The investigation of the frequency of COVID-19 in patients with a history of stroke

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ABSTRACT

Introduction: The emergence of the coronavirus in 2019 became a global epidemic disease. According to the World Health Organization, people with a history of chronic diseases such as brain stroke are among the main groups at risk of contracting COVID-19. Therefore, this study was performed with the aim of the determination amount of the frequency of contracting COVID-19 in stroke patients. **Materials and Methods:** This descriptive-analytical study was conducted on 100 patients with a history of stroke referred to Imam Hossein Hospital in Tehran (Iran) between 2019 and 2022, which had all the inclusion criteria in the study. The demographic information including (gender, weight, height) and clinical information was collected by a researcher-made questionnaire and analyzed by SPSS version 24 software. **Results:** The average age of the studied patients was 63 years. Among them, 53 people (53%) were infected with COVID-19. The most of underlying diseases were related to high blood pressure. All cases of stroke in patients with COVID-19 were associated with thrombotic type, and half of the other cases included involvement in large cerebral vessels. Lymphocyte count, CRP, and ESR levels were relatively higher in stroke patients with COVID-19, but there were observed no cases of pleural effusion and pericardial effusion associated with COVID-19 in stroke patients. In all of the patients with COVID-19, pulmonary involvement was observed in the Peripheral/Perihillar area. **Discussion and Conclusion:** According to the results and data of this research, the probability of infecting COVID-19 is higher in people with a history of stroke, and these patients have more severe strokes and more mortality than stroke patients without contracting COVID-19.

Keywords: Coronavirus, COVID-19, rTPA, stroke

Introduction

In December 2019, unexplained cases were reported in Wuhan, China, which due to symptoms similar to SARS, but more aggressive in symptoms and spread, the World Health Organization called it a "New coronavirus" that creates major health threats, especially to people with underlying diseases such as cardiovascular disorders, diabetes, and high blood pressure and people who had a stroke involvement.[1] The SARS-COV-2 virus enters body cells through the ACE2 receptor. This receptor is located in almost all cells of the body, including the heart, kidney, lung, intestine, and brain tissue.[2] Among the neurological complications caused by this viral disease, it can imply involvement changes in the level of consciousness, convulsion, headache, loss of sense of smell and taste, cerebrovascular involvement, neurology, and skeletal muscle damage. When the first wave of infections occurred in the United Kingdom, at the UCL Institute of Neurology, the Adem cases increased from

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one case per month before the epidemic disease to two or three per week in April and May months.[3,4] Among 12 patients with inflammation of the central nervous system, about 10 patients with brain disease are involved with a mental disorder or psychosis, eight patients with stroke, and other eight patients are involved with peripheral nerve problems which most of them were diagnosed with Guillain-Barré. This problem is fatal in 5% of cases.[3] The mechanism of neurological complications caused by the SARS-COV-2 virus is not precisely known, and theories also have been proposed including this it can be caused by respiratory involvement and hypoxia which leads to a lack of blood oxygen rate and an increase of CO_2, and this itself leads to brain dysfunction and change in level of consciousness of the patient or due to the direct attack of the virus on the central nervous system which through blood circulation and or through the angiotensin-converting enzyme 2 (ACE2) receptor in the endothelium of the vessels, and then the brain receptor causes the attack on the central nervous system, and or through the nerve pathway by infecting the terminals of sensory or motor nerves (such as olfactory nerves) reach themselves to the central nervous system by forward or backward (retrograde or anterograde) nerve transmission through motor proteins (dynein and kinesin).[5,6] According to the mentioned cases, and based on this fact people with vascular risk factors such as high blood pressure and also people who have had a stroke, are exposed more at risk of contracting COVID-19 and the risk of death and disability resulting from it, it is necessary and important to investigate the frequency of people with the underlying disease of stroke who are infected with COVID-19. In this study, it is attempted to investigate the prevalence rate of COVID-19 in stroke patients to help for improvement of the care of patients with stroke and co-infection with COVID-19.

Materials and Methods

Type of research and studied community

This study is a descriptive-analytical study. The studied population included all stroke patients who were referred to Imam Hossein Hospital in Tehran (Iran) from 2019 to 2022.

Sampling method and sample size

In this study, the sampling method was conducted using the census sampling method among all stroke patients referred to Imam Hossein Hospital in Tehran (Iran). The sample size was estimated equal to the statistical population of 135 people which according to the unwillingness of some patients to participate in the study, and the lack of inclusion criteria, the number of samples was limited to 100 patients.

Inclusion and exclusion criteria

Complete medical documents, including CT scan and MRI, and the existence of a medical record indicating the presence of a stroke in the patient, as well as the presence of full consent, were considered among the inclusion criteria of the study. Also, unwillingness to participate in the study, and defects in the medical record were considered among the exclusion of this study.

Data collection tool

In this study, data collection was performed using a researcher-made checklist, which consists of two parts which are as follows: demographic information and clinical information. Also, the validity and reliability coefficient of the mentioned questionnaire were calculated based on Cronbach's alpha, 0.90, which indicates the appropriate validity of this questionnaire.

Work method

In this retrospective-prospective study, after the approval of the project in the Research Center of the Faculty of Medicine, Shahid Beheshti University of Medical Sciences and the approval of the ethics committee in medical research and receiving the code of ethics with the number IR.SBMU.MSP.REC.1399.091, among 135 stroke patients who were referred to Imam Hossein Hospital in Tehran (Iran) from 2019 to 2022, 100 patients with the inclusion criteria to the study were selected and included in the study. First, all demographic information of the patients was recorded in the checklist. Then, by referring to the medical records, stroke patients were identified through PCR and CT scan of the lungs in terms of contracting the disease of COVID-19. In the next stage, the prevalence rate of COVID-19 in patients with stroke (ischemic and hemorrhagic stroke) was calculated. Patients who were treated with rTPA were examined in terms of response to treatment, drug side effects such as intracranial bleeding and systemic bleeding with the help of clinical examination, examination of consciousness level and CT scan, and then, the rate of response to treatment and incidence of side effects among stroke patients with contracting the disease of COVID-19 and healthy patients were compared in terms of COVID-19 infection. Stroke patients were also examined in terms of the involvement status of large cerebral vessels and its frequency was compared between two groups of COVID-19 and healthy patients who in terms of COVID-19 had a stroke. All information was statistically analyzed after being recorded in the checklist.

Data analysis method

The obtained data were statistically analyzed using SPSS version 24 statistical software. To describe the data in terms of the type of data, the mean and standard deviation and for the data analysis in terms of the distribution, the Chi-square tests, and *t*-test were used. A logistic regression test was used to investigate the effect of various factors on the rate of COVID-19 infection in stroke patients. All the tests were performed with 95% confidence and a significance level of less than 0.05.

Ethical considerations

Participation in the study was completely voluntary, and before the patients were included in the study, a written consent for participation in the study was filled by the patients fully informed. The participation of patients in the study did not mean that the patient was deprived of treatment and did not incur additional

costs for him. No name of the patients was mentioned in any part of the study during the study, all the information of the patients will remain completely confidential by the researcher, and the researcher is committed to keeping their information.

Results

In this study, among 100 studied patients, their average age was calculated to 63.32 ± 5.1 years. Among these, 55 patients were men (55%) and the other 45 patients were women (45%). Among the examined patients, 23 patients had hemorrhagic stroke and 77 patients had thrombotic/embolic stroke, which among these, 53% of stroke patients (53 people) were infected with COVID-19, in which the frequency distribution of patients was found that 38 people of these patients were women and the other 15 people of these patients were men [Table 1]. Also, in the research, it was found that there is no significant relationship between the infection of COVID-19 and thrombotic/embolic in stroke patients ($P = 0.375$).

In this study, based on the obtained results of data analysis, it was determined that the rate of stroke has a significant relationship with increasing age ($p \leq 0.001$). This means that the rate of stroke increases with increasing age. Among the examined patients, 18 patients were smokers and 13 patients were drug users. Alcohol consumption was not reported in any of the patients. The frequency distribution of lung CT scan results between smokers and non-smokers ($P = 0.621$), and drug users and non-users ($P = 0.237$) did not show a significant relationship with their infection with COVID-19 [Table 2].

Among the examined patients, there were 32 patients with diabetes, 70 patients with hypertension, 38 patients with hyperlipidemia, and 28 patients with ischemic heart disease. The frequency of patients according to the underlying disease and based on the results of the CT scan of the lungs in terms of being infected with COVID-19 was collected in Table 3.

The findings showed that the presence of an underlying disease will increase the incidence of COVID-19. The results of the regression analysis showed that in patients with a history of stroke (previous history), the incidence of COVID-19 is associated with a significant increase ($P > 0.001$) [Table 4].

In the examination of the severity of stroke in patients, it was found that among the examined patients, 56 patients had mild or moderate stroke and 44 patients had severe stroke. In the conducted analysis, it was found that there is a significant relationship between patients with high stroke severity and their infection with COVID-19 ($P > 0.001$). By looking at the collected results in Table 5, it was observed that the infection of COVID-19 among the patients who suffered from a severe stroke is almost 8 times that patients who suffered from a mild stroke. In other words, there is a significant relationship between patients with high stroke severity and their infection with COVID-19 ($P > 0.001$).

The comparison of different parameters between stroke patients with and without COVID-19, showed that many parameters can predict the probability of COVID-19 infection in stroke patients. Parameters such as examining the incidence of rTPA complications, examining the cerebral vessels involved in a patient's stroke, lymphocytes count, CRP and ESR levels, oral effusion, pericardial effusion, coronary atherosclerosis, the presence of cardiomegaly, the presence of pulmonary fibrosis, the presence of emphysema, the presence of lung disease at the same time, ferritin and hemoglobin can predict the probability of stroke patients with COVID-19.

Table 1: Frequency distribution of lung CT scan results based on age group and gender of patients

| Demographic factor | Lung CT scan results | | | | | | P* |
| | COVID-19 findings | | Normal | | Total | | |
	Number	Percent	Number	Percent	Number	Percent	
Total patients	53	53%	47	47%	100	100	-
Age							
<50 years	0	0	2	4.2%	2	2%	0.001
50 years and more	53	53%	45	95.8%	98	98%	
Gender							
Male	15	28.3%	40	71.7%	55	55%	0.001
Female	38	71.69%	7	28.31%	45	45%	

*Chi-square statistical test

Table 2: Results of logistic regression analysis based on the comparison of the effect of drug use and smokers on the rate of infection with COVID-19

| Underlying factor | B | Standard Error | Df | P | Exp (B) | 95% CI for Exp (B) | |
						Lower limit	Upper limit
Smoking use	0.723	0.423	18	0.067	2.060	0.900	4.717
Drug use	0.183	0.529	13	0.730	1.201	0.426	3.388
Constant	-1.519	0.201	1	<0.001	0.219		

Table 3: Frequency distribution of lung CT scan results based on type of underlying disease

Underlying disease	Normal		COVID-19 findings		Non-COVID-19 findings		Total		P*
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
Total patients	73	0/73	4	0/4	23	0/23	100	100	0/730
Diabetes									
No	50	5/73	2	9/2	16	5/23	68	100	
Yes	23	9/71	2	3/6	7	9/21	32	100	
High blood pressure									
No	21	0.70	1	3.3	8	26.7	30	100	0.839
Yes	52	74.3	3	4.3	15	21.4	70	100	
Hyperlipidemia									
No	45	72.6	2	3.2	15	24.2	62	100	0.840
Yes	28	73.7	2	5.3	8	21.1	38	100	
Ischemic heart disease									
No	56	8.77	2	8.2	14	4.19	72	100	204.0
Yes	17	60.7	2	7.1	9	32.1	28	100	

Table 4: Results of logistic regression analysis based on the comparison of the effect of underlying diseases on the rate of infection with COVID-19

Underlying factor	B	Standard Error	Df	P	Exp (B)	95% CI for EXP (B)	
						Lower limit	Upper limit
High blood pressure	-0.087	0.399	6	0.731	0/813	0/398	2/009
Heart disease	129.1	0. 398	2	0.067	3/043	1/306	6/755
Dialysis	301.1	0. 809	1	0.102	3/234	0/694	17/563
Cancer	555.1	0. 951	1	0.100	3/604	0/740	30/502
Kidney disease	439.0	0. 504	1	0.294	1/154	0/400	4/166
Pituitary disease	1/946	1/435	1	0/188	6/944	0/487	116/500
COPD	0/364	0/812	1	0/650	1/518	0/302	7/068
Liver disease	0/769	0/332	1	0/482	2/158	0/166	29/344
Hypothyroidism	-1/371	1/030	3	0/103	0/254	0/030	1/910
Hyperthyroidism	1/646	0/968	1	0/079	5/201	0/639	34/562
Previous stroke	1/365	0/577	100	0/001	3/910	1/260	12/129
Constant	-2/113	0/350	1	>0/001	0/121		

Table 5: Frequency distribution of lung CT scan results based on stroke severity

Stroke Severity	Lung CT scan results					P*
	COVID-19 findings		Normal		Total	
	Number	Percent	Number	Percent	Number	
Mild	6	11.32%	38	80.85%	44	100	0.001
Severe	47	88.67%	9	19.15%	56	100	
Total	53	100%	47	100%	100	100	

*Chi-square statistical test

According to what was obtained in the data analysis, it was found that the level of lymphocytes, the levels of CRP and ESR increased significantly, and thus the amount of blood hemoglobin decreased in stroke patients with COVID-19. Also, in the patients with COVID-19 [Table 6], consolidation, the presence of ground glass appearance and the involvement in the peripheral/perihillar area were observed, but these complications were not observed in the stroke patients who were not infected with COVID-19. The examination of the final outcome of stroke patients with COVID-19 who were referred to Imam Hossein Hospital in Tehran (Iran) showed that among 53 patients with COVID-19 with a previous history of stroke, 12 patients (22.64%) received outpatient treatment, and about 77. 36% of patients with COVID-19 were hospitalized in ICU wards and under special care, and at the end, the mortality rate of stroke patients with COVID-19 in these patients was reported as 33.96% (18 people).

Discussion

Coronaviruses are the cause of a wide range of viral diseases, from colds to more severe diseases such as the Middle East respiratory syndrome coronavirus and SARS acute respiratory syndrome.[7] According to the extensive studies that have been performed on this virus, it was found that most of the people suffering from this disease have underlying diseases such as high blood pressure and cardiovascular disorders, stroke and diabetes, and the mortality rate in these people is more than the other people who not suffering from this disease.[8] COVID-19 can aggravate stroke symptoms or cause cerebrovascular accidents, and thus suitable personal protective equipment should be used in every suspected patient. Far from the expected prediction,

Table 6: Comparison of different parameters in stroke patients with COVID-19 and non-COVID-19 patients

Complications	Lung CT scan result						P*
	COVID-19 findings		Normal		Total		
	Number	Percent	Number	Percent	Number		
Incidence of rTPA complication							
No	53	53.53	46	46.47	99		0.645
Yes	0	0	1	100	1		
Cerebral vessels involvement							
Large	18	75	6	25	24		006.0
Other vessels	4	33.33	8	66.66	12		
ICH	0	0	23	100	23		
Lymphocyte count							
<1100	5	10	45	90	50		0.001
>1100	48	96	2	4	50		
CRP level							
<10	5	10	45	90	50		0.002
>10	48	96	2	4	50		
ESR level							
<20	0	0	44	90	44		00.001
>20	53	64.94	3	36.5	56		
Pleural effusion							
No	53	63.64	29	37.35	82		0.009
Yes	0	0	18	100	18		
Pericardial effusion							
No	53	55.2	43	44.8	96		0.463
Yes	0	0	4	100	4		
Coronary atherosclerosis							
No	53	53	47	47	100		0.172
Yes	0	0	0	0	0		
Presence of cardiomegaly							
No	47	56.62	36	43.37	83		0.186
Yes	6	4.5	11	64.7	17		
Presence of pulmonary fibrosis							
No	52	54.73	43	45.26	95		0.193
Yes	1	20	4	80	5		
Presence of emphysema suffering to lung disease							
No	52	54.73	43	45.26	95		0.269
Yes	1	20	4	80	5		
Presence of co consolidation							
No	41	47	47	53	88		0.008
Yes	12	100	0	0	0		
Ground glass opacity in CT scan profile							
No	41	47	47	53	88		0.008
Yes	12	100	0	0	0		
Hemoglobin level							
Normal	19	29.23	46	70/77	65		0.009
Reduction	34	14.97	1	2.86	35		
Involvement in the Peripheral/Perihillar area							
No	46	49.46	47	50/54	93		00.001
Yes	7	100	0	0	7		
Involvement in the peribronchovascular area							
No	53	53	47	47	100		0.293
Yes	0	0	0	0	0		

COVID-19 infection has suddenly increased the frequency of stroke and death caused by stroke; so that, practically, the risk of ischemic stroke combined with COVID-19 infection is undeniable and involves both healthy young and old people and people who have a history of stroke disease.[9] Acute ischemic stroke (AIS) is emerging as an important neurological/vascular complication of COVID-19, which is associated with severe immune reactions that lead to disruption in the coagulation

system and thromboembolism and ultimately increasing the risk of AIS, especially among middle-aged people.[10] In these patients, higher levels of NLR, CRP, serum ferritin, D-dimer, and fibrinogen are associated with a weaker prognosis of acute stroke in patients with COVID-19.[11,12] In a study which was conducted by Martí-Fàbregas *et al.* in 2021,[13] entitled "The effect of COVID-19 infection on patients with ischemic stroke" it was determined that the average stroke score in patients with COVID-19 compared to patients without COVID-19 is higher. Also, the mortality rate in patients with COVID-19 was equal to 33.7% and in non-COVID-19 patients, it was stated equal to 16.1%. In the end, Martí-Fàbregas *et al.* in 2021[13] stated that patients with ischemic stroke and COVID-19 infection have a higher risk of severe stroke and mortality than patients with stroke without COVID-19 infection. However, the functional outcome is comparable in both groups. In another study which was conducted by Li *et al.* (2020)[14] on 219 hospitalized patients with COVID-19 in Wuhan, China, patients with acute stroke had a higher average age and more severe symptoms and also had cardiovascular risk factors, such as hypertension, diabetes, and history of cerebrovascular disease. In this study, the incidence rate of hemorrhagic stroke was lower compared to cerebral acute ischemic stroke. Our study also indicated that the patients with COVID-19 had a higher average age and the incidence rate hemorrhagic stroke was also higher in patients who were not infected with COVID-19. In our study, stroke patients with COVID-19 had higher levels of CRP, and ESR, as well as lower levels of lymphocytes and, as a result, higher levels of NLR. The presence of coronary atherosclerosis was also higher in the patients of our study who had a stroke and were also infected with COVID-19 and all the patients who were infected with COVID-19 had a thrombotic stroke, which is an indication of severe immune reactions that lead to disruption in coagulation system and thromboembolism and ultimately increasing the risk of AIS. A study which was conducted by Dhamoon *et al.* (2021),[15] it was implied the prevalence of 38% of COVID-19 in stroke patients, in comparison, positive COVID-19 patients were more likely to have a cryptogenic stroke and thus the risk of ischemic stroke in the temporal lobe, occiput and cerebellum have been reported in them. In these patients, disruption in coagulation tests was more frequent and stroke outcomes were also reported worse. The examination of the obtained results of our study also shows the prevalence of 53% of COVID-19 in stroke patients. Also, the prevalence of thrombotic stroke in these people was higher than in people without COVID-19, which is consistent with the study of Dhamoon *et al.* in 2021. [15] Also, Zakeri *et al.* (2020)[16] implied a higher prevalence of arterial thrombosis, including stroke, myocardial infarction, and peripheral arterial thrombosis in patients with SARS-CoV-2, which despite maximum medical, endovascular, and microscopic treatment compared to patients non-infected with COVID 19 have weaker outcomes and long-term follow-up is required if thrombectomy is performed. The patients of our study who after stroke were infected with COVID-19 did not need rTPA treatment in any case and all of them improved with medical treatment, which showed results

contrary to the study of Zakeri *et al.* in 2021.[16] Of course, maybe this subject is also an emphasis on the proper effect of medical treatment of stroke in patients with COVID-19. The findings of our research showed that about 75% of COVID-19 patients who have a history of stroke are exposed at risk of large vessel involvement, and the results of regression analysis showed that the coexistence of stroke and COVID-19 infection in the elderly and young people with a significant increase ($p > 0.006$) causes a twofold increase in the probability of re-stroke in these patients. These results are similar to the results of Qin *et al.* in 2020.[17] In a study which was conducted by Qin *et al.* in 2020.[17] It was stated that even if SARS-CoV infection was a predisposing factor, this risk was mainly seen in individuals who were already exposed at risk of acute ischemic stroke due to other vascular risk factors. In other words, SARS-CoV infection can act as a trigger for common stroke causes.[17] Since the findings obtained from neurological diseases and other viral infections show that systemic inflammatory mediators may access the CNS through blood-brain barrier (BBB) dysfunction, it is possible that systemic inflammation caused by COVID-19 may contribute to neuroinflammatory processes and increase sensitivity to nervous syndromes; therefore, CNS infections may cause the progression of neurological disease in people with a history of stroke.[18,19] According to the results of our research and previous studies, ischemic stroke may be one of the characteristics of COVID-19. The cause of it is still unknown, but severe disease of COVID-19 may increase the risk of strokes in the large cerebral arteries. The underlying diseases including diabetes, hypertension, ischemic heart disease, and hyperlipidemia are among the factors affecting the severity of stroke disease in patients with COVID-19 and according to the major effect of coagulation disorders in COVID-19 on stroke, it seems medical treatment has a better effect.

Limitations and strengths

In this study, there was no specific limitation on the way of research.

Conclusion

The results of this study and previous studies showed that in patients with a history of stroke, the probability of COVID-19 virus and increasing their hospitalization in hospital and mortality increases, so people with a history of stroke should be prioritized for national vaccination and if they are infected with COVID-19, they should be given priority for treatment. In addition, it should be attempted to prevent people with a history of certain diseases, such as patients with a history of stroke, from getting infected by providing preventive solutions, in order to help reduce the frequency of complications and deaths among patients and impose the cost and financial burden on the healthcare system.

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Conflicts of interest

There are no conflicts of interest.

References

1. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: Summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. JAMA 2020;323:1239-42.

2. Cummings MJ, Baldwin MR, Abrams D, Jacobson SD, Meyer BJ, Balough EM, *et al.* Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: A prospective cohort study. Lancet 2020;395:1763-70.

3. Romero-Sánchez CM, Díaz-Maroto I, Fernández-Díaz E, Sánchez-Larsen Á, Layos-Romero A, García-García J, *et al.* Neurologic manifestations in hospitalized patients with COVID-19: The ALBACOVID registry. Neurology 2020;95:e1060-70.

4. Ellul M, Varatharaj A, Nicholson TR, Pollak TA, Thomas N, Easton A, *et al.* Defining causality in COVID-19 and neurological disorders. J Neurol Neurosurg Psychiatry 2020;91:811-2.

5. Veerbeek JM, Kwakkel G, van Wegen EEH, Ket JCF, Heymans MW. Early prediction of outcome of activities of daily living after stroke. Stroke 2011;42:1482-8.

6. Chen T, Wu DI, Chen H, Yan W, Yang D, Chen G, *et al.* Clinical characteristics of 113 deceased patients with coronavirus disease 2019: Retrospective study. BMJ 2020;368:m1091.

7. Oxley TJ, Mocco J, Majidi S, Kellner CP, Shoirah H, Singh IP, *et al.* Large-vessel stroke as a presenting feature of Covid-19 in the young. N Engl J Med 2020;382:e60.

8. Al Qawasmeh M, Ahmed YB, Nsour OA, Qarqash AA, Al-Horani SS, Hazaimeh EA, *et al.* Functional outcomes of COVID-19 patients with acute ischemic stroke: A prospective, observational, single-center study in North Jordan. Medicine (Baltimore) 2022;101:e29834.

9. Stamenković M, Radmilo L, Jovićević M, Rabi-Žikić T, Žarkov M, Ružička-Kaloci S, *et al.* Clinical characteristics of patients with acute ischemic stroke previously vaccinated against COVID-19. J Stroke Cerebrovasc Dis 2022;31:106483.

10. Nia AM, Srinivasan VM, Lall RR, Kan P. COVID-19 and stroke recurrence by subtypes: A propensity-score matched analyses of stroke subtypes in 44,994 patients. J Stroke Cerebrovasc Dis 2022;31:106591.

11. Vahidy FS, Pan AP, Ahnstedt H, Munshi Y, Choi HA, Tiruneh Y, *et al.* Sex differences in susceptibility, severity, and outcomes of coronavirus disease 2019: Cross-sectional analysis from a diverse US metropolitan area. PLoS One 2021;16:e0245556.

12. Tsivgoulis G, Katsanos AH, Ornello R, Sacco S. Ischemic stroke epidemiology during the COVID-19 pandemic: Navigating uncharted waters with changing tides. Stroke 2020;51:1924-6.

13. Martí-Fàbregas J, Guisado-Alonso D, Delgado-Mederos R, Martínez-Domeño A, Prats-Sánchez L, Guasch-Jiménez M, *et al.* Impact of COVID-19 infection on the outcome of patients with ischemic stroke. Stroke 2021;52:3908-17.

14. Li Y, Li M, Wang M, Zhou Y, Chang J, Xian Y, *et al.* Acute cerebrovascular disease following COVID-19: A single center, retrospective, observational study. Stroke Vasc Neurol 2020;5:279-84.

15. Dhamoon MS, Thaler A, Gururangan K, Kohli A, Sisniega D, Wheelwright D, *et al.* Acute cerebrovascular events with COVID-19 infection. Stroke 2021;52:48-56.

16. Zakeri A, Jadhav AP, Sullenger BA, Nimjee SM. Ischemic stroke in COVID-19-positive patients: An overview of SARS-CoV-2 and thrombotic mechanisms for the neurointerventionalist. J Neurointerv Surg 2021;13:202-6.

17. Qin C, Zhou L, Hu Z, Yang S, Zhang S, Chen M, *et al.* Clinical characteristics and outcomes of COVID-19 patients with a history of stroke in Wuhan, China. Stroke 2020;51:2219-23.

18. Finsterer J, Stollberger C. Causes of hypogeusia/hyposmia in SARS-CoV2 infected patients. J Med Virol 2020;92:1793-4.

19. Akhmerov A, Marbán E. COVID-19 and the heart. Circ Res 2020;126:1443-55.