Patients must thus seek help, receive a clinical diagnosis, and reach a center of care for imaging and treatment without delay.

The Problem

This is a problem in remote and rural areas, leading to a relative disadvantage for rural dwellers: symptom-to-needle time is nevertheless often too long even for people in major urban centers. In the Scottish Highlands, for example, the total amount of time taken from calling for help, transfer to the nearest diagnostic center, undergoing computed tomography scanning to exclude contraindications to thrombolysis treatment, and then receiving thrombolysis often exceeds the 4.5-hour limit. The ambulance service reports that the more rural the patient’s location, the longer their response time is likely to be, reflecting the geography and road network as well as the limited number of vehicles. Even among patients with stroke in the Highlands who make it to hospital within the 4.5-hour thrombolysis window, mean times from onset to thrombolysis range from 130 to 210 minutes at the various hospitals audited, and <8% of patients with stroke actually receive the treatment at all.

Scotland has a telestroke program run by the Scottish Center for Telehealth and Telecare, featuring 5 networks around the country. They use videoconferencing from the acute hospital site where local physicians can discuss their patients with specialists many miles away. This service has been running successfully since 2008, and thus the idea of using communications technology in stroke assessment is already in place and being successfully used. However, this service is hospital-based, providing support to smaller institutions rather than in prehospital situations.

Initial code stroke systems were set up within hospitals to organize multidisciplinary rapid–response teams and to expedite diagnosis and treatment in stroke, and these proved successful at reducing time to treatment. This idea then moved into the prehospital sphere, with paramedics alerting hospitals when they encountered suspected acute stroke, and further studies included expert sign-off before a code stroke was activated, to help reduce false-positive cases. In the past year, initial feasibility studies have appeared building on the work of the TeleBAT system, looking at the use of telemedicine systems in real-time prehospital stroke assessment, but these have been based in urban areas, using telecommunications networks which generally provide good area coverage. In remote and rural areas, not only are patients subject to lengthy transport times but there is also frequently poor cellular network coverage—with 38% receiving no 2G signal reception and 70% no 3G signal—which is likely to hamper mobile telemedicine-facilitated assessment.

A Solution

A mobile acute telestroke assessment service could provide crucial information about patients with a suspected stroke while they are being transported to hospital by ambulance. This could allow them to bypass the emergency department and go straight to computed tomography to ensure thrombolysis treatment is appropriate and, if indicated, administered rapidly. This novel audio-visual assessment performed en route could help streamline the patient’s pathway and reduce treatment delays.

This article reports the results of our study investigating the feasibility of mobile telestroke assessment while in transit around the notoriously cellular signal-poor Scottish Highlands.

Methods

Participants were 12 healthy volunteers who took on the role of a patient or responding paramedic, using a script providing details about the suspected stroke patient’s condition. The scripts were chosen at random from a pool describing people with thrombolysable stroke, those with contraindications to thrombolysis, and those with a non-stroke condition (eg, epilepsy and risk of noncompressible hemorrhage). Four experts took part as assessors, following the telestroke checklist prepared by NHS Highland stroke specialists, which incorporates the Recognition of Stroke in the Emergency Room Score, exclusion criteria for thrombolysis, Modified Rankin Scale, and National...
Institutes of Health Stroke Scale. This is used clinically by the stroke team and allowed the experts in this study to reach a conclusion about whether the simulated patient was a candidate for thrombolysis. The assessment of the simulated patient was conducted using live audio and video (AV) feeds streamed from various locations around Inverness (Figure), and was done from a vehicle either while it was in motion (under standard driving conditions) or as a control group, while stationary (parked in a lay-by or car park). The clinical assessor asked questions from the checklist and the volunteer taking the role of patient/paramedic responded with verbal answers or demonstrated the physical movements required for the camera.

The AV streams were transmitted via an Omni-Hub communications system and bandwidth management device (Tactical Wireless, United Kingdom) using bandwidth from a combination of 2G and 3G cellular networks when the vehicle was both stationary and mobile.

The time taken to determine whether the patient was a potential candidate for thrombolysis was recorded. The ability of the AV connection to facilitate diagnosis was rated by the clinical assessor on a 5-point scale (1: unable to make a diagnosis using the communication channels; to 5: diagnostic assessment made, no problems with the connection), as was their assessment of the overall quality of the connection (again using a similar 5-point scale). The data transfer rates and any problems with the equipment or connectivity were recorded.

Ethical approval for the study was provided by the North of Scotland National Research Ethics Service committee (ref: 14/NS/0087).

Results

Nineteen mobile and 4 stationary telestroke assessments were completed. None were abandoned because of connectivity or other technical problems and all were correctly categorized as potentially thrombolysable or not. The mean time to reach this diagnostic assessment, with standard deviation, for the various experimental combinations is shown in Table 1. There were no significant differences between the times of mobile compared with static assessments. The quality of the communications connection, shown in Table 2, was rated lower by the experts during mobile assessments compared with during the stationary trials. Both types of assessment received high ratings when asked whether the AV system allowed adequate diagnosis.

| Table 1. Times to Diagnostic Assessment for the Mobile and Static Telestroke Assessments |
|---------------------------------|-----------------|-----------------|
| Time to Diagnostic Assessment   | Mobile          | Stationary      |
| (minutes): Mean±SD (Range)      | (n=19)          | (n=4)           |
| All assessments                 | 11.1±8.7 (1–31) | 9.8±4.9 (4–16)  |
| Thrombolysable scripts          | 15.0±9.7 (8–31) | 12.5±4.9 (9–16) |
| Nonthrombolysable scripts       | 8.7±7.5 (1–27)  | 7.0±4.2 (4–10)  |

It should be noted that the overall duration of interview and assessment required for the nonthrombolysable scripts was less because of the ability to terminate the checklist at the point when a simulated patient was judged to have a contraindication.

There were occasional breaks or freezes in the transmission (experienced in 47% of the tests), but connection was re-established quickly and only minor delays (eg, several trials reported delays of 2–3 minutes in total during the assessment) were reported. Connectivity data rates ranged from 22 to 1900 kilobits per second (Kbps), with a mean of ≈1250 Kbps. Higher rated AV quality (rated 4/5 or 5/5) was associated with a higher mean upload rate (1021 Kbps, range: 336–839), compared with AV rated 1/5 or 2/5 (553 Kbps, range: 447–1657).

The latency of the transmission was low, at a mean of 300 ms, and this was not considered to be a limitation by the participants at both ends of the communication.

Conclusions

These initial tests have shown that it is feasible to perform telestroke assessments while mobile in rural areas, a service that could be applied when transporting patients the often long distances to hospital. The transmission of live AV feeds in real time to hospital-based experts provided adequate information for a patient to be designated as a candidate for thrombolysis—or not—and this information could help accelerate their path to appropriate treatment on arrival at a center of care. This assessment, because it was done in transit, added no additional time to the patient’s transfer and meant that the usual stationary assessments by paramedics at the scene, on arrival at the hospital, and in the ward or pre-computed tomography scanning were not required. This service could readily be incorporated into stroke care pathways in both rural and urban areas, saving time and potentially improving outcomes by reducing the time to treatment.

AV transmission was performed successfully despite greatly varying levels of connectivity as the vehicle passed in and out of cellular signal areas. The Omni-Hub system is also able to connect to satellite networks in the event of cellular networks being totally unavailable.

| Table 2. Ratings of the Communications Connection for the Mobile and Static Telestroke Assessments by Expert Telestroke Assessors |
|-----------------|-----------------|-----------------|
| Rating (Range; Scale: 1=Worst; 5=Best) | Mobile (n=19) | Stationary (n=4) |
| Rating of whether AV allowed adequate diagnosis | 5 (1–5) | 5 (5–5) |
| Rating of AV quality | 3 (1–5) | 5 (4–5) |

AV indicates audio and video.
These results compare favorably to Liman et al’s study investigating telestroke ambulances in Berlin, in which over half of the scenarios could not be completed because of technical problems involving poor quality, loss, or absence of AV signal. Similarly, Wu et al reported a success rate of 85% without technical complications when performing National Institutes of Health Stroke Scale assessments. This study, performed in rural areas of the Scottish Highlands and including not only the National Institutes of Health Stroke Scale assessment but also the Recognition of Stroke in the Emergency Room Score, Modified Rankin Scale and thrombolysis exclusion criteria, achieved a determination of eligibility for thrombolysis in an average of 11 minutes, which could save considerable time by bypassing these initial checks on arrival at hospital.

Although this enhanced communications system (which also incorporates a portable ultrasound machine) is currently experimental only, to equip an ambulance would cost somewhere in the region of £30K–45K ($48K–72K; €38K–57K), depending on the ultrasound machine chosen. It would require ambulance service approvals to ensure compatibility with operational and power supply factors. The Omni-Hub is of a similar size to a laptop computer, with small dome-shaped aerials that are fitted to the vehicle roof, and portable ultrasound scanners are now little bigger than briefcases. The addition of this equipment to an ambulance would therefore not affect its general usability, but could offer possibilities of remote support for many emergency situations.

Limitations of the study include the use of healthy volunteers to simulate patients: ideally the system should be tested with real patients and their responses to the telestroke checklist, and this would be the next step for the project. The study was not powered for statistical analysis, and so the conclusions reported may be at risk of type 1 error.

In conclusion, this report shows that a remotely performed full assessment for thrombolysis for stroke is possible from a moving vehicle even in the variable connectivity of rural areas of the Scottish Highlands, and could be incorporated into systems of stroke care.

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Disclosures

None.

References


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