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Original Article

Results of an International Questionnaire Investigating Changes in Acute Stroke Management between Before and During the COVID-19 Pandemic

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Objective: The present study investigated changes in the management of acute stroke patients between before and during the coronavirus disease 2019 (COVID-19) pandemic in several countries using a questionnaire.

Methods: A questionnaire survey was conducted at 23 stroke centers in 20 countries to examine how stroke management systems have changed from 2019 (before the COVID-19 pandemic) to 2020 (during the COVID-19 pandemic).

Results: Questionnaire responses were obtained from 14 stroke centers (61%) in 14 countries. Among the surveyed stroke centers, 36% utilized full personal protective equipment (PPE) including N95 masks in all cases. After the proper application of infection precautions and screening for COVID-19, the initial imaging modality and indications for endovascular thrombectomy (ET) for ischemic stroke remained unchanged in more than 85% of the surveyed stroke centers. The transmission of COVID-19 from stroke patients to doctors or nurses was confirmed in 29% of the surveyed stroke centers, and hospital-acquired infection from patients to other patients occurred in 25%. The number of cases undergoing ET decreased by 10–70% in 50% of stroke centers during the COVID-19 pandemic. Despite successful recanalization, 50% of patients who underwent ET died, and death was mainly attributed to COVID-19-related systemic complications.

Conclusion: No significant differences were observed in stroke management or treatment strategies between before and during the COVID-19 pandemic in most stroke centers, except for COVID-19 precautions. However, the higher proportion of hospital-acquired infections and increased morbidity rate among patients despite successful recanalization due to COVID-19-related systemic complications are important findings.

Keywords ▶ stroke, thrombectomy, coronavirus disease 2019

Introduction

The prompt diagnosis of acute stoke and the indication and initiation of recanalization treatment with minimal delays are the most important factors for achieving good clinical outcomes. However, the setting of the coronavirus disease 2019 (COVID-19) global pandemic has made it difficult to minimize the time delay from admission to the first diagnostic step and subsequent treatment because of the need to perform stroke management while preventing the further spread of COVID-19.

Several guidelines and manuals with recommendations for the management of acute stroke patients in the setting of the COVID-19 pandemic have been published.[1–4] However, it is currently unclear how the management of these patients has changed between before and during the COVID-19 pandemic in real-world clinical practice.

Therefore, the present study investigated changes in the management of acute stroke patients during the COVID-19 pandemic in several countries using a questionnaire, with

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Table 1 Contents of the questionnaire

1) How has stroke management changed due to the COVID-19 pandemic?
Q. What measures are you taking to prevent the spread of COVID-19 in the emergency room of your hospital?
Q. What COVID-19 screening tests are performed in the emergency room?
Q. Has there been any change in the primary imaging examination for evaluating stroke in the emergency room during the COVID-19 pandemic?
Q. Has the indication for ET for ischemic stroke been changed during the COVID-19 pandemic?
Q. How has the COVID-19 pandemic affected the volume of ET in your hospital?
Q. What measures are you taking to prevent the spread of COVID-19 during ET?
2) Safety of clinicians and hospital staff during the COVID-19 pandemic
Q. Does your institution accept COVID-19 patients, including stroke and non-stroke patients?
Q. Please describe the status of stroke onset in patients with COVID-19.
Q. Have there been any cases of the transmission of COVID-19 from patients to doctors or nurses in charge of the care of COVID-19 stroke patients?
Q. Have there been any cases of hospital-acquired COVID-19 infection from COVID-19 stroke patients?
3) Clinical characteristics of LVO stroke patients with COVID-19
Q. What is the stroke etiology of COVID-19-associated LVO patients?
Q. Does the treatment strategy for LVO stroke with COVID-19 differ from that for regular (non-COVID-19) LVO patients?
Q. Has there been any change in the method of anesthesia during ET between before and during the COVID-19 pandemic?
Q. From the viewpoint of infection control, does your department divide doctors who enter the intervention room (angiosuite) into multiple teams when performing ET?
Q. What outcomes of endovascular thrombectomy did you observe in COVID-19 stroke patients and non-COVID-19 stroke patients?
Q. Have there been any bleeding complications (any ICH) in COVID-19 stroke patients who underwent ET?
Q. Did any patients die after ET despite successful recanalization?
4) Future perspectives

COVID-19: coronavirus disease 2019; ET: endovascular thrombectomy; ICH: intracerebral hemorrhage; LVO: large vessel occlusion

the aim of increasing preparedness in areas not yet heavily affected by COVID-19.

Materials and Methods

A questionnaire was sent to 23 stroke centers in 20 countries by electronic mail to investigate how stroke management systems have changed between 2019 (before the COVID-19 pandemic) and 2020 (during the COVID-19 pandemic). **Table 1** shows the contents of the questionnaire, which was divided into the following four categories: (1) how stroke management has changed due to the COVID-19 pandemic, (2) the safety of clinicians and hospital staff during the COVID-19 pandemic, (3) the clinical characteristics of large vessel occlusion (LVO) stroke patients with COVID-19, and (4) future perspectives. In the questionnaire, full personal protective equipment (PPE) was defined as wearing a full-sleeved gown, surgical mask, N95 mask, eye protection, and gloves.

Stroke centers were informed that their participation was voluntary and confidential. The working group guaranteed the use of data solely for the purpose of this study and its presentation or publication in a manner that maintains the anonymity of participants. Free-text responses to open questions were categorized and percentages were calculated.

Results

Stroke centers that responded to the questionnaire

Questionnaire responses were obtained from 14 stroke centers (61%) in the following 14 countries: Taiwan, Hong Kong, India, Indonesia, Malaysia, China, Kazakhstan, the United States, Canada, Italy, South Africa, Lebanon, Russia, and Brazil.

How has stroke management changed due to the COVID-19 pandemic?

Table 2 shows the results of the questionnaire on changes in stroke management due to the COVID-19 pandemic. To prevent the spread of infection by COVID-19 in the emergency room, 36% of surveyed stroke centers used full PPE in all cases. The other centers (64%) decided whether to use full PPE based on the protocol of each hospital. Regarding COVID-19 infection screening tests, the COVID-19 antigen test or polymerase chain reaction (PCR) was performed in 86% of stroke centers (**Fig. 1**).

Table 2 Changes in stroke management due to the COVID-19 pandemic

Q.	What measures are you taking to prevent the spread of COVID-19 infection in the emergency room of your hospital?	(%)
	1) Full PPE in all cases	36
	2) Based on the possibility of COVID-19, whether full PPE should be used depends on each case (a protocol is prepared in the hospital)	64
	3) Based on the possibility of COVID-19, whether full PPE should be used depends on each case (a protocol is not prepared in the hospital)	0
	4) Although full PPE is not performed, infection prevention measures differ from those before the COVID-19 epidemic, such as the mandatory use of a surgical mask	0
	5) There has been no change in infection prevention measures between before and during the COVID-19 epidemic	0
	6) We do not take actions in the emergency room	0
	7) Other	0
Q.	Has there been any change in the primary imaging examination used to evaluate stroke in the emergency room during the COVID-19 pandemic?	(%)
	1) No change (before pandemic: CT → during pandemic: CT)	93
	2) No change (before pandemic: MRI → after pandemic: MRI)	7
	3) Changed (before pandemic: CT → after pandemic: MRI)	0
	4) Changed (before pandemic: MRI → after pandemic: CT)	0
	5) Changed (other)	0
Q.	Has the indication for ET for ischemic stroke been changed during the COVID-19 pandemic?	(%)
	1) The indication for ET was changed to stricter indications than before the pandemic	14
	2) The indication for ET was not changed	86
	3) The indication for ET was changed to less strict indications than before the pandemic	0
Q.	How has the COVID-19 pandemic affected the volume of ET in your hospital?	(%)
	1) Decreased	50
	2) No obvious change	29
	3) Increased	21
Q.	What measures are you taking to prevent the spread of COVID-19 infection during ET?	(%)
	1) Full PPE in all cases	29
	2) Based on the possibility of COVID-19, the decision for full PPE usage depends on each case (a protocol is available in the hospital)	64
	3) Based on the possibility of COVID-19, the decision for full PPE usage depends on each case (a protocol is NOT available in the hospital)	7
	4) Without full PPE	0
	5) Other	0

COVID-19: coronavirus disease 2019; ET: endovascular thrombectomy; PPE: personal protective equipment

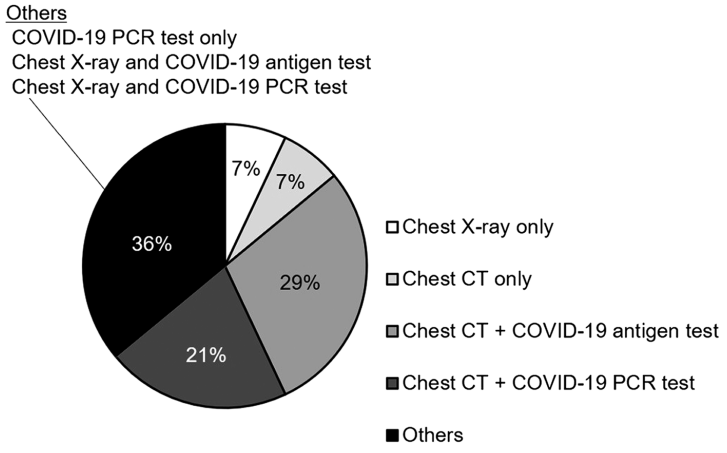

Fig. 1 COVID-19 screening tests performed in the emergency room. COVID-19: coronavirus disease 2019; PCR: polymerase chain reaction

Table 3 Comparison of the number of cases undergoing endovascular thrombectomy between before and during the COVID-19 pandemic

Countries	Number of cases	
	Before the pandemic (2019)	During the pandemic (2020)
Indonesia	13	3
China	248	222
Kazakhstan	7	12
Canada	130	90
Italy	308	301
Lebanon	64	23
Brazil	40	23
India	Approximately 30% decrease	

Table 4 Safety of clinicians and hospital staff during the COVID-19 pandemic

Q.	Does your institution accept COVID-19 patients, including stroke and non-stroke patients?	(%)
	1) Accept (all COVID-19 patients including patients using ventilators or assisted circulation devices)	86
	2) Accept (only mild COVID-19 patients)	7
	3) Do not accept	7
Q.	Please describe the status of stroke onset in patients with COVID-19.	(%)
	During hospitalization with COVID-19 for other symptoms	22
	Diagnosed with COVID-19 after the onset of stroke	78
Q.	Have there been any cases of the transmission of COVID-19 from patients to doctors or nurses in charge of the care of COVID-19 stroke patients?	(%)
	1) There were infected doctors or nurses	29
	2) There were no infected doctors or nurses	50
	3) No experience with COVID-19 stroke patients	21
Q.	Have there been any cases of hospital-acquired COVID-19 from COVID-19 stroke patients?	(%)
	1) There were patients with hospital-acquired COVID-19 infection	25
	2) There were no patients with hospital-acquired COVID-19 infection	58
	3) No experience with COVID-19 stroke patients	17

COVID-19: coronavirus disease 2019

No changes were reported in the method used in the initial imaging examination to evaluate stroke in the emergency room in any stroke center between before and during the COVID-19 pandemic. Indications for endovascular thrombectomy (ET) for ischemic stroke were modified toward stricter indications than before the pandemic in 14% of stroke centers, but remained unchanged in 86% of stroke centers. The number of cases managed by ET decreased by 10–70% in 50% of stroke centers (**Tables 2** and **3**).

Safety of clinicians and hospital staff during the COVID-19 pandemic

Eighty-six percent of the surveyed stroke centers accepted the COVID-19 patients including in any condition (**Table 4**). In total, 78% of stroke patients who were finally diagnosed with COVID-19 were found to be infected with COVID-19 after the onset of stroke. The transmission of COVID-19 from patients to doctors or nurses in charge of the care of COVID-19-positive stroke patients was reported in 29% of the surveyed stroke centers. Hospital-acquired COVID-19 infection from stroke patients to other patients occurred in 25% of the surveyed stroke centers (**Table 4**). Stroke centers that implemented COVID-19 infection screening using COVID-19 antigen test or PCR together with chest imaging (X-ray or CT) appeared to have a lower rate of nosocomial infections from patients to doctors than those centers that did not perform these type of screening (29% vs. 40%).

Clinical characteristics of LVO stroke patients with COVID-19

Among the 66 stroke patients with LVO in the surveyed stroke centers, the etiology of stroke was unknown in 24% (**Table 5**). The treatment strategy for LVO did not significantly differ between before and during the COVID-19 pandemic in any stroke center, whereas the method of

Table 5 Clinical characteristics of LVO stroke patients with COVID-19

Q.	What is the stroke etiology of COVID-19 associated LVO patients?	(%)
	Large artery atherosclerosis	29
	Cardioembolic	41
	Others	6
	Unknown	24
Q.	Does the treatment strategy for LVO stroke with COVID-19 differ from that for regular (non-COVID-19) LVO patients?	(%)
	1) The treatment strategy for LVO stroke with COVID-19 is the same as that for non-COVID-19 LVO	100
	2) The treatment strategy was changed (skip rt-PA and only perform ET)	0
	3) The treatment strategy was changed (perform only rt-PA, not ET)	0
	4) The treatment strategy was changed (neither rt-PA nor ET was performed)	0
	5) Other	0
Q.	Have there been any changes in the method of anesthesia during ET between before and during the COVID-19 pandemic?	(%)
	1) No change (local anesthesia)	50
	2) No change (general anesthesia)	30
	3) Changed (before pandemic: general anesthesia → during pandemic: local anesthesia)	10
	4) Changed (before pandemic: local anesthesia → during pandemic: general anesthesia)	10
	5) Changed (others)	0
Q.	From the viewpoint of infection control, does your department divide doctors who enter the intervention room (angiosuite) into multiple teams when performing ET?	(%)
	1) Divided into teams	58
	2) Not divided into teams	42
	3) Other	0
Q.	Have there been any bleeding complications (any ICH) in COVID-19 stroke patients who underwent ET?	(%)
	1) Yes	25
	2) No	75
Q.	Did any patients die after endovascular thrombectomy despite successful recanalization?	(%)
	1) Yes	50
	2) No	50

COVID-19: coronavirus disease 2019; ET: endovascular thrombectomy; ICH: intracerebral hemorrhage; LVO: large vessel occlusion; rt-PA: recombinant tissue-type plasminogen activator

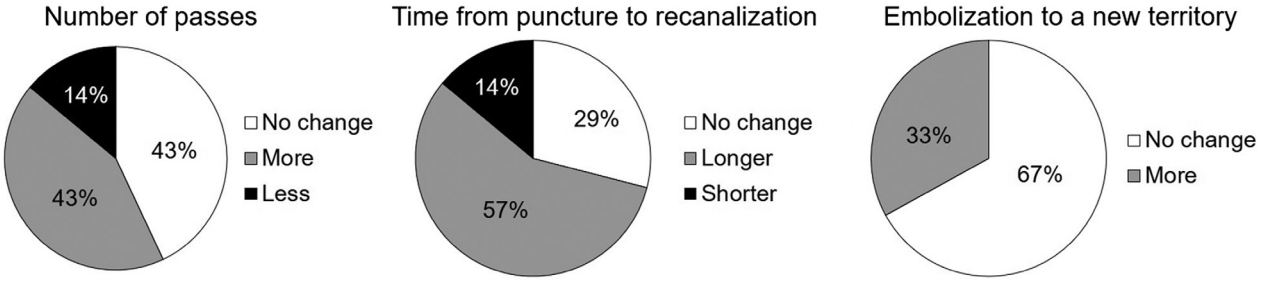

Fig. 2 Outcomes of ET in stroke patients with and without COVID-19. COVID-19: coronavirus disease 2019; ET: endovascular thrombectomy

anesthesia during ET was changed in 20% of the surveyed stroke centers. Regarding the outcomes of ET in stroke patients with COVID-19, a higher number of passes and a longer duration from puncture to recanalization were required, and embolization to a new territory was more frequent than in stroke patients without COVID-19 (**Fig. 2**). Among patients who underwent ET, 50% died despite successful recanalization (**Table 5**), with COVID-19-related systemic complications, including pulmonary dysfunction, accounting for 83% of these deaths.

Comments about future perspectives

Many comments were provided about the vaccine including the need for medical staff, particularly ET teams, to be vaccinated and the potential of vaccination to reduce the number of cases of COVID-induced stroke.

Discussion

In the proposed algorithm for protected code stroke during the COVID-19 pandemic, PPE including the use of a N95 mask (full PPE) was considered to be a requirement during aerosol-generating procedures.[1] However, the results of the present questionnaire revealed that in real-world clinical practice, full PPE for all cases was implemented in 36% of the surveyed stroke centers regardless of the possible spread of COVID-19. After taking precautions and screening for COVID-19 infection using antigen testing or PCR, imaging modalities at arrival and indications for ET for ischemic stroke remained unchanged in the majority of surveyed stroke centers. These results suggest that stroke management and treatment strategies did not significantly change between before and during the COVID-19 pandemic in most stroke centers, except for COVID-19 precautions.

The transmission of COVID-19 from patients to doctors or nurses and hospital-acquired COVID-19 infection from stroke patients to other patients were confirmed in 29 and 25% of the surveyed stroke centers, respectively. Based on these numbers, nosocomial infection is an important issue. Since most stroke patients have impaired consciousness and/or aphasia, difficulties are associated with recognizing the symptoms of COVID-19 infection, such as fever, dysgeusia, and dysosmia, in the emergency room. Furthermore, many stroke patients occasionally require the suction of sputum, an aerosol-generating medical procedure, which may expose medical staff to aerosols from COVID-19 stroke patients, thereby increasing the risk of nosocomial infection.

The present results also showed that the number of cases of ET decreased by 10–70% in 50% of the surveyed stroke centers during the COVID-19 pandemic. This reduction is consistent with the findings of an observational study in Italy and those in Switzerland, Italy, France, Spain, Portugal, Germany, Canada, and the United States[5,6]; however, the extent of this decrease markedly differed between the countries. A previous study reported that the incidence of stroke decreased by approximately 31.3% worldwide during the COVID-19 pandemic; however, the number of patients who underwent ET may have been even lower, with some not undergoing ET due to COVID-19.[7] One plausible explanation for the reduction of number of ET in the present study despite no change in imaging modalities and indications for ET might be the increased delay from onset to door during the COVID-19 pandemic compared to that before.[7,8] This time delay may cause the patients to miss the opportunity for ET.

The etiology of LVO was unknown in 24% of patients with COVID-19 in the present study, which was higher than that reported in a previous study on the distribution of stroke etiologies before the COVID-19 pandemic.[9] This higher percentage of an unknown etiology of LVO may be related to COVID-19-induced coagulopathy.[10] The present results showed that 50% of patients who underwent ET died despite successful recanalization, and the main cause of death was COVID-19-related systemic complications. This high mortality rate after successful recanalization suggested that the functional outcome of ET was associated not only with successful recanalization but also with the severity of COVID-19 itself.[11]

The present study has several limitations. It remains unknown whether the results obtained reflect worldwide conditions because the sample size of surveyed stroke centers was small. Furthermore, the extent of the COVID-19 pandemic markedly differed in each country. Therefore, its impact on stroke centers may vary widely among regions and countries. Additionally, the availability of medical resources, such as PPE, was unknown in each stroke center, which may affect initial precautionary strategies employed in the emergency room.

Conclusion

The present study described the impact of the COVID-19 pandemic on the management and clinical outcomes of acute stroke patients in different regions worldwide and investigated changes between before and during the COVID-19 pandemic using a questionnaire. The high rate of nosocomial infections and potentially poorer outcomes of ET in patients with COVID-19 will raise the awareness and the attentiveness of medical staff in areas that have not yet been markedly affected by the pandemic.

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Disclosure Statement

All authors declare that they have no conflicts of interest regarding this manuscript.

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