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Authors

Leira, Enrique
Russman, Andrew
Biller, José
et al.

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Preserving stroke care during the COVID-19 pandemic

Potential issues and solutions

Enrique C. Leira, MD, MS, Andrew N. Russman, DO, José Biller, MD, Devin L. Brown, MD, Cheryl D. Bushnell, MD, Valeria Caso, MD, PhD, Angel Chamorro, MD, PhD, Claire J. Creutzfeldt, MD, Salvador Cruz-Flores, MD, MPH, Mitchell S.V. Elkind, MD, MS, Pierre Fayad, MD, Michael T. Froehler, MD, PhD, Larry B. Goldstein, MD, Nicole R. Gonzales, MD, Brian Kaskie, PhD, Pooja Khatri, MD, MSc, Sarah Livesay, DNP, ARNP, David S. Liebeskind, MD, Jennifer J. Majersik, MD, Asma M. Moheet, MD, MHDS, Jose G. Romano, MD, Nerses Sanossian, MD, Lauren H. Sansing, MD, MS, Brian Silver, MD, Alexis N. Simpkins, MD, PhD, MS, Wade Smith, MD, PhD, David L. Tirschwell, MD, MSc, David Z. Wang, DO, Dileep R. Yavagal, MD, and Bradford B. Worrall, MD, MSc

Correspondence
Dr. Leira
enrique-leira@uiowa.edu

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Abstract

The coronavirus 2019 (COVID-19) pandemic requires drastic changes in allocation of resources, which can affect the delivery of stroke care, and many providers are seeking guidance. As caregivers, we are guided by 3 distinct principles that will occasionally conflict during the pandemic: (1) we must ensure the best care for those stricken with COVID-19, (2) we must provide excellent care and advocacy for patients with cerebrovascular disease and their families, and (3) we must advocate for the safety of health care personnel managing patients with stroke, with particular attention to those most vulnerable, including trainees. This descriptive review by a diverse group of experts in stroke care aims to provide advice by specifically addressing the potential impact of this pandemic on (1) the quality of the stroke care delivered, (2) ethical considerations in stroke care, (3) safety and logistic issues for providers of patients with stroke, and (4) stroke research. Our recommendations on these issues represent our best opinions given the available information, but are subject to revision as the situation related to the COVID-19 pandemic continues to evolve. We expect that ongoing emergent research will offer additional insights that will provide evidence that could prompt the modification or removal of some of these recommendations.

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From the Departments of Neurology, Neurosurgery & Epidemiology (E.C.L.), University of Iowa, Iowa City, IA; Cerebrovascular Center (A.N.R.), Cleveland Clinic, OH; Department of Neurology (J.B.), Loyola University Chicago, Maywood, IL; Department of Neurology (D.L.B.), University of Michigan, Ann Arbor, MI; Department of Neurology (C.D.B.), Wake Forest School of Medicine, Winston-Salem, NC; Stroke Unit (V.C.), University of Perugia, Italy; Department of Neurology (A.C.), Hospital Clinic, Barcelona, Spain; Department of Neurology (C.J.C., D.L.T.), University of Washington, Seattle, WA; Department of Neurology (S.C.-F.), Texas Tech University, El Paso, TX; Departments of Neurology & Epidemiology (M.S.V.E.), Columbia University, New York, NY; Department of Neurological Sciences (P.F.), University of Nebraska, Omaha, NE; Department of Neurology & Neurosurgery (M.T.F.), Vanderbilt University, Nashville, TN; Department of Neurology (L.B.G.), University of Kentucky, Lexington, KY; Department of Neurology (N.R.G.), McGovern Medical School at UTHealth, Houston, TX; Department of Health Management and Policy (B.K.), University of Iowa, Iowa City, IA; Department of Neurology (P.K.), University of Cincinnati, OH; Department of Adult Health & Gerontology Nursing (S.L.), Rush University, Chicago, IL; Department of Neurology (D.S.L.), UCLA; Department of Neurology (J.J.M.), University of Utah, Salt Lake City, UT; Neurocritical Care, OhioHealth Riverside Methodist Hospital (A.M.M.), Columbus, OH; Department of Neurology (J.G.R.), University of Miami, FL; Department of Neurology (N.S.), University Southern California, Los Angeles, CA; Department of Neurology (L.H.S.), Yale School of Medicine, New Haven, CT; Department of Neurology (B.S.), University of Massachusetts, Worcester, MA; Department of Neurology (A.N.S.), University of Florida, Gainesville, FL; Department of Neurology (W.S.), UCSF; Department of Neurology (D.Z.W.), Barrow Neurological Institute, Phoenix, AZ; Department of Neurology & Neurosurgery (D.R.Y.), University of Miami, FL; and Department of Neurology (B.B.W.), University of Virginia, Charlottesville, VA.

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Glossary

COVID-19 = coronavirus 2019; **GETA** = general endotracheal anesthesia; **ICU** = intensive care unit; **PPE** = personal protective equipment.

The novel coronavirus disease 2019 (COVID-19) pandemic,[1] with reported cases in >200 countries, represents a major crisis challenging all aspects of the health care systems around the world.[2,3] The management of this emergency is now an international priority,[1] which requires drastic changes in allocation of resources. This can affect the delivery of care for other health conditions, including stroke.[4] Many health care providers are now seeking guidance related to the provision of stroke care in this unprecedented setting. This statement, which was developed by a diverse group of stroke experts, aims to address this need. Our recommendations represent our best opinions given the available information, but are subject to revision as the situation related to the COVID-19 pandemic continues to evolve. It is intended to supplement the recent statement and recommendations from the American Heart Association.[5,6] We expect that ongoing emergent research will offer additional insights that will provide evidence that could prompt the modification or removal of some of these recommendations and subsequent revisions of this statement.[5] There is no previous model to guide our approach to the ferocious COVID-19 pandemic, which has brought the world to a standstill. Still, we hope that these recommendations prove useful to the neurologic community in this time of considerable uncertainty.

General principles

As health care delivery providers, members of the public health community, and vascular neurologists, neurointensivists, and interventional neurologists, we are guided by 3 distinct principles that will occasionally conflict during the pandemic as crisis standards of care are adopted[7]: (1) we must ensure the best care for those stricken with COVID-19, (2) we must provide excellent care and advocacy for patients with cerebrovascular disease and their families, and (3) we must advocate for the safety of health care personnel managing patients with stroke, with particular attention to those most vulnerable, including trainees in all specialties.

As hospitals fill with patients infected with COVID-19, hospital beds, personnel, and other resources are being allocated to those with the infection. In addition, clinical providers may be redeployed to other areas. Outpatient services and diagnostic testing may be limited or shifted to telehealth options due to risk of disease transmission. Bed availability may be constrained. All of this could result in reduced capacity for non–COVID-19 patients, potentially limiting the ability to transfer patients for acute stroke interventions and expert management to tertiary health facilities. Such resource redistribution is necessary to address the current health care crisis and to care for the increasing number of critically ill patients with COVID-19. Nonetheless, we must find ways to provide the best care possible to patients with stroke and their families and advocate for their best interests, at a time when social distancing limits social support in most settings. As a common and frequently devastating health event, stroke cannot be ignored during the pandemic, especially with the availability of highly effective treatments.[8,9] Furthermore, we must equip our providers with adequate personal protective equipment (PPE) to reduce their chances of contracting COVID-19 and potentiating its spread.[6,10] Maintaining a healthy workforce is essential to provide uncompromised care to our patients, and we must assure that staff, medical trainees, and colleagues have the tools they need to protect themselves as they care for patients with stroke, and we should maximize the use of remote learning technologies so as not to expose our students to unnecessary risk.

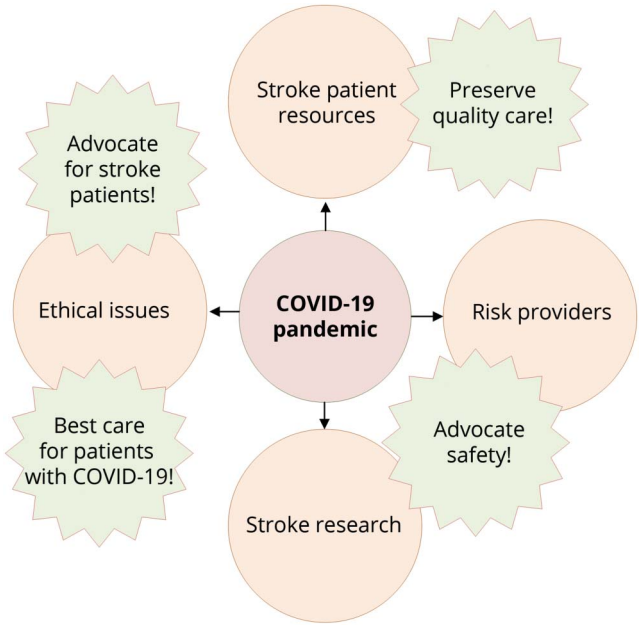
Individual hospitals and health care systems will need to adopt and adapt protocols that work best within local frameworks,[5] but should continue to abide by these aforementioned principles. For example, the exact approach to reduce the number of individuals potentially exposed, the duration of any necessary direct contact, and the risks associated with any direct contact will differ in each setting, but the overarching goal of reducing and mitigating risk is the same. Moreover, when these guiding principles conflict, the context of the local situation may drive compromise in one direction or another. We sought to address the following specific issues (figure):

Acute stroke care delivered during the COVID-19 pandemic

Patient demand and provider supply

It is uncertain how the crisis will affect the demand for acute stroke care. A surge of patients with acute stroke among those with severe COVID-19 infection[11] might increase the need for stroke care services. However, the experience of countries at the forefront of the epidemic, such as Spain and Italy, actually showed a reduction in acute stroke cases. For example, in Catalonia during March 2020, the number of code stroke activations and thrombectomy cases was reduced by 18% and 20%, respectively (*Chamorro, personal communication*). In Italy, there was a 50%–60% reduction in the number of patients with stroke arriving at hospitals compared with the same period the prior year, and more patients are arriving too late to be eligible for reperfusion treatment (*Baracchini* et al. *Neu Sci in press*). Of interest, Spain also reports a reduction in stroke mimics, and minor strokes or TIAs, suggesting that patients with mild symptoms may not seek care, accounting

Figure Potential effects of COVID-19 and principles guiding the cerebrovascular community



COVID-19 = coronavirus 2019.

for a perceived shift toward more severe strokes among those presenting to the hospital. Future data analyses will be needed to test these hypotheses and enhance our understanding of public health behaviors during a pandemic.[12]

The stroke community must prepare for the possibility of a shortage of neurologists practicing stroke medicine, as well as residents and fellows, either due to illness or because of redeployment to other medical duties.[13] This could significantly worsen the current shortage of stroke specialists taking stroke call[14,15] and potentially negatively affect the quality of care. Neurointerventionalists are typically a scarce resource, and the effect of having 1 or 2 quarantined could be catastrophic for any given institution. It might require temporary reorganization of the stroke on-call force, involving nonvascular neurologists and other providers.[16] Restructuring stroke call[15] and inpatient services might be necessary to maintain a viable workforce of providers, using the principle of isolating a reserve of health care workers to conserve a group of health providers. Contingency plans should include that neurologists with stroke expertise might have to assume consultative roles in different facilities and provide treatment triage decisions in a multidisciplinary manner, similar to the tiered staffing strategy used in critical care.[17]

Quality of care: potential issues and solutions

Addressing bed capacity

Table 1 summarizes the potential issues and solutions. High inpatient census, which may exceed hospital capacity, could force stroke clinicians to determine which patients with acute stroke are more likely to benefit from hospitalization. The priority should be to optimize the allocation of scarce hospital beds to those patients eligible for indispensable interventions per local protocols, such as revascularization with thrombolytics or mechanical thrombectomy, surgical interventions such as hemicraniectomy or posterior fossa decompression, or severe strokes that benefit from a specialized stroke unit or neurologic intensive care management. Also, each facility could consider developing specific criteria to limit the admission of patients after emergency department evaluation of possible TIA and minor stroke appropriate to the local situation and resources. In those cases, however, the center should be committed to the same level of diligence that they would otherwise provide. Potential strategies may include restricting hospitalization to those with a high likelihood of needing emergent surgery (e.g., carotid endarterectomy/stenting) and those requiring additional urgent evaluation that could not otherwise be provided in an ambulatory setting. Clinically stable ambulatory patients with low ABCD^2 scores or those having an obvious etiology warranting a specific and readily available intervention (atrial fibrillation requiring anticoagulation) may be discharged home from the emergency department. The use of direct-acting oral anticoagulants during the pandemic could be prioritized because of their rapid onset of action and to avoid follow-up visits for anticoagulation adjustment. Transient relaxation of the current restrictions by insurance bodies would be needed, however, to ensure patient adherence in times of potential financial distress. Consideration should be given to implementing a systematic approach for contacting these patients discharged from the emergency department for follow-up, assessing their clinical status, and assuring that treatment plans are being followed via telephone or virtual encounters.

To maximize the availability of intensive care unit (ICU) beds for patients with COVID-19, hospitals that normally admit all patients post-IV thrombolysis to an ICU could develop a protocol with the critical care/neurocritical care team to place less acute patients in a step-down unit.[5,18] Reduced frequency of vital signs and neurologic examination monitoring after reperfusion therapies for selected patients might become required, as limited data support its safety.[18] Using a similar principle, hospitals may admit stable patients with small ICHs to non-ICU beds, provided that nursing and other health care staffing support safe provision of care and close monitoring on these units. It remains crucial to determine which patients with acute stroke or intraparenchymal hemorrhage require ongoing neurocritical care services due to risk of imminent deterioration, and efforts should be made to preserve the availability of these services.[5,19] Patients with subarachnoid hemorrhage, for example, should continue to be admitted to neurologic ICUs.

Thrombectomy protocols may need to be revised for unknown, suspected, or confirmed COVID-19 cases[20] when they include intubation with the use of general endotracheal anesthesia (GETA), which may both increase the risk due to aerosolization during intubation[21] and simultaneously pose less of a transmission risk to neurointerventional and operating room staff, given that ventilation is managed through a closed

Table 1 Potential threats and recommendations for delivering quality stroke care during COVID-19

Potential issue	Potential threats	Recommendations
Demand/workforce balance	Shift toward more severe strokes Decreased workforce due to illness or reassignment	Partner with other specialties and transition to more consultative role/triage decisions, tiered staffing strategy[17]
High census limiting capacity	Not enough beds available for patients with stroke	Need to prioritize, per local protocols: Which patients can benefit most from admission Which mild/TIA patients could be managed as outpatients with telehealth services
Availability of ICU beds	Overflow of patients with COVID-19 might force triage of which patients with stroke need the ICU most	Emphasize neurocritical care of severe patients over monitoring mild post-rtPA patients in the ICU[5] Continue geographic cohorting of neurocritically ill patients as able
Minimize personal contact	Difficulties in assessment and detection of neurologic change	Minimize team member exposure and use of remote technologies Intubation with only the required personnel in the room
Interhospital transfer	The desire to ensure bed availability in saturated tertiary centers might collide with loss of bed capacity and/or human resources at spoke centers	Prioritize transfers of patients more likely to benefit from tertiary care Use COVID-19 screening criteria to appropriately cohort persons with COVID under investigation on arrival to destination facility Use current relaxation of telemedicine regulations to keep nonessential transfers locally
Need to readjust emergency medical services local protocols	Current protocols might overflow institutions in crisis stage	Fluid communication with local emergency medical services agencies on real-time capabilities
Limitation of neuroimaging and investigations	Limitations/unavailability or concerns for provider exposure	Reconsider the need for follow-up imaging on a case-by-case basis, favor CT over MRI and TTE over TEE
Limitation of exposure during stroke thrombectomy	High risk of exposure of stroke and neurointerventional team to asymptomatic, suspected, or known patients with COVID-19	Considering modifying criteria for intubation during the procedure Use PPE for conscious sedation patients
Limitation of elective procedures	Increased risk of recurrent stroke due to nonoptimal treatment	Explore possibility of delivering interventions during acute admission (e.g., carotid angioplasty and stenting following thrombectomy)
Discharge to facilities	Demand for COVID-19 screening and shunting to home rehabilitation due to fear	Advocate to categorize facilities by COVID status Potentiate telerehabilitation
Outpatient clinics	Limitation of in-person visits	Use current relaxation of telemedicine regulations to provide virtual appointments Use local facilities for imaging

Abbreviations: COVID-19 = coronavirus 2019; ICU = intensive care unit; PPE = personal protective equipment.

circuit.[22] If diversion of a ventilator is required, it should be done in a controlled setting that can be quickly cleaned by providers using appropriate PPE. It should be recognized that the use of conscious sedation, rather than intubation for thrombectomy in a patient infected with COVID-19, may still pose a considerable risk to the neurointerventional team, requiring the use of effective PPE by all personnel inside the angiography. Perhaps the greatest contagion risk related to thrombectomy would be the need for conversion from conscious sedation to GETA requiring intubation during the procedure. Thus, a low threshold to start with GETA for agitated patients may be advisable. Also, consideration can be given to eventually extubate these patients in a different location than the angiography suite preferably to minimize aerosolization and contamination that could render the suite unusable until adequate cleaning is done. To date, little attention has been paid to how to provide acute stroke care in temporary hospitals created to address the bed shortage caused by the large numbers of patients with COVID-19 already being cared for or expected. We encourage explicit discussions with such temporary facilities to plan the logistics needed to support acute stroke evaluations in these settings with clear processes for stroke code activation and response.

Changes from limiting exposure

The guidelines for minimizing health care workers' direct exposure to patients, including an increase in bed-to-nurse ratios, could affect the ability to assess and monitor neurologic status. We encourage centers to use the best qualified neuroscience nurses to ensure quality care. A tiered staffing strategy might be appropriate.[17] Technology-assisted solutions, such as inpatient telemedicine equipment, may help to partially compensate for these limitations. For patients admitted with suspected or confirmed COVID-19, telemedicine may allow the required

and appropriate neurologic monitoring while limiting exposure of staff or consumption of PPE. Such options should be explicitly considered by the stroke team at the beginning of rounds. As redeployment affects who is available in specific clinical contexts, hospitals must consider the use of virtual approaches to interactions among providers to maintain service.

Potential restrictions in testing and elective procedures

Restrictions in neuroimaging[23] and other diagnostic testing (e.g., transesophageal echocardiography) may require using alternative imaging modalities to guide therapeutics whenever possible (e.g., CT instead of MRI). Facilities may consider developing algorithms for triaging neuroimaging studies performed, putting a preference on imaging modalities that are high yield and essential. Similarly, transthoracic echocardiography or cardiac MRI might need to replace transesophageal studies given the aerosol risks associated with that technique. Clinically unstable or fluctuating patients with symptomatic severe carotid stenosis may need urgent revascularization (carotid endarterectomy or stenting), whereas stable outpatients awaiting elective revascularization or other procedures to reduce stroke or hemorrhagic risk (e.g., patent foramen ovale closure) could be deferred, recognizing that delaying some elective procedures could have a potential impact on the rates of recurrent stroke. Even short stays in postoperative units required by these procedures may not be justified in the setting of the COVID-19–induced resource shortages, including the consumption of PPEs.

Interhospital transfer

Interhospital transfer protocols might need to change in unpredicted ways. On the one hand, the drive to avoid unnecessary exposure of patients and providers,[13] coupled with the need to ensure the ability to deliver proven interventions at saturated tertiary centers, may result in a decrease in the number of patients transferred. Alternatively, changes in the workforce due to illness at the transferring institution and the subsequent inability to manage those patients could result in an increase in transferred volume. The economic issues due to the pandemic may affect smaller and larger hospitals across the country by furloughing staff and health care providers, whereas others may be forced to close. All patients being transferred should be clinically screened for potential COVID-19 symptoms if not aphasic, and consideration should be given to review of objective data such as the presence of fever, leukocytosis, or abnormal chest radiograph findings to ensure appropriate risk stratification during transfer. In the case of individuals with suspected or confirmed COVID-19, hospitals are expected to consider current guidance of CDC and public health officials in determining whether they have the capability to provide appropriate isolation required for stabilizing treatment and/or to accept appropriate transfers.[24] If tertiary care centers are incapable of providing a higher level of care, or the patient does not meet the criteria for interventions, transfers may not be appropriate under EMTALA. To do this ethically and consistently, we suggest having a cerebrovascular specialist on the committee for triage protocols at the hospital or health care system as a best practice (see section Ethical considerations for stroke care during the COVID-19 pandemic).[25]

Use of telemedicine could optimize the use of thrombolytics, protect patients and providers, reduce PPE use, and minimize unnecessary transfers. We recognize that certified telestroke technology might not be available at many small hospitals. We fully support the waiver of portions of the Social Security Act, which allow for non–HIPAA-compliant 2-way audiovisual communication tools to facilitate telestroke and other virtual patient interactions during this pandemic.[26] In those patients who could benefit from intraarterial thrombectomy, consider the criteria for intubating patients in the local emergency department, if a negative pressure room is available in that setting before transfer.[27] An effort should be made to reduce the need to repeat imaging studies. It is crucial to have good systems of image transfer and remote interpretation to compensate for shortages of neuroradiologists. We also recommend sharing real-time information with local emergency medical services regarding bed capacity, and resource capabilities for stroke, so the appropriate triage decisions are made.

Discharge planning

The COVID-19 pandemic may affect discharge planning to inpatient rehabilitation and skilled nursing facilities and will likely have a significant impact on patients with stroke who typically would benefit from postacute care services. Some postacute facilities may need to adapt to being COVID-only facilities, such as skilled nursing facilities affiliated with an acute care hospital,[28] or have cohorted COVID-19 units. Testing of all patients for COVID-19 who will be discharged to a lower level acute care hospital or other facility is desirable, but may be impractical due to delays in turnaround time.[28] In some states, legislation has forbidden rehabilitation facilities from refusing patients due to COVID-19 status. Many facilities may restrict visitors to reduce the risk to both patients and providers, affecting key social support systems. The value of multidisciplinary rehabilitation therapy of appropriate intensity to facilitate recovery after stroke is of proven values and should remain a priority.[29,30] Inpatient rehabilitation for otherwise appropriate patients should be preserved to the extent possible.[31] To address social isolation related to necessary infection control measures in rehabilitation facilities, 2-way audiovisual or at least telephone communication with family and friends is encouraged. Still, potential barriers to use inpatient rehabilitation include patient and caregiver fears of exposure, and the need to protect the facility, and reduce PPE utilization. It is possible that even patients with strokes who would normally be candidates for inpatient rehabilitation might instead be discharged home, creating the need for additional in-home services including remote education of caregivers. Telerehabilitation services should develop quickly to meet the needs of patients who cannot participate in outpatient therapies, as it has been shown to be noninferior to outpatient rehabilitation.[32] These presumptions need to be

shared with hospital leadership to appropriately prioritize the care of patients with stroke relative to others.

Outpatient rehabilitation for new and return visits will be affected, as many institutions have developed priority tiers for patient scheduling, as determined by the providers. For example, patients who would experience significant negative consequences if not evaluated and treated promptly, such as patients with stroke, are given priority. Others are restricting or canceling those appointments altogether. Virtual visits including telephone-only or 2-way audiovisual communication, instead of in-person outpatient clinic appointments, can provide reciprocal exposure protections. Alternatives or delays in diagnostic and follow-up neuroimaging may be necessary.

In summary, although the COVID-19 pandemic presents a challenge to stroke systems of care, it is also an opportunity. Some of the adjustments required during the crisis could lead to new efficiencies that can be further exploited in the future. Similarly, it provides an opportunity to reorganize the current system of care, so it is less vulnerable should another crisis occur in the future.

Ethical considerations for stroke care during the COVID-19 pandemic

Table 2 summarizes the potential issues and solutions. The current pandemic is likely to create new ethical dilemmas and scenarios for the stroke care provider. During the contingency stage,[33] there is disruption of the ordinary use of resources and practices, but the care provided is functionally equivalent to usual standards. In general, usual care of the patient with stroke is provided but supplemented with additional plans and processes related to possible or confirmed COVID-19 infection. The issue of whether all patients with acute stroke need to be tested for COVID-19 is unresolved, but unless previously tested or a point-of-care test with immediate results is developed, decisions will need to be made with incomplete information related to disease status. Regardless, neither persons under investigation for COVID-19 infection nor those known to be infected should not be disqualified from receiving usual stroke care that is modified to incorporate the new standards for PPE. Although care should continue to be individualized for each patient, changes are expected. These include reasonable steps to increase the surge capacity to care for critically ill patients. Initial approaches should target use of resources, which, if not used, might still lead to minimal (acceptable) changes in the protocols without lowering the standard of care per medical teams' judgment. These will vary in different institutions and may include some of the previously discussed measures, such as canceling elective procedures to preserve PPE, revise care protocols as much as possible (e.g., weighing risks and benefits of intubation before thrombectomy), admitting some patients post-IV thrombolysis or with a small stable intracerebral hemorrhage to stroke or step-down units, and allowing stroke specialists to continue to safely evaluate and make treatment recommendations for patients, using methods that have demonstrated noninferiority compared with in-person evaluations.[5] In this contingency stage, it is also important to prioritize advanced care planning before serious acute illness (e.g., during clinic visits), especially for those patients at high risk of stroke or the need to be intubated.[34] Goals of care should be discussed as a major priority at the time of hospital admission for patients at risk of severe outcomes (from COVID-19, stroke, or both).[34] The negative impact on patient and family outcome because of visitation restrictions should also be discussed. This might be in part moderated by daily telephone/video conversations with family. Communication skills are paramount in this crisis, including how to communicate around topics such as the need to triage and resourcing.[35]

When critical care capacity is, or shortly will be, overwhelmed, a regional-level authority may declare an emergency (crisis capacity). This crisis status should be adequately documented in the electronic medical record to highlight reasons that usual care could not be provided. Similarly, emergency medical services should be notified. In this type of situation, our primary responsibility becomes the best interest of the larger population (equitable provision of scarce resources). Still, every effort should be made to maintain the standard of care for patients with stroke. As described previously, triage officers or triage committees can help make these painful decisions instead of the treating clinician and might help to diminish moral distress.[25] It is important to have vascular neurology and/or neurocritical care representation in such committees, available to address immediate issues, to counteract any potential nihilism or negative biases toward patients with stroke. These specialists are best trained to provide accurate long-term

Table 2 Ethical issues to consider for stroke care during COVID-19

Stage	Potential threats	Recommendations
Contingency	Changes in stroke care to preserve resources	Modify stroke care to accommodate without impact on outcomes Enhance goals-of-care discussions
Crisis	Triage decisions with COVID-19–infected patients	Triage committee with vascular neurology and neurocritical care representation to inform about accurate prognosis Electronic medical record/emergency medical services notification status

Abbreviation: COVID-19 = coronavirus 2019.

prognostic information for patients with stroke. Past randomized trials of stroke therapy often excluded patients with frailty and multiple comorbid conditions that could affect longevity or functional outcome for scientific or methodological reasons. This could lead to unfair assumptions in clinical practice. The input of vascular neurology and/or neurocritical care specialists could help counteract this limitation of clinical trials by interpreting those results in a broader clinical context.

Safety and logistic issues for providers of patients with stroke

Table 3 summarizes the potential issues and solutions. Acute stroke is an area with high risk for provider exposure to infection; it is a fast-paced setting, involving multiple patient interactions and limited opportunities for COVID-19 screening with patients who often have impaired cognition and language. In highly contaminated areas, all patients should be approached as potentially infected. In the setting of shortages of PPE, hospitals should consider the code stroke team a priority for deployment, and we should advocate that code stroke personnel and neurointerventionalists are a priority to receive adequate PPE resources.[6] The code stroke workflow may need to change to minimize bedside assessments to limit exposure risk for both patients and providers.[6] The neurologic examination needs to be adapted to the risk, and the observational parts of the examination, such as the NIH Stroke Scale score, should be emphasized.[5] Potential considerations are increased utilization of telemedicine in the emergency department, huddling outside of patient rooms to allow transfer of information with social distancing, identifying which member of the team, if any, needs to participate in direct patient contact, and ensuring the availability of adequate and appropriate PPE.

Initial reports suggest that a subset of patients infected with COVID-19 will present with acute ischemic or hemorrhagic stroke.[11,36] Although the virus has direct effect on the cardiovascular system, predominantly myocardial injury,[37] the nature of the association with stroke remains uncertain, as well as concerns for microangiopathy and thromboses, and needs further study. Nevertheless, the apparent temporal association would increase the potential for exposure for stroke neurologists. Therefore, acute stroke teams should have high awareness of COVID-19 infection, with attention to fever, cough, dyspnea, diarrhea, acute anosmia, and lymphopenia. Stroke teams should consider expanding imaging of the aortic arch on stroke protocol computerized tomography angiograms to extend further caudally to include lung fields, in collaboration with radiology at their local institution. The results of the initial COVID-19 risk assessment should be communicated with neurointerventional and critical care teams.

Protocols to protect personnel in the subsequent care of patients with acute stroke will depend on the availability and reliability of COVID-19 screening and testing. The role of trainees might also need to be redefined. A common response has been to reduce or eliminate any exposure to these patients. On the other hand, in a crisis capacity mode, trainees might need to be deployed to assist with patient care duties. Others have advocated a distinction between students and postgraduate trainees, although there is no broad consensus on these issues.[38] As has been seen across the country at all levels of educational programing, video conferencing can be used to supplement trainee education while maintaining physical distancing.

Although not yet FDA approved, AHA guidelines endorse that it may be reasonable to choose tenecteplase rather than IV alteplase before mechanical thrombectomy and might be considered as an alternative to alteplase in selected patients without large vessel occlusion.[39] One potential advantage is that treatment does not require a 1-hour infusion, therefore reducing health care provider exposure, as well as eliminating the need for infusion pump use.[39] Changing usual treatment paradigms in the setting of an upheaval in the medical care system, however, could increase the chances of additional medical errors. Cohorting patients may also be an option. Depending on the resources, some institutions may have the capability to designate COVID-19 neuroimaging facilities and care areas. For example, the University Hospital of

Table 3 Safety and logistic issues to consider for stroke care during COVID-19

Issue	Potential threats	Recommendations
Not enough time to accurately assess COVID-19 status on code strokes	Infection of code stroke team members and spread within the hospital	Use of adequate PPE for all code stroke interactions in community-spread areas
Lack of COVID-19 testing for all inpatients		Minimize team exposure
		Use of PPE
		Adapt neurologic examination to emphasize observation
		Use of audio/video technology
Patients with stroke infected with COVID-19		Establish COVID+ allocated areas within stroke or neurocritical care units

Abbreviations: COVID-19 = coronavirus 2019; PPE = personal protective equipment.

Padua activated a dedicated stroke triage protocol with a high-performance mobile CT outside the emergency department for all 3 clinical scenarios: COVID-19 positive, COVID-19 negative, and COVID-19 suspected. COVID-19–positive patients are managed outside the Stroke Unit by stroke physicians for thrombolysis and thrombectomy and then admitted to dedicated COVID-19 departments and followed up by stroke physicians. In the case of patients with suspected COVID-19, nasopharyngeal swabs are taken and managed as if the patient were COVID-19 positive. If the COVID-19 screen is negative, the patient is transferred to the Stroke Unit or the Neuro-ICU based on their neurologic conditions. The advantages of this workflow are (1) protection of Stroke Unit areas and personnel from COVID-19 infection, (2) preservation of continuous open access pathways for patients with stroke, and (3) increased access to specialized care for COVID-19–positive patients.[40] At the Hospital Clinic of Barcelona, the Stroke Unit is sectorized to limit contamination. Thus, all COVID-19–suspected patients are first admitted to an isolated Stroke Unit bed and then transferred to another bed in the Stroke Unit if COVID-19 negative or to a COVID-19 area if COVID-19 positive. This approach allowed maintaining the Stroke Unit free of COVID-19 following several weeks of the pandemic.

Stroke research during the pandemic

Stroke research is vital to scientific discovery and ultimately to the advancement of stroke care, prevention, and recovery for all patients. The pandemic, however, has raised new issues related to the need to balance risks and allocation of scarce resources. Any research that involves direct person-to-person contact, including study staff-to-patient or family contact, or staff-to-staff contact, increases the risk of COVID-19 transmission. Furthermore, person-to-person contact for research in the health care setting could use precious PPE for nonclinical purposes and contribute to shortages as well as the spread of the epidemic. Acute stroke trials that use stroke physicians who play a dual role of provider and researcher may not expose additional personnel or expend additional PPE. However, the exposure may be prolonged through consent processes, data collection, and research-related assessments, and performance of research activities may distract these clinician researchers from important clinical activities at a point when their clinical time is in high demand. In addition, in-person follow-up for protocol-mandated assessments may not be possible.

For these reasons, many institutions have halted all nonessential research. On a national level, the investigators of the NINDS-funded clinical trials network, NIH StrokeNet, have temporarily paused enrollment in all of its clinical trials, inclusive of acute stroke trials, that require in-person activities of coordinators or clinical staff with each other or patients. As a compromise, enrolled participants are being followed up by video or telephone, and ongoing study drugs continue to be mailed to patients while minimizing coordinator in-person contact during its acquisition and mailing.[41] Restarting these trials is an equally pressing concern, given the continued major impact of stroke on public health and the potential for lost data on patients already enrolled. The decision to restart a trial is a complex one, however, that requires input from key stakeholders (including trial, clinical, and ethics leadership both nationally and locally) on a continuous basis, rather than individual investigators weighing potential risks and benefits. Considerations include whether the trial would increase the hospital length of stay, offer potential direct benefit to the participant, allow study activities to be performed while minimizing infection exposure to participants and staff, and not increase utilization resources and staff in clinically short supply. The status of COVID-19 is being monitored closely, and protocols and processes are being modified as feasible, to allow optimal restart of trial enrollment and other halted activities at selected sites within this national network. As a research community, a reasonable conclusion is that research that does not involve in-person contact is logistically feasible. Epidemiologic investigations including those that require prospective data collection, other types of surveillance studies, administrative data analysis, and retrospective studies will shed light on the impact of COVID-19 on stroke and stroke care. To the extent possible, this should include biobanking of samples to allow detailed investigation of the relationship to all cerebrovascular phenotypes. Cerebrovascular manifestations of COVID-19 are not currently well studied, and further research is needed in this area. A retrospective study identified acute cerebrovascular events in 6% of patients with COVID-19.[11] In addition, the experience of the COVID-19 pandemic is a persuasive rationale to include contingency plans for virtual or remote conduct of future research projects or trials.

Conclusion

The COVID-19 pandemic is a major crisis challenging all aspects of the health care system, including stroke management. Stroke providers must balance the overall needs of the community while remaining advocates for patients with stroke and the safety of providers. This includes adjustments in the delivery of stroke care during the contingency period, as well as in an eventual crisis stage. There are no universally established solutions, and those adjustments need to be adapted to each unique local environment. As we move forward in providing stroke care in the context of the pandemic, we will need to rely on prediction modeling and surge planning to inform our adaptation to best serve all of our patients.

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Appendix Authors

Name	Location	Contribution
Enrique C. Leira, MD, MS	University of Iowa, Iowa City, IA	Design or conceptualization of the study and drafting and revising the manuscript for intellectual content
Andrew N. Russman, DO	Cleveland Clinic, Cleveland, OH	Design or conceptualization of the study and drafting and revising the manuscript for intellectual content
José Biller, MD	Loyola University Chicago, Maywood, IL	Drafting or revising the manuscript for intellectual content
Devin L. Brown, MD	University of Michigan, Ann Arbor, MI	Drafting or revising the manuscript for intellectual content
Cheryl D. Bushnell, MD	Wake Forest School of Medicine, Winston-Salem, NC	Drafting or revising the manuscript for intellectual content
Valeria Caso, MD, PhD	University of Perugia, Italy	Drafting or revising the manuscript for intellectual content
Angel Chamorro, MD, PhD	University of Barcelona, Spain	Drafting or revising the manuscript for intellectual content
Claire J. Creutzfeldt, MD	University of Washington, Seattle, WA	Drafting or revising the manuscript for intellectual content
Salvador Cruz-Flores, MD, MPH	Texas Tech University, El Paso, TX	Drafting or revising the manuscript for intellectual content
Mitchell S. V. Elkind, MD, MS	Columbia University, New York, NY	Drafting or revising the manuscript for intellectual content
Pierre Fayad, MD	University of Nebraska, Omaha, NE	Drafting or revising the manuscript for intellectual content
Michael T. Froehler, MD, PhD	Vanderbilt University, Nashville, TN	Drafting or revising the manuscript for intellectual content
Larry B. Goldstein, MD	University of Kentucky, Lexington, KY	Drafting or revising the manuscript for intellectual content
Nicole R. Gonzales, MD	McGovern Medical School at UTHealth, Houston, TX	Drafting or revising the manuscript for intellectual content
Brian Kaskie, PhD	University of Iowa, Iowa City, IA	Drafting or revising the manuscript for intellectual content
Pooja Khatri, MD, MSc	University of Cincinnati, Cincinnati, OH	Drafting or revising the manuscript for intellectual content
Sarah Livesay, DNP, ARNP	Rush University, Chicago, IL	Drafting or revising the manuscript for intellectual content
David S. Liebeskind, MD	UCLA, Los Angeles, CA	Drafting or revising the manuscript for intellectual content
Jennifer J. Majersik, MD	University of Utah, Salt Lake City, UT	Drafting or revising the manuscript for intellectual content
Asma M. Moheet, MD, MHDS	OhioHealth Riverside Methodist Hospital, Columbus, OH	Drafting or revising the manuscript for intellectual content
Jose G. Romano, MD	University of Miami, Miami, FL	Drafting or revising the manuscript for intellectual content
Nerses Sanossian, MD	University Southern California, Los Angeles, CA	Drafting or revising the manuscript for intellectual content
Lauren H. Sansing, MD	Yale School of Medicine, New Haven, CT	Drafting or revising the manuscript for intellectual content
Brian Silver, MD	University of Massachusetts, Worcester, MA	Drafting or revising the manuscript for intellectual content
Alexis N. Simpkins, MD, PhD, MS	University of Florida, Gainesville, FL	Drafting or revising the manuscript for intellectual content
Wade Smith, MD, PhD	UCSF, San Francisco, CA	Drafting or revising the manuscript for intellectual content
David Tirschwell, MD	University of Washington, Seattle, WA	Drafting or revising the manuscript for intellectual content
David Z. Wang, DO	Barrow Neurological Institute, Phoenix, AZ	Drafting or revising the manuscript for intellectual content
Dileep R. Yavagal, MD	University of Miami, Miami, FL	Drafting or revising the manuscript for intellectual content
Bradford B. Worrall, MD, MSc	University of Virginia, Charlottesville, VA	Design or conceptualization of the study and drafting and revising the manuscript for intellectual content

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