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The effect of COVID-19 on stroke hospitalizations in New York City

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Background: Little is known about the effect of the Coronavirus disease 2019 pandemic on stroke care and the impact of the epidemic on acute stroke hospitalizations has not been described. Methods: We analyze the stroke admission rate in three hospitals in New York City from January 1, 2020 through April 17, 2020, identifying all cases of acute ischemic stroke, intraparenchymal hemorrhage and subarachnoid hemorrhage. Results: We confirmed 518 cases of out-of-hospital stroke. During the baseline period up to February 25, 2020, the daily stroke admission rate was stable, with the slope of the regression describing the number of admissions over time equal to -0.33 (se = 1.21), not significantly different from 0 (p = 0.79), with daily admissions averaging 41. During the pandemic period, the slope was -4.4 (se = 1.00); i.e., the number of stroke admissions decreased an average of 4.4 per week, (p = 0.005), with weekly admissions averaging 23, a reduction of 44% versus baseline. This general result was not different by patient age, sex, or race/ethnicity. Conclusions: The weekly stroke admission rate started declining two weeks prior to the local surge of coronavirus admissions. The consequences of lack of diagnosis and treatment of a large proportion of acute stroke patients are likely severe and lasting.

Key Words: COVID-19—acute stroke care—tissue plasminogen activator—tPA—mechanical thrombectomy—racial disparities—ischemic stroke—intracerebral hemorrhage—subarachnoid hemorrhage

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Introduction

Acute stroke is a medical emergency with a yearly United States (US) incidence of nearly 800,000. Of these, approximately 150,000 will eventually die and even more will be left with life-altering physical or cognitive disability.1 Reducing post-stroke morbidity and mortality depends on hospital-based diagnosis and management, including disease-changing treatment with intravenous tissue plasminogen activator (tPA) or mechanical thrombectomy (MT), secondary stroke prevention through risk factor identification and mitigation, and therapy for stroke complications. Little is known about the effect of the coronavirus disease 2019 (COVID-19) pandemic on acute stroke care.

Since early March, 2020, when COVID-19 became recognized as a major public health threat in the US, there have been reports of decreased treatment for MI and acute stroke. A nine-center report on ST-elevation myocardial infarction activations in the US found a 38% reduction in March 2020 versus the previous 14 months2 and a survey of 73 hospitals in Spain reported a 40% reduction in intervention for STEMI comparing the last week in February to the third week in March, 2020.3 A recent correspondence reported a 39% nationwide decrease in RAPID neuroimaging software use in late March compared to February, 2020.4 This corroborates an earlier observation from Italy,5 but cannot distinguish the time relationship between the start of a local pandemic and decrease in stroke hospitalizations, and further does not measure potentially valuable differences in race, stroke type and acute stroke treatment.6

Herein we report weekly rates of hospitalization for acute ischemic stroke (IS), intraparenchymal hemorrhage (IPH) and subarachnoid hemorrhage (SAH) starting before the COVID-19 pandemic and running through its peak in three
hospitals in the Bronx, New York, a diverse, urban county which at the time of the study had one of the highest COVID-19 attack rates in the world. We include proportion of cases treated with tPA or MT, and assess differences in admission rates by age, sex and race/ethnicity.

**Methods**

We included all cases of acute IS, IPH or SAH admitted to the three Montefiore Health System hospitals in the Bronx, comprising a community hospital, a New York State-designated primary stroke center and a Joint Commission-certified comprehensive stroke center, between January 1, 2020 and April 17th, 2020. Potential cases were ascertained by any primary or secondary stroke ICD 10 discharge code (I60.x, I61.x or I63.x) and transient ischemic attack (TIA) discharge codes (G45.x) from hospital administrative records or by identification of stroke by screening of daily patient logs derived from the hospital problem list in Epic by stroke data analysts, including inpatients who had not yet been discharged by the end of the study period. Difficult ischemic stroke cases and all IPH, SAH and TIA cases were reviewed by a vascular neurologist. Demographic data, COVID-19 status, in-hospital deaths and transfer source were ascertained from hospital administrative data. Race and ethnicity were categorized as Hispanic if the patient self-identified as Spanish, Hispanic or Latino, otherwise by race, categorized as white, black, other or unknown. TPA, MT and stroke onset location (inpatient versus community) were ascertained from medical record review. TPA treatment at other hospitals prior to transfer was not included. Daily COVID-19 census at the three hospitals was extracted from data released by Montefiore Medicine.

We summarize acute stroke cases by age, sex, race/ethnicity. We also report COVID-19 status, in-hospital mortality and the proportion of cases receiving tPA and/or MT.

Changes in the admission rates of acute stroke over time, described by week, are modeled using piecewise regression. Two distinct linear regression models describing the number of acute strokes, one for each time period, were obtained by a single model with number of stroke cases as the dependent variable, week (from 1 to 16) and period (baseline or pandemic) as independent variables, and the interaction between week and period. The definition of period as baseline or pandemic was not pre-defined, but was empirically determined based on the definition that yielded the best-fitting model. All analyses were performed in Microsoft Excel and SAS using 2-sided chi-square or piecewise regression, alpha 0.05. This study was approved by the Montefiore Medical Center Institutional Review Board.

**Results**

We screened 742 potential stroke cases and confirmed 567 cases, of which 518 occurred outside the hospital and are included in subsequent analysis. Cohort characteristics are provided in Table 1.

The best fitting piecewise regression model defined the baseline period as the first 8 weeks of 2020 (ending February 25) and the pandemic period as weeks 9-16. Statistical significance of differing slopes during these periods was based on the statistical significance of the interaction term of the regression model described previously (p = 0.024), with weekly admissions averaging 41. During the baseline period, the weekly stroke admission rate was stable, with the slope of the regression describing the number of admissions over time equal to -0.33 (se = 1.21) which does not significantly differ from 0 (p = 0.79). During the pandemic period, the number of arriving acute strokes decreased an average of 4.4 per week (i.e., the slope was -4.4, with se = 1.00), which differs significantly from 0 (p=0.005), with weekly admissions averaging 23, a 44% reduction versus baseline. This general result was not

| Stroke type, No. (%)       | Baseline (Weeks 1-8) | Pandemic (Weeks 9-16) | Total   |
|----------------------------|----------------------|-----------------------|---------|
| Ischemic stroke            | 270 (82)             | 153 (82)              | 423 (82) |
| Intraparenchymal hemorrhage| 42 (13)              | 24 (13)               | 66 (13)  |
| Subarachnoid Hemorrhage    | 19 (6)               | 10 (5)                | 29 (6)   |
| Age, median (IQR)          | 66 (56-79)           | 69 (58-75)            | 67 (56-77) |
| Women, No. (%)             | 171 (52)             | 88 (47)               | 259 (50) |
| Race/ethnicity, No. (%)    |                      |                       |         |
| Hispanic                   | 100 (30)             | 39 (21)               | 139 (27) |
| Black, non-Hispanic        | 135 (41)             | 75 (40)               | 210 (40) |
| White, non-Hispanic        | 45 (14)              | 39 (21)               | 84 (16)  |
| Other, non-Hispanic        | 24 (7)               | 22 (12)               | 46 (9)   |
| Unknown                    | 27 (8)               | 12 (6)                | 39 (8)   |
| Transfers from other hospitals, No. (%) | 57 (17) | 41 (22) | 98 (19) |
| In-hospital death, No. (%) | 30 (9)               | 25 (15)               | 55 (11)  |
different by patient age, sex, or race/ethnicity. A graph of the 7-day moving average of daily stroke admissions super-imposed on the daily census of COVID-19 patients is shown in Fig. 1.

TPA or MT was performed on 53 patients, with 36 treated prior to the admission rate inflection point (11% of IS cases) and 17 after (13%), p = 0.45. Transfers from other hospitals in the Bronx and beyond did not decline significantly.

The earliest admission tested for COVID-19 arrived on March 8 and the earliest admission who had a positive test arrived on March 9. Assessment for COVID-19 was completed in 86 patients during hospitalization, of whom 31 (36%) were diagnosed with COVID-19. Hospitalization ended in death in a higher proportion of patients who were diagnosed with COVID-19 (12/31, 39%) versus patients in whom COVID-19 was excluded or not tested (43/487, 9%), p < 0.001.

**Discussion**

Starting in the last week of February we observed a rapid decline in the weekly stroke admission rate across the three Montefiore Medicine hospitals in the Bronx. The 44% decline in weekly admissions occurred about two weeks before the first COVID-19 admission to the hospital network on March 9, 2020 and admissions remained low as the number of COVID-19 admissions surged. The decline spanned demographic categories and stroke types but was not associated with a decrease in the proportion of ischemic stroke patients treated with tPA or MT. Patients admitted with stroke and COVID-19 infection had a high risk of death.

The decline in admissions most likely reflects a fear of exposure to coronavirus rather than a decrease in capacity to admit and treat stroke patients (we had no such change) or in stroke risk. Decades of educational efforts to get people to come immediately to the hospital with symptoms of acute stroke were immediately overwhelmed and it is unclear how quickly stroke admission rates will recover. The fear crossed all demographic boundaries, equally affecting old and young, men and women, whites, blacks and Hispanics. The consequences of lack of diagnosis and treatment of a large proportion of acute stroke patients are likely widespread, severe and lasting.

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