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In December 2019, coronavirus disease 2019 (COVID-19), an infectious disease caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) caused an international outbreak. The World Health Organization designated this as a global pandemic on March 11, 2020, with over 200 countries affected worldwide. As of April 24, 2020, there were 2790986 patients with confirmed COVID-19 and 195775 deaths worldwide, with the United States, Spain, Italy, France, Germany, United Kingdom, Turkey, and Iran surpassing China in the number of confirmed cases. In a consecutive series of 221 patients with confirmed COVID-19 admitted to a hospital in Wuhan, China, acute ischemic stroke occurred in 11 (5%) of patients with a broad range of stroke subtypes. These patients with stroke were older, more likely to have cardiovascular risk factors, presenting with severe COVID-19 with multiple organ involvement. Of note, presence of COVID-19 in these patients does not imply that COVID-19 was the mechanism leading to the patient’s stroke.

Shortages of Personal Protective Equipment (PPE) such as N95 masks, facial shields, hand sanitizer, and cleansing wipes have presented a major challenge in the allocation of resources, as healthcare workers are frontline in the treatment of these patients. Redeployment of clinical staff, nursing, stroke and neurocritical care specialists to care for patients with COVID-19 may create staffing shortages for dedicated stroke care.

In an effort to mitigate the spread of COVID-19 to neuroscience healthcare workers, their patients, and their families, and to optimize allocation of healthcare resources, we present a modified algorithm to acute ischemic large vessel occlusion stroke workflow in the era of the COVID-19 pandemic. This guidance statement is based on shared best practices, consensus among academic and nonacademic practicing vascular and interventional neurologists, literature review, and would be adapted to the available resources of a local institution. The patients with acute stroke are a vulnerable group to address because these patients often come emergently from the community with little information. Radical changes are felt to be necessary to optimize the safety of the providing team and our patients, limit unnecessary tests, conserve PPE resources and mechanical ventilator usage. This document divides into the following: prehospital phase to the Emergency Department (ED), prethrombectomy procedure, thrombectomy intraprocedure, and postreperfusion therapy phases (Table).

**Mechanical Thrombectomy in the Era of the COVID-19 Pandemic: Emergency Preparedness for Neuroscience Teams**

A Guidance Statement From the Society of Vascular and Interventional Neurology

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**Special Report**
Table. Guidance Summary for Large Vessel Occlusion Stroke in the Era of COVID-19

<table>
<thead>
<tr>
<th>Prehospital care</th>
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<tbody>
<tr>
<td>Every patient with acute stroke (direct presenting to ED or in transfer) should be triaged for symptoms and signs of COVID-19, including potential contact.</td>
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<tr>
<td>If there is a positive screen, this patient should wear a surgical mask and be placed in isolation in a negative pressure room. If telecommunication (phone + video) is available, it should be utilized. Identify the minimum number of providers needed to care for the patient and wear PPE for any patient contact.</td>
</tr>
<tr>
<td>If there is a positive pulmonary symptom, consider noncontrast chest CT at the same time as head and neck CT/CTA, provided this addition does not occur &gt;5 min delay. Note, if a patient is received in transfer from another hospital or has already returned from radiology, chest CT should not be performed before reperfusion therapies such as intravenous thrombolysis or thrombectomy.*</td>
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<tr>
<td>A direct to angiography suite approach should be considered for stable patients with stroke symptoms onset within 24 h, who are transferred from other hospitals with time from last neuroradiography within 2 h and ASPECTS ≥7.</td>
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<tr>
<th>Consent and health care proxy</th>
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<tr>
<td>If the patient is not consentable, the legally authorized representative (LAR) should consent for the patient. Two physician emergency consent should be obtained if the LAR is not available.</td>
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<tr>
<td>If the patient is consentable, perform verbal procedural consent with witness. Include consent for general anesthia.</td>
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<tr>
<td>If the patient is consentable, perform verbal healthcare proxy consent with a witness.</td>
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<tr>
<th>Airway preparation</th>
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<tr>
<td>The anesthesiologist should be alerted early of a patient with COVID-19 or suspect patient.</td>
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<tr>
<td>Consider conscious sedation as first line if the patient is stable.</td>
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<tr>
<td>Discus whether there should be dedicated COVID-19 glidescope ready in the angiography suite in case the patient deteriorates.</td>
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<tr>
<td>In a patient who is considered at risk for airway deterioration (ie, orthopnea, tachypnea, or respiratory distress lying flat, high oxygen requirement), inability to protect airway, active vomiting, agitation, or uncooperative, then early and controlled intubation is preferred.</td>
</tr>
<tr>
<td>Discuss with primary team on additional blood tests the proceduralist can (e.g., ABGs, CBC, Chem7, LFTs, BNP, CRP in young patients, Procalcitonin, cholesterol panel, HbA1c, etc) perform by one provider and minimized to conserve PPE.</td>
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<tr>
<td>Review in advance whether anesthesia presence is required in the room or as needed for intubation or hemodynamic issues.</td>
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<th>Thrombectomy room preparation before patient arrival</th>
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<tbody>
<tr>
<td>Remove all unnecessary objects or items in the angiography suite to minimize need for periop team for cleaning post procedure (ie, lead aprons that will not be utilized).</td>
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<tr>
<td>Cover countertop items with plastic or remove them.</td>
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<tr>
<td>Prepare all procedural elements in the room before patient arrival (ie, medications, devices, cover detector, pedals with plastic, bags, etc) to minimize time of the patient in the room, protect room equipment, and prevent breaking scrub.</td>
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(Continued)
Prehospital and ED Care of Acute Large Vessel Occlusion
Adhering to existing local protocols, all patients (including stroke) presenting to the ED or as interhospital transfers, are screened for signs and symptoms of COVID-19. Any patient who is COVID-19 positive or screen positive should be managed under local protocols to ensure both patient and staff safety. Use of remote telestroke technology should be considered to obtain history and perform neurological examination, if available. During a Code Stroke, coordination between team members with predefined assigned roles (ie, one team member in PPE with patient, another member talks to family over telephone, looks at images, laboratories, and orders thrombolysis in PPE with patient, another member talks to family over telephone, looks at images, laboratories, and orders thrombolysis or medications) will help reduce staff exposure while maintaining quality care.

If there is positive screening for COVID-19, this patient should wear a surgical mask and immediately be placed in a negative pressure room in the ED if one is available. A test for COVID-19 should be considered if the patient meets local criteria for investigation. If a patient or their family is unable to provide corroborative history, then a surgical mask should be worn at risk for airway deterioration (ie, orthopnea, tachypnea, or respiratory distress lying flat, high oxygen requirement), unable to protect their airway, agitation, uncooperative, or actively vomiting, then early and controlled intubation is preferred. An aerosol box can be used as a cover as an additional measure of PPE protection during intubation. High-flow oxygen, bag-valve mask, and noninvasive positive pressure ventilation are not recommended due to the concern for aerosolization of virus. Rapid sequence intubation may be the preferred course.

Airway Preparation

The anesthesiologist should be alerted early of a COVID-19 or suspect patient. Local policies for intubation and general anesthesia versus conscious sedation differ at different centers. If appropriate, consider conscious sedation as first-line to protect anesthesiologists from exposure and to protect our patients from unnecessary intubation as well as conserving mechanical ventilator resources. Converting a patient from conscious sedation to general anesthesia in the middle of the procedure in the angiography suite should be avoided due to high risk of aerosolization in a positive pressure room. In a patient who is considered at risk for airway deterioration (ie, orthopnea, tachypnea, or respiratory distress lying flat, high oxygen requirement), unable to protect their airway, agitation, uncooperative, or actively vomiting, then early and controlled intubation is preferred. An aerosol box can be used as a cover as an additional measure of PPE protection during intubation. High-flow oxygen, bag-valve mask, and noninvasive positive pressure ventilation are not recommended due to the concern for aerosolization of virus.

There should be a discussion regarding where the patient gets intubated if it is seen necessary (ie, in a negative pressure room in the ED, operating theater, ICU versus angiography suite). If no negative pressure room is immediately available, the treatment plans should continue forward. Any breach in the ventilator tubing should be avoided, which can be a source for aerosolization and exposure to health care workers.
If the decision is for conscious sedation, consideration for a dedicated COVID-19 glidescope or video laryngoscopy can be prepared in the angiography suite in case the patient deteriorates. Advance discussion on whether the anesthesiologist is required in the angiography suite during the case should be reviewed or as needed for intubation or hemodynamic support. If the patient requires intubation in the angiography suite, all nonessential persons should leave the room. Following intubation, any person entering the room should be in full PPE because of concern for residual aerosolization of virus post intubation.

**Procedural Consent and Health Care Proxy**

If the patient is unable to consent, a legally authorized representative should consent for the patient. If no contact can be reached, 2-physician emergency consent may be obtained or the proper documentation for the treatment risks and benefits and the failed attempts to contact family can be made in the medical record as per local institutional protocols. If the patient is consentable, it is preferable to have a patient verbally authorize staff to sign the consent form for them. Inanimate objects such as pens and tablets can become a vehicle of spread for COVID-19. This may be considered appropriate in the setting of the COVID-19 pandemic; however, local standards should be adhered to. The staff assistant would sign the patient’s name and document themselves as witness in the presence of the patient. If the patient declines directed signature, they should be provided a new pen and sign the form.

At the same time, as the procedural consent, consent for general anesthesia should be obtained. In a consentable patient, designation of a healthcare proxy consent should be conducted with a staff witness in the event the patient loses the ability to provide informed consent. This step may be important because rehabilitation or long-term care facilities may require this document to accept a candidate patient.

**Preprocedure Room Preparation**

The charge nurse and technologist should be alerted as soon as there is a suspected or patient with confirmed COVID-19 patient and room preparation dependent on the institution. If there are multiple angiography rooms available, a COVID-19 room can be designated. The procedure room should be cleared of any unnecessary items (ie, lead aprons that will not be utilized) to minimize the need of perioperative staff cleaning post-procedure. Countertop items should be covered with plastic or removed. The detectors on the angiography suite, foot pedal, and lead shields should be covered in plastic or an equivalent. The hanging lead shields and the detectors on the angiography suite, foot pedal, and lead shields should be covered with plastic or removed. The detectors on the angiography suite should be taped with a sign to prevent people from entering inadvertently without protective gear. Most angiography suites are positive pressure rooms. Opening any doors to the angiography suite should be minimized once the patient is in the room to prevent movement of the virus to adjacent spaces.

In the control room, consider limiting the number of people to maintain a 6-foot distance between team members. These persons should wear a mask if the door between the angio suite and control room is opened because the angiography suite is likely to be a positive pressure room and can contaminate the adjacent rooms.

Negative or even fluid balance should be maintained given the risk for pulmonary edema in patients with COVID-19. Heparinized bag flushes should be monitored closely to ensure inadvertent excess fluid administration. Blood loss should be minimized given concurrent national shortages of blood.

After the procedure is completed, discuss with the admitting team and draw blood tests from the sheath that may be necessary for COVID-19 and stroke workup if not already done (ie, arterial blood gas, complete blood count, Chem 7, creatinine, and hypercoagulable panel in younger patients, B-type natriuretic peptide, troponin, hemoglobin A1c, cholesterol panel, etc) to limit the need for additional blood draws and exposures.

Cone-beam head CT (Xper or Dyna) should be considered while the patient is on the angiography suite table post-procedure to obviate the need for travel to CT, with the caveat of limited quality.

Ensure any trash is completely inside the trash bag. If the room is big enough, place red tape on the floor of the angio suite 6 feet from the patient’s bed. This would be the area outside of which a provider would doff their gown. Again, an observer to watch team members doff off their gown and gear can be helpful to identify potential contamination or technique mistakes, if available.

**Neurological, Vital Signs, and/or Access Site Checks Postreperfusion Therapy**

Nonintubated, stable patients can be moved to a step-down unit with appropriate nursing expertise in the setting of...
a shortage or anticipated shortage of critical care beds. Repatriation or transfer of a patient post-thrombectomy from a comprehensive stroke center to a primary stroke center with appropriate physician and nursing expertise can be considered in the setting of hospitals overwhelmed by a shortage of ventilators or critical care beds while maintaining thrombectomy access. Communication between transferring and receiving teams, advance notification to patient families of repatriation is important to maintain optimal patient care.

Postprocedure or postthrombolytic neurological exam and/or access site checks should be combined and performed by one person and the frequency minimized to conserve PPE. When the patient is handed off to the receiving team, have the provider check the neurological exam, vitals, and/or access site before doffing their gown. This can qualify as the 15- or 30-minute check post-procedure or post thrombolytic, depending on the time that has elapsed.

Video can be utilized as a continuing monitor of the patient’s neurological exam and/or access site. Otherwise, consider another combined exam, vital sign, and/or access site check 15 or 30 minutes after hand-off, and then every hour x 2. Thereafter, if the patient has remained stable, the intervals for the combined checks can be spread to q4h. The frequency of checks should be adjusted depending on the patient’s status (less if they are intubated and sedated), hemodynamic stability, perceived risk of hemorrhagic transformation, and concern for bleeding at the access site.

Post-Procedure
There should be a minimum 30 minutes delay before perioperative cleaning staff cleans the angiography suite to allow the room to air out.

In-room providers should wash their hands, sanitize, and change out their scrubs or follow local protocol. Telephone communication with the patient’s family should then be pursued as with any reperfusion therapy or procedure, but even more so with the COVID-19 pandemic and restriction of family/visitors.

Intubated patients should be extubated in a negative pressure room.

A definitive diagnosis of COVID-19 should be made as soon as possible as patients who rule out will decrease the use of protective equipment. Any tests that do not change management should be delayed or deferred (to protect staff, virus trafficking, and conserve protective gear).

Imaging of COVID-19 or suspected patients should be limited to imaging that will impact management.

When rounding, the usual sequence is by acuity of patient illness or geographic convenience. In the era of the COVID-19 pandemic, assuming that all patients are equally stable, patients on contact or droplet precaution should be rounded on at the end of rounds to avoid unintentional viral spread to patients not on precautions as clinical circumstances allow.

If a provider develops any symptoms of cough, fever, or shortness of breath, they should seek testing and potential quarantine based on local protocols.

Psychosocial Intervention
When appropriate, an evaluation of a patient’s mental health is important to alleviate the psychosocial impact of the COVID-19 epidemic for a patient in isolation with a new or recurrent diagnosis of stroke.

It is helpful to debrief with the team to learn, improve best practices and workflow. Healthcare workers, particularly nurses and frontline healthcare workers directly engaged in the care of patients with COVID-19 are vulnerable to the psychological burden of depression, anxiety, insomnia, and distress.

Postacute Care
In preparation for the patient’s postacute care, testing for COVID-19 may be required for a patient being discharged to a postacute care facility, regardless of whether the patient was being treated for COVID-19 at the hospital. Patients who are asymptomatic or with minor signs of infection have been shown capable of shedding potentially infectious virus. Long- or short-term care facilities are vulnerable to respiratory disease outbreaks, including the spread of COVID-19. Early coordinated communication between the primary team, case management, and postacute care facilities is important to reduce bottlenecks in patient transitions once the patient is medically ready.

Conclusions
We live in uncharted times amidst the COVID-19 pandemic. The word crisis in Chinese is composed of 2 characters, one representing danger, the other opportunity. We cannot see this dangerous enemy, the coronavirus. Every opportunity and detail to recalibrate our acute neurological workflow to protect our frontline healthcare workers, our families, our colleagues, and our patients should be sought, implemented, and adapted to a resource-constrained environment. It is incumbent upon us to protect each other so that we are not unknowingly exposed or spread to our most vulnerable patients, while at the same time, providing optimal care, patient safety, and access for our patients with stroke. Optimizing protection of the healthcare worker should not compromise emergency stroke patient care. This guidance statement pertains to current practice and can change as new evidence arises.

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Disclosures
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Mismatch in the Triage of Wake Up and Late Presenting Strokes Undergoing Neurointervention) and AURORA (Analysis of Pooled Data From Randomized Studies of Thrombectomy More Than 6 Hours After Last Known Well) trials (Stryker Neurovascular). Dr Nogueira disclosures are Stryker Neurovascular (DAWN Trial Principal Investigator—no compensation, TREVO [Trevo Registry Post Marketing Surveillance] Registry Steering Committee—no compensation; significant consultant); Cerenevus/ Neuravi (ENDOLEV Trial Principal Investigator—no compensation, EXCELLENT [Embocath Extraction & Clot Evaluation & Lesion Evaluation for Neurothrombectomy] Registry Principal Investigator—no compensation, ARISE-2 trial [Analysis of Revascularization in Ischemic Stroke With EmboTrap] Steering Committee—no compensation, Physician Advisory Board, modest); Phenox (PROST Trial [Preset for Occlusive Stroke Treatment] Principal Investigator, Physician Advisory Board, modest); Anaconda (Physician Advisory Board, modest); Genentech (physician advisory board, modest); Biogen (CHARM Trial [BIH093 (glioblastomide) for Severe Cerebral Edema Following Large Hemispheric Infarction] Steering Committee; physician advisory board, modest); Prolong Pharmaceuticals (physician advisory board, modest); Brainomix (physician advisory board, stock options); Viz-AI (physician advisory board, stock options); Corindus Vascular Robotics (physician advisory board, stock options); Viz-AI (physician advisory board, stock options); Ceretrieve (physician advisory board, stock options); Cerebrotech (physician advisory board, stock options); Astrocyte (physician advisory board, stock options); Diogo Haassen is consultant for Stryker, Vasalio and Cerenevus; has stock options with VizAi. A.E. Hassan is consultant and speaker for Medtronic, Stryker, Microvention, Penumbra, Balt, Viz Ai, Scientia, Genentec, and GE Healthcare; received personal fees with Cerenevus outside of submitted work. Dr Ortega-Gutierrez is consultant for Medtronic and Stryker Neurovascular. Dr Hsiang-Yi Chou receives research support from the National Institutes of Health 1 R21 NS113037-01. Dr Janardhan reports grants from National Science Foundation (Principal Investigator), other from Insera Therapeutics, Inc (Board Member); other from the Society of Vascular and Interventional Neurology outside submitted work; has notice of allowances or awarded >65 patents in the United States and worldwide and over 20 patents pending in the United States and worldwide to the broader field but not part of this article. Dr Yavagal reports personal fees from Medtronic, personal fees from Cerenevus, other from Rapid Medical, personal fees from Vascular Dynamics, other from Poseydon, other from Neuroave, and other from Neuroanalytics outside the submitted work. Dr Liebeskind is consultant to Cerenevus, Genentech, Stryker, Medtronic as Imaging Core Lab.

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