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Acute stroke care in a New York City comprehensive stroke center during the COVID-19 pandemic

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Background and Purpose: The coronavirus disease-2019 (COVID-19) pandemic caused unprecedented demand and burden on emergency health care services in New York City. We aim to describe our experience providing acute stroke care at a comprehensive stroke center (CSC) and the impact of the pandemic on the quality of care for patients presenting with acute ischemic stroke (AIS). *Methods:* We retrospectively analyzed data from a quality improvement registry of consecutive AIS patients at New York University Langone Health's CSC between 06/01/2019-05/15/2020. During the early stages of the pandemic, the acute stroke process was modified to incorporate COVID-19 screening, testing, and other precautionary measures. We compared stroke quality metrics including treatment times and discharge outcomes of AIS patients during the pandemic (03/01/2020-05/15/2020) compared with a historical pre-pandemic group (6/1/2019-2/29/2020). *Results:* A total of 754 patients (pandemic-120; pre-pandemic-634) were admitted with a principal diagnosis of AIS; 198 (26.3%) received alteplase and/or mechanical thrombectomy. Despite longer median door to head CT times (16 vs 12 minutes; $p = 0.05$) and a trend towards longer door to groin puncture times (79.5 vs. 71 min, $p = 0.06$), the time to alteplase administration (36 vs 35 min; $p = 0.83$), door to reperfusion times (103 vs 97 min, $p = 0.18$) and defect-free care (95.2% vs 94.7%; $p = 0.84$) were similar in the pandemic and pre-pandemic groups. Successful recanalization rates (TICI \geq 2b) were also similar (82.6% vs. 86.7%, $p = 0.48$). After adjusting for stroke severity, age and a prior history of transient ischemic attack/stroke, pandemic patients had increased discharge mortality (adjusted OR 2.90 95% CI 1.77 – 7.17, $p = 0.021$) *Conclusion:* Despite unprecedented demands on emergency healthcare

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services, early multidisciplinary efforts to adapt the acute stroke treatment process resulted in keeping the stroke quality time metrics close to pre-pandemic levels. Future studies will be needed with a larger cohort comparing discharge and long-term outcomes between pre-pandemic and pandemic AIS patients.

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Introduction

Treatment of acute ischemic stroke (AIS) is time-dependent and impacts functional outcomes and mortality. On March 1, 2020, New York City reported its first case of coronavirus disease 2019 (COVID-19) and within a month was the global epicenter. The velocity of the increased demand on emergency health care services, disruptions in supply chains, and the highly infectious nature of COVID-19 placed unprecedented demands on emergency health care services, including ambulances, emergency departments (ED), and inpatient units. Existing emergency treatment protocols, such as thrombolytic therapy and endovascular revascularization for treatment of AIS, were at risk of significant time delays in this setting.

Here we describe our experience in maintaining the quality of care for AIS patients at a Joint Commission-certified comprehensive stroke center (CSC) during the COVID-19 pandemic and compare time metrics for those receiving thrombolysis or mechanical thrombectomy (MT) to a pre-pandemic cohort.

Methods

Study design and population

We retrospectively analyzed quality improvement data of consecutive AIS patients at the NYU Langone Health CSC (comprising NYU Langone-Manhattan and NYU Langone-Brooklyn campuses) from June 1, 2019, to May 15, 2020. We compared patients discharged with a principal diagnosis of AIS during the pandemic (March 1, 2020, to May 15, 2020) to a historical cohort (June 2019–February 2020). This registry study was exempt from NYU Institutional Review Board approval. Data can be shared by emailing the corresponding author.

COVID-19 stroke code protocol changes

Our acute stroke protocol changes to COVID-19 were implemented in the first week of March 2020

ED COVID-19 screening

Per existing policy, stroke codes were activated for patients arriving with acute neurological changes within 24 hours of ED arrival. All patients in the ED, regardless of etiology, underwent immediate screening by ED staff for signs, symptoms, and risk factors for COVID-19 exposure. A positive screen or inability to complete screening (due to

aphasia, etc.) triggered nasopharyngeal reverse transcriptase-polymerase chain reaction (RT-PCR) testing for COVID-19 and institution of contact and droplet isolation precautions. All stroke team members used personal protective equipment (PPE) consistent with the Centers for Disease Control and Prevention guidelines.¹ In general, patients with a negative screen did not undergo COVID-19 testing. After screening, the patient was assessed by the ED physician for airway, breathing, and circulation and, if stable, transported to an adjacent computed tomography (CT) suite with the stroke team. Intubations were performed in a designated respiratory isolation room with limited personnel.

Outside hospital transfers for MT

Our hospital remained committed to accepting outside hospital transfers for any patients requiring advanced stroke treatments. While in pre-pandemic times patients without confirmed large vessel occlusion were occasionally transferred, given the strain on resources, we required all facilities who could obtain advanced imaging to do so prior to transfer. Imaging was reviewed by the on-call vascular neurologist or neuro-interventionalist and the patient was transferred to our facility if there was evidence of proximal large vessel occlusion and the patient was deemed to be a candidate for MT. All transferred patients underwent COVID-19 screening by a transfer center nurse and additional in-person screening was performed upon arrival at our ED.

NeuroInterventional Suite and Pre-Procedural

Strategy: All patients who qualified for thrombolysis or MT were treated accordingly

All patients undergoing MT were tested for COVID and were persons under investigation (PUI) pending COVID-19 RT-PCR assays. As such, the neuro-intervention team followed standardized precautions for PUIs per institutional policy. At our institution, each case is assessed individually as a team by the ED physician, neurologist, anesthesiologist, and the neuro-interventional radiologist to determine if the patient needs to be intubated for the procedure. Neurointerventional procedural suites were set to negative pressure if possible and if not, portable high-efficiency particulate air filtered forced air units were employed to convert designated rooms to negative pressure to allow containment of airborne pathogens. The suite was cleared of any unnecessary items to reduce the spread of infection via surfaces.

Vitals assessment, Neurological and/or access site checks post reperfusion therapy

Our institution relaxed the post-procedure and post-thrombolytic therapy vitals assessment, neurological exam and/or access site checks and asked that they be combined and performed by one person at a reduced frequency to conserve PPE and limit infectious exposures.² Vital signs, groin puncture site, and neurological assessments were performed as following – every 1 hour \times 8, then every 2 h \times 2 then every 4 hr for 12 hours or more frequent as per treating team's discretion.

Study variables

Standard stroke quality variables were prospectively collected per American Heart Association Get With The Guidelines Stroke Program. Discharge outcomes were represented by the discharge modified Rankin Scale (mRS), NIHSS, and disposition. Good outcome was defined as discharge mRS score \leq 3 and discharge disposition dichotomized as good (discharged home or to an acute inpatient rehabilitation facility) vs. poor (dead, discharged to a skilled nursing facility, subacute rehabilitation, long term assisted care facility or hospice).

Defect-free care

We also calculated a binary “defect-free care” score, which was defined as compliance with 5 care measures—ED arrival to head CT <25 minutes, ED arrival to alteplase <60 min, discharge on an anti-platelet, anticoagulation for patients with atrial fibrillation, and statin medication at discharge.³ Patients were classified as having had defect-free care if they received all elements for which they were eligible. Defect-free care does not take into account the number of care components patients are eligible to receive. Thus, a patient who is eligible for 3 care components and received all is declared as having had defect-free care, while a patient who received 4 out of 5 indicated care components is identified as not having had defect-free care.

Statistical analysis

Patients were divided into two groups: pandemic (March 1, 2020, to May 15, 2020) and pre-pandemic (June 1, 2019, to February 29, 2020). Baseline NIHSS, stroke quality metrics, and clinical outcomes were compared between groups in patients who received alteplase and/or MT therapy. Continuous variables were compared using the Mann–Whitney U test and categorical variables using chi-square or Fisher exact test, as appropriate. We compared the door to alteplase time < 45 min and door to groin puncture time < 90 min between cohorts in unadjusted and adjusted models (adjusting for admission NIHSS). *p*-values < 0.05 were

considered statistically significant. Statistical analyses were conducted using SPSS version 25.0.

Results

A total of 754 patients (120 during pandemic and 634 during pre-pandemic) were admitted with a principal diagnosis of AIS from June 1, 2019, to May 15, 2020; 198 (26.3%) received alteplase and/or MT. The number of AIS cases per month and COVID-19 hospitalizations are shown in Fig. 1. The incidence of hospital-presenting AIS was lower during the pandemic (Fig. 1). The demographic variables between the two cohorts were similar except, a higher proportion of patients in the pre-pandemic cohort with a history of prior TIA or AIS (Table 1). Patients presented with a higher median admission NIHSS scores (5 vs 3; *p* = 0.01) during the pandemic (Table 1). The time from symptom onset to presentation was not significantly different (Fig. 2). Among eligible patients who received alteplase and/or MT (*n* = 198), stroke time metrics were not different between pre-pandemic and pandemic cohorts except for the slightly longer door to head CT time (16 vs 12 min; *p* = 0.05) and a trend towards the longer door to groin puncture (71 vs. 79.5 min, *p* = 0.06) (Table 2). The proportion of patients who were treated within stroke quality recommended time limits and who received “defect-free care” was also similar between the two cohorts (Table 3). Successful recanalization rates (TICI \geq 2b) were not significantly different (82.6% vs. 86.7%, *p* = 0.48). During the pandemic, discharge outcomes were worse (good discharge disposition, 80.6% vs 90.7%; *p* = 0.01; good discharge mRS, 57.3% vs 68.3%; *p* = 0.02), and mortality (7.7% vs 2.5%; *p* = 0.004). The compliance rate for post-treatment neuro checks and BP checks was 100% in both the pandemic and pre-pandemic era. There was no difference in the length of hospital stay between the pandemic and pre-pandemic cohorts (3.8 vs 3.7 days; *p* = 0.87).

After adjusting for NIHSS at baseline which differed between the two groups, the door to needle times < 45 min (OR 0.79, 95% CI 0.24 – 2.61, *p* = 0.70) or door to groin puncture times < 90 min (OR 0.93, 95% CI 0.26–3.31, *p* = 0.91) were non-significantly different between the pandemic and pre-pandemic era. However, when adjusting for admission NIHSS, age and a prior history of transient ischemic attack (TIA) and stroke, there was an association between the pandemic period and mortality at discharge (OR 2.90 95% CI 1.77–7.17, *p* = 0.021) but not poor discharge outcome (OR 1.40 95% CI 0.85 – 2.32, *p* = 0.187).

Discussion

We observed a lower volume of AIS admissions and performed less thrombolysis and MT during the COVID-19 pandemic, consistent with prior studies.⁴ We adapted

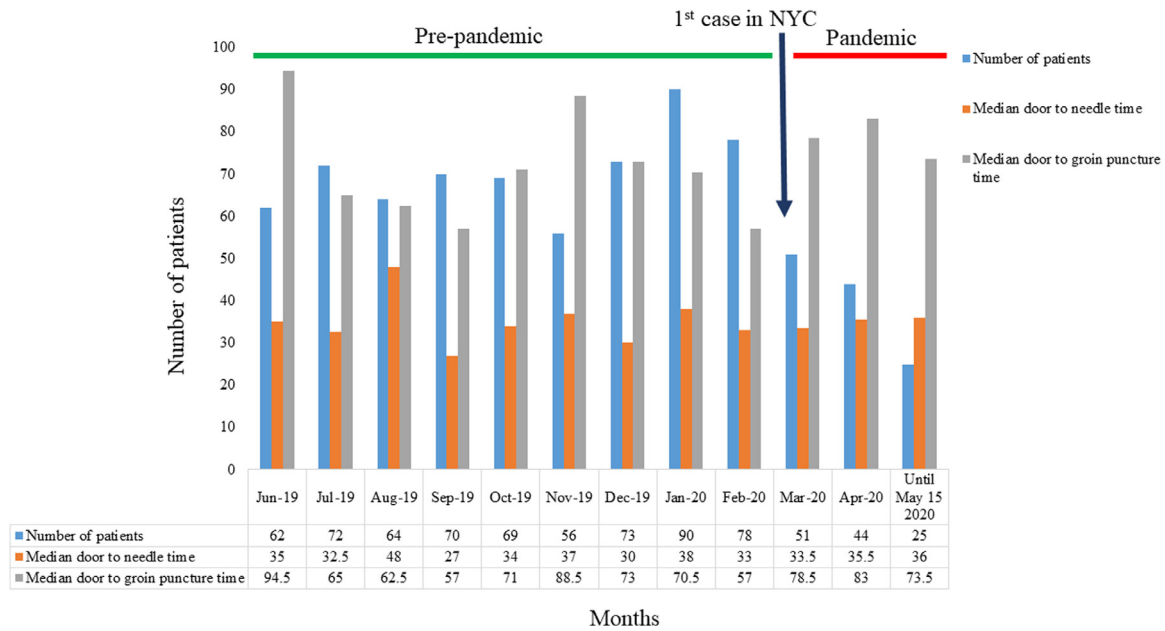


Fig. 1. Total number of stroke admissions, Door to alteplase and groin puncture times per month.

Table 1. Demographics and admission characteristics of the patients.

	Pre-pandemic (n = 634)	Pandemic (n = 120)	p
Age, median (IQR)–yrs	72 (60–81)	68 (58–79)	0.14
Male gender–no. (%)	346 (54.7%)	59 (49.2%)	0.27
Race			
Caucasian–no. (%)	341 (53.8%)	67 (56.3%)	0.09
African–American–no. (%)	90 (14.2%)	13 (10.9%)	
Asian–no. (%)	56 (8.8%)	13 (10.9%)	
UTD–no. (%)	145 (22.9)	23 (19.3%)	
Ethnicity, Hispanic–no. (%)	67 (10.6%)	15 (12.6%)	0.51
Stroke risk factors			
Atrial Fibrillation/ Flutter–no. (%)	100 (15.8%)	20 (16.8%)	0.78
Hypertension–no. (%)	448 (70.7%)	92 (77.3%)	0.14
Dyslipidemia–no. (%)	287 (45.3%)	54 (45.4%)	0.98
Diabetes mellitus–no. (%)	207 (32.6%)	37 (31.1%)	0.74
Coronary artery disease–no. (%)	130 (20.5%)	23 (19.3%)	0.77
Obesity–no. (%)	21 (3.3%)	8 (6.7%)	0.08
Smoking–no. (%)	78 (12.3%)	15 (12.6%)	0.93
Previous TIA or stroke–no. (%)	188 (29.7%)	22 (18.5%)	0.013
Renal Insufficiency–no. (%)	45 (7.1%)	4 (3.4%)	0.13
Stroke preventive medications			
Antihypertensive–no. (%)	401 (63.2%)	73 (61.3)	0.69
Anticholesterol–no. (%)	313 (49.4%)	52 (43.7%)	0.26
Antidiabetics–no. (%)	138 (21.8%)	26 (21.8%)	0.98
Anti–thrombotics–no. (%)	321 (50.6%)	55 (46.2%)	0.38
Antiplatelets–no. (%)	236 (37.3%)	42 (35.0%)	0.66
Anticoagulants–no. (%)	85 (13.3%)	13 (10.8%)	
Admission platelet count, median (IQR)	220 (189–271)	224 (196–293)	0.52
Admission INR, median (IQR)	1.1 (1.0–1.3)	1.1 (1.0–1.2)	0.22
admission NIHSS, median (IQR)	3 (1–8)	5 (2–12.5)	0.01

INR–International normalized ratio; IQR–Interquartile range; NIHSS–National Institutes of Health Stroke Scale; no. – number; TIA–Transient ischemic attack; UTD–unable to determine.

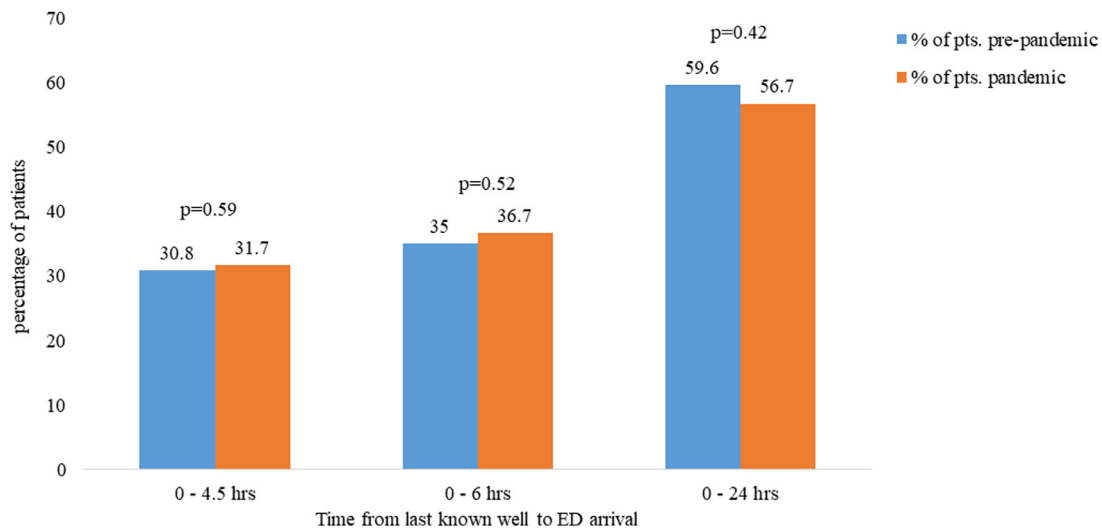


Fig. 2. Percentage of patients presenting within 4.5 h, 6 h, and 24 h within the pre-pandemic vs. pandemic times.

Table 2. Stroke quality time metrics and outcomes during the pandemic vs pre-pandemic times

	Pre-pandemic (n = 634)	Pandemic (n = 120)	p
LKW–arrival*	326 (93–936)	283 (89.25–768.5)	0.42
Door–ED physician*	3 (1–5) (n=164)	3 (2–7) (n=33)	0.28
Door–Stroke team*	3 (0–7) (n=162)	3.5 (0.25–9.75) (n=32)	0.63
Door–Head CT*	12 (9–18) (n=147)	16 (12–20) (n=28)	0.05
Door–needle*	35 (27–47.5) (n=93)	36 (26–53) (n=15)	0.83
Door–groin puncture*	71 (54–89.5) (n=69)	79.5 (70–102.25) (n=16)	0.06
Door–reperfusion*	97 (82–23)	103 (92–160) (n=16)	0.18
mTICI 2b or 3	19/23 (82.6%)	78/90 (86.7%)	0.48
Length of stay (days)	3.7 (2.5–7.5)	3.8 (1.8–7.6)	0.87
Good disposition, %	362/399 (90.7%)	58/72 (80.6%)	0.011
Good discharge mRS (0–3), %	430/630 (68.3%)	67/117 (57.3%)	0.021
Mortality, %	16/630 (2.5%)	9/117 (7.7%)	0.004

LKW – last known well; ED emergency department; CT–computed tomography; mTICI–modified thrombolysis in cerebral infarction; mRS–modified rankin score.

*All times are in minutes.

early to this pandemic and instituted changes in the acute stroke care protocol^{2,5,6} which may have helped streamline the process and minimize treatment delays while ensuring patient and healthcare worker protection from potential exposures.⁷ Patients in our study had a similar door to ED physician assessment times but longer door to head CT times. This was likely due to additional triage screening, ensuring proper PPE for staff, and cleaning between CT scans.

The findings of our study show no significant difference between door to needle times between the pandemic and pre-pandemic groups, although there was a trend towards longer door to groin puncture times, likely due to additional institutional precautionary measures to prevent contamination of surgical equipment and to ensure the safety of the medical staff and other patients.

Our findings also demonstrate higher discharge mortality during the pandemic. Possible reasons for this included a

delay in hospital arrival due to fear of COVID-19 infection but this did not seem to be a major contributor in our study population. In addition, we found increased stroke severity during the COVID-19 pandemic similar to other studies,^{8–11} presumably because patients with mild symptoms were staying at home. Another important reason for this association is that some of the strokes that occurred during the pandemic were associated with COVID-19 where the mortality may have been related to COVID-19 complications rather than stroke.⁹ Our study findings demonstrated that the length of hospitalizations during the pandemic was similar to the pre-pandemic cohort in contrast to some other reports.¹² This was likely possible because our own Rusk inpatient rehabilitation institute was accepting COVID-19 positive patients.

Our study does have limitations. It is a single-system experience with a fewer number of patients in the pandemic cohort due to the early nature of this disease process. Another major limitation of our study is that we

Table 3. Proportion of patients* within stroke quality recommended time limits in pandemic vs pre-pandemic cohorts

	n	Pre-pandemic (n=165)	Pandemic (n=33)	p
Door–ED physician–no. (%)	196	147/163 (90.2%)	27/33 (81.8%)	0.17
Door–Stroke team–no. (%)	193	140/161 (87%)	29/32 (90.6%)	0.57
Door–Head CT–no. (%)	173	120/145 (82.8%)	25/28 (89.3%)	0.39
Door–needle–no. (%)	108	76/93 (81.7%)	14/15 (93.3%)	0.26
Door–groin puncture–no. (%)	85	52/69 (75.4%)	11/16 (68.8%)	0.59
Defect-free care–no. (%)	690	555/586 (94.7%)	99/104 (95.2%)	0.84

*Patients who received alteplase and/or mechanical thrombectomy ED emergency department; CT – computed tomography Door–ED physician time < 10 min; Door–Stroke team < 15 min; Door – Head CT < 25 min; Door–needle (alteplase) time < 60 min; Door–groin puncture time < 90 min.

do not have the cause of mortality collected in our quality improvement database and thus while the mortality was increased during the pandemic period, the cause of mortality remains unknown and needs further study. On the other hand, the strength of our study is that it provides real-world information about stroke quality metrics in a CSC at the world's epicenter of the COVID-19 pandemic.

Conclusion

Timely and appropriate multidisciplinary changes to an institution's acute stroke treatment process may result in maintaining stroke quality time metrics comparable to the pre-pandemic era. Future studies will be needed to confirm our findings with a larger cohort and in other practice settings such as non-academic hospitals and primary stroke centers comparing discharge and long-term outcomes between pre-pandemic and pandemic AIS patients.

Declaration of Competing Interest

None.

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