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Optimization of resources and modifications in acute ischemic stroke care in response to the global COVID-19 pandemic

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Background: The COVID-19 pandemic has presented unprecedented challenges to healthcare organizations worldwide. A steadily rising number of patients requiring intensive care, a large proportion from racial and ethnic minorities, demands creative solutions to provide high-quality care while ensuring healthcare worker safety in the face of limited resources. Boston Medical Center has been particularly affected due to the underserved patient population we care for and the increased risk of ischemic stroke in patients with COVID-19 infection. *Methods:* We present protocol modifications developed to manage patients with acute ischemic stroke in a safe and effective manner while prioritizing judicious use of personal protective equipment and intensive care unit resources. *Conclusion:* We feel this information will benefit other organizations facing similar obstacles in caring for the most vulnerable patient populations during this ongoing public health crisis.

Keywords: Acute ischemic stroke—Thrombolysis—Interventional neuroradiology—COVID-19

Introduction

The ongoing coronavirus disease 2019 (COVID-19) pandemic has challenged healthcare systems around the world. In the United States, there have been more than 1.4 million confirmed infections and 85,000 COVID-19-related deaths as of May 15, 2020. Infected patients present with a wide range of clinical syndromes, with approximately 5% progressing to multisystem organ failure requiring intensive care.[1] The rapid spread of COVID-19 has significantly depleted the resources of many healthcare systems around the world, requiring drastic measures in order to support an ever-growing census of critically ill patients.

The American Heart Association / American Stroke Association Stroke Council has issued broad guidance on stroke care in the midst of the pandemic, but has encouraged development of protocols in order to fulfill the needs of individual institutions.[2] This is especially important given the growing body of evidence showing that approximately 5% of patients with severe COVID-19 infection (and 1% of patients with non-severe infection) develop acute ischemic stroke.[3] At Boston Medical Center, we provide care to a large, underserved population, with a significant proportion of patients coming from racial and ethnic minorities, a group that has been demonstrated to be disproportionately affected by this pandemic. We present our protocol modifications for evaluation, management, and hospital care of acute ischemic stroke patients in response to the ongoing COVID-19 pandemic. These measures, which are informed by existing literature and expert opinion, were developed with the goal of conserving personal

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protective equipment (PPE), intensive care unit beds, and other finite resources while continuing to deliver high quality stroke care.

Initial evaluation

When an acute stroke code is activated for a patient with suspected or confirmed COVID-19 infection, a surgical mask is placed on the patient and the Stroke Team designates a single member to don PPE and perform the bedside evaluation as described in previous work on COVID-19 stroke evaluation.[4] Outside of the patient's room, additional Stroke Team members gather data from the electronic medical record, contact family members for collateral information, and review imaging in order to reduce the time between the discovery of symptoms and decision-making regarding intervention with intravenous recombinant tissue plasminogen activator (IV rtPA) and/or emergent mechanical thrombectomy. The bedside evaluator remains in the patient's room during transport to the computed tomography (CT) scanner to minimize repeated donning / doffing of PPE, which both conserves resources and limits accidental exposure. Upon the patient's return, communication between the bedside evaluator and the stroke attending or fellow is facilitated by use of a telephone or tablet already located within the room. This differs significantly from our typical approach, which includes the immediate arrival of multiple Stroke Team members to the bedside for a comprehensive initial evaluation and assistance in transport to the CT scanner. These changes greatly reduce the number of team members exposed and the amount of PPE consumed in the process of initial evaluation and management in the acute stroke setting.

Patients not amenable to IV rtPA or emergent mechanical thrombectomy

For patients with confirmed or suspected COVID-19 and symptoms consistent with acute ischemic stroke who do not meet criteria for IV rtPA or mechanical thrombectomy, the frequency of subsequent neurologic monitoring is determined based on an assessment of their relative risk of actionable neurologic decline (Fig. 1). Clinical features suggestive of increased risk include location of infarct within the cerebellum, large hemispheric infarction, and presentation with alteration in level of consciousness.[4] For patients that meet any of these parameters but do not require intensive care unit (ICU) level of care, a tablet with video capabilities is placed at the bedside. Once per shift, a neurologist uses this device to remotely observe a bedside nurse perform a neurologic check to calibrate the exam, as well as to determine the frequency of required examinations for the remainder of the shift. Any concern raised during a nursing evaluation prompts a bedside evaluation by a member of the Stroke Team. For patients lacking high-risk features, neurologic examination will take place when bedside nursing staff enters the room to perform other care tasks, which is approximately once every four hours.

The stratification of stroke patients into low- and high-risk groups is not a significant departure from the existing practice at our institution, where patients are triaged to an appropriate level of care based on the required frequency of neurologic checks. Where this protocol differs from our typical procedure is in the longer monitoring intervals and the incorporation of technology in making shift-by-shift decisions on frequency of examination, thus limiting personnel exposure and PPE utilization. There is evidence

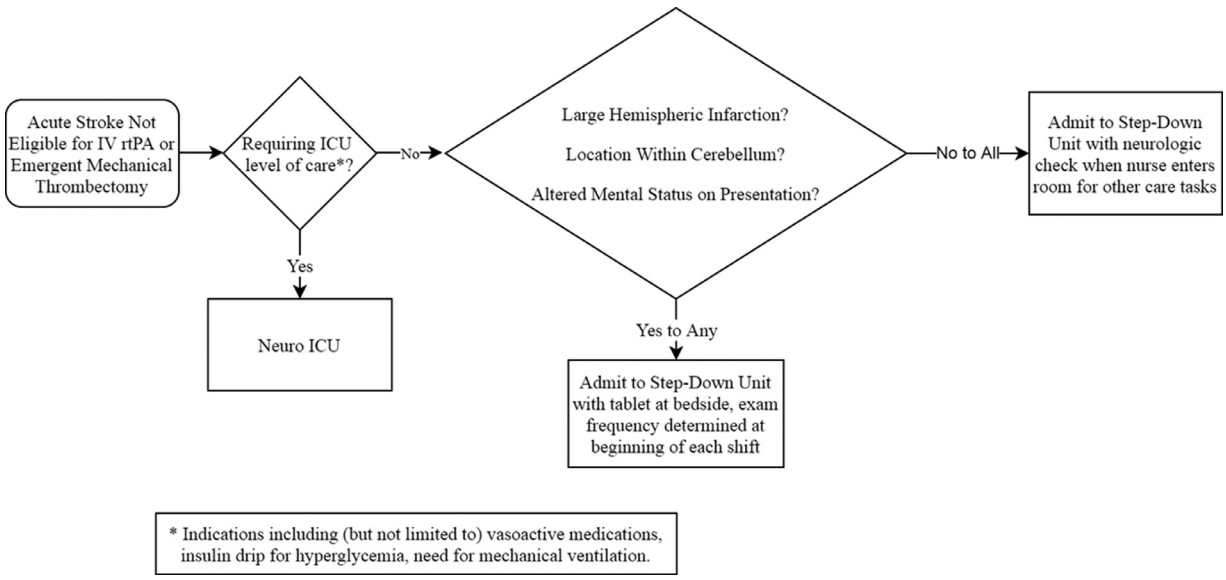

Fig. 1. *Neurologic monitoring frequency in patients not receiving IV rtPA or emergent mechanical thrombectomy.*

supporting the validity of National Institutes of Health Stroke Scale (NIHSS) evaluation by neurologists over video, which helps reduce the amount of PPE consumed while also allowing flexibility to go to the patient's bedside when necessary.[5] In addition, studies have demonstrated inter-rater reliability for nurses performing the NIHSS evaluation, providing further reassurance about the safety of spacing out neurologic checks.[6]

Patients receiving intravenous rtPA

If the decision is made to administer IV rtPA (regardless of COVID-19 status), the procedure for initial administration (including monitoring of blood pressure and neurologic examination every 15 min during the infusion and for one hour afterward) remains the same as in our current practice guidelines. Following the infusion and immediate post-infusion monitoring period, these patients are then triaged to admission to either a step-down level of care or to the intensive care unit, based on an assessment of relative risk of actionable neurologic decline (Fig. 2). Upon arrival at their designated care unit, the bedside nurse performs a neurologic check, which is repeated one hour later. After 2 hours from treatment bolus, patients will be evaluated every two hours until they are eight hours from thrombolytic treatment initiation, at which point they are further spaced to evaluation every four hours.

Typically, patients who have received IV rtPA are admitted to our neurosciences intensive care unit for a period of 24 h, allowing for evaluation on an hourly basis for signs of early decompensation. However, as the number of ventilator-dependent COVID-19 patients has increased, ICU bed availability has dwindled, making it necessary to identify which patients may be suitable for monitoring outside of an intensive care unit. The recent OPTIMIST trial sought to define a subgroup of patients who are able to be monitored less closely after receiving thrombolytic therapy, ultimately finding that patients meeting the criteria we have adopted were able to remain in a step-down level of care without

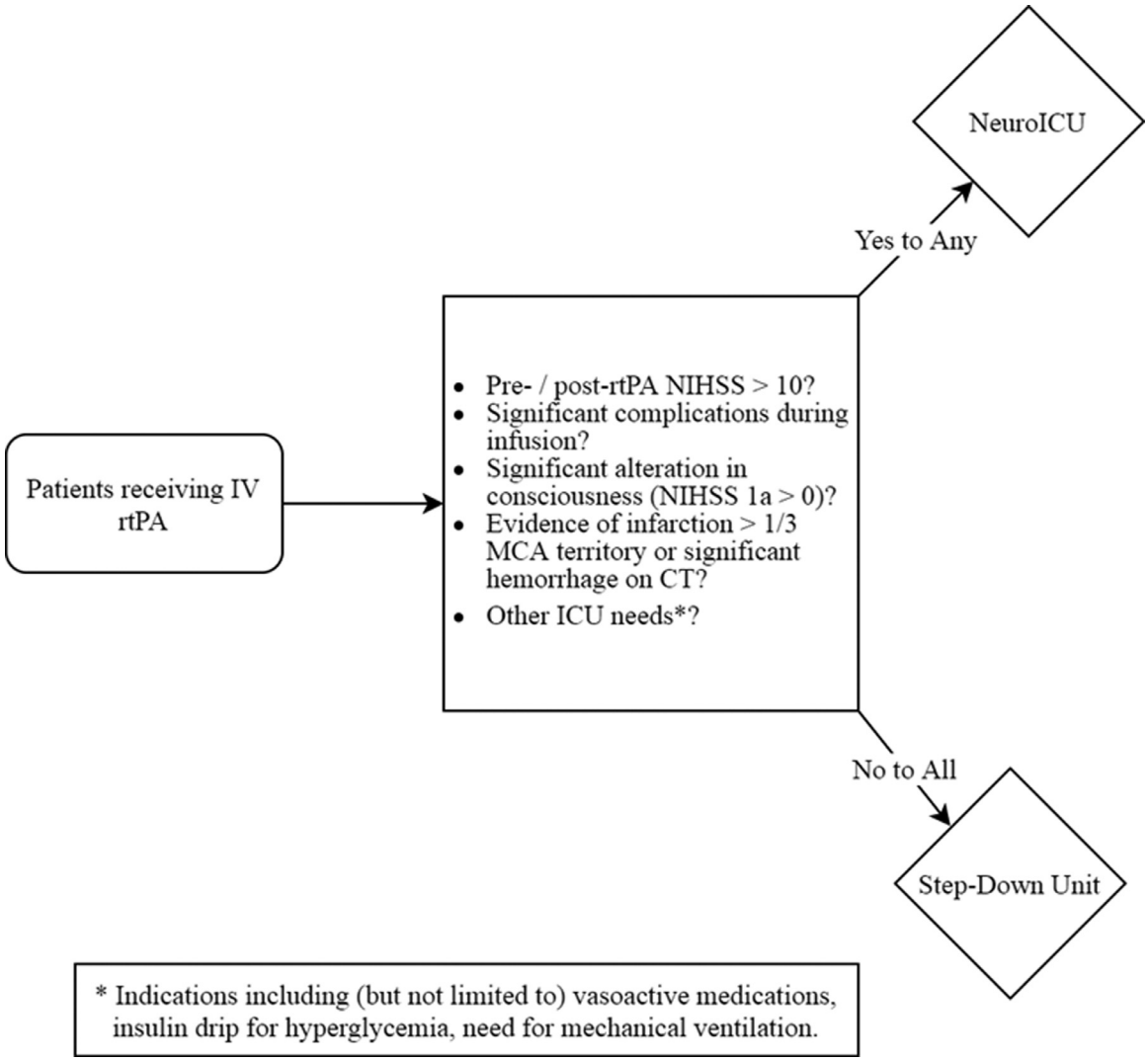

Fig. 2. *Disposition determination algorithm following administration of IV rtPA.*

adverse events.[7] Our own experience is in agreement: we observed a 3% complication rate in patients monitored at our institution after receiving IV rtPA, (and less than 1% when it was administered at our institution) during 2018 and 2019. Utilizing low-intensity monitoring for these patients (with the flexibility to increase frequency of checks or transfer to a higher level of care if concerns arise) allows for the conservation of ICU beds and PPE, both of which are crucial to meeting the demands of the growing number of COVID-19 patients.[8]

Patients undergoing emergent mechanical thrombectomy

Patients receiving mechanical thrombectomy (regardless of COVID-19 status) are directly transported to the neurointerventional radiology (NIR) suite and prepped according to standard procedures. At the present time, our institution performs rapid testing on all patients being admitted from the Emergency Department, including patients with large vessel occlusion (LVO) strokes in need of mechanical thrombectomy. However, even with rapid testing, a positive or negative determination will not result prior to skin puncture, requiring that all patients going to the neurointerventional radiology suite from the ED for emergent mechanical thrombectomy be considered as PUI for COVID-19. We have not incorporated routine chest CT as a screening tool in these patients given the nonspecific findings and wide range of reported sensitivities, a decision supported by the American College of Radiology.[9] In line with societal guidance statements, adjustments of care are indicated based on the patient's COVID-19 status, including airway assessment and potential need for intubation.[10]

Under normal circumstances, the Stroke Team accompanies the patient to the NIR suite to facilitate active collaboration with the neuro-interventional team during the case. However, given the confines of the control room area and the positive-pressure environment of the NIR suite, this communication is now conducted via telephone. Staff who remain in the control room wear a surgical mask. After the procedure, the neuro-interventional team performs two skin puncture site and pulse evaluations separated by 15 min to assess for early complications. These patients are then triaged to either a step-down level of care or to the intensive care unit, again based on an assessment of relative risk (Fig. 3). Upon arrival at their designated care unit, nursing performs a skin puncture site evaluation and neurologic check, which is repeated one hour later. Beyond this time period, patients will be evaluated every two hours until eight hours after completion of the procedure, at which point they are further spaced to evaluation every four hours. These intervals can be adjusted based on physician concern for access site bleeding or patient stability.

In addition to admission to our neurosciences ICU for close neurologic monitoring, these patients typically undergo frequent skin puncture site evaluations for the first six hours after the procedure. However, current evidence shows that groin site complications from mechanical thrombectomy (even when using a large-bore sheath) are rare, supporting the reduced frequency of skin puncture site evaluations after the procedure.[11] While there is no currently available data akin to that from the OPTIMIST study that evaluates the safety of low-intensity monitoring after mechanical thrombectomy, our institution has adopted similar criteria for determining disposition post-procedure in order to conserve ICU beds, with the ability to transfer a patient to a higher level of care if necessary. As with the modifications to our post-intravenous rtPA protocol, these changes allow for reduced consumption of intensive care unit beds and resources while maintaining acute ischemic stroke treatment capabilities.

Referrals from outside hospitals for emergency mechanical thrombectomy

In addition to treating patients who initially present to our own hospital, a major role Boston Medical Center serves within the Greater Boston area is that of a referral center for mechanical thrombectomy. As such, our institution is in active collaboration with referring hospitals to develop a process for transferring patients to our center for thrombectomy with repatriation of patients to the referring hospital or to the "flagship" hospital within the referral network. This will allow for us to continue providing thrombectomy care to our large catchment area despite higher inpatient volume and reduced bed availability. Repatriation of patients back to primary stroke centers has been demonstrated to work successfully in other stroke systems of care models, with comparably good outcome of patients post thrombectomy.[12,13]

Imaging considerations

In the post-stroke period, imaging modalities such as MRI, carotid duplex, and transthoracic / transesophageal echocardiography are frequently used to guide etiology-specific secondary prevention measures. However, in light of limited resources, unless they would have a substantial impact on management in the immediate post-stroke period (such as echocardiography when there is a strong suspicion for endocarditis), these ancillary studies are being deferred until after a COVID-19 patient is cleared from isolation precautions. In addition, while non-contrast head CT plays an important role in the rapid assessment of an acute ischemic stroke patient with a change in examination, routine surveillance CT scans on neurologically stable patients are avoided.

Stewardship of imaging studies in stroke patients is particularly important during the COVID-19 pandemic, given the desire to avoid frequent transportation to

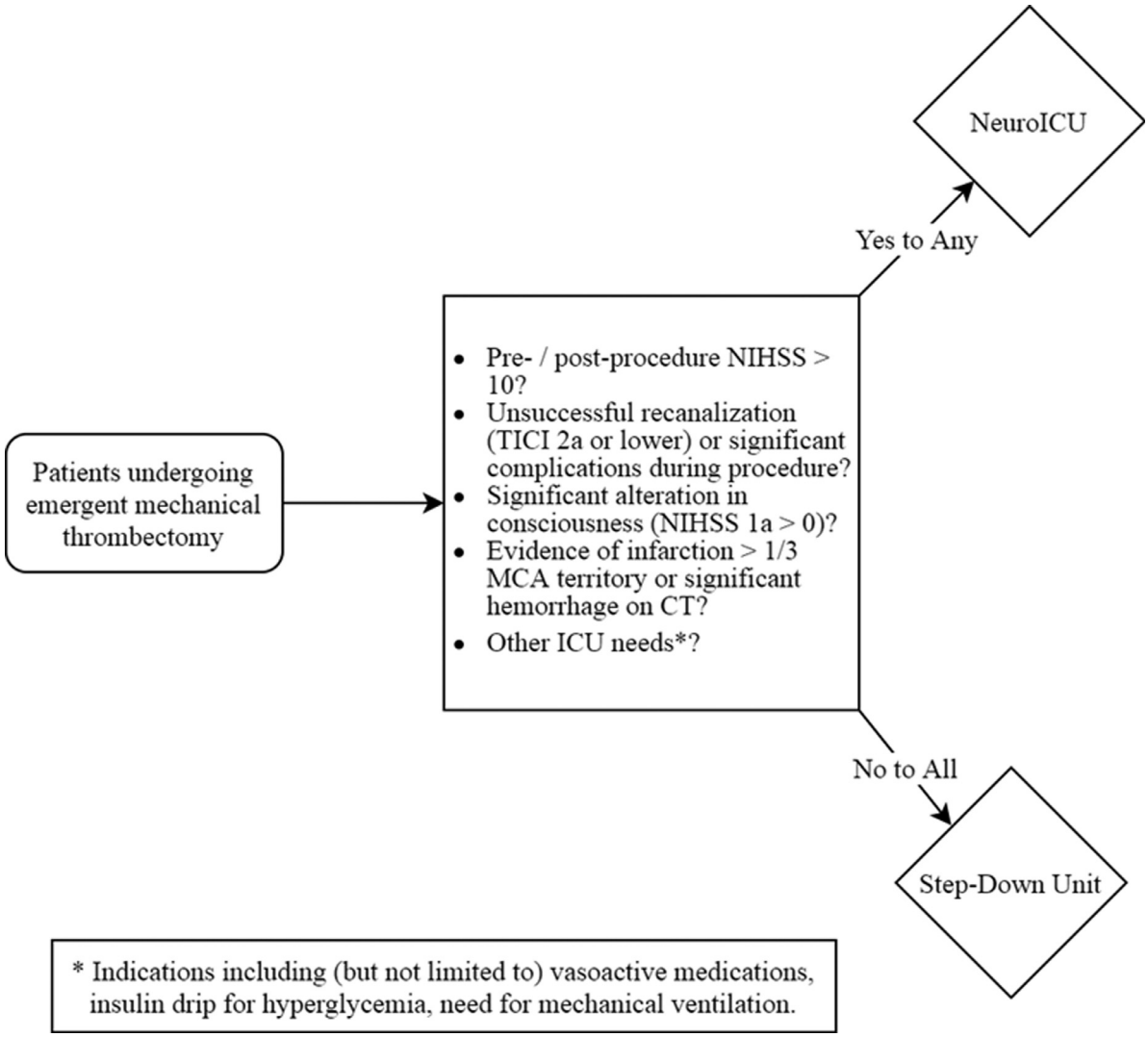

Fig. 3. *Disposition determination algorithm following emergent mechanical thrombectomy.*

testing, as well as the intensive decontamination required between patients that further reduces scanner availability. While brain MRI is generally included in the evaluation of all stroke patients at our institution, most recent guidelines indicate that this practice does not consistently affect short-term management.[14] Similarly, while it is fairly standard to obtain a non-contrast head CT 24 h post-administration of rtPA, some studies have shown that this does not change management in neurologically stable patients.[15,16] In light of this data and the increased risk of healthcare worker exposure associated with performing a CT scan in a COVID+ patient, we recommend that pharmacologic prophylaxis to prevent deep vein thrombosis and antiplatelet therapy for secondary stroke prevention can be initiated 24 h following administration of IV rtPA in the absence of a CT scan in neurologically stable patients. These measures allow for a reduction in the number of technicians and other staff facing potential exposure while minimally impacting the care of our patients.

Limitations

While the protocol modifications we have detailed are supported by existing literature, there have not been any clinical trials examining the optimal frequency of neurologic monitoring after acute ischemic stroke. There are gaps in our understanding of the underlying risk for both acute ischemic stroke and for decompensation in the COVID-19 patient population. The factors that lead to increased risk of thrombotic complications in COVID-19 patients may extend to development of hemorrhage or complications following emergent mechanical thrombectomy, a predisposition that may not be well understood until a larger cohort of these patients is gathered. Given this uncertainty and the rapidly changing nature of these conditions, we have made our protocols living documents, designed to be viewed on our frequently updated website (www.covidneurology.org).

In addition, while systems are in place to facilitate continued stroke care once patients leave the hospital, there is concern about an additional delay in stroke work-up with

the significant increase in the volume of studies being deferred to the post-pandemic period. The benefit of expedited workup in the inpatient setting includes more expedient initiation of etiology-specific secondary prevention measures (such as cardiology referral in the case of patent foramen ovale), which will generally be deferred to the outpatient setting.

Conclusion

The unique burden that the COVID-19 pandemic places upon healthcare systems requires ongoing effort from providers to adapt to increasingly depleted resources and disrupted stroke systems of care. The protocols outlined above were developed based on our institution's needs and represent fluid guidelines that will continue to be informed by emerging evidence. The purpose of these adaptive protocols is to ensure continuous access to high quality acute ischemic stroke treatment by strategically deploying and utilizing key resources in a resource constrained environment. We hope that our protocol can be helpful for other centers who are faced with similar challenges in caring for the most vulnerable patient populations during this ongoing public health crisis, as well as in future instances of severe strain on our healthcare system.

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Declaration of Competing Interest

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