Rethinking Prehospital Stroke Notification: Assessing Utility of Emergency Medical Services Impression and Cincinnati Prehospital Stroke Scale

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Background and Purpose: Although prehospital stroke notification has improved stroke treatment, incorporation of these systems into existing infrastructure has resulted in new challenges. The goal of our study was to design an effective prehospital notification system that allows for early and accurate identification of patients presenting with acute stroke. *Methods:* We conducted a retrospective single-center cohort study of patients presenting with suspicion of acute stroke from 2014 to 2015. Data recorded included patient demographics, time of symptom onset, Cincinnati Prehospital Stroke Scale (CPSS) score, Glasgow Coma Scale score, National Institutes of Health Stroke Scale (NIHSS) score, emergency medical services (EMS) impression, acute stroke pager activation, acute intervention, and discharge diagnosis. Univariate logistic regression was performed with discharge diagnosis of stroke as the end point. *Results:* A total of 130 patients were included in the analysis; 96 patients were discharged with a diagnosis of stroke or transient ischemic attack. Both NIHSS and the presence of face, arm and speech abnormalities on CPSS were significantly higher in patients with stroke ($P < .05$). EMS correctly recognized stroke in 77.1% of cases but falsely identified stroke in 85.3% of negative cases. CPSS identified 75% of acute stroke cases, but specificity was poor at only 20.6%. All patients receiving intervention had acute stroke pager activation in Emergency Department. *Conclusions:* Prehospital stroke notification systems utilizing EMS impressions and stroke screening tools are sensitive but lack appropriate specificity required for modern acute stroke systems of care. Better solutions must be explored so that prehospital notification can keep pace with advances in acute stroke treatment.
Key Words: Emergency medical service—prehospital notification—stroke—telemedicine.

Introduction

Treatment of acute ischemic stroke has seen tremendous advancement over the last 20 years, first with the introduction of intravenous recombinant tissue plasminogen activator (rt-PA), and more recently, with numerous positive clinical trials promoting endovascular therapy.[1-3] The expression "time is brain" has become the mantra of acute stroke treatment, as an estimated 1.9 million neurons are lost each minute that a stroke is left untreated,[4] and patient outcomes are substantially improved with shorter treatment times.[5,6] As a result, emphasis has been placed on designing systems of care that can rapidly triage patients with acute strokes to deliver treatment with minimal delay.

Approximately 50% of patients with acute ischemic stroke utilize emergency medical services (EMS) to reach the hospital[7]; therefore, EMS personnel have become crucial

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stakeholders in the continuous improvement of acute stroke management. Multiple national guidelines[8,9] have recognized the growing importance of prehospital stroke care by calling for EMS providers to provide early prenotification to the receiving hospital when stroke is recognized in the field.[9] Prehospital notification allows for rapid mobilization of downstream resources, including stroke team activation and access to computed tomography scanners, to expedite intra-hospital triage and improve treatment times. Moreover, it offers a window of opportunity for providers to review relevant medical history and inclusion and exclusion criteria for rt-PA. The implementation of prehospital notification systems have been one of the most successful interventions globally in reducing time to treatment and improving patient outcomes.[6,10-17]

Despite advantages of prehospital notification systems, EMS personnel lack the necessary time and training to perform detailed neurologic assessments. Several scales have been designed and validated to help providers recognize stroke in the field, including the Los Angeles prehospital stroke screen (LAPSS) and the Cincinnati Prehospital Stroke Scale (CPSS).[18-20] Although initial studies showed promising sensitivity and specificity, further reviews demonstrated wide performance variability in clinical practice.[20,21] Major contributors to this variability included underutilization of stroke recognition tools, lack of appropriate education of EMS providers, and the inherent complexity of acute stroke presentations.[22-24]

The low specificity of EMS prehospital notification has led to concerns about effective resource allocation. With each notification, stroke teams are mobilized, computed tomography scanners are reserved, and clinicians are required to step away from other clinical obligations to rapidly triage the incoming patient. High levels of false positives may become overly burdensome for the system, and potentially detrimental to the care of other patients. Therefore, the goal of our study was to design an effective prehospital notification system that allows for early and accurate identification of patients presenting with acute stroke.

Materials and Methods

This study was a retrospective single center cohort study approved by the Mayo Clinic Institutional Review Board, who waived the need to obtain patient consent. The study population included all patients who were identified with potential stroke by our emergency dispatchers at the time of EMS dispatch between January 1, 2014, and December 31, 2015. All patients were transported by ground ambulance to the Mayo Clinic Hospital—St. Mary's Campus Emergency Department (ED) and matched to the Gold Cross EMS database and Mayo Clinic electronic medical record (EMR). Gold Cross is the sole EMS provider within the city of Rochester, Minnesota, and it maintains an electronic database of all patient encounters including date of service, patient name, sex, date of birth, chief complaint, transport times, impression of diagnosis by EMS provider, vital signs, Glasgow Coma Score (GCS), blood glucose, treatment summary, and brief narrative of the encounter. Gold Cross utilizes the CPSS to evaluate all patients with suspected stroke. All Gold Cross paramedics complete a 1-hour online module annually on stroke recognition and assessment in the field as part of their required job training. During the study period, our system did not yet require prehospital notification by EMS.

Data collected from the Gold Cross database for this study included 3 time measures: (1) response time (EMS dispatch to arrival on scene), (2) on-scene time, and (3) transport time. Also included were finger stick glucose; CPSS, subdivided into components of facial droop, arm drift, and speech; GCS, subdivided into eyes, verbal, and motor; dispatcher impression of diagnosis; and EMS impression of diagnosis. EMS impression of diagnosis was recorded as a stroke if primary or secondary diagnosis included the words "transient ischemic attack (TIA)" or "cerebrovascular accident (CVA)." Transport times were recorded in minutes. Gold Cross data were then matched manually with hospital EMR by correlating name, gender, and date of birth. These were confirmed by matching date of EMS with date of ED visit. All patients included in initial population were matched with corresponding Mayo Clinic EMR.

Review of EMR resulted in the collection of the following data: patient demographics; last known well time; acute stroke pager (ASP) activation in the ED; National Institutes of Health Stroke Scale (NIHSS) score at presentation; final diagnosis upon hospital discharge; administration of intravenous rt-PA; and utilization of endovascular intervention. Last known well time was recorded in hours and rounded to the nearest 15 minutes. ASP activation was directed by the ED physician if the patient presentation was consistent with an acute stroke, which was determined by review of the Neurology consultation note and ED physician note. NIHSS score at presentation, use of rt-PA, and endovascular intervention were recorded based on review of neurology consultation note and hospital admission note. Final diagnosis at discharge was documented based on review of hospital admission note and discharge summary.

Inclusion criteria included any one of the following: (1) positive CPSS in field; (2) EMS impression of CVA or TIA; (3) ASP activation in the ED; or (4) discharge diagnosis of CVA or TIA. Exclusion criteria included any one of the following: (1) hospital arrival via helicopter; (2) outside hospital transfer; (3) direct admission without ED evaluation; or (4) last known well time greater than 6 hours.

Data were subsequently organized into continuous and categorical variables. Categorical variables were described as proportions, expressed as a percent of total. Continuous variables were all summarized based on mean, median, standard deviation, and interquartile range. A univariate logistic regression was performed utilizing discharge diagnosis of stroke as the end point. We performed sensitivity and specificity analyses of EMS impression, CPSS, and CPSS combined with EMS impression to determine the impact of these measures in predicting diagnosis of stroke at discharge. An additional univariate logistic regression was then performed on all patients with discharge diagnosis of stroke utilizing APS activation as an end point.

Results

A total of 377 patients identified by EMS dispatchers with a possible stroke were transported to Mayo Clinic Hospital—St. Mary's Campus by Gold Cross EMS from January 1, 2014, to December 31, 2015. Of these patients, 185 met inclusion criteria; 55 were excluded based upon predetermined exclusion criteria; and 5 did not have CPSS documentation in the Gold Cross database (Fig 1). In total, 130 patients were included in data analysis; demographic data and main characteristics of our cohort are shown in Table 1. Ninety-six patients (73.8%) were ultimately discharged with a diagnosis of stroke or TIA (64.5% were ischemic strokes, 20.8% were TIA, and 14.6% were intracerebral hemorrhage). The other 34 patients were misidentified as stroke by the EMS providers, and the discharge diagnoses for this group are presented in Table 2. There was no significant difference in age or gender between the patients with confirmed stroke and those without. The NIHSS score was significantly higher in patients with confirmed stroke ($P < .0001$). The GCS score—both total and individual components—was not significantly different between the 2 groups. Neither mean CPSS nor individual CPSS components were significantly different between the 2 groups, but CPSS score of 3 was a significant predictor for stroke ($P = .007$). EMS personnel correctly recognized stroke in 77.1% of cases but falsely identified stroke in 85.3% of negative cases. Intervention with rt-PA, endovascular therapy, or both occurred in 26 cases; all patients who received intervention had stroke diagnosis at discharge (Table 1).

The ASP was activated by ED providers for 70.1% of patients with stroke and 58.8% of patients without stroke at discharge (Table 3). All patients who received intervention had ASP activated in the ED. Factors associated with ASP activation included NIHSS ($P = .002$), facial droop ($P = .037$), arm drift ($P = .012$), and EMS impression ($P = .017$). Speech difficulty was not significant in either stroke recognition or activation of the ASP. Although EMS impression was a significant factor in determining ASP

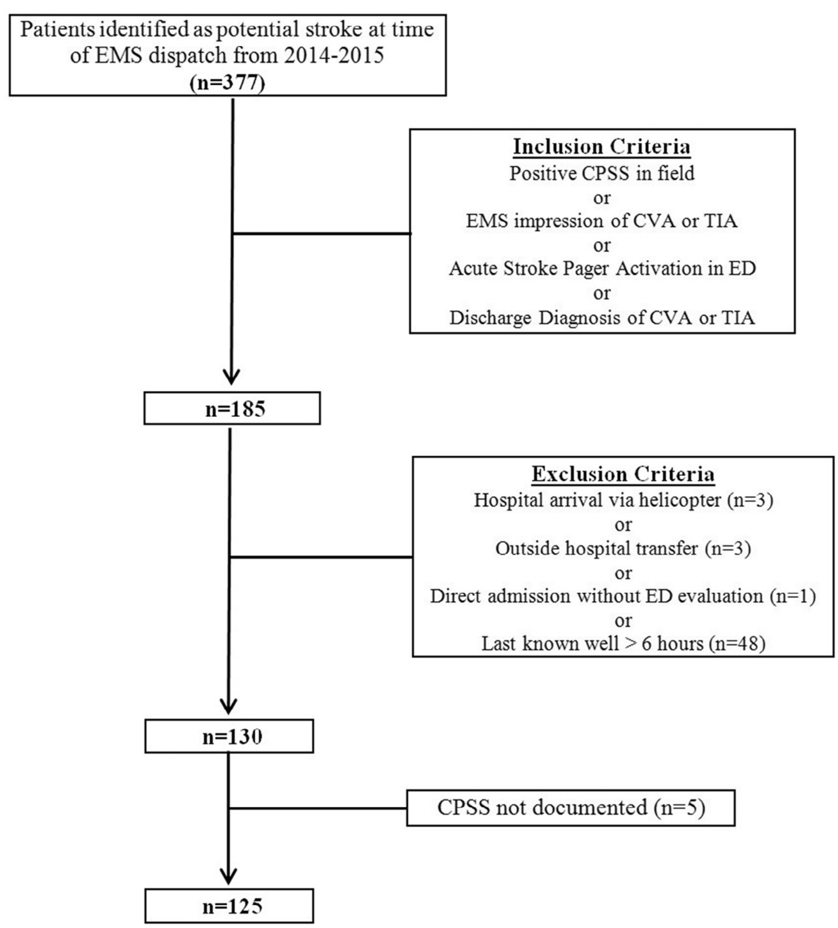

Figure 1. *Inclusion and exclusion critieria flow chart. Abbreviations: CPSS, Cincinnati Prehospital Stroke Scale; CVA, cerebrovascular accident; ED, emergency department; TIA, transient ischemic attack.*

Table 1. *Patient demographics, prehospital metrics, and clinical findings in patients presenting through EMS with possible stroke*

	Stroke	No stroke	*P* value	OR	95% CI
Number of patients (%)	96 (73.8)	34 (26.2)			
Mean age ± SD	76.6 ± 13.5	72.1 ± 14.6	.11	1.023	.995-1.052
Male, number (%)	44 (50)	22 (52.4)	.615	.818	.374-1.79
Characteristics (mean)					
Glucose, mg/dL	133.9	131	.789	1	.992-1.01
Last known well, h	1.3	1.5	.593	.934	.729-1.198
EMS time (mean ± SD)					
Dispatch to scene, min	7.3 ± 4.53	6.2 ± 3.41	.212	1.07	.962-1.19
On-scene time, min	13.5 ± 6.4	14.4 ± 5.7	.487	.979	.922-1.04
Transport time, min	9.8 ± 4.2	10.1 ± 5.96	.712	.985	.907-1.069
GCS (mean)					
Eyes	3.8	4	.227	.312	.047-2.061
Verbal	4.3	4.6	.19	.749	.486-1.154
Motor	5.8	5.9	.443	.746	.353-1.578
Total	14	14.5	.18	.817	.608-1.098
NIHSS, median (IQR)	6 (1.25-14)	1 (0-2)	<.001	1.254	1.099-1.432
CPSS (% positive)					
Facial droop	66.7	44.4	.122	1.909	.842-4.329
Arm drift	84.7	63	.135	1.852	.826-4.155
Speech difficulty	69.4	55.6	.381	1.429	.643-3.175
CPSS (mean)	1.7	1.3	.076	1.4	.965-2.032
EMS impression (%)	74 (77.1)	29 (85.3)	.315	.58	.021-1.677
ASP activation (%)	68 (70.1)	20 (58.8)	.20	1.7	.754-3.831
Type of event (%)					
TIA	20 (20.8)	0			
Ischemic stroke	62 (64.5)	0			
Intracerebral hemorrhage	14 (14.6)	0			
Other	0	34 (100)			
Intervention (%)	26 (27.1)	0			
rt-PA administration	23 (24.0)	0			
Endovascular therapy	9 (9.4)	0			

Abbreviations: ASP, acute stroke pager; CI, confidence interval; CPSS, Cincinnati Prehospital Stroke Scale; EMS, emergency medical services; GCS, Glasgow Coma Score; IQR, interquartile range; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; rt-PA, recombinant tissue plasminogen activator; SD, standard deviation; TIA, transient ischemic attack.

Table 2. *Discharge diagnoses of patients falsely identified as stroke by EMS in the field.*

Discharge diagnosis, number of patients (%)	
Seizure	9 (26.5)
Infection	7 (20.6)
Encephalopathy	6 (17.6)
Syncope	3 (8.8)
Migraine	2 (5.9)
Peripheral nerve injury	2 (5.9)
Electrolyte disturbance	2 (5.9)
Other	3 (8.8)

Abbreviation: EMS, emergency medical services.

activation, EMS personnel had an impression of stroke in 60.7% of cases where ASP was not activated. Only 35% of patients with TIA had ASP activation; ASP activation was much higher in patients with acute ischemic stroke (79%) and intracerebral hemorrhage (85.7%).

Both EMS impression and CPSS were assessed to determine the sensitivity, specificity, positive predictive value, and negative predictive value for prehospital stroke recognition (Table 4). EMS impression (77.1% sensitivity and 14.7% specificity) and CPSS (75% sensitivity and 20.6% specificity) had similarly suboptimal predictive value. As expected, higher CPSS criteria yielded higher specificity and lower sensitivity. The highest sensitivity was attained through the combination of EMS impression of stroke and positive CPSS (85.1%). Conversely, the highest

Table 3. *Clinical determinants of acute stroke pager activation in patients with stroke diagnosis at discharge*

	ASP	No ASP	*P* value	OR	95% CI
Number of patients	68	28			
Mean age ± SD	74.8 ± 14.1	80.8 ± 11	.053	.963	.928-1.0
Male, number (%)	33 (48.5)	17 (60.7)	.279	1.64	.670-4.012
Characteristics (mean)					
Glucose, mg/dL	132.6	137.6	.652	.997	.987-1.008
Last known well, h	1.2	1.65	.18	.825	.623-1.093
EMS time (mean ± SD)					
Dispatch to scene, min	7.3 ± 4.5	7.5 ± 4.6	.833	.99	.899-1.090
On-scene time, min	12.1 ± 4.1	17.0 ± 9.3	.004	.881	.808-.961
Transport time, min	9.6 ± 4.3	10.2 ± 3.9	.572	.97	.874-1.077
NIHSS, median (IQR)	9.7 (4-17)	3.5 (0-4.5)	.002	1.172	1.059-1.297
CPSS (% positive)					
Facial droop	59.1	34.6	.037	2.728	1.060-7.022
Arm drift	74.2	46.2	.012	3.363	1.303-8.678
Speech difficulty	57.6	46.2	.324	1.583	.636-3.944
CPSS (mean)	1.9	1.3	.018	1.639	1.087-2.471
EMS impression (%)	83.8	60.7	.017	3.353	1.239-9.077
Type of event (%)					
TIA	7 (10.3)	13 (46.4)			
Ischemic stroke	49 (72.1)	13 (46.4)			
Intracerebral hemorrhage	12 (17.6)	2 (7.2)			
Intervention	26 (38.2)	0			
rt-PA administration	23 (33.8)	0			
Endovascular therapy	9 (13.2)	0			

Abbreviations: ASP, acute stroke pager; CI, confidence interval; CPSS, Cincinnati Prehospital Stroke Scale; EMS, emergency medical services; IQR, interquartile range; NIHSS, National Institute of Health Stroke Scale; OR, odds ratio; rt-PA, recombinant tissue plasminogen activator; SD, standard deviation; TIA, transient ischemic attack.

specificity was reached through the CPSS scale alone without factoring EMS impression in patients that scored on all 3 CPSS metrics (94.1%).

Discussion

Given the impact of prehospital notification on acute stroke care, the major question to consider is how to best recognize and triage stroke patients in the field. Numerous interventions have been attempted through the implementation of new stroke scales, investment in EMS education programs, and development of mobile stroke units (MSU), which have been shown to reduce the door-to-needle times by over 20 minutes.[25-27] Although the MSU may become the gold standard in densely populated areas where the economics can be justified, we must consider alternative strategies to serve the rest of the population.

In our study, the sensitivity of EMS impression of stroke was 77.1%, indicating that our EMS personnel only missed

Table 4. *Sensitivity and specificity analysis for stroke or TIA diagnosis at discharge comparing EMS impression, CPSS, and combination or both*

		CPSS			EMS impression and CPSS		
	EMS impression	≥1	≥2	3	≥1	≥2	3
Sensitivity	77.1	75.0	58.3	32.3	85.1	68.9	39.2
Specificity	14.7	20.6	55.9	94.1	17.2	51.7	93.1
PPV	71.8	72.7	78.8	93.9	72.4	78.4	93.5
NPV	18.5	22.6	32.2	32.9	31.2	39.5	37.5

Abbreviations: CPSS, Cincinnati Prehospital Stroke Scale; EMS, emergency medical services; NPV, negative predictive value; PPV, positive predictive value; TIA, transient ischemic attack.

approximately 1 in 4 acute strokes in the field. However, specificity of EMS impression was only 14.7%, which would result in significant overactivation if our system relied solely on EMS impression. This is one reason why tools such as the CPSS and the LAPSS were developed. However, the CPSS did not result in greater sensitivity or specificity when compared to EMS impression alone. When both EMS impression and CPSS were factored, this resulted in higher sensitivities and lower specificities across all CPSS scores. Overall, EMS impression, CPSS or a combination of both failed to achieve a sensitivity and specificity desired for an optimal prehospital stroke activation system. However, the value of an early stroke alert in facilitating timely treatment is underscored by our finding that all patients in our cohort who received acute reperfusion therapy had ASP activation in the ED. Although approximately 30% of patients with stroke did not have ASP activation, the majority of patients did not meet criteria for reperfusion therapy and thus do not necessarily represent a missed treatment opportunity.

The results of our study are comparable with those of previous studies evaluating EMS stroke recognition in the field.[23,24] In one systematic review, the CPSS sensitivities ranged from 44% to 95%, whereas specificities ranged from 24% to 79%.[20] Newer scales have been developed to help recognize patients with large vessel occlusions who may benefit from endovascular therapy by stressing certain aspects of the NIHSS, including level of consciousness, gaze deviation or palsy, and arm weakness.[28-30] This is an area of intense research interest, as this subset of patients may be triaged and taken directly to a hospital with endovascular capabilities. Although these scales still require thorough validation, reported sensitivities have ranged from 60% to 83% and specificities, from 40% to 89%.[28-30]

The suboptimal performance of these scales can be attributed to high prevalence of stroke mimics, including seizures, confusion, syncope, and vertigo.[23,31] In our study, we observed that seizure, infection, and encephalopathy constituted approximately 65% of false-positive ASP activations, similar to other reports.[22,23,31] Despite the increasing focus on developing better prehospital stroke recognition tools, recognizing the subtle differences between true stroke and its mimics often requires significant experience and training.

Although many authors have called for increased emphasis on EMS education as part of our acute stroke management,[8,32] intensive EMS training programs have not seen the same widespread implementation as prehospital stroke scales. This is likely related to the variability in EMS structure, competing nature of private EMS companies, and significant rates of personnel turnover. However, this is an area with great potential for optimization in acute stroke management. Kidwell et al[18] achieved excellent sensitivity of 91% and specificity of 97% when they validated LAPSS, but this study involved 18 paramedics who completed a training process that included small-group educational sessions, pre- and post-training testing, and a required 100% post-training test score.[18,22] This hardly reflects the inherent challenges of "real world" clinical practice where EMS personnel do not have the same level of training. Follow-up studies were unable to maintain those rates of sensitivity and specificity.[20] This highlights that we cannot simply implement new scales without arming our EMS personnel with the training necessary to properly employ them.

As we look to the future of acute stroke management, incorporating new technologies may help improve our prehospital processes. Tremendous investment has been placed in the MSU, but perhaps a more practical and cost-effective strategy may be the utilization of mobile technologies that allow trained personnel to evaluate a patient in the field. Taqui et al[26] implemented teleneurology consultation in an MSU, allowing for patients to be evaluated and triaged by a vascular neurologist instead of an EMS provider. Wu et al demonstrated the value of vascular neurologists performing an NIHSS through videoconference in the field.[33] Another study evaluated the feasibility of a tablet-based mobile telestroke network to videoconference with standardized stroke patients and found very similar NIHSS assessments between the face-to-face and the videoconference encounter.[34] This approach alleviates the issue of specialized EMS training and likely increases the prehospital specificity through the reliance on highly trained physicians.

Our study has limitations. First, this is a retrospective review that did not assess the prospective results of the implementation of a prehospital notification system. Second, our analysis was based on patients that were screened with possible stroke by EMS dispatchers, thereby priming our EMS personnel to screen for stroke and suspect stroke before on-scene arrival. This may have led to overestimation of sensitivity and underestimation of specificity. Lastly, the database for this study was from a single EMS provider (Gold Cross), and patients transported by other EMS services were not included in this study.

Conclusions

Along with the development of new treatments for acute ischemic stroke, we must also focus on improving patient identification and triage in the prehospital setting. Although prehospital screens have been designed to achieve high sensitivity, we cannot ignore the downstream effects of overactivation on our emergency care systems. Our study demonstrates that we cannot rely solely on EMS personnel that may lack the education and training necessary to effectively utilize available stroke recognition tools. Therefore, alternative solutions need to be explored, and emerging technologies leveraged to improve prehospital notification for patients with suspected acute stroke.

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