Acutely ischemic stroke (AIS) management is limited by time-dependent interventions that rely on early recognition and transport. Intervention with tissue-type plasminogen activator (tPA) is possible for patients presenting within a maximum of 4.5 hours of symptom-onset.1 Although 80% of the US population lives within 1-hour driving distance of a stroke center,2 tPA administration remains uncommon (3%–15%).3 Most patients remain ineligible because of presentation outside the time window.3

Large-vessel occlusions (LVO) predict poor neurological outcomes.4 Endovascular interventions may be beneficial for patients with LVO, but are also dependent on time and availability.5,6 This remains an option for patients outside the tPA window. Endovascular interventions are available only at Comprehensive Stroke Centers (CSCs), not at Primary Stroke Centers.

Most patients with stroke access health care through EMS.7 Early recognition by paramedics is associated with shorter door-to-computed tomographic times and higher rates of thrombolytic therapy.3 However, prehospital providers have limited ability to recognize and assess stroke.9 The ability of prehospital providers to perform the NIHSS appropriately and triage to Primary Stroke Centers versus CSCs is unknown. This study aimed to determine the agreement between HEMS and stroke team providers using the NIHSS and the ability to predict LVO.

**Methods**—We reviewed all patients with ischemic stroke transported by helicopter emergency medical services (HEMS) to a single comprehensive stroke center in 2010. HEMS NIHSS were compared with in-hospital stroke team physician scores. NIHSS was categorized based on 3 clinically relevant groupings and ability to predict LVO was investigated.

**Results**—Three-hundred five patients met inclusion criteria, 68.9% having LVO. Moderate agreement existed between HEMS and physicians (72.1%; κ=0.571). Interclass correlation was 0.879 (95% confidence interval, 0.849–0.904). Excluding patients with tissue-type plasminogen activator before HEMS transport, there were 216 patients and good agreement (82.7%; κ=0.619). Among patients presenting within 8 hours postonset and NIHSS ≥12, HEMS had a sensitivity of 55.9% and positive predictive value of 83.7% in predicting LVO.

**Conclusions**—HEMS providers can administer NIHSS with moderate to good agreement with the receiving stroke team. The use of the NIHSS in HEMS may identify patients with LVO and inform triage decisions for patients ineligible for tissue-type plasminogen activator. (Stroke. 2015;46:00-00. DOI: 10.1161/STROKEAHA.114.007850.)

**Key Words:** aircraft communication system, EMS
Patients receiving tPA before HEMS arrival (therefore, more likely to have a dynamic NIHSS) were excluded in a secondary analysis. The predictive ability of NIHSS to identify LVO is time dependent, and therefore we analyzed the entire cohort and conducted a subanalysis for those presenting within 8 hours of symptom-onset. In stroke triage, undertriage may have dire outcomes, so we determined the incidence of HEMS assigning lower NIHSS scores than ED stroke team. HEMS performance was characterized using $\kappa$ and interclass correlation. The ability of NIHSS to predict LVO was demonstrated with receiver operating curves. We also investigated the correlation between flight time and NIHSS differences between HEMS and stroke team.

**Results**

We studied 1416 patients admitted to the CSC, of which 957 had AIS. HEMS transported 404, and 305 had both ED and HEMS NIHSS recorded (Figure 1). This cohort consists of 52% of women (158/305) with a median (interquartile range) age of 70 (59–82) years. Transports from the scene represent 18% (55/305) of the cohort. The median HEMS NIHSS was 8 (4–15), and the stroke team was 9 (4–15; Wilcoxon rank-sum, $P=0.877$). Spearman correlation between scoring was 0.838 ($P<0.001$). There were 240 of 305 patients (78.7%) with NIHSS≥4 and 108 (35.4%) that had NIHSS≥12. Median time between symptom-onset and arrival at CSC was 4.1 hours (2.9–6.4). Symptom-onset to HEMS arrival was 3.8 hours (2.7–6.0). There were 210 of 293 (71.7%) patients with LVOs, with 12 missing specific vessel data (3.9%).

We characterized agreement globally using a Bland–Altman plot (Figure 2) and in clinically relevant groups with $\kappa$ ($\kappa=0.571$). Interclass correlation was 0.879 (95% confidence interval, 0.849–0.904). There were 85 cases of disagreement, and of those, only 16 (5.2%) were undertriaged by HEMS (Table). There were 89 (29.2%) patients administered tPA before HEMS transport. There was no significant correlation between length of flight time and differences in HEMS and Stroke team NIHSS ($P=0.655$ for all patients; $P=0.579$ for patients with tPA before HEMS). Stratifying by tPA administration, NIHSS grouping agreement between HEMS and stroke team providers was 178 of 216 (82.7%; $\kappa=0.619$) in the non-tPA group and 58 of 89 (65.1%; $\kappa=0.448$) in the tPA group.

HEMSs and the stroke team demonstrated similar performance in their ability to predict LVO (receiver operating curve area under curve, 0.768 and 0.770, respectively). At NIHSS≥12, HEMS had a positive predictive value (PPV) of 80.5% (sensitivity, 51.9%; specificity, 87.4%), and stroke team had a PPV of 88.5% (sensitivity, 48.6%; specificity, 93.7%).

**Figure 1.** Cohort of patients from helicopter emergency medical services (HEMS) to a Comprehensive Stroke Center (CSC).

**Figure 2.** Bland–Altman plot of agreement between helicopter emergency medical services and emergency department stroke team. Diameter of circle indicates number of patients. The lines represent 95% confidence interval. NIHSS indicates National Institutes of Health Stroke Scale.
Table. Agreement of NIHSS Clinical Groups Between HEMSs and ED

<table>
<thead>
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<th>HEMS NIHSS</th>
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ED indicates emergency department; HEMS, helicopter emergency medical services; and NIHSS, National Institutes of Health Stroke Scale.
*HEMS undertriaged.

In previous literature, the ability of the NIHSS to predict LVO has been time dependent. Within 8 hours of symptom-onset for non-tPA patients, HEMS NIHSS≥2 had a PPV of 83.7% (sensitivity, 55.9% and specificity, 89.1%). The stroke team had a PPV of 93.5% (sensitivity, 52.0% and specificity, 96.8%). This time point is clinically relevant because these are patients most likely to benefit from therapies only available at CSCs.

Discussion

We demonstrate that HEMS can accurately perform the NIHSS and use it to triage patients with stroke to appropriate care. HEMS providers have good agreement with stroke team physicians, despite the limitations of the prehospital environment and the temporal separation between the prehospital and ED evaluation. Previous studies of prehospital stroke assessment focusing on NIHSS use by ground EMS demonstrated poor performance. The experience and training of HEMS may contribute to better agreement with the stroke team. When excluding patients with tPA before HEMS arrival, agreement was good ($\kappa=0.619$). Furthermore, prehospital NIHSS can identify LVO with high sensitivity and could be incorporated as a tool to triage patients who are not eligible for tPA.

Prehospital application of the NIHSS has been considered time consuming, difficult, and unreliable. EMS favors simplified screening tools, such as the Cincinnati Stroke Scale. When combined with the time of symptom-onset, the Cincinnati Stroke Scale is commonly used to triage patients to PCSs for potential tPA administration. Despite extensive campaigns to educate the public and EMS providers on AIS recognition, many patients present outside of the tPA-time window, and intervention rates remain low.

Although the Cincinnati Stroke Scale is able to identify the presence of stroke, it has limited capacity to identify severity. Prehospital NIHSS may benefit patients who present outside the tPA window with an LVO by directing that subgroup to a CSC.

Previous studies looking at the NIHSS to predict LVO have focused on the PPV. These have studied cohorts with known AIS in the inpatient setting where a high PPV would prevent futile interventions. In the field, a definitive AIS diagnosis is impossible. Without advanced imaging, patients with AIS cannot be separated from other causes of focal neurological deficit. In the prehospital setting, sensitivity may be more relevant than PPV, allowing providers to catch those who would be eligible for treatments only available at CSC.

Although overtage drains resources, many patients with stroke mimics require tertiary care. However, undertriage and subsequent transport to non-CSC facilities may lead to delays in care resulting in greater morbidity and mortality. Using an NIHSS≥12, prehospital providers had a modest undertriage rate of 5.2%. Unfortunately, patients with LVOs and low NIHSS may have a perfused penumbra and be ideal candidates for endovascular intervention.

Limitations include selection and spectrum bias among patients with HEMS. Providers may only call a helicopter with perceived high severity of symptoms. Conducting the NIHSS in the prehospital environment is suboptimal and may be limited by constraints of space, lighting, and ambient noise. There are often dynamic changes in the clinical conditions that increase the difficulty of the assessment. The time difference between prehospital assessment and ED-arrival is often longer than an hour. However, we found no correlation between the length of flight time and the difference between HEMS and stroke team NIHSS. The data do not have the resolution to determine the exact time during transport that the NIHSS was administered, and therefore cannot precisely determine the difference in time between HEMS and ED stroke team administration.

Conclusions

Prehospital providers can administer the NIHSS with good agreement with the receiving stroke team. Prehospital use of NIHSS may increase the likelihood triage to the appropriate hospital.

Disclosures

None.

References


Comparing National Institutes of Health Stroke Scale Among a Stroke Team and Helicopter Emergency Medical Service Providers
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