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Neuroendovascular Treatment of Acute Stroke During COVID-19: A Guide From the Frontlines

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Keywords:
Coronavirus
COVID-19
Acute stroke
Mechanical thrombectomy
Radiology nurses

A B S T R A C T
Since the initial reports surfaced of a novel coronavirus causing illness and loss of life in Wuhan, China, COVID-19 has rapidly spread across the globe, infecting millions and leaving hundreds and thousands dead. As hospitals cope with the influx of patients with COVID-19, new challenges have arisen as healthcare systems care for patients with COVID-19 while still providing essential emergency care for patients with acute strokes and acute myocardial infarction. Adding to this complex scenario are new reports that patients with COVID-19 are at increased risk of thromboembolic complications including strokes. In this article, we detail our experience caring for acute stroke patients and provide some insight into neurointerventional workflow modifications that have helped us adapt to the COVID-19 era.

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Introduction

The first case of COVID-19 was reported in Wuhan, China, in December 2019 (Huang et al., 2020; Guan et al., 2020). Since that time, the virus has rapidly disseminated throughout the globe and is now in over 180 countries, with millions infected and hundreds and thousands dead. In the United States alone, over 1.3 million people have been infected, and the death toll exceeds 80,000 (CSSW, 2020). Owing to its exponential progression in the United States over the course of 3 months, COVID-19 has dominated the news cycle and caused drastic painful changes in the daily lives of Americans, while also altering the social, economic, and potentially political landscape for the foreseeable future.

Amidst the focus on caring for patients with COVID-19 while also minimizing the spread to health-care workers and the community in general, reports have begun to emerge on the hidden cost or ‘untold toll’ of COVID-19 on other patients who require emergent medical care (Rosenbaum, 2020). For the neurointerventional team, perhaps this is most readily demonstrable in patients with acute strokes from large vessel occlusions (LVOs), a population that shares many features common to patients with COVID-19 that are at risk for deterioration. Many patients with acute stroke from LVOs are older than 60 years and have other comorbidities (Berkhemer et al., 2015). Like sick patients with COVID-19, patients with LVOs under consideration for mechanical thrombectomy may also require field triage by paramedics, ambulance transport, intubation (an aerosolizing procedure), and intensive care unit (ICU) admission. Adding to the complexity of this situation, there are now reports in medical journals and the press about acute strokes occurring in relatively young patients (Oxley et al., April; Cha, 2020).

As before, nurses in radiology continue to participate heavily in the care of acute stroke patients with LVOs (Logue et al., 2018). This

Conflicts of interest: The authors declare that they have no conflicts of interest. Ethics statement: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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https://doi.org/10.1016/j.jradnu.2020.05.007
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is especially evident during the COVID-19 pandemic, a situation that has increased the demands on radiology nurses during neurointervention for stroke patients of unknown status of COVID-19 (so-called patients under investigation [PUI] for COVID-19). The burgeoning demands on radiology nurses in our practice are twofold; first, the number of mechanical thrombectomies for stroke in our practice has increased during the COVID-19 pandemic, and second, our modified institutional thrombectomy protocol for PUI with stroke requires twice the number of nurses and staff to maintain sterility and decrease the risk of transmission. In this article, we detail our experience with mechanical thrombectomy for acute stroke during this time when any patient could potentially be COVID-19 positive.

Methods

Our prospectively maintained institutional mechanical thrombectomy database was retrospectively reviewed to determine the number of patients undergoing thrombectomy before and during the COVID era (February 1, 2020, onward). The COVID status of the

| Table 1 |
| Number of mechanical thrombectomies for acute ischemic stroke in the last 16 months |

| Number of Mechanical Thrombectomies |
|---|
| Jan-19 | Feb-19 | Mar-19 | Apr-19 | May-19 | Jun-19 | Jul-19 | Aug-19 | Sep-19 | Oct-19 | Nov-19 | Dec-19 | Jan-20 | Feb-20 | Mar-20 | Apr-20 |
| 0 | 5 | 10 | 15 | 20 | 25 | 30 |

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| Table 2 |
| Donning and doffing guide for neurointerventional radiology |

| Putting on (Donning) PPE | Removing (Doffing) PPE |
|---|---|
| 1 Remove Jacket, ID, Cell Phone, Watches | 1 Sanitize Gloved Hands |
| 2 Don't use if desired, though they are not required | 2 Remove Booties |
| 3 Perform Hand Hygiene | 3 Sanitize Gloved Hands |
| 4 Don First Pair of Gloves | 4 Remove Outer Gloves (1st Pair of Gloves) |
| 5 Don Face Protection | 5 Sanitize Inner Gloves |
| Surgical mask & eye protection | 6 Remove thyroid shield and disinfect thyroid shield in procedure room |
| N95 mask & eye protection | 7 Clean tech will clean the thyroid shield |
| 6 Don Dos | 8 Remove Gown |
| 7 Don Lead (Make sure thyroid shield is separated from body shield) | 9 Remove Gown and Perform Hand Hygiene |
| Don PAPR: Clip Battery to lead, plug PAPR cord into battery, confirm air flow and lights, Don PAP and adjust ratchet for snug fit | 10 Exit Patient Room |
| Don Bouffant | 11 Perform Hand Hygiene and Don Clean Gloves |
| Don Gown | 12 Remove Eye Protection and Disinfect. Place eye wear on top of peroxide wipe on counter. |
| Don 2nd Pair of Gloves | 13 If wearing PAPR, remove and disinfect |
| 14 Remove Bouffant | 15 Remove Gloves and Wash Hands |
patients was also recorded. In addition, our modified protocols for resource utilization and management of stroke patients with LVOs were also reviewed and clarified.

Results

Our highest number of monthly thrombectomies on record in the last 15 months occurred in April 2020, at 24 thrombectomies for that month (see Table 1). The mean number of monthly thrombectomies in the 15 months before April 2020 was 11.1, with a standard deviation of 2.9. This results in a Z score of 4.4, where Z equals the [(observed number of thrombectomies in April 2020) − (mean score of the thrombectomies in the prior 15 months)]/standard deviation. A Z score of 4.4 corresponds to a p value less than 0.00001, which is statistically significant (p < .05 considered statistically significant). The statistically significant increase in

Figure 1. A 58-year-old man presenting with right-sided face, arm, and leg weakness and unknown status of COVID-19. CTA showed occlusion of the proximal and mid-basilar artery (not shown). He was taken emergently for mechanical thrombectomy, and the initial frontal angiographic image of the basilar artery from a left vertebral artery injection showed occlusion of the proximal and mid-basilar artery just above the right posterior inferior cerebellar artery (the arrow in first image). After two passes with direct aspiration thrombectomy of the basilar artery, there was recanalization of the artery (the arrow in second image). The patient’s COVID-19 test later came back negative. CTA, computed tomography angiography.

Figure 2. A 73-year-old woman with atrial fibrillation and hypertension presented to an outside hospital with acute-onset left face, arm, and leg weakness. She was COVID-19 positive before transfer to our hospital system for mechanical thrombectomy, and appropriate precautions were taken. The first image is a frontal view of a right common carotid angiogram in the late arterial phase just before thrombectomy, showing occlusion of the right M1 segment (arrow), with hypoperfusion of the right MCA territory (star). The second image is a frontal view of a right common carotid angiogram in the early arterial phase just after thrombectomy, showing recanalization of the right M1 segment (arrow), with reperfusion of the right MCA territory (arrowhead). MCA = middle cerebral artery.
Diffusion-weighted images (arrows).

showed acute infarcts in the left frontoparietal lobe and right occipital lobe on the positive. Brain MRI performed for the left upper extremity weakness and confusion.

Discussion

thrombectomies during the month of April also coincided with our hospital system COVID-19 peak. Four of 24 (16%) patients were identified to be COVID-19 positive by PCR at the time of thrombectomy.

In-Hospital Preintervention Phase

On arrival to the hospital, the patient is taken straight to the CT scanner where a formal National Institute of Health Stroke Scale, a marker of stroke severity, is performed by the neurology resident in personal protective equipment (PPE), and a noncontrast CT of the head is obtained. If the results of the noncontrast CT of the head do not show any intracranial hemorrhage or large infarct/hypodensity, intravenous tissue plasminogen activator is administered and a computed tomography angiography (CTA) of the head and neck as well as a CT perfusion of the head is obtained. The neuroradiologist on call is alerted to give a preliminary review of the study, while the patient waits in the CT scanner. If the scan is positive for a LVO (i.e. if the case is a ‘go’), then the neurointerventional team including nursing and anesthesia is alerted to prepare for the patient’s arrival to the angiography suite. In the meantime, if the patient has significant pulmonary symptoms by history or during the initial triage, a CTA of the chest can be considered to minimize future trips to the CT scanner (note that the current national guidelines only support chest CT in patients with severe respiratory symptoms).

Intervention Phase

Once an LVO is documented on imaging, a biplane angiography suite dedicated to the care of patients with COVID-19 is readied for patient arrival and rapid mechanical thrombectomy. Given the unknown status of COVID-19 of the patient, every attempt is made to minimize the number of staff in the room during intubation, and also during the actual procedure. Only the anesthesiology staff, gowned and gloved with N95 masks, is allowed to be in the room during intubation. A separate ‘clean’ team of nurses and technologists are present outside the room for the duration of the case to help with donning and doffing of PPE and to obtain items that may not be available in the angiography room during the case. During intubation, a nasopharyngeal or tracheal swab is obtained for PCR testing and sent to the laboratory for processing before starting the case. The COVID-19 test at our institution takes approximately 45 minutes and is usually reported less than 2 hours after receipt in the laboratory. Sending a COVID-19 test at the start of the case allows for effective patient triage after mechanical thrombectomy, as the results are usually available by the end of the procedure. At our institution, a negative COVID-19 test by PCR in a patient without respiratory symptoms, or known exposure to COVID-19—positive

Prehospital Evaluation

All patients with strokes undergoing evaluation for transfer and treatment at our facility are considered potentially COVID-19 positive by the emergency management services (EMS) staff (Figures 3 and 4), and at a minimum, N95 masks, gloves, and eye protection should be worn by the paramedics evaluating these patients (Jalili, 2020). A mask is placed on the patient as tolerated. If the patient has severe respiratory distress and is unable to tolerate a face mask, or is otherwise unable to protect their airway because of an altered mental state, strong consideration should be given to intubating the patient in the field. An abbreviated stroke scale is performed by the EMS, supplemented by telestroke evaluation from a neurologist or other qualified physicians as soon as possible. The neurointerventional team including the nurses, technologists, and attending physician is alerted early for a potential thrombectomy transfer (usually via the neurointerventional fellow). A computed tomography (CT) scanner dedicated to scanning patients with COVID-19 is cleared about 20 minutes before the arrival of the patient, so hallways and the scanning area can be free of patients and other staff to minimize transmission of COVID-19.

Figure 3. A 44-year-old man with diabetes, hypertension, and hyperlipidemia presented with shortness of breath, malaise, progressive altered mental status, and mild left upper extremity weakness. Frontal view chest radiograph showed bilateral airspace opacities consistent with pneumonia (arrows in first image). He was COVID-19 positive. Brain MRI performed for the left upper extremity weakness and confusion showed acute infarcts in the left frontoparietal lobe and right occipital lobe on the diffusion-weighted images (arrows).

Our study shows a definite increase in mechanical thrombectomies at our institution in April, coinciding with the peak phase of the admission of patients with COVID-19 in our hospital system. It remains to be seen whether this increase in the number of acute stroke patients with LVOs requiring mechanical thrombectomy will be sustained, but the effects are the same with respect to time and effort on the part of nursing and the rest of the neurointerventional team. Almost all of the patients undergoing mechanical thrombectomy during the month of April at our institution were of unknown status of COVID-19 at the time of intervention, requiring significant modifications to our usual workflow to accommodate the necessities of infection control (Figures 1 and 2). After multiple cycles of caring for patients with unknown status of COVID-19 undergoing mechanical thrombectomy, we present our workflow in the following paragraphs, with the hope that others may adopt any features that may be helpful for their own institutions and established workflows.
contacts, is treated as a true negative. Therefore, this rapid reporting system allows for quick turnaround of the room after the procedure and for patient room assignment. Using a portable ventilator at the start of the case during intubation minimizes aerosolization during patient transport at the end of the case by obviating the need to disconnect and reconnect the patient from one ventilator to another.

After intubation, the radiology nurse enters the room, also in PPE, to place the Foley catheter, assists with the placement of the arterial line, and sets up the vial sign monitors, placing any additional IVs and obtaining activated clotting times. The neurointerventionalists then enter the room in sterile gowns and PPE, and the case proceeds as usual.

Postintervention Phase

After mechanical thrombectomy, the neurointerventionalists start the doffing process in the room and remove the rest of their equipment outside the room (see Table 2). The patient is transferred to the stretcher and usually remains intubated for transfer to the neuro ICU. If the thrombectomy case was uncomplicated (no suspicion for intracranial hemorrhage, no more than one pass with a retrievable stent performed, or use of aspiration only for thrombectomy), then a postprocedural head CT can be omitted to avoid exposure to the CT staff. A portable CT of the head can be obtained in the neuro ICU instead or as soon as the COVID status is known to be negative. Once the patient leaves the room, the rest of the staff in the room undergo the doffing process, and the room is cleaned with disinfectant and ultraviolet light (ultraviolet germicidal irradiation is used to disinfect the air and exposed surfaces of procedure rooms [Reed, 2010]). The room then cannot be used for 1 hour after a case involving a COVID-19–positive patient. If the COVID status comes back negative before the end of the thrombectomy procedure, then the stringent COVID protocol does not need to be followed (a negative COVID-19 test result during a thrombectomy case is heralded by much relief among the staff, a testament to the added stress that this necessary protocol entails). After mechanical thrombectomy, a patient with a positive COVID-19 test is assigned to a room on a dedicated COVID-19 ICU after mechanical thrombectomy and is transferred to a COVID-19 floor when ICU care is no longer required. A patient with a negative COVID-19 test can be assigned to the neuro ICU and a regular floor after ICU care. A patient whose COVID-19 test comes back positive during thrombectomy (or whose test is still pending after thrombectomy) requires a more time- and personnel-intensive transport protocol; the transport team including nurses and respiratory therapists in full PPE picks up the patient while the procedure team ‘doffs’ their PPE, and then a new team in the COVID-19 unit in full PPE receives the patient while the transport team ‘doffs.’ This handoff process is much simplified and quicker for a patient whose COVID-19 test comes back negative.

Conclusions

Our single-institution experience shows that acute stroke patients with LVOs are at least as high and likely higher than during the pre-COVID era, with increasing demands on nursing and the rest of the neurointerventional staff to adequately care for these patients while minimizing exposure to themselves and others. The guide presented in this article may be helpful for other institutions that have to care for patients with stroke and COVID-19 in the background of limited or even scarce resources. In tandem with providing consistent high-quality care to our stroke patients during the COVID-19 pandemic, efforts to raise awareness of acute stroke must continue (Figure 5), as some patients are afraid to seek care for fear of becoming infected with COVID-19 (Rosenbaum, 2020).

Acknowledgments

The authors would like to thank Eric James Schmitt, MD, for his help with the statistical analysis of the data.

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