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Value of Multimodal CT in Predicting and Evaluating Collateral Circulation in Patients with Ischemic Stroke

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Abstract: Stroke is a disease that seriously threatens human health. Acute occlusion or rupture of cerebral blood vessels can cause ischemic stroke or cerebral hemorrhage, resulting in neurological deficits and even death. The purpose of this study was to investigate the value of multimodal CT in predicting and evaluating collateral circulation in patients with ischemic stroke. In this article, multimodal computed tomography (mCTA combined with CTP) was used to evaluate collateral circulation, infarct core, and ischemic peninsula in patients with acute ischemic stroke (AIS), and to explore the effects of multimodal CT on blood flow, prevalence, and ischemic peninsula. Prognostic implications of AIS patients. According to the mCTA massage compensation score, the patients were divided into a good circulation group and a poor circulation group (4-5 for good circulation, 0-3 for poor collateral circulation). Affect insurance claims. The differences of CTP parameters in the infarct core area (or ischemic crescent area) between the good and bad coronary groups were compared. The differences of CTP parameters between the infarct core area and the mirror area, the ischemic penumbra area and the mirror area, and the infarct core area and the ischemic penumbra area were compared. Experiments have shown that people with higher LDL levels are less likely to obtain good collateral circulation than those with lower LDL levels (OR=0.672), indicating that lower LDL levels predict collateral circulation. Compensation is good.

1. Introduction

Acute ischemic stroke (AIS) is the most common type of stroke, accounting for about 70% of all strokes in my country. Among them, symptomatic intracranial arterial stenosis caused by large artery atherosclerosis is the main stroke subtype in my country. With the characteristics of high

morbidity, high mortality, high disability rate and high recurrence rate, the disease burden is heavy. Therefore, strengthening the management of such patients is one of the priorities of the prevention and treatment of chronic diseases in my country. Intravenous thrombolysis and mechanical thrombectomy within the time window are the main methods for the treatment of AIS in the hyperacute phase [1-2].

In the analysis of the value of multimodal CT in predicting and evaluating collateral circulation in patients with ischemic stroke, many scholars have studied it and achieved good results. The blood vessels and proximal intracranial blood vessels are well evaluated, but the examination takes a long time and the image quality is easily affected by motion artifacts, and the evaluation of secondary collaterals such as pia mater is not effective [3]. Haranhalli N et al believed that the collateral blood flow visible on MRA played an important role in maintaining regional cerebral blood flow [4].

In this paper, a number of patients with ischemic stroke underwent multimodality computed tomography scans, including computed tomography (NCCT), CT perfusion imaging (CTP), and computed tomography angiography (CTA) within 3 days of admission. Germany Siemens 64 coil CT system for post-processing software. The subjects' cerebral perfusion status and head vascular status were assessed. Exclude cerebral hemorrhage, brain tumor and other diseases through NCCT, record and analyze the hemodynamic statistics provided by CTP, namely cerebral blood flow (CBF), cerebral blood volume (CBV), mean transit time (MTT) and the maximum value of Time (TTP), then assess the perfusion of the cerebral cortex, determine the location and degree of cerebral artery stenosis by CTA, and evaluate the characteristics of circulatory compensation.

2. Analysis of the Value of Multimodal CT in Predicting and Evaluating Collateral Circulation in Patients with Ischemic Stroke

2.1. Evaluation Method of Collateral Circulation

(1) Transcranial Doppler (TCD)

TCD has high sensitivity and specificity in evaluating blood flow by blood flow velocity, blood flow direction, visual changes, and neck pressure test, especially in the evaluation of ocular vascular disease. Although TCD is non-invasive, economical, and easy to operate, it is limited by the poor penetration of the temporal window. The neck compression test will lead to the release of unstable manual signals, resulting in serious complications such as embolism [5].

(2) Cranial Vascular Imaging: MRA and CTA

The study of circulation with this method is limited to the major vessels surrounding the circle of Willis and provides relevant information, including vessel morphology and flow direction. Depending on the MRA imaging technology, MRA may not accurately reflect the blood flow status, and is easily affected by factors such as blood flow, blood flow velocity, post-stenotic lesions, eddy currents, and vehicle negative feedback. Improved MRA average. Likewise, CTA and its complement proteins can provide information about circulation, and in small studies, the DSA grading scale correlates well with the use of CTA. However, neither CTA nor MRA can show cerebral perfusion after cerebral infarction, and the advent of multimodal CT makes up for this deficiency.

2.2. Advantages of Multimodal CT

Multimodal CT is a brain imaging and cerebral angiography technology that has been proven in recent years. It can complete multiple indications (conventional CT plain scan, CT perfusion image and dynamic CTA image) in one examination. Under normal circumstances, the above three

inspections can be completed within 20 minutes, which is very suitable for emergency inspections. Head CTP mapping can assess perfusion status in all directions in patients with cerebrovascular disease. The existence and degree of hemispheric ischemia can be predicted and judged by the changes of CBF and CBV parameters, and the cerebral circulation can be judged by the changes of TTP, MTT, CBF and CBV values. The CTA can detect the stenosis or occlusion of intracranial blood vessels and blood vessels, further clarify the root cause and extent of cerebrovascular disease, and guide clinical diagnosis and treatment [6-7].

2.3. Algorithm Selection

In this paper, the data of multimodal CT prediction evaluation is processed by Bayesian algorithm. The maximum information coefficient can be said to be a broad and fair standard, we can use it to measure the dependence between two variables X and Y, relative to mutual information, its dependence between variables Relationships have higher sensitivity [8-9].

First, the definition of the maximum information coefficient is explained:

In a dataset D containing two node variables X, Y, the eigenmatrix of X and Y is an infinite matrix, which is defined as:

$$M(X,Y|D)_{i,j} = \frac{I^*(X,Y,D,i,j)}{\log \min\{i, j\}} \tag{1}$$

Where $I^*(X,Y,D,i,) = \max I(X,Y,F,D,I_G)$ is the maximum mutual information value between random variables X and Y in grid G at row j and column i.

For a data sample D of sample size n, the maximum information coefficients of the variables X and Y are defined as:

$$MIC(X,Y|D) = \max_{i \times j < B(n)} \{M(X,Y|D)i, j\} \tag{2}$$

Among them, B(n)=n0.6, i ×j<B(n) represents the division dimension limit of grid G.

According to the symmetry of mutual information, the maximum information coefficient between variables X and Y is symmetric, namely [10]

$$MIC(X,Y|D) = MIC(Y,X|D) \tag{3}$$

2.4. Influencing Factors of Collateral Circulation

In this paper, according to the evaluation results of mCTA on collateral circulation, the patients were divided into good and poor collateral circulation groups, and the clinical and laboratory indicators that may affect collateral circulation were counted. Through univariate analysis, it was found that the previous cerebrovascular disease, low-density lipoprotein and homocysteine were significantly different between the two groups. At the same time, in order to explore the relationship between age, hypertension, diabetes and collateral circulation, this study used a decision tree to rank the three significant indicators in univariate analysis, age, hypertension and diabetes, and the six variables were feature importance ranking. According to the ranking results, the top 3 indicators (age, low-density lipoprotein and homocysteine) were selected as independent variables, and whether the collateral circulation was good or not was used as the dependent variable, and multivariate Logistic regression analysis was performed. The final results showed that lower LDL and lower homocysteine predicted good collateral circulation status. Therefore, by controlling the patient's low-density lipoprotein and homocysteine, it is conducive to the formation of good

collateral circulation [11-12].

3. Analysis of the Value of Multimodal CT in Predicting and Evaluating Collateral Circulation in Patients with Ischemic Stroke

3.1. Research Methods

Collateral circulation: First, univariate analysis was carried out on the influencing factors and indexes of collateral circulation with statistical significance in the results of univariate analysis, and the clinically relevant indexes were selected according to the ranking of decision tree. For the importance of attributes, then select the top-ranked important indicators as independent variables, and the quality of side traffic as the dependent variable[13].

Analysis of influencing factors of clinical prognosis: Firstly, the relationship between clinical, laboratory, imaging and other indicators and clinical prognosis was analyzed by univariate, and then the collinearity diagnosis was carried out, and the variables with collinearity were excluded. The statistically significant indicators and demographic information in univariate analysis were used as independent variables, and whether the clinical prognosis was good or not was used as the dependent variable, and were included in different Logistic regression models to explore the factors affecting the prognosis of patients and find the best prognosis prediction model. Model 1: Imaging indicators (compensation of collateral circulation, infarct volume). Model 2: Demographic information (sex, age), clinical variables (admission mRS score), and imaging indicators. Model 3: Demographic information, laboratory measures (homocysteine), and imaging measures. Model 4: Demographic information, clinical variables, laboratory measures, and imaging measures.

3.2. Experimental Design

In this paper, multiple regression analysis is carried out on the three most influential factors ranked by the decision tree algorithm in this paper to judge their influence on the evaluation results. Physicians of the same 45 cases of collateral circulation evaluation results to explore the comparison[14].

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4.1. Regression Analysis

Other studies in this paper on the influencing factors of collateral circulation indicate that age, hypertension and diabetes may also have a certain influence on the establishment of collateral circulation. However, which of these six variables has a greater impact on collateral circulation needs to be further explored[15]. Therefore, this study uses a decision tree to rank these 6 variables by feature importance. Through the ranking results, it can be seen that the top 3 variables are used as independent variables, and whether the collateral circulation is good or not is used as a dependent variable, and multi-factor Logistic regression is performed. Analysis, the data are shown in Table 1.

Table 1. Binary Logistic regression analysis of the factors affecting the collateral circulation

	regression coefficient	standard error	odds ratio
age	0.011	0.397	1.010
low density lipoprotein	-0.392	0.394	0.672
homocysteine	-0.746	0.478	0.460

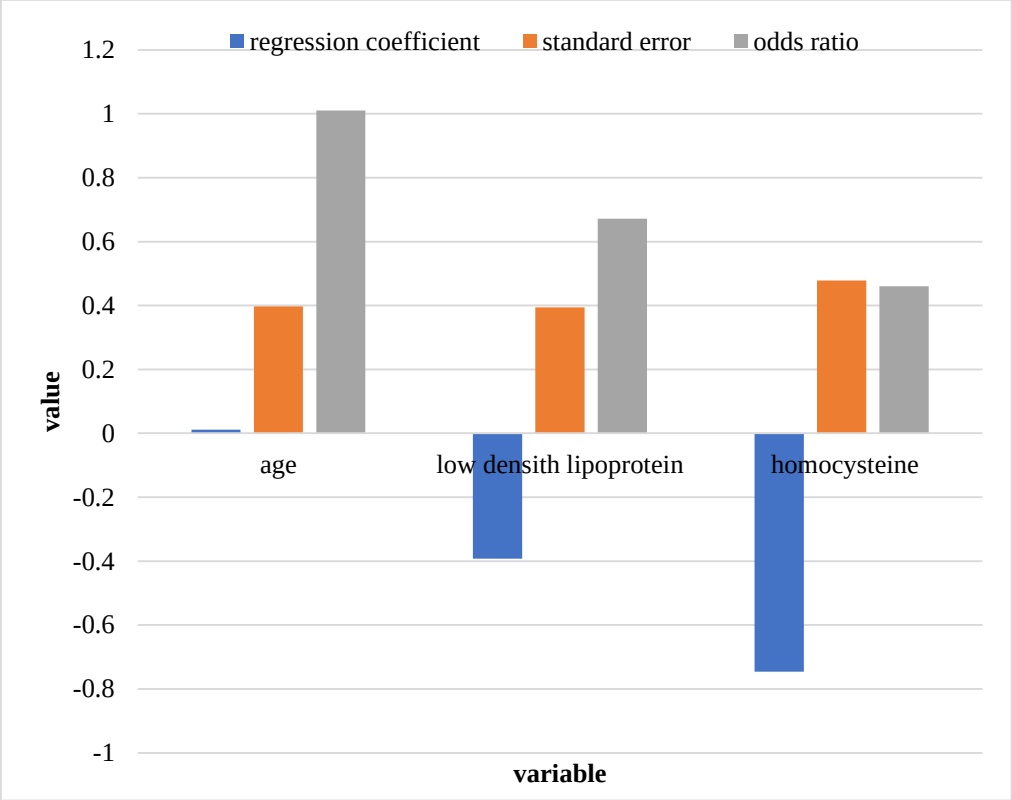

Figure 1. Multivariate logistic regression analysis plot in Fig

As can be seen from Figure 1, those with higher LDL levels are less likely to obtain good collateral circulation than those with lower LDL levels (OR=0.672), indicating that lower LDL levels predict the collateral circulation is well compensated. People with higher homocysteine levels are less likely to obtain good collateral circulation than those with lower homocysteine levels (OR=0.460), indicating that lower homocysteine levels predict collateral circulation generation. Compensation is good. Compared with the younger ones, the possibility of obtaining good collateral circulation was basically the same in older people (OR $\approx$ 1), indicating that age did not significantly affect collateral circulation compensation.

4.2. Consistency Test of Collateral Circulation Assessment Results by Different Assessors

In this paper, in order to verify the consistency of the assessment results of collateral circulation by different assessors, three physicians with different working qualifications were specially invited to assess the same 45 cases of collateral circulation diagrams, and the results of the assessment were recorded. The data are shown in Table 2.

Table 2. Results of different evaluators in assessing cerebral collateral circulation according to mCTA

	Low seniority Neuroologist	Low-seniority imaging physician	Senior senior imaging physician
Good collateral circulation (example)	twenty three	twenty one	twenty three
Poor collateral circulation (example)	twenty two	twenty four	twenty two

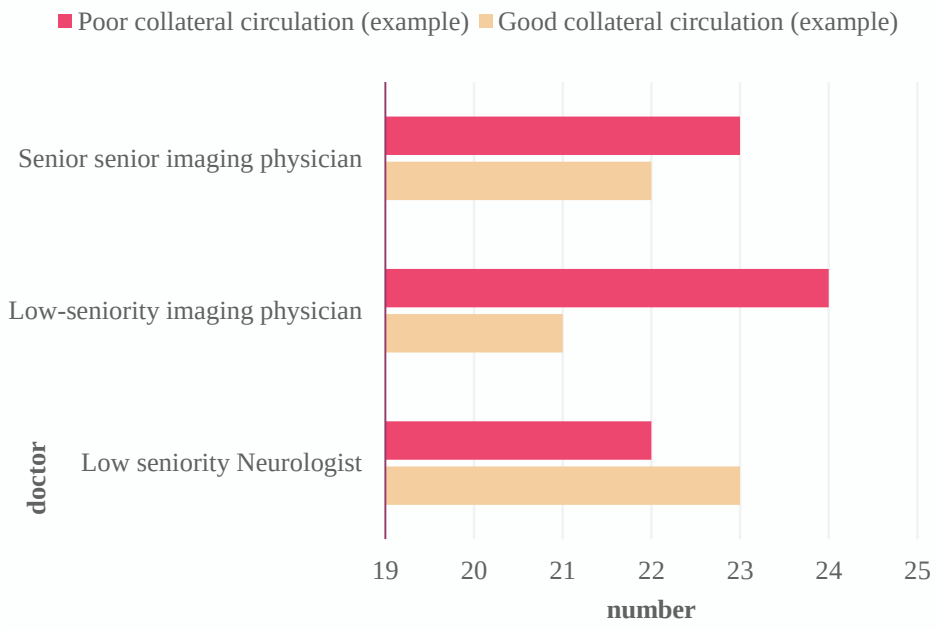

Figure 2. Comparison of evaluation results of the same images with different working years

It can be seen from Figure 2 that the results of the assessment of collateral circulation by the three assessors are consistent, K=0.93 between senior and junior radiologists, and the difference between senior radiologists and junior neurologists Between K=1.0, between junior radiologists and junior neurologists K=0.93.

5. Conclusion

In this study, the multivariate analysis of different clinical outcomes in the short and long term showed that collateral circulation status was an independent factor affecting the short- and long-term prognosis of ischemic stroke beyond the time window. Patients with good collateral scores had better 90-day mRS scores In addition, in the long-term prognosis ROC curve analysis, its area under the curve is the largest, indicating that it has the strongest predictive effect on clinical outcomes. When a large blood vessel in the brain is occluded or severely stenotic, good collateral vessels can keep the ischemic brain tissue at risk alive, and blood flow can reach the blood supply area of the diseased blood vessels in time through collateral branches of different paths. To ensure the blood perfusion of ischemic brain tissue, it is said that the state of collateral circulation has a decisive effect on the infarct core and the area of the penumbra. In the same abnormal area of tissue perfusion, the larger the area of the penumbra, the probability that the patient will obtain a good functional prognosis will be higher. Increase.

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If any, should be placed before the references section without numbering.

Data Availability

The datasets used during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

The author states that this article has no conflict of interest.

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