Review Article

Telestroke Network Fundamentals

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The objectives of this manuscript are to identify key components to maintaining the logistic and/or operational sustainability of a telestroke network, to identify best practices to be considered for assessment and management of acute stroke when planning for and developing a telestroke network, to show practical steps to enable progress toward implementing a telestroke solution for optimizing acute stroke care, to incorporate evidence-based practice guidelines and care pathways into a telestroke network, to emphasize technology variables and options, and to propose metrics to use when determining the performance, outcomes, and quality of a telestroke network. **Key Words:** Evidence—fundamentals—stroke—telemedicine—telestroke.

Please access related webinars at www.stroke.org/telestroke_main. Please note that these webinars may be removed by the NSA in the future if the information is determined to be out of date or no longer valid.

Learning Objectives

- Identify best practices to be considered for assessment and management of acute stroke when planning for and developing a telestroke network
- Identify practical steps to enable progress toward implementing a telestroke solution for optimizing acute stroke care
- Discuss how to incorporate evidence-based practice guidelines and care pathways into a telestroke network
- Discuss telestroke technology
- Discuss what metrics to use when determining performance, outcomes, and quality of a telestroke network

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Section 1: Rationale for Building Telestroke Networks

The use of telemedicine, especially as it is relates to telestroke, has significantly expanded over the past 1 to 2 decades. The fact that stroke therapy is a time-critical disease process, coupled with the relative paucity of stroke-trained practitioners, makes telestroke an attractive technique of care. The promise of telestroke was detailed many years ago. Levine et al[1] noted the power of telestroke to improve elements of stroke care, including increasing recombinant tissue plasminogen activator (rt-PA) rates, consults, education, trial enrollments, mentoring, and even data collection. The attractiveness of this relatively new technology care option and the perception of low patient risk has enabled the use of telestroke to outpace the initial presentation of data to support that

use. Over time, the evidence has now begun to support this technique within stroke systems of care.[2] With this evidence, robust telestroke networks have begun to develop in order to care for a growing number of stroke patients throughout the nation.[3-6]

Section 2: Implementation of Telemedicine within Stroke Systems of Care: The Evidence

There is certainly a great need for immediate and acute care of stroke patients throughout the nation and the world. Although not a full measure of all stroke management elements, the ability to effectively provide acute rt-PA treatment is generally a surrogate marker for readiness and ability to care for acute stroke patients in a given facility. rt-PA is underused for stroke, with estimates of use being <5%.[7] Reasons for this low use are many, but likely include the lack of immediate specialist availability because of geographic barriers and the complexity of decision-making as key factors. By removing this geographic barrier, telemedicine may increase access to this stroke expertise, especially for remote areas. Implementing telemedicine in a systems of care model may be the final piece to ensuring that there is complete and consistent patient care at all remote spoke facilities that care for acute stroke patients.

Telemedicine evidence is available for both the prehospital and acute hospital evaluations of stroke patients. In the prehospital arena, one way to potentially decrease "symptom to treatment" times would be to assist emergency medical personnel in identifying potential stroke patients in the field and then transporting them to designated strokes. To that end, enabling telestroke in the ambulance may not only help increased diagnostic accuracy, but could provide earlier resource mobilization at the hub in order for the patient's arrival. This improved patient triage could potentially improve patient outcomes by decreasing "door to needle" times. In addition, the ability to provide neurologic expertise in the ambulance could enable potential neuroprotective therapies to be given in the field.[8] To date, there is only limited evidence supporting this use. The Maryland Brain Attack Team (Tele-BAT) assessed using cellular technologies to communicate with a hospital-based station via their Intranet.[9,10] Investigators showed the feasibility of evaluating prehospital neurologic deficits, even though there was unacceptably low bandwidth available for these assessments at that time. Because of these low frame rates, the broad application of telemedicine in emergency medical services vehicles was felt to be impractical, and no official recommendation was rendered in an evidence review publication.[2] Since that time, additional data on both feasibility and reliability are now being reported, and future use seems likey.[11]

There has also been evidence for the use of telestroke in acute stroke evaluations in the hospital setting. The National Institutes of Health Stroke Scale (NIHSS) is a 13-item graded neurologic examination that assesses consciousness, visual fields, gaze, motor, sensory, speech/language, and inattention/neglect. The scale was developed for use in clinical trials and is now frequently used in the evaluation of stroke patients clinically. This scale can be performed rapidly during a time-sensitive stroke evaluation. Inter-rater reliability data has been published showing excellent kappa reliability for performing an NIHSS examination at bedside[12,13] and telestroke, with 31% to 100% of the scores being in the excellent kappa range.[9,14-16] In the American Hearth Association (AHA) evidence manuscript, performing an NIHSS telestroke examination in nonacute stroke patients was felt to be comparable to a bedside assessment (class I, level A). Similarly, when no bedside specialist is available, performing a NIHSS via telestroke in the acute setting was granted the same rating (class I, level A) based on clinical trial publications[16,17] and comparative reliability data from acute stroke consultations.[3,6,9,18-25]

Neuroimaging evidence for teleradiology in stroke also has a great deal of evidence. Teleradiology systems approved by the US Food and Drug Administration (FDA) or equivalent organizations are recommended for the timely review of computed tomographic (CT) scans of the brain in patients with suspected acute stroke. The review of CT scans of the brain via teleradiology is useful for identifying exclusions for thrombolytic therapy in acute stroke patients (class I, level A) and can be effective in supporting rapid imaging interpretation in time for thrombolysis decision-making (class I, level B).

The evidence for using telestroke for rt-PA recommendations comes both from large comparative cohort data and randomized clinical trial data. The Telemedical Project for integrative Stroke Care (TEMPiS) study assessed 170 rt-PA patients at telestroke hospitals and compared them to 132 rt-PA patients in stroke center hospitals for mortality and good functional outcome.[26] The 6-month mortality was not different (14.2% *v* 13%; $P = .45$), and the functional outcome was equivalent both for modified Rankin Scale (39.5% *v* 30.9%; $P = .10$) and Barthel index (47.1% *v* 44.8%; $P = .44$). The Stroke Team Remote Evaluation using a Digital Observation Camera (STRokE DOC) trial was a randomized trial comparing telemedicine to telephone for appropriateness of medical decision-making using a complex, multi-level, central adjudication process.[27] This National Institutes of Health–funded trial was halted early, and the final results revealed the correctness of decision-making to be superior in the telestroke arm compared to the telephone-only arm (98% *v* 82%; $P = .0009$) with no differences in poststroke intracerebral hemorrhage. On the strength of these assessments, it was determined that a stroke specialist using high-quality videoconferencing to provide a medical opinion in favor of or against the use of intravenous (IV) rt-PA in patients with suspected acute ischemic stroke when on site stroke