Remote Evaluation of Acute Ischemic Stroke
Reliability of National Institutes of Health Stroke Scale via Telestroke

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Background and Purpose—Despite Food and Drug Administration approval of tissue-type plasminogen activator for stroke, obstacles in the US healthcare system prevent its widespread use. The Remote Evaluation for Acute Ischemic Stroke (REACH) program was developed to address these issues in rural settings. A key component of stroke assessment in the REACH system is the National Institutes of Health Stroke Scale (NIHSS) evaluation. We sought to determine whether, using the REACH system, NIHSS values of bedside and remote evaluators would correspond.

Methods—Twenty patients were recruited. On obtaining consent, a neurologist performed a bedside NIHSS evaluation on each patient. Within 1 hour, using any broadband-connected workstation—either office or home personal computer and a landline phone to speak with the patient—a second neurologist remotely evaluated the patient through the REACH system. Paired $t$ tests and Pearson correlation coefficients were used to examine NIHSS reliability performed bedside and remotely.

Results—NIHSS ranged from 1 to 24. Correlations between bedside and remote locations ($r=0.9552, P=0.0001$) were very strong, and $t$ tests indicate that the means were not different.

Conclusions—The NIHSS can be reliably performed over the REACH system. This supports our endeavor to bring stroke expertise to rural community hospitals.

Key Words: reproducibility of results ■ stroke assessment ■ stroke, ischemic ■ telemedicine

The thrombolytic tissue-type plasminogen activator (tPA) was approved in 1996 by the Food and Drug Administration for treatment of acute ischemic stroke. However, therapeutic intervention in rural Georgia with tPA is virtually nonexistent because of the lack of neurologists$^1$ in rural hospitals. Eligibility for treatment is also restricted to a 3-hour window, further reducing the chances that emergent stroke victims will receive therapy in outlying areas. In an effort to provide stroke expertise in a timely manner, a telestroke initiative is being developed at the Medical College of Georgia (MCG) to bring neurological expertise to these outlying areas via novel telemedicine methods. This initiative was designed to provide an easy-to-use remote video evaluation incorporating a Web application to allow trained stroke specialists at MCG to rapidly assist colleagues at outlying hospitals in the evaluation of stroke patients and thereby facilitate treatment with tPA if needed. The Remote Evaluation in Acute Ischemic Stroke (REACH) program was envisioned because of a stroke care need in Georgia that has not been met by other means.

The first step in stroke evaluation is to determine the level of neurological deficit in the patient. The National Institutes of Health Stroke Scale (NIHSS) is a validated$^2,3$ tool for measuring the severity of stroke. Other studies$^4$ have shown that the NIHSS remains a reliable clinical instrument when used over interactive video, but this was done under controlled conditions with proprietary videoconferencing equipment and dedicated bandwidth. We report here the results obtained from evaluating the NIHSS with 20 patients under more real-life network conditions.

Subjects and Methods
Twenty patients presenting with acute ischemic stroke in the emergency room or hospital were evaluated after providing informed consent in a study approved by the Institutional Review Board. Seven consents were obtained from family members when large deficits were present. One of 4 participating physicians (R.A., F.N., H.G., D.H.) performed the bedside NIHSS. Within the hour, an assistant brought the REACH cart bedside and entered patient name and date of birth into the cart workstation. The second physician logged onto the reachmcg.com Web site from his office or home, located the patient from the list, and remotely conducted the NIHSS evaluation of the patient with help from an assistant. Both were blinded to the other’s score until after the examination.

Software
A web application was developed to present multiple patients from various locations to the consulting physician, allowing the consultant to use any accessible browser to locate the appropriate patient.
Figure 1. REACH cart.

Figure 2. REACH neurologist control panel displaying online NIHSS form.
REACH Cart Interface
To enter the patient into the system, the assistant brought the cart to the stroke patient’s bedside, where the camera was operated remotely by the remote physician. The assistant entered patient name, date of birth, and weight (optional for calculation of tPA dosage) into the REACH cart workstation. Once this information was entered, the assistant helped the remote physician perform the NIHSS.

REACH Consulting Physician Interface
The consultant control panel provided a page displaying patient video feed, the data entered from the assistant, and an online NIHSS form (Figure 2). This allowed the physician to observe the patient while scrolling through each NIHSS item as it was performed. The NIHSS was reordered so that all items requiring zoomed-in assessment were performed first (questions 1a, 1b, 2, 4, 9, 10), followed by zoomed-out assessment items (questions 1c, 3, 5 through 8, 11).

Hardware
The remote evaluation cart comprised an Axis 2130 Pan/Tilt/Zoom camera (Axis Communications), a 1.5-GHz Dell PC workstation and LCD monitor (Dell Corp) running Microsoft Windows 2000 with Internet Explorer 5.5 (Microsoft Corp), a Linksys WET11 wireless bridge (Linksys), Netgear 5 port ethernet switch (Netgear Inc), and a universal power supply, all housed on a mobile, ergonomic medical cart (Figure 1). The computer workstation and camera were connected to the ethernet switch and wireless networked to the hospital local area network via a Linksys WAP11 802.11b wireless access point (Linksys). The universal power supply and wireless bridge allowed the cart to be maneuvered anywhere in the emergency room or hospital wing without the need for a wired infrastructure.

Because the system was designed to be on constant standby, it took ~2 to 3 minutes to wheel the cart from the storage closet to the patient’s bedside. This meant no connection or boot-up times, and remote physician login times took 1 to 2 minutes.

Finally, paired t tests and Pearson correlation coefficients were calculated to examine reliability of the NIHSS done at bedside and remotely.

Results
NIHSS values ranged from 1 to 24 points. There was no difference of >3 points between bedside and remote evaluators. Results are shown in the Table. The length of each evaluation was recorded for the last 10 patients, averaging ~6:43 minutes bedside, while remote evaluations took 9:11 minutes.

Means and SD are given in the Table for 20 patients by location (bedside or remote). The t value was 0.13, and the probability value was 0.90. There were no statistically significant differences between the bedside and remote locations, indicating that administering the NIHSS remotely gives results similar to administering the NIHSS at bedside. The mean “remote” was also higher than at bedside, although not significantly higher, indicating that physicians were more conservative in their assessment remotely than at bedside. Correlations between the bedside and remote locations were very strong for the NIHSS ($r=0.9552$, $P=0.0001$), indicating that high scores at bedside correspond to high scores remotely.

Discussion
Rural Status of Georgia
Rural hospitals in Georgia and the southeast are medically underserved. For example, there are no1 neurologists in the hospitals serving each of the 12 counties surrounding Augusta (Ga), with average bed sizes of 52 throughout these counties. In many areas of the United States, there has been increasing pressure to provide tPA, partly from lawsuits against community physicians alleging deviations from the standard of care for failure to deliver thrombolytics.6 Organizations such as the American Academy of Emergency Medicine8 and the Canadian Association of Emergency Physicians9 recommend against the widespread use of thrombolytics in stroke unless neurological experts are directly involved in reading the CT scan and recommend its use with strict adherence to National Institute of Neurological Disorders and Stroke (NINDS) criteria. The REACH initiative seeks to address this by supplementing neurologists from the metropolitan Augusta region to community emergency rooms via a telenueurology presence.

Remotely Evaluating Acute Ischemic Stroke
Our goal in this report was to show that the NIHSS could be remotely performed reliably. The high degree of correlation between the 2 NIHSS locations when 45% of recruits presented to our study with mild deficits (NIHSS score <5) allowed us to fully determine that the system could detect these less obvious deficits as reliably as the bedside neurologist performing the evaluation in person.

This is the first step in developing an easy-to-use tool for both the community hospital staff and consulting physicians. The cart was designed to be manageable by a single person and to be on constant standby. Bringing the cart to the bedside is the only requirement to use the system. If the emergency

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Mean±SD: 7.45±5.69, 6:24, 7.50±5.95, 9:11
Remote Evaluation of Acute Ischemic Stroke: A Reliable Tool to Extend Tissue Plasminogen Activator Use to Community and Rural Stroke Patients?

In order to apply thrombolytic therapy to patients presenting with an acute stroke in community hospitals without permanent access to consulting neurologists, Wang et al report an interesting replenishment of the classic stroke unit concept. They present an easy-to-use video evaluation tool, which allows the raising of a bedside NIHSS score remotely. According to their data, this remote NIHSS score strongly correlates with the NIHSS score evaluated by a blinded bedside investigator. Although remote evaluation of NIHSS by telemedicine has been reported before,1 the technical approach presented here may allow scoring under more real-life conditions. Nevertheless, the small number of 20 patients can only serve as a proof of principle, since an evaluation especially of patients with complex deficits like neglect, other neuropsychological deficits, or visual field defects might be challenging even under real-life conditions, which means examination in the short 3-hour time window.

Moreover, the NIHSS is only one critical step in the decision about a thrombolytic therapy, according to the NINDS criteria. It remains to be shown by the already ongoing trial that remote evaluation of NIHSS and, even more critical, of the CT scan will lead to reliable and safe decisions about intravenous rtPA administration in this setting. Another fundamental disadvantage of remote evaluation is the fact that examination of the patient is restricted to one given time point. This neglects the fact that many patients present not with stable but with fluctuating, decreasing or increasing deficits that complicate the decision about thrombolytic therapy in everyday life. The same is true in the case of relative contraindications, where a decision about thrombolytic therapy is difficult to reach remotely.

Compared with other community-based stroke networks2,3 it may be an advantage that only a few stroke experts at least virtually examine the patient on their own, which should lead to more reproducible decisions about stroke treatment as compared with settings where the NIHSS is obtained by a large number of heterogeneously trained physicians. However, the safety of rtPA application in community hospitals has been proven for small cohorts of patients,2,3 while this remains to be demonstrated for the remote concept.

Further, in community-based concepts thrombolytic therapy is performed in hospitals without facilities or expertise for the treatment of complications like bleeding or brain edema. Even for successfully treated patients, sophisticated diagnostic tools are usually not available. Other studies have already shown that secondary prevention or blood pressure treatment often does not follow the existing guidelines and recommendations for the management of acute stroke in such settings, which may influence the final outcome of the patients even more profoundly than access to thrombolysis.4,5 Therefore, we think that referral to a tertiary stroke center after thrombolytic therapy is inevitable for many patients, even in the case of remote rtPA treatment. This raises the question of why such a referral should not be performed...
immediately within the therapeutic time window. A recent study has already demonstrated the feasibility of a helicopter transfer in an acute stroke transport program within an acceptable time window in rural regions in northeastern Florida and southeastern Georgia. Such an approach is encouraged by the findings of the Southwestern Ontario Stroke Program. In this prospective, study patients referred from rural hospitals to the academic medical center were treated with the same success as patients who were admitted directly to the academic medical center. In accordance with our own experience as an academic tertiary stroke center, patients referred from outside hospitals had a significantly lower door-to-needle time, which compensated for most of the referral time in the Ontario study. This observation proves that no significant time is finally lost in referred patients, because laboratory routine examinations are already performed, informed consent of the patient is obtained, facts about medical history are collected, and, most importantly, the stroke team in the tertiary center and a radiologist are already in standby once the patient reaches the stroke unit.

The German concept of regional stroke units in addition to the tertiary, mainly academic medical centers, which close the gaps in between the tertiary centers, also aims in this direction. Such a network of hospitals with stroke expertise—not necessarily run by neurologists—that can be reached in an appropriate time window is currently being developed. In this concept, stroke expertise is available in a limited number of hospitals that cover also rural and remote regions, and trained staff for stroke treatment must not be kept available in other hospitals.

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References
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