doi.org/10.36721/PJPS.2025.38.3.REG.14092.1

The effect of pentoxifylline on blood biomarkers in patients with cerebral infarction combined with senile debilitating syndrome: Implications for prognosis

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Abstract: Cerebral infarction combined with senile debilitating syndrome seriously affects the quality of life of patients, this study analyzed the effect of pentoxifylline on the expression of blood biomarkers in patients with this disease and its relationship with prognosis. 100 patients with cerebral infarction combined with senile debilitating syndrome admitted to our hospital from December 2022 to December 2024 were divided into control and study groups, both groups were treated with basic therapy, and study group were additionally treated with pentoxifylline. The neurological deficit degree (NIHSS score) and Montreal Cognitive Assessment (MoCA) score, coagulation function indicators, blood rheology indicators, inflammatory indicators, clinical efficacy and adverse reactions were analyzed. The relationship of blood biomarker expression with prognosis was assessed using logistic regression analysis and receiver operating characteristic (ROC) curve. After treatment, all indicators in both groups were superior to the pre-treatment (P<0.05). NIHSS score, haematological indicators, inflammatory indicators and adverse reaction incidences of study group were below to control group, MoCA score, coagulation function indexes and clinical efficacy were above to control group (P<0.05). Logistic regression and ROC results showed the effect of blood biomarker expression and prognosis were remarkably correlated. The treatment is efficacious and worthy of clinical promotion.

Keywords: Pentoxifylline; cerebral infarction; senile debilitating syndrome; blood biomarkers; prognosis

Submitted on 07-02-2025 – Revised on 01-04-2025 – Accepted on 03-04-2025

INTRODUCTION

Cerebrovascular disease is characterized by high mortality and disability rates, and has now become an important disease that jeopardizes the lives and health of the elderly (Y Li *et al*., 2025; Mi *et al*., 2024). Being among the most common categories of cerebrovascular diseases, the prevalence and severity of acute cerebral infarction cannot be ignored (Y Zhang *et al*., 2023). As the aging process continues to intensify, the incidence of acute cerebral infarction in the elderly population is also increasing year by year, which has become a social health problem that cannot be ignored (Shao *et al*., 2022). Firstly, with ageing, a series of physiological changes occur in the human body's blood vessels and organs, and problems such as decreased vascular elasticity, slowed blood flow, and abnormal lipid metabolism gradually emerge. All these factors provide a pathological basis for the occurrence of acute cerebral infarction. Secondly, the elderly often suffer from a variety of chronic diseases, such as hypertension and diabetes. These diseases will further aggravate vascular damage and increase the risk of cerebral infarction. The lifestyle and dietary habits of the elderly may also increase the risk of acute cerebral infarction. Poor lifestyle habits such as lack of exercise, unbalanced diet and excessive intake of high-salt and high-fat foods may increase the risk of blood vessel blockage, which in turn may induce cerebral infarction (Yang *et al*., 2022). Elderly patients with acute cerebral infarction may suffer from post-stroke motor dysfunction, speech disorders, anxiety, and depression, which not only seriously affects their physical and mental health, but also imposes a heavy economic burden on their families and society. Therefore, it is necessary to carry out relevant studies on elderly patients with cerebral infarction (Umemura *et al*., 2020).

Some studies have pointed out that cerebral infarction is an important cause of debilitating syndrome in elderly patients, and debilitating syndrome will accelerate the deterioration of cerebral infarction, trigger the decline of the patient's body functions, and increase the risk of cognitive disorders, which seriously affects the patient's quality of life (J Li *et al*., 2024). As a common geriatric syndrome, frailty has become a key focus in geriatric research. Frailty refers to the increased susceptibility of older adults to endogenous or exogenous stimuli due to various degenerative changes and the presence of many chronic diseases, and is centred on a decline in the cumulative physiological reserve function of multiple systems in older adults. Older adults experiencing frailty have a reduced capacity to respond to the stresses of the external environment, and when smaller external stimuli are present, a variety of adverse outcomes, such as falls, hospitalisation, disability and even death, can occur in this population (Bai, 2022; Gu *et al*., 2023). An increasing number of studies over the recent years showed that

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debility is the key factor of cerebral infarction. The impact of debility on cerebral infarction extends throughout the pre-hospitalisation, hospitalisation and post-hospitalisation period, and is associated with a range of adverse outcomes such as prolonged hospitalisation, disability and death after cerebral infarction (Evans *et al*., 2022). Cerebral infarction combined with senile debilitating syndrome further complicates the disease and places a heavy burden on the healthcare system and the patient's family. Therefore, early detection of cerebral infarction combined with senile debilitating syndromes and targeted interventions can help to slow down their disease process and improve prognosis, thus avoiding adverse outcomes (Vasconcelos *et al*., 2021).

Pentoxifylline is a blood rheology improving agent with the effects of inhibiting inflammatory response and regulating immunity etc. It can improve blood circulation without dilating blood vessels, and is commonly used clinically to improve the cerebral circulation and peripheral vascular disease treatment after acute cerebral infarct (González Pacheco *et al*., 2020). In addition, as an anti-inflammatory drug, pentoxifylline alleviates cognitive deficits in schizophrenia and reduces the symptom of psychiatric disorders (Sinichi *et al*., 2023). Wang *et al*. found that pentoxifylline has a significant therapeutic effect on patients with nondemented cerebral small-vessel disease, which effectively improves cognitive and neurological functions and improves patients' clinical symptoms (S Wang *et al*., 2021). Therefore, pentoxifylline was chosen to treat cerebral infarction combined with senile debilitating syndrome in this study to analyze its clinical efficacy.

There are fewer clinical studies on pentoxifylline on the therapy of cerebral infarction with senile debilitating syndrome. By combining these two conditions in elderly patients and analyzing the relationship between their blood biomarkers and prognosis after treatment, it is possible to understand the effectiveness of the treatment plan by detecting the changes in the blood biomarkers in the patient's body, so as to make corresponding adjustments and decisions.

It has important implications for the clinical treatment. Hence, the research mainly observes the clinical effectiveness of pentoxifylline on cerebral infarction combined with senile debilitating syndrome, analyses its effect on the improvement of mental state and cognitive dysfunction of patients and explores its effect on the expression of blood biomarkers. Meanwhile, the relationship between blood biomarker expression and prognosis was analysed in conjunction with the relationship between coagulation function indexes, hematological indexes and serum inflammatory factor levels and prognosis, with a view to providing a new scientific basis on the therapy of cerebral infarction with senile debilitating syndromes.

MATERIALS AND METHODS

Research design

This study is a systematic evaluation and integration aimed at comparatively analysing the therapeutic efficacy of pentoxifylline on the therapy of cerebral infarction with senile debilitating syndrome and further evaluating its impact on the expression of blood biomarkers and its relationship with prognosis. The design of this study is that of controlled randomized trial design conducted in multiple clinical centres. One hundred patients with cerebral infarction with senile debilitating syndrome patients admitted from December 2021 to December 2024 were enrolled and categorised into two groups, the study group (n=50) and the control group (n=50), based on various treatment protocols. fig. 1 is a flow chart showing that after recruiting patients and passing the inclusion and exclusion criteria in this study, the patients were randomly divided into the study group and the control group according to the treatment method, and the indicators changes before and after the treatment were observed, and finally statistically analyzed.

Randomization and blinding

Randomisation for this study was carried out by an independent member of staff. A computer programme generated a random allocation table and placed each allocation in a separate envelope as a means of randomising participants into observation and control groups, a process that was opaque to participants. The interventions during treatment could not be blinded to patients and treating physicians, but the outcome assessment worker in this study was blinded to treatment allocation.

Diagnostic standards

(1) Diagnostic criteria for cerebral infarction refer to the Guide to Diagnosis and Treatment of Acute Ischaemic Stroke in China (Chinese Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke 2023); (2) Diagnostic criteria for debilitating syndrome refer to Geriatrics (Erbas Sacar, 2020).

Inclusion and exclusion criteria

Inclusion criteria: (1) Meeting the above standards; (2) Belonging to the patients in the recovery stage and conscious; (3) First time onset of illness; (4) Age range 60-85; (5) Patients and their families were informed and consented.

Exclusion criteria

(1) Combined with craniocerebral trauma, cerebral haemorrhage or subarachnoid haemorrhage; (2) Coagulation disorders or immune system diseases; (3) Allergy to the study drug; (4) Haemorrhagic cerebral infarction; (5) Received cerebral infarction-related treatment before admission.

Table 1: Modified Rankin Scale

Level	Judgement Criteria
0	Completely normal
1	Combined symptoms of neurological deficits, but no obvious functional impairment, able to complete usual daily life
2	Mildly disabled, unable to complete all activities, but can do things on their own without help from others.
3	Moderate disability, unable to live independently, requiring supervision, only able to carry out part of indoor activities, limited ability to work and social interaction
4	Severe disability, requiring assistance at all times in daily life. Limiting all activities to bed or wheelchair, unable to carry out normal work, and with severely impaired social functioning
5	Severe disability, totally unable to take care of oneself in daily life, totally dependent on others, otherwise life cannot be maintained. Unconsciousness. Bed-ridden due to limitation of all activities, total loss of labour ability

Table 2: Baseline characteristics of patients in each group

Parameter	Control group (n=50)	Study group (n=50)	t/x^2	P
Age (year)	70.52±8.68	69.03±8.73	-0.856	0.394
Gender (Male/Female)	26/24	27/23	0.040	0.841
Body mass index (kg/m^2)	21.78±2.67	22.19±1.98	0.872	0.385
Smoking	19/31	20/30	0.042	0.838
Alcohol consumption	31/19	29/21	0.167	0.683
Hypertension	33/17	31/19	0.174	0.677
Diabetes	40/10	41/9	0.065	0.799
Systolic blood pressure (mmHg)	132.63±16.25	130.06±16.21	-0.792	0.430
Diastolic blood pressure (mmHg)	75.29±8.89	76.24±9.12	0.527	0.599
Hyperlipidaemia	30/20	32/18	0.170	0.680
Coronary heart disease	13/37	11/39	0.219	0.640

Table 3: Comparison of NIHSS scores ($\bar{x}$±s, score)

	Control group	Study group	t/x^2	P
Pre-treatment	13.78±1.86	14.26±1.76	1.325	0.188
Post-treatment	9.88±1.35	7.54±1.51	-8.169	<0.001
t/x^2	-11.999	-20.491		
P	<0.001	<0.001		

Table 4: Comparisons of MoCA scores ($\bar{x}$±s, score)

	Control group	Study group	t/x^2	P
Pre-treatment	19.28±3.27	19.59±3.45	0.461	0.646
Post-treatment	22.27±4.05	25.08±4.01	3.486	<0.001
t/x^2	4.062	7.339		
P	<0.001	<0.001		

Table 5: Comparison of coagulation function indexes ($\bar{x}$±s, s)

norm	time	Control group	Study group	t	P
TT	Pre-treatment	9.81±2.07	9.59±2.01	-0.539	0.591
	Post-treatment	14.15±2.23*	17.36±2.65*	6.554	<0.001
PT	Pre-treatment	10.87±2.01	11.02±1.90	0.383	0.702
	Post-treatment	12.98±1.62*	15.06±1.72*	6.225	<0.001
APTT	Pre-treatment	22.65±2.07	22.79±1.73	0.367	0.714
	Post-treatment	24.96±1.91*	28.09±2.67*	6.742	<0.001

Note: '*' indicates a marked discrepancy from pre-treatment, P<0.05.

Table 6: Comparisons of haematological indices ($\bar{x}$±s, mPas)

norm	time	Control group	Study group	*t*	*P*
LBV	Pre-treatment	12.85±2.03	12.71±1.99	-0.348	0.728
	Post-treatment	9.27±1.54*	6.61±1.46*	-8.864	<0.001
HBV	Pre-treatment	7.01±0.94	6.98±1.06	-0.150	0.881
	Post-treatment	4.81±1.06*	4.07±0.65*	-4.208	<0.001
PV	Pre-treatment	2.02±0.42	2.01±0.40	-0.122	0.903
	Post-treatment	1.52±0.35*	1.16±0.20*	-6.315	<0.001

Note: '*' indicates a marked discrepancy from pre-treatment, $P<0.05$.

Table 7: Comparisons of serum inflammatory factor ($\bar{x}$±s)

norm	time	Control group	Study group	*t*	*P*
IL-6	Pre-treatment	58.12±10.73	59.17±8.60	0.540	0.591
(ng/L)	Post-treatment	30.29±8.12*	22.07±4.72*	-6.189	<0.001
TNF-α	Pre-treatment	9.78±1.11	9.98±0.87	1.003	0.318
(μg/L)	Post-treatment	5.13±0.53*	2.86±0.54*	-21.214	<0.001
CRP	Pre-treatment	14.99±0.94	15.02±0.92	0.161	0.872
(mg/L)	Post-treatment	6.99±0.54*	4.09±0.50*	-27.864	<0.001

Note: '*' indicates a marked discrepancy from pre-treatment, $P<0.05$.

Table 8: Clinical efficacy analysis

Group	Obvious effect (*n*)	Effective (*n*)	Ineffective (*n*)	Total effective rate (*n*, %)
Control group	18	24	8	42 (84.00)
Study group	20	27	3	47 (94.00)
x^2			5.107	
P			<0.05	

Table 9: Adverse reactions

Group	Nausea (*n*)	Dizziness (*n*)	Haemorrhage (*n*)	Itchy skin (*n*)	Total reaction rate (*n*, %)
Control group	2	2	2	1	7 (14.00)
Study group	1	1	0	0	2 (4.00)
x^2			6.105		
P			<0.05		

Table 10: Binary logistic regression analysis of coagulation indices on prognosis

Variable	Regression coefficient	Standard deviation	Wald value	*P*	OR	95% CI
TT	1.071	0.481	4.956	0.026	2.918	1.137 ~ 7.491
PT	1.190	0.502	5.612	0.018	3.286	1.228 ~ 8.794
APTT	1.067	0.445	5.741	0.017	2.907	1.214 ~ 6.957

Table 11: Binary logistic regression analysis of haematological indices on prognosis

Variable	Regression coefficient	Standard deviation	Wald value	*P*	OR	95% CI
LBV	1.038	0.459	5.107	0.024	2.824	1.148 ~ 6.948
HBV	1.100	0.443	6.171	0.013	3.006	1.261~ 7.162
PV	1.132	0.472	5.760	0.016	3.102	1.231 ~ 7.820

Table 12: Binary logistic regression analysis of serum inflammatory factors on prognosis

Variable	Regression coefficient	Standard deviatio	Wald value	*P*	OR	95% CI
IL-6	1.022	0.465	4.838	0.028	2.779	1.118 ~ 6.910
TNF-α	1.085	0.474	5.243	0.022	2.960	1.169 ~ 7.495
CRP	1.024	0.436	5.500	0.019	2.783	1.183 ~ 6.547

Table 13: ROC curve analysis of blood biomarker expression and prognosis

Variable	AUC	Standard error	*P*	95% CI
TT	0.727	0.050	<0.001	0.630 ~ 0.824
PT	0.793	0.044	<0.001	0.706 ~ 0.880
APTT	0.706	0.052	<0.001	0.603 ~ 0.808
LBV	0.680	0.054	0.002	0.574 ~ 0.786
HBV	0.702	0.052	0.001	0.600 ~ 0.803
PV	0.709	0.051	<0.001	0.608 ~ 0.809
IL-6	0.682	0.054	0.002	0.577 ~ 0.788
TNF-α	0.692	0.053	0.001	0.588 ~ 0.795
CRP	0.688	0.053	0.001	0.585 ~ 0.791

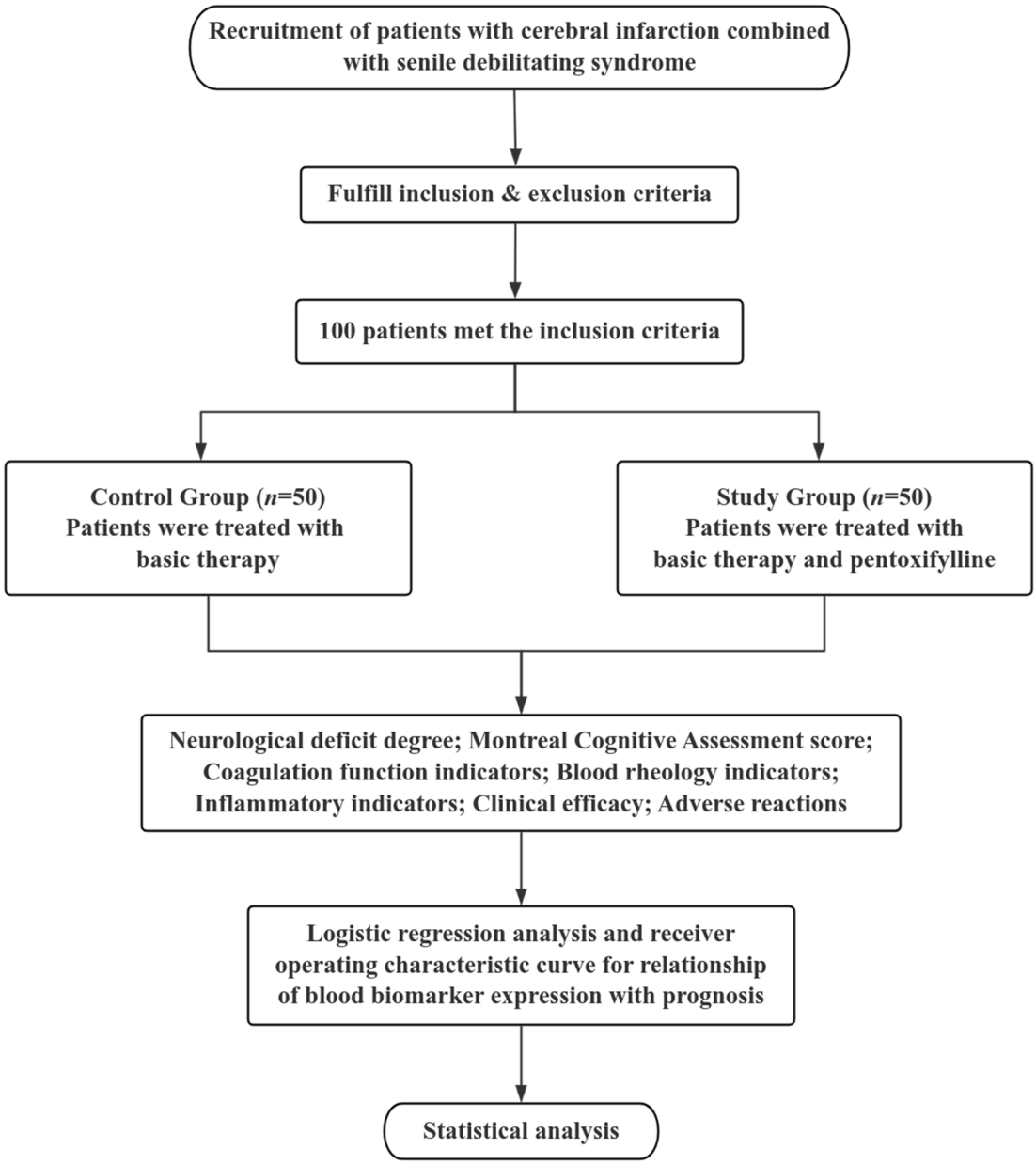

Fig. 1: Flow chart

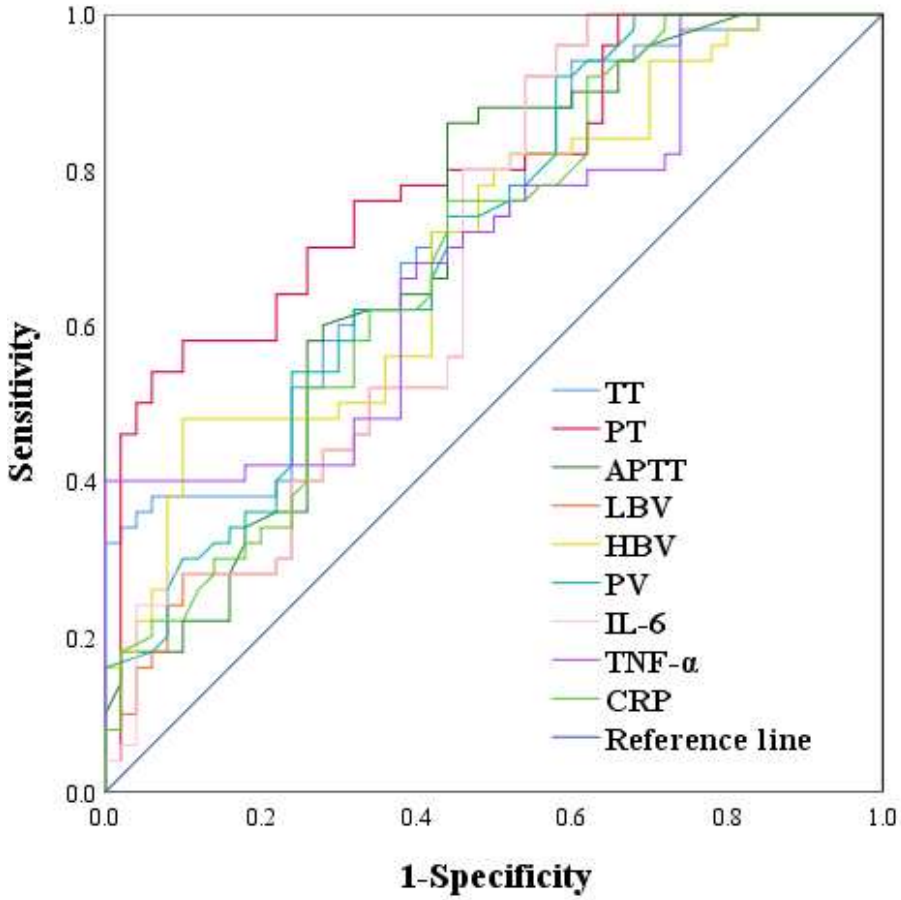

Fig. 2: ROC curves of blood biomarker expression and prognosis

Intervention measures

Both groups of patients were given oxygen to maintain breathing patency, including monitored and controlled blood pressures and blood glucoses, antiplatelet, improving collateral circulation, neuro-nutrition and cerebral protection, and other comprehensive treatments. Secondly, routine instructions were given on diet and work and rest, including protein supplementation, psychological counselling and comfort.

The control group patients were given betahistine hydrochloride injection treatment (National drug code: H44024396, specification: 10mg: 2mL), 20mg/times, once/d. The study group was treated with pentoxifylline injection (National drug code: H13023214; Specification: 0.1 g: 5mL), 0.2g/times, once/d, for 7 d. During the treatment period, attention was paid to controlling the pressure in the brain, avoiding the brain oedema from becoming serious, and preventing the brain structure from undergoing serious changes.

Observation indicators

National Institute of Health stroke scale (NIHSS) score

The NIHSS score was used to assess the neurological function of patients in the two groups before and after treatment, respectively (Garavelli *et al*., 2021). The total score ranged from 0 to 42, with 0 representing everything normal and higher scores representing more severe neurological deficits in the patients.

Assessment of cognitive functions

The Montreal Cognitive Assessment (MoCA) scale was adopted to assessment the patients' cognitive functions, including attention, memory and language functions, before and after treatment, respectively (Carlew *et al*., 2021). The overall scores ranged from 0-30, with higher scores representing better cognitive functions of the patients.

Coagulation function indexes

The patients' peripheral venous blood of 3mL in the fasting state was collected before and after treatment respectively, and anticoagulated with sodium citrate, and the thrombin time (TT), prothrombin time (PT) and activated partial thromboplastin time (APTT) were detected by using the MRX-auto400 automatic coagulation analyser (Beijing Beiken Hengye Science and Technology Development Co., Ltd.) (J Zhang *et al*., 2024).

Haematological indices

The peripheral venous blood 5mL of patients was collected in fasting state before and after treatment, respectively, and

a fully automated haemorheometer (South990JK-1000, Jinan Oulabo E-commerce Co., Ltd.) was used to detect low blood cut viscosity (LBV), high blood cut viscosity (HBV), plasma viscosity (PV) (T Li *et al*., 2024).

Serum inflammatory factor

The peripheral venous blood 5mL of patients was collected in fasting state before and after treatment, respectively, and centrifuged to separate the serum, and the inflammatory factors interleukin-6 (IL-6), tumour necrosis factor-α (TNF-α), and C-reactive protein (CRP) levels were detected by using the CS450 fully automated biochemical analyser (Direxion Medical Technology Co. Ltd.) (Q Wang and Wang, 2020).

Clinical efficacy

The National institutes of health stroke scale (NIHSS) and modified Rankin scale (table 1) were used to assess efficacy (Zöllner *et al*., 2020). Reduction in NIHSS score = (pre-treatment score - post-treatment score) /pre-treatment score × 100%. Ineffective: less than 18% reduction in scores and greater than 3 levels of disability; effective: 18% to 45% reduction in scores and 1 to 3 levels of disability; and significant: greater than 45% reduction in scores and 0 levels of disability.

Prognostic assessment

The prognosis after treatment was evaluated by measuring the recovery from treatment in both groups through the modified Rankin scale (table 1). 0-2 was classified as a good prognosis, and 3-6 was classified as a poor prognosis.

Adverse reactions

Observe the adverse reaction incidence such as nausea, dizziness and other adverse reactions during the treatment of the both groups of patients.

Sample size calculation

Power analysis was carried out in this study using G*Power 3.1.9.7 software to determine the sample size required to detect statistical differences. With an alpha level of 0.05 and 90% power analysis, the research revealed that a sample size of 42 patients per group was required. Therefore, in order to draw reliable conclusions, the study sample sizes were 50 patients per group.

Ethical approval

The study was performed in compliance with the Declaration of Helsinki and hospital ethical guideline, approved by CR&WISCO General Hospital Integtated Therapy Ethics Committee. Ethics endorsement number is HRWGZYY20210106.

STATISTICAL ANALYSIS

SPSS 27.0 statistical software was used for data analysis. Measurements that conform to normally distributed value are represented as ($\bar{x}$±s), and comparisons among groups adopts act independently pattern t examination, and counting data is expressed as rate (%) using x^2 test, with P<0.05 indicating that the difference was statistically significant. Logistic regression trend analyses were adopted to explore the relationship among coagulation function indexes, haematological indices and serum inflammatory factor levels and prognosis, and the association and closeness between the expression of blood biomarkers and prognosis were assessed using receiver operating characteristic curve (ROC) and area under the curve (AUC).

RESULTS

Baseline information

The baseline demographic characteristic and baseline status of patients randomly randomized to control and study groups are described in table 2, and no significant differences among the both groups in terms of demographic variables/instruments/status (P>0.05). Thus, the randomisation process achieved the important goal of evenly assigning participants to the two groups, the two groups were comparable at the pre-treatment level, and confounding by demographic/clinical factors did not affect the analysis of treatment outcomes.

Comparison of NIHSS scores

The results of the comparisons of the NIHSS scores of the both groups are described in table 3. No marked variations in the comparisons of the NIHSS scores of the both groups of patients pre-treatment (P>0.05). After treatment, the scores of both groups were significantly below to pre-treatment (P<0.05), and the degree of reductions were more obvious in the study group. It indicates that the degree of neurological deficits in the study group is better improved to control group.

Cognitive function

The results of the comparisons of the MoCA scores of the both groups are described in table 4, no marked variations in the comparison of the MoCA scores of the both groups pre-treatment (P>0.05). After treatment, the MoCA scores of patients in both groups increased markedly compared to patients pre-treatment, and were markedly above the control group in both study groups (P<0.05). It indicates that the improvement of cognitive functioning in the study group was greater to the control group.

Coagulation function indexes

The results of the comparison of the coagulation function indexes (TT, PT and APTT) of the both groups are illustrated in table 5, and no marked variations in the comparison of the coagulation function indexes of the both groups pre-treatment (P>0.05). After treatment, the coagulation function indexes of patients in both groups increased markedly to pre-treatment, and the study group was markedly above to the control group (P<0.05). The

results revealed that the coagulation function in the study group was superior to the control group after treatment.

Haemorheological indicators

The comparison results of the haematological indices of LBV, HBV and PV of the both groups are presented in table 6, and no marked variations in the comparison of the haematological indicators of the both groups pre-treatment (P>0.05). After treatment, the hematological indicators of patients in both groups were remarkably below to pre-treatment, and the study group was remarkably below to control group (P<0.05). The results showed that the degree of blood viscosity of patients in the study group was below to control group after treatment, and the haematological indices were remarkably improved.

Serum inflammatory factors

The results of the comparisons of inflammatory factors levels among the both groups are presented in table 7, and no marked variations in the comparisons of the levels of inflammatory factors among the both groups pre-treatment (P>0.05). After treatment, the blood inflammatory factor levels of patients in both groups were remarkably below to pre-treatment, and the study group was remarkably below to control group (P<0.05). It indicate that the blood inflammatory response of patients in the study group was remarkably improved after treatment, and the level of inflammatory factors was below to the control group.

Clinical efficacy

The clinical effectiveness of clinical efficacy of the both groups of patients are presented in table 8, the total treatment efficiency of the control group was 84.00% (42/50), and that of the study group was 94.00% (47/50), and the study group was markedly above to control group (P<0.05), which indicated that the patients of the study group had a better therapeutic efficacy after treatment.

Adverse reactions

Adverse reactions such as nausea and dizziness occurred to varying degrees in both groups during the treatment period as presented in table 9, the total adverse reaction incidences in control group patients was 14.00% (7/50), and the study group was 4.00% (2/50), and the total adverse reactions incidence in the study group was below to control group (P<0.05).

Relationship between blood biomarker expression and prognosis

The prognosis of patients was conducted through outpatient follow-up, telephone inquiry, and other follow-up methods, based on the main complaints of patients, and asked whether the patients had events such as disease recurrence/unintended as expected/all-cause death, which was recorded as 1, otherwise as 0, and the time of occurrence, symptoms, and diagnosis, etc., and the cumulative occurrence of the event > 1 time, which was still recorded as 1. The effects of blood biomarker expression and patient prognosis were analyzed by binary logistic regression model with prognosis as the independent variable and then blood biomarker expression (0 is positive, 1 is negative) as the dependent variable, respectively, in order to explore the pathogenesis or influencing factors of the disease. As shown in table 10, there was a significant correlation between coagulation function indexes and prognosis, and coagulation function indexes were positive influences on patients' prognosis, with the likelihood of prognosis improvement increasing 1.918, 2.286 and 2.907 times for each unit increase in TT, PT and APTT. Haematological indices had a remarkable effects on the prognosis of patients (table 11) and were independent risk factors for prognosis, whereby for each unit increase in LBV, HBV and PV, the likelihood of prognosis being affected increased by 1.824, 2.006 and 2.102 times, respectively. Serum inflammatory factors were significantly associated with patient's prognosis (table 12) and were positive prognostic influencers where each unit increase in IL-6, TNF-α and CRP increased the likelihood of prognosis being affected by 1.779, 1.960 and 1.783 times.

ROC curve analysis

To evaluate the effectiveness of blood biomarker expression for classification and diagnosis of e.g. patients and normal individuals, we further plotted the ROC curves and calculated the respective AUCs to find the optimal index thresholds. We used blood biomarker expression as the test variable and patient prognosis as the state variable and set it to 1. The results of ROC curve analysis were plotted as presented in table 13 and fig. 2. Strong correlation between blood biomarker expression and prognosis (P<0.05), the AUC of coagulation function indexes on prognosis was PT (0.793) > TT (0.727) > APTT (0.706), the AUC of haematological indices was PV (0.709) > HBV (0.702) > LBV (0.680), and the AUC of serum inflammatory factors was TNF-α (0.692) > CRP (0.688) > IL-6 (0.682).

DISCUSSION

Cerebral infarction is a localised injury to the brain due to insufficient blood supply, and the causes of cerebral infarction are diverse, mainly including atherosclerosis, cardiogenic embolism, small artery occlusion, etc., which is a common disease that seriously harms the health of the elderly, and has a high rate of disability and death (Zhao *et al*., 2022). Debilitating syndrome is more common in patients with cerebral infarction, which can lead to physiological changes in several organs and systems, memory loss, neurological and cognitive dysfunction, and increase the risk of falls and death, and it is an age-related physiological state that significantly increases the risk of disability in the elderly (Fu, 2024; Thomas *et al*., 2021). The main features of frailty include diminished body reserves, reduced resistance to external stresses, and

abnormalities in the functioning of the immune and endocrine systems, accompanied by cognitive decline. These changes may adversely affect the overall health of the individual (Rohrmann, 2020). After the occurrence of cerebral infarction, neural stem cells in normal organism can be activated to migrate to the infarcted area and differentiate into neurons and glial cells to participate in nerve repair. However, in the debilitated state, the proliferation, differentiation and migration of neural stem cells are weakened, which leads to the obstruction of the neural remodeling process around the infarcted foci, and affects the recovery of neurological function (Luo *et al*., 2024). In addition, patients with senile debilitating syndrome not only have chronic low-grade inflammation, but also often have immune dysfunction. After the occurrence of cerebral infarction, on the one hand, the low immune function is unable to timely and effectively clear the infectious pathogens, which is prone to cause complications such as lung infection, and the infection will again activate the inflammatory response, forming a vicious circle, aggravating brain damage, and is not conducive to neurological restoration, which greatly reduces the quality of the patient's prognosis (Marsool *et al*., 2024). Some studies have pointed out that cerebral infarction is an important cause of debilitating syndrome in elderly patients, and debilitating syndrome can accelerate the deterioration of cerebral infarction, trigger the decline of the patient's body functions, and increase the risk of cognitive disorders, which seriously affects the patient's life quality (Qin *et al*., 2020). Therefore, the treatment of cerebral infarction with senile debilitating syndrome is important for the patients prognosis.

Treatment for cerebral infarction and debilitating syndromes usually consists of pharmacologic and non-pharmacologic options. Pharmacologic options include thrombolytic and anticoagulant therapy. Thrombolytic therapy is usually performed 4.5 - 6 h after the onset of the disease, such as the use of recombinant tissue-type fibrinogen activator, but the duration of thrombolytic therapy is relatively short, and it is easy to miss the optimal time for treatment (Mumtaz *et al*., 2024). Anticoagulants such as warfarin, dabigatran etexilate and rivaroxaban are more effective in preventing cerebral infarction in some specific etiologies, but carry a higher risk of bleeding (Kim *et al*., 2025). Non-pharmacological treatments, including rehabilitation programs and lifestyle modifications, need to be adhered to by patients in the long term, and their outcomes may vary depending on individual patient differences, severity of the disease, and other factors. For patients with senile debilitating syndrome, due to their poor physical functioning, it may be difficult for them to tolerate intense and prolonged rehabilitation or lifestyle programs, resulting in poor outcomes (B Zhang *et al*., 2025).

Pentoxifylline, a methylxanthine derivative, is often used in the treatment of peripheral vascular diseases as a non-selective phosphodiesterase inhibitor because of its haemorheological activity. It may reduce cerebral white matter damage and ameliorate cognitive deficits by inhibiting neuropathic pain, decreasing the secretion of inflammatory factors (Ghasemnejad Berenji *et al*., 2021). Previous studies have reported that when pentoxifylline is used in the treatment of peripheral vascular disease, it counteracts the deleterious effects of brain aging, and also improves brain function and counteracts cognitive aging by enhancing the body's antioxidant capacity and promoting mitochondrial biogenesis (Y Wang *et al*., 2020; Y Wang *et al*., 2021). However, the clinical effectiveness of pentoxifylline in patients with cerebral infarction with senile debilitating syndrome of old age is unclear. Based on this, the present study was conducted to investigate the effectiveness of pentoxifylline in patients with cerebral infarction combined with senile debilitating syndrome and to analyse the improvement of neurological and cognitive dysfunctions in the patients, and to explore the relationship between the expression of blood biomarkers and prognosis by combining the analysis of coagulation function indexes, haematological indices, serum inflammatory factors and prognosis, with a view to providing new information on the therapy of cerebral infarction combined with senile debilitating syndrome.

The NIHSS score is mainly used to assess the degree of neurological deficit in acute stroke patients. Improvement in the score usually implies how well the patient's neurological function has recovered, and also reduces the degree of inability to take care of themselves as a result of physical disability (Dong *et al*., 2024). Improvement of MoCA score reflects the improvement of patients' cognitive function, which enables patients to think more clearly and express their thoughts more accurately, so that they can better communicate and interact with others, which further improves patients' quality of life (Yuan *et al*., 2025). The results of the present study indicated that the NIHSS scores of the patients in both the groups were remarkably reduced after the treatment and the extent of change was more pronounced in the study group, which suggests that pentoxifylline helps to improve neurological functioning in elderly debilitated patients. This study also found that the MoCA scores in both groups were remarkably above to after treatment compared to pre-treatment, and the degree of increase was greater in the study group. Which is consistent with what was reported by Li *et al*. in their study off acute cerebral infarction patients treated with intravenous thrombolysis with pentoxyfylline with alteplase (B Li *et al*., 2022). This suggests that pentoxifylline can significantly improve cognitive dysfunction in patients with cerebral infarction with senile debilitating syndrome, which warrants further investigation. The reason for this is that pentoxifylline can down-regulate Caspase-3 protein expression, reduce the incidence of ischemia-induced neuronal apoptosis, enhance neuroprotective mechanisms, and to a certain

extent improve the memory and cognitive function of patients. Meanwhile, pentoxifylline can improve the incidence of vascular resistance by reducing blood viscosity in patients with cerebral infarction combined with senile debilitating syndrome, which in turn affects the microcirculation of the organism and improves the organismal function of patients. In patients with cerebral infarction combined with senile debilitating syndrome, the improvement of these clinical symptoms contributes to the clinical outcome (Liang *et al*., 2022).

It has been pointed out that the improvement of coagulation function has a greater correlation with the patient's prognosis in cerebral infarcts (D Tian *et al*., 2022). TT, PT and APTT are the main indicators reflecting the coagulation function of the organism, of which TT is the time required for fibrin filaments to appear after the addition of thrombin solution to the plasma examined, and a decrease in the level of which indicates that there is a disorder in the coagulation mechanism. PT reflects the coagulation status of the exogenous coagulation system, and a decrease in its level indicates that the organism may be suffering from thrombosis and blood circulation is affected. APTT reflects the status of endogenous coagulation, and a decrease in its level indicates that the organism is suffering from an abnormality of endogenous coagulation factors (G Feng and Gong, 2022). The study revealed that the coagulation function of patients in both groups improved remarkably after treatment, and the improvement of coagulation function was more obvious with the addition of pentoxifylline injection, indicating that pentoxifylline injection can improved the coagulation functions of cerebral infarction patients. The study is similar to the findings of Feng *et al* in their clinical research on pulsatilla injection combined with pentoxifylline injection therapy for acute cerebral infarction (Z Feng *et al*., 2023).

Poor blood flow can lead to insufficient blood and oxygen supply to the brain (Rasmussen *et al*., 2022). In this study, we analysed the haematological indices of the both groups and the results showed that after treatment, the haematological indices of both groups improved significantly, with the patients in the study group showing a better improvement than the control group. It shows that pentoxifylline can effectively improve the haemodynamic situation of the patients, so that the brain gets enough blood and oxygen, and relieve the ischemic condition. Saeed *et al*. reported that pentoxifylline reduced platelet aggregation and lowered blood viscosity in their study on the effects of pentoxifylline on endothelial dysfunction, oxidative stress and inflammatory markers in patients with myocardial infarction (Saeed *et al*., 2024), which is similar to the results of the present study.

Inflammatory response is the main factor leading to brain damage after the occurrence of cerebral infarction in patients, and the abnormal expression of inflammatory factors can lead to the aggravation of the condition of patients with cerebral infarction, which is one of the important causes of death. IL-6, TNF-α, and CRP are closely related to the severity of the patient's condition and are the main indicators of the inflammatory response (Xu *et al*., 2021). In this study, comparing the serum IL-6, TNF-α, and CRP levels before and after treatment of the two groups of patients, it was found that the inflammatory response of patients in both groups was significantly reduced, and the effect of reduction was more pronounced in patients in the study group, suggesting that pentoxifylline injection inhibited the inflammatory response of patients more significantly. Similar findings were reported by Brie *et al*. in their study on the potential role of pentoxifylline as an anti-inflammatory agent in patients with acute coronary syndromes (Brie *et al*., 2022). Li *et al*. in their study comparing the efficacy and safety of atorvastatin and resuvastatin in the treatment of cerebral infarction reported that both drugs reduced NIHSS scores and inflammatory markers, whereas resuvastatin showed superior efficacy in lipid control (Y Li *et al*., 2024). In the present study, patients with cerebral infarction combined with senile debilitating syndrome were treated with pentoxifylline, and the results showed that the clinical efficacy of the study group was better and the total incidence of adverse effects was lower than the control group. These results indicate that the efficacy of pentoxifylline in the treatment of cerebral infarction combined with senile debilitating syndrome is precise, and it can significantly improve the cognitive function and coagulation function of patients, improve the hemodynamic situation of patients, and reduce the inflammatory response, which is a significant efficacy.

A binary logistic regression analysis of the relationship between the expression of blood biomarkers and prognosis revealed a significant correlation between blood biomarkers and patient prognosis. Increases in coagulation indices often reflect depletion of coagulation factors and microthrombosis, which can cause local vascular embolization and vasoconstriction, among other things important for assessing severity of disease and prognosis. Clinical decision-making may favor more aggressive anticoagulation and thrombolysis (Iba *et al*., 2021). Increased blood flow indices are an important risk factor for thrombosis, which can further lead to vascular endothelial cell damage and promote atherosclerosis formation, which can lead to diseases such as cerebral infarction. Clinical decision-making often takes the form of therapeutic measures to improve blood rheology in order to reduce blood viscosity and improve cerebral blood supply (Karlström *et al*., 2022). Patients with cerebral infarction generally suffer from cerebral ischemia and hypoxia, which can lead to the accumulation of serum inflammatory factors in some areas of the brain tissue, disrupting the structural integrity of the blood-brain barrier,

thus aggravating brain damage, among other things. If the inflammatory indicators are not effectively controlled and the prognosis is poor, clinical decision-making favors adjusting the treatment regimen, intensifying anti-infective therapy, and giving supportive care, among other things (J Wang *et al*., 2021). The study results demonstrated that coagulation indices, haematological indices and serum inflammatory factors were all closely related to the prognosis of the disease.

We further analysed the relationship between blood biomarker indices and prognosis, and the findings revealed that the significant correlation between coagulation indices, haematological indices and serum inflammatory factors on prognosis. The ROC curve analysis revealed that there was a strong correlation between blood biomarker expression and prognosis (P<0.05), the AUC of coagulation function indexes on prognosis was PT (0.793) >TT (0.727) >APTT (0.706), the AUC of haematological indices was PV (0.709) > HBV (0.702) > LBV (0.680), and the AUC of serum inflammatory factors was TNF-α (0.692) > CRP (0.688) > IL-6 (0.682). These results indicate that pentoxifylline is effective in reducing neurological deficits, improving cognitive function, improving the expression of blood biomarkers, and reducing adverse effects in patients with cerebral infarction with senile debilitating syndrome. The logistic regression analyses revealed that the relationship between blood biomarker indicators and prognosis was closely related, and the results were verified again by combining with ROC curve analysis. Li *et al*. reported HALP as an independent predictor of patient prognosis in their study of a novel biomarker-based HALP (hemoglobin, albumin, lymphocytes and platelets) prognostic model in patients with cerebral venous sinus thrombosis (S Li *et al*., 2023). Tian *et al*. reported in a study of CRP, calcitoninogen and immune cell ratio in 194 patients with sepsis that CRP was an independent risk factor affecting the prognosis of patients with sepsis (T Tian *et al*., 2021). These studies were similar to the findings. Therefore, we believe that monitoring these blood biomarkers during the prognostic process, detecting abnormalities at an early stage, correcting them in a timely manner, and strictly following the treatment plan are crucial to improved the clinical prognosis of patients with cerebral infarction with senile debilitating syndrome.

This study has some limitations. The relatively small sample size did not cover all the different conditions of patients with cerebral infarction combined with senile debilitating syndrome, including other co-morbidities (e.g., hypertension, diabetes mellitus, or cardiovascular disease) that are common in elderly patients, which may lead to biased results and affect the extrapolation and reliability of the conclusions. The limitation of single-center studies is that there are differences in patients' own underlying conditions, which may affect the generalizability of the findings. In addition, the relatively short follow-up period does not allow adequate assessment of the long-term effects and safety of the treatment. And long-term effects are crucial for a comprehensive understanding of treatment effects and the development of scientific treatment strategies. Therefore, future studies should further expand the sample size and extend the follow-up time to more comprehensively assess the efficacy and safety of this treatment program.

CONCLUSION

In this study, the comparative analyses of the clinical effectiveness of pentoxifylline in patients with cerebral infarction combined with senile debilitating syndrome revealed that the NIHSS score, haematological indices, serum inflammatory factors and adverse reactions in study group treated with pentoxifylline were below to the control group, while the MoCA score, coagulation function indexes and clinical efficacy were above to the control group. Both logistic regression analysis and ROC results showed a significant correlation between blood biomarker expression and prognosis. It is important to monitor blood biomarkers during the prognostic process of patients to detect abnormalities early and treat them appropriately, which is essential for the clinical prognosis of patients.

Conflict of interest

There is no conflict of interest.

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