Published in final edited form as:
Stroke. 2011 August ; 42(8): 2263–2268. doi:10.1161/STROKEAHA.110.605857.

Prehospital Notification by Emergency Medical Services Reduces Delays in Stroke Evaluation: Findings from the North Carolina Stroke Care Collaborative

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Abstract

Background and Purpose—Individuals with stroke-like symptoms are recommended to receive rapid diagnostic evaluation. Emergency medical services (EMS) transport, compared to private modes, and hospital notification prior to arrival may reduce delays in evaluation. This study estimated associations between hospital arrival modes (EMS or private; with or without EMS pre-notification) and times for completion and interpretation of initial brain imaging in presumed stroke patients.

Methods—Among suspected stroke patients identified and enrolled by the North Carolina Stroke Care Collaborative (NCSCC) registry in 2008-2009, we analyzed data on arrival modes, meeting recommended targets for brain imaging completion and interpretation times (<25 minutes and <45 minutes since hospital arrival, respectively), and patient- and hospital-level characteristics. We used modified Poisson regression to estimate adjusted risk ratios (RR) and 95% confidence intervals (CI).

Results—Of 13,894 eligible patients, 21% had their brain imaging completed and 23% had their brain imaging interpreted by a physician within target times. Arrival by EMS (versus private transport) was associated with both brain imaging completed within 25 minutes of arrival [EMS with pre-notification: RR=3.0, 95% CI=2.1-4.1; EMS without pre-notification: RR=1.9, 95% CI=1.6-2.3] and brain imaging interpreted within 45 minutes [EMS with pre-notification: RR=2.7, 95% CI=2.3-3.3; EMS without pre-notification: RR=1.7, 95% CI=1.4-2.1].

Conclusions—Presumed stroke patients arriving to the hospital by EMS were more likely to receive brain imaging and have it interpreted by a physician in a timely manner than those arriving by private transport. Moreover, EMS arrivals with hospital pre-notification experienced the most rapid evaluation.

Keywords

acute stroke; emergency medical services; in hospital delay time

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Disclosures
None

Introduction

Thrombolytic therapy can improve neurological outcomes in appropriate stroke patients. Intravenous tissue plasminogen activator (tPA) is most beneficial when administered in a qualified acute care facility within 3 hours of symptom onset.[1,2] Therefore, it is imperative that stroke patients receive timely emergency medical care and evaluation. Only 2-3% of acute strokes are given thrombolytics,[3] which is partly due to both prehospital and in-hospital delays.[4] A recent study found that only 23% of acute stroke patients arrived to the emergency department (ED) within 3 hours of symptom onset.[5] Even when patients arrive soon after symptom onset, physician evaluation and brain imaging studies are required to determine eligibility for thrombolytics. Consensus guidelines recommend a target time of 25 minutes or less from hospital arrival to computed tomography (CT) scan and another 20 minutes for the CT to be interpreted by a neurologist or other physician.[1,6]

Emergency medical services (EMS) can significantly benefit acute stroke patients, but only about half of acute stroke patients use EMS.[7-12] EMS responders can accurately identify suspect strokes in the field[13,14] and notify the receiving facility that a potential stroke patient is en route,[15,16] allowing hospitals to prepare and mobilize resources prior to the patient's arrival. Studies report that EMS utilization is associated with reduced prehospital and in-hospital delays in acute stroke patients.[7-9,12,17-24] However, few have explored more advanced levels of EMS care, such as prehospital notification to the receiving facility.[25]

We examined the associations between hospital arrival mode (EMS versus private transport) and meeting recommended times for completion and interpretation of brain imaging in stroke patients. Further, we compared EMS arrivals by whether or not the receiving hospital was pre-notified.

Methods

Study Population and Data Collection

In 2001, the Paul Coverdell National Acute Stroke Registry (PCNASR) program was established to measure, track, and improve the quality of in-hospital stroke care.[12,26] These state-based registries collect data on quality-of-care indicators based on established guidelines. The North Carolina Stroke Care Collaborative (NCSCC) is one of six PCNASR and includes 52 participating acute care hospitals covering 39 of 100 North Carolina counties, representing 61% of all stroke discharges in the state. As previously described,[27,28] trained hospital staff prospectively identify presumptive stroke patients ages 18 years and older and collect data on demographics, initial presentation, quality-of-care indicators, in-hospital outcomes, and discharge disposition using a standardized, web-based data collection tool.

We used 2008 and 2009 NCSCC data. During this period, hospitals enrolled 16,179 presumptive stroke patients with an admission diagnosis of ischemic stroke, intracerebral hemorrhage, subarachnoid hemorrhage, non-specified stroke, or transient ischemic attack. For our study, patients were excluded if they were transfers from another hospital or had an unknown mode of arrival (N=725), had outside brain imaging prior to hospital arrival (N=1,858), were missing hospital arrival time (N=186), had implausible imaging times (N=9), and had imaging delays greater than 24 hours (N=147). The final study size was 13,894 patients.

Study Measures and Variables

Hospital arrival mode was defined as "private" for arrivals by private car, taxi, or other. Information in the medical record was used to classify EMS arrivals by whether or not there

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was pre-notification to the hospital of a suspected stroke. We calculated delay times from ED or hospital arrival to (1) completion of initial brain imaging and (2) its interpretation by a physician. Imaging completion times were entered from the film printout or the digital image of the radiology report. Imaging interpretation time was defined as the time results were first read by a radiologist, neurologist, ED physician, or any other physician. Times were recorded from various sources including radiology reports, ED notes, and tPA protocol sheets. As a secondary outcome, we examined tPA administration in the subset of eligible patients.

Covariates included age (18-44, 45-64, 65-84, 85+ years), sex, race (White, Black, other), insurance status (Medicare or private insurance, Medicaid only, no insurance), time of day of arrival (7AM-6:59PM, 7-11:59PM, 12-6:59AM), weekend or weekday arrival, documented history of stroke or TIA, presumptive stroke diagnosis (ischemic, hemorrhagic, not-specified, TIA), ambulation at admission (independent or with device, with personal assistance, or unable to ambulate), and patient location at time of symptom onset (not in a healthcare facility, another healthcare facility). Hospital-level characteristics were Joint Commission Primary Stroke Center (JCPSC) certification status, teaching hospital status, and number of beds (<100, 100-300, >300 beds). We defined prehospital delay as the time between when the patient was last known well and hospital arrival, with further categorization by the optimal ≤ 2 hours prehospital delay.

Statistical Analysis

Delays from arrival to brain imaging completion and physician interpretation were compared by arrival mode. Since the distribution of delay times were right skewed, we reported median times (in hours). Per recommended time targets, we calculated crude and covariate-adjusted proportions (risks) of brain imaging completion within 25 minutes of arrival and brain imaging interpretation within 45 minutes of arrival. Crude and adjusted risk ratios (RR) and 95% confidence intervals (CI) comparing arrival modes were estimated using modified Poisson regression with robust variance estimators to account for clustering of patients within hospitals. We adjusted for all covariates to limit potential bias due to confounding and estimated adjusted risks using the distribution of covariates in the total study population. The number needed to treat (NNT) with pre-notification was calculated as the reciprocal of the difference between the risks in the two EMS arrival modes. We repeated analyses restricted to those patients with a prehospital delay of ≤ 2 hours. As a secondary analysis, we fit adjusted regression models comparing tPA administration among ischemic stroke patients who arrived within 2 hours of symptom onset and were identified as having no contraindications.

Since time of brain imaging interpretation was missing for 44% of patients, we conducted a sensitivity analysis using multiple imputation methods to explore potential bias and loss of precision from missing data (see online supplement). Because changes in estimates and loss of precision were minimal, we present results from the complete case analysis only.

Results

Of the 13,894 study patients, 45% arrived by private transportation, and 55% used EMS. Of the EMS arrivals, the receiving hospital was pre-notified in 58% of cases. Table 1 presents patient and hospital characteristics in the total study population and by arrival mode. The strongest predictors of arrival mode were age, time of day of arrival, presumptive stroke diagnosis, ambulatory status on admission, patient location at onset, and hospital bed size. Shorter prehospital delays were also associated with EMS transport and hospital pre-notification. Overall median time (interquartile range) to initial brain imaging completion was 1.0 hours (0.5 – 1.8 hours) and brain imaging interpretation was 1.4 hours (0.8 – 2.3

hours). On average, delay times were longest in the private transport group and shortest in the EMS with pre-notification group (Figure 1).

Overall, 21% of presumed stroke patients had initial brain imaging completed and 23% had their imaging interpreted by a physician within the recommended 25 and 45 minutes following arrival, respectively. For patients receiving imaging within 25 minutes, 60% had results interpreted within the next 20 minutes. Crude and covariate-adjusted probabilties of meeting these targets ("Risks") are presented by arrival mode in Table 2 with RRs and 95% CIs comparing EMS arrival types to private transport (referent). In adjusted analyses, patients arriving by EMS were significantly more likely to have imaging completed and interpreted within the target times. Moreover, pre-notification by EMS (versus no pre-notification) was positively associated with imaging completed within 25 minutes of arrival (RR = 1.5; 95% CI = 1.0, 2.3) and imaging interpreted within 45 minutes of arrival (RR = 1.6; 95% CI = 1.3, 2.0). According to estimated NNTs, on average, 8.8 patients arriving by EMS with pre-notification versus without pre-notification would result in one additional patient having imaging completed within 25 minutes of arrival. Similarly, for every 7.7 patients arriving with pre-notification by EMS, one additional patient would have imaging results interpreted by a physician within 45 minutes of arrival.

Imaging completion and interpretation were almost twice as likely to occur within the optimal time windows when patients arrived within 2 hours of symptom onset or last known well. Adjusted relative risks (RRs) were weaker compared to the entire study population; however, absolute risk differences, particularly between EMS with pre-notification and without, were of similar magnitude (Table 3). Intravenous tPA was initiated in 317 of 467 ischemic stroke patients who arrived within 2 hours of symptom onset and were medically eligible for this treatment. In adjusted analyses, patients arriving by EMS with pre-notification were more likely to receive tPA than those arriving by private transport (RR = 1.5; 95% CI = 1.1, 1.9). Moreover, EMS arrival with pre-notification (versus no pre-notification) was significantly associated with higher tPA administration (RR = 1.6; 95% CI = 1.4, 2.0).

Discussion

The immediate evaluation of stroke patients is critical to identify the best course of treatment and ensure timely administration of therapy, yet meeting in-hospital timing goals continues to be a major challenge. In the NCSCC, about one-fifth of suspected stroke patients had their brain imaging completed or interpreted within the recommended times. A recent comprehensive literature review found that only 2 of 20 published studies reported median times to CT scan less than 25 minutes.[4] Still, they estimated a 0.1-hour annual decline in CT scan delays from 1994-2005. When compared to CT delays reported in a similar NC patient population from 2005-2008[28], we observed 0.2-hour shorter average delay times, suggesting a trend of decreasing delays.

Our findings confirm arrival mode is strongly associated with in-hospital delays in stroke evaluation. Further, the proportion of suspect stroke patients having a brain imaging study completed and interpreted in a timely manner was higher with hospital pre-notification by EMS. This is consistent with a previous study that found shorter times to CT with EMS pre-notification.[25] To illustrate the public health impact of our findings, given approximately 28,000 stroke discharges from NC hospitals per year,[29] an estimated 15,400 would arrive by EMS, and according to our NNT analysis, pre-notification would increase the number of patients having imaging completed within 25 minutes from 4,216 to 4,957, or by 741 patients. Similarly, the number of patients having imaging interpreted within 45 minutes would increase from 4,478 to 5,321, or by 843. Therefore, incorporating pre-notification in large populations could increase timely evaluation in a substantial number of stroke patients.

Our study has several strengths and limitations. NCSCC collects the time of imaging interpretation by a physician, which allowed us to examine a second important source of in-hospital delay. Although current guidelines specifically state a target time,[1,6] we are aware of only one other study that has reported on this endpoint.[30] Measuring time to brain imaging interpretation is challenging. Although NCSCC personnel are instructed to record the time images are first read by any physician, the sources of this information can vary by site and patient. Data quality and completeness are important considerations for collection and analysis of this measure. Even though interpretation time was missing for about 44% of patients in this study, we were reassured that our sensitivity analysis demonstrated consistent estimates (see online supplement).

We conducted a secondary analysis of the NCSCC, so our study was limited to existing data. Nonetheless, given the extensive information collected, we were able to adjust for confounding by numerous patient and hospital characteristics. However, we could not adjust for stroke severity since it was not adequately measured. Since more severe strokes may have shorter prehospital delays,[9] we may have accounted for some confounding by severity in the analysis restricted to patients arriving within 2 hours of onset, where we found positive, although weaker, associations. Hospital participation in the NCSCC is voluntary; thus, our study may not be representative of all hospitals in North Carolina. However, NCSCC hospitals are located in geographic regions across the state and are diverse in terms of size and type.

A main strength of the NCSCC is that patients are enrolled prospectively based on a presumptive stroke diagnosis. Trained hospital personnel examine various information sources including ED discharge diagnoses and physician admission notes for evidence of a suspected stroke. Therefore, we were able to study the in-hospital evaluation of patients with an initial clinical impression of stroke or TIA, regardless of final diagnosis. To show that our results are robust to the exclusion of TIAs, we performed a stroke only analysis and found slightly stronger associations between arrival mode and imaging delay times, while observing the same relationships as with the overall study population.

Our assessment of EMS pre-notification was limited to present or absent; thus, we did not capture additional details communicated to hospitals, such as type of symptoms and prehospital stroke screening results. Moreover, data on the capabilities and resources of EMS agencies and their personnel were also not available. These characteristics are known to vary substantially by region[31] and should be explored as potentially modifying factors of the perceived benefits associated with individual EMS actions. Nonetheless, our study addresses an important characteristic of EMS transport of potential stroke patients with implications for policies that influence the role of EMS in stroke systems of care. Our results suggest that implementing hospital pre-notification in EMS protocols may significantly reduce delays in the evaluation of acute stroke patients. Additional analyses suggest a similar impact of EMS pre-notification on rates of tPA administration. Further research is needed on how faster completion of diagnostic procedures translates into improvements in the delivery of acute stroke care.

Conclusions

In the NCSCC from 2008-2009, hospitalized patients with stroke-like symptoms arriving by EMS were more likely to receive brain imaging and have it interpreted by a physician in a timely manner than those arriving by private transport. Moreover, EMS arrivals with pre-notification to the hospital experienced the most rapid evaluation. Nevertheless, the proportion of patients who met recommended target times was only about 20%. Patients arriving soon after symptom onset were more likely to meet these targets, although there were still reductions in hospital delays with EMS pre-notification. These findings support the practice of pre-notification by EMS personnel when transporting suspected stroke patients to the hospital.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We thank participating hospitals and staff.

Sources of Funding

This study was supported by the Centers for Disease Control and Prevention (CDC) as a Paul Coverdell National Acute Stroke Registry (PCNASR) via a subcontract with the North Carolina Division of Public Health (Contract # 01602-10).

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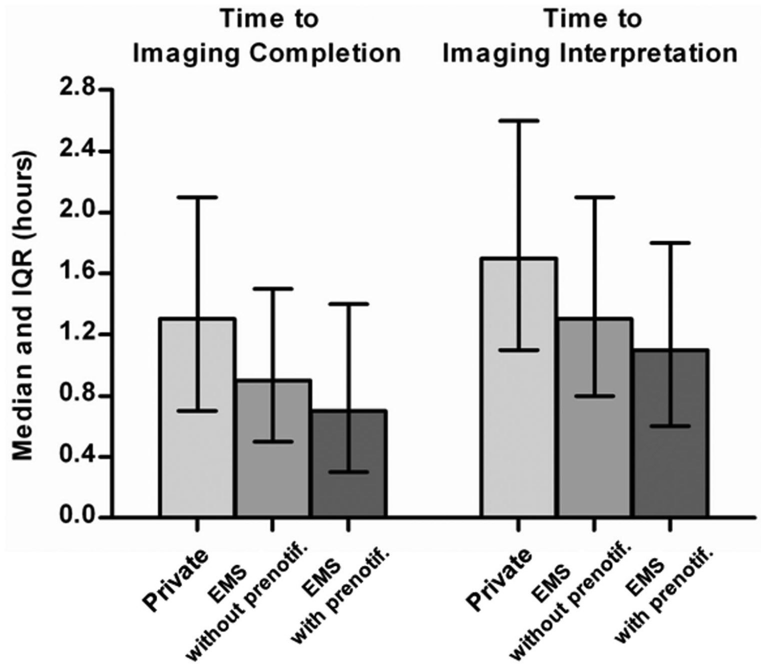

Figure 1.
Median In-hospital Delay Times (and Interquartile Range, IQR) by Arrival Mode, NCSCC, 2008-2009

Table 1

Patient- and Hospital-level Covariates by Arrival Mode, North Carolina Stroke Care Collaborative (NCSCC), 2008-2009

	Arrival Mode							
					EMS			
Covariates	**Total (N=13,894)**		**Private (N=6,300)**		**Without pre-notification (N=3,214)**		**With pre-notification (N=4,380)**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Age, years								
18-44	713	5%	419	7%	120	4%	174	4%
45-64	4,401	32%	2,422	38%	817	25%	1,162	27%
65-84	6,547	47%	2,850	45%	1,569	49%	2,128	49%
85+	2,233	16%	609	10%	708	22%	916	21%
Female Sex	6,430	46%	3,017	48%	1,405	44%	2,008	46%
Race								
White	10,000	72%	4,482	71%	2,281	71%	3,237	74%
Black	3,564	26%	1,654	26%	859	27%	1,051	24%
Other	270	2%	137	2%	55	2%	78	2%
missing	60		27		19		14	
Insurance Status								
Medicare or Private	12,027	87%	5,310	85%	2,828	89%	3,889	89%
Medicaid only	601	4%	296	5%	139	4%	166	4%
None	1,182	9%	652	10%	219	7%	311	7%
missing	84		42		28		14	
Time of Day of Arrival								
7:00AM-6:59PM	10,258	74%	4,903	78%	2,262	70%	3,093	71%
7:00PM-11:59PM	2,570	19%	1,067	17%	640	20%	863	20%
12:00AM-6:59AM	1,066	8%	330	5%	312	10%	424	10%
Weekend Arrival	3,716	27%	1,618	26%	896	28%	1,202	27%
Prehospital Delay								
≤ 2 hours	2,588	46%	804	38%	554	44%	1,230	54%
> 2 hours	3,083	54%	1,315	62%	701	56%	1,067	46%
missing	8,223		4,181		1,959		2,083	
History of Stroke or TIA	4,946	36%	2,045	32%	1,260	39%	1,641	37%
Presumptive Stroke Diagnosis								
Ischemic	4,916	35%	2,141	34%	978	30%	1,797	41%
Hemorrhagic	1,329	10%	293	5%	420	13%	616	14%
TIA	3,524	25%	1,909	30%	746	23%	869	20%
Not-specified	4,125	30%	1,957	31%	1,070	33%	1,098	25%
Ambulatory Status at Admission								
Independent	11,997	91%	5,833	96%	2,596	87%	3,568	86%
Other or Unable	1,239	9%	259	4%	405	14%	575	14%

Covariates	Total (N=13,894)		Arrival Mode					
			Private (N=6,300)		EMS			
					Without pre-notification (N=3,214)		With pre-notification (N=4,380)	
	No.	%	No.	%	No.	%	No.	%
missing	658		208		213		237	
Patient Location at Onset								
Not a Health Care Facility	12,631	92%	6,076	98%	2,703	85%	3,852	89%
Another Health Care Facility	1,075	8%	134	2%	459	15%	482	11%
missing	188		90		52		46	
JCPSC Certification	6,974	50%	3,060	49%	1,675	52%	2,239	51%
Teaching Hospital	5,164	37%	2,248	36%	1,284	40%	1,632	37%
Hospital Beds								
< 100	789	6%	420	7%	229	7%	140	3%
100-300	5,794	42%	2,853	45%	1,581	49%	1,360	31%
> 300	7,311	53%	3,027	48%	1,404	44%	2,880	66%

TIA indicates transient ischemic attack; JCPSC, Joint Commission Primary Stroke Center

Table 2

Associations between Meeting Brain Imaging Target Times and Arrival Mode, NCSCC, 2008-2009

	Brain Imaging completed within 25 minutes			Brain Imaging interpreted within 45 minutes		
	Risk	**RR**	**95% CI**	**Risk**	**RR**	**95% CI**
Crude						
EMS with pre-notification	0.32	2.9	(2.1, 3.9)	0.34	2.5	(2.1, 3.1)
EMS without pre-notification	0.22	1.9	(1.5, 2.5)	0.24	1.8	(1.4, 2.3)
Private (ref)	0.11	1		0.13	1	
Adjusted*						
EMS with pre-notification	0.32	3.0	(2.1, 4.1)	0.35	2.7	(2.3, 3.3)
EMS without pre-notification	0.21	1.9	(1.6, 2.3)	0.22	1.7	(1.4, 2.1)
Private (ref)	0.11	1		0.13	1	

RR indicates risk ratio; CI, confidence interval

*Adjusted for age, sex, race, health insurance, time of day of arrival, weekend arrival, documented history of stroke/TIA, presumptive stroke diagnosis, ambulatory status at admission, patient location at onset, JCPSC certification, teaching hospital, hospital beds

Table 3

Associations between Meeting Brain Imaging Target Times and Arrival Mode among Patients Arriving Within 2 Hours of Stroke Onset, NCSCC, 2008-2009

	Brain Imaging completed within 25 minutes			**Brain Imaging interpreted within 45 minutes**		
	Risk	**RR**	**95% CI**	**Risk**	**RR**	**95% CI**
Crude						
EMS with pre-notification	0.55	2.3	(1.8, 2.8)	0.57	1.8	(1.5, 2.1)
EMS without pre-notification	0.34	1.4	(1.1, 1.8)	0.43	1.3	(1.1, 1.7)
Private (ref)	0.25	1		0.32	1	
Adjusted*						
EMS with pre-notification	0.52	1.9	(1.6, 2.3)	0.53	1.5	(1.3, 1.7)
EMS without pre-notification	0.34	1.2	(1.0, 1.6)	0.43	1.2	(1.0, 1.5)
Private (ref)	0.27	1		0.35	1	

RR indicates risk ratio; CI, confidence interval

*Adjusted for age, sex, race, health insurance, time of day of arrival, weekend arrival, documented history of stroke/TIA, presumptive stroke diagnosis, ambulatory status at admission, patient location at onset, JCPSC certification, teaching hospital, hospital beds