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Efficacy and Safety of Monosialotetrahexosylganglioside Sodium in the Treatment of Acute Ischemic Stroke: A Real-World Study

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Abstract: *Objective*: The purpose of this study was to evaluate the efficacy and safety of monosialotetrahexosylganglioside (GM1) in patients with acute ischemic stroke (AIS) based on real-world data. *Methods*: From March 2022 to January 2023, patients with AIS treated with GM1 were included in this study. Functional outcomes were assessed using the modified Rankin Scale (mRS) and the NIH Stroke Scale (NIHSS) at baseline and at 2, 6, and 10 weeks after treatment initiation. Safety was evaluated through adverse event (AE) monitoring. *Results*: A total of 1772 patients with AIS were collected for analysis after the exclusion of the exclusion criteria. GM1 treatment significantly improved functional outcomes. The mRS score decreased from a baseline of 1.32 to 0.97 at the third follow-up (mean reduction: 0.35 points, $P < 0.05$). The NIHSS score decreased from 5.14 to 2.32 (mean reduction: 2.82 points, $P < 0.05$). A total of 128 AEs were reported in 98 patients (5.5%). The majority of AEs were mild to moderate (124 events, 7.0%), with only 4 severe AEs (Grade 3, 0.2%) observed. No life-threatening or fatal AEs occurred. *Conclusion*: GM1 treatment significantly improves the mRS score and NIHSS score of AIS patients, and the safety is high. AIS patients showed obvious advantages in neurological function recovery after GM1 treatment, and these results provide a clinical basis for GM1 in the real diagnosis and treatment environment of AIS patients.

Keywords: Acute ischemic stroke; GM1; mRS score; NIHSS score

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1. Introduction

Acute ischemic stroke (AIS) has a high incidence and recurrence rate, and is one of the leading causes of death and disability worldwide. At present, some progress has been made in the treatment of AIS in the acute stage, such as the popularization and application of intravenous drug thrombolysis and mechanical thrombectomy, but the long-term efficacy is still limited by many factors, such as treatment time window, access to medical resources, and

patient differences. Therefore, exploring new treatments to improve the long-term prognosis of AIS remains one of the important topics in the field of neuroscience. As a ganglioside, monosialotetrahexosylganglioside (GM1) has multiple effects, such as neuroprotection, improving nerve repair, and delaying apoptosis, and is widely used in the clinical treatment of neurological diseases. Previous studies have confirmed that GM1 can protect ischemic brain injury by resisting inflammatory responses, reducing oxidative stress, maintaining cell membrane morphology, and promoting energy metabolism. However, large-scale, multi-center, high-quality evidence on the clinical efficacy of GM1 in the treatment of AIS is still lacking, especially with limited data on real-world application effects. This study evaluates the efficacy and safety of GM1 in patients with AIS based on real-world research data, filling in the gaps of previous studies. We hope that through this study, we will provide stronger evidence-based data for clinical practice, thereby promoting the standardized application of GM1 in AIS and providing more treatment options to improve the prognosis of AIS patients.

2. Data and methods

2.1. General information

This multicenter, prospective, observational, real-world enrolled AIS patients who used GM1 from March 2022 to January 2023 were included in this study. Inclusion criteria: (1) Age ≥ 18 years old; (2) The diagnostic criteria meet the diagnostic criteria for acute ischemic stroke in the 2018 Chinese Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke, and are confirmed by head CT or MRI; (3) Patients who received standardized acute treatment, including thrombolysis, mechanical thrombectomy, etc., and were treated with GM1[1–3]. Exclusion criteria: (1) Allergy to GM1 and its components or drug contraindications; (2) History of other serious diseases of the central nervous system (such as severe brain trauma, skull tumor, cerebral hemorrhage, etc.); (3) Previously combined with heart, liver, renal insufficiency or other systemic major diseases, with an expected survival time of < 3 months; (4) Pregnant and lactating women; (5) Patients who have received other drug treatments or interventions that may affect the study outcomes before admission; (6) Patients who are in critical condition at the time of admission and are not expected to benefit in the short term (such as malignant large-scale cerebral infarction, etc.) [4,5]. The GM1 treatment regimen was administered in accordance with the instructions. For the acute phase of ischemic stroke, the recommended dosage was 100 mg once daily, administered via intravenous infusion. The duration of the acute phase high-dose treatment was 2 to 3 weeks, followed by a maintenance phase of 20–40 mg once daily via intramuscular injection or intravenous infusion for a subsequent 3 to 4 weeks. The total treatment course was approximately 6 weeks. Follow-ups were conducted at 2, 6, and 10 weeks after treatment. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Wuhan University People's Hospital as well as the ethical committees of all participating sites. Written informed consent was obtained from all participants or their legally authorized representatives prior to any study-specific procedures.

2.2. Research indicators

(1) The basic condition and disease status of the patient;

(2) Evaluation of long-term functional prognosis of patients: the primary efficacy endpoint was the proportion of patients achieving an excellent functional outcome (modified Rankin Scale [mRS] score of 0 to 1) and a favorable functional outcome (mRS score 0 to 2) over time. The mRS score was also presented as an ordinal measure for descriptive purposes [6].

(3) Evaluation of the degree of neurological deficit in patients: The secondary functional outcome was the

NIHSS score, which is a quantitative tool for assessing the degree of neurological deficit in patients with acute stroke, and is used to quickly judge the severity of stroke and changes in the condition [7];

(4) Adverse event (AE) evaluation: The CRF scale was used to collect related AEs before and after treatment.

2.3. Statistical methods

SPSS 26.0 software was used for statistical analysis. The continuity index is represented by " mean ± standard deviation (SD)." The categorical indexes were expressed as "*n*,%", and the differences between groups were compared by the χ^2 test. Changes in NIHSS over time was analyzed by repeated-measures analysis of variance (ANOVA). The difference was statistically significant by two-sided $P < 0.05$.

3. Results

3.1. Patient demographic data

A total of 1772 patients with AIS were included in this study, including 1069 males (60.3%) and 703 females (39.7%), as shown in **Table 1**.

Table 1. Demographic data of patients [*n*,(%)]

Variable	Patients with AIS (*n* = 1772)
Gender	
Male	1069 (60.3)
Female	703 (39.7)
Age	
18–45 years old	57 (3.2)
46–60 years old	818 (46.2)
61–79 years	750 (42.3)
> 80 years old	147 (8.3)
Hypertension	
Yes	1321 (74.5)
Not	451 (25.5)
Diabetes	
Yes	646 (36.5)
Not	1126 (63.5)
Dyslipidemia	
Yes	607 (34.4)
Not	1165 (65.6)
Heart disease	
Yes	378 (21.3)
Not	1394 (78.7)
Vasculitis	
Yes	142 (8.0)
Not	1630 (92.0)

3.2. Clinical symptoms of stroke and previous treatment methods

The clinical manifestations of the enrolled patients with confirmed acute ischemic stroke were as follows: 44.2%

presented with a progressive stroke, 31.7% with a complete stroke, 20.7% with reversible ischemic neurological deficits, and 3.4% with other clinical manifestations (**Table 2**).

Table 2. Clinical symptoms and previous treatment methods of stroke [*n*,(%)]

Variable	Statistics
Clinical manifestations	
Progression stroke	783(44.2)
Complete stroke	562(31.7)
Reversible ischemic neurological deficits	367(20.7)
Other clinical manifestations	640(3.4)
Stroke duration	
< 1 year	1432(80.8)
1–2 years	177(10.0)
> 2 years	163(9.2)
Prior medication	
Yes	1536(86.7)
Not	236(13.3)
Rehabilitation training	
Yes	511(28.8)
Not	1261(71.2)
surgery	
Yes	306(17.3)
Not	1466(82.7)

3.3. Changes in mRS score before and after treatment

Compared with the baseline assessment, the distribution of patients across modified Rankin Scale (mRS) categories showed significant improvement after GM1 treatment. The proportion of patients with a favorable outcome (mRS score 0–1) significantly increased from 25.0% at baseline to 34.0%, 40.0%, and 43.0% at the first, second, and third follow-ups, respectively (P for trend < 0.001) (**Table 3**).

Table 3. Changes in mRS score before and after treatment

Patient	n	mRS score	mRS 0–1, *n*(%)	mRS 0–2, *n*(%)
Baseline	1772	1.32 ± 0.78	443 (25.0%)	1418 (80.0%)
The first follow-up visit	894	1.07 ± 0.62	304 (34.0%)	847 (94.7%)
Second follow-up visit	795	1.01 ± 0.58	318 (40.0%)	763 (96.0%)
Third follow-up visit	654	0.97 ± 0.54	281 (43.0%)	637 (97.4%)
P	< 0.001			

Note: Data are presented as mean ± standard deviation for descriptive purposes. The statistical significance of the ordered change in mRS distributions over time was analyzed using the χ^2 test.

3.4. Changes in NIHSS score before and after treatment

Compared with the first treatment, the NIHSS score of AIS patients was significantly reduced after GM1 treatment ($P < 0.001$). Post hoc analyses confirmed that scores at all follow-up time points were significantly reduced compared to baseline (all $P < 0.05$) (**Table 4**).

Table 4. Changes in NIHSS score before and after treatment

Patient	n	NIHSS score
First diagnosis	1772	6.82 ± 6.50
The first follow-up visit	894	4.21 ± 5.20
Second follow-up visit	795	3.15 ± 4.60
Third follow-up visit	654	2.32 ± 4.11
F	185.7	
P	< 0.001	

Note: Data presented as mean ± standard deviation. The *P*-value represents the result of the omnibus test for the main effect of time using repeated-measures ANOVA. Post hoc pairwise comparisons with baseline were performed using Bonferroni-adjusted tests.

3.5. Safety evaluation

The safety profile of GM1 was evaluated in all 1772 treated patients. A total of 128 adverse events (AEs) were reported in 98 patients (5.5%). The vast majority of AEs were mild to moderate in severity (Grade 1-2), accounting for 124 events (7.0%). Only 4 severe AEs (Grade 3, 0.2%) were observed, which included 2 cases of severe vomiting and 2 cases of severe headache; all resolved with appropriate medical intervention and without sequelae. No Grade 4-5 AEs were reported. The most common AEs were gastrointestinal disorders, affecting 45 patients (2.5%) with 62 events (3.5%), primarily nausea (1.7%) and vomiting (1.2%) (**Table 5**).

Table 5. Summary of adverse events by severity (Safety population, *N* = 1772)

Preferred term (System organ class)	Patients, *n* (%)	Events, *n* (%)	Grade 1–2, *n* (%)	Grade ≥ 3, *n* (%)
Any Adverse Event	98 (5.5)	128 (7.2)	124 (7.0)	4 (0.2)
Gastrointestinal disorders	45 (0.5)	62 (3.5)	60 (3.4)	2 (0.1)
Nausea	25 (1.4)	30 (1.7)	30 (1.7)	0 (0.0)
Vomiting	15 (0.8)	22 (1.2)	20 (1.1)	2 (0.1)
Diarrhea	5 (0.3)	10 (0.6)	10 (0.6)	0 (0.0)
Nervous system disorders	27 (1.5)	35 (2.0)	33 (1.9)	2 (0.1)
Dizziness	15 (0.8)	18 (1.0)	18 (1.0)	0 (0.0)
Headache	10 (0.6)	15 (0.8)	13 (0.7)	2 (0.1)
Somnolence	2 (0.1)	2 (0.1)	2 (0.1)	0 (0.0)
Skin and subcutaneous tissue disorders	12 (0.7)	15 (0.8)	15 (0.8)	0 (0.0)
Rash	8 (0.5)	10 (0.6)	10 (0.6)	0 (0.0)
Pruritus	4 (0.2)	5 (0.3)	5 (0.3)	0 (0.0)
General disorders and administration site conditions	8 (0.5)	10 (0.6)	10 (0.6)	0 (0.0)
Injection site reaction	5 (0.3)	7 (0.4)	7 (0.4)	0 (0.0)
Fatigue	3 (0.2)	3 (0.2)	3 (0.2)	0 (0.0)
Others	6 (0.3)	6 (0.3)	6 (0.3)	0 (0.0)
Insomnia	3 (0.2)	3 (0.2)	3 (0.2)	0 (0.0)
Palpitations	2 (0.1)	2 (0.1)	2 (0.1)	0 (0.0)
Increased ALT	1 (0.1)	1 (0.1)	1 (0.1)	0 (0.0)

Note: Adverse events were graded according to Common Terminology Criteria for Adverse Events (CTCAE) version 5.0. No Grade 4 (life-threatening) or Grade 5 (fatal) adverse events were observed. ALT: Alanine Aminotransferase.

4. Discussion

The results of this study showed that GM1 treatment significantly improved the mRS score and NIHSS score of AIS patients, and the treated patients showed more obvious advantages in functional prognosis and neurological function recovery. These results show that the application of GM1 in AIS patients can effectively reduce disability rates and improve quality of life, further proving its clinical value in the field of neuroprotection.

This study also inevitably has the following limitations. First, based on data analysis from real-world studies, this study can reflect the application effect of GM1 in actual clinical diagnosis and treatment settings, but compared with clinical trials with strict quality control and full-process implementation management, there may be inherent systemic bias due to the type of study. Second, the follow-up time of this study is relatively short, and it is impossible to comprehensively evaluate the impact of GM1 on the long-term prognosis of AIS. Finally, due to the limited sample size, this study cannot extensively explore the differences in response to GM1 treatment in different subgroups (such as different ages, stroke severity, comorbidities, etc.), and we will explore the impact of different clinical factors on long-term prognosis in future studies.

AIS is one of the leading causes of disability and mortality worldwide, with a high burden of disease. A large number of ASI patients are accompanied by limited daily physiological functions and impaired quality of life, which has a long-term heavy impact on families and society. The pathophysiological process of AIS mainly involves ischemia-induced nerve cell damage, inflammatory response, oxidative stress, and disruption of the blood-brain barrier. GM1 stimulates multiple pathways to play protective neuronal functions at the same time: first, GM1 can maintain the stability of nerve cell membranes, delay the circulation of calcium ions, and reduce ischemic injury [8,9].

At the same time, GM1 hinders the release of a large number of inflammatory factors, keeping the inflammatory response in the internal environment at a low level. In addition, GM1 reduces free radical damage to nerve cells by reducing oxidative effects [10]. In addition, GM1 can promote nerve repair and regeneration, helping to improve patients' nerve function and daily life ability [11,12]. Under the combined effect of these multiple mechanisms, GM1 can significantly improve the outcomes of adverse clinical events in patients with AIS. In addition, no adverse reactions were found in all patients during multiple follow-up visits after treatment, indicating a high safety profile with GM1 treatment [13,15].

5. Conclusion

In summary, this study verified the efficacy and safety of GM1 in the treatment of acute ischemic stroke using real-world data, and the results showed that GM1 significantly improved functional outcome and neurological recovery, and reduced the burden of disease in patients. This study provides a strong evidence-based basis for the clinical application of GM1 in AIS, and lays a foundation for further exploration of the mechanism of action of GM1 and the optimization of treatment options in the future.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Zhong J, Cao W, Zhou H, et al., 2024, Research Progress on Multisystem Complications Caused by Autonomic

Dysfunction After Acute Ischemic Stroke. Journal of Shanghai Jiao Tong University (Medical Science), 44(7): 928–934.

[2] Yang X, Li H, 2024, Research Progress on Contrast Agent Extravasation After Endovascular Treatment of Acute Ischemic Stroke. Modern Medicine and Health, 40(13): 2298–2301 + 2304.

[3 Lu B, Sun N, Lu J, et al., 2024, Analysis of the Current Status of Quality of Life Survey and Related Influencing Factors of Acute Ischemic Stroke Patients. General Nursing, 22(14): 2722–2724.

[4] Xu Y, Yao X, Luo H, 2024, Effects of Tetrahexoshave Ganglioside Sodium Monosialic Acid for Injection Combined With Xingnaojing Injection on Neurological Function and Inflammation in Stroke Patients. Clinical Rational Medicine, 17(24): 13–16.

[5] Ren L, He H, Bai L, et al., 2023, Effects of Tetrahexoshave Ganglioside Monosialic Acid on Polyol Metabolism Pathway and Caudal Nerve Electrophysiological Changes in DPN Rats. Chinese Journal of Gerontology, 43(2): 414–418.

[6] Sun W, Tian T, Wang G, et al., 2024, Effect of Alteplase Dose Selection Before Vascular Intervention in Macrovascular Occlusive Stroke on Recanalization Time, Reperfusion Grade, mRS Score, and Cost-Utility. Stroke and Neurological Disorders, 31(3): 242–246.

[7] Hu D, Min F, Chen L, et al., 2024, Predictive Effectiveness of NIHSS Score and Daily Activity Level in the Risk of Constipation in Elderly Patients With First Stroke. Evidence-Based Nursing, 10(15): 2774–2778.

[8] Yang J, 2022, Application of Tetrahexoshave Ganglioside Sodium Monosialic Acid Injection in Patients With Hypertensive Intracerebral Hemorrhage. Practical Integrative Medicine, 22(24): 5–8.

[9] He L, Zhong Q, 2022, Clinical Study of Tetrahexoshave Ganglioside Combined With Rehabilitation Training in the Treatment of Stroke. Journal of Cardiovascular and Cerebrovascular Diseases of Integrative Traditional Chinese and Western Medicine, 20(17): 3107–3110.

[10] Ye Y, Li X, 2022, Effects of Tetrahexoshave Ganglioside Monosialic Acid in the Treatment of Cerebral Infarction With Cognitive Dysfunction on Neurological Function and Serum NSE and sCD40L Levels in Patients. Cardiovascular Disease Prevention and Treatment Knowledge, 12(32): 33–36.

[11] Cao J, Wang H, Huo K, et al., 2021, Effects of Tetrahexose Ganglioside Sodium Monosialic Acid Combined With Hypothermia on Serum Inflammatory Factors, Nerve Damage, and Neurobehavior in Neonatal HIE. China Maternal and Child Health Research, 32(11): 1649–1653.

[12] Cheng Y, Gao H, 2022, Effects of Ganciclovir Combined With Tetrahexoshave Ganglioside Monosialic Acid on Clinical Symptoms, Neurotrophic Factors, and Immune Function in Children With Viral Encephalitis With Psychobehavioral Abnormalities. Journal of Practical Cardiovascular, Cerebropulmonary and Vascular Diseases, 30(1): 96–102.

[13] Guo D, Wang M, 2002, Clinical Study on the Addition of GM_1 Monosialic Acid Ganglioside in the Treatment of Acute Ischemic Stroke. Chinese Clinical Neuroscience, 10(2): 190–191.

[14] Li H, 2021, Efficacy Analysis of Tetrahexosate Ganglioside Sodium Combined With Butaphthalein in the Treatment of Ischemic Stroke. China Modern Pharmaceutical Application, 15(19): 180–182.

[15] Zhang D, 2021, Observation on the Effect of Agatroban Combined With Tetrahexoshave Ganglioside Sodium Monosialic Acid in the Treatment of Acute Ischemic Stroke. Contemporary Medicine, 27(29): 6–8.