Reliability of Prehospital Real-Time Cellular Video Phone in Assessing the Simplified National Institutes of Health Stroke Scale in Patients With Acute Stroke

A Novel Telemedicine Technology

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Background and Purpose—The National Institutes of Health Stroke Scale (NIHSS) is the gold standard to assess patients with acute stroke. We aimed to examine the feasibility and reliability of prehospital real-time cellular video phone (VP) in performing the NIHSS.

Methods—Forty physicians prospectively performed a simplified NIHSS (sNIHSS) on a standardized patient remotely using VP with the assistance of a bedside emergency medical technician and later performed a bedside examination. We tested the hypothesis that there is high reliability between these 2 methods. Physicians were timed and sNIHSS scores were recorded. Finally, physicians were asked to rate the VP technology.

Results—A total of 480 pair comparisons of the sNIHSS scores between the VP and bedside examination were generated. After adjusting for the physician's specialty, level of training, and certification status, there was a strong positive linear correlation ($r=0.97$, $P<0.01$) between the 2 methods with high average physician reliability (0.99; 95% CI, 0.992 to 0.995). The mean sNIHSS scores using VP and bedside examination were not different (6.82 ± 1.06 versus 6.63 ± 0.98; $P=0.08$). The mean time to perform the sNIHSS using VP was approximately 38 seconds longer than the bedside examination (3.38 ± 0.77 versus 2.93 ± 0.83 minutes; $P=0.006$).

Conclusions—The VP is a feasible, reliable, and timely tool with the potential for remotely assessing the sNIHSS for patients presenting with acute stroke and may expedite the initial evaluation and treatment strategies. **(*Stroke*. 2011; 42:00-00.)**

Key Words: acute stroke ■ cellular video phone ■ National Institutes of Health Stroke Scale ■ telemedicine

The National Institutes of Health Stroke Scale (NIHSS) is a reliable[1–12] method of assessing neurological deficit in patients with acute stroke with good interrater agreement.[13] Multiple prospective[1,14] and retrospective[15,16] studies have validated the NIHSS when applied remotely using telemedicine technology in patients with acute[1,7,13,14,17–24] and subacute[25] stroke. The NIHSS score correlates with clinical outcomes[21,25–28] and has a formal certification process.[2–6,9,29] However, performing the 15 subscales is time-consuming, complicated, and may not be feasible or practical in the prehospital setting. Most patients with acute stroke are initially evaluated by emergency medical technicians and nonneurologist physicians before the stroke specialist is consulted and therefore a modified NIHSS has been validated.[8,9,19,30–32] A review of the evidence of telemedicine in acute stroke evaluation by the American Heart Association/American Stroke Association found insufficient data to issue a recommendation on prehospital telemedicine assessment of the NIHSS and stated the need for further research in this area.[33]

We sought to examine the feasibility and reliability of a novel telemedicine technology called prehospital real-time cellular video phone (VP) in performing a simplified NIHSS (sNIHSS). Our first aim was to study the intermethod reliability between the sNIHSS performed remotely with VP and assisted by a bedside emergency medical technician compared with a bedside examination by physicians from different specialties and levels of training in an acute stroke standardized patient. Our secondary aims included the interrater reliability on each subscale of the sNIHSS using the VP, the time to complete the scale, and the evaluation of the VP technology by participating physicians.

Materials and Methods

Forty physicians volunteered to perform a sNIHSS on a standardized patient with right middle cerebral artery acute stroke. Physicians first

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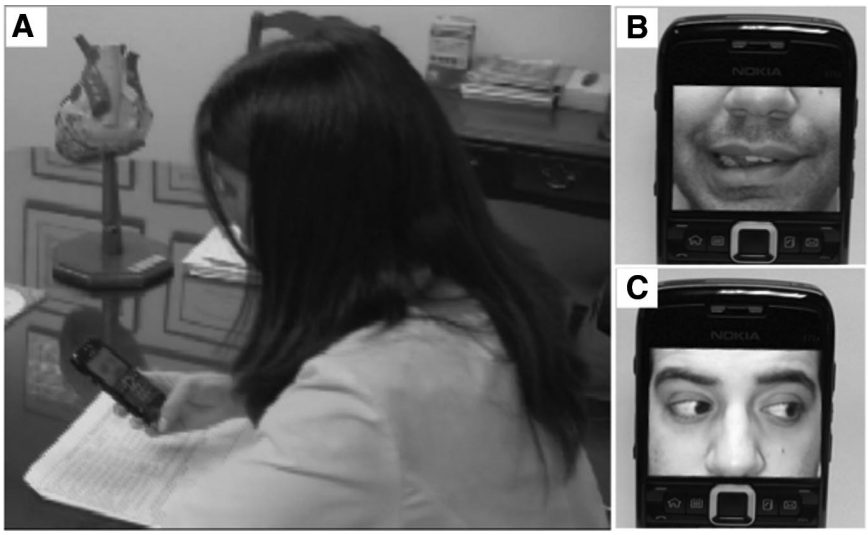

Figure 1. Physician performing the modified National Institute of Heath Stroke Scale using the cellular video phone (VP). **A**, Physician investigator demonstrating the use of VP in performing the simplified National Institutes of Health Stroke Scale (sNIHSS); (**B**) performing the level of consciousness follows commands (smiling) subscale; (**C**) performing the best gaze subscale.

performed the sNIHSS assessment remotely using the VP (Figure 1 and Video) with the assistance of a bedside emergency medical technician (Figure 2) and within 5 minutes performed a bedside examination. Physicians were asked to rate the VP on a scale of 1 to 5 with 1 being the lowest and 5 being the highest rating (1=poor, 2=fair, 3=good, 4=very good, and 5=excellent). Participating physicians were given instructions on how to use the cellular VP, the research protocol, the case presentation, and the description of the neurological deficit (Supplemental Appendix I; http://stroke.ahajournals.org). In addition, physicians were asked: "Assuming that this patient with the deficits that you identified has a CT scan of the brain revealing no evidence of intracranial hemorrhage and no contraindication to thrombolytics, would you recommend thrombolytic therapy?" Finally, if the physician had no NIHSS certification, a 5-minute in-service on how to administer the sNIHSS scale was given.

Simplified National Institutes of Health Stroke Scale

The original NIHSS has 15 subscales.[12] The modified NIHSS is a reliable method of assessing patients with stroke.[8,9,19,30–32] Kothari and others demonstrated that in prehospital evaluation of patients with acute stroke the most reliable subscales are facial palsy, arm motor deficit, and abnormal speech with 100% sensitivity and 88% specificity.[19] We simplified the NIHSS by keeping these subscales and removing the visual field, sensory, and extinction/neglect subscales with the goal of shortening the time needed for completion at the same time as maintaining good test performance as illustrated in the Table.

Cellular VP

AT&T provided the cellular VP (Nokia model E71x), the third generation (3G) network service with data speed up to 3.6 megabits per second, and the Video Share software that allows 2-way voice and 1-way real-time video. AT&T's network uses an advanced data encryption standard of 128 key by 128 block size. The Nokia E71x specifications include a speaker phone and a display with 2.4 inches, 16 million colors, and 240×320 pixels. Further specifications can be found at: www.wireless.att.com/businesscenter/NokiaE71x/index.jsp.

Statistical Analysis

Continuous variables were summarized as mean±SD and compared using the *t* test, whereas categorical variables were summarized as frequencies and compared using the χ^2 test. Multiple linear regression analysis was performed to test the intermethod reliability of the sNIHSS scores between VP and bedside examination adjusting for

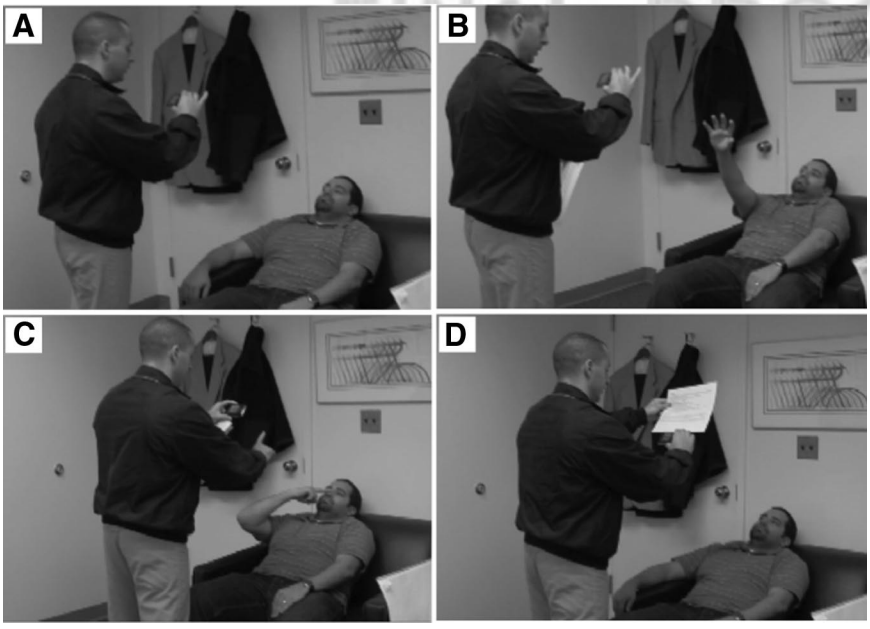

Figure 2. Emergency medical technician assisting the physician with prehospital real-time cellular video phone assessment of modified National Institute of Heath Stroke Scale. **A**, Performing level of consciousness calling patient's name and asking questions subscales; (**B**) performing the arms motor subscale examination; (**C**) performing limb ataxia subscale (finger-to-nose maneuver) examination; (**D**) performing language and dysarthria subscales examination.

Table. Interrater Agreement on National Institutes of Health Stroke Scale Administration With Prehospital Real-Time Cellular Video Phone Compared With Other Studies

Subscales	VP wK (95% CI; n=40) in 2010	Handschu et al[13] wK (95% CI; n=41) in 2003	Meyer et al[34] wK (95% CI; n=25) in 2005	Shafqat et al[1] wK (n=20) in 1999	Goldstein et al[12] wK (n=20) in 1989	Brott et al[36] wK (n=24) in 1989
1a—LOC call name	0.99 (0.98–1)	0.97 (0.97–1)	N/R	. . .	0.50	0.49
1b—LOC questions	1 (1–1)	0.90 (0.82–0.96)	0.92 (0.79–1)	0.75	0.64	0.80
1c—LOC commands	0.63 (0.32–0.95)	0.93 (0.86–1)	1 (1–1)	0.29	0.41	0.58
2—Best gaze	1 (1–1)	0.95 (0.90–0.99)	1 (1–1)	0.41	0.33	0.82
3—Visual field	N/R	N/R	0.86 (0.65−1)	0.60	0.57	0.81
4—Facial palsy	0.59 (0.27–0.91)	0.85 (0.79–0.90)	N/R	0.40	0.22	0.57
5a—Motor left arm	0.74* (0.44–1)	0.90* (0.85–0.95)	0.84 (0.64–1)	0.82*	0.77*	0.85*
5b—Motor right arm	. . .	. . .	0.82 (0.57–1)	. . .	. . .	. . .
6a—Motor left leg	0.62* (0.30–0.94)	0.92* (0.89–0.96)	0.74 (0.47–1)	0.83*	0.78*	0.83*
6b—Motor right leg	. . .	. . .	0.80 (0.56–1)	. . .	. . .	. . .
7—Limb ataxia	0.98 (0.74–1)	0.95 (0.90–0.99)	N/R	−0.07	−0.16	0.57
8—Sensory	N/R	0.91 (0.86–0.96)	0.83 (0.60–1)	0.48	0.50	0.60
9—Best language	0.99 (0.75–1)	0.98 (0.96–1)	0.69 (0.33–1)	0.65	0.79	0.64
10—Dysarthria	0.66 (0.36–0.96)	0.92 (0.90–0.97)	N/R	0.55	0.32	0.55
11—Extinction and inattention	N/R	0.96 (0.93–1)	0.80 (0.51–1)	0.77	0.61	0.58
Total NIHSS score	0.73 (0.43–1)	0.87 (0.85–0.99)	0.95 (0.91–0.99)	N/R	N/R	N/R

Handschu et al[13]=NIHSS within 6 h of symptom onset in 41 patients with stroke; Meyer et al[34]=remote and bedside NIHSS was performed in 25 patients (sNIHSS in 9 patients); Shafqat et al[1]=telemedicine administration of NIHSS in 20 patients with acute stroke with the assistance of a nurse at the bedside; Goldstein et al[12]20 patients with stroke had NIHSS performed by 4 stroke fellows; Brott et al[36]=admission NIHSS scores in 24 patients with acute stroke.

VP indicates prehospital real-time cellular video phone; wK, weighted κ (interrater agreement); LOC, level of consciousness; N/R, not reported or performed; NIHSS, National Institutes of Health Stroke Scale; sNIHSS, simplified NIHSS.

*Either side affected.

physician specialty, level of training, and physician NIHSS certification status. The average physician reliability performing the sNIHSS scores was tested with intraclass correlation coefficient analysis. The interphysician agreement on individual subscales using the VP was assessed with weighted κ analysis. Finally, the mean time differences between the methods in completing the sNIHSS were tested with paired samples t test. Statistical analysis was performed with the SAS 9.1 (Cary, NC) software package. All tests were 2-sided with a probability value <0.05 considered significant. No actual patients were involved in the study; therefore, informed consent was not necessary.

Results

A total of 40 physicians (internal medicine, 40%; neurology, 7.5%; cardiology, 25%; and emergency medicine, 27.5%) participated in the study. The training levels were as follows: attending (30%), postgraduate Year 1 (22%), postgraduate Year 2 (12.5%), postgraduate Year 3 (15%), postgraduate Year ≥4 (20.4%). With the exception of the 3 stroke fellows, no other participating physicians had NIHSS certification or extensive experience administering the scale before this study. After adjusting for specialty, level of training, and NIHSS certification status, there was a strong positive linear correlation (Figure 3) and high overall absolute agreement (0.99; 95% CI, 0.992 to 0.995) between physicians performing the sNIHSS with VP and the bedside examination. The interphysician agreement on each sNIHSS subscale between VP and bedside examination is presented in the Table. The mean sNIHSS scores using VP and bedside examination were not significantly different (6.82±1.06 versus 6.63±0.98; $P=0.08$). There were no differences in the sNIHSS subscales or total score between NIHSS certified and noncertified physicians.

The mean time to perform the sNIHSS using VP was approximately 38 seconds longer than in the bedside examination (Figure 4). The physician ratings of the VP technology are presented in Figure 5. The proportion of physicians who rated the image quality, ease of use, and reception in the hospital as very good to excellent was 80%; the use to expedite the assessment and make the diagnosis was 95%, and the sound quality was 65%. All physicians recommended the use of thrombolytic after performing sNIHSS with both methods.

Discussion

The main findings in our study are that there is very good intermethod reliability performing the sNIHSS with VP and bedside examination, there are no differences in the final sNIHSS scores between the methods, and there is good interphysician agreement performing the sNIHSS with VP, but it takes 38 seconds longer to be completed compared with bedside examination. However, participating physicians evaluated the VP technology very favorably and were equally likely to recommend thrombolytic therapy with either method.

Agreement With the Published Literature

Advances in telemedicine have improved mobility with wireless Internet-based stations[7,34] and more recently mobile personal device assistant applications.[35] The application of NIHSS in its original[1,7,13,14,17–24] or modified format[8,9,19,30–32] in evaluating patients with acute stroke has been validated by neurologists,[7,8,10] nonneurologist physicians,[2,4,11] trainees, 12 nurse coordinators,[2,4,10,11,37,38] and emergency medical technicians.[32,39] Studies have confirmed the benefits of telemedicine application

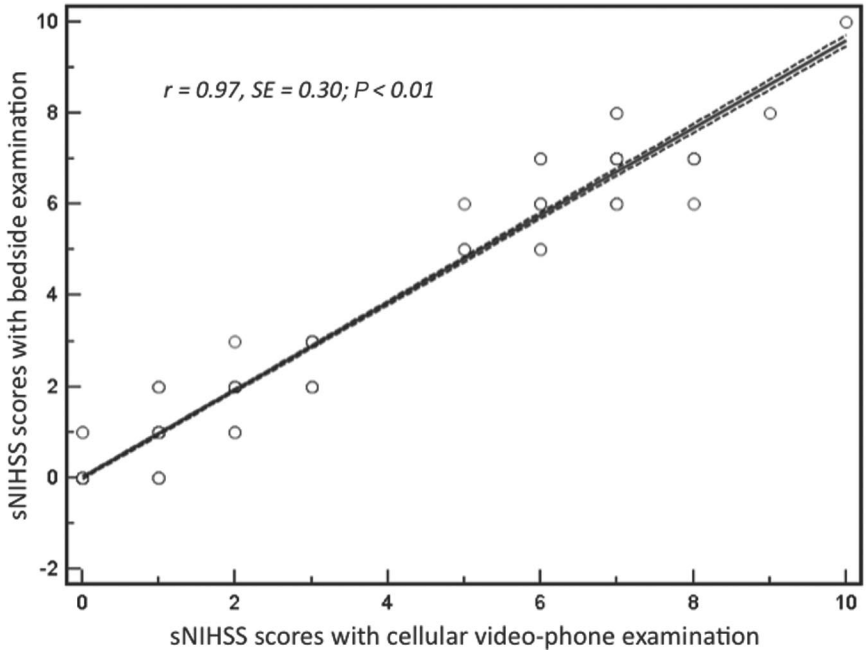

Figure 3. Correlation of simplified National Institute of Heath Stroke Scale scores with cellular video phone and bedside examination. *r* indicates regression correlation coefficient (measure of reliability); sNIHSS, simplified National Institute of Health Stroke Scale.

of NIHSS in the prehospital setting,[19,20,31,32,40] aiming to decrease ischemic time and facilitate the use of thrombolytic.[16,18,21,23,26] The mean time of 3.4±0.8 minutes it took to complete the sNIHSS with VP in our study is shorter than the mean of 11.4 minutes (range, 8 to 18 minutes)[13] and the mean 9.7 minutes[1] it took to complete a full NIHSS in other studies. The high proportion of physicians rating the VP technology as very good to excellent compares favorably with the 50% of medical staff rating video quality, time consumption, and medical relevance as excellent in the Telemedical Project for Integrative Stroke Care (TEMPIS).[40]

Disagreement With the Published Literature

The overall reliability of the VP is good and is consistent with previous telemedicine studies.[1,12,13,34,41] However, the analysis of individual subscale performance in the Table reveals that level of consciousness commands, facial palsy, leg motor, and dysarthria has lower interphysician agreement compared with those reported by Handschu et al[13] and Meyer et al,[34] but overall are not dissimilar to other studies.[1,12,41] In particular, the least agreement is observed in the facial palsy and leg motor subscales. It appears that the image quality or the angle of projection in these 2 subscales was not sufficiently clear to make an accurate assessment. Our standardized patient was instructed to follow all commands and to answer all questions correctly. However, the interphysician agreement for the "follows commands" subscale was only 0.63 due to 6 physicians incorrectly scoring this subscale rather than a problem with the VP technology.

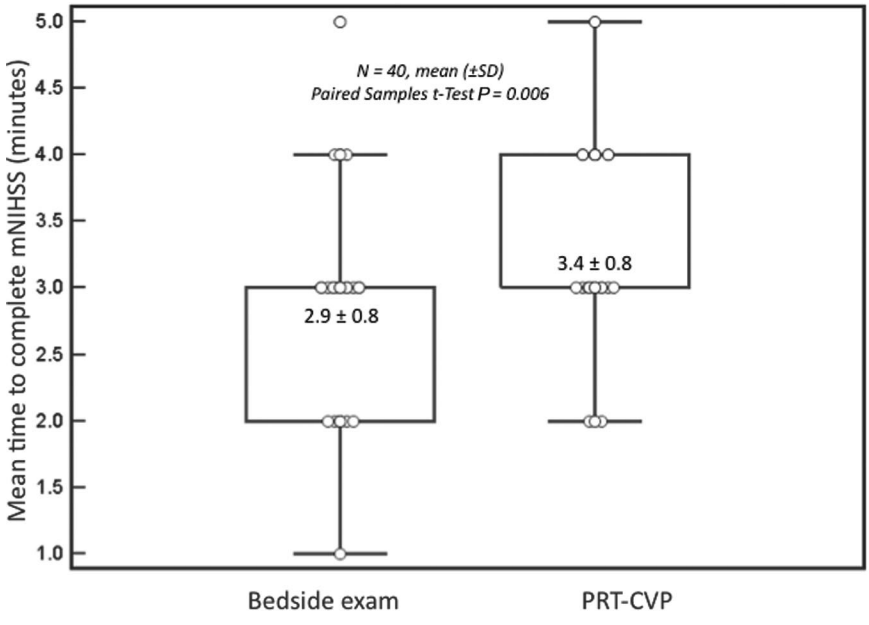

Figure 4. Time differences in performing the simplified National Institute of Heath Stroke Scale with cellular video phone and bedside examination. PRT-CVP indicates prehospital real-time cellular video phone; mNIHSS, modified National Institute of Health Stroke Scale.

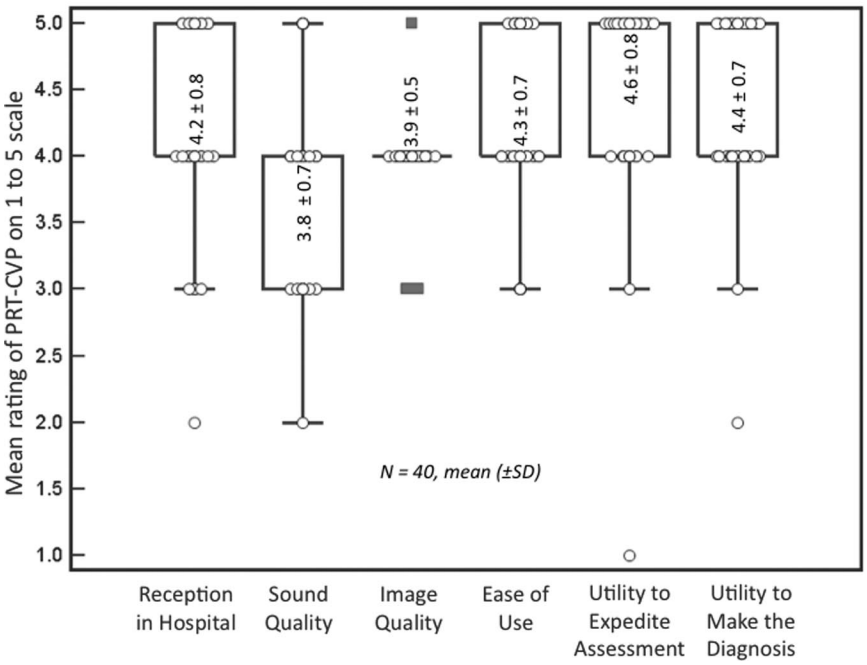

Figure 5. Physician rating of cellular video phone technology after performing the simplified National Institute of Heath Stroke Scale. Rating on scale of 1 to 5 with 1 being the lowest and 5 being the highest (1=poor, 2=fair, 3=good, 4=very good, and 5=excellent). PRT-CVP indicates prehospital real-time cellular video phone.

Implication for Practice

The VP technology has the potential to advance our knowledge, quality of care, and the outcome of patients with acute stroke. However, a careful analysis of the advantages and barriers in implementing this technology in the prehospital setting is important. Among the most important advantages are: (1) expediting of the patient assessment, improvement in the accuracy of the history, help in clarifying the time of symptom onset, and the differential diagnosis; (2) allowing real-time remote performance of NIHSS by physicians in a simple, inexpensive, and reliable fashion; (3) decreasing healthcare costs by reducing false activation of the stroke team and unnecessary transfer of patients; (4) speeding up the initiation of the informed consent process for thrombolytic therapy with patients and the family; (5) good physician acceptance; (6) increased access any time and anywhere to stroke neurologists and primary stroke centers; (7) potentially shorter ischemic time and increased number of candidates for thrombolysis and neurointerventions; and (8) potential decrease in death rate, length of stay, and permanent disability.

The most important limitations and implementation barriers of VP technology include: (1) limited coverage in remote areas; (2) quality of the sound and image, speed of data transmission, and only 1-way video and 2-way audio (future 4G network will have 2-way video and 2-way audio); (3) security of information, inappropriate or unauthorized use, compliance with privacy and security laws, and telemedicine regulations and compliance with fraud and abuse statutes; (4) limited reimbursement and funding opportunities; (5) physician adoption and promotion of the new technology; and (6) physician licensure, credentialing, and medical liability.[17,22,33,41–43] To comply with telemedicine, privacy, and security laws, VP uses advanced data encryption standard of 128 key by 128 block size, the data are transmitted over a virtual private network, the phone is password-protected, has auto log-out, and has remote wipe-out data capability if needed. Finally, the VP technology is relatively inexpensive, but a cost analysis is important. The retail price of the Nokia model E71x cellular VP is approximately $200 and the monthly service fee for the AT&T 3G network is approximately $135 per month or $1620 per year. This compares favorably with other telemedicine systems estimated to cost approximately $30 000 to $50 000 per year for 1 hub and spoke center.[22]

Our study has several limitations. First, we had a small number of neurologists and physicians with NIHSS certification participating in the study. Second, we used a sNIHSS for practical reasons and we do not know whether these results can be replicated with the full scale. Third, we only evaluated 1 form of acute stroke syndrome (right middle cerebral artery) in a standardized patient to control for variability under experimental conditions and we do not know how these results apply to a heterogeneous stroke population. Furthermore, the study was performed in a quiet room and we do not know whether sound quality will be adequate when the examination is performed in the field, ambulance, or a noisy emergency department. In addition, we did not involve real patients in this stage of the VP evaluation because of the lack of safety data on clinical application. Finally, the effects of confounding variables and remaining bias cannot be completely excluded.

Conclusions

The VP is a feasible, reliable, and inexpensive telemedicine method of administering the sNIHSS to standardized patients with acute stroke in the prehospital setting by physicians from a wide range of specialties and levels of training using the assistance of bedside emergency medical technicians. The technology has high acceptance and has the potential to expedite initial assessment and management of patients with acute stroke.

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Disclosures

None.

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Reliability of Prehospital Real-Time Cellular Video Phone in Assessing the Simplified National Institutes of Health Stroke Scale in Patients With Acute Stroke: A Novel Telemedicine Technology

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SUPPLEMENTAL MATERIAL

Legend for video file

Physician performing the simplified National Institutes of Health Stroke Scale assessment remotely in real time using the video-phone with the assistance of a bedside emergency medical technician.