

Coronavirus Disease 2019 is Threatening Stroke Care Systems: Challenge and Management

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Abstract

Background Since the onset of the coronavirus disease 2019 (COVID-19) pandemic, the stroke care systems have been seriously affected because of social restrictions and other reasons. As the pandemic spreads further to global, it is of great significant to understand how COVID-19 affect the stroke care systems. **Methods** We retrospectively studied the real-world data of one comprehensive stroke center in China from January to February, 2020, and compared it with the same period in 2019. We analyzed time from stroke onset to admission, severity, effect after treatment, hospital stays, cost of hospitalization, etc., and correlation among them. **Results** We observed a great extension of the onset-to-door time of stroke patients during the pandemic. The degree of neurological deficit of the patients was significantly higher, both admission and discharge. Longer onset-to-door time and higher degree of neurological deficit were significantly correlated with longer hospital stays and higher medical burden. **Conclusions** COVID-19 pandemic is threatening the stroke care systems. Measures must be taken to minimize the collateral damage caused by COVID-19.

Background

The coronavirus disease 2019 (COVID-19), which caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has developed into a global pandemic since it first spread in mainland China in late 2019. This pandemic has been causing a global public health event and a global health threat [1], not only because of COVID-19 itself, but also all other diseases who are directly or indirectly affected. As of August 2, 2020, COVID-19 has infected more than 17 million people worldwide and killed more than 680,000 people [2].

Stroke patients and stroke care systems have been significantly affected during COVID-19 pandemic. On the one hand, COVID-19 can affect the cardiovascular and cerebrovascular systems [3] by down-regulating the angiotensin-converting enzyme 2 and decreasing the activation of the alternative renin-angiotensin system pathway in the brain [4], which may contribute to stroke during SARS-CoV-2 infection. On the other hand, some media and doctors have noticed a drop in admissions for acute myocardial infarction patients [5, 6] and stroke patients [7], while their morbidities are rarely possible to decline during the pandemic.

There is no doubt that the social restrictions, the government interventions, and many other factors have inevitable affected tens of thousands of stroke patients during COVID-19 pandemic. To make matters worse, as the pandemic continues, these effects may last for several years or even longer. However, the exact effects on stroke care systems caused by COVID-19 stay unclear, and the conclusions of previous studies remain controversial [7, 8]. In addition, because of the obvious differences in national conditions, medical standards, medical systems, political systems, customs and cultures among countries, it is necessary to conduct fully studies on different economies such as China, the United States, the Europe Union, etc.

The present study aimed to: (a) review the impact of COVID-19 pandemic on the stroke care systems in mainland China by comparing the real-world data during the pandemic and the same period last year; (b) explore the correlation between changes during the pandemic and clinical outcomes; and (c) better understand the changes of stroke care systems caused by COVID-19 to help make effective and feasible measures and strategies.

Methods

Study Design and Population

Fujian Medical University Union Hospital is a nationally certified acute stroke-ready hospital with one of the biggest regional comprehensive stroke centers in southeastern China. We retrospectively analyzed the quality improvement data of acute ischemic stroke (AIS) patients admitted at the comprehensive stroke center of Fujian Medical University Union Hospital from January to February, 2020, which was the most severe period of the COVID-19 pandemic in mainland China. We compared these patients discharged with a principal diagnosis of AIS to patients from the same period in 2019. The study was conducted from data already collected and did not collect any identifiable information of patients. The study was approved by the institutional review board. The study data are available from the corresponding author upon reasonable request.

Quality Improvement Data

To review and monitor stroke care quality benchmarks, indicators, evidence-based practices, and outcomes, the data of each AIS patient is collected and recorded in detail by the hospital. We queried the demographic data of the patients, whether accepted thrombolysis and/or thrombectomy and the door-to-needle (DTN) time among thrombolysis, and other clinical characteristics data. Clinical characteristics data includes time from stroke onset to admission, the degree of neurological deficit on admission and on discharge evaluated by National Institutes of Health Stroke Scale (NIHSS), effect after treatment, hospital stays in days, cost of hospitalization, etc.

Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM, Armonk, New York). Demographic data, DTN time, time of stroke onset to admission, severity, effect after treatment, hospital stays, cost of hospitalization, etc. were compared between 2020 and 2019. Continuous variables were compared using the Mann-Whitney U test and the Chi-square test was used for categorical variables. The Spearman correlation analyses were used to detect the associations between clinical characteristics and outcomes. The statistical threshold was set to $p < 0.05$. The statistical tests were two-sided.

Results

From January to February, a total of 118 patients was admitted to the Department of Neurology, including 37 AIS patients. While this number was 305 in 2019 (including 38 patients diagnosed AIS). Although the number of hospitalized patients decreased by 61.3% compared with 2019, the number of AIS patients was about the same. In addition, the admission rate of cerebral hemorrhage decreased from 9.51% in 2019 to 4.24% in 2020.

Compared with 2019, several key indicators of evaluating AIS patients have changed significantly. The onset-to-door time was greatly extended from $28.92(\pm 35.86)$ hours to $60.62(\pm 113.27)$ hours (Fig. 1A). Only 8.1% of AIS patients arrived at the stroke center within 4.5 hours (10.5% in 2019), 18.9% arrived within 6 hours (31.6% in 2019), and still 40.5% of patients did not seek for stroke care until more than 24 hours after onset (only 26.3% in 2019) (Fig. 1B). Among the AIS patients who accepted thrombolytic therapy with IV alteplase, the DTN time was also extended from $42(\pm 16.4)$ minutes by 21.4% to $51(\pm 12.7)$ minutes (Fig. 1C). During the pandemic, the average NIHSS score of AIS patients on admission was $6.84(\pm 6.96)$, and dropped to $5.41(\pm 6.66)$ on discharge. The average NIHSS score decreased by $1.43(\pm 1.88)$ after treatment. While in 2019, the average NIHSS score was $5.47(\pm 6.24)$ on admission, $3.11(\pm 5.02)$ on discharge, and decreased by $2.37(\pm 2.76)$ after treatment, which were significantly lower than 2020 (Fig. 1D & Table 1). The average hospital stays of AIS patients increased slightly from $13.61(\pm 9.03)$ days to $14.59(\pm 9.53)$ days (Fig. 1E). However, the average total cost of hospitalization rose sharply by 42.0%, from $19895.88(\pm 20968.41)$ yuan to $28244.35(\pm 45694.10)$ yuan (Fig. 1F).

Correlation analyses were performed to determine the relationship between the changes during the pandemic and prognosis of the AIS patients. The onset-to-door time was negatively correlated with age ($r = -0.265$, $p = 0.022$), NIHSS score on admission ($r = -0.382$, $p = 0.001$), NIHSS score on discharge ($r = -0.305$, $p = 0.008$), and decreased NIHSS score ($r = -0.266$, $p = 0.021$) (Fig. 2A). The hospital stays were positively correlated with NIHSS score on admission ($r = 0.493$, $p = 0.000$), NIHSS score on discharge ($r = 0.485$, $p = 0.000$), and decreased NIHSS score ($r = 0.348$, $p = 0.002$) (Fig. 2B). And the total cost of hospitalization was positively correlated with NIHSS score on admission ($r = 0.618$, $p = 0.000$), NIHSS score on discharge ($r = 0.541$, $p = 0.000$), decreased NIHSS score ($r = 0.473$, $p = 0.000$), and hospital stays ($r = 0.776$, $p = 0.000$) (Fig. 2C).

Discussion

Challenges and Changes in Stroke Care Systems

During the pandemic, extreme measures were taken to prevent the spread of COVID-19. Chinese government locked down cities and communities, shut down public transportation and most public services, declared temporary suspensions of production and schools, etc., aiming to reduce population movements and aggregation. In health system, body temperature was strictly monitored. Fever patients were compulsively arranged to an independent procedure called “fever clinic”. After excluding the possibility of COVID-19 infection, the fever patients would then be transferred to the regular medical

system. In the meantime, more than 40 thousand doctors and nurses nationwide were sent to Hubei Province, China, to combat COVID-19 [9].

The admission of AIS patients were not decreased during the pandemic, which was quite different from the United States [7]. This may be because: (a) as a regional comprehensive stroke center, the stroke unit remained open during the pandemic; (b) even during the pandemic, patients still tended to visit a comprehensive stroke center rather than a nearest primary stroke center; (c) stroke causes more concern and afraid even than COVID-19 due to the serious sequelae and consequence; (d) the popularity of stroke education to the public in recent years. In contrary to AIS, the admission rate of cerebral hemorrhage dropped by more than a half. A possible explanation of this phenomenon is that ordinary hospitals can be competent for the treatment of patients with cerebral hemorrhage, so during the pandemic patients with cerebral hemorrhage may just choose the nearest hospital as possible. In China, patients can decide by themselves to ignore the system of tiered diagnosis and treatment, and even emergency medical service personnel tend to send patients directly to comprehensive stroke centers for treatment. This also reflects the importance of the construction of stroke centers, the optimization of stroke care systems, and stroke education.

Obviously, COVID-19 pandemic had a negative impact on stroke patients and stroke care. The onset-to-door time was greatly extended during the pandemic for the possible reasons: (a) the will of patients to go to hospital reduced; (b) the emergency medical systems were overloaded; (c) the lockdowns of communities, and the cumbersome body temperature monitoring procedures objectively hindered the timeliness of patient visits. The average NIHSS scores on admission and on discharge were both higher than in 2019, while the decreased NIHSS score after treatment was lower than the same period last year, suggesting that the degree of neurological deficit on admission and on discharge, the effects after treatment, and the long-term prognosis were all worse during the pandemic. In addition, compulsory lung CT scan of stroke patients may cause potential negative effects. These changes eventually lead to an increase of the hospital stays and the total cost of hospitalization. In total, onset-to-door time is still the most important factor affecting the prognosis and the treatment cost of stroke patients. COVID-19 pandemic directly and indirectly affected the will, time, and capacity of the AIS patients to the stroke centers, which in turn caused negative effects and a higher medical burden.

Suggestions and Strategies for Government, Medical systems, and Patients

As the worst global public health event in recent decades, COVID-19 pandemic keeps continuing and it seems difficult to obtain effective control in the short term. Therefore, it is of great significance to understand how the COVID-19 affect stroke care systems in the real-world and then take effective measures. We recommend the following strategies to be implemented as soon as possible:

For government: (a) make a decision very carefully on the lockdown of cities and communities; (b) keep the public transportation and services as normal as possible, especially the emergency medical system; (c) optimize allocations of medical resources to prevent a collapse of medical system; (d) remind the

public even during the pandemic it is highly recommended to visit a nearest stroke center as soon as possible; (e) continue improving the public stroke education, encouraging primary prevention, advancing acute therapy, appreciating secondary prevention and recovery, and reducing regional disparities in stroke care[10].

For medical systems: (a) ensure that stroke centers still provide high-quality stroke care during the pandemic; (b) review and optimize the stroke care quality according to the pandemic situation; (c) add body temperature monitoring, lung CT scan and COVID-19 nucleic acid detection to the standard stroke care system if possible, and ensure that the DTN time of more than 50% of AIS patients treated with IV alteplase is still within 60 minutes [11]; (d) Establish independent passages and isolation wards for stroke patients with fever, a history of epidemics, or suspected COVID-19 infection; (e) provide necessary and sufficient personal protective equipment against COVID-19 for healthcare professionals in stroke centers [12]; (f) prevent healthcare professionals from overwork; (g) use telemedicine in locked-down regions for timely review of brain imaging in stroke patients, decision making for rapid imaging interpretation in time for IV alteplase [11], etc.; (h) explore the feasibility of high-tech applications for stroke care during the pandemic, such as unmanned wards, artificial intelligence, big data analysis, virtual reality technology, etc.

For patients: (a) adhere to the primary prevention of stroke, such as hypertension, diabetes, etc.; (b) as soon as early stroke symptoms appear, seek help from the nearest stroke center; (c) provide doctors with detailed medical history, such as epidemiology, close contact history of patients with COVID-19 infection, etc.

This study was a real-world study and it was observational and retrospective. Although the present study has provided some evidence suggesting that COVID-19 posed a threat to stroke care systems, large-sample and long-term follow-up studies are still needed to determine the ultimate impact of COVID-19 on stroke patients and stroke care systems.

Conclusions

Evidence and data from real-world suggest that COVID-19 pandemic is threatening stroke care systems. Effective measures must be taken immediately to minimize the collateral damage caused by COVID-19.

Abbreviations

COVID-19

the coronavirus disease 2019; SARS-CoV-2:severe acute respiratory syndrome coronavirus 2; AIS:acute ischemic stroke; DTN:door-to-needle; NIHSS:National Institutes of Health Stroke Scale.

Declarations

Acknowledgments

None.

Authors' contributions

All authors listed (JX, XH, CL, YH) have contributed sufficiently to the project to be included as authors. JX: Conception and design, acquisition of data, drafting of the manuscript, obtaining funding. XY: Conception and design, analysis and interpretation of data, critical revision of the manuscript for important intellectual content, statistical analysis, supervision. CL: Acquisition of data, obtaining funding, technical, or material support. YH: Analysis and interpretation of data, statistical analysis, technical, or material support. All authors consent for this manuscript's publication. All authors have read and approved the manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study was consented by the Ethics Committee of Fujian Medical University Union Hospital (NO: 2019KJTZD009).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interest. To the best of our knowledge, no competing interests, financial or other, exist.

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Tables

Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.

Figures

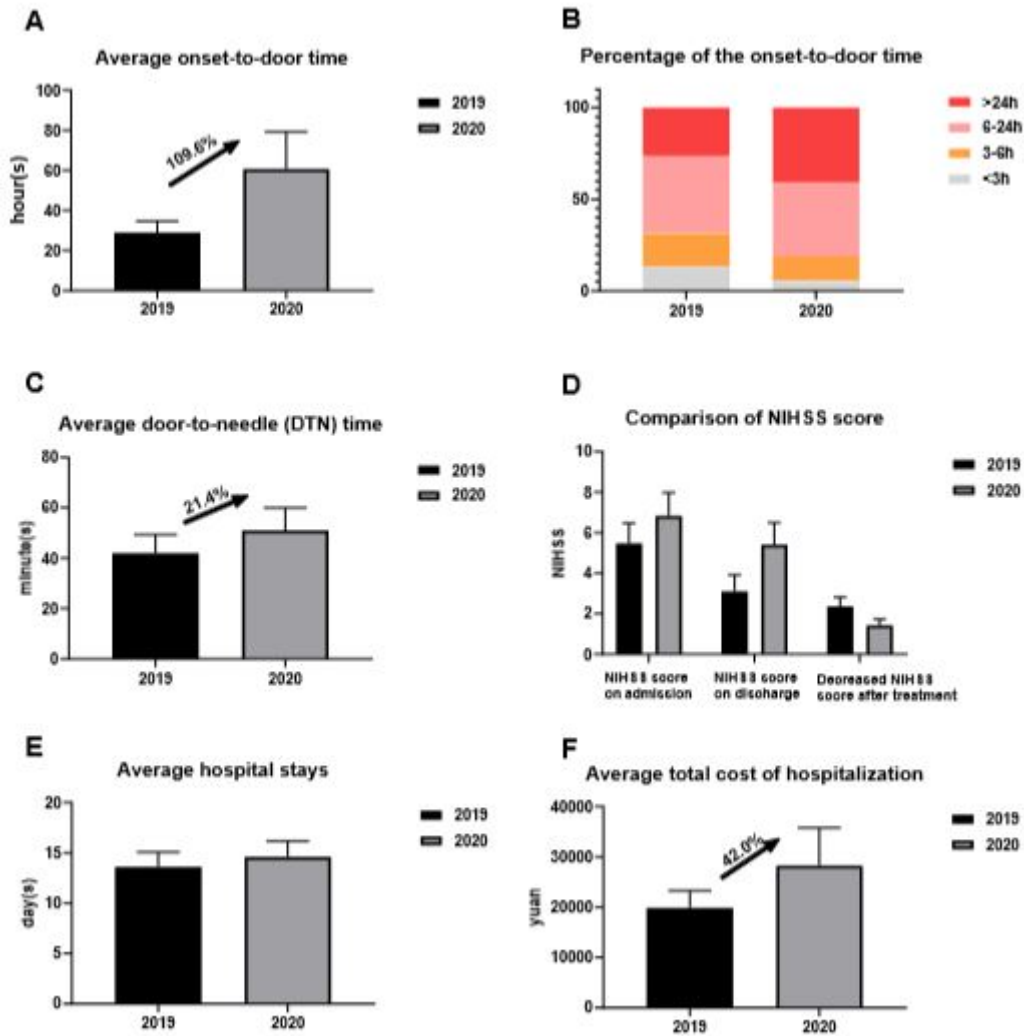


Figure 1

Comparisons of acute ischemic stroke patients in 2019 and 2020. (A) Average onset-to-door time. (B) Percentage of the onset-to-door time. (C) Average door-to-needle time. (D) Comparison of NIHSS score. (E) Average hospital stays. (F) Average total cost of hospitalization. NIHSS, National Institutes of Health Stroke Scale.

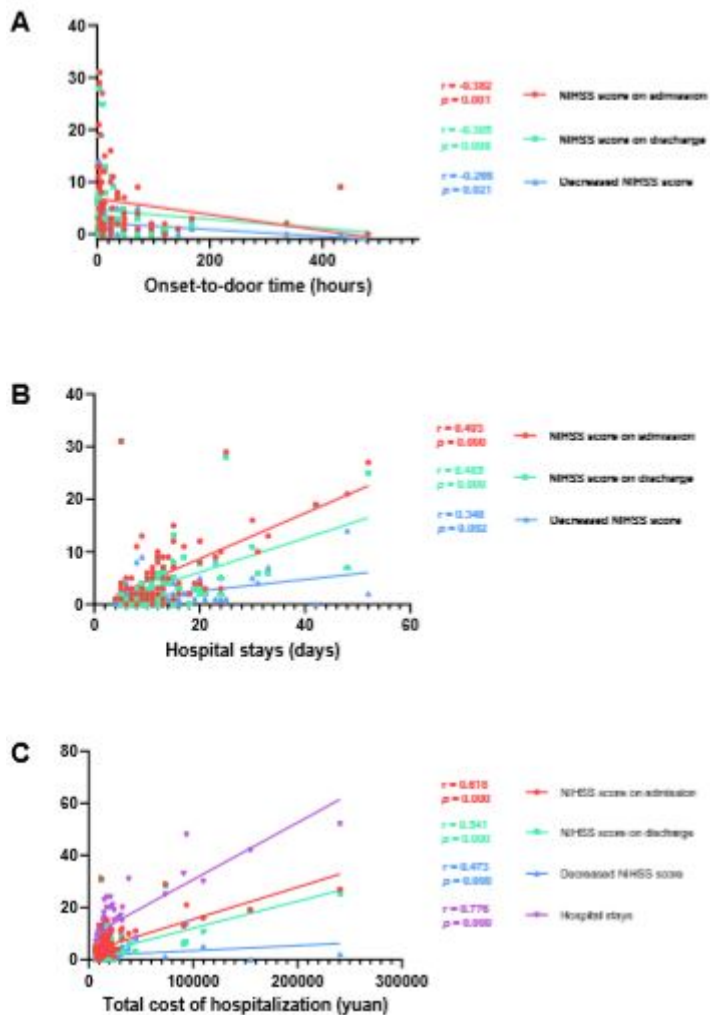


Figure 2

Correlation between clinical characteristics and prognosis of acute ischemic stroke patients. (A) Correlation between onset-to-door time and NIHSS score. (B) Correlation between hospital stays and NIHSS score. (C) Correlation between total cost of hospitalization and NIHSS score and hospital stays. NIHSS, National Institutes of Health Stroke Scale.

Supplementary Files

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- [Table1.xlsx](#)