



Center for  
**Connected  
Health Policy**  
The National Telehealth Policy Resource Center

## Telestroke Research Catalogue

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August 2018

To increase and organize the evidence for the use of telehealth, the Center for Connected Health Policy (CCHP) has been examining published studies that have been designed to measure the use of telehealth in achieving one or more of the goals of the Triple Aim. CCHP has been cataloguing studies published in peer reviewed journals that meet certain criteria. This catalogue of Telestroke studies is one result.

CCHP employed several search parameters when selecting Telestroke studies. Selected studies in the main catalogue are U.S. based, though international studies that fit the remainder of the criteria have been noted in a separate section beginning on page 20. The studies had to be published post 2007, have a sample size of no less than 50 (for studies with control groups, there needed to be a minimum of at least 30 subjects per group), a study period of no less than 6 months (however, if the study length wasn't specified, the study was still included) and a primary focus on the outcomes, quality and or costs of a selected telehealth modality.

Pub Med, Science Direct, Scopus, EBSCO, ProQuest, WorldCat, JSTOR and Sage Journals were used in the peer-reviewed articles search. If CCHP was unable to obtain a copy of the full article, it was not included in the catalogue due to the inability to measure the quality fully. Search terms included, but were not limited to: telestroke, telemedicine and stroke, telehealth and stroke, telemedicine and t-PA, telehealth and t-PA, telestroke and quality, telestroke and outcomes, telestroke and cost, telestroke and cost-savings, and telestroke and cost-efficiency. Each search was duplicated using a hyphenated form of the word (ex. Tele-stroke).

This catalogue was prepared by Taylor Whited; the work was supervised by Mei Wa Kwong and Christine Calouro. The catalogue was updated in August 2017 by Marcus Warren, and again in July 2018 by McKenna Thompson.

Al, K. S., Orabi, M. Y., Harvey, J. B., Turner, N., Aysse, P., Debenham, E., & Holmstedt, C. A. (2018). Rate of Symptomatic Intracerebral Hemorrhage Related to Intravenous tPA Administered Over Telestroke Within 4.5-Hour Window. *Telemedicine Journal and E-Health: the Official Journal of the American Telemedicine Association*.

Study Length	State	Sample Size	Telehealth Modality Type	Method	Outcome	Quality	Cost
8 years, 8 months	SC	830	Live Video; Store-and-Forward	Retrospective Analysis	x	x	

### Summary

**Background:** Intravenous tissue plasminogen activator (tPA) remains the cornerstone medical treatment for acute ischemic stroke. The establishment of telestroke technology has allowed patients presenting to hospitals that lack expert stroke care to be evaluated and receive tPA. The safety of tPA administered through telestroke has been evaluated only when tPA is given within the 3-h window of last known normal. The purpose of this study is to evaluate the safety of tPA when administered through telestroke within a 4.5-h window.

**Methods:** A retrospective analysis on the prospectively collected database for all patients who received tPA at the Medical University of South Carolina Comprehensive Stroke Center (MUSC) (hub), as well as the MUSC telestroke network partner hospitals (spokes), was performed. Collected data included demographics, baseline characteristics, time from last known well to tPA administration, and symptomatic intracerebral hemorrhage (sICH) rates. Logistic regression was used to examine the odds of a sICH in patients at spoke sites compared with the hub controlling for patient stroke severity, gender, age, and race.

**Results:** A total of 830 patients were identified. Median National Institute of Health Stroke Scale was significantly higher among patients treated at the hub (9 vs. 8,  $p = 0.013$ ), and the hub treated a higher percentage of nonwhite patients ( $p = 0.039$ ). sICH occurred in 27 (4.8%) in the spoke group and 10 (3.8%) in the hub group ( $p = 0.523$ ). Logistic regression results found no significant difference in the odds of sICH if tPA is given in a spoke site.

**Conclusions:** Our study shows similar rates of sICH when intravenous tPA is administered at spokes through telestroke network compared with the hub.

Access: <https://www.ncbi.nlm.nih.gov/pubmed/29369743>

Sauser-Zachrison, K. (2016). Safe and Effective Implementation of Telestroke in a US Community Hospital Setting. *The Permanente Journal*.

Study Length	State	Sample Size	Telehealth Modality Type	Method	Outcome	Quality	Cost
1 year, 6 months	CA	2657	Live Video; Store-and-Forward	Stepped-Wedge Cluster Randomized Trial	x	x	

#### Summary

**Context:** There is substantial hospital-level variation in use of tissue plasminogen activator (tPA) for treatment of acute ischemic stroke. Telestroke services can bring neurologic expertise to hospitals with fewer resources.

**Objective:** To determine whether implementation of a telestroke intervention in a large integrated health system would lead to increased tPA utilization and would change rates of hemorrhagic complications.

**Design:** A stepped-wedge cluster randomized trial of 11 community hospitals connected to 2 tertiary care centers via telestroke, implemented at each hospital incrementally during a 1-year period. We examined pre- and post-implementation data from July 2013 through January 2015. A 2-level mixed-effects logistic regression model accounted for the staggered rollout.

**Main Outcome Measures:** Receipt of tPA. Secondary outcome was the rate of significant hemorrhagic complications.

**Results:** Of the 2657 patients, demographic and clinical characteristics were similar in pre- and post-intervention cohorts. Utilization of tPA increased from 6.3% before the intervention to 10.9% after the intervention, without a significant change in complication rates. Post-

intervention patients were more likely to receive tPA than were pre-intervention patients (odds ratio = 2.0; 95% confidence interval = 1.2-3.4). Before implementation, 8 of the 10 community hospitals were significantly less likely to administer tPA than the highest-volume tertiary care center; however, after implementation, 9 of the 10 were at least as likely to administer tPA as the highest-volume center.

**Conclusion:** Telestroke implementation in a regional integrated health system was safe and effective. Community hospitals' rates of tPA utilization quickly increased and were similar to the largest-volume tertiary care center.

**Access:** <https://www.ncbi.nlm.nih.gov/pubmed/27479951>

Agrawal, K., Raman, R., Ernstrom, K., Claycomb, R. J., Meyer, D. M., Hemmen, T. M., Modir, R. F., Meyer, B. C. (2016). Accuracy of Stroke Diagnosis in Telestroke-Guided Tissue Plasminogen Activator Patients. *Journal of Stroke and Cerebrovascular Diseases*, 25, 12, 2942-2946.

Study Length	State	Sample Size	Telehealth Modality Type	Method	Outcome	Quality	Cost
1 year, 9 months	CA	80	Live Video	Retrospective Review	x	x	

#### Summary

**Objectives:** The objective of the study is to assess the accuracy of final diagnosis in telestroke-guided tissue plasminogen activator (rt-PA) patients compared with bedside evaluation using computed tomography (CT) or magnetic resonance imaging (MRI) as a surrogate for final stroke diagnosis. The overall goal was to determine if telestroke had similar diagnostic accuracy as bedside evaluations in diagnosing rt-PA-treated patients.

**Materials and Methods:** We analyzed all acute stroke code calls who received intravenous rt-PA at our center from October 2013 to June 2015. Calls were grouped into patients who were initially evaluated by telestroke at a spoke partner site (spoke) and patients evaluated in person at the hub. Patients receiving additional neurointervention were excluded to avoid confounding. Relevant variables included

severity of stroke (National Institutes of Health Stroke Scale [NIHSS]), rt-PA times, presence of intracranial hemorrhage (ICH), and primary outcome of CT or MRI evidence of stroke after rt-PA administration. Post-rt-PA imaging used included CT or MRI within 72 hours after treatment.

**Results:** Overall, 80 patients received intravenous rt-PA (spoke [n = 23] and hub [n = 57]). There was no difference in mean NIHSS score prior to treatment ( $10.3 \pm 9.2$  and  $9.8 \pm 8.4$ ;  $P = .936$ ), “onset-to-treatment” time ( $143.6 \pm 53.5$  minutes and  $141.0 \pm 54.1$  minutes;  $P = .915$ ), and ICH rate (13% and 8.8%; adjusted  $P = .898$ ). The presence of radiographic evidence of stroke at spoke versus hub was not different (78.3% and 66.7%; adjusted  $P = .338$ ). The most commonly used radiographic modality was MRI (MRI: 80%, CT: 20%).

**Conclusions:** Using imaging as a surrogate for final diagnosis resulted in no difference in final stroke diagnosis rate between the groups, reinforcing that telestroke evaluations are as accurate as bedside evaluations in diagnosing acute stroke.

**Access:** <https://www.ncbi.nlm.nih.gov/pubmed/27599906>

Sanders, K., Patel, R., Kiely, J., Gwynn, M., Johnston, L. (2016). Improving Telestroke Treatment Times in an Expanding Network of Hospitals. *Journal of Stroke and Cerebrovascular Diseases*, 25(2), 288-291.

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
2 years	GA, AL, SC, TN	165	Live Video	x	x	

#### Summary

**Background:** Like all medical innovations, telestroke must demonstrate successful outcomes to achieve sustained growth and acceptance. Asserting that telemedicine is faster, employs the latest technology, or promotes a better use of limited resources is laudable but insufficient. An analysis of stroke treatment within a telemedicine network in 2013 showed that tissue-type plasminogen activator (tPA) could be safely and reliably administered within a practice-based model of telestroke care. Since then, hospital volume and tPA administration within this network have tripled. We hypothesize that a practice-based model of telestroke can maintain positive

outcomes in the face of rapid growth.

**Methods:** Data on tPA treatment times and outcomes after thrombolysis were gathered for 165 patients treated with alteplase between November 2012 and November 2014. Comparisons were made to a previous published study of 54 patients seen between October 2010 and October 2012 in the same network. Primary outcome measures were average door-to-needle (DTN) time for TPA administration and average call-to-needle (CTN) time.

**Results:** Significant reductions were observed in median DTN (93 versus 75 minutes,  $P < .01$ ) and median CTN (56 versus 41 minutes,  $P < .01$ ). Quality outcome measures such as post-tPA symptomatic hemorrhage (2 [4%] versus 9 [5%],  $P = .23$ ), length of stay (4 versus 4 days,  $P = .45$ ), mortality (8 [15%] versus 16 [10%];  $P = .32$ ), and percentage of stroke patients treated remained stable.

**Conclusions:** This study shows that a practice-based telemedicine system can produce meaningful improvement in markers of telestroke efficiency in the face of rapid growth of a telestroke network.

**Access:** <http://www.ncbi.nlm.nih.gov/pubmed/26654667>

Heffner, D., Thirumala, P., Pokharna, P., Chang, Y., Wechsler, L. (2015). Outcomes of Spoke-Retained Telestroke Patients Versus Hub-Treated Patients After Intravenous Thrombolysis: Telestroke Patient Outcomes After Thrombolysis. *Stroke*, 46(11), 3161-3167.

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
8 years	PA	272, 134	Unspecified	x	x	

#### Summary

**Background and Purpose:** The outcomes of patients remaining at a community spoke hospital after tissue-type plasminogen activator treatment via telemedicine are unclear. Our aim was to compare medical outcomes between these patients and those treated at a hub stroke center.

**Methods:** We retrospectively examined patient medical records from 2006 to 2014 of 272 consecutive patients treated with intravenous tissue-type plasminogen activator at University of Pittsburgh Medical Center (UPMC) Presbyterian Hospital, a telestroke hub, and 134 consecutive patients treated after telemedicine consultation at 5 UPMC spoke hospitals, who then remained at these hospitals (drip-and-stay). Complications included mortality, length of stay, and common post-stroke medical complications. We performed multivariate analysis to identify complications that are independently increased or decreased in the drip-and-stay population. We also performed a Cox proportional hazards regression to compare long-term survival.

**Results:** The drip-and-stay patients had less severe strokes (National Institutes of Health Stroke Scale score,  $9.5 \pm 5.9$  versus  $12.7 \pm 7.1$ ;  $P < 0.001$ ) and fewer large vessel occlusions (11.9% versus 36%;  $P < 0.001$ ). After controlling for all variables with multivariate analysis, we found that the drip-and-stay patients had an increased risk of adjusted in-hospital mortality (adjusted odds ratio 11.046; 95% confidence interval, 2.785–43.810) and having a length of stay  $> 6$  days (adjusted odds ratio, 4.696, 95% confidence interval, 2.428–9.083) [corrected]. Furthermore, the drip-and-stay patients had significantly decreased long-term survival compared with the hub patients ( $P < 0.001$ ).

**Conclusions:** Despite having less severe strokes, the drip-and-stay patients had an increased adjusted risk of in-hospital mortality, longer length of stay, and lower long-term survival than hub hospital patients. Further studies are needed to confirm the findings and address differences in post-tissue-type plasminogen activator medical care.

**Access:** <http://www.ncbi.nlm.nih.gov/pubmed/26396027>

**Lazaridis, C., DeSantis, SM., Jauch, EC., Adams, RJ. (2013). Telestroke in South Carolina. *Journal of Stroke and Cerebrovascular Diseases* 22(7):946-950.**

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
2.5 years	SC	519	Live Video	x	x	

#### Summary

**Background:** The administration of thrombolysis to eligible patients is often limited to centers with expertise. This study was intended to report on the safety and efficacy (in increasing thrombolysis availability) of telemedicine in the acute assessment and treatment of stroke

patients presenting to hospitals in distant locations from a designated stroke center.

**Methods:** A web-based telestroke tool (remote evaluation of acute ischemic stroke at Medical University of South Carolina [REACH-MUSC]), was implemented to provide acute stroke care 24 hours per day, 7 days per week to 12 community hospitals in South Carolina.

**Results:** Nine hundred sixty-five consults were performed. Among the 525 patients with a National Institutes of Health Stroke Score  $\geq 3$ , 185 (35.7%) were treated with intravenous tissue plasminogen activator (t-PA) alone, 15 (2.9%) received combination of intravenous and intra-arterial thrombolysis/thrombectomy, and 11 (2.1%) were treated with intra-arterial therapy alone. Of those who received intravenous t-PA, 119 (64.3%) were transferred to the hub; the medians (interquartile range) for onset to treatment for the intravenous t-PA and the intravenous t-PA and intra-arterial groups were 152 (range 115-193) minutes and 147 (range 107-179) minutes, respectively. Three patients (1.6%) who received intravenous t-PA alone experienced symptomatic intracerebral hemorrhage. The most common reason for not receiving thrombolysis was patient presentation outside the time window for treatment.

**Conclusions:** Telestroke can have a major impact in increasing thrombolysis rates in remote areas from specialized centers, and in particular in areas where t-PA is underutilized.

**Access:** <http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2011.11.008>

Amorim, E., Shih, MM., Koehler, SA., Massaro, LL., Zaidi, SF., Jumaa, MA., Reddy, VK., Hammer, MD., Jovin, TG., Wechsler, LR. (2013). Impact of Telemedicine Implementation in Thrombolytic Use for Acute Ischemic Stroke: The University of Pittsburg Medical Center Telestroke Network Experience. *Journal of Stroke and Cerebrovascular Diseases* 22(4):527-531.

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
3 years	PA	2588	Live Video	x	x	

#### Summary

**Background:** Intravenous thrombolysis is the only therapy for acute ischemic stroke that is approved by the US Food and Drug

Association. The use of telemedicine in stroke makes it possible to bring the expertise of academic stroke centers to underserved areas, potentially increasing the quality of stroke care.

**Methods:** All consecutive admissions for stroke were reviewed for 1 year before telemedicine implementation and for variable periods thereafter. A retrospective review identified 2588 admissions for acute stroke between March 2005 and December 2008 at 12 hospitals participating in a telestroke network, including 919 patients before telemedicine was available and 1669 patients after telemedicine was available. The primary outcome measure was the rate of intravenous tissue plasminogen activator (IV tPA) use before and after telemedicine implementation.

**Results:** One hundred thirty-nine patients received IV tPA in both study phases, with 26 (2.8%) patients treated before starting telemedicine and 113 (6.8%) after starting telemedicine ( $P < .001$ ). Incorrect treatment decisions occurred 7 times (0.39%), with 2 (0.2%) pre-telemedicine and 5 (0.3%) post-telemedicine ( $P = .70$ ). Arrivals within 3 hours from symptom onset were more frequent in the post-telemedicine compared to the pre-telemedicine phases (55 [6%] vs 159 [9.5%];  $P = .002$ ). Among the patients treated with IV tPA, symptomatic intracranial hemorrhage occurred in 2 patients (1 [10.7%] pre-telemedicine vs 1 [1.8%] post-telemedicine;  $P = .34$ ).

**Conclusions:** Telestroke implementation was associated with an increased rate of thrombolytic use in remote hospitals within the telemedicine network.

**Access:** <http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2013.02.004>

Chalouhi, N., Dressler, JA., Kunkel, ESI., Dalyai, R., Jabbour, P., Gonzalez, LF., Starke, RM., Dumont, AS., Rosenwasser, R., Tjoumakaris, S. (2013). Intravenous Tissue Plasminogen Activator Administration in Community Hospitals Facilitated by Telestroke Service. *Neurosurgery* 73:667-672.

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
1.5 years	PA, NJ, DE	1643	Live Video	x	x	

### Summary

**BACKGROUND:** Stroke is a leading cause of death and disability in the United States. Despite the proven benefits of intravenous tissue plasminogen activator (IV-tPA), only a small percentage of patients who have had a stroke (3.4%-5.2%) receive this US Food and Drug Administration-approved therapy.

**OBJECTIVE:** To prospectively assess the impact of a telestroke network on the rate of IV-tPA administration in patients with acute ischemic stroke in community hospitals.

**METHODS:** Thomas Jefferson University Hospital has developed a telestroke system providing acute stroke care in 28 community hospitals within the region (Pennsylvania, New Jersey, and Delaware). Telemedicine consultations are delivered through Remote Presence robotic technology.

**RESULTS:** A total of 1643 telemedicine stroke consultations were provided between January 2011 and June 2012. The mean interval from consultation request to telemedicine response was 12.0 minutes. The overall rate of IV-tPA use was 14% among all stroke consultations. A total of 237 patients (14.4%) were determined to be eligible for intravenous thrombolysis. Of those, 97% received IV-tPA. Most hospitals (82%) within the telemedicine program reported an increase in IV-tPA use (mean increase, 55%). The proportion of patients transferred to a primary stroke center after teleconsultation decreased from 44% in the first 2 quarters of 2011 to 19% in the first 2 quarters of 2012 ( $P < .001$ ).

**CONCLUSION:** Implementing a telestroke system facilitates high rates of intravenous thrombolysis in patients who have had a stroke in community hospitals within a relatively short time frame. These results are higher than the national average rate (3.4%-5.2%) and support

the implementation of telestroke networks for wider access to stroke expertise in underserved regions.

**Access:** <http://dx.doi.org/10.1227/NEU.0000000000000073>

**Bruno, A., Lanning, KM., Gross, H., Hess, DC., Nichols, FT., Switzer, JA. (2013). Timeliness of Intravenous Thrombolysis via Telestroke in Georgia. *Stroke* 44:2620-2622.**

Study Length	State	Sample Size	Telehealth Modality Type	Method	Outcome	Quality	Cost
20 months	GA	115	Live Video	Retrospective	x	x	

#### Summary

**BACKGROUND AND PURPOSE:** Through 2-way live video and audio communication, telestroke enhances urgent treatment of patients with acute stroke in emergency departments (EDs) without immediate access to on-site specialists. To assess for opportunities to shorten the door to thrombolysis time, we measured multiple time intervals in a telestroke system.

**METHODS:** We retrospectively analyzed 115 records of consecutive acute stroke patients treated with intravenous thrombolysis during a 20-month period via a statewide telestroke system in 17 EDs in Georgia. On the basis of times documented in the telestroke system, we calculated the time elapsed between the following events: ED arrival, telestroke patient registration, start of specialist consultation, head computed tomography, thrombolysis recommendation, and thrombolysis initiation.

**RESULTS:** The most conspicuous delay was from ED arrival to telestroke patient registration (median, 39 minutes; interquartile range, 21-56). Median time from ED arrival to thrombolysis initiation was 88 minutes, interquartile range 75 to 105. Thrombolysis was initiated within 60 minutes from ED arrival in 13% of patients.

**CONCLUSIONS:** The greatest opportunity to expedite acute thrombolysis via telestroke is by shortening the time from ED arrival to

telestroke patient registration.

**Access:** <http://dx.doi.org/10.1161/STROKEAHA.113.001898>

**Demaerschalk, BM., Vegunta, S., Vargas, BB., Wu, Q., Cahnner, DD., Hentz, JG. (2012). Reliability of Real-Time Video Smartphone for Assessing National Institutes of Health Stroke Scale Scores in Acute Stroke Patients. *Stroke* 43:3271-3277.**

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
unspecified	AZ	100	Live Video	x	x	

### Summary

**Background and Purpose**—Telestroke reduces acute stroke care disparities between urban stroke centers and rural hospitals. Current technologies used to conduct remote patient assessments have high start-up costs, yet they cannot consistently establish quality timely connections. Smartphones can be used for high-quality video teleconferencing. They are inexpensive and ubiquitous among health care providers. We aimed to study the reliability of high-quality video teleconferencing using smartphones for conducting the National Institutes of Health Stroke Scale (NIHSS).

**Methods**—Two vascular neurologists assessed 100 stroke patients with the NIHSS. The remote vascular neurologist assessed subjects using smartphone videoconferencing with the assistance of a bedside medical aide. The bedside vascular neurologist scored patients contemporaneously. Each vascular neurologist was blinded to the other's NIHSS scores. We tested the inter-method agreement and physician satisfaction with the device.

**Results**—We demonstrated high total NIHSS score correlation between the methods ( $r=0.949$ ;  $P<0.001$ ). The mean total NIHSS scores for bedside and remote assessments were  $7.93\pm 8.10$  and  $7.28\pm 7.85$ , with ranges, of 0 to 35 and 0 to 37, respectively. Eight categories had high agreement: level of consciousness (questions), level of consciousness (commands), visual fields, motor left and right (arm and leg), and best language. Six categories had moderate agreement: level of consciousness (consciousness), best gaze, facial palsy, sensory, dysarthria, and extinction/inattention. Ataxia had poor agreement. There was high physician satisfaction with the smartphone.

**Conclusions**—Smartphone high-quality video teleconferencing is reliable, easy to use, affordable for telestroke NIHSS administration, and has high physician satisfaction.

**Access:** <http://dx.doi.org/10.1161/STROKEAHA.112.669150>

Demaerschalk, BM., Vargas, JE., Channer, DD., Noble, BN., Kiernan, TEJ., Gleason, EA., Vargas, BB., Ingall, TJ., Aguilar, MI., Dodick, DW., Bobrow, BJ. (2012). Smartphone Teleradiology Application is Successfully Incorporated Into a Telestroke Network Environment. *Stroke* 43:3098-3101.

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
unspecified	AZ	53	Store and Forward	x	x	

#### Summary

**Background and Purpose**—ResolutionMD mobile application runs on a Smartphone and affords vascular neurologists access to radiological images of patients with stroke from remote sites in the context of a telemedicine evaluation. Although reliability studies using this technology have been conducted in a controlled environment, this study is the first to incorporate it into a real-world hub and spoke telestroke network. The study objective was to assess the level of agreement of brain CT scan interpretation in a telestroke network between hub vascular neurologists using ResolutionMD, spoke radiologists using a Picture Archiving and Communications System, and independent adjudicators.

**Methods**—Fifty-three patients with stroke at the spoke hospital consented to receive a telemedicine consultation and participate in a registry. Each CT was evaluated by a hub vascular neurologist, a spoke radiologist, and by blinded telestroke adjudicators, and agreement over clinically important radiological features was calculated.

**Results**—Agreement ( $\kappa$  and 95% CI) between hub vascular neurologists using ResolutionMD and (1) the spoke radiologist; and (2) independent adjudicators, respectively, were: identification of intracranial hemorrhage 1.0 (0.92–1.0), 1.0 (0.93–1.0), neoplasm 1.0 (0.92–1.0), 1.0 (0.93–1.0), any radiological contraindication to thrombolysis 1.0 (0.92–1.0), 0.85 (0.65–1.0), early ischemic changes 0.62 (0.28–0.96), 0.58 (0.30–0.86), and hyperdense artery sign 0.40 (0.01–0.80), 0.44 (0.06–0.81).

**Conclusions**—CT head interpretations of telestroke network patients by vascular neurologists using ResolutionMD on Smartphones were in excellent agreement with interpretations by spoke radiologists using a Picture Archiving and Communications System and those of

independent telestroke adjudicators using a desktop viewer.

**Access:** <http://dx.doi.org/10.1161/STROKEAHA.112.669325>

**Meyer, BC., Raman, R., Ernstrom, K., Tafreshi, GM., Huisa, B., Stemer, AB., Hemmen, TM. (2012). Assessment of Long-Term Outcomes for the STROkE DOC Telemedicine Trial. *Journal of Stroke and Cerebrovascular Diseases* 21(4):259-264.**

Study Length	State	Sample Size	Telehealth Modality Type	Method	Outcome	Quality	Cost
1 year	N/A (USA)	75	Live Video and telephone	Retrospective	x		

#### Summary

Telemedicine can provide stroke evaluations in locations with limited available expertise. The reliability of telestroke has been established. Decision making efficacy has been shown in the National Institutes of Health's STROkE DOC trial. No prospective trial has assessed long-term telestroke outcomes, however. In an institutional review board-approved trial (NCT00936455), we contacted patients originally enrolled in the STROkE DOC trial. A telephone script was used to verify consent. Patients were asked standardized questions regarding disposition, modified Rankin Scale (mRS) score, mortality, and recurrent stroke for 2 retrospective time points (6 and 12 months postevent) and one current time point. Blind was maintained. Primary outcome measures of mortality and percent mRS score of 0-1 [%mRS(0-1)] at 6 months are reported. Wilcoxon's rank-sum test was used for continuous variables, and Fisher's exact was used for categorical variables. Of the original 222 participants, 75 patients or surrogates could be contacted. Mean time from enrollment was  $3.96 \pm 1.0$  years (range, 2.33-5.45 years). Mean National Institutes of Health Stroke Scale (NIHSS) score was  $8 \pm 7$  ( $5 \pm 8$  for telephone;  $12 \pm 8$  for telemedicine;  $P = .002$ ). The rate of intravenous recombinant tissue plasminogen activator (rt-PA) use was 31%. Six-month %mRS(0-1) outcome was not different, at 42%. Mortality after imputation to the entire study sample also was not different, at 18%. There was no difference in the rate of recurrent stroke ( $P = .61$ ). Some 85% of patients were home at 6 months. This study reports a good 6-month outcome for stroke patients evaluated by telemedicine or telephone. This design is limited by the time since original enrollment and

resultant inability to contact participants. Although these findings can add to the limited data on telemedicine outcomes, a prospective trial is needed.

**Access:** <http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2010.08.04>

**Demaerschalk, BM., Raman, R., Ernstrom, K., Meyer, BC. (2012). Efficacy of Telemedicine for Stroke: Pooled Analysis of the Stroke Team Remote Evaluation Using a Digital Observation Camera (STRoKE DOC) and STRoKE DOC Arizona Telestroke Trials. *Telemedicine and e-Health* 18(3):230-237.**

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
unspecified	CA, AZ	276	Live Video and Telephone	x	x	

#### Summary

**Background and Purpose:** Telemedicine can disseminate vascular neurology expertise and optimize recombinant tissue plasminogen activator (rt-PA) use for acute ischemic stroke in rural underserved communities. The purpose of this study was to prospectively assess whether telemedicine or telephone was superior for decision-making.

**Methods:** The study design is a pooled analysis of two identically designed randomized controlled trials conducted in a multistate hub and spoke telestroke network setting with acute stroke syndrome patients, comparing telemedicine versus telephone-only consultations. From each trial, common data elements were pooled to assess, principally, for correctness of thrombolysis decision-making. Secondary outcomes included rt-PA use rate, 90-day functional outcome, post-thrombolysis intracranial hemorrhage, and data completeness.

**Results:** Two hundred seventy-six pooled patients were evaluated. Correct thrombolysis eligibility decisions were made more often with telemedicine (96% telemedicine, 83% telephone; odds ratio [OR] 4.2; 95% confidence interval [CI] 1.69–10.46; p=0.002). Intravenous rt-PA usage was 26% (29% telemedicine, 24% telephone; OR 1.27; 95% CI 0.71–2.25; p=0.41). Ninety-day outcomes were not different for Barthel Index, modified Rankin Scale, or mortality. There was no difference in post-thrombolysis intracranial hemorrhage (8%

telemedicine, 6% telephone;  $p > 0.999$ ).

**Conclusions:** This pooled analysis supports the hypothesis that stroke telemedicine consultations, compared with telephone-only, result in more accurate decision-making. Together with high rt-PA utilization rate, low post-rt-PA intracranial hemorrhage rate, and acceptable patient outcome, the results confirm that telemedicine is a viable consultative tool for acute stroke. The replication of the hub and spoke network infrastructure supports the generalizability of telemedicine when used in broader settings.

**Access:** <http://dx.doi.org/10.1089/tmj.2011.0116>

Zaidi, SF., Jumma, MA., Urra, XN., Hammer, M., Massaro, L., Reddy, V., Jovin, T., Lin, R., Wechsler, LR. (2011) Telestroke-Guided Intravenous Tissue-Type Plasminogen Activator Treatment Achieves a Similar Clinical Outcome as Thrombolysis at a Comprehensive Stroke Center. *Stroke* 42:3291-9293.

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
1.5 years	PA	351	Live Video	x		

#### Summary

**Background and Purpose**—Telestroke networks offer an opportunity to increase tissue-type plasminogen activator use in community hospitals.

**Methods**—We compared 83 patients treated with intravenous tissue-type plasminogen activator by telestroke to 59 patients treated after in-person evaluation by the same neurologists at a tertiary care stroke center. Onset and door-to-treatment times and functional outcome at 90 days were obtained prospectively. Favorable outcome was defined as modified Rankin Scale score  $\leq 2$ .

**Results**—Favorable outcome rates were comparable between the groups (42.1% versus 37.5%,  $P=0.7$ ). There was no significant difference in the rate of symptomatic hemorrhage.

**Conclusions**—Telestroke is a viable alternative to in-person evaluation when stroke expertise is not readily available.

**Access:** <http://dx.doi.org/10.1161/STROKEAHA.111.625046>

Pervez, MA., Silva, G., Masrur, S., Betensky, RA., Furie, KL., Hidalgo, R., Lima, F., Rosenthal, ES., Rost, N., Viswanathan, A., Schwamm, LH. (2010). Remote Supervision of IV-tPA for Acute Ischemic Stroke by Telemedicine or Telephone Before Transfer to a Regional Stroke Center is Feasible and Safe. *Stroke* 41:e18-e24.

Study Length	State	Sample Size	Telehealth Modality Type	Method	Outcome	Quality	Cost
5 years	MA	296	Remote Patient Monitoring	Retrospective	x		

#### Summary

**Background and Purpose**— Because of a shortage of stroke specialists, many outlying or “spoke” hospitals initiate intravenous (IV) thrombolysis using telemedicine or telephone consultation before transferring patients to a regional stroke center (RSC) hub. We analyzed complications and outcomes of patients treated with IV tissue plasminogen activator (tPA) using the “drip and ship” approach compared to those treated directly at the RSC.

**Methods**— A retrospective review of our Get With the Guidelines Stroke (GWTG-Stroke) database from 01/2003 to 03/2008 identified 296 patients who received IV tPA within 3 hours of symptom onset without catheter-based reperfusion. GWTG-Stroke definitions for symptomatic intracranial (sICH), systemic hemorrhage, discharge functional status, and destination were applied. Follow-up modified Rankin Score was recorded when available.

**Results**— Of 296 patients, 181 (61.1%) had tPA infusion started at an outside spoke hospital (OSH) and 115 (38.9%) at the RSC hub. OSH patients were younger with fewer severe strokes than RSC patients. Patients treated based on telestroke were more frequently octogenarians than patients treated based on a telephone consult. Mortality, sICH, and functional outcomes were not different between OSH versus RSC and telephone versus telestroke patients. Among survivors, mean length of stay was shorter for OSH patients but

discharge status was similar and 75% of patients walked independently at discharge.

**Conclusions**— Outcomes in OSH “drip and ship” patients treated in a hub-and-spoke network were comparable to those treated directly at an RSC. These data suggest that “drip and ship” is a safe and effective method to shorten time to treatment with IV tPA.

**Access:** <http://dx.doi.org/10.1161/STROKEAHA.109.560169>

**Meyer, BC., Raman, R., Hemmen, T., Obler, R., Zivin, JA., Rao, R. (2008). Efficacy of site-independent telemedicine in the STRokE DOC trial: a randomized, blinded, prospective study. *Lancet Neurology* 7(9):787-795.**

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
4 years	CA	234	Live Video and Telephone	x	x	

#### Summary

**Background**—To increase effective use of rt-PA for acute stroke, vascular neurology expertise must be disseminated more widely. We prospectively assessed whether telemedicine (real-time, 2 way audio/video and DICOM interpretation) or telephone was superior for decision-making in acute telemedicine consultations.

**Methods**—Acute stroke patients were randomized to telemedicine or telephone consultation. Primary outcome measure was whether the thrombolytic treatment decision was correct, as determined by central adjudication. Secondary outcomes included rt-PA use-rate, 90 day functional outcomes, hemorrhages, and technical observations.

**Findings**—Two hundred thirty-four patients were prospectively evaluated. Mean NIHSS score was 9.5 (11.4±8.7 telemedicine, 7.7±7.0 telephone; p=0.0020). One telemedicine consult (0.9%) was aborted for technical reasons, though was included in intention-to-treat analyses. Correct treatment decision was made more often in telemedicine (98.2% telemedicine, 82% telephone; OR 10.9; 95% CI 2.7-44.6; p=0.0009). IV rt-PA use-rate was 25% (28% telemedicine, 23% telephone; OR 1.3; 95% CI 0.7-2.5; p=0.4248). Ninety day functional

outcomes were not different for BI(95–100) (OR 0.6; 95%CI 0.4-1.1; p=0.1268) or for mRS (OR 0.6; 95%CI 0.3-1.1; p=0.0898). There was no mortality difference (OR 1.6; 95%CI 0.8-3.4; p=0.2690). Post-rt-PA ICH rates were not different (7% telemedicine, 8% telephone; OR 0.8; 95%CI 0.1-6.3; p=1.0). There was a difference noted for amount of non-completed data (3.1% telemedicine, 12.0% telephone; OR 0.2; 95%CI 0.1-0.3; p<0.001).

**Interpretation**—This trial reports that stroke telemedicine consultations result in more accurate decision making, compared to telephone, and can serve as a model for the effective use of telemedicine in other medical fields. The more appropriate decisions, high rt-PA userates, improved data collection, low ICH rates, low technical complications, and favorable time requirements all support telemedicine’s efficacy, most specifically for decision-making, and may enable more practitioners to use telemedicine in daily stroke care.

**Access:** [http://dx.doi.org/10.1016/S1474-4422\(08\)70171-6](http://dx.doi.org/10.1016/S1474-4422(08)70171-6)

**Switzer, JA., Hall, C., Gross, H., Waller, J., Nichols, FT., Wang, S., Adams, RJ., Hess, DC. (2008). A Web-Based Telestroke System Facilitates Rapid Treatment of Acute Ischemic Stroke Patients in Rural Emergency Departments. *The Journal of emergency Medicine* 36(1):12-18.**

Study Length	State	Sample Size	Telehealth Modality Type	Outcome	Quality	Cost
3 years	GA	50	Live Video	x	x	

#### Summary

Patients in rural communities lack access to acute stroke therapies. Rapid administration of thrombolytic therapy increases the likelihood of a favorable outcome in ischemic stroke. We aimed to detail the safety, feasibility, and treatment times of thrombolytic therapy with a web-based telestroke system. At the Medical College of Georgia, we have developed a telestroke system (Remote Evaluation of Acute IsCHemic Stroke; REACH) in which emergency physicians in surrounding counties may consult stroke specialists at our institution. The web-based system allows the stroke consultant to obtain history, examine the patient with live video, and review computed tomography. A recommendation is made regarding the administration of tissue plasminogen activator (tPA) before patient transport to the tertiary

medical center. A systematic review of the literature was conducted regarding the use of tPA in academic and community hospitals. Symptomatic hemorrhagic transformation and stroke onset-to-treatment times were compared between the REACH network and other stroke care delivery systems. Between February 2003 and March 2006, 50 patients were treated with intravenous tPA using the REACH telestroke system. There was one (2%) symptomatic hemorrhage. The mean onset-to-treatment time was 127.6 min (95% confidence interval 117.1–138.0) using REACH compared with 145.9 min (95% confidence interval 126.9–164.9) in our Emergency Department and 147.8 min in other published systems. REACH, a web-based telestroke system, facilitates the safe administration of thrombolytic therapy to patients within rural communities suffering an acute ischemic stroke

Access: <http://dx.doi.org/10.1016/j.jemermed.2007.06.041>

### INTERNATIONAL STUDIES

**Barlinn, J., Gerber, J., Barlinn, K., Pallesen, L.P., Siepmann, T., Zerna, C., Wojciechowski, C., Puetz, V., Kummer, R., Reichmann, H., Linn, J., Bodechtel, U. (2017). Acute Endovascular Treatment Delivery to Ischemic Stroke Patients Transferred Within a Telestroke Network: a Retrospective Observational Study. International Journal of Stroke, 12(5): 502-509.**

Study Length	Location	Sample Size	Telehealth Modality Type	Method	Outcome	Quality	Cost
5 years	Germany	151	Live Video	Retrospective Observational Study from Prospectively Maintained Database	x		

#### Summary

**Background** - Five randomized controlled trials recently demonstrated efficacy of endovascular treatment in acute ischemic stroke. Telestroke networks can improve stroke care in rural areas but their role in patients undergoing endovascular treatment is unknown.

**Aim** - We compared clinical outcomes of endovascular treatment between anterior circulation stroke patients transferred after teleconsultation and those directly admitted to a tertiary stroke center.

**Method** - Data derived from consecutive patients with intracranial large vessel occlusion who underwent endovascular treatment from January 2010 to December 2014 at our tertiary stroke center. We compared baseline characteristics, onset-to-treatment times, symptomatic intracranial hemorrhage, in-hospital mortality, reperfusion (modified Treatment in Cerebral Infarction 2b/3), and favorable functional outcome (modified Rankin scale  $\leq 2$ ) at discharge between patients transferred from spoke hospitals and those directly admitted.

**Results** - We studied 151 patients who underwent emergent endovascular treatment for anterior circulation stroke: median age 70 years (interquartile range, 62–75); 55% men; median National Institutes of Health Stroke Scale score 15 (12–20). Of these, 48 (31.8%) patients were transferred after teleconsultation and 103 (68.2%) were primarily admitted to our emergency department. Transferred patients were younger ( $p = 0.020$ ), received more frequently intravenous tissue plasminogen activator ( $p = 0.008$ ), had prolonged time from stroke onset to endovascular treatment initiation ( $p < 0.0001$ ) and tended to have lower rates of symptomatic intracranial hemorrhage (4.2% vs. 11.7%;  $p = 0.227$ ) and mortality (8.3% vs. 22.6%;  $p = 0.041$ ) than directly admitted patients. Similar rates of reperfusion (56.2% vs. 61.2%;  $p = 0.567$ ) and favorable functional outcome (18.8% vs. 13.7%;  $p = 0.470$ ) were observed in telestroke patients and those who were directly admitted.

**Conclusion** - Telestroke networks may enable delivery of endovascular treatment to selected ischemic stroke patients transferred from remote hospitals that is equitable to patients admitted directly to tertiary hospitals.

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