



Acute telestroke evaluations during the COVID-19 pandemic

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Abstract

We sought to analyze the effect of COVID-19 on telestroke requests and to characterize patients remotely evaluated for acute ischemic stroke (AIS) during this time. This study is a retrospective database review of all telestroke requests at one academic vascular neurology center telestroke network with seven remote sites in the USA between March 15 and April 30, 2020. Data were compared with historical cohort spanning same time frame in 2019 using parametric or nonparametric methods as appropriate. Among telestroke requests, characteristics of age, gender, race/ethnicity, National Institutes of Health Stroke Scale (NIHSS), primary diagnosis of AIS or transient ischemic attack (TIA), and number of patients receiving intravenous alteplase (IV-rtPA) and endovascular therapy (ET) were recorded. There was a 53% decrease in telestroke evaluation requests in 2020 from 2019 ($p < 0.00001$). Mean NIHSS in 2020 was 9.1 ($SD \pm 8.4$) and mean NIHSS in 2019 was 7.2 ($SD \pm 7.3$) ($p = 0.122$). Among patients with primary diagnosis of suspected AIS or TIA, mean age was 60.5 years in 2020 ($SD \pm 17.5$) and mean age of 67.0 years in 2019 ($SD \pm 16.0$) ($p = 0.038$). A significant lower number of telestroke evaluations were performed with a higher mean NIHSS overall and a lower mean age among AIS/TIA-suspected patients. Higher NIHSS and severity in all telestroke evaluations reflect neurological manifestations of AIS and mimics, possibly influenced by COVID-19. The younger age of those with suspected AIS or TIA reflects thrombotic complications in atypical stroke populations.

Keywords Telestroke · Acute ischemic stroke · Transient ischemic attack

Introduction

The emergence of a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), in Wuhan, China, has led to a new disease termed coronavirus disease 2019 (COVID-19) which was declared a pandemic on March 11, 2020, by the World Health Organization [1]. The highly transmissible nature of the virus makes acute care treatment challenging. COVID-19 has impacted emergent care in acute vascular emergencies, including acute coronary syndrome and acute ischemic stroke (AIS) [2, 3]. On March 15, 2020, Illinois ordered bars and restaurants to close to dine-in customers to improve social distancing methods due to the COVID-19 pandemic. On March 20, 2020, Illinois took more aggressive measures and issued a stay-at-home order. This stay-at-home order had been maintained as of

April 30, 2020, when the Illinois curve of new cases began to flatten, and reflects the study period. We sought to characterize the impact of COVID-19 on telestroke practice or evaluations as well as patient characteristics during this time by comparing it with a control time period to correct for seasonal variations.

Methods

Patient population

Telestroke consults performed by an urban comprehensive stroke center that serves as the hub for multiple telestroke partner hospitals throughout a multi-state region. Telestroke requests are logged into a secure deidentified database for purposes of data collection and feedback and quality improvement with each telestroke spoke site. Secondary research was carried out on this deidentified and non-coded dataset. Informed consent was waived due to the retrospective nature of this study, and ethical board approval was not necessary. During the period March 15 to April 30, 2020, the

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telestroke program included 7 sites with an estimated emergency department annual visit census of 308,000 patients. Telestroke evaluations are performed by six vascular neurology trained physicians, and in each spoke hospital emergency, medicine physicians oversee care of these patients.

Data was reviewed retrospectively from the established database, and patients from the same time frame of the previous year were also selected to correct for seasonal variations. In order to avoid confounders, only data from the same 7 sites during March 15 to April 30, 2019, were included as historical comparison in the analysis to serve as historical controls, and other patients from 2019 during the same time frame but from other sites no longer telestroke partners were included to minimize confounders. The same six vascular neurology physicians were the only ones performing telestroke evaluations for both years of data. Patient characteristics of age, gender, race/ethnicity, National Institutes of Health Stroke Scale (NIHSS), primary diagnosis of AIS or transient ischemic attack (TIA), and number of patients receiving intravenous alteplase (IV-rtPA) and endovascular therapy (ET) were recorded. Cutoff values of NIHSS scores of < 5 for mild, 5–14 for moderate, and > 14 for severe stroke severity were used.

Statistical methods

Continuous variables were reported as mean and SD and were compared with the Student's *t* or Mann–Whitney tests. Categorical variables were reported as proportions and compared with the χ^2 and Fisher's exact test. The analysis was performed using SPSS Version 22.0, and the level of significance was established at a 0.05 level (2-sided).

Results

In the 2020 study period (from March 15 to April 30, 2020), 55 telestroke evaluations were requested at seven sites. In the 2019 matched date range (from March 15 to April 30, 2019), 116 telestroke evaluations were requested at the same sites. This marked a 53% decrease in telestroke evaluation requests in 2020 from 2019 ($p < 0.00001$). An average of 7.9 telestroke requests per site during the study period in 2020 were made, a decrease from an average of 16.6 requests per site during the same dates in 2019. An average of 1.2 telestroke requests per day at all sites during the study period in 2020 were made, a decrease from an average of 2.5 requests per day during the same study dates and sites in 2019.

All telestroke evaluation requests in the 2020 study period were compared against the same matched date range in 2019. The mean age in 2020 was 60.7 years ($SD \pm 16.9$), with a mean age of 66.0 years ($SD \pm 16.6$) in 2019 ($p = 0.053$). Among all patients in the 2020 study period, 29 (52.7%)

were white, 19 (34.5%) were African American, 6 (10.9%) were of Hispanic origin, and 1 (1.8%) was Asian. Among all patients in the 2019 matched site and date range, 56 (48.3%) were white, 52 (44.8%) were African American, and 8 (6.9%) were of Hispanic origin. A primary diagnosis of AIS or TIA was documented for 43 patients in the 2020 study period (78.2%) and 80 patients in 2019 (69.0%) ($p = 0.210$). Mean NIHSS in the 2020 study period was 9.1 ($SD \pm 8.4$), and mean NIHSS in 2019 was 7.2 ($SD \pm 7.3$) ($p = 0.122$). In the 2020 study period, 65 patients (56.0%) had NIHSS < 5, 27 patients (23.3%) had NIHSS 5–14, and 24 patients (20.7%) had NIHSS > 14. In the 2019 study period, 25 patients (45.5%) had NIHSS < 5, 17 patients (30.9%) had NIHSS 5–14, and 13 patients (23.7%) had NIHSS > 14, which was not significantly different than 2020 ($p = 0.409$). No differences in IV-rtPA administration or transfer for consideration of ET were noted between 2020 and 2019. This data is summarized in Table 1.

A subsequent analysis of all telestroke evaluations with primary diagnosis of AIS or TIA after evaluation in the 2020 study period was compared against the same matched date range and sites in 2019 (suspected stroke mimics after evaluation were excluded from the same cohort). The mean age

Table 1 Effects on and patient characteristics among all telestroke requests between March 15 to April 30 during COVID-19 pandemic compared to historical controls

	2019	2020	<i>p</i> value
Telestroke requests	116	55	<0.00001
Telestroke requests/site	16.6	7.9	-
Telestroke requests/day	2.5	1.2	-
Age, y (SD)	66.0 (16.6)	60.7 (16.9)	0.053
Male gender (%)	44 (37.9%)	26 (47.3%)	0.246
Race/ethnicity			
White	56 (48.3%)	29 (52.7%)	0.587
African American	52 (44.8%)	19 (34.5%)	0.202
Hispanic	8 (6.9%)	6 (10.9%)	0.382
Other	0 (0%)	1 (1.8%)	0.322
Primary AIS/TIA diagnosis (%)	80 (69.0%)	43 (78.2%)	0.210
NIHSS mean (SD)	7.2 (7.3)	9.1 (8.4)	0.122
NIHSS by severity			0.409
NIHSS < 5	65 (56.0%)	25 (45.5%)	
NIHSS 5–14	27 (23.3%)	17 (30.9%)	
NIHSS > 14	24 (20.7%)	13 (23.7%)	
IV-rtPA (%)	35 (30.2%)	21 (38.2%)	0.297
Transfer for possible ET (%)	18 (15.5%)	9 (16.4%)	0.887

Values are presented as mean (SD) or absolute (%), as appropriate. AIS indicates acute ischemic stroke, TIA indicates transient ischemic attack, NIHSS indicates National Institutes of Health Stroke Scale, IV-rtPA indicates intravenous alteplase, ET indicates endovascular therapy

in the 2020 study period was 60.5 years ($SD \pm 17.5$), with a mean age of 67.0 years in 2019 ($SD \pm 16.0$) ($p = 0.038$). Among AIS or TIA patients in the 2020 study period, 22 (51.2%) were white, 15 (34.9%) were African American, 5 (11.6%), were of Hispanic origin, and 1 (2.3%) was Asian. Among all patients in the 2019 matched site and date range, 40 (50.0%) were white, 32 (40.0%) were African American, and 8 (10.0%) were of Hispanic origin. Mean NIHSS in the 2020 study period was 9.2 ($SD \pm 8.2$), and mean NIHSS in 2019 was 8.1 ($SD \pm 7.9$) ($p = 0.446$). In the 2020 study period, 42 patients (52.5%) had NIHSS < 5 , 18 patients (22.5%) had NIHSS 5–14, and 20 patients (25.0%) had NIHSS > 14 . In the 2019 study period, 19 patients (44.2%) had NIHSS < 5 , 14 patients (32.6%) had NIHSS 5–14, and 10 patients (23.2%) had NIHSS > 14 , which was not significantly different than 2020 ($p = 0.469$). No differences in IV-rtPA administration or transfer for consideration of ET were noted between 2020 and 2019. This data is summarized in Table 2.

Discussion

With the compounding shortage of neurologists, telestroke has proven effective in remote evaluation and rapid treatment of AIS, with reliable examination and NIHSS, increase in recommendation of chemical thrombolysis with rtPA, early screening for large-vessel occlusion, and

facilitation of transfer to appropriate higher level of care [4]. Our telestroke evaluation frequency dropped significantly by 53% from March 15 to April 30, 2020, when compared to March 15 to April 30, 2019. As a historical comparison, 101 evaluations were performed during March 15 to April 30, 2018, over the same sites (at a rate of 14.4 per site, similar to the 2019 rate), so the only difference in the observed decrease during the 2020 study period could be attributed to the COVID-19 pandemic. This mirrors the described decrease in telestroke evaluations reported from other centers [5, 6].

Despite rapid adaptation of the medical community in general and the stroke responders in particular to the impact of COVID-19, delays in presentation and decreases in ET have been reported [7–9]. These changes may be possibly attributed to the saturation of medical services, a more strict adherence to guidelines in patient selection, the shelter-in-place policies adapted by local government, and delays in presentation to medical services for fear of contracting COVID-19 [7–9]. The impact on providers and systems of care is also being transformed during this pandemic. Hyperacute stroke management recommendations have been suggested to best utilize healthcare staff, limit the use of personal protective equipment, and enhance resource management and still provide timely and efficacious care [10]. The COVID-19 pandemic has also demonstrated the benefits and importance of more widespread use of telemedicine not just in stroke, but in other neurological states, such as Parkinson's disease and amyotrophic lateral sclerosis (ALS) [11–13].

A review of published cases demonstrated the prevalence of pre-existing neurological disease in the COVID-19 population, as well as the incidence of neurological complications including affecting both the central and peripheral nervous systems, including AIS, cerebral venous sinus thrombosis, intracerebral hemorrhage, neuromuscular injury, encephalopathy, electroencephalogram abnormalities and seizure, encephalitis, and Guillain–Barre syndrome [14]. Additionally, many COVID-19 manifestations may be masking neurological symptoms, especially in the severely ill and intubated patients. Any acute neurological presentation may be confused as AIS and still warrant immediate evaluation. We do note a non-statistically significant trend of less mild strokes (NIHSS < 5) and more moderate strokes (NIHSS 5–14) in all 2020 telestroke evaluations and those with primary diagnosis of stroke and TIA compared to date-matched controls from 2019. The mean NIHSS was 9.1 in 2020 and 7.2 in 2019. As a historical comparison, the mean NIHSS was 6.7 in a matched date range of 2018 at the same sites. Stroke and stroke mimic presentations may both be influenced by COVID-19 neurological manifestations during the study time frame. Patients with milder

Table 2 Patient characteristics among suspected AIS or TIA as primary diagnosis telestroke requests between March 15 to April 30 during COVID-19 pandemic compared to historical controls

	2019 (n=80)	2020 (n=43)	p value
Age, y (SD)	67.0 (16.0)	60.5 (17.5)	0.038
Male gender (%)	34 (42.5%)	20 (46.5%)	0.669
Race/ethnicity			
White	40 (50.0%)	22 (51.2%)	0.902
African American	32 (40.0%)	15 (34.9%)	0.578
Hispanic	8 (10.0%)	5 (11.6%)	0.767
Other	0 (0%)	1 (2.3%)	0.350
NIHSS mean (SD)	8.1 (7.9)	9.2 (8.2)	0.446
NIHSS severity			0.469
NIHSS < 5	42 (52.5%)	19 (44.2%)	
NIHSS 5–14	18 (22.5%)	14 (32.6%)	
NIHSS > 14	20 (25.0%)	10 (23.2%)	
IV-rtPA (%)	34 (42.5%)	20 (46.5%)	0.669
Transfer for possible ET (%)	18 (22.5%)	9 (20.9%)	0.841

Values are presented as mean (SD) or absolute (%), as appropriate. AIS indicates acute ischemic stroke, TIA indicates transient ischemic attack, NIHSS indicates National Institutes of Health Stroke Scale, IV-rtPA indicates intravenous alteplase, ET indicates endovascular therapy

stroke symptoms may also forego seeking medical attention for fear of contracting COVID-19, thus influencing mean NIHSS in 2020 during the study period.

A case series initially described large-vessel stroke in the young among COVID-19 patients New York City during the height of the pandemic [15]. Increasing reports support an association between COVID-19 and stroke in young populations without identified risk factors [16]. The thrombotic complications described elsewhere in relation to COVID-19 infection may have a relation to inflammation in critically ill patients [17]. We did observe among those patients where AIS or TIA was the primary diagnosis among our telestroke evaluations, a statistically significant lower age compared to date-matched controls from 2019. The mean age was 60.5 in 2020 in comparison to 67.0 in 2019. As a historical comparison, the mean age was 64.9 in a matched date range of 2018 at the same sites. We also noted a higher mean NIHSS and higher percentage of NIHSS 10 or above in these patients, but it was not significant. This mirrors reports of large-vessel stroke in younger patients in New York City [15]. Younger age may be a reflection of those without recognized, or yet diagnosed, traditional vascular risk factors for AIS having neurological symptoms and complications (such as AIS) from COVID-19; however, positivity status and medical history are not collected in this database. A recent systematic review and meta-analysis revealed increased proportions of younger patients and severe strokes attributed to a LVO but also noted that higher rates of undiagnosed and thus untreated atrial fibrillation following regional lockdowns were seen and could be an explanation for younger age [18]. This apprehension to go outside and possibly contracting COVID-19 could also skew the population as older patients with more risk factors may have stayed home and not sought emergent care despite stroke symptoms.

Race/ethnic differences have also been described in the COVID-19 pandemic with relationship to stroke. Despite total decrease in telestroke presentations, it was most pronounced in Black patients highlighting possible racial disparities [19]. This mirrors a small report where Blacks and Latinos composed the majority (76.8% of a cohort) [20].

Our data, however, did not demonstrate significant shifts in race/ethnic demographics in telestroke evaluations or suspected AIS/TIA patients when compared to previous years.

Limitations include the retrospective nature of patients from one single telestroke hub-site cohort. Another limitation includes the lack of final diagnosis and COVID-19 status. Other limitations include the lack of medical history among patients and the overall number of visits at each spoke site. All telestroke providers, however, have been the same in all telestroke evaluations since 2018 to remove any possible clinician practice changes.

Conclusions

During the COVID-19 study period of 2020, a significantly lower number of telestroke evaluations were performed in comparison to the same dates of 2019. A non-significant higher mean NIHSS in all evaluations and a significantly lower age among AIS/TIA-suspected patients were also seen. Higher NIHSS and severity in all telestroke evaluations reflect neurological manifestations of AIS and mimics, possibly influenced by COVID-19. The younger age of those with suspected AIS or TIA reflects thrombotic complications in atypical stroke populations. Future published data will further elucidate the direct and indirect influence of COVID-19 on acute presentation of stroke and neurological disease.

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Declarations

Conflict of interest The authors declare no competing interests.

References

1. Coronavirus Disease 2019 (COVID-19) Situation report-51. Available at who.int. https://www.who.int/docs/default-source/coronavirus/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10. Accessed June 3, 2020.
2. Tam CCF, Cheung KS, Lam S, Wong A, Yung A, Sze M et al (2020) Impact of coronavirus disease 2019 (COVID-19) outbreak on ST-segment-elevation myocardial infarction care in Hong Kong China. *Circ Cardiovasc Qual Outcomes*. 2020:e006631
3. Zhao J, Li H, Kung D, Fisher M, Shen Y, Liu R. Impact of the COVID-19 epidemic on stroke care and potential solutions. [published online May 20, 2020]. *Stroke*. 2020. <https://www.ahajournals.org/doi/abs/0.1161/STROKEAHA.120.030225>. Accessed June 3, 2020.
4. Wechsler LR, Demaerschalk BM, Schwamm LH, Adeoye OM, Audebert HJ, Fanale CV, Hess DC, Majersik JJ, Nystrom KV, Reeves MJ et al (2017) Telemedicine quality and outcomes in stroke: a scientific statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke* 48:e3–e25
5. Shah SO, Dharia R, Stazi J, DePrince M, Rosenwasser RH (2020) Rapid decline in telestroke consults in the setting of COVID-19. *Telemed J E Health*. 27:227–230. <https://doi.org/10.1089/tmj.2020.0229>
6. Huang JF, Greenway MRF, Nasr DM, Chukwudelunzu FE Sr, Demaerschalk BM, O'Carroll CB, Nord CA, Pahl EA, Barrett KM, Williams LN (2020) Telestroke in the time of COVID-19: the Mayo Clinic experience. *Mayo Clin Proc* 95(8):1704–1708. <https://doi.org/10.1016/j.mayocp.2020.06>.
7. Markus HS, Brainin M (2020) COVID-19 and stroke—a global world stroke organization perspective. *Int J Stroke* 15:361–364
8. Jasne AS, Chojecka P, Maran I, Mageid R, Eldokmak M, Zhang Q, Nystrom K, Vlieks K, Askenase M, Petersen N, Falcone GJ, Wira CR 3rd, Lleva P, Zeevi N, Narula R, Amin H, Navaratnam D, Loomis C, Hwang DY, Schindler J, Hebert R, Matouk C,

- Krumholz HM, Spudich S, Sheth KN, Sansing LH, Sharma R (2020) Stroke code presentations, interventions, and outcomes before and during the COVID-19 pandemic. *Stroke* 51(9):2664–2673. <https://doi.org/10.1161/STR.0000000000000347> (Epub 2020 Jul 31)
9. Kerleroux B, Fabacher T, Bricout N, Moïse M, Testud B, Vingadassalom S, Ifergan H, Janot K, Consoli A, Ben Hassen W, Shotar E, Ognard J, Charbonnier G, L'Allinec V, Guédon A, Bolognini F, Marnat G, Forestier G, Rouchaud A, Pop R, Raynaud N, Zhu F, Cortese J, Chalumeau V, Berge J, Escalard S, Boulouis G, SFNR, the ETIS registry, and the JENI-research collaborative (2020) Mechanical thrombectomy for acute ischemic stroke amid the COVID-19 outbreak: decreased activity, and increased care delays. *Stroke*. 51(7):2012–2017. <https://doi.org/10.1161/STROKEAHA.120.030373>
 10. Khosravani H, Rajendram P, Notario L, Chapman MG, Menon BK (2020) Protected code stroke: hyperacute stroke management during the coronavirus disease 2019 (COVID-19) Pandemic. *Stroke* 51:1891–1895
 11. Iodice F, Romoli M, Giometto B, Clerico M, Tedeschi G, Bonavita S, Leocani L, Lavorgna L, Digital technologies, web and social media study group of the Italian Society of Neurology (2021) Stroke and digital technology: a wake-up call from COVID-19 pandemic. *Neurol Sci*. 42(3):805–809. <https://doi.org/10.1007/s10072-020-04993-3>
 12. Miele G, Straccia G, Moccia M, Leocani L, Tedeschi G, Bonavita S, Lavorgna L, Digital technologies, web and social media study group of the Italian Society of Neurology (2020) Telemedicine in Parkinson's disease: how to ensure patient needs and continuity of care at the time of COVID-19 pandemic. *Telemed J E Health*. 26(12):1533–1536. <https://doi.org/10.1089/tmj.2020.0184>
 13. Bombaci A, Abbadessa G, Trojsi F, Leocani L, Bonavita S, Lavorgna L, Digital technologies, web and social media study group of the Italian Society of Neurology (2021) Telemedicine for management of patients with amyotrophic lateral sclerosis through COVID-19 tail. *Neurol Sci*. 42(1):9–13. <https://doi.org/10.1007/s10072-020-04783-x>
 14. Herman C, Mayer K, Sarwal A (2020) Scoping review of prevalence of neurologic comorbidities in patients hospitalized for COVID-19. *Neurology* 95(2):77–84. <https://doi.org/10.1212/WNL.00000000000009673>
 15. Oxley TJ, Mocco J, Majidi S, Kellner CP, Shoirah H, Sing IP, De Leacy RA, Shigematsu T, Ladner TR, Yaeger KA et al (2020) Large-vessel stroke as a presenting feature of Covid-19 in the young. *N Engl J Med* 382:e60
 16. Fifi JT, Mocco J (2020) COVID-19 related stroke in young individuals. *Lancet Neurol* 19(9):713–715. [https://doi.org/10.1016/S1474-4422\(20\)30272-6](https://doi.org/10.1016/S1474-4422(20)30272-6)
 17. Maier CL, Truong AD, Auld SC, Polly DM, Tanksley CL, Duncan A (2020) COVID-19-associated hyperviscosity: a link between inflammation and thrombophilia? *Lancet* 395(10239):1758–1759. [https://doi.org/10.1016/S0140-6736\(20\)31209-5](https://doi.org/10.1016/S0140-6736(20)31209-5)
 18. Katsanos AH, PalaioDIMOU L, Zand R, Yaghi S, Kamel H, Navi BB, Turc G, Benetou V, Sharma VK, Mavridis D, Shahjouei S, Catanese L, Shoamanesh A, Vadikolias K, Tsioufakis K, Lagiou P, Sfikakis PP, Alexandrov AV, Tsiodras S, Tsvigoulis G (2021) Changes in stroke hospital care during the COVID-19 pandemic: a systematic review and meta-analysis. *Stroke* 52(11):3651–3660. <https://doi.org/10.1161/STROKEAHA.121.034601>
 19. Cummings C, Almallouhi E, Al Kasab S, Spiotta AM, Holmstedt CA (2020) Blacks are less likely to present with strokes during the COVID-19 pandemic: observations from the buckle of the stroke belt. *Stroke* 51(10):3107–3111. <https://doi.org/10.1161/STROKEAHA.120.031121>
 20. Grewal P, Pinna P, Hall JP, Dafer RM, Tavarez T, Pellack DR, Garg R, Osteraas ND, Vargas A, John S, Da Silva I, Conners JJ (2020) Acute ischemic stroke and COVID-19: experience from a comprehensive stroke center in Midwest US. *Front Neurol* 20(11):910. <https://doi.org/10.3389/fneur.2020.00910>

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