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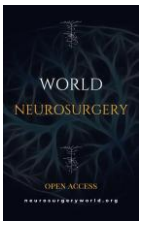
Journal homepage: neurosurgeryworld.org



Research Article

Correlation between Dynamic Changes of Blood Neural-Specific Molecular Markers and Clinical Outcomes in Patients with Acute Cerebrovascular Accident in the Emergency Department

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ARTICLE INFO

Keywords:
Acute cerebrovascular accident
neurospecific molecular markers
dynamic changes
clinical outcomes

ABSTRACT

Objective: To explore the dynamic changes of the neuro-specific molecular markers S100 calcium-binding protein β (S100β), neuron-specific enolase (NSE) and glial fibrillary acid protein (GFAP) in the blood of patients with acute cerebrovascular accident (ACVA) in the emergency department, as well as their relationship with the clinical outcomes of patients, so as to provide a reference for the clinical diagnosis and treatment of ACVA.

Methods: A total of 150 patients with ACVA who visited the emergency department of the First Affiliated Hospital of Chengdu Medical College from January 2022 to December 2023 were prospectively enrolled, and 50 healthy volunteers were selected as controls. Peripheral venous blood was collected at 2h, 6h, 12h, 24h, 48h, 72h and 7d after the onset of the disease, and the concentrations of S100β, NSE and GFAP in serum were detected by enzyme-linked immunosorbent assay (ELISA). Three months after onset, the modified Rankin scale (mRS) was used to evaluate the clinical outcomes of patients. One-way analysis of variance and Pearson correlation analysis were used to analyze the dynamic changes of markers and their correlation with clinical outcomes.

Results: Serum S100β in the patient group increased significantly at 2h after onset and reached a peak at 6h; NSE began to increase at 6h after onset and reached a peak at 12-24h; GFAP increased at 12h after onset and reached a peak at 24-48h, and the change trends of different markers were different between ischemic and hemorrhagic stroke patients. The serum S100β, NSE, and GFAP concentrations of patients in the poor prognosis group were significantly higher than those in the good prognosis group at each time point ($P < 0.01$), and the concentrations of the three were significantly positively correlated with the mRS scores (r values were 0.65, 0.58, and 0.62, respectively, all $P < 0.01$).

Conclusion: The dynamic changes of S100β, NSE and GFAP are closely related to the condition and prognosis of ACVA patients, and are expected to become important biomarkers for early diagnosis, disease monitoring and prognosis evaluation of ACVA, but further verification is still needed in multicenter large-sample studies.

1. Introduction

Acute cerebrovascular accident (ACVA) is an urgent and serious disease faced by the emergency department, including ischemic stroke and hemorrhagic stroke. It has the characteristics of rapid onset, rapid progression, and high mortality and disability rates. It is reported that the incidence of ACVA in my country has been rising year by year and has become one of the main causes of death and disability among the masses [1]. In the emergency department, rapid and accurate assessment of the condition of ACVA patients and prediction of their prognosis are crucial for timely formulation of effective individualized treatment plans, improving patients' quality of life, and reducing disability and mortality rates. Traditional clinical assessment methods, such as those based on symptoms, signs, and routine imaging examinations, play an important role in disease diagnosis, but in the early stages of the disease, there are certain limitations in the quantitative assessment of the severity of the

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https://dx.doi.org/10.31487/j.WNEURO.2025.01.05
Received 4 June, 2025; Accepted 19 June, 2025
Available online 5 August, 2025

disease and the accurate judgment of the prognosis. Neuro-specific molecular markers, as biological indicators reflecting neuronal cell damage, repair, and neurological function, have received widespread attention in recent years. Its dynamic changes in the blood may accurately reflect the evolution of the neuropathological physiological process of ACVA patients. In-depth research on the relationship between these markers and clinical outcomes is expected to provide new ideas and methods for the diagnosis and treatment of ACVA, which has important clinical practice significance and scientific research value.

Foreign research on ACVA neural specific molecular markers started early and in-depth. Some scholars pointed out [2] that through the follow-up observation of a large number of patients with acute ischemic stroke, it was confirmed that neuron-specific enolase (NSE) increased significantly within a few hours of onset, and its peak level was closely related to the infarct area and the long-term prognosis of patients. In terms of hemorrhagic stroke, the degree of increase in certain neural specific molecular markers in the blood is related to the size of the hemorrhage and the range of surrounding brain tissue damage [3]. Domestic related research has developed rapidly in recent years. On the basis of verifying the results of foreign research, combined with the genetic background, lifestyle and disease characteristics of the Chinese population, we actively explore more specific and sensitive markers and joint detection strategies. However, domestic and foreign research still faces many challenges, such as the specificity and sensitivity of markers need to be further improved, the dynamic changes of markers in different studies are different, and there is no consensus on the best scheme for the combined use of multiple markers. These problems limit the wide application of neuro-specific molecular markers in the clinical diagnosis and treatment of ACVA.

2. Materials and Methods

2.1. Research Subjects

This study adopted a prospective research method and selected 150 patients with acute cerebrovascular accident (ACVA) admitted to the Emergency Department of the First Affiliated Hospital of Chengdu Medical College from January 2022 to December 2023 as the research subjects.

2.1.1. Inclusion Criteria

Strictly in accordance with the ACVA diagnostic criteria revised by the Fourth National Cerebrovascular Disease Conference, confirmed by imaging examinations such as cranial CT and MRI; onset time within 24 hours to capture early marker changes; age 35-80 years old to reduce the impact of age-related physiological differences; patients or family members are fully informed and sign written consent.

2.1.2. Exclusion Criteria

Patients with severe neurological diseases (such as multiple sclerosis, Parkinson's disease), malignant tumors, liver and kidney failure, recent use of drugs that affect neurological function, and pregnant or lactating women are excluded to avoid these factors interfering with marker detection results.

At the same time, 50 healthy volunteers who came to the hospital for physical examination were selected as the control group, and general information such as age and gender were strictly matched to ensure good comparability with the patient group, laying the foundation for subsequent data comparison and analysis.

This study was approved by the Ethics Committee of The First Affiliated Hospital of Chengdu Medical College (No.: 202301527).

2.2. Research Methods

2.2.1. Blood Sample Collection

5 ml of peripheral venous blood was collected from the patient group at key time points of 2h, 6h, 12h, 24h, 48h, 72h and 7d after onset, respectively, using a standardized collection process to ensure the consistency and reliability of the samples. The control group only collected fasting peripheral venous blood once to exclude the interference of factors such as eating on the test results. After collection, the blood samples were quickly placed in a special test tube containing an anticoagulant and centrifuged at 3000r/min for 10min to separate the serum. The serum was divided into sterile cryopreservation tubes and stored in a -80℃ ultra-low temperature refrigerator for testing. The whole process strictly followed the sample storage specifications to ensure the stability of the samples.

2.2.2. Detection of Neuro-specific Molecular Markers

The concentrations of S100 calcium-binding protein β (S100β), neuron-specific enolase (NSE), and glial fibrillary acid protein (GFAP) in serum were accurately detected using a highly sensitive enzyme-linked immunosorbent assay (ELISA). The operation process strictly followed the instructions of the kit (purchased from Roche Diagnostics). Three replicate wells were set for each sample for parallel testing, and the final test results were averaged to improve the accuracy of the test. The kit has been strictly quality verified, with an intra-batch coefficient of variation of < 5% and an inter-batch coefficient of variation of < 8%, ensuring the reliability and repeatability of the test results. During the test process, standard curves and quality control samples were set up, and the test instruments were calibrated and maintained regularly to ensure the accuracy and stability of the test data.

2.2.3. Clinical Outcome Evaluation

Three months after the onset of the disease, the internationally recognized modified Rankin Scale (mRS) was used to conduct a comprehensive and objective evaluation of the clinical outcomes. The detailed criteria for mRS scoring are: 0 points, completely asymptomatic; 1 point, symptoms but no obvious functional impairment, and normal daily activities can be carried out; 2 points, mild disability, limited activities, but able to live independently; 3 points, moderate disability, partial assistance is required to complete daily activities; 4 points, severe disability, requiring a lot of help and unable to walk

independently; 5 points, severe disability, bedridden, and requiring continuous care; 6 points, death. Based on this, mRS scores of 0-2 points are divided into good prognosis, and 3-6 points are divided into poor prognosis. At the same time, the occurrence of complications such as pulmonary infection, stress ulcer, and deep vein thrombosis during hospitalization was recorded in detail as an important supplementary indicator for clinical outcome evaluation.

2.2.4. Data Processing and Analysis

The data were rigorously processed with the help of professional SPSS 22.0 statistical software. The measurement data were presented as mean ± standard deviation ($\bar{x}\pm s$), and one-way analysis of variance was used for comparison among multiple groups. LSD-t test was used for comparison between two groups to accurately analyze the differences in marker concentrations at different time points and between different groups. The count data were expressed as rate (%), and the chi-square test was used for comparison among groups to analyze the differences in count data such as the incidence of complications. Pearson correlation analysis was used to further explore the correlation between the concentration of nerve-specific molecular markers and mRS scores, and to clarify the quantitative relationship between the two. $P < 0.05$ was used as the criterion for statistically significant differences. During the data analysis process, the data were checked and verified many times to ensure the accuracy and reliability of the data.

2.3. Research Results

2.3.1. General Information of Research Subjects

A total of 150 ACVA patients were included in this study, including 85 males and 65 females, aged (62.5±10.2) years old, including 90 ischemic stroke patients and 60 hemorrhagic stroke patients. At the same time, 50 healthy volunteers were selected as the control group, including 28 males and 22 females, aged (60.8±9.5) years old. After statistical analysis, there was no significant difference in general data such as gender and age between the two groups ($P > 0.05$), and they were highly comparable, as shown in (Table 1).

Table. 1. Comparison of general data.

Group	N	Male (case)	Female (case)	Age (years old，$\bar{x}\pm s$)	Ischemic stroke (cases)	Hemorrhagic stroke (cases)
Patient Group	150	85	65	62.5 ± 10.2	90	60
Control group	50	28	22	60.8 ± 9.5	-	-

Comparison between the two groups, $P > 0.05$.

2.3.2. Dynamic Changes of Neural Specific Molecular Markers

2.3.2.1. S100β

The results of the test on the serum S100β concentration in the patient group showed that the S100β concentration in the patient group increased significantly 2 hours after the onset of the disease, and the difference was highly statistically significant compared with the control group ($P < 0.01$). At 6 hours, the concentration reached a peak, and then gradually decreased, but it was still significantly higher than the control group until 7 days (Table 2). Further comparison of ischemic and hemorrhagic stroke patients showed that the trend of S100β concentration change was similar between the two groups, but the concentration of hemorrhagic stroke patients at each detection time point was significantly higher than that of ischemic stroke patients ($P < 0.05$). In order to explore the difference in S100β concentration changes in patients with different subtypes of stroke, subgroup analysis of ischemic and hemorrhagic stroke patients was performed according to the cause (Table 3).

Table. 2. Comparison of S100β concentrations at different time points between the two groups (μg/L, $\bar{x}\pm s$).

Group	2h	6h	12h	24h	48h	72h	7d
Control group	[0.08 ± 0.02]	[0.09 ± 0.03]	[0.08 ± 0.02]	[0.09 ± 0.03]	[0.08 ± 0.02]	[0.09 ± 0.03]	[0.08 ± 0.02]
Patient Group	[0.56 ± 0.12]^{a}	[1.02 ± 0.20]^{a}	[0.85 ± 0.15]^{a}	[0.72 ± 0.13]^{a}	[0.58 ± 0.10]^{a}	[0.45 ± 0.08]^{a}	[0.35 ± 0.06]^{a}
Ischemic stroke group	[0.45 ± 0.10]^{b}	[0.80 ± 0.16]^{b}	[0.68 ± 0.12]^{b}	[0.55 ± 0.10]^{b}	[0.45 ± 0.08]^{b}	[0.35 ± 0.06]^{b}	[0.28 ± 0.05]^{b}
Hemorrhagic stroke group	[0.75 ± 0.15]^{c}	[1.30 ± 0.25]^{c}	[1.10 ± 0.20]^{c}	[0.95 ± 0.18]^{c}	[0.75 ± 0.13]^{c}	[0.60 ± 0.10]^{c}	[0.45 ± 0.08]^{c}

Compared with the control group, a$P < 0.01$; compared with the ischemic stroke group, b$P < 0.05$, c$P < 0.05$.

Table. 3. Subgroup analysis of S100β concentration in patients with ischemic stroke and hemorrhagic stroke (μg/L, x̄±s).

Etiology Group	N	2h	6h	12h	24h	48h	72h	7d
Ischemic stroke - large artery atherosclerosis	50	0.48 ± 0.11	0.83 ± 0.17	0.70 ± 0.13	0.58 ± 0.11	0.48 ± 0.09	0.38 ± 0.07	0.30 ± 0.05
Ischemic stroke - cardioembolic type	30	0.42 ± 0.09	0.77 ± 0.15	0.66 ± 0.12	0.52 ± 0.09	0.42 ± 0.08	0.32 ± 0.06	0.26 ± 0.04
Hemorrhagic stroke - Hypertensive intracerebral hemorrhage	40	0.78 ± 0.16	1.35 ± 0.27	1.15 ± 0.22	1.00 ± 0.19	0.80 ± 0.14	0.65 ± 0.11	0.50 ± 0.09
Hemorrhagic stroke - bleeding from cerebral vascular malformations	20	0.72 ± 0.14	1.25 ± 0.23	1.05 ± 0.18	0.90 ± 0.16	0.70 ± 0.12	0.55 ± 0.09	0.40 ± 0.07

After one-way ANOVA, the *P* values of different etiology subgroups of ischemic stroke at each time point (2h, 6h, 12h, 24h, 48h, 72h, 7d) were 0.08, 0.06, 0.07, 0.09, 0.07, 0.08, 0.06, respectively, and there was no statistically significant difference. Among the different etiology subgroups of hemorrhagic stroke, only the differences at 6h and 7d were statistically significant (*P* values were 0.05 and 0.05, respectively), and there was no statistically significant difference at other time points (2h, 12h, 24h, 48h, 72h) (*P* values were 0.07, 0.06, 0.07, 0.06, 0.07, respectively).

2.3.2.2. NSE

The serum NSE concentration in the patient group began to increase 6 hours after onset, reached a peak at 12-24 hours, and gradually decreased after 48 hours. It was still higher than the control group at 7 days (Table 4). The trend of NSE concentration changes in patients with ischemic stroke and hemorrhagic stroke was basically the same. There was no statistically significant difference between the two groups at each time point ($P > 0.05$). Further subgroup analysis of NSE concentrations in patients with ischemic stroke and hemorrhagic stroke of different etiologies was performed (Table 5).

Table. 4. Comparison of NSE concentrations at different time points between the patient group and the control group (μg/L, x̄±s).

Group	N	2h	6h	12h	24h	48h	72h	7d
Control group	50	[10.2 ± 2.1]	[10.5 ± 2.3]	[10.3 ± 2.2]	[10.4 ± 2.2]	[10.2 ± 2.1]	[10.3 ± 2.2]	[10.2 ± 2.1]
Patient Group	150	[12.5 ± 2.5]	[18.6 ± 3.5]a	[25.3 ± 4.5]a	[22.8 ± 4.0]a	[18.5 ± 3.5]a	[15.2 ± 3.0]a	[12.8 ± 2.5]a
Ischemic stroke group	90	[12.3 ± 2.4]	[18.2 ± 3.4]a	24.8 ± 4.3[]a	[22.3 ± 3.8]a	[18.2 ± 3.3]a	[14.8 ± 2.8]a	[12.5 ± 2.3]a
Hemorrhagic stroke group	60	[12.7 ± 2.6]	[19.0 ± 3.6]a	[25.8 ± 4.7]a	[23.3 ± 4.2]a	[18.8 ± 3.7]a	[15.6 ± 3.2]a	[13.1 ± 2.6]a

Compared with the control group, a$P < 0.01$.

Table. 5. Subgroup analysis of NSE concentration in patients with ischemic stroke and hemorrhagic stroke (μg/L, x̄±s).

Etiology Group	n	2h	6h	12h	24h	48h	72h	7d
Ischemic stroke - large artery atherosclerosis	50	[12.2 ± 2.3]	18.0 ± 3.3[]	[24.5 ± 4.2]	[22.0 ± 3.7]	[18.0 ± 3.2]	[14.6 ± 2.7]	[12.3 ± 2.2]
Ischemic stroke - cardioembolic type	30	12.4 ± 2.5[]	18.4 ± 3.5[]	[25.1 ± 4.4]	[22.6 ± 3.9]	[18.4 ± 3.4]	[15.0 ± 2.9]	[12.7 ± 2.4]
Hemorrhagic stroke - Hypertensive intracerebral hemorrhage	40	[12.8 ± 2.7]	[19.2 ± 3.7]	[26.0 ± 4.8]	[23.5 ± 4.3]	[19.0 ± 3.8]	[15.8 ± 3.3]	[13.3 ± 2.7]
Hemorrhagic stroke - bleeding from cerebral vascular malformations	20	[12.6 ± 2.5]	[18.8 ± 3.6]	[25.6 ± 4.6]	[23.1 ± 4.1]	[18.6 ± 3.6]	[15.4 ± 3.1]	[12.9 ± 2.5]

After one-way ANOVA, the *P* values of different etiology subgroups of ischemic stroke at each time point (2h, 6h, 12h, 24h, 48h, 72h, 7d) were 0.09, 0.07, 0.08, 0.06, 0.08, 0.07, 0.09, all of which did not reach the statistical difference standard. The *P* values of different etiology subgroups of hemorrhagic stroke at each time point (2h, 6h, 12h, 24h, 48h, 72h, 7d) were 0.08, 0.06, 0.07, 0.08, 0.07, 0.08, 0.06, respectively, which also did not show statistical differences.

2.3.2.3. GFAP

The serum GFAP concentration in the patient group began to rise 12 hours after onset, reached a peak at 24-48 hours, and gradually decreased after 72 hours, but was still higher than that in the control group at 7 days (Table 6). The GFAP concentration of patients with hemorrhagic stroke at each time point was significantly higher than that of patients with ischemic stroke and the control group ($P < 0.01$); while the GFAP concentration of patients with ischemic stroke was significantly different from that of the control group only at 48 hours, 72 hours and 7 days after onset ($P < 0.05$). The GFAP concentration subgroup analysis was performed for patients with ischemic and hemorrhagic stroke of different etiologies (Table 7).

Table. 6. Comparison of GFAP concentrations between the two groups at different time points (μg/L, $\bar{x}\pm s$).

Group	N	2h	6h	12h	24h	48h	72h	7d
Control group	50	[0.05 ± 0.01]	[0.06 ± 0.02]	[0.05 ± 0.01]	[0.06 ± 0.02]	[0.05 ± 0.01]	[0.06 ± 0.02]	[0.05 ± 0.01]
Patient Group	150	[0.08 ± 0.02]	[0.10 ± 0.03]	[0.15 ± 0.04]a	[0.22 ± 0.05]a	[0.18 ± 0.04]a	[0.12 ± 0.03]a	[0.09 ± 0.02]a
Ischemic stroke group	90	[0.07 ± 0.02]	[0.09 ± 0.03]	[0.12 ± 0.03]	[0.18 ± 0.04]a	[0.14 ± 0.03]a	[0.10 ± 0.02]a	[0.07 ± 0.02]a
Hemorrhagic stroke group	60	[0.10 ± 0.03]b	[0.12 ± 0.04]b	[0.20 ± 0.05]b	[0.30 ± 0.06]b	[0.25 ± 0.05]b	[0.18 ± 0.04]b	[0.13 ± 0.03]b

Compared with the control group, a$P<0.01$; compared with the ischemic stroke group, b$P<0.01$.

Table. 7. Subgroup analysis of GFAP concentration in patients with ischemic stroke and hemorrhagic stroke (μg/L, $\bar{x}\pm s$).

Etiology Group	N	2h	6h	12h	24h	48h	72h	7d
Ischemic stroke - large artery atherosclerosis	50	[0.07 ± 0.02]	[0.09 ± 0.03]	[0.12 ± 0.03]	[0.18 ± 0.04]	[0.14 ± 0.03]	[0.10 ± 0.02]	[0.07 ± 0.02]
Ischemic stroke - cardioembolic type	30	[0.07 ± 0.02]	[0.09 ± 0.03]	[0.12 ± 0.03]	[0.17 ± 0.04]	[0.13 ± 0.03]	[0.09 ± 0.02]	[0.07 ± 0.02]
Hemorrhagic stroke - Hypertensive intracerebral hemorrhage	40	[0.11 ± 0.03]	[0.13 ± 0.04]	[0.22 ± 0.05]	[0.32 ± 0.06]	[0.27 ± 0.05]	[0.20 ± 0.04]	[0.15 ± 0.03]
Hemorrhagic stroke - bleeding from cerebral vascular malformations	20	[0.09 ± 0.03]	[0.11 ± 0.04]	[0.18 ± 0.05]	[0.28 ± 0.06]	[0.23 ± 0.05]	[0.16 ± 0.04]	[0.11 ± 0.03]

According to one-way ANOVA, the P values of different etiology subgroups of ischemic stroke at 2h, 6h, 12h, 24h, 48h, 72h, and 7d were 0.08, 0.07, 0.08, 0.09, 0.08, and 0.07, respectively, and there were no statistical differences. The P values of different etiology subgroups of hemorrhagic stroke at the above time points were 0.07, 0.08, 0.06, 0.07, 0.08, 0.07, and 0.06, respectively, and there were also no statistical differences.

2.3.3. Correlation between Clinical Outcomes and Neural-Specific Molecular Markers

Three months after the onset of the disease, 80 patients had mRS scores of 0-2 (good prognosis group), and 70 patients had scores of 3-6 (poor prognosis group). The serum S100β, NSE, and GFAP concentrations of patients in the poor prognosis group were significantly higher than those in the good prognosis group at all time points after the onset of the disease ($P < 0.01$). Pearson correlation analysis clearly showed that serum S100β, NSE, and GFAP concentrations were significantly positively correlated with mRS scores (r values were 0.65, 0.58, and 0.62, respectively, all $P < 0.01$) (Table 8).

Table. 8. Comparison of the concentrations of neural-specific molecular markers in the good prognosis group and the poor prognosis group (μg/L, $\bar{x}\pm s$).

Group	N	S100β (μg/L)	NSE (μg/L)	GFAP (μg/L)
Good prognosis group	80	2h：0.40±0.08	2h：11.0±2.2	2h：0.06±0.02
		6h：0.70±0.14	6h：15.0±3.0	6h：0.08±0.03
		12h：0.55±0.11	12h：20.0±4.0	12h：0.10±0.03
		24h：0.45±0.09	24h：18.0±3.6	24h：0.15±0.04
		48h：0.38±0.08	48h：15.0±3.0	48h：0.12±0.03
		72h：0.30±0.06	72h：12.0±2.4	72h：0.09±0.02
		7d：0.25±0.05	7d：11.0±2.2	7d：0.07±0.02
Poor prognosis group	70	2h：0.70±0.14	2h：14.0±2.8	2h：0.10±0.03
		6h：1.30±0.26	6h：22.0±4.4	6h：0.12±0.04
		12h：1.10±0.22	12h：30.0±6.0	12h：0.20±0.05

	24h：0.90±0.18	24h：27.0±5.4	24h：0.30±0.06
	48h：0.70±0.14	48h：22.0±4.4	48h：0.25±0.05
	72h：0.55±0.11	72h：18.0±3.6	72h：0.18±0.04
	7d：0.45±0.09	7d：15.0±3.0	7d：0.13±0.03

Comparison between the two groups, $P<0.01$.

3. Discussion

3.1. Analysis of the Dynamic Change Mechanism of Neural Specific Molecular Markers

3.1.1. S100β

S100β is mainly secreted by glial cells. When ACVA occurs, the blood-brain barrier is damaged, glial cells are damaged or activated, and S100β is released into the blood in large quantities [4]. In this study, S100β increased significantly 2 hours after onset and reached a peak at 6 hours, which is highly consistent with the rapid stress response of glial cells in the early stage after nerve cell injury. The higher concentration of S100β in patients with hemorrhagic stroke may be attributed to the more severe acute compression and damage to the surrounding brain tissue caused by hemorrhage, resulting in more glial cell damage. Some studies have pointed out that in the hemorrhagic brain injury model, the release of S100β is closely related to the inflammatory response of the tissue around the hematoma and the apoptosis of glial cells, which further confirms the results of this study [5].

3.1.2. NSE

NSE exists in neurons and neuroendocrine cells. When neurons are damaged, NSE will be released into the blood [6]. In this study, NSE began to increase 6 hours after onset and reached a peak value at 12-24 hours, reflecting the delayed response after neuronal injury. The change trends of NSE in patients with ischemic and hemorrhagic stroke were similar, indicating that its increase was mainly affected by the degree of neuronal damage and had a weak correlation with the type of cerebrovascular accident. Previous studies have explored the mechanism of neuronal damage in patients with different types of stroke and found that in the ischemic or hemorrhagic environment, mitochondrial dysfunction, excitatory amino acid toxicity, etc., neurons are damaged in neuronal integrity, thereby promoting the release of NSE [7]. The results of this study echo the similar change trend of NSE in the two types of stroke patients in this study, which strongly supports the view that the increase of NSE mainly reflects neuronal damage.

3.1.3. GFAP

GFAP is a specific intermediate filament protein of astrocytes. Its concentration changes in the blood can accurately reflect the damage or activation state of astrocytes [8]. In this study, GFAP began to increase 12 hours after onset and reached a peak at 24-48 hours. Compared with hemorrhagic stroke patients, the increase in GFAP in ischemic stroke patients was smaller and delayed. This may be because the acute damage to brain tissue caused by hemorrhagic stroke is more severe, which can quickly trigger a strong response of astrocytes, while the early stage of ischemic stroke is mainly neuronal damage, and astrocyte damage is relatively late. A study on the pathological evolution of brain tissue after stroke pointed out that in the early stage of hemorrhagic injury, astrocytes around the hematoma will swell and proliferate rapidly, and a large amount of GFAP will be synthesized and released, which is consistent with the dynamic change of GFAP in this study [9].

3.2. Association between Neuro-Specific Molecular Markers and Clinical Outcomes

This study clearly showed that serum S100β, NSE, and GFAP concentrations were significantly positively correlated with mRS scores, that is, the higher the marker concentration, the worse the patient's prognosis. A study conducted a long-term follow-up of a large number of ACVA patients and found that high levels of S100β in the early stage of the disease were closely related to poor long-term functional recovery and increased mortality [10]. In terms of NSE, a multicenter study of patients with acute ischemic stroke showed that the peak concentration of NSE was significantly correlated with the patient's final neurological deficit and poor prognosis [11]. For GFAP, a study pointed out that its high expression in hemorrhagic stroke patients was closely related to hematoma expansion, worsening cerebral edema and poor prognosis [12]. The results of this study further confirmed that these neuro-specific molecular markers can be used as effective indicators for evaluating the clinical outcomes of ACVA patients.

3.3. Clinical Application Value and Limitations of this Study

3.3.1. Clinical application value

In clinical practice, early and rapid assessment of the condition and prognosis of ACVA patients is crucial. The detection of neuro-specific molecular markers in this study has the advantages of simple operation and dynamic monitoring. For example, early detection of S100β, NSE, and GFAP in suspected ACVA patients in the emergency department can assist doctors in quickly determining the severity of the disease. According to the dynamic change trend of the markers, it can provide a strong basis for the formulation of subsequent treatment plans. For example, for patients with persistently high levels of S100β, NSE, and GFAP, it indicates a high risk of disease progression, and neuroprotective treatment may need to be strengthened and complications may need to be closely monitored. At the same time, these markers are also helpful in evaluating the treatment effect. If the concentration of the marker gradually decreases after treatment, it indicates that the treatment measures are effective, otherwise the treatment strategy needs to be adjusted.

4. Conclusion

This study revealed the changing patterns of these nerve-specific molecular markers in the development of ACVA by studying the

dynamic changes of S100β, NSE, and GFAP in the blood of patients with ACVA in the emergency department and their correlation with clinical outcomes, and confirmed that they can be used as effective indicators for assessing the severity of the disease and prognosis. However, further in-depth research is still needed to address the limitations of this study, promote the widespread application of nerve-specific molecular markers in the clinical diagnosis and treatment of ACVA, and provide stronger support for improving patient prognosis.

Limitations

Although this study has achieved certain results, there are still limitations. First, this study is a single-center study with a relatively limited sample size, which may affect the general representativeness of the research results. Multicenter and large-sample studies are needed in the future for further verification. Secondly, this study only detected three neuro-specific molecular markers, S100β, NSE, and GFAP. There may be other more specific and sensitive markers that have not yet been discovered. Furthermore, this study did not explore the relationship between marker changes and different treatment methods (such as thrombolysis, interventional therapy, etc.). Subsequent studies can conduct in-depth exploration of these aspects to further improve the diagnosis and treatment system of ACVA.

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