

ORIGINAL CONTRIBUTION

Impact of the COVID-19 Epidemic on Stroke Care and Potential Solutions

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BACKGROUND AND PURPOSE: When the coronavirus disease 2019 (COVID-19) outbreak became paramount, medical care for other devastating diseases was negatively impacted. In this study, we investigated the impact of the COVID-19 outbreak on stroke care across China.

METHODS: Data from the Big Data Observatory Platform for Stroke of China consisting of 280 hospitals across China demonstrated a significant drop in the number of cases of thrombolysis and thrombectomy. We designed a survey to investigate the major changes during the COVID-19 outbreak and potential causes of these changes. The survey was distributed to the leaders of stroke centers in these 280 hospitals.

RESULTS: From the data of Big Data Observatory Platform for Stroke of China, the total number of thrombolysis and thrombectomy cases dropped 26.7% ($P < 0.0001$) and 25.3% ($P < 0.0001$), respectively, in February 2020 as compared with February 2019. We retrieved 227 valid complete datasets from the 280 stroke centers. Nearly 50% of these hospitals were designated hospitals for COVID-19. The capacity for stroke care was reduced in the majority of the hospitals. Most of the stroke centers stopped or reduced their efforts in stroke education for the public. Hospital admissions related to stroke dropped $\approx 40\%$; thrombolysis and thrombectomy cases dropped $\approx 25\%$, which is similar to the results from the Big Data Observatory Platform for Stroke of China as compared with the same period in 2019. Many factors contributed to the reduced admissions and prehospital delays; lack of stroke knowledge and proper transportation were significant limiting factors. Patients not coming to the hospital for fear of virus infection was also a likely key factor.

CONCLUSIONS: The COVID-19 outbreak impacted stroke care significantly in China, including prehospital and in-hospital care, resulting in a significant drop in admissions, thrombolysis, and thrombectomy. Although many factors contributed, patients not coming to the hospital was probably the major limiting factor. Recommendations based on the data are provided. (*Stroke*. 2020;51:00-00. DOI: 10.1161/STROKEAHA.120.030225.)

Key Words: coronavirus ■ humans ■ infections ■ stroke ■ thrombectomy

When the coronavirus disease 2019 (COVID-19) outbreak became paramount, medical care for other devastating diseases was negatively impacted. We recently discussed the potential challenges and solutions for stroke care during the COVID-19 outbreak.¹ The American Heart Association and American Stroke Association also issued a temporary emergency guidance for stroke care during the COVID-19 pandemic for stroke centers in the United States.² There is

no evidence that patients with stroke are more (or less) susceptible to COVID-19. Patients with COVID-19 can, however, develop a new stroke, and the neurological symptoms of COVID-19 could potentially make stroke recognition more difficult.³ How much has stroke care been affected in this pandemic? In this study, we investigate the impact of the COVID-19 outbreak on stroke care across China to find potential solutions to maintain high-quality stroke care without interruption during crisis.

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METHODS

The study design, the de-risked raw data, and any related materials are available by reasonable request to the first author (J.Z.). The Institutional Review Board of the Minhang Hospital affiliated to the Fudan University approved the study protocol.

The Big Data Observatory Platform for Stroke of China (BOSC; <https://sinosc.org/home/index>), which was established in 2017, currently collects data from 280 hospitals in the network across China. The stroke centers in these hospitals were certified by the Stroke Prevention Project Commission of the National Health Commission in China. In 2018, there were 200 hospitals registered in BOSC; these hospitals have registered data in 2018, 2019, and 2020 for comparison purposes. BOSC monitored a significant drop in both the thrombolysis and thrombectomy cases from January to February in 2020 as compared with the same period in 2019. We designed a survey to investigate the major changes in stroke care during the COVID-19 outbreak. A focus on February data for both 2019 and 2020 was selected for this study because the burden of COVID-19 peaked during February in China, and March data were not available at the time of investigation. Some hospitals were designated by the government as COVID-19 centers in February 2020. Confirmed or suspected COVID-19 patients identified elsewhere were generally transferred to these designated hospitals for centralized care. To speed up the investigation, we only asked specific questions on major changes, including the changes in prehospital and in-hospital care of patients with stroke (Appendix).

Statistical Analysis

This is a retrospective and simple descriptive study. Data are presented as actual numbers or as percentages. χ^2 with Yates correction was used to calculate 2-tailed *P* using Graphpad Prism (version 8.2.1; San Diego, CA).

RESULTS

Data Extracted From the National Data Platform

Among the 280 hospitals in the data registry of BOSC, the numbers of thrombolysis cases did not change significantly in January (3397) and February (3422) of 2019 but dropped significantly from 3638 cases in January 2020 to 2508 in February 2020 (31.1% decrease; $P < 0.0001$). The numbers of thrombectomy cases did not change significantly in January (1334) and February

(1298) of 2019 but dropped from 1378 cases in January 2020 to 970 in February 2020 (29.6% decrease; $P < 0.0001$). Comparing the total number of thrombolysis and thrombectomy cases in February 2020 to the same period in 2019, we see a drop of 26.7% ($P < 0.0001$) and 25.3% ($P < 0.0001$), respectively. Since there were only 200 hospitals registered in BOSC in 2018, we present the data from these 200 hospitals for January and February of 2018 to 2020 (Table 1) for comparison purpose to demonstrate there is no trend of case decrease over the years. There was a significant increase in the number of thrombolysis (around 30%; $P < 0.0001$) and thrombectomy cases (around 50%; $P < 0.0001$) in January and February in 2019 as compared with the same period of the previous year. There was no significant change of thrombolysis and thrombectomy cases in January in 2020 as compared with January 2019. A significant drop in the number of thrombolysis and thrombectomy cases of $\approx 30\%$ in February was observed from 2019 to 2020.

Characteristics of the Data Sets and the Impact

There were a total of 227 valid and complete datasets from the survey of the 280 stroke centers. The retrieval rate of 81% covers 29 of 31 provinces and municipalities across China. Nearly 50% of the hospitals were designated hospitals for COVID-19, as indicated in Table 2. The capacity and capability of stroke care was reduced and impaired in the majority of these hospitals. In 2020, hospital admissions related to stroke dropped by $\approx 40\%$ as compared with the same period in 2019. Based on Table 3, in February 2019, the thrombolysis treatment rate was 7.8% (2726/34 725), compared with 9.4% (2031/21 581) in February 2020 ($P < 0.0001$). In February 2019, the thrombectomy treatment rate was 2.7% (941/34 725), compared with 3.4% (727/21 581) in February 2020 ($P < 0.0001$). Despite the slight increase in thrombolysis and thrombectomy rates, the absolute number of thrombolysis and thrombectomy cases dropped by $\approx 25\%$ among all hospitals (Table 3). The majority of the stroke centers have stopped or reduced their efforts in stroke education for the public. There was no difference

Table 1. Changes in Thrombolysis and Thrombectomy in 200 Hospitals in February From 2018 to 2020

	Thrombolysis			Thrombectomy		
	2018	2019	2020	2018	2019	2020
January	2155	2737*	2774	723	1091*	1100
Percentage of change		27.01%	1.35%		50.90%	0.82%
February	1986	2729*	1893*	711	1099*	765*
Percentage of change		37.41%	-30.63%		54.57%	-30.39%

BOSC indicates Big Data Observatory Platform for Stroke of China.

* $P < 0.0001$ increases or decreases as compared with the same period of the previous year. These data are from the registry of the BOSC from 2018 to 2020 that includes data from 200 hospitals.

Table 2. COVID-19 Impact on Hospitals, Stroke Care Capacity, and Stroke Education

Characteristics	No. of Hospitals	%
Is your hospital a designated hospital for COVID-19?		
Yes	114	50.22
No	113	49.78
The impact on emergency stroke capacity		
No change	55	24.23
Partial reduction	159	70.04
All changed to diagnosis and treatment of fever patients	10	4.41
Other	3	1.32
The impact on prehospital stroke education		
Stopped completely	46	20.26
Stopped partially	163	71.81
As usual	18	7.93

These data are from the survey results from 227 hospitals. COVID-19 indicates coronavirus disease 2019.

in the pattern of changes between hospitals designated for COVID-19 and nondesignated hospitals.

Potential Causes of the Observed Changes

As indicated in Table 3, patients or patients' families not coming to the hospital is likely the most important factor resulting in reduced hospital admission rate and reduced thrombolysis and thrombectomy cases. Deficiencies in stroke awareness is the second critical factor, as we have discussed in the past in the absence of the pandemic.⁴⁻⁶ Other contributing factors are listed in Table 4, such as lack of adequate transportation methods, including insufficient ambulance resources. Only a small portion of hospitals closed its fast-track stroke care channels. The COVID-19 screening process was considered the major factor that caused the potentially increased door-to-needle time, although we do not have the actual data. Febrile patients affected the stroke evaluation process, and insufficient stroke medical staff could also affect door-to-needle time.

Table 3. Impact of COVID-19 Outbreak on Stroke Admissions, Thrombolysis, and Thrombectomy

	No. of Admissions in February		Thrombolysis in February		Thrombectomy in February	
	2019	2020	2019	2020	2019	2020
All hospitals	34 725	21 581	2726	2031	941	727
Percentage of drop		37.9%		25.5%		22.7%
Undesignated hospitals	17 618	10 928	1417	1065	445	336
Percentage of drop		38.0%		24.8%		24.5%
Designated hospitals	17 107	10 653	1309	966	496	391
Percentage of drop		37.7%		26.2%		21.2%

These are the data from the survey results from 227 hospitals. COVID-19 indicates coronavirus disease 2019.

Table 4. Potential Reasons for the Impact of COVID-19 Outbreak on Stroke Services

Reasons	No. of Answers	%
The potential reasons for prehospital delay (arrival within 4.5 h)		
No change	19	8.37
Patients' and their families' fear of contracting virus in hospital	198	87.22
Lack of first aid knowledge	96	42.29
Insufficient ambulance resources	35	15.42
Insufficient other transportation resources	98	43.17
Lack of family support	72	31.72
The potential reasons for decreased stroke care admission		
No change	7	3.08
Patients' and their families' fear in coming to hospital	213	93.83
Insufficient ambulance resources	32	14.10
Insufficient public transportation	106	46.70
Lack of stroke first aid knowledge	80	35.24
The potential reasons for increased door-to-needle time		
No change	63	27.75
Stroke fast-track channel temporarily closed	9	3.96
COVID-19 screening process delay	143	63.00
Fever patients occupy stroke examination resources	70	30.84
Relevant medical personnel shortage	36	15.86
The potential reasons for decreased thrombolysis		
No effect	17	7.49
Reduced number of patients coming to hospital	201	88.55
Prehospital delay	156	68.72
Stroke care personnel shortage	37	16.30
COVID-19 screening delay	91	40.09
Lack of protective equipment	18	7.93
Cautious measures to prevent in-hospital infection	65	28.63
The potential reasons of decreased thrombectomy		
No change	16	7.05
Reduced number of patients coming to hospital	183	80.62
Prehospital delay	146	64.32
Infectious prevention strategy affects procedure	61	26.87
Lack of surgeons	26	11.45
Lack of anesthesiologists	13	5.73
Lack of protective measures	25	11.01
No thrombectomy ability	13	5.73

COVID-19 indicates coronavirus disease 2019.

DISCUSSION

The major finding of this study was that stroke care in China was significantly affected by the outbreak of COVID-19, with a significant reduction in both thrombolysis and thrombectomy. The change in the number of treatment cases was consistent between the National Data Registry of BOSC from 280 hospitals and our

survey results from 227 hospitals, with a similar drop in the number of thrombolysis and thrombectomy cases (around 25%) in February 2020 as compared with February 2019. The most prominent factor was that patients with stroke were not coming to the hospital for various reasons. The screening process for COVID-19 also interfered with stroke care significantly.

Changes in Absolute Number and Rate of Thrombolysis and Thrombectomy

While we observed a significant drop in the absolute number of thrombolysis and thrombectomy cases, the rate of thrombolysis and thrombectomy increased slightly. The thrombolysis treatment rate increased from 7.9% in February 2019 to 9.4% in February 2020, which is similar to the 8.6% rate reported in the US Get With The Guidelines Registry published in 2017.⁷ The thrombectomy rate increased from 2.7% in February 2019 to 3.4% in February 2020, which is similar to the 3.3% rate reported in the United States in 2017 for all patients with ischemic stroke at all hospitals.⁸ While the changes were small, they were statistically significant due to the large sample size. Thus, the drop in the absolute number of thrombolysis and thrombectomy cases is due to the drop in stroke admissions.

The drop in the absolute number of therapeutic interventions likely had a profound negative impact on stroke outcome. First of all, the stroke-related disability likely increased. Based on Table 3 for the data from 227 hospitals, there were 13 144 (34 725–21 581) fewer stroke admissions. Assuming the stroke incidence is unchanged from 2019 to 2020 and assuming a conservative 8% thrombolysis rate, the drop in stroke admissions resulted in 1051 fewer patients being treated with thrombolysis. Similarly, assuming a conservative 3% thrombectomy rate, ≈394 fewer patients received thrombectomy intervention. Additionally, the patients who were not admitted to the hospital potentially lost the opportunity to have appropriate secondary prevention treatment such as carotid revascularization, anticoagulation for atrial fibrillation, antiplatelet therapies, as well as lipid lowering and blood pressure management. The loss of appropriate secondary stroke prevention would have a significant impact on recurrent stroke rate. It is important to note that here we present only a 1-month data comparison from <300 hospitals out of a large number of hospitals that have a stroke center in China.

Patients Not Coming to the Hospital

Patients not coming to the hospital for an immediate evaluation of acute stroke is nothing new; however, this became more prominent during the outbreak of COVID-19. On top of a lack of stroke knowledge, the lack of knowledge compounded with fear of the virus made patients

with stroke much less likely to seek help. The emphasis on social distancing might have inappropriately persuaded patients with acute stroke to avoid in-person medical care. Increased social isolation may also have decreased the chance of friends and family members recognizing that a patient was having a stroke. Proper education including stroke awareness and COVID-19 knowledge is needed in countries affected by COVID-19. Stroke awareness education is probably never so important as during a pandemic. Unfortunately, the majority of the hospitals stopped or reduced stroke awareness education.

Under city lockdown, the availability of transportation became severely limited. However, as long as there are sufficient ambulances and drivers, prehospital delay time should be reduced due to less traffic. Stroke priority triage plans should be established for conditions of limited emergency resources. We initially hypothesized that there would be a difference in the number of admissions between designated and undesignated hospitals; however, this assumption was not supported by the data. This could potentially be explained by patients going to the hospital that they would normally go to and not being aware which hospitals were designated as COVID-19 centers. Another possibility is the relatively robust system of stroke care networks across China.

COVID-19 Screening and Stroke Management Processes

The COVID-19 screening process could add a significant barrier to door-to-needle time and groin puncture for timely thrombolysis and thrombectomy. During the pandemic, all patients admitted to the hospital needed to have epidemiological screening and relevant examinations, which added a significant in-hospital delay for a time-sensitive disease like stroke. When laboratory resources and computed tomography (CT) scanners are occupied by a large number of patients with potential COVID-19, proper resource management needs to prioritize time-sensitive diseases such as stroke and myocardial infarction. Due to potential false negative results in the currently available coronavirus serology test, and the fact that many patients may be asymptomatic for COVID-19, the screening process should not delay timely therapy. The protocol for infectious disease should be initiated with proper personal protective equipment. It is important to note that because hospitals have potentially the highest density of patients with COVID-19, to protect the patient, the patient must wear a mask at all times in the hospital. Such a policy also protects the medical providers. The scientific evidence indicates that putting a mask on the potential infectious source offers the highest protection⁹; this is called infectious source control. Policies to protect the healthcare team, such as proper application of personal protection equipment for the care team, and patient isolation during evaluation and treatment, added significant

time to delivery of time-sensitive stroke treatment. With the rise of intravenous tissue-type plasminogen activator use and more recently acute stroke thrombectomy, much effort was devoted to optimize the timing of therapeutic delivery. The current viral pandemic has added new obstacles to the system and requires constant adaptation as our knowledge of the disease, and local resources and policies, changes daily.

Resource Management

Resource management is critical during a pandemic. Such resources include relevant experts, other assisting personnel, equipment, laboratory examination, and personal protective equipment, etc. As we analyzed the data, we noticed that a small portion of hospitals have closed their stroke care channels. As we proposed in our recent editorial, it might be beneficial to have designated stroke centers during the crisis to ensure adequate resources are available to offer high-quality stroke care.¹ The emergency medical service and the public should be informed that suspected stroke patients should be sent to such designated hospitals.

Recommendations

Based on the data, we are making the following recommendations for stroke care during the crisis of the COVID-19 pandemic:

1. Improving stroke awareness during the crisis is the key. Stroke awareness education activities should not stop or be reduced; they should be enhanced. A robust systematic educational network should be established and enhanced to educate patients on what to do during the pandemic.
2. Establishing a fast-track COVID-19 screening process for patients with potential stroke is highly desirable. One practical approach is to have a full chest CT scan together with the head and neck CT angiogram scan for all potential stroke patients. Existing evidence suggests a good correlation between chest CT scan findings and reverse transcription polymerase chain reaction testing in COVID-19.^{10,11} A positive CT scan appears before symptoms in many cases and before a positive virology test in some patients.^{11,12} The initial CT should include bilateral multilobar ground-glass opacification, mainly in the lower lobes, which is not included in the current routine practice for CT scan for patients with stroke.
3. A rapid laboratory test for the virus should be prioritized for patients with stroke, and the test should be part of the existing stroke fast-track pathway.
4. The initiation of stroke therapy should not be hindered by the COVID-19 screening process. Patients should always wear a surgical mask for infectious disease source control. Infectious

disease experts should work closely with the acute stroke team to develop a workflow pattern that minimizes delays while ensuring proper protection of the medical staff.

5. Resource management should be established as quickly as possible. The fast-track stroke care channel should remain open. Designated stroke centers should be assigned to conserve resources for delivery of high-quality stroke care.
6. A campaign to encourage appropriate hospital evaluation for emergent, treatable, time-sensitive diseases such as stroke and myocardial infarction should be initiated at a national level. Leaders of professional societies should work closely with policy makers and governmental officials to ensure that this occurs.

Limitations of the Study

This is a simple descriptive study. We did not investigate the incidence of virus infection among patients with stroke, nor did we investigate whether virus infection affected stroke outcomes. No actual time for prehospital or in-hospital delays (door-to-needle time) was ascertained. The potential reasons for such delays are largely observational. Further study of these issues is needed. Another limitation of this study is that the data were obtained from highly selected stroke centers that have been certified by an official certification bureau. We used 3 sets of data from different numbers of hospitals, which could potentially be confusing. The mechanism of the increase in the number of thrombolysis and thrombectomy from 2018 to 2019 is unclear. It could have been caused by rapid development of stroke centers in these hospitals or by better data registration.

In conclusion, the COVID-19 outbreak affected stroke care significantly, impairing both prehospital and in-hospital care, resulting in a significant decline in thrombolysis and thrombectomy. Patients not coming to the hospital was likely a major limiting factor. Patients with stroke should be encouraged to come to the hospital and be reassured that they will have infectious disease precautions. Enhanced stroke awareness activities, proper resource management, and stroke center designation during the crisis are needed. Recommendations based on the data are provided.

ARTICLE INFORMATION

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Disclosures

None.

APPENDIX

- Where is your hospital located?
- Is your hospital a designated hospital for coronavirus disease 2019 (COVID-19)?
 - Yes
 - No
- The impact on emergency stroke capacity
 - No change
 - Partial reduction
 - All changed to diagnosis and treatment of fever patients
 - Other
- The impact on prehospital stroke education
 - Stopped completely
 - Stopped partially
 - As usual
- Please fill in the total number of stroke-related admissions, thrombolysis, and thrombectomy in February 2019 and 2020, respectively.
- The potential reasons for prehospital delay (arrival within 4.5 hours)
 - No change
 - Patients' and their families' fear of contracting virus in hospital
 - Lack of stroke first aid knowledge
 - Insufficient ambulance resources
 - Insufficient other transportation resources
 - Lack of family support
 - Other
- The potential reasons for decreased stroke care admissions
 - No change
 - Patients' and their families' fear in coming to hospital
 - Insufficient ambulance resources
 - Insufficient public transportation
 - Lack of stroke first aid knowledge
 - Other
- The potential reasons for increased door-to-needle time
 - No change
 - Stroke fast-track channel temporarily closed
 - Delayed by COVID-19 screening process
 - Fever patients occupy stroke examination resources
 - Relevant medical personnel shortage
 - Other

- The potential reasons for decreased thrombolysis
 - No effect
 - Reduced number of patients coming to hospital
 - Prehospital delay
 - Stroke care personnel shortage
 - COVID-19 screening delay
 - Lack of protective equipment
 - Cautious measures to prevent in-hospital infection
 - Other
- The potential reasons for decreased thrombectomy
 - No change
 - Reduced number of patients coming to hospital
 - Prehospital delay
 - Infection prevention strategy affects procedure
 - Lack of surgeons
 - Lack of anesthesiologists
 - Lack of protective measures
 - No thrombectomy ability
 - Other

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