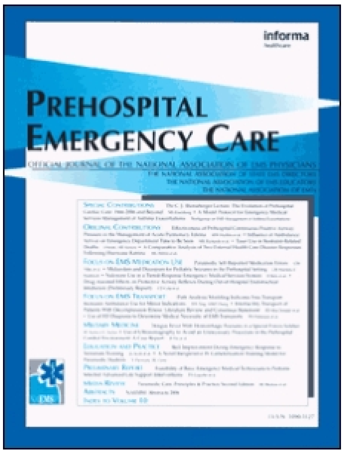

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Advance Hospital Notification by EMS in Acute Stroke Is Associated with Shorter Door-to-Computed Tomography Time and Increased Likelihood of Administration of Tissue-Plasminogen Activator

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Advance Hospital Notification by EMS in Acute Stroke Is Associated with Shorter Door-to-Computed Tomography Time and Increased Likelihood of Administration of Tissue-Plasminogen Activator

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Abstract

Background. Rapid brain imaging is a critical step in facilitating the use of intravenous (IV) tissue-plasminogen activator (tPA) or catheter-based thrombolysis. We hypothesized that advance notification by emergency medical services (EMS) would shorten emergency department (ED) arrival-to-computed tomography (CT) time and increase the use of IV and intra-arterial thrombolysis, even at a tertiary care stroke center with high baseline rates of tPA use. **Methods.** We analyzed data on all acute stroke patients transported from March 2004 to June 2005 by EMS from the scene to our facility arriving ≤6 hours from symptom onset. We reviewed digital voice recordings of all EMS communications to our hospital and in-hospital time intervals and outcomes from our stroke database. **Results.** Among the 118 patients who met criteria, there were no significant differences between those with notification ($n = 44$) and those without ($n = 74$) in terms of age, gender, history of prior stroke, median National Institutes of Health Stroke Scale (NIHSS) score in the ED, proportion with mild stroke (NIHSS score ≤4), or mean onset-to-ED arrival time. Door-to-CT time was 17% shorter (40 vs. 47 minutes, $p = 0.01$) in the advance-notification group, and thrombolysis occurred twice as often (41% vs. 21%, $p = 0.04$). **Conclusion.** Advance notification of patient arrival by EMS shortened time to CT and was associated with a modest increase in the use of thrombolysis at our hospital. This occurred even with protocols in place to shorten the time to CT for all acute stroke patients. Further research is needed to understand how to increase rates of advance notification by EMS in potential tPA candidates. **Key words:** advance notification; stroke; tissue-plasminogen activator; computer tomography

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Introduction

Rapid acquisition and interpretation of computed tomography (CT) scans are critical steps in facilitating the use of intravenous (IV) tissue-plasminogen activator (tPA) and catheter-based thrombolysis. Earlier notification may allow for faster time to treatment and quick mobilization of scarce hospital resources, enabling hospitals to achieve targets promulgated by the Brain Attack Coalition[1] and the National Institute of Neurological Disorders and Stroke (NINDS).[2] A prior single-center study has shown that advance notification by emergency medical services (EMS) providers in the setting of a stroke code system has shortened times from door to CT and increased rates of thrombolysis.[3] Because time from symptom onset to treatment is a potent predictor of return to functional independence, any strategies that can safely shorten door-to-needle time can be expected to result in better patient outcomes.[4,5]

EMS providers, at both the basic and paramedic levels, can be taught to identify symptoms of stroke or transient ischemic attack (TIA).[6] Several prehospital stroke scales have been developed to improve identification of strokes at dispatch and by first responders, thus minimizing the amount of delay from symptom onset to stroke recognition. Proper recognition of stroke by EMS providers not only channels transport of the patient to the most appropriate facility, but also allows the use of stroke-specific basic or advanced life support (ALS) interventions prior to the patient's arrival at the hospital.[7,8]

Prior to the time of our study, Massachusetts EMS protocols required EMS personnel to provide advance notification to hospitals when transporting acute stroke patients. The aim of our study was to determine whether advance notification by EMS providers of acute stroke patient transport from the scene to our facility for those patients who were within six hours from onset of stroke symptoms was associated with shorter door-to CT-time and increased use of thrombolysis. We hypothesized that such advance notification would improve hospital-based response times, even at a tertiary care stroke center such as ours with high baseline rates of tPA utilization for eligible patients.

Methods

Study Population

We analyzed consecutive patient and imaging data collected between March 1, 2004, and June 30, 2005, as part

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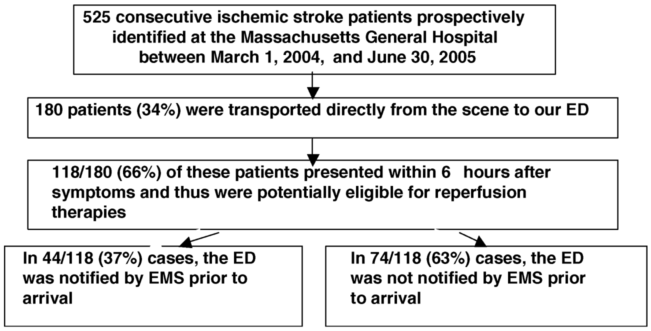

FIGURE 1. Characteristics of the study population. ED = emergency department; EMS = emergency medical services.

of our ongoing institutional "Get With the Guidelines–Stroke" database. Our institutional review board approved the retrospective review of our stroke database. To identify the subset of patients who were eligible for analysis, we reviewed 525 ischemic stroke patients who presented via EMS to our tertiary care center's emergency department (ED) and were concurrently identified by review of hospital admission and acute stroke team logs. There were 180 of 525 patients (34%) who were transported by EMS directly from the scene to our ED. Of these, 118 of 180 acute stroke patients (66%) presented by EMS directly from the scene within six hours after symptom onset and were therefore potentially available for reperfusion therapies (IV or intra-arterial thrombolysis [IAT]) according to our institutional protocols (Fig. 1). The 345 patients (525 minus 180) remaining did not arrive via the ED from the scene, were transferred from other facilities, or were directly admitted to the hospital.

Data Collection

The Get With the Guidelines–Stroke quality improvement program includes real-time concurrent case ascertainment and both concurrent and retrospective review of the medical records for patients discharged with ischemic stroke or TIA. A study physician at our institution reviewed the medical record for demographic and medical information, time of symptom onset, and use of thrombolysis. The time of unenhanced brain CT scan performance was recorded as the digital imaging and communications in medicine (DICOM) time stamp on the digital scout film, extracted from the DICOM header file in the picture archival and storage (PACS) system (AGFA R4, Mortsel, Belgium, and AMICAS, Inc., Boston, MA). All patients were evaluated by a vascular neurologist who, according to institutional protocol, documented the initial National Institutes of Health Stroke Scale (NIHSS), duration of stroke symptoms, and time of thrombolysis if given.

According to regional EMS point-of-entry triage protocols for acute stroke in Massachusetts, emergency medical technician (EMT) personnel are instructed to notify the receiving ED of impending patient arrival for stroke patients within two hours after symptom onset or considered candidates for thrombolytic therapy. Emergency medical services are delivered by a wide range of providers in the greater Boston area. The city of Boston itself maintains a public ambulance service, Boston EMS, under the direction of the Boston Public Health Commission. The Boston fire department also provides first response for selected 9-1-1 calls. Boston EMS is a tiered system with five paramedic ALS ambulances and multiple basic life support (BLS) ambulances covering the city. Boston EMS responds to more than 100,000 calls each year.

The cities and towns that surround Boston are covered by a mixture of private ambulance service companies and fire department ambulances. Paramedic services for the majority of cities and towns that surround Boston are provided by private companies. Many of the cities and towns outside of Boston have contracts with private EMS providers mandating ALS response to all calls. BLS services in other areas are distributed between private companies and fire departments. Under Massachusetts EMS regulations, a paramedic ambulance responding to 9-1-1 calls must have two trained paramedics on board. Potential stroke patients are identified by paramedics using the Boston Operation Stroke Scale (BOSS). BOSS is a modification of the Cincinnati Stroke Scale in which the wording of the text to be repeated was changed to "The sky is blue in Boston" and the use of a fingerstick capillary blood glucose measurement in the field was added.

There were 72 acute care hospitals in Massachusetts during the study period. The Massachusetts Primary Stroke Service program of stroke center designation went into effect during 2004 with triage of acute stroke patients to designated centers starting in July 2005. By January 2005, there were 33 designated centers, including six in the city of Boston.

At our hospital, the audio portion of all EMS advance notification calls are digitally archived in an electronic ED database. Study personnel reviewed these digital voice recordings and classified them according to the following criteria: Calls were divided according to the relative certainty of stroke, as perceived and communicated by EMS personnel. Calls were classified as "probable stroke" when the word "stroke" was used, or as "possible stroke" when the diagnosis of stroke was not mentioned but specific stroke symptoms (e.g., weakness, numbness, facial droop, speech disturbance) were communicated to the ED during the call. This was a retrospective classification applied during data analysis. The distinction is justified on the basis that for "probable stroke," the ED staff receiving the call would unequivocally know that a potential stroke patient was due to arrive and could act accordingly. With "possible stroke," the description of neurologic symptoms may have been interpreted differently by different providers, and acute stroke resources might not have been immediately made available.

The data analysis was based on the information provided by the EMTs during prenotification and the final stroke diagnosis. Data about the presenting complaint as documented by the ED staff on arrival were not collected.

The data were collected and analyzed based on the information provided by the EMTs during prenotification and the final stroke diagnosis. The data were not collected about the presenting complaint as documented by the ED staff on arrival, because such a measure is very difficult to control. Information related to a presenting complaint is captured by many different staff members (nurses, physicians, and sometimes non–health personnel) and has significant heterogeneity.

Statistical Analyses

Comparisons of proportions were conducted by Fisher's exact test. Continuous variables were compared by t-test or Wilcoxon rank-sum test, as appropriate. Correlations between door-to-CT time and other continuous variables were performed by Spearman correlation coefficient, because of nonnormal distributions. Door-to-CT time had a right-skewed distribution; therefore, in order to perform linear regression, it was transformed to a normal distribution by taking the natural logarithm. NIHSS score was treated as a dichotomous variable (0–4 vs. $\geq$5) in the regression model because of nonlinear relationships with door-to-CT and thrombolysis times, and because prior data from our institution suggested that stroke patients with NIHSS scores $\leq$4 are not commonly considered candidates for thrombolysis.[9] Because of the relatively small number of subjects who received thrombolytic agents, we did not perform logistic regression for determination of predictors of thrombolysis.

RESULTS

Patients were classified and analyzed according to whether or not advance notification occurred. Among the 118 patients who met criteria, there were no significant differences between those with notification (n = 44) and those without (n = 74) in terms of age, gender, history of prior stroke, median NIHSS score in the ED, proportion with mild stroke (NIHSS score $\leq$4), or mean onset-to-ED arrival time (Table 1). There was a trend toward higher median NIHSS scores (8.5 vs. 6, p = 0.09) and a higher proportion of more severe strokes (defined as NIHSS score >4; 70% vs. 54%, p = 0.08) among the patients who had advance notification compared with those who did not have notification. In the advance-notification group, door-to-CT time was significantly shorter (p = 0.01) and thrombolysis occurred almost twice as often (p = 0.04) as in the without-notification group (Table 1). Median door-to-CT time was 40 minutes (interquartile range [IQR] 25–49 minutes) in the advance-notification group and 47 minutes (IQR 43–48 minutes) in the without-notification group (p = 0.01). There was a trend toward more patients receiving CT within the NINDS-recommended window of 25 minutes after ED arrival in the advance-notification group compared with the without-notification group (23% vs. 11%, p = 0.11) (Fig. 2).

Nine patients in the group without notification had extremely long (2–5-hour) door-to-CT times. Medical record review revealed the following causes for very long door-to-CT delays: In four of nine cases, the acute stroke team either was not consulted or was notified after the opportunity for thrombolysis had expired because of either waxing and waning of symptoms or the low NIHSS score (<2). In three of nine

TABLE 1. Baseline Characteristics Associated with Advance Notification

Characteristic	Notification by EMS (n = 44) n (%)	No Notification by EMS (n = 74) n (%)	p-Value
Age—mean ± SD*	74.5 ± 15.6 y	71.1 ± 14.8 y	0.23
Gender—female	23 (52)	42 (57)	0.70
Previous stroke	13 (30)	17 (23)	0.51
Previous MI	9 (20)	19 (26)	0.66
Diabetes mellitus	11 (25)	16 (22)	0.82
Identified by EMS as probable stroke	20 (44)	—	—
Onset-to-ED time*	1.1 [0.7, 2.1] h	1.5 [0.7, 2.9] h	0.42
Door-to-CT time*	40 [25, 49] min	47 [34, 81] min	0.01
Door-to-CT time <25 min	10 (23)	8 (11)	0.11
NIHSS score*	8.5 [4, 16]	6 [1, 13]	0.07
NIHSS score >4	31 (70)	40 (54)	0.08
Thrombolysis†	18 (41)	16 (21)	0.04

*Continuous variables are given as mean ± standard deviation (SD) if normally distributed, or median [25th percentile, 75th percentile] if nonnormally distributed.

†Intravenous (IV) tissue-plasminogen activator (tPA) in 20, IV tPA intra-arterial (IA) thrombolysis in 12, and IA thrombolysis alone in two patients.

CT = computed tomography; ED = emergency department; EMS = emergency medical services; MI = myocardial infarction; NIHSS = National Institutes of Health Stroke Scale.

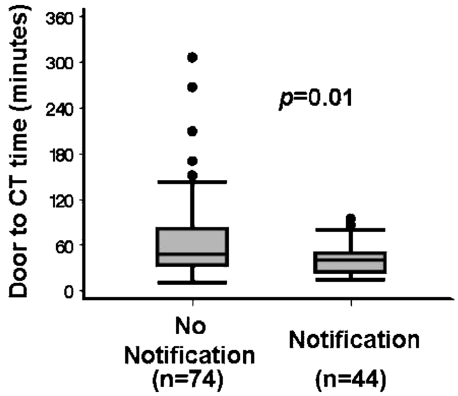

FIGURE 2. Box-and-whisker plot of door-to-computed tomography (CT) times (minutes) in the patients with vs. those without advance notification by emergency medical services to the receiving hospital. The box borders are the 25th and 75th percentiles, the middle bar is the median, and the whiskers extend to 1.5 interquartile ranges. Outlying values are shown as points.

patients, the preexisting diagnosis of diabetes mellitus may have obscured recognition of possible acute stroke. In two of nine cases, no explanation was found in the medical record for the very long door-to-CT times.

There were 27 diabetic patients in the population. There were no differences between the diabetic patients in those with and those without advance notification for mean NIHSS score (7.8 vs. 6.2; $p = 0.5$), or mean $\pm$ standard deviation (SD) blood glucose concentration on arrival (165 $\pm$ 23, range 49–344, vs. 174 $\pm$ 19, range 53–395; $p = 0.7$). Five of the nine patients with very long door-to-CT times (2–5 hours) were diabetic; none of the glucose values were in the range of <50 or >400 mg/dL, which would have excluded stroke as a possible etiology a priori (values = 98, 165, 190, 218, and 395 mg/dL).

The EMS providers gave advance notification for only 44 of 118 stroke patients transported. We cannot know if there was accurate prehospital diagnosis among these patients because they either chose not to call or did not perceive the need to call ahead. Among the 44 patients in the advance-notification group, only 20 of 44 patients (45%) were classified as "probable stroke," whereas 24 of 44 additional patients were classified as "possible stroke." Among those with advance notification, the sensitivity for stroke detection was 20 of 44 (45%) using the stricter criteria of "probable stroke," whereas it increases to 100% using the broader criteria of "possible stroke" (45% vs. 100%; $p = 0.0001$). The advance notification of "probable stroke" was not associated with any additional shortening of median door-to-CT time compared with advance notification of "possible stroke" (42 vs. 39 minutes; $p = 0.5$). Patients with diabetes mellitus were more likely to have longer door-to-CT times than those without diabetes (median 48 minutes vs. 40 minutes, $p = 0.02$). Increasing door-to-CT time was positively correlated with increasing delays between onset to ED arrival ($r = 0.23$, $p = 0.01$) and negatively correlated with increasing stroke severity as measured by NIHSS score ($r = -0.35$, $p = 0.0001$). In a multivariable linear regression model, advance notification by EMS shortened the door-to-CT time by 23% (Table 2).

TABLE 2. Linear Regression Model of Predictors of Shortened Door-to-Computed Tomography Time

Variable	% Decrease in Door-to-CT Time	95% CI	p-Value
Notification	23%	14% to 31%	0.02
Onset-to-ED time	−8%*	−12% to −4%	0.05
NIHSS score >4	27%	18% to 34%	0.005
Diabetes mellitus	−34%	−52% to −34%	0.02

Positive numbers are associated with decreases in door-to-CT time, whereas negative numbers are associated with increases in door-to-CT time.
*For each extra hour of onset-to-ED time. CI = confidence interval; CT = computed tomography; ED = emergency department; NIHSS = National Institutes of Health Stroke Scale.

Thrombolytic therapy was delivered to 34 of 118 patients (29%) and consisted of IV tPA in 20 patients, IV tPA followed by IAT in 12 patients, and IAT alone in two patients. Characteristics associated with thrombolysis are displayed in Table 3. Patients with advance notification by EMS were more likely to be given thrombolysis than those without notification (41% vs. 21%, $p = 0.04$). There were no significant differences in the type of thrombolysis (IV, IA, or combined IV and IA) between the groups with and without advance notification.

DISCUSSION

The rapid evaluation of acute stroke patients and the timely delivery of IV tPA is a highly complex, labor-intensive task that requires coordination among several key providers and the use of various resources. Advance notification to the ED prior to the arrival of an acute stroke patient may increase availability of critical resources and allow the assembly of the team of providers to shorten the evaluation time. It may also help to identify patients at high likelihood of eligibility for tPA, either through a description of symptoms, onset time, and risk factors or by positive identification of an acute stroke diagnosis. Patients with conditions that may mimic stroke (e.g., diabetes, epilepsy, dementia) might be less likely to be accurately identified by EMS as experiencing an acute stroke; therefore, training of prehospital personnel should focus on defining the minimum thresholds and type of data required for activation of hospital-based acute stroke teams. Standardized, validated instruments for acute stroke detection should be developed and implemented systematically.

In univariate analysis of our group of stroke patients, advance notification was associated with a decrease in both the time to completion of brain imaging and an increase in the percentage of patients who received IV tPA. The association with decreased door-to-CT

TABLE 3. Patient and Process Characteristics Associated with Thrombolysis

Characteristic	Thrombolysis ($n = 34$) n(%)	No Thrombolysis ($n = 84$) n (%)	p-Value
Age—mean ± SD*	69.2 ± 18.8 y	73.7 ± 13.3 y	0.15
Gender—female	19 (56)	46 (55)	0.99
Notification by EMS	18 (53)	26 (31)	0.04
Identified by EMS as probable stroke	7 (21)	13 (15)	0.59
Previous stroke	7 (21)	23 (27)	0.49
Previous MI	9 (26)	19 (23)	0.64
Diabetes mellitus	4 (12)	23 (27)	0.09
Onset-to-ED time*	0.6 [0.4, 1.1] h	1.7 [1.0, 3,4] h	<0.0001
Door-to-CT time*	33 [25, 40] min	48 [38, 82] min	<0.0001
Door-to-CT time <25 min	7 (21)	11 (13)	0.39
Door-to-CT time <60 min	32 (94)	49 (58)	<0.0001
NIHSS score*	17 [11, 20]	4 [1, 9.5]	<0.0001

*Continuous variables are given as mean ± standard deviation (SD) if normally distributed, or median [25th percentile, 75th percentile] if nonnormally distributed.
CT = computed tomography; ED = emergency department; EMS = emergency medical services; MI = myocardial infarction; NIHSS = National Institutes of Health Stroke Scale.

time remained significant in multivariate analysis. A comprehensive review of the literature shows that the majority of time delays in acute stroke evaluation and treatment occur in the prehospital arena, prior to contact with hospital staff.[10] The use of EMS has been shown to be associated with shorter delays to being seen by an emergency physician and to receiving a CT scan, but achieving goals determined by the NINDS still remains a huge challenge.[11] Hospitals have made significant efforts to focus on training EMS personnel or first responders to accurately diagnose acute stroke.[12] Some efforts have produced higher sensitivity in detecting acute stroke as demonstrated in the Field Administration of Stroke Therapy–Magnesium (FAST-MAG) pilot trials using the Los Angeles Prehospital Stroke Screen (LAPSS) to identify stroke patients at the scene and the Los Angeles Motor Scale (LAMS) subscore to rate stroke severity. Of the 20 patients enrolled by EMS, all had a final diagnosis of stroke (80% ischemic and 20% hemorrhagic).[13] According to one study, the accuracy of LAMS was as good as the full NIHSS and a shortened NIHSS in predicting functional outcomes.[14] In our study, we collected both field diagnosis of stroke and reporting of symptoms associated with stroke. Our data suggest that accuracy of field diagnosis was not as sensitive as accuracy of field detection of symptoms common in stroke. This finding suggests that the sensitivity of EMS identification of acute stroke could be enhanced by strategies and algorithms that emphasize symptom detection as well as physical examination findings and categorical stroke diagnosis. This may be particularly true in patients with comorbid conditions that mimic stroke. Given the low rates of advance notification and the use of the word "stroke" during this communication, sensitivity to acute stroke would likely be increased if a formal assessment system and calling criteria were used that rely on stroke symptoms and not just the term "stroke."

Cardiologists face a similar challenge in reducing door-to-balloon times for the management of patients with ST-elevation myocardial infarction (STEMI). A recent study has shown that empowering paramedics to evaluate and communicate (via telephone) their observations from prehospital electrocardiograms (ECGs) to a cardiologist in a coronary care unit results in a 54-minute reduction in door-to-balloon times for STEMI.[15]Some hospitals have been successful in reducing door-to-balloon times by promoting the use of prehospital ECGs to allow emergency physicians to activate the catheterization laboratory without cardiology approval. A study of these hospitals indicates that patients transported by paramedics with a prehospital ECG have improved door-to-balloon times.[16] A considerable interdisciplinary collaboration throughout the process is needed to achieve the goals necessary for reducing door-to-treatment times. Applying this lesson to acute stroke, activation of acute stroke teams by EMS personnel directly might help decrease time to imaging and ultimately time to treatment.

In our study, univariate analysis showed that prehospital advance notification shortened time to imaging and increased rates of tPA treatment, even at a well-resourced tertiary care hospital with protocols to rapidly evaluate all suspected stroke patients. The association between advance notification and imaging times remained significant in multivariate analysis. In addition, our study showed that this shortening of door-to-CT time occurred regardless of whether the patient was characterized as "probable stroke" or "possible stroke." This highlights the importance of advance notification per se and not simply proper categorical classification of stroke (as present or absent) by EMS. Furthermore, all the patients who had extremely long door-to-CT times (2–5 hours) were in the group without notification, despite the presence of readily apparent stroke symptoms. Advance notification by EMS may heighten suspicion for acute stroke by ED providers even when EMS providers do not recognize the symptoms as indicative of stroke. Patients with diabetes mellitus were more likely to have longer door-to-CT times; this may be due to the initial misattribution of their symptoms as being due to hyper- or hypoglycemia rather than brain ischemia.

Unlike some trials, our study emphasized the importance of field detection of stroke symptoms. Another recent study has shown that reorganizing the ED (i.e., moving the CT scanner to the ED and streamlining triage based on advance notification by EMS) may help reduce in-hospital delays and increase access to stroke thrombolysis.[17] Others have shown that pathways for acute stroke triage can help reduce door-to-CT and door-to-needle times in patients presenting directly to the ED. To be successful, primary stroke centers must engage in periodic review of their performance using continuous quality improvement methods to ensure that eligible patients are evaluated and treated in a timely manner.[18]

Limitations and Future Research

Our study was limited by the relatively small cohort of patients, the retrospective design, and the potential for bias in the use of advance notification. The higher median NIHSS score in the group with notification may reflect a bias toward notification in the patients with more obvious strokes who receive more rapid evaluation even without notification. However, as previously stated, Massachusetts Department of Health regulations require EMTs to call in advance whenever they are transporting a patient with suspected acute ischemic stroke, without regard to the severity or diagnostic certainty.[19] Given the inherent bias in the current system of advance notification by EMS, it is difficult to determine whether increased notification rates per se will result in increased acute stroke detection in the ED, rapid CT acquisition, and, ultimately, increased use of IV tPA in other hospital settings. We do not have specific data on why EMTs did or did not provide advance notification and can only speculate as to their reasons. Although a study comparing stroke response times in patients with acute stroke arriving by private transport versus EMS would eliminate the issue of bias relating to notification, previous studies have already shown that more severe strokes are associated with EMS activation. This makes such a comparison study infeasible, even when controlling for NIHSS score.

Further, multicenter research is necessary to validate our preliminary findings and understand how advance notification for stroke by EMS impacts patient outcomes.

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