# In-Transit Telemedicine Speeds Ischemic Stroke Treatment
## Preliminary Results

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***Background and Purpose***—Time to treatment is critically important in ischemic stroke. We compared the efficacy and cost of teleneurology evaluation during patient transport with that of mobile stroke transport units.

***Methods***—Using cellular-connected telemedicine devices, we assessed 89 presumptive stroke patients in ambulances in transit. Paramedics assisted remote teleneurologists in obtaining a simplified history and examination, then coordinating care with the receiving emergency department. We prospectively assessed door-to-needle and last-known-well-to-needle times for all intravenous alteplase–treated stroke patients brought to our emergency departments by emergency medical services' transport, comparing those with and without in-transit telestroke.

***Results***—From January 2015 through March 2016, 111 stroke patients received intravenous alteplase at study emergency departments. Mean door to needle was 13 minutes less with in-transit telestroke (28 versus 41; $P$=0.02). Although limitations in cellular communication degraded transmission quality, this did not prevent the completion of satisfactory patient evaluations.

***Conclusions***—Improvement in time to treat seems comparable with in-transit telestroke and mobile stroke transport units. The low cost/unit makes this approach scalable, potentially providing rapid management of more patients. **(*Stroke*. 2016;47:00-00. DOI: 10.1161/STROKEAHA.116.014270.)**

**Key Words:** emergency medical services ■ stroke ■ telemedicine ■ therapy ■ time to treatment



More rapid treatment of ischemic stroke[1–3] improves outcomes. Because improved in-hospital processes have reduced door-to-needle (DTN) time,[4] focus has shifted to prehospital time.[5–8] Emergency medical services' (EMS) identification of likely strokes helps,[9,10] and in-ambulance teleneurology has been considered but not tested clinically.[11,12] Mobile stroke transport units (MSTUs), computed tomographic scanner–equipped ambulances with a neurologist, either in person or by telemedicine,[8] to assess thrombolytic appropriateness and oversee treatment, in the prehospital setting, decrease treatment time 25 minutes.[5,8] However, MSTUs cost US$0.75M to $1.4M[5] and require a computed tomographic technologist, an emergency medical technician, and a licensed healthcare practitioner to administer medication, incurring operating costs that can exceed US$1M/y. Consequently, centers use a single MSTU with limited access hours; several operate alternate weeks.[5,6]

Time to treatment can be reduced by performing assessments either before (MSTU) or during patient transport. Time saved must be balanced against additional time needed for specialized units to reach patients; for this reason, the Berlin group chose a 16-minute radius from the MSTU's base.[5] This limits the number of patients treated, ≈1/week in Cleveland, 1 every 2 operating days in Berlin. During times the Berlin unit was functioning, 44% of patients needing alteplase could not be served because of unit unavailability; consequently, the population average savings were 15 minutes/patient.

We, therefore, tested the feasibility of using teleneurology for patients in transit in ambulances. Our goal was to develop a practical, affordable, scalable prehospital approach, providing more rapid care to more patients at lower cost.



## Methods

Atlantic Health System, a not-for-profit multihospital system in suburban New Jersey, includes Overlook Medical Center (OMC), a Joint Commission–certified Comprehensive Stroke Center, and Chilton Medical Center (CMC), a Primary Stroke Center. OMC provides 24/7 telestroke coverage to 6 emergency departments (EDs), including CMC. The current study was piloted at OMC and CMC, selected for well-functioning ED telestroke systems (DTN <60 minutes in >85% of patients at both) and an EMS structure facilitating implementation.

New Jersey's EMS is organized in a 2-tiered system. More than 500 Basic Life Support (BLS) units, mostly town volunteer squads, act as 911 first responders and transport patients in their ambulances. The state's 22 advanced life support (ALS) units, staffed by paramedics, each work with many BLS units and are called to life-threatening emergencies and strokes, as dictated by 911 dispatch protocols. ALS units cover defined geographies. When involved, ALS paramedic units join BLS crews at the scene, then accompany patients to the

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**Table 1. Times From LKWTN to Ambulance Arrival On-Scene, From Scene to ED Arrival, and From ED Door to Alteplase Initiation**

| | EMS Without ITTS | | | | EMS With ITTS | | | |
|---|---|---|---|---|---|---|---|---|
| | All | | W Prenotification | | | | | |
| | n | Mean, min | n | Mean | n | Mean | *P* ITTS vs All EMS | *P* ITTS vs Prenotification |
| DTN | 71 | 41 (36–47) | 43 | 40 (33–47) | 15 | 28 (20–36) | 0.02 | 0.04 |
| LKW to scene | 44 | 50 (35–64) | 28 | 43 (27–59) | 15 | 31.1 (11–81) | NS | NS |
| Scene to ED | 44 | 34 (31–36) | 28 | 32 (29–35) | 15 | 29 (23–35) | NS | NS |
| LKWTN | 71 | 122 (109–135) | 43 | 111 (96–126) | 15 | 92 (69–115) | 0.037 | 0.12 |
| Negative MRI | 17 (24%) | | | | 3 (20%) | | | |
| Seizure | 2 | | | | 0 | | | |
| Deaths | 0 | | | | 0 | | | |
| Complications | 1 retroperitoneal bleed, 1 small traumatic SAH, 3 ICH | | | | 1 hemothorax (rib fracture, fall from stroke) | | | |

Stroke mimics (transient ischemic attacks: brief focal symptoms consistent with a stroke with a normal diffusion-weighted brain MRI). Mean (95% CI). Statistical comparisons by Mann–Whitney *U* test. DTN indicates door to needle; ED, emergency department; EMS, emergency medical service; ICH, intracerebral hemorrhage; ITTS, in-transit telestroke; LKWTN, last-known well to needle; MRI, magnetic resonance imaging; NS, not significant; and SAH, subarachnoid hemorrhage.

ED. The 2 Atlantic Health System ALS units serving OMC work with 11 BLS units covering a population of 300 000. The 2 serving CMC partner with 10 BLS units covers a population of 160 000.

Each of these 4 ALS units was provided an InTouch Xpress device, a portable unit incorporating a high-definition camera, microphone, and screen allowing transparent bidirectional communication. Units cost ≈$23 000; annual connectivity and maintenance costs <$10 000 each. Units are easily clamped onto BLS ambulance stretchers and images transmitted by 4G wireless during patient transport. Atlantic Health System paramedics, trained for neurological emergencies in accordance with the Paramedic National Curriculum, in the Cincinnati Stroke Scale, and in Xpress device use, determined patient eligibility, then collaborated with the stroke teleneurologist in performing the neurological evaluation. In the ED, the stroke team (OMC: in person, normal working hours; teleneurologist, after hours; CMC: teleneurologist), typically with the same stroke neurologist performing in-ambulance assessment, assumed care.

From January 2015 through March 2016, all patients managed by these 4 ALS units, with an abnormal Cincinnati Stroke Scale or otherwise suspected stroke, brought to these 2 EDs, were assessed with in-transit telestroke (ITTS). We compared DTN and last-known-well to needle (LKWTN) times in this group with all other intravenous alteplase–treated stroke patients brought to these 2 EDs by EMS. Twenty-five treated walk-in stroke patients were excluded. Analysis was intention to treat; patients with failed ITTS were included in the telestroke group.

Statistical analyses were performed with StatPlus for Mac (AnalystSoft Inc, version 6). Prespecified primary outcome measures were the differences in DTN and LKWTN times between these 2 groups.

## Results

Eighty-nine patients with suspected strokes were evaluated by ITTS. There were no misses; all alteplase-treated strokes brought to the OMC ED by these 2 U had ITTS. Mean teleconsult duration was 7.3 minutes (95% confidence interval [CI], 4.9–9.8) among the 15 (17%) receiving alteplase, 4.7 minutes (95% CI, 3.9–5.4) among the 74 who did not. Although 39% of teleconsults required reconnection, connectivity was rapidly reestablished in all but 2; in all but these 2, the teleneurologist felt the clinical evaluation was satisfactory. During this same period, 71 alteplase-treated stroke patients were transported to OMC and CMC by EMS without Atlantic Health System paramedic units. Patient demographics were similar for the 2 groups (Table I in the online-only Data Supplement). Mean DTN time (Table 1) was 28 minutes (95% CI, 23–35) in ITTS patients, 41 in controls (95% CI, 36–47; *P*=0.02). Mean LKWTN time was 30 minutes less, 92 with ITTS (95% CI, 69–115), and 122 without (n=71; 95% CI, 109–135; *P*=0.037; Mann–Whitney *U* test). Among patients with known ambulance scene arrival time, mean patient transport time (scene arrival to ED arrival) was 29 minutes with ITTS, 34 without (not significant); control

**Table 2. Exploratory Subgroup Analyses Comparing Patients Treated by ED Telemedicine at CMC and OMC, Versus in Person at OMC**

| | EMS Without ITTS | | EMS With ITTS | | |
|---|---|---|---|---|---|
| | n | DTN Mean (U/LCI) | n | DTN Mean (U/LCI) | *P* (Mann–Whitney *U* test) |
| OMC, ED in person | 48 | 34 (21–40) | 6 | 24 (8–41) | NS (0.11) |
| OMC ED telestroke | 36 | 48 (42–54)* | 5 | 27 (12–42) | 0.02 |
| CMC ED telestroke | 12 | 67 (48–86) | 4 | 35 (12–59) | 0.06 |

Statistical comparisons by Mann–Whitney *U* test (upper/lower CI [UCI/LCI]). CMC indicates Chilton Medical Center; DTN, door to needle; ED, emergency department; EMS, emergency medical service; ITTS, in-transit telestroke; NS, not significant; and OMC, Overlook Medical Center.

*OMC, excluding ITTS, in person vs tele *P*<0.001.

patients were transported a somewhat greater distance (Table I in the online-only Data Supplement). Time from LKW to ambulance on-scene arrival was 31 minutes for ITTS patients, 50 for others. Although not statistically significant, at least partly because of incomplete data, this did contribute to shorter overall LKWTN time.

On post hoc exploratory analyses (Table 2), time saving was greater with ITTS than with EMS ED prenotification without ITTS ($P$=0.04). Among non-ITTS patients evaluated by telemedicine in the OMC ED (n=36), DTN was 12 minutes longer than with in-person assessment (n=48; $P$<0.001). This difference all but disappeared when ITTS and ED telemedicine were combined.

Among the 15 treated ITTS patients, the only alteplase-related complication was a postfall pneumohemothorax, which resolved with a chest tube. There were no symptomatic intracerebral hemorrhages. Three had normal diffusion-weighted magnetic resonance imaging after treatment, as did 17 non-ITTS patients, suggesting either a transient ischemic attack or complete resolution of the arterial obstruction. Other than 2 patients subsequently found to have seizures, all others were judged to have strokes (Table 1).

## Discussion

Our pilot data indicate that mean DTN time can be shortened 13 minutes using ITTS for clinical assessment and preliminary management, comparable with the population estimate of 15 minutes with MSTUs.[5,8] Acceptance among patients and EMS has been uniformly positive. There are obvious challenges examining patients restrained on stretchers in moving vehicles, and maintaining cellular connectivity, but neither precluded obtaining useful information. Perhaps most telling was the preferential time saving when telemedicine was used both in transit and ED, eliminating the time disadvantage inherent in telestroke. We presume that having the same neurologist assessing the patient in both sites allows more time for the relevant thought processes and initiation of needed additional steps to give alteplase. Whether the 23% normal post–alteplase magnetic resonance imaging reflects the efficacy of rapid treatment or difficulty identifying transient ischemic attacks as DTN gets so short is an important question as more hospitals achieve DTN <45 minutes.

Although confirmation in a larger study will be essential, our preliminary observations suggest that ITTS may provide a scalable, inexpensive alternative to MSTUs, with comparably expeditious treatment.

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## Disclosures

Dr Belt was an expert witness in legal proceedings and served as a member of speaker bureau for Teva. Dr Felberg served as a member of speaker bureau for Medtronic. Dr Halperin served on the Editorial Board for *Neurology*; received royalties from Up to Date; received honoraria from various academic institutions and organizations; and was an expert witness in legal proceedings. The other author reports no conflicts.

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Supplemental Table 1. Baseline characteristics of included alteplase-treated, EMS-transported stroke patients. In the first group, EMS management was standard care; in the second in-transit telestroke (ITTS) was used to initiate clinical assessment. Mean (95% confidence intervals [CI]). NS not significant

| | **EMS w/o ITTS** | **EMS w/ ITTS** | |
|---|---|---|---|
| N | 71 | 15 | |
| Male/female | 30/41 | 7/8 | NS |
| Age | 73.9 (70.4-77.3) | 72.7 (66.0-79.4) | NS |
| NIHSS | 10 (8-12) | 10 (7-12) | NS |
| Distance | 8.4 (7.3-9.5) | 5.7 (4.2-7.2) | NS |
| Scene to ED time | 34 (31-36) | 29 (23-35) | NS |