

Original Article

The application of the emergency green channel integrated management strategy in intravenous thrombolytic therapy for AIS

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Abstract: Objective: To apply the emergency green channel integrated management strategy in intravenous thrombolytic therapy for acute ischemic stroke (AIS). Methods: This retrospective study involved a cohort of 82 AIS patients. Among them, 40 patients admitted to the emergency department of our hospital were treated using the emergency green channel integrated management strategy (the green channel group). Meanwhile, 42 AIS patients were rescued in accordance with the traditional grading and zoning treatment principles (the traditional group). The treatment times, the compliance rates of the times between when the patients entered the emergency department and when they underwent the thrombolysis treatment (the door-to-needle time or DNT), the neurological deficit scores, the Barthel index scores, and the ability of daily living scores before and after the treatment were compared between the two groups. Results: Compared with the traditional group, the triage times, the DNTs, the thrombolysis times, and the emergency department lengths of stay in the green channel group were significantly shorter (all $P < 0.001$). The DNT compliance rate in the green channel group was significantly higher than it was in the traditional group ($P < 0.05$). The neurological deficit scores in both groups after the treatment were lower than they were before the treatment (both $P < 0.01$). The neurological deficit score in the green channel group after the treatment was lower than the neurological deficit score in the traditional group ($P < 0.01$). The Barthel index and ability of daily living scores in the two groups after the treatment were significantly increased when compared with before the treatment (all $P < 0.001$). The Barthel index and ability of daily living scores in the green channel group after the treatment were higher than they were in the traditional group (both $P < 0.001$). The incidence of complications during the process of thrombolysis in the green channel group was significantly lower when compared with the incidence in the traditional group ($P < 0.05$). Conclusion: The emergency green channel integrated management strategy is more effective at shortening AIS patients' stays in the emergency department, increasing their DNT compliance rates, and at saving time for their thrombolytic therapy, improving patients' neurological function to a greater extent. It is worthy of clinical application.

Keywords: The emergency green channel integrated management strategy, acute ischemic stroke, intravenous thrombolysis

Introduction

Strokes are a relatively high risk cerebrovascular disease, and ischemic strokes are the most common type. Ischemic stroke patients account for about 80% of all stroke patients, and acute ischemic stroke (AIS) patients account for over 60% of all stroke patients [1, 2]. AIS is a main cause of death and disability in China [3]. Thrombolysis can significantly improve the AIS patients' prognoses and reduce their mortality and disability rates [4]. Accord-

ingly, it is still the most important and effective treatment in clinical practice. However, there are some problems in the current system of pre-hospital emergency medical services for AIS patients in China. Specifically, the pre-hospital emergency treatment for AIS is delayed in most cases. As a result, the time between the AIS patients entering the emergency department and their receiving thrombolysis treatment (the door-to-needle time or DNT) is greatly extended [5]. The thrombolysis time has a direct influence on AIS patients' prognoses [6].

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The average DNT of emergency stroke patients in China is 116 minutes, which is twice that of developed countries located in Europe and America [7]. Therefore, it is urgent to implement appropriate management strategies to shorten the DNT. The emergency green channel integrated management strategy refers to the rapid and unblocked diagnosis and treatment strategy carried out through multi-department collaboration. It is set up to unblock the rescue process and save the lives of the emergent and critical patients. The rapid, ordered, safe, and effective diagnosis and treatment service is available using the strategy. At present, this strategy is widely employed for acute cardiovascular and cerebrovascular diseases like AIS and acute myocardial infarction, providing sufficient time for patient rescue [8]. In order to shorten the DNT, we have used the emergency green channel integrated management strategy in the emergency department of our hospital since January 2019. Positive clinical effects have been achieved, and the results are reported below.

Materials and methods

General information

This retrospective study was conducted in a cohort of 82 AIS patients. Among them, 40 patients admitted to the emergency department of our hospital from January 2019 to January 2020 were assigned to the green channel group, and 42 patients admitted before 2019 were allocated to the traditional group. The emergency green channel integrated management strategy was first carried out in 2019. In other words, the patients in the green channel group were treated using the emergency green channel integrated management strategy, but those in the traditional group were not.

Inclusion criteria: patients with complete medical records; patients 45 to 75 years old; patients who met the diagnostic criteria for AIS as defined in the *Chinese Guidelines for Diagnosis and Treatment of Acute Ischemic Stroke (2014)* and who had been diagnosed using relevant imaging examinations [9]; patients who had no previous stroke history, patients for whom the times from onset to hospital admission were less than six hours; and patients who underwent intravenous thrombolytic therapy after their admission.

Exclusion criteria: patients who had contraindications to thrombolysis; patients (or their family members on their behalf) who refused to undergo intravenous thrombolytic therapy; patients who suffered from brain diseases such as head trauma and brain tumors; patients who were implanted with a pacemaker or who had intracranial metal implants; patients who were transferred midway; patients who had coagulation dysfunction or other diseases of the circulatory system; patients who had previous head trauma or intracranial hemorrhages; patients who had malignant tumors; patients who had major internal medical diseases, such as myocardial infarction and heart failure.

This study was approved by the ethics committee of our hospital.

Methods

In the traditional group, the patients were rescued based on the traditional grading and zoning treatment principles [10]. The diagnosis and treatment areas in the emergency department were divided into an observation area (yellow), an infusion area (green), and a rescue area (red). The patients were graded according to the severity of their conditions. Level 1: patients who needed an immediate diagnosis and treatment and who were sent to the rescue area. Level 2: patients who needed to be treated within 10 minutes and who were sent to the rescue area. Level 3: patients who were sent the observation area. Level 4: patients who were sent to the infusion area.

The patients in the green channel group were treated using the emergency green channel integrated management strategy designed for acute strokes [11, 12]. The strategy consisted of 3 parts. (1) First, a special green channel was established for the AIS patients. The hospital departments including the emergency department, the neurology department, the laboratory department, the imaging department, and the pharmacy department were combined together. A special rescue team, which was composed of personnel with adequate work experience, was set up for the treatment of AIS. (2) Second, first aid procedures relevant to AIS were formulated. In these procedures, pre-hospital and intra-hospital first aid were included. Additionally, the work responsibilities of the medical staff in each department were

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Table 1. Baseline data ($\bar{x} \pm sd$)

Group	Green channel group (n=40)	Traditional group (n=42)	χ^2/t	P
Gender (n)			1.233	0.267
Male	23	19		
Female	17	23		
Age (years)	58.8±6.4	59.4±6.3	0.428	0.670
BMI (kg/m ²)	23.30±3.22	23.11±2.93	0.279	0.781
Brunnstrom staging (n) [17]			1.092	0.579
Stage I	15	12		
Stage II	12	12		
Stage III	13	18		
Underlying disease (n)			1.026	0.599
diabetes	4	2		
Hypertension	10	9		
Hyperlipidemia	5	7		
Smoking history (n)			0.734	0.392
Present	16	13		
Absent	24	29		
Drinking history (n)			0.094	0.759
Present	13	15		
Absent	27	27		
Education background (n)			0.648	0.723
Junior high school	28	26		
Senior high school and junior college	8	10		
University	4	6		

Note: BMI: body mass index.

clarified, and regular training and assessment were conducted. (3) The nurses who had worked in the emergency department for more than 5 years were the triage nurses. They were responsible for the quick identification of the patients' diseases and the assessment of the severity of their conditions. What's more, they were in charge of arranging the medical guide to send patients to the designated doctors' office for diagnostic and emergency treatment. What's more, measures like printing signs saying AIS green channel and hanging warning lights, were carried out to help ensure the patients were quickly and accurately sent to the designated areas. Special packages for AIS examinations and special first aid kits for thrombolysis were prepared, enabling the patients to be quickly diagnosed and immediately treated with thrombolytic therapy.

Outcome measures

The main outcome measures: (1) The onset times (the time from the patients realizing they

were sick to their entering the emergency department), the triage times (the time between first seeing the triage nurses to the time they first saw the doctors), DNT, the onset to thrombolysis times (the times from the patients realizing they were sick to their thrombolysis treatment), the thrombolysis times (the time between the intravenous thrombolytic therapy and the issuance of a CT report), and the emergency department lengths of stay (the lengths of the patients' stays in the emergency department) were compared between the two groups. (2) The DNT compliance rates were compared between the two groups. The patients with a DNT less than 60 minutes were treated using intravenous thrombolytic therapy [13].

Secondary outcome measures: (1) The neurological deficit scores (NIHSS) were used to assess the neurological deficit levels before and after the thrombolytic therapy. The total possible score was 42 points, and the higher the score, the more severe the neurological deficits [14]. (2) The Barthel index was used to

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Table 2. The treatment times ($\bar{x} \pm sd$)

Group	Green channel group (n=40)	Traditional group (n=42)	t	P
The time of onset (h)	4.04±1.11	4.21±1.30	0.638	0.525
The time of triage (min)	8.36±2.05	10.64±2.21	4.846	<0.001
DNT (minutes)	55.32±10.04	69.40±12.59	5.613	<0.001
The time from onset to thrombolysis (h)	5.19±1.28	5.22±1.25	0.107	0.915
The thrombolysis time (minutes)	9.94±1.10	12.80±1.36	10.494	<0.001
The emergency department length of stay (minutes)	16.94±4.40	21.57±5.11	4.403	<0.001

Note: DNT: door-to-needle time.

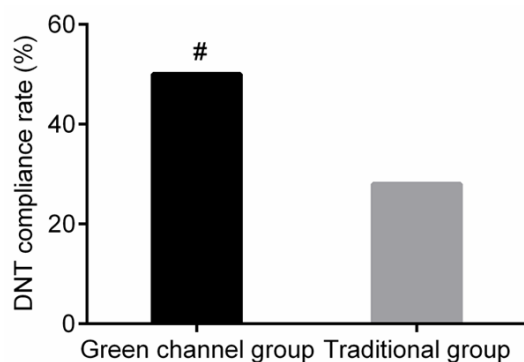


Figure 1. Comparison of DNT compliance rate before and after treatment. Compared with traditional group, #P<0.05. DNT: door-to-needle time.

evaluate the functional status of the patients' daily living activities before and after the thrombolytic therapy. The total possible score was 100 points, and the higher the score, the better the functional status of the daily living activities [15]. (3) Daily living abilities (ADL): the total possible score was 100 points, and the higher the score, the stronger the daily living abilities [16]. (4) During the thrombolysis process, the incidences of complications, such as bleeding around the puncture point, bleeding gums, bleeding in the digestive tract, and infections at the puncture points, were compared between the two groups.

Statistical methods

All the data were analyzed using SPSS statistical software version 20.0. The enumeration data were expressed as a number/percentage (n/%). Comparisons were conducted using chi-square tests. The normally distributed measurement data were calculated as the mean \pm standard deviation ($\bar{x} \pm sd$). Independent sam-

ple t tests were used for the inter-group comparisons, and paired t-tests were used for the before and after comparisons within the same group. A difference was considered statistically significant when the P value was less than 0.05.

Results

Baseline data

There were no significant differences in the baseline data between the two groups (all P>0.05, **Table 1**).

Various treatment times

As shown in **Table 2**, there were no significant differences in the onset times or the times from onset to thrombolysis (both P>0.05). The triage times, the DNT, the thrombolysis times, and the emergency department lengths of stay in the green channel group were significantly shorter when compared with the corresponding times in the traditional group (all P<0.001).

DNT compliance rate

The DNT compliance rate in the green channel group was significantly higher than the DNT compliance rate in the traditional group (50.00% vs. 28.57%, $\chi^2=3.954$, P=0.047, **Figure 1**).

NIHSS

As displayed in **Table 3**, the NIHSS in both groups after the treatment were declined when compared with before the treatment (both P<0.01). The NIHSS in the green channel group after the treatment was lower than that it was in the traditional group (P<0.01).

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Table 3. NIHSS ($\bar{x} \pm sd$)

Group	NIHSS		t	P
	Before treatment	After treatment		
Green channel group (n=40)	32.74±4.44	24.57±5.11	7.633	<0.001
Traditional group (n=42)	33.10±4.95	27.60±4.82	5.159	<0.001
t	0.347	2.759		
P	0.729	0.007		

Note: NIHSS: neurological deficit score.

Table 4. The Barthel index and ADL scores ($\bar{x} \pm sd$)

Group	The Barthel index score	ADL score
Green channel group (n=40)		
Before treatment	50.59±6.44	62.20±6.85
After treatment	70.06±6.03***###	79.33±6.30***###
Traditional group (n=42)		
Before treatment	51.14±5.80	61.88±7.03
After treatment	63.30±6.69***	70.04±6.66***

Note: Compared with before the treatment, ***P<0.001; compared with the traditional group, ###P<0.001. ADL: ability of daily living.

The Barthel index and ADL scores

As shown in **Table 4**, the Barthel index and the ADL scores in the two groups after the treatment were significantly higher when compared their levels with before the treatment (all P<0.001). The Barthel index and ADL scores in the green channel group after the treatment were higher than they were in the traditional group (both P<0.001).

Complications

Compared with the traditional group, the incidence of complications during thrombolysis in the green channel group was significantly lower (P<0.05, **Table 5**).

Discussion

AIS is a disease with a rapid onset and a quick progression. If AIS patients are not treated immediately, they will die. Intravenous thrombolysis therapy is the essential treatment for AIS. Its therapeutic effect is definite. Specifically, it can significantly decrease the disability and mortality rates of AIS patients and improve their prognoses [18]. However, there is a strict requirement on the intravenous thrombolytic

therapy time window. For AIS patients meeting the criteria for thrombolytic therapy, the earlier the thrombolytic time is, the more significant the therapeutic effect, and the better the prognosis [19]. A simple, fast, and efficient emergency procedure is effective in shortening DNT.

The special green channel for AIS patients in our hospital was established and implemented under the joint collaboration of multiple departments. The medical staff in the rescue team had rich clinical experience. The triage nurse was able to quickly and accurately identify the patients' diseases and evaluate the severity of their conditions. What's more, the special packages for the AIS examinations and special first

aid kits for thrombolysis prepared for the AIS patients were beneficial in saving time during the various examinations. Accordingly, the patients' stays in the emergency department were shortened to a great extent. Here, our results show that the time of triage, the DNT, the thrombolysis times, and the emergency department lengths of stay in the green channel group were significantly lower when compared with the traditional group, indicating that the emergency green channel integrated management strategy can effectively shorten patients' stays in the emergency department. In this way, the AIS patients can be diagnosed as early as possible and can be treated effectively. Arulprakash et al. reported that the application of the green channel integrated management strategy in the emergency department can greatly shorten the emergency department length of stay, providing sufficient time for thrombolytic therapy, which is consistent with our results [20]. In the United States, the DNT compliance rates of the AIS patients admitted in Get With The Guidelines-Stroke (GWTG-Stroke) hospital was 26.6%, but it increased to 96% after the application of the Helsinki model [21]. In China, the DNT compliance rate of AIS patients admitted to Nanjing

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Table 5. Complications (n (%))

Group	Bleeding around the puncture point	Bleeding gums	Bleeding in the digestive tract	Infection at the puncture point	The total incidence of complications
Green channel group (n=40)	1 (2.50)	1 (2.50)	1 (2.50)	1 (2.50)	4 (10.00)
Traditional group (n=42)	3 (7.14)	5 (11.90)	2 (4.76)	2 (4.76)	12 (28.57)
χ^2	0.952	2.672	0.297	0.297	4.499
P	0.329	0.102	0.586	0.586	0.034

General Hospital of Nanjing Military Command was 31.0%, and it reached 34.1% at Huashan Hospital Fudan University [22]. In this study, the DNT compliance rate in the traditional group was 28.57%, but it increased to 50.00% in the green channel group. This indicates that the emergency green channel integrated management strategy is more effective at shortening DNT and increasing the DNT compliance rate, saving time for thrombolytic therapy. The DNT compliance rate is significantly higher than it is at the Nanjing General Hospital of Nanjing Military Command and Huashan Hospital Fudan University model. However, it is lower than it is using the Helsinki model in the United States. This might be related to our imperfect emergency green channel integrated management strategy, which was used for a short period of time. In the future, a more perfect emergency green channel integrated management strategy will be formulated, actually avoiding the waste of a minute or even a second. By doing so, the patients can undergo professional treatment as quickly as possible, improving their prognoses.

Cerebral ischemia in stroke patients can cause neuron necrosis and even neurological damage. With the development of the disease, most patients also suffer from an impairment of various physiological functions, like cognitive function and sensory function. As a result, the patients' quality of life is affected [23]. The emergency green channel integrated management strategy is helpful at saving time for the patients' thrombolytic therapy. For AIS patients, the shorter the time from onset to thrombolysis, the better the therapeutic effect, and the faster the prognosis [24]. In our study, the NIHSS in both groups after the treatment were decreased when compared with before the treatment. The NIHSS in the green channel group after treatment were lower than they were in the traditional group. The Barthel index and ADL scores in both groups after the treatment were significantly higher than they were

before the treatment, and compared with the traditional group, the Barthel index and ADL scores in the green channel group after treatment were higher. These results suggest that the neurological deficits of the patients in the two groups after the thrombolytic therapy were significantly declined, but their ADL were significantly improved. Moreover, the neurological function and ADL of the AIS patients treated with the emergency green channel integrated management strategy were improved more significantly. Kamal et al. also found that the emergency green channel integrated management strategy is helpful for the significant improvement of AIS patients' various physiological functions [25].

However, this was a single-centered and short-term follow-up clinical study performed using an inadequate number of patients. Subsequently, a long-term follow-up study will be conducted using a larger cohort of AIS patients to confirm the impact of the emergency green channel integrated management strategy on their long-term prognoses.

In summary, the emergency green channel integrated management strategy is more effective at shortening AIS patients' stays in the emergency department, increasing the DNT compliance rate, and saving time for thrombolytic therapy, thus improving patients' neurological functions to a greater extent. It is worthy of clinical application.

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Disclosure of conflict of interest

None.

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