Use of Wearable Technology in Remote Evaluation of Acute Stroke Patients: Feasibility and Reliability of a Google Glass-Based Device

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Background: Telestroke is an efficient, cost-effective way to standardize care and improve access to immediate neurologic expertise for rural hospitals and other underserved areas. Hands-free wearable technology potentially allows for faster evaluations that fit easily within prehospital workflows and could improve prehospital triage of stroke patients to appropriate receiving stroke centers. The goal of this study is to assess the feasibility and inter-rater reliability of wearable eyeglass video technology in assessing stroke-related neurologic deficits in patients with suspected acute stroke. *Methods:* Consecutive patients with suspected stroke were evaluated concurrently by an on-site neurologist using wearable eyeglass video technology and a remotely located neurologist viewing the patient through an online platform. Inter-rater reliability in assigning National Institutes of Health Stroke Scale (NIHSS) scores was evaluated using inter-rater correlation coefficient (ICC) and weighted kappa scores. *Results:* Among 17 enrolled patients, mean age was 58 (SD ± 20) and 29% were female. There was a high degree of correlation in total NIHSS score (ICC .99 and weighted kappa .88) and across all NIHSS subitems (ICC .81-1 and weighted kappa .68-1) between the examiner evaluating remotely via wearable eyeglass video technology with access to the patient and the in-person examiner. The maximum difference between the 2 NIHSS scores was 3. *Conclusions:* The use of wearable eyeglass video technology in telestroke is feasible and reliable. Use of this technology in the prehospital setting has the potential to improve early assessment of patients with acute stroke symptoms and to facilitate transfer to appropriate stroke centers in the regional systems of care.

Key Words: Acute stroke—wearable technology—Google Glass—telestroke—mHealth.

Introduction

Stroke is one of the leading causes of death and disability in the United States. Currently, the mainstay for acute ischemic stroke treatment is timely recanalization strategies using intravenous tissue plasminogen activator and/or endovascular stroke treatment. Such complex treatments require immediate evaluation by a neurologist, ideally with vascular neurology training and are underused in rural hospitals, due to lack of local stroke expertise. Telestroke has been a cost-effective sustainable way to standardize care and improve access to immediate vascular neurology care for rural hospitals with limited neurology coverage based on Level 1 Class A evidence.[1,2]

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The ability to remotely evaluate a patient using an audiovisual paradigm in real-time as in computer carts is an important feature in accurate evaluation of patients suspected of having strokes. One of the limitations to current telestroke carts is the stationary nature of it in the Emergency Department (ED) and lack of flexibility in transporting the patient between different points of care as in ED, imaging and angiography suites, and intensive care units. In cell phone-based technology, one can carry the device along with the patient; however, carrying the device limits the health care provider to use her hands to stabilize the patient and/or performing the exam at the same time.

Wearable technology can facilitate the evaluation of suspected stroke patient, in a real-time and hands-free manner. In addition, by using wireless internet technology, the evaluation of suspected stroke patient can be advanced to the prehospital state in the ambulance or at the scene by paramedics closing the current information gap from the scene to the ED door.

XpertEye (AMA XpertEye Inc., Cambridge, MA) is a Google Glass-based device which is connected to a dedicated proprietary encrypted mobile and uses a platform that is protected according to the Health Insurance Portability and Accountability Act. This device works over both Wi-Fi and cellular connection and enables the person wearing it to share their field of view with a remotely located observer and have a 2-way real-time videoconference.

In this study, we assessed the feasibility and reliability of wearable eyeglass video technology in evaluating patients with suspected acute stroke by comparing National Institutes of Health Stroke Scale (NIHSS) scores between the on-site neurologist using wearable eyeglass video technology and a remotely located neurologist viewing the patient through an online platform.

Materials and Methods

The study was approved by University of California Los Angeles Institutional Review Board.

Inclusion

Consecutive eligible English-speaking patients older than 18 with suspected ischemia or hemorrhage, admitted to the University of California Los Angeles Stroke Center Inpatient Unit were included in the study after informed consent was taken from them or their families.

Assessments

Following informed consent, the patient was evaluated by the on-site neurologist, wearing the XpertEye device while the remote neurologist was evaluating the patient at the same time through the monitor using the Health Insurance Portability and Accountability Act protected platform at office or home. The 2 physicians performed the standard NIHSS. The 2 physicians were able to communicate with each other real-time; however, there was no exchange in the score subitems at the time of evaluation, and the 2 physicians documented the scores independently (Fig 1).

IBM SPSS Statistic 24 was used for statistical analysis. The inter-rater reliability in calculating the total NIHSS score and its subitems were measured using Cohen's weighted kappa coefficient. Cohen's weighted kappa ranges less than .4 demonstrated poor, between .4 and .74 good, and above .75 excellent inter-rater reliability.

Results

Seventeen patients were included in the study, with mean age of 58 (SD ± 20) and 29% female. Final diagnoses were 70% ischemic stroke, 12% transient ischemic attack, 12% intracranial hemorrhage, and 6% stroke mimic (seizure). The duration of evaluation was 9 ± 2 minutes. The median time from last known well to the evaluation was 5 ± 4 days. The NIHSS measured by the in-person and remote neurologists were 7 ± 6 and 8 ± 7, respectively. Table 1 shows the intraclass correlation coefficient (ICC) and weighted kappa coefficient scores for NIHSS total score and subitems between the 2 examiners.

Our results demonstrate a high correlation between the 2 examiners total NIHSS score (ICC .99 and weighted kappa .88) and across all NIHSS subitems (ICC .81-1 and weighted kappa .68-1). The maximum difference between the 2 NIHSS scores was 3.

The LOC questions, commands, and vision exam subitems had complete concordance while gaze and dysarthria correlations were on the lower range of the spectrum yet showed substantial correlation.

Discussion

This is one of the first studies to evaluate the feasibility and reliability of wearable eyeglass video technology in evaluating suspected acute stroke patients. The study found excellent inter-rater reliability in assessment of neurologic deficit on the NIHSS and all the 15 NIHSS subitems between a remote examiner accessing the patient via wearable eyeglass video technology and an in-person examiner.

The findings of this study are consonant with, and importantly extent, prior studies. The preponderance of previous studies of telemedical performance of the NIHSS in stroke patients has employed large cart-based or anthropoid robotic telemedicine systems.[3-5] These systems are well suited for use in ED or intensive care unit settings, but not for deployment in the prehospital setting, including in patient homes, stores, workplaces, and other sites of first paramedic contact with individuals with potential strokes. The current study found that the wearable eyeglass video computer interface, well designed for use in the field, performed comparably to bulkier hospital

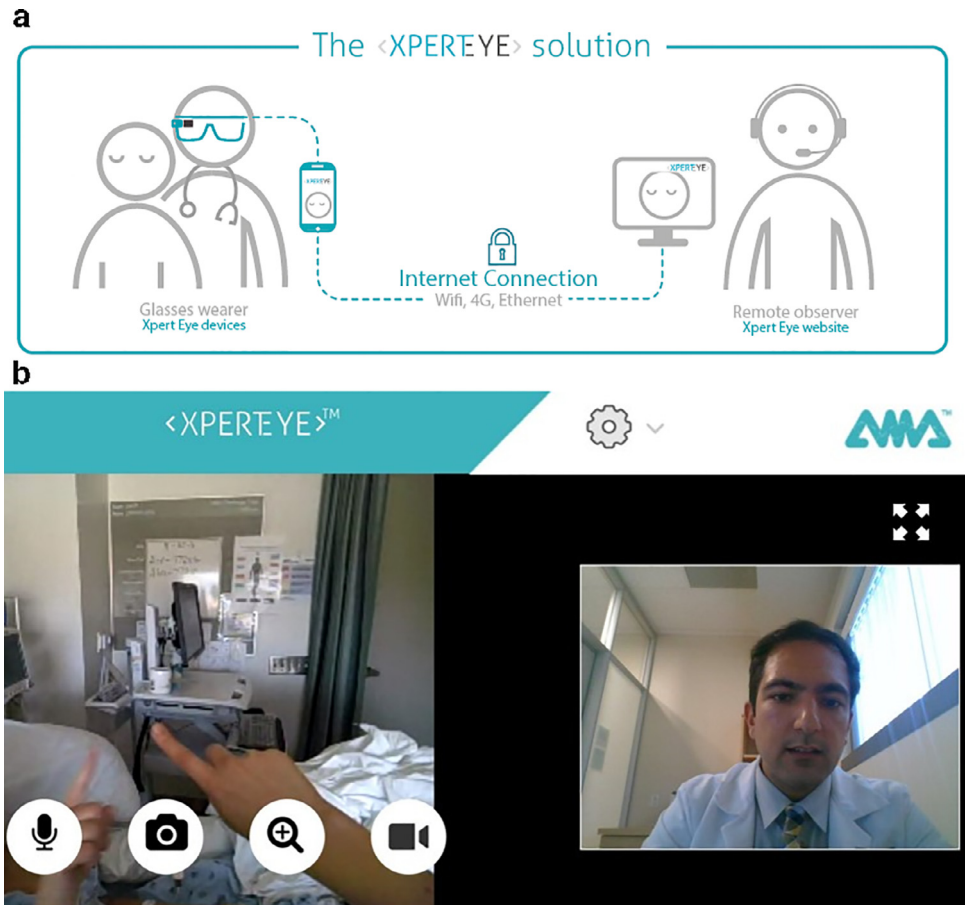

Figure 1. *(a) Wearable eyeglass-video technology set-up: the onsite physician, evaluating the suspected stroke patient wearing the glasses while connected real-time to the remote physician though Xpert Eye platform. (b) Screen display viewed by the remote physician. Left side of screen shows view from the eyeglass-video camera, displaying testing of targeted hand movement, with patient's index finger moving to touch the examiner's index finger. Right side of screen shows view from the remote desktop computer of the off-site examining physician — this view could be projected as a heads-up display onto the eyeglasses allowing visualization by the on-site examiner. Color version of figure is available online.*

Table 1. *Correlation of the NIHSS and its subitems between the 2 examiners*

	Intraclass correlation coefficient	Weighted Kappa
LOC	.93	.83
Qs	1	1
Commands	1	1
Gaze	.82	.68
Vision	1	1
Face	.97	.93
Left arm	.99	.95
Right Arm	.98	.93
Left leg	.99	.96
Right leg	1	1
Ataxia	.97	.9
Sensory	1	.77
Language	.95	.89
Dysarthria	.87	.72
Neglect	.95	.83
Total NIHSS	.99	.88

systems in inter-rater reliability against the gold standard of an in-person evaluator.

Since the original introduction of the term "telestroke" in 1999, substantial advances have been made in the field with widespread expansion to provide acute stroke care in remote areas when a neurologist is not readily available.[6] By implementation of telestroke for evaluation of stroke patients, there has been improvement in timely stroke identification, increased intravenous reverse transcriptase tissue Plasminogen Activator (IV rtPA) administration rate, improved process times, and higher adherence to protocols. In the controlled STRoke DOC trial, the investigators compared telemedicine consultation using telestroke video carts with telephone consultation and demonstrated that video telemedicine consultation results in more accurate decision making in IV rtPA administration.[7]

Subsequently, a few studies have been performed of smaller, more mobile, handheld video devices, such as smartphones and tablets. In an investigation conducted by our group, the iPhone platform was employed for

remote evaluation of stroke patients, and a strong concordance was demonstrated between remote and in-person NIHSS scoring of stroke patients.[8] Anderson et al also demonstrated a strong level of agreement in total NIHSS scores in evaluating stroke patients using iPhone.[9] The duration of assessment using eyeglass video wearable technology in our study was similar to that with the iPhone in the study by Anderson et al and shorter compared to previous cart-based studies.[3-5,9] Demaerschalk et al evaluated the inter-rater reliability for the NIHSS using smartphones in 100 patients and also found high rates of score concordance, as well as high physician satisfaction.[10] However, smartphone- and smart pad-based tele-video interactions require an on-scene individual to hold the video device while directing it at the patient. In contrast, the wearable eyeglass video computer interface allows on-scene individuals full bimanual freedom to perform needed clinical care while the video assessment is taking place.

In recent years, wearable video-interface technologies have been introduced for potential use in a variety of medical disciplines. Wearable technologies have several potentially advantageous features. They provide the remote provider with a first-person perspective in viewing and interacting with the patient, family, on-scene providers, and the scene. Wearable devices are hands-free, require less effort for special positioning, manual attention, and maintenance from the on-site provider and can be seamlessly integrated into clinical workflow. In current clinical practice, there is limited communication between the paramedics and the receiving facility, and at patient arrival, his or her neurologic condition, details of the symptoms, onset time and time course may be unknown to the receiving medical staff or may be found to differ substantially from the basic description that was communicated by telephone. However, few studies have yet tested the feasibility and reliability of wearable eyeglass video systems for stroke assessment and decision-making. In a single case report, a Google Glass system worn by a local physician in the ED was used to communicate with a remote neurologist in complex decision making to give IV rtPA successfully with an excellent outcome.[11]

The current study sought to test whether the eyeglass video remote viewing platform technically provides an adequate information stream to enable reliable deficit rating. For this aim, it was important to have both the remote rater and the on-site physician be expert neurologists. With physician expertise matched, the differences between raters would attributable to the transmission technology and not differences in examiner expertise. Now that the current study has shown the technological platform permits reliable NIHSS assessment, future studies can explore the reliability of assessment when the local individual wearing the wearable technology is a paramedic or nurse and also whether thrombolytic and thrombectomy decisions are congruent when made by remote expert physicians compared with on-site expert physicians.

In summary, this is the first study on the feasibility and reliability of wearable eyeglass video technology in evaluating patients with suspected acute stroke. We demonstrated that the use of the device is easy, reliable, and comparable to previous means of remote evaluation of stroke patients. Use of this technology in the prehospital setting has the potential to improve early assessment of patients with acute stroke symptoms and patient to facilitate transfer to appropriate stroke centers in the regional systems of care.

Conflicts of Interest

The authors have no conflicts of interest to disclose.

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