University of Cincinnati

Date: 3/27/2018

I, Jason T McMullan M.D., hereby submit this original work as part of the requirements for the degree of Master of Science in Clinical and Translational Research.

It is entitled:

Prospective Prehospital Evaluation of the Cincinnati Stroke Triage Assessment Tool

Student's name: **Jason T McMullan M.D.**

This work and its defense approved by:

Committee chair: Erin Haynes, Dr.P.H.

Committee member: Opeolu Adeoye, M.D.

30402

Prospective Prehospital Evaluation of the Cincinnati Stroke Triage Assessment Tool

A thesis submitted to the
Graduate School
of the University of Cincinnati
in partial fulfillment of the
requirements for the degree of

Master of Science
in Clinical & Translational Research

In the Department of Environmental Health
Division of Epidemiology
of the College of Medicine

March 2018

by

Jason T. McMullan, M.D.

Doctor of Medicine, Medical University of South Carolina, May 2004

Bachelor of Arts, Davidson College, May 1999

Committee Chair: Erin Haynes, Dr.P.H.

Abstract

Background and Purpose: A simple, easily adoptable scale with good performance characteristics is needed for EMS providers to appropriately triage suspected stroke patients to comprehensive stroke centers (CSC). Many existing tools are complex, require substantial training, or have not been prospectively validated in the prehospital setting. We describe the feasibility and effectiveness of prehospital implementation of our previously retrospectively derived and validated Cincinnati Stroke Triage Assessment Tool (C-STAT) to identify subjects with severe stroke (NIHSS ≥ 15) among all prehospital patients with clinical suspicion of stroke/TIA. Secondly, we evaluated the tool's ability to identify subjects with NIHSS ≥ 10 , large vessel occlusion (LVO), or needing services available only at a CSC.

Methods: Without formalized training, Cincinnati Fire Department providers performed standard stroke screening ("face, arm, speech, time;" FAST) and C-STAT as part of their assessment of suspected stroke/TIA patients. Outcomes for patients brought to the region's only CSC or assessed by the regional stroke team were determined through structured chart review by a stroke team nurse. C-STAT test characteristics for each outcome were calculated with 95% confidence intervals.

Results: Complete prehospital and outcome data were available for 58 FAST-positive subjects among 158 subjects with prehospital suspicion for stroke/TIA. Subjects were excluded if FAST was negative (n=22), FAST or C-STAT was incompletely documented (n=24), if the patient was taken to a non-CSC and did not receive a stroke team consult (n=48), or if outcome data were missing (n=6). C-STAT sensitivity and specificity for each outcome were: NIHSS ≥ 15 , 77% (95% CI 46-95) and 84% (95% CI 69-93); NIHSS ≥ 10 , 64% (95% CI 41-83) and 91% (95% CI 76-98); LVO, 71% (95% CI 29-96) and 70% (95% CI 55-83); overall CSC need 57% (95% CI 34-78) and 79% (95% CI 61-91).

Conclusion: In this pilot prospective evaluation performed in the prehospital setting by EMS providers without formalized training, C-STAT is comparable to other published tools in test characteristics and may inform appropriate CSC triage beyond LVO ascertainment alone.

Copyright Notice

This work has been published in *Prehospital Emergency Care* (vol 21, issue 4, 481-488), copyright 2018 Informa UK Limited.

Acknowledgements

Special thanks to my co-authors: Brian Katz, MD; Joseph Broderick, MD; Pamela Schmit RN, BSN; Heidi Sucharew, PhD; Opeolu Adeoye, MD

Sources of Funding

University of Cincinnati Neurosciences Institute Neurobiology Research Center Pilot Research Program.

Conflicts of Interest/Disclosures

Dr. Broderick has received research monies to the Department of Neurology from Genentech for the PRISMS Trial. The other authors report no conflicts.

Table of Contents

Abstract.....	ii
Copyright Notice	iii
Acknowledgements.....	iv
Sources of Funding.....	iv
Conflicts of Interest/Disclosures	iv
Introduction	1
Methods.....	2
Feasibility/Roll-out.....	2
Prospective Tool Evaluation.....	3
Setting	3
FAST and C-STAT	3
Subjects	4
Outcome Assessments.....	4
Data Abstraction	5
Statistical Analysis.....	5
Results.....	6
Subject Characteristics.....	6
C-STAT Performance	7
Discussion.....	7
Conclusion.....	11
References	12

List of Tables and Figures

Figure 1. Cincinnati Stroke Triage Assessment Tool	17
Figure 2. Participant flow diagram.....	18
Table 1. Comparison of FAST-positive subjects with complete or incomplete C-STAT and outcome data.	19
Table 2. Test characteristics and 95% confidence intervals of C-STAT in FAST+ subjects.	20
Table 3: False Positive case (C-STAT + without severe stroke or CSC need) among FAST+ subjects, n=7..	21
Table 4: False Negative cases (C-STAT - with severe stroke or CSC need) among FAST + subjects, n=9....	22

Introduction

Comprehensive Stroke Centers (CSC) offer advanced care to patients suffering severe, acute cerebrovascular emergencies through dedicated neurosurgery, neurointerventional therapy, and neuroscience intensive care services. Because of the recently demonstrated benefit of endovascular therapy for patients with severe acute ischemic strokes (AIS) due to large vessel occlusion (LVO; e.g. the middle cerebral artery or one of its main branches), and the strong association of outcome with time to reperfusion, appropriate triage to a CSC is critically important.¹⁻⁵

Prehospital screening and triage is an accepted practice in the setting of trauma and ST-segment elevation myocardial infarction; such triage has morbidity and mortality benefit.^{6,7} While half of all AIS patients arrive at the hospital by ambulance,⁸ and recommendations support preferential transport to the highest level of stroke care,⁹ there is not a widely accepted tool to identify the patients most likely to benefit from triage to a CSC.

We have previously described the retrospective derivation and validation of such a tool, the Cincinnati Stroke Triage Assessment Tool (C-STAT, formerly known as the Cincinnati Prehospital Stroke Severity Scale), and it has been externally retrospectively validated.^{10,11} However, the tool had yet to prospectively evaluated in the prehospital setting. The objective of this study is to describe the feasibility of prehospital implementation of the C-STAT (Figure 1) to identify subjects with severe stroke [National Institutes of Health Stroke Scale (NIHSS) ≥ 15] among all prehospital patients with clinical suspicion of stroke. Secondarily, we evaluated the ability for the tool to identify subjects with NIHSS ≥ 10 , the presence of LVO, or the need for services available only at a CSC.

Methods

Feasibility/Roll-out

Our retrospective derivation and validation of the C-STAT has been previously described.¹⁰

Briefly, the C-STAT is comprised of select NIHSS items (1b and 1c—level of consciousness commands and questions, 2—gaze, and 5—arm motor) and simplified to either normal or abnormal. To clarify the wording of the items into something usable by Emergency Medical Technicians, we hosted two small groups of EMS physicians, EMS educators, and EMS providers (paramedics, supervisors, administrators; n=15 total) and used an iterative process to finalize the C-STAT assessment questions.

After the items were finalized, a cohort of on-duty field providers (n=22; 10 EMTs, 11 paramedics, 1 paramedic supervisor) applied the tool to five standardized patients. Importantly, we provided no instruction to the EMS providers in how to use the tool or how to perform the assessment. All providers correctly assessed all scenarios. Finally, the C-STAT items were combined with traditional stroke assessment items, formatted for and incorporated into the prehospital electronic patient care reporting system, and designated as required elements whenever there was a prehospital provider impression of “stroke,” “TIA,” or “hemiparesis” (SafetyPad, OPEN, Inc., Minneapolis, MN).

Prospective Tool Evaluation

Setting

Cincinnati Fire Department is an urban, fire-based, advanced life support EMS system that responds to more than 55,000 emergency medical calls each year. The department is the sole provider of 911 medical response in the City of Cincinnati. Patient care protocols allow transport of suspected stroke patients to any stroke ready hospital (defined as ability to administer tPA and immediate CT availability); there is no preferential triage to primary or comprehensive stroke centers. All hospitals in Greater Cincinnati are supported by the regional University of Cincinnati Stroke Team, which is based out of the region's only CSC.

FAST and C-STAT

FAST (also known as the Cincinnati Prehospital Stroke Scale¹²) and C-STAT assessments were performed by EMS personnel at the time of initial patient evaluation. FAST consists of three elements: facial droop, arm drift, and speech abnormality (dysarthria or aphasia). For each element of FAST and C-STAT, findings were reported as present, absent, or unable to be obtained. The unable to be obtained option was used to identify problematic aspects of the assessments in need of future revision.

FAST was considered positive if at least one element was determined to be abnormal, and served as a screening tool for stroke. A positive C-STAT was defined as a score ≥ 2 (Figure 1) in patients who were FAST-positive. Cases with missing C-STAT elements that could not be definitively categorized as ≥ 2 or < 2 were excluded.

Subjects

Over a period of six months (June-November 2015), all patients transported by Cincinnati Fire Department EMS with a prehospital clinical impression of stroke or TIA were screened with FAST and evaluated with C-STAT. Subjects received standard prehospital care, including transport to a local hospital as per patient/caregiver preference. Patients aged 18+ years were included in this analysis if they were FAST-positive by EMS with calculable C-STAT, transported to the CSC or had a stroke team consult at an outside hospital, and had outcome data (e.g. NIHSS upon arrival to hospital) available in the medical record.

The University of Cincinnati Institutional Review Board approved the study procedures without requirement of informed consent.

Outcome Assessments

The first documented physician performed NIHSS in the medical record was used to define the primary outcome of severe stroke. Cases without clearly documented NIHSS underwent chart review, and a retrospective NIHSS was assigned using validated methods.¹³ Severe stroke was defined as NIHSS ≥ 15 based on the likelihood of large vessel occlusion and the published threshold for consideration of hemicraniectomy after AIS.¹⁴ An NIHSS ≥ 10 was used as a secondary outcome.¹⁵ For other secondary outcomes, the presence of large vessel occlusion (LVO) was determined by dual record review by two stroke team physicians, and discrepancies were independently adjudicated by a third stroke team physician. A composite secondary outcome of “the need for a CSC” was defined based on those patients most likely to benefit from services only available at the CSC which included: NIHSS ≥ 15 , cerebral angiography with or without endovascular thrombectomy, radiographic evidence of LVO, neurosurgical intervention (e.g., hemicraniectomy, external ventricular drainage, hematoma evacuation), or a diagnosis requiring neurosurgical evaluation (i.e., intracerebral hemorrhage or subarachnoid hemorrhage).

Data Abstraction

The electronic patient care reporting system required EMS providers to record FAST and C-STAT assessments into the record before the report could be finalized and submitted. Data were abstracted from the EMS prehospital patient care reports, stroke team consult records for patients assessed by the stroke team, and the electronic medical records of the CSC for patients transported to the CSC for the event of interest.

For each patient, detailed EMS/medical record abstractions were carried out by a trained stroke research nurse. Data capture included subject demographics, EMS transport location, date, time, prehospital and initial hospital assessments and therapies (including vital signs, measures of mental status, and need for medication or resuscitation), initial NIHSS, presence of waxing/waning or rapidly changing symptoms, imaging results, and final diagnoses. Data were directly entered into an electronic data management system (RedCAP). Data discrepancies were adjudicated by study investigators.

Statistical Analysis

Outcome data were only available for subjects transported to the CSC or who were assessed by the stroke team at an outside hospital as part of clinical care. Demographic and clinical characteristics were summarized for the entire cohort and those with outcome data by use of counts and percentages or median and interquartile range and were compared using chi-square test, Fischer's exact test, or Wilcoxon rank sum, as appropriate.

C-STAT performance among FAST positive subjects was assessed for predicting stroke severity ($\text{NIHSS} \geq 15$, $\text{NIHSS} \geq 10$), LVO, and CSC need. Sensitivity, specificity, and positive (PLR) and negative likelihood ratios (NLR) were calculated with 95% confidence intervals.

Results

Subject Characteristics

Over the 6-month study period, 158 subjects aged 18 or older were evaluated by Cincinnati Fire EMS with a clinical suspicion of stroke or TIA. Of the 158, 131 (83%) were FAST-positive, and C-STAT was able to be definitively scored in 112 (85%); in 19 cases, at least one C-STAT item was documented as unable to be obtained by EMS. Sixty-four subjects were transported to the CSC or evaluated by the stroke team at another hospital, and 58 had at least one primary or secondary outcome available. (Figure 2)

The median age of the final cohort of subjects (n=58) was 63 years (IQR 53, 75), 30 (52%) were male, and 30/51 (59%) were African-American. C-STAT was ≥ 2 in 19 (33%). NIHSS (primary outcome) was available for 56 subjects; determination of the presence of LVO was available for 54 subjects; final diagnoses were known for 55; and determination of the need for a CSC need was determined for 54. (Figure 2)

The median NIHSS was 7 (IQR 2, 12) and 7/54 subjects (13%) had documented LVO, including 7 of 17 ischemic stroke subjects. Of the 55 with an available final diagnosis, there were 17 (31%) acute ischemic strokes, 8 (15%) with intracerebral hemorrhages, 6 (11%) with a transient ischemic attack, and 24 (44%) with a diagnosis other than a stroke or TIA. No subject had a subarachnoid hemorrhage. Of the 24 with non-stroke/TIA diagnoses, 15 had acute encephalopathy, 4 had seizures, 2 were determined to have functional deficits, and one each had unilateral vision loss from acute glaucoma, non-operative subdural hematoma, or complex migraine.

The final cohort was younger (63 vs 71 years, $p=0.03$) than the FAST-positive group who had neither CSTAT or outcome data. Otherwise, there were no meaningful differences between the groups. (Table 1).

C-STAT Performance

Test characteristics for the primary and secondary outcomes for FAST-positive subjects are presented in Table 2 (raw data for each outcome appears in Supplemental Table). For NIHSS ≥ 15 , C-STAT had a sensitivity of 77% (95% CI 46-95) and a specificity of 84% (95% CI 69-93). For NIHSS ≥ 10 , the sensitivity of C-STAT was 64% (95% CI 41-83) and specificity 91% (95% CI 76-98). For presence of LVO, the sensitivity was 71% (95% CI 29-96) and specificity 70% (95% CI 55-83); and for overall CSC need sensitivity was 57% (95% CI 34-78) and specificity was 79% (95% CI 61-91).

Of seven false-positive cases (C-STAT ≥ 2 without severe stroke or CSC need), four had prior neurological deficits, one had seizure/status epilepticus, one had a complex migraine and none were determined to have a CSC need (Table 3). Of nine false-negative cases (C-STAT < 2 with severe stroke or CSC need), five had ICH and three had AIS with NIHSS ≥ 15 (Table 4).

C-STAT was not able to be scored in 19/131 (14%) of FAST-positive subjects, primarily due to gaze deviation listed as “unable to be assessed.” Based on post hoc discussions, EMS providers frequently recorded “unable to be assessed” for gaze when the patient would not open their eyes to command or track through cardinal eye movements.

Discussion

In this pilot feasibility study of prehospital application of the C-STAT by EMS providers in patients with suspected stroke, C-STAT was successfully performed in 85% of FAST-positive

patients by EMS providers with no formal training in the instrument. Further, a C-STAT score ≥ 2 demonstrated promising sensitivity and specificity in predicting severe stroke (NIHSS ≥ 15) among all suspected stroke patients in the prehospital setting. Thus, the C-STAT has potential to guide EMS providers in the prehospital triage of FAST-positive patients with suspected stroke, and can be implemented without a significant training burden.

Our cohort was defined by paramedic impression of stroke, and not by final diagnosis. The proportion of non-stroke cases (“mimics”) is understandably high and is similar (44% vs 32%) to that recently reported in a description of helicopter transport of stroke cases.¹⁶

Of the previously published potential prehospital stroke triage tools,^{17,18} only the Rapid Arterial Occlusion Evaluation (RACE) score was assessed in the prehospital setting.¹⁹ However, 60% of stroke patients transferred by EMS were not included and those subjects had less severe strokes and less frequency of LVO than those included in the RACE analysis. Further, the prospective validation cohort for RACE included patients transferred directly to the CSC by EMS or patients who were transferred to the CSC after initial evaluation at a community hospital or primary care center; 18% of patients in the “prehospital” cohort for the validation of RACE had been previously evaluated by a community hospital or primary care center.¹⁹ RACE also requires EMS providers to subjectively grade the severity of facial droop, motor strength, and sensory neglect (agnosia) which complicates inter-rater reliability and adds additional training burden to maintain fluency among EMS providers. In contrast, the C-STAT uses objective measures that take about a minute to complete, and one of the items is already incorporated in the prehospital FAST scale (arm drift). Rapid assessments are important so as to avoid prolonging scene time prior to transport, which already frequently exceed recommendations.²⁰

We specifically chose to evaluate the effectiveness of C-STAT by implementing C-STAT assessments without a formalized training program in a large, urban, Fire Department based EMS system. Cincinnati Fire Department has more than 800 EMTs-and paramedics. Implementing C-STAT without formalized training allowed us to estimate the feasibility of adoption of the approach without extensive use of resources. This approach may have biased our results towards the null, but likely reflect what could be expected if the C-STAT is implemented for triage decisions. In contrast, a recent description of prehospital triage using RACE was implemented after vascular neurologists provided ten 4-hour educational sessions, with 2 hours of each session dedicated to training 464 EMS personnel to use RACE. Despite the dedicated training and incorporation of RACE into a multifaceted stroke alert protocol, more than 31% of “RACE alerts” were false positive activations,²¹ and the need for periodic refresher training to maintain knowledge of RACE is likely substantial. In contrast, our C-STAT based approach with no training would have resulted in 13% false positives. Continuing education availability is a barrier to prehospital stroke recognition,²² suggesting that a simpler scale requiring limited training is more likely to be generalizable to all EMS agencies.

We found that prehospital C-STAT score ≥ 2 had modest sensitivity and specificity for predicting NIHSS ≥ 10 and/or LVO (Table 2) in patients who scored positive on the FAST score as a possible stroke. Published stroke severity tools have been developed preferentially to identify LVO.^{18,19,23} While this subset of patients could benefit from prehospital triage to a CSC for endovascular therapy, such a limited approach ignores other stroke patients that could benefit from CSC services. Arguably, ICH²⁴ and subarachnoid hemorrhage patients may benefit from direct transport to facilities with on-site neurosurgeons to manage early deterioration from hydrocephalus or hemorrhage expansion, while added costs of subsequent transport to dedicated

neuroscience intensive care units may be avoided in young patients with large AIS and outside of the time window for endovascular therapy but who may benefit from decompressive hemicraniectomy. We defined the “need for a CSC” as an outcome parameter to assess how C-STAT performs in the prehospital setting for the composite group of suspected stroke patients who may benefit from direct transport to a CSC from the prehospital setting. Overall, C-STAT had modest sensitivity and specificity for identifying such a group of patients in the prehospital setting (Table 2). Interestingly, none of the patients with ICH and C-STAT ≤ 2 required neurosurgical intervention. A consensus definition of patients who should be triaged directly to a CSC should be a priority in prehospital guidelines.

The greatest limitation of this pilot study is the small sample size and resulting wide confidence intervals around the measured test characteristics. While the point estimates are promising, a larger prospective study in a variety of prehospital settings is needed. We were also limited to following those subjects who had FAST and C-STAT scores who also had clinical evaluations by members of the UC Stroke Team at regional hospitals. It is possible that these excluded subjects were outside of the treatment window for tPA or endovascular therapy, had exclusions for tPA and endovascular therapy, or were determined by treating physicians to have an acute encephalopathy. Inclusion of these subjects may also affect the test characteristics. Future studies should track all subjects who are scored in the prehospital setting. Incorporating additional regional centers in future studies would verify the effectiveness of the limited training approach. C-STAT has not been evaluated in languages other than English.

Gaze deviation documentation was the primary reason for inability to score the C-STAT, and patients in whom gaze was unable to be obtained were frequently unconscious or not following commands. While dedicated training sessions could overcome this deficit, other alternatives

exist (i.e. adding simple instructions to C-STAT score sheets, mirroring Glasgow Coma Scale assessments).

Conclusion

A simple, easily adoptable scale with good performance characteristics is needed for EMS providers to appropriately triage patients with suspected stroke. In this pilot study, the C-STAT was easily performed in the prehospital setting by EMS providers without formalized training, is comparable to other published tools in test characteristics,²⁵ and may inform appropriate CSC triage beyond LVO ascertainment alone in patients with suspected stroke in the prehospital setting. Larger prospective studies are warranted to advance prehospital stroke care.

Acknowledgements--none

Sources of Funding: University of Cincinnati Neurosciences Institute Neurobiology Research Center Pilot Research Program.

Conflicts of Interest/Disclosures: Dr. Broderick has received research monies to the Department of Neurology from Genentech for the PRISMS Trial. The other authors report no conflicts.

References

1. Berkhemer OA, Fransen PS, Beumer D, van den Berg LA, Lingsma HF, Yoo AJ, Schonewille WJ, Vos JA, Nederkoorn PJ, Wermer MJ, van Walderveen MA, Staals J, Hofmeijer J, van Oostayen JA, Lycklama a Nijeholt GJ, Boiten J, Brouwer PA, Emmer BJ, de Bruijn SF, van Dijk LC, Kappelle LJ, Lo RH, van Dijk EJ, de Vries J, de Kort PL, van Rooij WJ, van den Berg JS, van Hasselt BA, Aerden LA, Dallinga RJ, Visser MC, Bot JC, Vroomen PC, Eshghi O, Schreuder TH, Heijboer RJ, Keizer K, Tielbeek AV, den Hertog HM, Gerrits DG, van den Berg-Vos RM, Karas GB, Steyerberg EW, Flach HZ, Marquering HA, Sprengers ME, Jenniskens SF, Beenen LF, van den Berg R, Koudstaal PJ, van Zwam WH, Roos YB, van der Lugt A, van Oostenbrugge RJ, Majoie CB, Dippel DW. A randomized trial of intraarterial treatment for acute ischemic stroke. *N Engl J Med* 2015;372:11-20.
2. Campbell BC, Mitchell PJ, Kleinig TJ, Dewey HM, Churilov L, Yassi N, Yan B, Dowling RJ, Parsons MW, Oxley TJ, Wu TY, Brooks M, Simpson MA, Miteff F, Levi CR, Krause M, Harrington TJ, Faulder KC, Steinfort BS, Priglinger M, Ang T, Scroop R, Barber PA, McGuinness B, Wijeratne T, Phan TG, Chong W, Chandra RV, Bladin CF, Badve M, Rice H, de Villiers L, Ma H, Desmond PM, Donnan GA, Davis SM. Endovascular therapy for ischemic stroke with perfusion-imaging selection. *N Engl J Med* 2015;372:1009-18.
3. Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J, Roy D, Jovin TG, Willinsky RA, Sapkota BL, Dowlatshahi D, Frei DF, Kamal NR, Montanera WJ, Poppe AY, Ryckborst KJ, Silver FL, Shuaib A, Tampieri D, Williams D, Bang OY, Baxter BW, Burns PA, Choe H, Heo JH, Holmstedt CA, Jankowitz B, Kelly M, Linares G, Mandzia JL, Shankar J, Sohn SI, Swartz RH, Barber PA, Coutts SB, Smith EE, Morrish WF, Weill A, Subramaniam S, Mitha AP, Wong JH, Lowerison MW, Sajobi TT, Hill MD. Randomized assessment of rapid endovascular treatment of ischemic stroke. *N Engl J Med* 2015;372:1019-30.

4. Jovin TG, Chamorro A, Cobo E, de Miquel MA, Molina CA, Rovira A, San Roman L, Serena J, Abilleira S, Ribo M, Millan M, Urra X, Cardona P, Lopez-Cancio E, Tomasello A, Castano C, Blasco J, Aja L, Dorado L, Quesada H, Rubiera M, Hernandez-Perez M, Goyal M, Demchuk AM, von Kummer R, Gallofre M, Davalos A. Thrombectomy within 8 hours after symptom onset in ischemic stroke. *N Engl J Med* 2015;372:2296-306.
5. Saver JL, Goyal M, Bonafe A, Diener HC, Levy EI, Pereira VM, Albers GW, Cognard C, Cohen DJ, Hacke W, Jansen O, Jovin TG, Mattle HP, Nogueira RG, Siddiqui AH, Yavagal DR, Baxter BW, Devlin TG, Lopes DK, Reddy VK, du Mesnil de Rochemont R, Singer OC, Jahan R. Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. *N Engl J Med* 2015;372:2285-95.
6. Mahmoud KD, Gu YL, Nijsten MW, de Vos R, Nieuwland W, Zijlstra F, Hillege HL, van der Horst IC, de Smet BJ. Interhospital transfer due to failed prehospital diagnosis for primary percutaneous coronary intervention: an observational study on incidence, predictors, and clinical impact. *Eur Heart J Acute Cardiovasc Care* 2013;2:166-75.
7. Sampalis JS, Denis R, Frechette P, Brown R, Fleiszer D, Mulder D. Direct transport to tertiary trauma centers versus transfer from lower level facilities: impact on mortality and morbidity among patients with major trauma. *J Trauma* 1997;43:288-95; discussion 95-6.
8. Adeoye O, Lindsell C, Broderick J, Alwell K, Jauch E, Moomaw CJ, Flaherty ML, Pancioli A, Kissela B, Kleindorfer D. Emergency Medical Services use by stroke patients: a population-based study. *Am J Emerg Med* 2009;27:141-5.
9. Higashida R, Alberts MJ, Alexander DN, Crocco TJ, Demaerschalk BM, Derdeyn CP, Goldstein LB, Jauch EC, Mayer SA, Meltzer NM, Peterson ED, Rosenwasser RH, Saver JL, Schwamm L, Summers D, Wechsler L, Wood JP. Interactions within stroke systems of care: a

policy statement from the American Heart Association/American Stroke Association. *Stroke* 2013;44:2961-84.

10. Katz BS, McMullan JT, Sucharew H, Adeoye O, Broderick JP. Design and validation of a prehospital scale to predict stroke severity: Cincinnati Prehospital Stroke Severity Scale. *Stroke* 2015;46:1508-12.

11. Kummer BR, Gialdini G, Sevush JL, Kamel H, Patsalides A, Navi BB. External Validation of the Cincinnati Prehospital Stroke Severity Scale. *J Stroke Cerebrovasc Dis* 2016;25:1270-4.

12. Kothari RU, Pancioli A, Liu T, Brott T, Broderick J. Cincinnati Prehospital Stroke Scale: reproducibility and validity. *Ann Emerg Med* 1999;33:373-8.

13. Williams LS, Yilmaz EY, Lopez-Yunez AM. Retrospective assessment of initial stroke severity with the NIH Stroke Scale. *Stroke* 2000;31:858-62.

14. Vahedi K, Hofmeijer J, Juettler E, Vicaut E, George B, Algra A, Amelink GJ, Schmiedeck P, Schwab S, Rothwell PM, Boussier MG, van der Worp HB, Hacke W. Early decompressive surgery in malignant infarction of the middle cerebral artery: a pooled analysis of three randomised controlled trials. *Lancet Neurol* 2007;6:215-22.

15. Cooray C, Fekete K, Mikulik R, Lees KR, Wahlgren N, Ahmed N. Threshold for NIH stroke scale in predicting vessel occlusion and functional outcome after stroke thrombolysis. *Int J Stroke* 2015;10:822-9.

16. Sequeira D, Martin-Gill C, Kesinger MR, Thompson LR, Jovin TG, Massaro LM, Guyette FX. Characterizing strokes and stroke mimics transported by helicopter Emergency Medical Services. *Prehosp Emerg Care* 2016;20:723-8.

17. Llanes JN, Kidwell CS, Starkman S, Leary MC, Eckstein M, Saver JL. The Los Angeles Motor Scale (LAMS): a new measure to characterize stroke severity in the field. *Prehosp Emerg Care* 2004;8:46-50.
18. Singer OC, Dvorak F, du Mesnil de Rochemont R, Lanfermann H, Sitzler M, Neumann-Haefelin T. A simple 3-item stroke scale: comparison with the National Institutes of Health Stroke Scale and prediction of middle cerebral artery occlusion. *Stroke* 2005;36:773-6.
19. Perez de la Ossa N, Carrera D, Gorchs M, Querol M, Millan M, Gomis M, Dorado L, Lopez-Cancio E, Hernandez-Perez M, Chicharro V, Escalada X, Jimenez X, Davalos A. Design and validation of a prehospital stroke scale to predict large arterial occlusion: the rapid arterial occlusion evaluation scale. *Stroke* 2014;45:87-91.
20. Schwartz J, Dreyer RP, Murugiah K, Ranasinghe I. Contemporary prehospital Emergency Medical Services response times for suspected stroke in the United States. *Prehosp Emerg Care* 2016;20:560-5.
21. Zaidi SF, Shawver J, Espinosa Morales A, Salahuddin H, Tietjen G, Lindstrom D, Parquette B, Adams A, Korsnack A, Jumaa MA. Stroke care: initial data from a county-based bypass protocol for patients with acute stroke. *J Neurointerv Surg* 2016.
22. Hodell E, Hughes SD, Corry M, Kivlehan S, Resler B, Sheon N, Govindarajan P. Paramedic perspectives on barriers to prehospital acute stroke recognition. *Prehosp Emerg Care* 2016;20:415-24.
23. Nazliel B, Starkman S, Liebeskind DS, Ovbiagele B, Kim D, Sanossian N, Ali L, Buck B, Villablanca P, Vinuela F, Duckwiler G, Jahan R, Saver JL. A brief prehospital stroke severity scale identifies ischemic stroke patients harboring persisting large arterial occlusions. *Stroke* 2008;39:2264-7.

24. Kim S, Shin SD, Ro YS, Song KJ, Lee YJ, Lee EJ, Ahn KO, Kim T, Hong KJ, Kim YJ. Effect of Emergency Medical Services use on hospital outcomes of acute hemorrhagic stroke. *Prehosp Emerg Care* 2016;20:324-32.
25. Hastrup S, Damgaard D, Johnsen SP, Andersen G. Prehospital acute stroke severity scale to predict large artery occlusion: design and comparison with other scales. *Stroke* 2016;47:1772-6.

Cincinnati Stroke Triage Assessment Tool (C-STAT)

2 points: Conjugate gaze deviation (≥ 1 on NIHSS item)

1 point: Cannot provide his/her age or current month
and does not follow one of 2 commands (eye closure,
opening and closing hand)

1 point: Cannot hold arm (either right or left) up for 10
seconds before arm falls to bed

Figure 1. Cincinnati Stroke Triage Assessment Tool

Figure 2. Participant flow diagram

TIA: transient ischemic attack; FAST: “face arms speech time” stroke screening; NIHSS: NIH stroke scale; LVO: large vessel occlusion; CSC: comprehensive stroke center.

Table 1. Comparison of FAST-positive subjects with complete or incomplete C-STAT and outcome data.

	Total FAST+ N=131	C-STAT and Outcome data N=58	C-STAT or outcome missing N=73	p-value
Age, median (IQR)	67 (57, 82)	63 (53, 75)	71 (59, 85)	0.03
Sex				0.13
Male	58 (44%)	30 (52%)	28 (38%)	
Female	73 (56%)	28 (48%)	45 (62%)	
Race	N=116	N=51	N=65	0.48
White	52 (45%)	21 (41%)	31 (48%)	
Black	64 (55%)	30 (59%)	34 (52%)	
C-STAT	N=112		N=54	0.50
<2 (-)	72 (64%)	39 (67%)	33 (61%)	
≥2 (+)	40 (36%)	19 (33%)	21 (39%)	
NIHSS	N= 60	N=56	N=4	0.33
Median (IQR)	7 (2, 15)	7 (2, 12)	11 (4, 19)	
LVO	N=64	N=54	N=10	0.99
Yes	8 (12%)	7 (13%)	1 (10%)	
No	56 (87%)	47 (87%)	9 (90%)	
Final Diagnosis	N=65	N=55	N=10	0.23
AIS	19 (29%)	17 (31%)	2 (20%)	
ICH	8 (12%)	8 (15%)	0	
TIA	6 (9%)	6 (11%)	0	
Not stroke/TIA	32 (49%)	24 (44%)	8 (80%)	
CSC need	N=57	N=54	N=3	0.07
Yes	24 (42%)	21 (39%)	3 (100%)	
No	33 (58%)	33 (61%)	0	

Table 2. Test characteristics and 95% confidence intervals of C-STAT in FAST+ subjects.

	Sensitivity		Specificity		PLR		NLR	
NIHSS ≥ 10	64	(41-83)	91	(76-98)	7.2	(2.3-22)	0.4	(0.2-0.7)
NIHSS ≥ 15	77	(46-95)	84	(69-93)	4.7	(2.3-9.9)	0.3	(0.1-0.8)
LVO	71	(29-96)	70	(55-83)	2.4	(1.3-4.6)	0.4	(0.1-1.3)
ICH	37	(9-76)	66	(51-79)	1.1	(0.4-2.9)	0.9	(0.5-1.7)
CSC	57	(34-78)	79	(61-91)	2.7	(1.3-5.7)	0.5	(0.3-0.9)

NIHSS: NIH stroke scale; LVO: large vessel occlusion; ICH: intracerebral hemorrhage; CSC: comprehensive stroke center; PLR: positive likelihood ratio; NLR: negative likelihood ratio.

Table 3: False Positive case (C-STAT + without severe stroke or CSC need) among FAST+ subjects, n=7

	FAST			C-STAT							
Case	droop	speech	drift	gaze	arms	orientation	commands	score	NIHSS	Previous Deficit	Diagnosis
FP-1	normal	abnormal	abnormal	UTO	abnormal	abnormal	abnormal	2	14	No	Acute Encephalopathy
FP-2	normal	abnormal	abnormal	abnormal	abnormal	normal	normal	3	7	Yes	TIA
FP-3	abnormal	normal	abnormal	abnormal	abnormal	normal	abnormal	3	11	Yes	AIS
FP-4	abnormal	abnormal	abnormal	abnormal	abnormal	abnormal	UTO	3-4	10	No	Partial Seizure Status Epilepticus
FP-5	normal	abnormal	normal	UTO	abnormal	abnormal	abnormal	2-4	10	Yes	Acute Encephalopathy
FP-6	normal	abnormal	abnormal	normal	abnormal	abnormal	abnormal	2	3	Yes	Acute Encephalopathy
FP-7	abnormal	normal	normal	abnormal	abnormal	normal	abnormal	3	4	No	Complex Migraine

NIHSS: NIH stroke scale; CSC: comprehensive stroke center; TIA: transient ischemic attack;

AIS: acute ischemic stroke; UTO: unable to be obtained.

Table 4: False Negative cases (C-STAT - with severe stroke or CSC need) among FAST + subjects, n=9

	FAST			C-STAT								
Case	droop	speech	drift	gaze	arms	orientation	commands	score	NIHSS	CSC need	Previous Deficit	Diagnosis
FN-1	abnormal	abnormal	UTO	normal	UTO	abnormal	normal	0-1	17	NIHSS ≥ 15	No	AIS
FN-2	normal	abnormal	UTO	normal	UTO	normal	normal	0-1	9	ICH	No	ICH
FN-3	abnormal	abnormal	abnormal	normal	abnormal	abnormal	normal	1	9	LVO	No	AIS
FN-4	abnormal	abnormal	abnormal	normal	abnormal	abnormal	normal	1	11	ICH, neurosurgery	No	ICH
FN-5	abnormal	abnormal	abnormal	normal	abnormal	normal	normal	1	7	ICH	No	ICH
FN-6	abnormal	abnormal	abnormal	normal	abnormal	abnormal	normal	1	26	NIHSS ≥ 15 , LVO, endovascular therapy	No	AIS
FN-7	abnormal	abnormal	abnormal	normal	abnormal	normal	normal	1	11	ICH	No	ICH
FN-8	normal	normal	abnormal	normal	abnormal	normal	normal	1	2	ICH	No	ICH
FN-9	normal	abnormal	abnormal	normal	abnormal	abnormal	normal	1	16	NIHSS ≥ 15	Yes	Todd's Paralysis

NIHSS: NIH stroke scale; LVO: large vessel occlusion; ICH: intracerebral hemorrhage; CSC:

comprehensive stroke center; AIS: acute ischemic stroke; UTO: unable to be obtained.