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“Staying Home” – Early Changes in Patterns of Neurotrauma in New York City During the COVID-19 Pandemic

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■ **OBJECTIVE:** New York City is the epicenter of the novel coronavirus disease 2019 (COVID-19) pandemic in the United States. Traumatic brain injury accounts for a significant proportion of admissions to our trauma center. We sought to characterize the effect of the pandemic on neurotraumas, given the cancellation of nonessential activities during the crisis.

■ **METHODS:** Retrospective and prospective reviews were performed from November 2019 to April 2020. General demographics, clinical status, mechanism of trauma, diagnosis, and treatment instituted were recorded. We dichotomized the data between pre–COVID-19 (before 1 March) and COVID-19 periods and compared the differences between the 2 groups. We present the timeline of events since the beginning of the crisis in relation to the number of neurotraumas.

■ **RESULTS:** A total of 150 patients composed our cohort with a mean age of 66.2 years (standard deviation ± 18.9), and 66% were male. More males sustained neurotrauma in the COVID-19 period compared with the pre–COVID-19 (60.4% vs. 77.6%, $P = 0.03$). The most common mechanism of trauma was mechanical fall, but it was observed less frequently compared with the pre–COVID-19 period (61.4% vs. 40.8; $P = 0.03$). Subdural hematoma, traumatic subarachnoid hemorrhage, and intracerebral contusion accounted for the most common pathologies in both periods. Nonoperative management was selected for most patients (79.2 vs. 87.8%, $P = 0.201$) in both periods.

■ **CONCLUSIONS:** A decrease in the frequency of neurotraumas was observed during the COVID-19 crisis concomitant with the increase in COVID-19 patients in the

city. This trend began after the cancellation of nonessential activities and implementation of social distancing recommendations.

INTRODUCTION

On 11 March, 2020 the World Health Organization declared the infection with the novel coronavirus disease 2019 (COVID-19) as a pandemic, after the initial outbreak in Wuhan, China in December 2019.^{1–6}

By February 23, the first 14 cases in the United States were confirmed. Since then, there has been an exponential growth in disease incidence, and the United States became the world's epicenter.^{1,7} New York City, in particular, saw the most significant impact, reaching an overwhelming number of 6368 new cases diagnosed in a single day, on 6 April.⁸ Since the outbreak began in the city on 3 March, there have been 164,794 confirmed cases and 13,440 confirmed deaths by 26 April.⁸ As a result, health care systems throughout the city had to divert significant resources and staff to newly created COVID-specialized units.

In an attempt to slow the progression of COVID-19 pandemic, New York state and city governments enacted strict social distancing policies starting 12 March, which included a progressive restriction and cancellation of nonfundamental activities, like the closure of schools, restaurants, bars, and business, as well as the cancellation of all elective surgical procedures.⁹

According to the last New York State Trauma Registry report, for discharges between 2014 and 2015, there was an average of 48,610 trauma incidents with a 3.35% case fatality rate, with falls accounting for 54% of the total leading cause of trauma followed by motor vehicle accidents (MVA) in 20.5% of the cases.¹⁰

We hypothesize that the social distancing and restrictive policies have changed the typical neurotrauma patterns throughout

Key words

- Coronavirus
- COVID-19
- Trauma
- Traumatic brain injury

Abbreviations and Acronyms

COVID-19: Coronavirus disease 2019

DNR: Do not resuscitate

MVA: Motor vehicle accident

TBI: Traumatic brain injury

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the city, given that fewer people are working and there has been less transportation and interpersonal contact. To assess these possible changes, we reviewed all neurotrauma admissions to our trauma center during the early COVID-19 period and assessed changes in frequency, demographics, and mechanisms, in order to highlight any changes due to social distancing policies.

MATERIALS AND METHODS

Mount Sinai Morningside is located in the Upper West Side of Manhattan, is a Level-2 trauma center accredited by the American College of Surgeons, and is the centralized trauma facility in our system. Institutional data on neurotrauma admissions were queried between 1 November, 2019 (1 month before the disease outbreak in China) until 26 April, 2020. The start date for our query was selected on the basis of the first confirmed cluster of pneumonia associated with the novel coronavirus (SARS-CoV-2), which was documented in China on 31 December, 2019.¹¹ Data analysis was done both retrospectively and prospectively, after Institutional Review Board approval [IRB 20-00402] was obtained. The data were dichotomized in pre-COVID (before 1 March, when the first case in New York City was confirmed)¹² and COVID groups (after 1 March).

General demographics (age, sex), date of the encounter, mechanism of the trauma, Injury Severity Score, Glasgow Coma Scale, radiologic diagnosis, length of stay in the intensive care unit, days intubated (if applicable), total in-hospital length of stay, and treatment instituted were obtained. Additionally, we recorded specific information during the pandemic, such as COVID-19 status (reported positive or negative by nasopharyngeal swab polymerase chain reaction (PCR), and unknown cases—if no test was obtained), presence of respiratory symptoms, known close contact with COVID-19 patients, and radiologic signs suggestive of active infection.

We excluded patients who presented with neurosurgical conditions other than related to trauma (i.e., spontaneous intracerebral hemorrhage, stroke, aneurysmal subarachnoid hemorrhage, central nervous system tumor).

Statistical Analysis

Descriptive and comparative analyses of data were performed using Chi-square, Fisher exact test, or a 2-sample t-test, depending on the variable type and observed values of the variables. The significance was set to $\alpha = 0.05$. We used R version 3.6.0 in RStudio interface (RStudio Integrated Development for RStudio, Inc, Boston, Massachusetts, USA).

RESULTS

During the study period, 150 patients with neurotraumas with a mean age of 66.2 years (standard deviation ± 18.9) and male prevalence of 66% presented to our institution, 101 in the pre-COVID-19 era and 49 in the COVID-19 period.

Figure 1 shows the monthly frequency of neurotrauma cases during the study period. An average of 25.5 cases was observed in the pre-COVID-19 period, and 24.5 cases in the COVID-19 time. An average of 1 case/day was observed in March and a decrease to 0.6 patients/day in April.

Figure 2 shows a timeline of events during the COVID-19 crisis. An inverse relationship was noticed between the number of positive cases and the frequency of neurotraumas since 1 March. By the third week of March, a drop in the frequency of neurotraumas was noticed, especially since the cancellation of nonessential activities (16 March). An increase in the frequency of cases was noticeable in the second week of April, which was observed concomitant with the decrease in number of new COVID-19 cases in the city.

COVID-19 Period in New York City

During the COVID-19 crisis, 49 patients with a mean age of 61.7 years (standard deviation ± 20.9 years) and 77.6% male distribution were evaluated by our service. The most common neurotrauma was caused by mechanical fall (40.8%), unknown mechanism (20.4%), and MVA/transit-related injuries (18.4%). The most common diagnoses were subdural hematoma, traumatic subarachnoid hemorrhage, and intracerebral contusion in 42.9%, 32.7%, 12.2% respectively. Medical management accounted for 87.8% of treatment instituted, and 12.2% required surgical intervention.

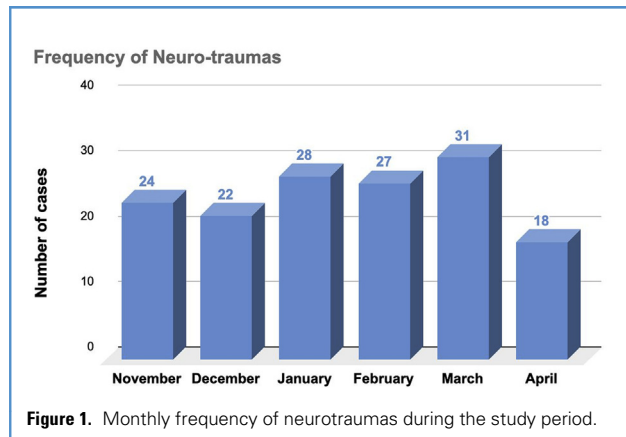
From this cohort, 3 patients (6.1%) tested positive for COVID-19, 21 (42.9%) tested negative, and 25 (51%) had an unknown status at the time of evaluation. Two patients (4.1%) had a recognized contact with a positive person, and 46 (93.9%) had an unknown contact. Five patients (10.2%) had positive clinical symptoms on arrival (cough, dyspnea, fever), and 6 (12.2%) patients had positive radiologic findings consistent with COVID-19 pneumonia.

Table 1 summarizes the comparative findings between pre-COVID-19 and COVID-19 groups. No significant difference between the groups regarding age was noticed (68.4 vs. 61.7 years, $P = 0.056$). In both groups, most of the traumas were observed in males, with an increased male gender predominance in the COVID-19 period (60.4% vs. 77.6%, $P = 0.037$). The most frequent mechanism of trauma in both cohorts was mechanical fall, with a higher frequency in the pre-COVID-19 period (61.4% vs. 40.8%, $P = 0.034$). Unknown mechanism (12.9% vs. 20.4%), MVA/transit-related (5% vs. 18.4%), and violence-related/inflicted traumas (9.9% vs. 12.2%) increased in frequency in the COVID-19 period with significant difference ($P = 0.034$). Subdural hematomas were the most frequent diagnosis between both groups, with a decrease in numbers of cases in the COVID-19 period (51.2% vs. 42.9%). Traumatic subarachnoid hemorrhage (22.7% vs. 32.7%), intracerebral contusion (9.9 vs. 12.2%), and epidural hematoma (5% vs. 8.2%) experienced a relative increase in frequency during the COVID crisis with a nonsignificant difference ($P = 0.36$).

Medical management was the most common treatment modality in both groups (79.2% vs. 87.8%, $P = 0.201$). Among the nonsurgical interventions, the frequency of conversion to Do Not Intubate/Do Not Resuscitate status and poor surgical candidacy increased in the COVID-19 period from 5.9% to 12.2% ($P = 0.181$). Overall, neurotraumas requiring surgical management decreased during COVID-19 (20.8% vs. 12.2%), but the difference did not reach statistical significance ($P = 0.20$).

DISCUSSION

Health care institutions in New York City witnessed an exponential growth of COVID-19 cases since 3 March, with the highest peak of



6368 diagnoses on 6 April, and a peak of 590 deaths on 7 April.⁸ During this time period, we observed a decrease in the frequency of neurotrauma at the early phase after the strict limitation of nonessential activities in the city, compared with the pre-COVID-19 period.

Overall, we noticed a significant increase in males who sustained neurotrauma, with a nonsignificant tendency to be younger in the COVID-19 period. Mechanical fall accounted for the majority of cases in both periods, but the frequency decreased during the COVID-19 crisis. Interestingly, transit-related neurotrauma and traumatic brain injuries (TBIs) related to violence (direct head trauma with an object) increased in frequency in the COVID-19 period, showing a significant difference. Subdural hematomas were the most frequent pathologies in both periods, and surgical management was observed less frequently in the COVID-19 period, but these differences did not reach significance.

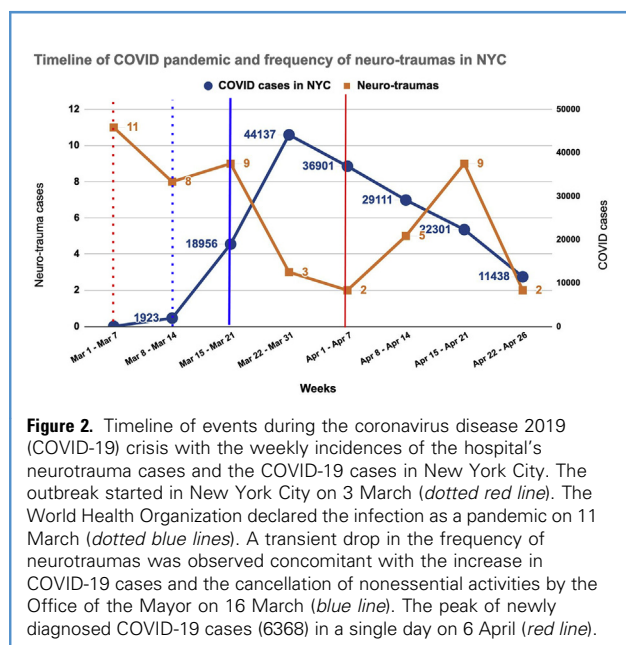


Figure 2. Timeline of events during the coronavirus disease 2019 (COVID-19) crisis with the weekly incidences of the hospital's neurotrauma cases and the COVID-19 cases in New York City. The outbreak started in New York City on 3 March (dotted red line). The World Health Organization declared the infection as a pandemic on 11 March (dotted blue lines). A transient drop in the frequency of neurotraumas was observed concomitant with the increase in COVID-19 cases and the cancellation of nonessential activities by the Office of the Mayor on 16 March (blue line). The peak of newly diagnosed COVID-19 cases (6368) in a single day on 6 April (red line).

In the past, several classic public health strategies have been implemented in a pandemic crisis. These include isolation, quarantine, social distancing, or community containment.¹³ In order to decrease the spread of the virus, social distancing is defined as spacing 6 ft away from individuals. Other related activities include avoiding public transportation, working remotely to decrease the number of possible contacts, and staying home as much as possible.¹⁴ By encouraging all these measures, the expectation is to decrease the community transmission of the disease and ensure separation between healthy and infected people. Ahmed et al¹⁵ found a reduction of 23% of the influenza attack rate and a delay in the peak of the influenza rate with the institution of social distancing strategies. We hypothesized that under these unique circumstances in which social interaction is expected to be limited, the frequency of traumas will decrease accordingly. Overall, the incidence of TBI has been reported to be 579 per 100,000 persons, as well as 40.1 cases per million in case of spinal cord injury in the United States.¹⁶⁻¹⁹ We found that a significant increase of males sustained neurotrauma compared with the pre-COVID-19 era (60.4 vs. 77.6%, $P = 0.037$). As previously reported, males are more likely to incur TBI compared with females, especially between the ages of 10 and 14 years (304.1 cases per 100,000 persons for females and 913.4 per 100,000 for males), but this tendency disappears by the age of 75 (927.2 per 100,000 for females, 940.1 per 100,000 for males).¹⁶ The increased incidence of TBIs in males could be attributed to the increased risk-taking behavior and high-risk activities, most commonly engaged by men.²⁰ In the setting of a pandemic and "lockdown," we can presume that males are more prone to be involved in activities that increase the risk of trauma even while social distancing policies are in place, such as exposure to violence-related/inflicted trauma, MVAs, and falls associated with alcohol use.

We noticed that the frequency of neurotraumas decreased the same week the social distancing and cancellation of nonessential activities were instituted (Figure 2). This trend was observed until the fourth week after the first case was reported and the second week after the Executive Order was implemented. The weekly maximum peak of COVID-19 cases was observed between 22 March and 31 March, 3 weeks after the first case was reported in NYC, and 1 week after the Executive Order started. This progressive increase in the incidence of new COVID-19 cases was observed inversely with the frequency of neurotraumas. The trend may be explained by mandatory restriction of nonessential activities and recommended social distancing policies that require avoidance of people crowding and limitation in public transportation in the city.

Experiences from Italy, one of the most impacted countries, reported a preliminary impression that public "lockdown" during the pandemic has diminished the number of traumatic cases, which eased the number of surgical cases.²¹ Similarly, Christey et al²² reported an overall reduction of 43% of all-injury related admission in New Zealand during a short period of lockdown due to COVID-19.

Fall-related brain injury comprises 61% of all TBIs in the elderly.¹⁶ It is believed that this is due to increases in fall-related arrhythmias and the high intake of medication for chronic diseases.¹⁶ We noticed the same tendency in our cohort, having

Table 1. Comparison Groups Between the Pre–COVID-19 and COVID-19 Periods

	Pre-COVID-19		COVID-19		P Value
Total (n)	101.0		49.0		
Male (n, %)	61.0	60.4	38.0	77.6	0.03751*
Female (n, %)	40.0	39.6	11.0	22.4	
Age (mean, SD)	68.4	17.6	61.7	20.9	0.05636
ISS (median—IQR)	10	8	9	12	
TBI severity (GCS) (median, IQR)	15	1	15	2	
Mild (n, %)	85.0	84.2	37.0	75.5	0.3296
Moderate (n, %)	7.0	6.9	7.0	14.3	
Severe (n, %)	9.0	8.9	5.0	10.2	
Mechanism of trauma (n, %)					
MVA/Transit accident	5.0	5.0	9.0	18.4	0.03405*
Mechanical fall	62.0	61.4	20.0	40.8	
Direct trauma with object/violence	10.0	9.9	6.0	12.2	
Syncope and head trauma	11.0	10.9	4.0	8.2	
Unknown	13.0	12.9	10.0	20.4	
Diagnosis (n, %)					
Subdural hematoma	52.0	51.5	21.0	42.9	0.3676
Epidural hematoma	5.0	5.0	4.0	8.2	
Traumatic subarachnoid hemorrhage	23.0	22.7	16.0	32.7	
Intracerebral contusion	10.0	9.9	6.0	12.2	
Other	11	10.9	2	4	
Intervention (n, %)					
Medical	80.0	79.2	43.0	87.8	0.2013
Surgical	21.0	20.8	6.0	12.2	
Goals of care (n, %)					
DNI/DNR/Palliative care	6	5.9	6	12.2	0.1819

SD, standard deviation; ISS, Injury Severity Score; IQR, interquartile; TBI, Traumatic brain injury; GCS, Glasgow Coma Scale; MVA, Motor vehicle accident; DNI, do not intubate; DNR, do not resuscitate.
* $P \leq 0.05$ was considered statistically significant.

mechanical fall in 54.7% of the cases overall. Once dichotomized, we found that this mechanism was evident in 61.4% of the cases in the pre–COVID-19 period and 40.8% of the neurotrauma cases in the COVID-19 crisis. Although we observed a significant decrease in the frequency of this mechanism compared with the pre–COVID-19 period, it remained the most frequent etiology. This may be explained by the fact that falls can still happen irrespective of the location of the patient and cannot necessarily be modified by the policies about the restriction in mobilization, especially in the elderly.

Following mechanical falls, the reported remaining leading causes of TBI are struck by an object (92.7 per 100.000 persons), MVA (74.7 per 100.000 persons), and those related to assaults

(50.6 per 100.000).¹⁶ We were expecting that the frequency of the aforementioned mechanism may be more common in an environment in which social interaction and personal mobilization are not limited. Interestingly, in our cohort, we noticed a significant increase in MVA/transit-related accidents and those related to violence. This tendency would not be expected during quarantine or lockdown, due to the theoretical restriction of interpersonal relationships and mobilization. Recent reports mentioned an increase in the frequency of traffic-related fatalities during the pandemic, probably related to the decrease in transit that allows drivers to exceed speed limits and the fact that more people choose to walk or bike while there is a limitation in public transportation.^{23–25} On the other hand,

several reports have mentioned the increased risk and vulnerability to suffering domestic violence, specifically associated with the isolation requirements during the pandemic.²⁶⁻²⁸ The possible factors that may lead to domestic violence in these circumstances have been associated with economic stress, exposure to previous exploitative relationships, disaster-related instability, and reduced support.^{27,29}

Medical management accounted for the majority of treatment modalities implemented in both time periods, with a decrease in numbers of surgical cases between the pre-COVID-19 and COVID-19 period, which was not statistically significant. Even though it did not reach statistical significance, it is worthy to note that the tendency to convert neurosurgical patients to a DNI/do not resuscitate (DNR) status increased in the COVID-19 period from 5.9% to 12.2%. DNR decisions are made after a conjoined evaluation between trauma and neurosurgery. If both teams agree that aggressive care is not warranted based on the severity of injury and prognosis, a goal of care discussion is scheduled with the health care proxy or an appropriate surrogate. Palliative care is often but not always involved in these discussions. The role of palliative care was definitely expanded during the COVID-19 crisis. In our institution, the DNR form must be signed by an attending physician (trauma surgeon, intensivist, or neurosurgeon depending on the primary service). The second physician can be a fellow or resident. In the case of a patient without capacity and surrogate, 2 attending physicians must agree that DNR is appropriate and complete the required DNR forms. During this crisis, it was of utmost importance to discuss advance care planning for adult patients. Overall, the reported rate of advance directive completion is <50% in adults who are 60 years old.³⁰ Several factors may influence this decision during the COVID-19 crisis, especially the predicted life expectancy.³⁰ By the moment this report is been written on 30 May, the national death count due to COVID-19 was 83,142 and 16,785 if limited to New York City, with an overall estimate of 134,475 by August.^{8,31,32} Interestingly, just 6.1% of our cohort tested positive and 51% had an unknown status at the time of evaluation. We may infer that the decision to change the status was based on the overall assessment and prognosis of the trauma and not exclusively limited to the COVID-19 status.

This pandemic is affecting almost all levels of care in a health system. The relocation of staff including neurosurgeons and neurointensivists to cover COVID-19 units has been necessary during this crisis to ensure proper coverage to the infected patient population.

Under normal circumstances, neurosurgery responds to and evaluates all trauma codes. The "trauma code" is the hospital's designation for the highest-level activation for a trauma patient who is brought to the emergency department. For lower-level trauma activations (trauma alerts), neurosurgery consults are obtained if there are positive findings on clinical assessment or imaging. In addition, all injured patients with positive computed tomography findings are evaluated by neurosurgery, regardless of activation level. All neurotrauma patients are initially admitted under the trauma service for a minimum of 24 hours. In isolated neurotrauma cases, the patient is then transferred to

neurosurgery no sooner than 24 hours after admission. This allows the trauma team to complete a tertiary survey and safely transition of the patient to care of a single service. Regarding spinal cord injury, the spine call schedule is shared by neurosurgery and orthopedics. There were no changes in the schedule during the COVID crisis, so this shared call does not interfere with the reported results.

We have modified our triaging process and admitting steps. As reported in other institutions worldwide, all transfers within our system and from outside hospitals are being restricted to life-rescue surgical cases and/or impending irreversible neurologic deficits.^{21,33,34} Each consult is evaluated by the on-call attending neurosurgeon. In case a transfer is indicated, the attending then discusses and obtains approval from a designated neurosurgeon that oversees all transfers, admissions, and surgical cases within the entire system. When the patient is not transferred, we provide a direct line to our neurosurgery service. This allows direct communication between services for the further management of the same patient. We are recommending the COVID-19 test for all patients before initiating the transfer. In case the patient was not tested or the result is not yet available, we treat the patient as a person under investigation. The person under investigation policy includes the implementation of contact, droplets, respiratory precautions, isolation of the patient, and the use of proper personal protective equipment, as well as radiographic and clinical screening for COVID-19 infection.

Limitations

One of the biggest limitations that we encountered is the single-center nature of the data, which may limit the generalizability of the results. The relatively small size of the cohort may lead to observational bias. We only explored the results of neurotrauma and not the total number of traumas, which may vary during the installment of social distancing policies. The type of trauma may vary between institutions, with some other hospitals having more inflicted traumas compared with ours due to the location in areas in which violence can be more prevalent. The total number of spine traumas may be underestimated due to the possible overlapping of more severe conditions because we used the primary diagnosis for the analysis. The true incidence of mild cases of neurotraumas may be underestimated because patients may have preferred to stay at home and avoid hospitals due to the fear of getting the infection.³⁵ Also, the system triage policy explained earlier may have prevented mild neurotraumas from being transferred from other institutions.

CONCLUSIONS

A temporary and progressive decrease of neurotraumas was observed during the initial phase and the peak of the COVID-19 crisis. This tendency was observed in conjunction with the implementation of social-distancing policies as the number of total infected patients was rising in New York City. More males sustained neurotraumas in the COVID-19 period. Mechanical falls are still the most frequent causes of neurotrauma in both periods

of time. Interestingly, MVAs and violence-related trauma increased in relative frequency during the lockdown.

CRedit AUTHORSHIP CONTRIBUTION STATEMENT

Jacques Lara-Reyna: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Kurt A. Yaeger:** Investigation, Data curation, Writing - review & editing. **Christina P. Rossitto:** Investigation, Data curation, Writing - review & editing. **Divaldo Camara:** Writing - review &

editing. **Raymond Wedderburn:** Writing - review & editing. **Saadi Ghatan:** Writing - review & editing. **Joshua B. Bederson:** Writing - review & editing. **Konstantinos Margetis:** Methodology, Formal analysis, Data curation, Writing - review & editing, Supervision.

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