logistic regression algorithm can analyze the linear relationship between these factors and the incidence of cardiovascular diseases and predict the individual incidence probability by calculating the weight of each factor [17]. The decision tree divides the data into tree structures, makes decisions according to different feature nodes, and intuitively shows the logical process of disease prediction. With the help of these models, doctors can intervene patients with high risk factors in advance to prevent the sudden onset of cardiovascular diseases [18]. Based on this, this study takes young hypertensive patients admitted to our hospital as the research object, analyzes the risk factors of anxiety in young hypertensive patients, and constructs a prediction model based on machine learning method.

2. Data and methods

2.1. Research object

According to the research content, young hypertensive patients admitted to our hospital from January 2022 to December 2024 were selected as the research object, and at least 950 patients were included according to the sample size calculation. According to the existence of anxiety, a total of 950 patients were divided into control group (n = 650) and observation group (n = 300), and randomly divided into training set (n = 665) and test set (n = 285) according to the ratio of 7:3. This study has been approved by the hospital's Ethics Committee.

2.2. Inclusion and exclusion criteria

Inclusion criteria: (1) Meet the diagnostic criteria in the Guidelines for Hypertension in China in 2018; (2) Hamilton Anxiety Scale score ≥ 14; (3) 18 years old ≤ 40 years old; (4) Perfect clinical data.

Exclusion criteria: (1) Malignant hypertension; (2) Being conscious and able to communicate normally; (3) Accompanied by blood system diseases; (4) Poor compliance.

2.3. Research methods

The clinical data (gender, age, BMI, education background, marital status, smoking, drinking, sleep disorder, family history of hypertension, history of diabetes, hyperlipidemia and history of cerebral infarction) and laboratory indicators (WBC, PLT, LDL, TG, TC, AST, ALT) were collected for univariate analysis and multivariate Logistic regression analysis, and the efficacy of different models in predicting anxiety in young hypertensive patients was analyzed.

2.4. Statistical methods

Data were analyzed using SPSS 26.0 software. For count data, they were expressed in the form of %, and the correlation between groups was explored with the help of the X^2 test or Fisher's exact probability method; for the metrics that conformed to the normal distribution, the study presented them in the form ($\bar{x} \pm s$) and the significance of the difference was assessed by the t-test. Multifactorial Logistic regression analysis was performed for indicators with differences in univariate analysis. In addition, seven models were constructed in the *R* language to evaluate the efficiency of different predictive models, and $P < 0.05$ indicated that the differences were statistically significant.

3. Results

3.1. Anxiety status of 950 patients

Among 950 patients, n = 300 patients have anxiety, accounting for 31.58%.

3.2. Comparison of clinical indicators between two groups of patients

Taking whether young hypertensive patients are complicated with anxiety as the dependent variable, and taking gender, age, BMI, education background, marital status, smoking, drinking, sleep disorder, family history of hypertension, diabetes, hyperlipidemia, cerebral infarction, WBC, PLT, LDL, TG, TC, AST and ALT as the independent variables, the results show that age, BMI, education background, marital status, as shown in **Table 1**.

Table 1. Univariate analysis of influencing factors of anxiety in young hypertensive patients

Index	Control group (n = 650)	Observation group (n = 300)	X^2/t value	*P* value
Gender			3.382	0.004
Male	320	160		
Woman	330	140		
Age (years)	27.68 ± 2.38	34.15 ± 2.22	39.771	< 0.001
BMI(kg/m2)	25.76 ± 1.37	26.18 ± 1.25	4.513	< 0.001
Academic degree			4.220	0.047
Primary school and below	105	52		
Junior high school and senior high school	365	189		
College or above	180	59		
Marital status			5.921	0.015
be unmarried	315	120		
married	270	115		
Divorced or widowed	65	65		
Smoke	112	130	73.668	< 0.001
Drink Wine/alcohol	106	141	82.500	< 0.001
Sleep disorder			55.134	< 0.001
Have	65	87		
Without	585	213		
Family history of hypertension	85	92	41.891	< 0.001
History of diabetes	67	121	116.582	< 0.001
History of hyperlipidemia	80	91	45.186	< 0.001
History of cerebral infarction	73	84	41.842	< 0.001
WBC(109/L)	6.59 ± 1.67	6.78 ± 1.72	1.615	0.107
PLT (109/L)	189.23 ± 60.02	189.12 ± 56.70	0.027	0.979
LDL(mmol/L)	2.15(1.81, 2.55)	2.20(1.59, 2.43)	-0.459	0.382
TG(mmol/L)	1.12(0.78, 1.85)	1.26(0.75, 1.81)	0.657	0.360
TC(mmol/L)	4.89(4.23, 5.67)	4.59(5.23)	3.390	0.001
AST(U/L)	25.47 ± 12.15	27.28 ± 10.13	1.145	0.175
ALT(U/L)	26.78 ± 11.10	28.10 ± 10.95	1.711	0.087

3.3. Multivariate logistic regression analysis of young hypertensive patients complicated with anxiety

Multivariate logistic regression analysis found that hypertension history, drinking history, coronary heart disease history, diabetes history, BMI, TC, and TG are important independent risk factors affecting anxiety in young hypertensive patients, as shown in **Table 2**.

Table 2. Multivariate logistic regression analysis of anxiety in young hypertensive patients

Variable	*β* value	SE value	Wald	*P*	*OR*	95% *CI*
Constant term	-1.579	0.478	8.239	0.004	0.180	
History of hypertension	1.780	0.312	27.671	0.001	4.579	3.110–10.648
Drinking history	1.167	0.314	12.145	0.001	2.891	1.657–5.420
History of coronary heart disease	0.745	0.750	0.234	0.002	1.760	1.213–3.165
History of diabetes	1.142	0.278	13.453	0.005	3.110	1.770–5.781
BMI	1.316	0.512	7.112	0.015	3.905	2.235–7.112
TC	0.981	0.530	10.901	0.010	2.675	1.678–5.104
TG	1.139	0.441	6.718	0.002	6.453	2.896–6.178

3.4. Model prediction efficiency comparison

As can be seen from the table, Extra Trees has the highest prediction efficiency for young people with hypertension complicated with anxiety, while Decision-Tree has the lowest prediction efficiency. See **Table 3** and **Figure 1**.

Table 3. Comparison of forecasting efficiency of different models

Model	Sensitivity	Specificity	Youden's index	AUC value (95% CI value)
ExtraT rees	0.897	0.916	0.975	0.917(0.981–1.001)
SVM	0.935	0.935	0.920	0.978(0.890–0.976)
XGBoost	0.957	0.827	0.779	0.958(0.943–0.967)
LightGBM	0.872	0.818	0.724	0.934(0.918–0.949)
KNN	0.742	0.825	0.579	0.867(0.814–0.883)
RF	0.710	0.839	0.582	0.855(0.812–0.876)
Decision-Tree	0.659	0.851	0.483	0.820(0.785–0.859)

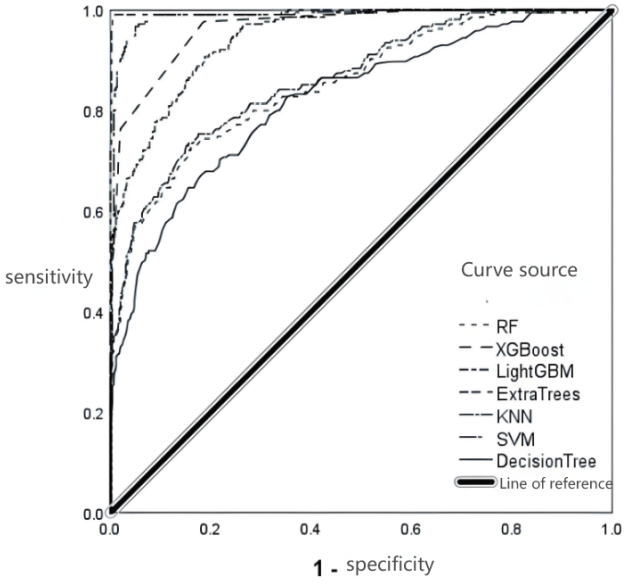

Figure 1. ROC curve of different models for predicting hypertension complicated with anxiety in young people.

4. Discussion

Multivariate logistic regression analysis showed that hypertension history, drinking history, coronary heart disease history, diabetes history, BMI, TC, and TG were important independent risk factors affecting anxiety in young hypertensive patients [19]. Logistic regression analysis shows that gender, drinking history, lack of exercise, other chronic diseases, and insomnia are the risk factors for anxiety and depression in middle-aged and elderly hypertensive patients [20]. Multivariate logistic regression analysis shows that poor economic situation, short medical history of hypertension, diabetes, and coronary heart disease are independent risk factors for anxiety in female hypertensive patients. The validity of this study is verified.

Moreover, the study also found that Extra Trees has the highest prediction efficiency for young people with hypertension complicated with anxiety, while Decision-Tree has the lowest prediction efficiency. To sum up, there are many factors that affect the anxiety of young hypertensive patients, and among different groups of models, Extra Trees model has the best prediction efficiency.

5. Conclusion

Hypertension, along with several other key risk factors, has been identified as significant independent predictors of anxiety in young hypertensive patients. Among these factors, a history of hypertension, alcohol consumption, coronary heart disease, and diabetes play crucial roles in influencing psychological distress. Additionally, body mass index (BMI), total cholesterol (TC), and triglyceride (TG) levels are closely associated with increased anxiety levels in this patient population.

To assess and predict anxiety risk in young hypertensive individuals, various predictive models have been developed and evaluated. Notably, the Extra Trees model (Extremely Randomized Trees) demonstrates superior predictive performance compared to other modeling approaches. Its high accuracy, robustness, and ability to handle complex interactions among risk factors make it the most effective tool for identifying anxiety susceptibility in this demographic. Further research and clinical application of the Extra Trees model could enhance early intervention strategies and improve mental health outcomes for young adults with hypertension.

Disclosure statement

The authors declare no conflict of interest

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