Telestroke in the Endovascular Era

A modern response to geographic gaps in acute stroke care.

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Acute ischemic stroke (AIS) remains a major public health burden. It is the leading cause of long-term disability and the fourth leading cause of mortality in the United States.[1,2] Emergent recanalization was an elusive goal of acute stroke therapy until the US Food and Drug Administration (FDA) approved tissue plasminogen activator (tPA) for use in 1996, which introduced a revolution in modern stroke management.[3,4] Because the therapeutic window for tPA is narrow and the treatment effect decreases with time,[5] there have been tremendous public awareness efforts to ensure patients present as soon as possible for care. Despite these efforts, only 3% to 5% of all ischemic stroke patients are treated with thrombolysis in the United States and Europe.[6,7]

The overwhelming majority of eligible patients with AIS present outside of the therapeutic window for intravenous tPA.[8] However, even when a patient presents within the therapeutic window, the national shortage of vascular neurologists means that some patients inevitably present to emergency departments without neurology coverage.[9] Nearly half of all hospitals in the United States do not have a neurologist on staff, and only 55% of Americans live within 60 miles of a primary stroke center.[10] In these circumstances, patients who are otherwise suitable for treatment go untreated because emergency medicine physicians often are uncomfortable administering tPA without a consulting neurologist.[11] This is one factor that has led to dramatic underutilization of thrombolytics in rural and underserved communities. For instance, in a review of 500,000 cases of AIS across 4,750 hospitals, 62% of surveyed hospitals never administered tPA over a 2-year period.[12]

This geographic disparity in thrombolysis ultimately prompted the use of telemedicine in acute stroke management, otherwise known as telestroke.[13] AIS is particularly suited to telemedicine—clinical exam findings are clearly visible, therapy is time sensitive, the incidence is too widely distributed to ensure timely in-person neurology evaluations, and therapy consists of a readily available intravenous medication, with limited investigational criteria for administration. By leveraging modern telecommunication technology, telestroke allows a neurologist or other stroke specialist to rapidly assess and treat patients remotely, regardless of their geographic location.

BACKGROUND

Telestroke was initially pioneered in Boston, where a hospital in Martha's Vineyard partnered with a tertiary referral center to assess the safety of remote neurologic assessment in AIS. Using the National Institutes of Health Stroke Scale (NIHSS), initial pilot studies demonstrated that nurse-assisted remote evaluation by a neurologist were comparable to that of a bedside neurologist, albeit slightly slower (9.7 vs 6.5 min, respectively).[14] This has since been replicated in acute settings, demonstrating the diagnostic reliability of telestroke in AIS.[15,16] A German effort extended this proof of principle to create the first telestroke network in which rural facilities (spokes) were connected to comprehensive referral centers (hubs) to create the first "spoke-and-hub" telestroke network.[17,18] Depending on the resources available at the local hospital and preexisting protocols, patients can either be thrombolysed and transferred to the referral center ("drip-and-ship") or thrombolysed and managed at the local hospital ("drip-and-keep"). Patients with severe strokes, requiring either endovascular therapy, critical care, or hemicraniectomy would be transferred to the referral center, regardless of whether they receive thrombolytics. These pilot studies demonstrated the feasibility of a large-scale telestroke network remotely evaluating and thrombolysing patients. There are now at least 56 telestroke networks in 27 states,[19] and with the increasing adoption of telestroke, a growing body

of evidence has demonstrated the safety and efficacy of telestroke in delivering acute care for AIS.

SAFETY AND EFFICACY

The principal safety concern with thrombolysis is iatrogenic intracranial hemorrhage (ICH), either from misdiagnosis leading to inappropriate treatment or protocol violations that are known to increase the risk of ICH. Reassuringly, telestroke has been shown to effectively identify stroke mimics and not increase the rate of protocol violations as compared to referral centers.[18,20,21] Consistent with these observations, the rate of ICH is comparable between telestroke evaluations and either trial data or in-person evaluations at referral centers.[21-25]

On the other hand, the effect of telestroke is dramatic and is exemplified in the change in stroke management in rural Georgia before and after telestroke implementation. As recently as 2002 (6 years after FDA approval), tPA was not given in the heart of the southeastern United States (the "stroke belt") due to the lack of local neurologists. The following year, a telestroke network was implemented, and tPA utilization increased to 16% within networked hospitals.[15,26] In multiple contexts, the implementation of a telestroke network invariably leads to significant increases in thrombolysis rates in rural and underserved communities[18,21,22,24,25,27-30] and equivalent rates of thrombolysis between referral centers and local hospitals.[15,29,31] Most importantly, these increased rates of thrombolysis improve stroke outcomes. In a prospective study comparing outcomes in more than 3,000 cases, the composite outcome of death, institutionalization, or disability is significantly less likely for patients who presented to a telestroke hospital versus those who presented to out-of-network hospitals.[23] Telestroke has helped to close the rural and underserved community treatment gap, demonstrating comparable rates of disability and mortality between stroke centers and telestroke hospitals in multiple networks.[22-24,27,31-33] Therefore, telestroke brings tertiary level care to local emergency departments in a safe and effective manner. Based on these experiences, the American Heart Association now endorses telestroke in underserved medical settings as safe and reliable.[34]

TELESTROKE AND ENDOVASCULAR THERAPY

Now that recent data have demonstrated improved outcomes with endovascular management for select patients with large vessel occlusions,[35-38] stroke care delivery systems must adapt to the new challenge of ensuring access for all communities. Access to endovascular therapy remains limited, including eccentric access in rural and urban communities.[39] Telestroke is already built to meet this challenge, providing an opportunity to extend the reach of endovascular therapy to patients who would otherwise do poorly.

Remote Assessment of the NIHSS

Patients with NIHSS > 6 are potential endovascular candidates, with higher thresholds increasing the specificity for large vessel occlusions.[40,41] Locally acquired imaging data can be reviewed by the remote interventionist to determine candidacy for therapy (Alberta Stroke Program Early CT Score [ASPECTS] and hyperdense vessel on noncontrast CT or level of occlusion, collateral vasculature, and tortuosity on CTA). The availability of telestroke also provides for preexisting transfer protocols, potentially overcoming time delays that represent a major barrier to endovascular therapy.[42,43] The role of telestroke in endovascular therapy has been demonstrated in a Spanish network comparing 90-day outcomes of thrombectomy-eligible patients who presented to hospitals within a telestroke network versus those who presented to out-of-network hospitals.[44] In this "drip, ship, and retrieve" model, groin puncture times were faster in telestroke facilities, likely because patients were remotely consented and the angiography suite was ready on arrival. At 90 days, functional outcomes were comparable between the main stroke center and the in-network telestroke hospitals but were significantly worse in patients who initially presented to out-of-network hospitals. Therefore, telestroke represents a strategy to bridge the geographic gap in access to both thrombolysis and mechanical recanalization.

BARRIERS TO TELESTROKE GROWTH

Despite mounting evidence demonstrating the promise of telestroke, expansion remains limited by rules and regulations that have not kept pace with advances in health care delivery. The most commonly cited barriers to expansion include licensing, credentialing, liability, and reimbursement.[19] Consider a Boston-based telestroke network in which an on-call neurologist covers 32 hospitals in three different states.[45] Each covering neurologist must maintain a medical license in all three states and maintain privileges at 32 different hospitals, creating an enormous administrative burden. Similarly, there is no legal standard on the medicolegal liability for these teleconsultations.[46] It remains unclear which physician assumes legal liability for treatment decisions and in which state that liability is assumed. Finally, reimbursement for telestroke continues to be inconsistent and frequently limited by regulations that do not account for the role of telemedicine. Ongoing efforts are required to continue to lobby state governments, insurers, and federal agencies to adapt to the changing landscape of telemedicine.

Supporting efforts such as the Interstate Medical Licensure Compact and reciprocal credentialing are initial steps to easing the barriers to expansion.

Despite these barriers to expansion, the growing need for neurologists in triaging acute stroke patients has spurred continued growth of telestroke. Along with extending acute stroke care, telestroke is evolving into new applications, including prehospital evaluations to maximize reperfusion speed. Ambulances equipped with mobile CT and point-of-care testing are now being sent out to suspected stroke patients in the field. Initially pioneered in Germany (where physicians are routinely in ambulances), this is now being studied in two separate clinical trials in the United States, leveraging telestroke for on-site evaluation and thrombolysis.[47,48] In addition to accelerating thrombolysis, prehospital evaluations can identify and triage embolectomy candidates to endovascular-capable centers, minimizing transfer delays and alerting the interventional team ahead of time. Beyond delivering acute care, telestroke can be leveraged to further clinical trials and develop novel therapy. Although most trials are performed in academic centers, the majority of patients are in the community. By linking academic medical resources to community hospitals, telestroke increases recruitment by tapping into a larger pool of patients.[49] With further efforts to ensure compliance with guidelines governing informed consent and clinical research guidelines, telestroke has the potential to help shape the future of therapeutics.

CONCLUSION

AIS remains an undertreated public health burden. The rise of both mechanical and pharmacologic approaches to reperfusion highlights the need for effective acute neurologic evaluation. Telestroke is the modern response to geographic gaps in acute stroke care, leveraging modern telecommunications technology to bring tertiary level stroke care to the local emergency department. In the endovascular era, telestroke is poised to extend the reach of endovascular-capable centers to patients who would otherwise go untreated. By safely, effectively, and efficiently delivering acute stroke therapy, telestroke has the potential to dramatically reorganize stroke care delivery systems in the endovascular era, and ultimately, maximize favorable patient outcomes. ■

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