Comparative Study of Head CT Scan Results in Stroke Cases During the Pre-Pandemic, Pandemic and Post-Pandemic of COVID-19

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ABSTRACT
Backgrounds: Stroke was the second-leading cause of death worldwide in 2019, with ischemic stroke being the most common type. In 2019, there were 77.19 million people globally who experienced ischemic stroke, with 63.48 million experiencing disability and 3.29 million experiencing death. It has been discovered that Covid-19 can increase the risk of stroke, with 1-6% of Covid-19 patients being diagnosed with stroke and a mortality rate of 30-40%. A head CT scan is a primary diagnostic tool for diagnosing stroke. As a result, researchers are interested in conducting a study to compare CT scan images of stroke patients before the pandemic, during the pandemic, and after the pandemic, both with and without COVID-19.
Objectives: This study aims to compare stroke patients' CT scan images pre-pandemic, during the pandemic and post-pandemic (with and without COVID-19) to identify any differences.
Method: The data was collected retrospectively by examining the medical records of stroke patients and their CT scan data at the Radiology Department of Airlangga University. The patients were selected from three periods: pre-pandemic, pandemic, and post-pandemic. Patients were grouped into two categories during the pandemic and post-pandemic periods - stroke with and without COVID-19 - based on their PCR results. The comparison of CT scan images of the head was then conducted during these three periods.
Results: From the results of head CT scans in the stroke group during the pre-pandemic, pandemic and post-pandemic periods both with and without Covid-19 and the stroke group with Covid-19, the highest number was small vessel ischemic stroke (63.1-67.8%), followed by large vessel ischemic stroke (7.5-23.1%) and bleeding stroke (0-20.6%) (P-value > 0.05), as well as the distribution of ischemic stroke in small vessels and large vessels, there is no significant difference statistically significant CT scan images of stroke patients in the post-pandemic period both without and with COVID-19.
Conclusion: From the results of head CT scans in the stroke group during the pre-pandemic, pandemic and post-pandemic periods, both with and without COVID-19, and in the stroke group with COVID-19, there were no significant differences.

Keywords: Stroke, COVID-19, Head CT Scan

Introduction

Stroke is the second leading cause of death globally in 2019. Ischemic stroke accounts for 62.4% of all stroke cases [1]. In 2019, Indonesia had 93.3 deaths per 100,000 people, one of the highest incidence rates of stroke in Asia [2].

In America, 1-6% of COVID-19 patients had a stroke in October 2020, with a 38% increase in mortality. Ischemic stroke frequency is independent of COVID-19 severity. Stroke in COVID-19 patients is mainly caused by embolism. COVID-19 patients with stroke are often younger, and the prognosis is worse with higher mortality rates compared to those without stroke [3].

COVID-19 was first reported in Wuhan, China on December 31, 2019, as pneumonia. WHO declared it a pandemic on March 11, 2020. Indonesia recorded its first cases on March 2, 2020. There were waves of COVID-19 in January 2021, July 2021, and February 2022, followed by a significant decrease in patients starting in December 2022 [4].

Approximately 5% of COVID-19 patients experience ischemic stroke, which has a high mortality rate ranging from 30-40% [5]. In Iranian stroke centres, there has been a significant increase in large vessel ischemic stroke patients by 38.7% during the pandemic compared to 26.5% before the pandemic. Additionally, small vessel ischemic strokes increased by 35% during the pandemic compared to 49% before the pandemic, while hemorrhagic strokes increased by 25% during the pandemic compared to 24.5% before the pandemic [6]. In the Philippines, the incidence of stroke during COVID-19 was 71.4% ischemic stroke and 27.5% hemorrhagic stroke [7]. Based on Maharani's study in 2022 in Surabaya, Indonesia, the incidence of hemorrhagic stroke in COVID-19 patients during the pandemic was 85% with the remainder being ischemic stroke, with the highest location in the cortex-subcortex of the frontal lobe at 24% [8].

Even though up to now, WHO has not declared that the COVID-19 pandemic has ended, researchers use a reference for a significant decrease in the number of COVID-19 patients based on data from WHO, namely December 2022 as a reference for the period after the pandemic. By studying stroke imaging patterns before, during and after the pandemic, it is hoped that this can be a predictor of whether there is an influence of COVID-19 on head CT scan images.

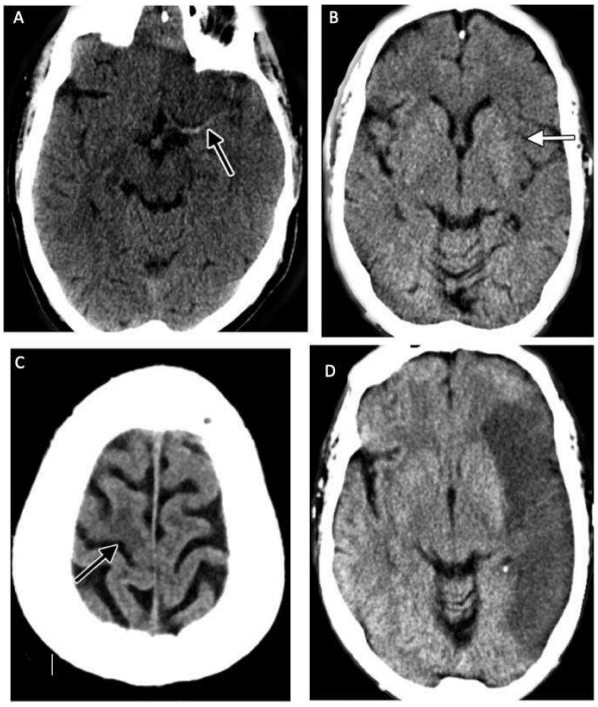

Figure 1. CT scan of the head without contrast, axial view, a. Hyperdense vessel sign in the left M1 MCA segment (arrow), b. shows unclear (smooth) hypodense in the insula and cortical oedema forming an insular band sign, c. loss of grey-white matter differentiation in the right frontal lobe indicates an acute infarction stroke, d. Extensive hypoattenuation of the left MCA territory and left insular edema due to vasogenic disease, indicated brain infarction/ischemic.

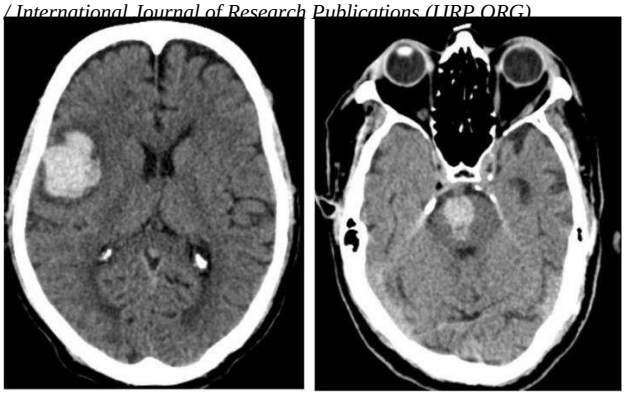

Figure 2. CT scan of the head without contrast, axial view, a. Hyperattenuating/hyperdense lesion in the right frontotemporal lobe with surrounding perifocal edema, b. hyperattenuation in the pons suggests an acute hemorrhagic stroke.

Methods and Materials

This research is an observational analytical study with a retrospective design at Airlangga University Hospital, Surabaya, Indonesia. The population of stroke patients who underwent CT scans of the head without contrast was divided into 3 periods, namely the pre-pandemic period (January-December 2019), during the pandemic (June 2020-December 2021) and the post-pandemic (January-June 2023), specifically the pandemic and post-pandemic, stroke patients underwent RT PCR examination—exclusion criteria for COVID-19 patients with stroke who have a normal image on CT scan or incomplete data. CT scan of the head was performed with a Siemens Somatom go.Top CT Scan (128 Slices) in the form of digital raw data which a head and neck consultant radiologist interpreted.

Hemorrhagic stroke patients were grouped into 3 categories based on bleeding volume (<30 ml, 30-60 ml, > 60 ml), calculated using formula ABC/2 [9], with variable locations. Ischemic stroke patients are grouped with ischemic strokes caused by occlusion of large vessels and small vessels with variable locations. Chi-square were used in comparing all the qualitative variables. A p-value of 0.05 or less was considered significant.

Result

Based on gender, there were more male patients (1: 0.84), with a total of 189 men and 158 women during the pre-pandemic, pandemic and post-pandemic periods. In the pre-pandemic period, the total for men was 95 and women was 65. During the pandemic, the total for men was 66 and women was 49, with the description of stroke patients with COVID-19 being 42 men, and 28 women. and stroke patients without COVID-19 were 24 men, and 21 women. In the post-pandemic period, the total for men was 28 and women was 44, with the description of stroke patients with COVID-19 being 3 men, 3 women, 10 and stroke patients without COVID-19 being 25 men, 34 women. (Table 1)

The data shows that in the pre-pandemic period, there were 21 stroke patients under the age of 50 and 139 stroke patients over the age of 50. During the pandemic, the number of stroke patients decreased for both age groups, with 19 patients under the age of 50 and 96 patients over the age of 50. Out of the stroke patients with COVID-19, there were 13 patients under the age of 50 and 57 patients over the age of 50. For stroke patients without COVID-19, there were 6 patients under the age of 50 and 39 patients over the age of 50. In the post-pandemic period, there were 11 stroke patients under the age of 50 and 61 stroke patients over the age of 50. Out of the stroke patients with COVID-19, there were 2 patients under the age of 50 and 11 patients over the age of 50. For stroke patients without COVID-19, there were 9 patients under the age of 50 and 50 patients over the age of 50. (Table 1)

Table 1. Characteristics of head CT scans without contrast on stroke patients in pre-pandemic, pandemic and post-pandemic based on gender and age.

Characteristic		Pre-Pandemic COVID-19 (Jan-Dec 2019) (n = 160)	Pandemic COVID-19 (Jun 2020-Dec 2021) (n = 115)		Post-Pandemic COVID-19 (Jan-Jun 2023) (n = 72)		P-value
			PCR (+)	PCR (-)	PCR (+)	PCR (-)	
Sex							
Man		95 (59,4%)	42 (60%)	24 (53,3%)	3 (23,1%)	25 (42,4%)	0,026
Woman		65 (40,6%)	28 (40%)	21 (46,7%)	10 (76,9%)	34 (57,6%)	
Age							
<50 years		21 (13,1%)	13 (18,6%)	6 (13,3%)	2 (15,4%)	9 (15,3%)	0,872
>50 years		139 (86,9%)	57 (81,4%)	39 (86,7%)	11 (84,6)	50 (84,7%)	
STROKE							
Ischemic stroke	Small vessel	101 (63,1%)	54 (77,1%)	34 (75,6%)	10 (76,9%)	40 (67,8%)	0,195
	Large vessel	12 (7,5%)	9 (12,9%)	4 (8,9%)	1 (7,7%)	11 (18,6%)	0,101
Haemorrhagic stroke	< 30 ml	33 (20,6%)	6 (8,6%)	4 (8,9%)	0 (0,0%)	5 (8,5%)	0,016
	30-60 ml	7 (4,4%)	1 (1,4%)	3 (6,7%)	1 (7,7%)	2 (3,4%)	0,628
	> 60 ml	8 (5,0%)	1 (1,4%)	1 (2,2%)	1 (7,7%)	1 (1,7%)	0,485

Table 2. Characteristics of head CT scans without contrast on small vessel ischemic stroke patients in pre-pandemic, pandemic and post-pandemic based on stroke location.

Characteristic	Location	Pre-Pandemic COVID-19 (Jan-Dec 2019)	Pandemic COVID-19 (Jun 2020-Dec 2021)		Post-Pandemic COVID-19 (Jan-Jun 2023)		P-value
			PCR (+)	PCR (-)	PCR (+)	PCR (-)	
Small vessel ischemic							
	Pons dan Medulla	13 (8,2%)	10 (14,2%)	2 (4,3%)	3 (23,0%)	3 (5,0%)	0,092
	Cortical subcortical lobus frontal and parietal	10 (6,3%)	9 (12,8%)	2 (4,3%)	2 (15,3%)	15 (35,4%)	0,001
	Capsula interna and eksterna	3 (1,9%)	11 (15,7%)	7 (15,6%)	2 (15,4%)	3 (5,1%)	0,001
	Basal ganglia, corona radiata	62 (38,8%)	20 (28,6%)	16 (35,6%)	1 (7,7%)	13 (22%)	0,038
	Insular	0 (0%)	0 (0%)	1 (2,2%)	0 (0%)	0 (0%)	0,151
	Centrum semiovale	9 (5,6%)	1 (1,4%)	0 (0%)	0 (0%)	2 (3,4%)	0,268
	Thalamus	2 (1,3%)	2 (2,9%)	3 (6,7%)	0 (0%)	3 (5,1%)	0,264
	Other	1 (0,6 %)	3 (4,2)	1 (2,1%)	2 (15,3%)	1 (1,7%)	0,010

The distribution of small vessel ischemic stroke locations in the pre-pandemic stroke group was highest in the ganglia and corona radiata, amounting to 62 (38.8%), followed by the pons and medulla oblongata at 13 (8.2%), cortical and subcortical frontal to parietal lobes at 10 (6.3%), centrum semiovale 9 (5.6%). During the pandemic with and without COVID-19, the basal ganglia and corona radiata were also most numerous with 20 (28.6%) and 16 (35.6%) respectively, followed by the internal and external capsules with COVID-19 at 11 (15.7%) and without COVID-19 as many as 7 (15.6%), pons and medulla oblongata with COVID-19 as many as 10 (14.2%) and without COVID-19 as many as 2 (4.3%). In the post-pandemic period, the majority were in the subcortical cortex of the frontal and parietal lobes with and without COVID-19, respectively 2 (15.3%) and 15 (35.4%), followed by basal ganglia and corona radiata locations with COVID-19. 1 (7.7%) and without COVID-19 as many as 13 (22%), in the internal and external capsules in patients with COVID-19 as many as 2 (15.4%) and without COVID-19 as many as 3 (5.1%). In the three periods (pre-pandemic, pandemic and post-pandemic) both with and without COVID-19, the largest location of small vessel ischemic stroke was in the basal ganglia and corona radiata with a total of 112 samples (32.3%). (Table 2)

Table 3. Characteristics of head CT scans without contrast on large vessel ischemic stroke patients in pre-pandemic, pandemic and post-pandemic based on stroke location

Characteristic		**Pre-Pandemic COVID-19 (Jan-Dec 2019)**	**Pandemic COVID-19 (Jun 2020-Dec 2021)**		**Post-Pandemic COVID-19 (Jan-Jun 2023)**		P-value
	Location		PCR (+)	PCR (-)	PCR (+)	PCR (-)	
Large vessel ischemic							
	MCA	10 (6,2%)	5 (7,1%)	5 (11,1%)	1 (7,7%)	6 (10,2%)	0,911
	PCA	1 (0,6%)	1 (1,4%)	1 (2,2%)	0 (0,%)	3 (5,1%)	0,250
	ACA	1 (0,6%)	1 (1,4%)	0 (0%)	0 (0%)	1 (1,7%)	0,853
	Other	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (1,7%)	0,298

The distribution of large vessel ischemic stroke locations, in pre-pandemic stroke patients consisted of 10 (6.2%) MCA territories, 1 (0.6%) PCA and 1 (0.6%) ACA. During the pandemic stroke with COVID-19 consisted of 5 (7.1%) MCA territories, PCA and ACA each had 1 (0.6%), and in strokes without COVID-19 in MCA territories 5 (11.1 %), PCA 1 (2.2%) for ACA 0 (0%). In the post-pandemic period, strokes with COVID-19 consisted of 1 (7.7%) MCA territory, 0 (0%) PCA and ACA, and 6 (10.2%) strokes without COVID-19 in the MCA territory. PCA 3 (5.1%) and ACA 1 (1.7%). In the three periods (pre-pandemic, pandemic and post-pandemic) both with and without COVID-19, the largest location of large vessel ischemic stroke was in the MCA territory with a total of 29 samples (8.4%). (Table 3)

Table 4. Characteristics of head CT scans without contrast on hemorrhagic stroke patients in pre-pandemic, pandemic and post-pandemic based on stroke location

Characteristic		**Pre-Pandemic COVID-19 (Jan-Dec 2019)**	**Pandemic COVID-19 (Jun 2020-Dec 2021)**		**Post-Pandemic COVID-19 (Jan-Jun 2023)**		P-value
	Location		PCR (+)	PCR (-)	PCR (+)	PCR (-)	
Hemorrhagic stroke							
	Frontal, parietal, temporal	8 (5,0%)	4 (5,7%)	3 (6,7%)	2 (15,4%)	5 (8,5%)	0,595
	Pons, midbrain, thalamus	9 (5,6%)	0 (0%)	0 (0%)	0 (0%)	2 (3,4%)	0,119
	Basal ganglia, centrum semiovale, corona radiata	25 (16,3%)	2 (2,9%)	3 (6,7%)	0 (0%)	2 (3,4%)	0,003
	IVH	0 (0%)	0 (0%)	1 (2,2%)	0 (0%)	0 (0%)	0,151
	Others	2 (1,3%)	1 (1,4%)	1 (2,2%)	0 (0%)	0 (0%)	0,853

Distribution of bleeding strokes on pre-pandemic stroke patients in the basal ganglia, centrum semiovale and corona radiata was 25 (16.3%), pons, midbrain and thalamus 9 (5.6%) and frontal, parietal and temporal lobes 8 (5.0%). %) and others 2 (1.3%). During the pandemic, stroke with COVID-19 in the basal ganglia, centrum semiovale and corona radiata was 2 (2.9%), pons, midbrain and thalamus 0 (0%) and frontal, parietal and temporal lobes 4 (5.7%) and others 1 (1.4%) and in strokes without COVID-19 in the basal ganglia, centrum semiovale and corona radiata 3 (6.7%), pons, midbrain and thalamus 0 (0%) and frontal lobe, parietal and temporal 3 (6.7%) and others 1 (2.2%). In the post-pandemic period, strokes with COVID-19 in the basal ganglia, centrum semiovale and corona radiata were 2 (15.4%), none in other locations and strokes without COVID-19 were in the basal ganglia, centrum semiovale and corona radiata as many as 2 (3.4%), pons, midbrain and thalamus 2 (3.4%) and frontal, parietal and temporal lobes 5 (8.5%). In the three periods (pre-pandemic, pandemic and post-pandemic) both with and without COVID-19, the highest number of bleeding stroke locations was in the MCA territory with a total of 33 samples (9.5%). (Table 4)

Discussion

There were 347 stroke patients during the pre-pandemic, pandemic and post-pandemic periods who underwent head CT scans without contrast who were included in the research inclusion. Gender is a risk factor for stroke that cannot be modified. Of all the samples obtained, the male gender had a greater number, namely 189 (54.5%) while the female gender was 158 (45.5%), by the literature states that the male gender has a greater risk of stroke than women [10]. However, based on Vyas' research, it is explained that the incidence of stroke is higher in women than in men at <30 years of age, while the incidence of stroke is higher in men than in women in middle age and the same or higher ratio in women starting in the last eight decade [11]. Generally, the number of men in the sample is greater than that of women. Still, in the post-pandemic period in this study, it appears that the number of stroke patients in women was greater, of which there were 10 strokes with COVID-19 compared to men 3, as well as 34 patients without COVID-19 compared to 25 men, with a P-value of 0.026 for gender, which means there is a statistically significant difference.

In terms of age, the dominant results showed that age > 50 years was 296 (85.3%), pre-pandemic stroke patients numbered 139 (40%) with an average age of 65 years, during the pandemic stroke patients with COVID-19 numbered 57 (16.4%) with an average age of 70 years and 39 stroke patients without Covid-19 (11.2%) with an average age of 55.5 years, and post-pandemic stroke patients with Covid-19 numbered 11 (3.1%) with an average age of 66.5 years and stroke patients without Covid-19 numbered 50 (14.4%) with an average age of 53 years. There is no significant difference between the age groups between pre-pandemic, pandemic and post-pandemic, both with and without COVID-19, with a P value of 0.876 for the age comparison. In line with research conducted by Belani, age was not significant in the stroke group with and without COVID-19 [12]. Classically, stroke is considered a disease of old age with the incidence rate increasing 2-fold at ages > 55 years [13].

Ischemic strokes affecting small vessels and large vessels also did not differ significantly in the pre-pandemic period, during the pandemic both with and without COVID-19 and post-pandemic both with and without COVID-19, with a P-value of 0.195 in small vessels and 0.101 in large vessel ischemic. For bleeding stroke, there was also no significant difference in pre-pandemic, pandemic and post-pandemic stroke patients both with and without COVID-19 with bleeding amounts of 30-60 ml and > 60 ml with P-values of 0.628 and 0.485 respectively. However, there were no bleeding strokes with a volume of <30 ml in COVID-19 patients during the pandemic, so statistically there appeared to be a significant difference with a P-value of 0.016. In the pre-pandemic, pandemic and post-pandemic periods, both with and without COVID-19, 63.1 -77.1% of small vessel ischemic strokes were found with 7.5-23.1% of large vessel ischemic strokes, where this number was significantly the percentage is greater than hemorrhagic stroke with the largest percentage being 20.6%. This is in line with research from Qatar, that there was a fairly large number of small vessel strokes during the pre-pandemic, pandemic and post-pandemic periods with percentages of 44.1%, 34.3% and 39.4% respectively, namely 40.1% of the entire sample followed by large vessel stroke respectively 14.4%, 24.5% and 21.3% with a total of 19.2% of the entire sample. In a stroke, there is as much bleeding as possible. 8.7% of the total sample, 8.1% in the pre-pandemic, 11.0% during the pandemic, and 8.0% in the post-pandemic period [14].

According to recent research, COVID-19 is linked to ACE2 in endothelial cells. Blood vessels can experience systemic inflammation, also known as a cytokine reaction, which increases the risk of hemorrhagic strokes [15]. One study conducted in an Iranian stroke centre found that the incidence of hemorrhagic strokes increased by 25% during the pandemic compared to 24.5% before the pandemic [6]. However, this study found that the incidence of hemorrhagic strokes decreased during the pandemic (17.5%) compared to the pre-pandemic period (20.6%). Furthermore, the incidence tended to be higher in patients without COVID-19 (8.9%) compared to patients with COVID-19 (8.6%), especially in the post-pandemic period (8.5%) among non-COVID-19 patients (8.5%). In comparison, patients with COVID-19 had no incidence of hemorrhagic strokes (0%).

There were no significant differences in the location of strokes involving small vessels, large vessels ischemic and the location of bleeding strokes during the pre-pandemic, pandemic with and without COVID-19 and post-pandemic with and without COVID-19. Small vessel strokes are the most dominant in pre-pandemic patients, as well as during the pandemic and post-pandemic in non-COVID-19 and COVID-19 patients, with the distribution of the most dominant locations in the basal ganglia to the corona radiata, especially in the pre-pandemic period. pandemic and during the pandemic, but in non-COVID-19 post-pandemic patients, the distribution was dominant in the subcortical cortex of the frontal and parietal lobes. Strokes involving large blood vessels in pre-pandemic patients were dominant in MCA, as well as during the pandemic and post-pandemic in non-Covid-19 and Covid-19 patients. The medial cerebral artery (MCA) is the most common artery involved in strokes. It supplies a large area of the lateral surface of the brain and parts of the basal ganglia and internal capsule through four segments (M1, M2, M3, and M4). The M1 (horizontal) segment supplies the basal ganglia, which is involved in motor control, motor learning, executive function, and emotion. The M2 (Sylvian) segment innervates the insula, superior temporal lobe, parietal lobe, and inferolateral frontal lobe [16].

Stroke hemorrhagic patients on pre-pandemic and non-COVID-19 patients during the pandemic tended to be dominant in the basal ganglia, centrum semiovale and corona radiata with the respective numbers being 25 (15.8%) and 3 (6.5%), in patients non-COVID-19 during the post-pandemic period was dominant in the frontal, parietal and temporal lobes, 5 (8.4%). Cerebral microvasculopathy associated with hypertension (which is one of the risk factors for stroke) is the most common cause of ICH, accounting for 56% of the population at risk. ICH associated with hypertension often occurs deep in the brain where small, thin-walled arteries originate directly from larger arteries. The best examples are the lenticulostriates, the tiny proximal branches of the middle cerebral artery (MCA), and the branches of the basilar artery. It is thought that high pressure in these thin-walled blood vessels overloads autoregulation and causes fibrinoid necrosis and arterial rupture, possibly via Charcot-Bouchard aneurysm. Therefore, ICH (haemorrhage) tends to occur in the basal ganglia, thalamus, cerebellum, and brain stem, especially the pons [17].

There are limitations in this research, namely the small sample size and does not exclude comorbid factors which will be confounding in the research.

Conclusion

The results of head CT scans in the stroke group during the pre-pandemic, pandemic and post-pandemic periods, both with and without COVID-19, and in the stroke group with COVID-19, there were no significant differences.

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Ethical clearance

This study was approved by the ethics committee of Universitas Airlangga Hospital, Surabaya, Indonesia (Protocol number: UA-02-23209).

Conflict of Interest

None

Source of funding

None

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