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# Stroke Systems of Care During the COVID-19 Epidemic in Kobe City

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*Background:* The novel coronavirus disease 2019 (COVID-19) outbreak raised concerns over healthcare systems' ability to provide suitable care to stroke patients. In the present study, we examined the provision of stroke care in Kobe City during the COVID-19 epidemic, where some major stroke centers ceased to provide emergency care. *Methods:* This was a cross-sectional study. The Kobe Stroke Network surveyed the number of stroke patients admitted to all primary stroke centers (PSCs) in the city between March 1 and May 23, 2020, and between March 3 and May 25, 2019. In addition, online meetings between all PSC directors were held regularly to share information. The survey items included emergency response system characteristics, number of patients with stroke hospitalized within 7 days of onset, administered treatment types (IV rt-PA, mechanical thrombectomy, surgery, and endovascular therapy), and stroke patients with confirmed COVID-19. *Results:* During the period of interest in 2020, the number of stroke patients hospitalized across 13 PSCs was 813, which was 15.5% lower than that during the same period of 2019 ( $p = 0.285$ ). The number of patients admitted with cerebral infarction, intracerebral hemorrhage, and subarachnoid hemorrhage decreased by 15.4% ( $p = 0.245$ ), 16.1% ( $p = 0.659$ ), and 14.0% ( $p = 0.715$ ), respectively. However, the rates of mechanical thrombectomy and surgery for intracerebral hemorrhage were

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slightly increased by 12.1% ( $p = 0.754$ ) and 5.0% ( $p = 0.538$ ), respectively. PSCs that ceased to provide emergency care reported a decrease in the number of stroke cases of 65.7% compared with the same period in 2019, while other PSCs reported an increase of 0.8%. No case of a patient with stroke and confirmed COVID-19 was reported during the study period. *Conclusion:* Kobe City was able to maintain operation of its stroke care systems thanks to close cooperation among all city PSCs and a temporal decrease in the total number of stroke cases.

**Key Words:** COVID-19—Stroke—Stroke systems of care—Primary stroke center—Online meeting

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## Introduction

The novel coronavirus disease 2019 (COVID-19), first reported in Wuhan, China, in December 2019, spread worldwide in 2020. As of June 1, 2020, the estimated number of global cases and deaths has exceeded 6 million and 370,000, respectively.<sup>1</sup> In Japan, the number of reported cases increased sharply in March 2020, with community transmission presenting at the highest rate in urban areas, leading to a state of emergency being declared by the Japanese government on April 7. Subsequently, on April 9, the Japan Stroke Society and the Japanese Circulation Society issued a joint statement on the importance of maintaining high-quality care in this rapidly evolving situation; finally, on April 24, a protocol for stroke care during the COVID-19 pandemic (Japan Stroke Society Protected Code Stroke; JSS-PCS) was issued.<sup>2</sup>

Afterward, the number of new confirmed COVID-19 cases gradually decreased due to the combination of social distancing measures and medical system support, resulting in the state of emergency being lifted on May 25. As of June 1, 2020, the Japanese Ministry of Health, Labor and Welfare, has reported a total of 16,884 COVID-19 cases and 892 associated deaths.<sup>3</sup> Despite stagnation in the increase of the number of cases, second and third waves of COVID-19 are expected; the situation remains rapidly evolving. Lessons from the present pandemic are paramount to effective safeguarding against future outbreaks. In the present study, we provide a summary of stroke care system management in Kobe City during this COVID-19 epidemic and discuss possible applications of present insights to future challenges. This is the first study to survey the total number of stroke patients during the COVID-19 epidemic in a government-designated city in Japan.

## Materials and Methods

Kobe is a government-designated city with a population >1.53 million and a total area of 557 km<sup>2</sup>. Due to the proximity of large cities such as Osaka and a well-developed transportation network, Kobe has a large transient population of people who commute to and from home or school. In general, patients requiring emergency care while in Kobe City receive treatments at facilities within the city, where there are 13 primary stroke centers (PSCs),

certified by the Japan Stroke Society; patients with suspected stroke can be transported to the nearest PSC within 15 minutes from nearly all city areas. In 2007, the Kobe Stroke Network was established to create a city where “you don’t have to worry about stroke,” inviting participation from all local medical facilities related to stroke care. The Network’s aim is to support collaboration between facilities during the acute, recovery, and chronic phase of stroke by coordinating patient progression through the regional clinical pathway, holding regular plenary meetings, and conducting surveys of stroke incidence.

Since the first COVID-19 confirmed case was reported on March 3, 2020, in Kobe City, many patients with severe disease were admitted to the Kobe City Medical Center General Hospital (KCGH), a designated infectious disease facility and a major PSC. Initially, most of the patients presenting with COVID-19 seemed to have come from a prefecture-based cluster; however, in late March, the number of patients with community-acquired infections of untraceable origin began to increase, and the number of COVID-19 inpatients at KCGH spiked in April. To ensure access to hospital beds for patients with severe COVID-19 and to retain a maximum number of staff covering the intensive care unit, KCGH ceased to provide emergency services other than those related to COVID-19. Due to a concurrent spike in the number of nosocomial infections recorded on April 9, a large number of medical staff and their close contacts were required to self-isolate, which reduced KCGH’s capacity. Meanwhile, another city PSC ceased to provide emergency care due to an outbreak of nosocomial infections.

These two major PSCs typically provide care to an estimated 20% of local stroke cases. When they ceased to provide emergency services, the Kobe Stroke Network launched a series of online meetings among PSC directors to monitor the functioning of the stroke care system in the city, provide consistent messaging to the public, and to continually survey the number of stroke patients treated at each PSC (including treatment type) between March 1 and May 23, 2020. Findings compiled during this period were then compared with equivalent data for the same period of the previous year (March 3 to May 25, 2019).

Survey items included emergency response system, number of patients hospitalized with stroke (cerebral

infarction [CI], nontraumatic intracerebral hemorrhage [ICH], subarachnoid hemorrhage [SAH]) within 7 days of onset, administered treatment (IV rt-PA, mechanical thrombectomy [MT], surgery for ICH, surgery, and endovascular therapy for SAH), and the number of stroke patients with confirmed COVID-19. In the present study, we report aggregated survey results. This study was approved by our Institutional Review Board (zn200731).

### Statistical analysis

This was a retrospective and descriptive study. To compare findings between the period of interest in 2020 vs. those of 2019, we examined the number of cases reported by all 13 PSCs; quantitative variables were analyzed using the Wilcoxon signed-rank sum test. All analyses were performed in R software version 4.0.0 (R Foundation for Statistical Computing, Vienna, Austria). The threshold for statistical significance was set at  $p$ -value < 0.05.

## Results

### Emergency response system

Thirteen PSCs included in the present survey were a single university hospital, three municipal hospitals, two public hospitals, and seven private hospitals. The Class 1 designated infectious disease facility was KCGH; the Class 2 designated infectious disease facility was Nishi-Kobe; nine hospitals submitted claims for additional reimbursement for infection prevention measures. Certified neurosurgeons and stroke specialists were employed by all hospitals. All PSCs treated stroke patients in accordance with the JSS-PCS.<sup>2</sup> Patients presenting with fever, respiratory symptoms, abnormal findings on chest computed tomography scan, or

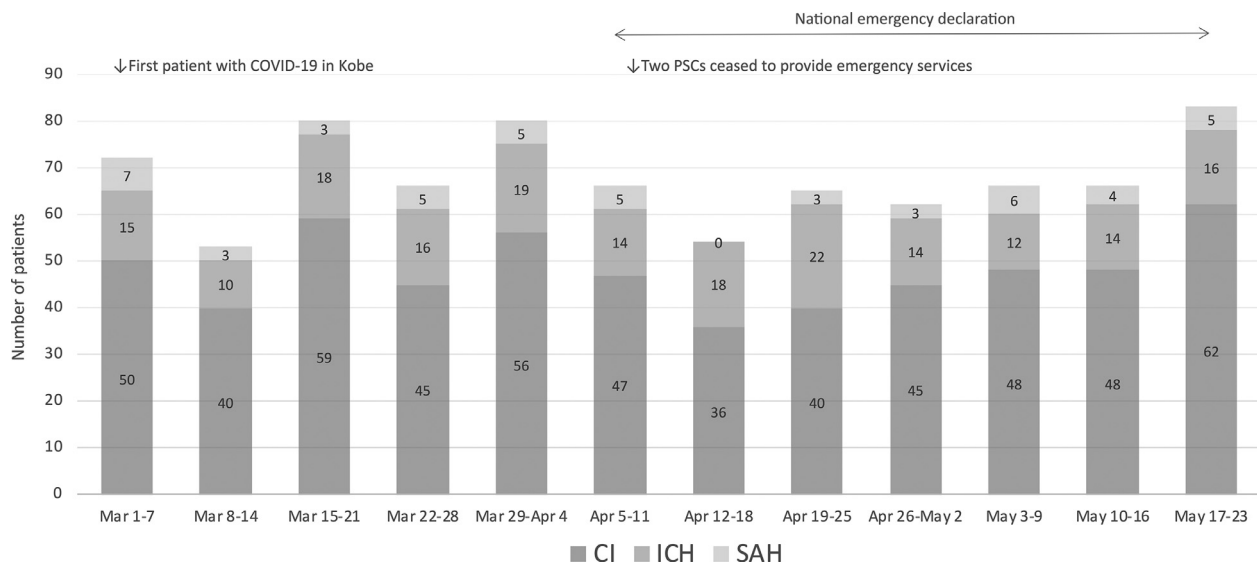
history of close contact with a confirmed COVID-19 patient, as well as patients unable to report history due to stroke symptoms such as aphasia were treated according to a protected code stroke algorithm, and testing for COVID-19 was performed with a patient under investigation (PUI) status. However, patients with status other than PUI and no history of exposure to or suspected COVID-19 did not undergo any testing for COVID-19 and were treated following a standard protocol. Ten hospitals accepted patients with confirmed COVID-19; three hospitals that did not accept them implemented a transfer policy for all suspected cases.

### Hospitalized stroke patients and administered treatments

During this 12-week period, the total number of stroke patients hospitalized across the 13 PSCs was 813 (specifically, CI: 576, ICH: 188, and SAH: 49) (Fig. 1). The daily average number of cases was 9.7. A total of 50 cases involved IV rt-PA and 65 cases involved MT. During the same period, there were 42 cases of surgery for ICH, 18 cases of surgical clipping of ruptured aneurysm for SAH, and 15 cases of endovascular coil embolization of ruptured aneurysm for SAH.

### Comparison with previous year

During the whole period of interest in 2019 (March 3 to May 25), the number of hospitalized stroke patients was 962. The corresponding number for the equivalent period in 2020 was 813, 15.5% lower than that in 2019. The number of patients with CI, ICH, and SAH decreased by 15.4%, 16.1%, and 14.0%, respectively, compared with the previous year. However, the rate of MT for CI and that of



**Fig. 1.** The number of stroke patients hospitalized per week across 13 primary stroke centers between March 1 and May 23, 2020.

CI=Cerebral infarction, ICH=Intracerebral hemorrhage, SAH=Subarachnoid hemorrhage, PSC=Primary stroke center, COVID-19=Coronavirus disease 2019

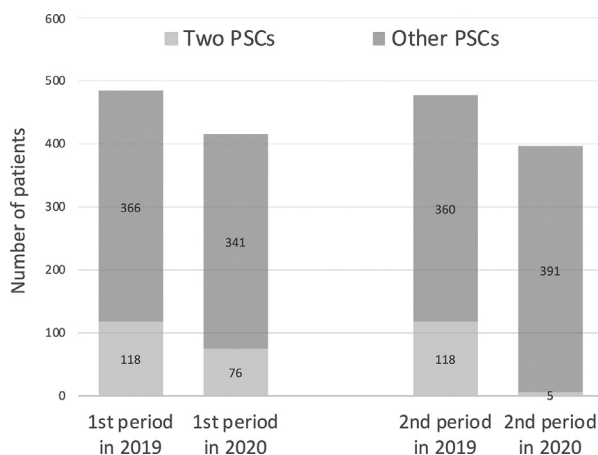
**Table 1.** The number of hospitalized stroke patients and treatment types administered at 13 primary stroke centers between March 3 and May 25, 2019, and March 1 and May 23, 2020 and the percentage of changes between the two periods.

	2019 Mar 3- May 25	2020 Mar 1- May 23	Percentage of change (%)	p value
CI	681	576	-15.4	0.245
IV rt-PA	52	50	-3.8	0.445
MT	58	65	12.1	0.754
ICH	224	188	-16.1	0.659
surgery	40	42	5.0	0.538
SAH	57	49	-14.0	0.715
surgery	20	18	-10.0	0.544
EVT	21	15	-28.6	0.630
Stroke, total	962	813	-15.5	0.285

CI=Cerebral infarction, ICH=Intracerebral hemorrhage, SAH=Subarachnoid hemorrhage, IV rt-PA=Intravenous recombinant tissue-plasminogen activator, MT=Mechanical thrombectomy, EVT=Endovascular therapy

surgery for ICH increased by 12.1% and 5.0%, respectively. None of these differences were significant (Table 1).

Fig. 2 presents the number of stroke patients hospitalized at PSCs that ceased to provide emergency care and at other PSCs, compared with the same period of the previous year during the 6 weeks before and after April 11. PSCs that ceased to provide emergency care reported a decrease in the number of cases of 35.6% (118 to 76 cases) and 95.8% (118 to 5 cases) in the first and second period, respectively; overall, these facilities reported a 65.7%



**Fig. 2.** The number of stroke patients hospitalized at two primary stroke centers, which ceased to provide emergency services at April 11, 2020, and at other primary stroke centers, compared with the same 6-week period in 2019 and 2020. The chart presents data for the primary stroke centers that ceased to provide emergency services and other centers separately.

1st period in 2019: from March 3 to April 13, 2019.

2nd period in 2019: from April 14 to May 25, 2019.

1st period in 2020: from March 1 to April 11, 2020.

2nd period in 2020: from April 12 to May 23, 2020.

PSC=Primary stroke center

decrease in number of stroke cases. Meanwhile, at other PSCs, the corresponding figures were a decrease of 6.8% (366 to 341 cases), an increase of 8.6% (360 to 391 cases), and an increase of 0.8%, respectively; these numbers were similar to those reported over the same period in 2019.

#### Patients with stroke and confirmed COVID-19

No symptomatic strokes were reported in any patients with confirmed COVID-19 during the study period. None of the patients hospitalized due to stroke was subsequently diagnosed with COVID-19.

#### Discussion

The challenges associated with COVID-19 were two-fold; on the one hand, the virus posed an invisible threat; on the other hand, high infectivity of the virus meant the disease spread quickly, creating an unprecedented burden on healthcare systems. A survey conducted by the Japan Stroke Society involving 922 PSCs nationwide in May 2020 revealed that only 77.8% of all facilities retained their capacity to provide usual levels of emergency care, while 21.5% had to restrict their services. Among them, 21 facilities, concentrated in areas with high transmission rate, suspended emergency response.<sup>4</sup> As a result, there were significant concerns that responding to COVID-19 would restrict availability of medical resources to a degree where care could no longer be provided to stroke patients, leading to an increased number of preventable deaths and severe disabilities.

These concerns were pronounced in Kobe City during the COVID-19 epidemic, leading to a close collaboration among all PSCs, which included holding online conferences, conferring on COVID-19 protocol compliance and stroke emergency response at each facility, and sharing weekly stroke case estimates to prevent exceeding facility capacity. Such prompt cooperation was enabled by the previously established Kobe Stroke Network. The presented survey findings provide comprehensive data from all participating facilities dedicated to acute stroke care in Kobe City, reflecting the real-life stroke care system in response to the COVID-19 crisis.

During the COVID-19 epidemic in Kobe City, the number of hospitalized stroke patients was lower, but not significantly so, for all stroke types compared with the corresponding period of the previous year. In contrast, there have been a growing number of reports showing a significant decrease in the number of stroke patients hospitalized during the COVID-19 pandemic worldwide. A previous study that compared the number of cases reported in February 2020 to that reported in the same period in 2019 across 280 facilities in China reported a decrease in stroke hospitalizations and cases of IV rt-PA and MT of 37.9%, 25.5%, and 22.7%, respectively.<sup>5</sup> According to a report of aggregated data from 65 hospitals in the United States, the number of stroke and acute



coronary syndrome cases recorded in February 2020 increased by 9.8% and 12.1%, respectively, compared with those reported for 2018 and 2019; however, the estimates reported in March 2020 were, respectively, 18.5% and 7.5% lower than those reported previously. Meanwhile, the number of cases involving IV rt-PA, MT, and percutaneous coronary intervention (PCI) increased by 36.8%, 38.4%, and 5.8% in February, respectively; however, in March, the number of instances of IV rt-PA decreased by 3.3%, of PCI decreased by 14.7%, and of MT increased by 18.8%. The authors concluded that these reductions may lead to worse outcomes among patients with stroke and cardiovascular disease, recommending that standard medical care continues throughout the COVID-19 pandemic.<sup>6</sup> Concurrently, reports from the United States have indicated that the number of patients using RAPID software (iSchemaView, Menlo Park, CA) decreased by 39% during the pandemic compared with before the outbreak, suggesting indirectly that the number of stroke patients requiring such evaluation was reduced.<sup>7</sup>

During the study period, the proportion of patients with CI undergoing MT increased from 8.5% to 11.2%, and that with ICH undergoing surgery increased from 17.9% to 22.3%, despite a reduction of the total number of stroke cases compared with the previous year. This finding might be due to the governmental restrictions imposed during the outbreak or the general population's concern regarding the risk of infection, resulting in patients with mild stroke refraining from hospital visits. In fact, a report from Brazil has suggested that the COVID-19 outbreak coincided with a reduction in transient, mild, and moderate strokes.<sup>8</sup>

There were no cases of symptomatic stroke among the 285 patients diagnosed with COVID-19 (including 12 deaths) during the study period.<sup>9</sup> A previous study of 214 COVID-19 patients (severe disease rate 41.1%) admitted to three centers in Wuhan, China, reported that 36.4% of them had some neurological symptoms, including 5.7% and 0.8% of patients presenting with severe and non-severe cerebrovascular disease, respectively.<sup>10</sup> Perhaps the most remarkable finding was that all 5 patients under the age of 50 with large vessel occlusions treated during the pandemic were COVID-19 patients treated at the New York Mount Sinai Health System.<sup>11</sup> Another report from New York indicated that the 32 patients with COVID-19 and CI observed were younger, presented with more severe symptoms, and had higher D-dimer levels than stroke patients without a concurrent COVID-19 diagnosis.<sup>12</sup> In patients presenting with severe COVID-19, stroke may not be diagnosed. Conversely, stroke patients may include those with asymptomatic infection that do not undergo COVID-19 testing; nevertheless, the present findings suggest that, in Kobe City, no patients were diagnosed with COVID-19 after presenting with stroke symptoms. The rate of infection in Japan was generally lower than that reported elsewhere in the world, meaning

that the number of patients with COVID-19 and stroke is likely to be relatively small; however, assessment of the COVID-19 epidemic's impact on stroke incidence in Japan requires a national survey.

Despite two major PSCs ceasing to provide emergency care during the outbreak, Kobe City maintained its system of stroke care, as the total number of stroke cases relatively decreased and the remaining PSCs retained their care capacity on par with that in the previous year. Concurrently, all city PSCs continued to collaborate and share information through online meetings. However, future outbreaks, in particular, those in the fall and winter seasons might be accompanied by a concurrent spike in the number of stroke cases; in such circumstances, restricting care services at some facilities may result in overburdening of those remaining. Continued close cooperation and information sharing between the facilities is paramount to good patient outcomes.

## Conclusion

The world faced a historic pandemic associated with an outbreak of a novel viral disease in 2020. Lessons must be learned from this rapidly evolving situation to ensure that stroke care continues to be provided at present and during future crises.<sup>13</sup> In Kobe City, continued cooperation between facilities was crucial to maintaining high quality stroke care. Stroke care will remain an important element of medical services after the epidemic and efforts are required to ensure the uninterrupted functioning of stroke care systems.

## Declaration of Competing Interest

None.

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## References

1. Johns Hopkins University Coronavirus Resource Center. <https://coronavirus.jhu.edu>. Accessed June 2, 2020.
2. Japan Stroke Society Protected Code Stroke: JSS-PCS. *Jpn J Stroke* 2020;42(4):315-343. <https://doi.org/10.3995/jstroke.108283>.
3. Japanese Ministry of Health, Labor and Welfare. [https://www.mhlw.go.jp/stf/newpage\\_11606.html](https://www.mhlw.go.jp/stf/newpage_11606.html). Accessed June 8, 2020.
4. Japan Stroke Society. [https://www.jsts.gr.jp/news/pdf/20200601\\_covid19.pdf](https://www.jsts.gr.jp/news/pdf/20200601_covid19.pdf). Accessed June 6, 2020.
5. Zhao J, Li H, Kung D, et al. Impact of the COVID-19 epidemic on stroke care and potential solutions. *Stroke* 2020;51:1996-2001. <https://doi.org/10.1161/STROKEAHA.120.030225>.
6. de Havenon A, Ney J, Callaghan B, et al. A rapid decrease in stroke, acute coronary syndrome, and corresponding interventions at 65 United States hospitals following

- emergence of COVID-19. medRxiv 2020. <https://doi.org/10.1101/2020.05.07.20083386>.
7. Kansagra AP, Goyal MS, Hamilton S, et al. Collateral effect of Covid-19 on stroke evaluation in the United States. *N Engl J Med* 2020;383:400-401. <https://doi.org/10.1056/nejmc2014816>.
  8. Diegoli H, Magalhães PSC, Martins SCO, et al. Decrease in hospital admissions for transient ischemic attack, mild, and moderate stroke during the COVID-19 Era. *Stroke* 2020;51:2315-2321. <https://doi.org/10.1161/strokeaha.120.030481>.
  9. Kobe City Website. [https://www.city.kobe.lg.jp/a73576/kenko/health/infection/protection/covid\\_19.html](https://www.city.kobe.lg.jp/a73576/kenko/health/infection/protection/covid_19.html). Accessed June 8, 2020.
  10. Mao L, Jin H, Wang M, et al. Neurologic manifestations of hospitalized patients with coronavirus disease 2019 in Wuhan, China. *JAMA Neurol* 2020;77:1-9. <https://doi.org/10.1001/jamaneurol.2020.1127>.
  11. Oxley TJ, Mocco J, Majidi S, et al. Large-vessel stroke as a presenting feature of Covid-19 in the young. *N Engl J Med* 2020;382:e60. <https://doi.org/10.1056/NEJMc2009787>.
  12. Yaghi S, Ishida K, Torres J, et al. SARS2-CoV-2 and stroke in a New York healthcare system. *Stroke* 2020;51:2002-2011. <https://doi.org/10.1161/STROKEAHA.120.030335>.
  13. Sheth SA, Wu T-C, Sharrief A, et al. Early lessons from world war COVID, reinventing our stroke systems of care. *Stroke* 2020;51:2268-2272. <https://doi.org/10.1161/STROKEAHA.120.030154>.