Prehospital Notification by Emergency Medical Services Reduces Delays in Stroke Evaluation

Findings From the North Carolina Stroke Care Collaborative

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

Methods—Among patients with suspected stroke identified and enrolled by the North Carolina Stroke Care Collaborative registry in 2008 to 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 and 95% CIs.

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 prenotification: risk ratio, 3.0; 95% CI, 2.1 to 4.1; EMS without prenotification: risk ratio, 1.9; 95% CI, 1.6 to 2.3) and brain imaging interpreted within 45 minutes (EMS with prenotification: risk ratio, 2.7; 95% CI, 2.3 to 3.3; EMS without prenotification: risk ratio, 1.7; 95% CI, 1.4 to 2.1).

Conclusions—Patients with presumed stroke 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 prenotification experienced the most rapid evaluation. **(*Stroke*. 2011;42:2263-2268.)**

Key Words: acute stroke ■ emergency medical services ■ in-hospital delay time

Thrombolytic therapy can improve neurological outcomes in appropriate patients with stroke. Intravenous tissue-type 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 patients with stroke receive timely emergency medical care and evaluation. Only 2% to 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 patients with acute stroke arrived to the emergency department 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 from hospital arrival to 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 patients with acute stroke, but only approximately half of patients with acute stroke use EMS.[7–12] EMS responders can accurately identify suspect strokes in the field[13,14] and notify the receiving facility that a patient with potential stroke is en route,[15,16] allowing hospitals to prepare and mobilize resources before the patient's arrival. Studies report that EMS use is associated with reduced prehospital and in-hospital delays in patients with 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 patients with stroke. Furthermore, we compared EMS arrivals by whether the receiving hospital was prenotified.

Methods

Study Population and Data Collection

In 2001, the Paul Coverdell National Acute Stroke Registry (PCNASR) program was established to measure, track, and improve

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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 1 of 6 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 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 patients with presumptive stroke with an admission diagnosis of ischemic stroke, intracerebral hemorrhage, subarachnoid hemorrhage, nonspecified 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 before hospital arrival (N=1858), were missing hospital arrival time (N=186), had implausible imaging times (N=9), and had imaging delays >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 there was prenotification to the hospital of a suspected stroke. We calculated delay times from the emergency department 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, emergency department physician, or any other physician. Times were recorded from various sources including radiology reports, emergency department notes, and tPA protocol sheets. As a secondary outcome, we examined tPA administration in the subset of eligible patients.

Covariates included age (18 to 44, 45 to 64, 65 to 84, 85+ years), sex, race (white, black, other), insurance status (Medicare or private insurance, Medicaid only, no insurance), time of day of arrival (7 AM to 6:59 PM, 7 to 11:59 PM, 12 to 6:59 AM), weekend or weekday arrival, documented history of stroke or transient ischemic attack, presumptive stroke diagnosis (ischemic, hemorrhagic, not specified, transient ischemic attack), ambulation at admission (independent or with device, with personal assistance, or unable to ambulate), and patient location at the time of symptom onset (not in a healthcare facility, another healthcare facility). Hospital-level characteristics were Joint Commission Primary Stroke Center certification status, teaching hospital status, and number of beds (<100, 100 to 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. Because the distribution of delay times was 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 and 95% CIs 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 with prenotification was calculated as the reciprocal of the difference between the risks in the 2 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 patients with ischemic stroke who arrived within 2 hours of symptom onset and were identified as having no contraindications.

Because 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; http://stroke.ahajournals.org). 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 prenotified 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 prenotification. Overall median time (interquartile range) to initial brain imaging completion was 1.0 hours (0.5 to 1.8 hours) and brain imaging interpretation was 1.4 hours (0.8 to 2.3 hours). On average, delay times were longest in the private transport group and shortest in the EMS with prenotification group (Figure).

Overall, 21% of patients with presumed stroke had initial brain imaging completed and 23% had their imaging interpreted by a physician within the recommended 25 and 45 minutes after arrival, respectively. For patients receiving imaging within 25 minutes, 60% had results interpreted within the next 20 minutes. Crude and covariate-adjusted probabilities of meeting these targets ("risks") are presented by arrival mode in Table 2 with risk ratios and 95% CIs comparing EMS arrival types with 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, prenotification by EMS (versus no prenotification) was positively associated with imaging completed within 25 minutes of arrival (risk ratio, 1.5; 95% CI, 1.0 to 2.3) and imaging interpreted within 45 minutes of arrival (risk ratio, 1.6; 95% CI, 1.3 to 2.0). According to estimated numbers needed to treat, on average, 8.8 patients arriving by EMS with prenotification versus without prenotification would result in 1 additional patient having imaging completed within 25 minutes of arrival. Similarly, for every 7.7 patients arriving with prenotification by EMS, 1 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 were weaker compared with the entire study population; however, absolute risk differences, particularly between EMS with prenotification and without, were of similar magnitude (Table 3). Intravenous tPA was initiated in 317 of 467 patients with ischemic stroke who arrived within 2 hours of symptom onset and were medically eligible for this treatment. In adjusted analyses, patients arriving by EMS with prenotification were more likely to receive tPA than those arriving by private transport

Table 1. Patient- and Hospital-Level Covariates by Arrival Mode, North Carolina Stroke Care Collaborative, 2008 to 2009

			Arrival Mode					
					EMS			
	Total (N=13 894)		Private (N=6300)		Without Prenotification (N=3214)		With Prenotification (N=4380)	
Covariates	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Age, y								
18–44	713	5%	419	7%	120	4%	174	4%
45–64	4401	32%	2422	38%	817	25%	1162	27%
65–84	6547	47%	2850	45%	1569	49%	2128	49%
85+	2233	16%	609	10%	708	22%	916	21%
Female sex	6430	46%	3017	48%	1405	44%	2008	46%
Race								
White	10 000	72%	4482	71%	2281	71%	3237	74%
Black	3564	26%	1654	26%	859	27%	1051	24%
Other	270	2%	137	2%	55	2%	78	2%
Missing	60		27		19		14	
Insurance status								
Medicare or private	12 027	87%	5310	85%	2828	89%	3889	89%
Medicaid only	601	4%	296	5%	139	4%	166	4%
None	1182	9%	652	10%	219	7%	311	7%
Missing	84		42		28		14	
Time of day of arrival								
7:00 AM–6:59 PM	10 258	74%	4903	78%	2262	70%	3093	71%
7:00–11:59 PM	2570	19%	1067	17%	640	20%	863	20%
12:00–6:59 AM	1066	8%	330	5%	312	10%	424	10%
Weekend arrival	3716	27%	1618	26%	896	28%	1202	27%
Prehospital delay								
≤2 h	2588	46%	804	38%	554	44%	1230	54%
>2 h	3083	54%	1315	62%	701	56%	1067	46%
Missing	8223		4181		1959		2083	
History of stroke or TIA	4946	36%	2045	32%	1260	39%	1641	37%
Presumptive stroke diagnosis								
Ischemic	4916	35%	2141	34%	978	30%	1797	41%
Hemorrhagic	1329	10%	293	5%	420	13%	616	14%
TIA	3524	25%	1909	30%	746	23%	869	20%
Not specified	4125	30%	1957	31%	1070	33%	1098	25%
Ambulatory status at admission								
Independent	11 997	91%	5833	96%	2596	87%	3568	86%
Other or unable	1239	9%	259	4%	405	14%	575	14%
Missing	658		208		213		237	
Patient location at onset								
Not a healthcare facility	12 631	92%	6076	98%	2703	85%	3852	89%
Another healthcare facility	1075	8%	134	2%	459	15%	482	11%
Missing	188		90		52		46	
JCPSC certification	6974	50%	3060	49%	1675	52%	2239	51%
Teaching hospital	5164	37%	2248	36%	1284	40%	1632	37%
Hospital beds								
<100	789	6%	420	7%	229	7%	140	3%
100–300	5794	42%	2853	45%	1581	49%	1360	31%
>300	7311	53%	3027	48%	1404	44%	2880	66%

EMS indicates emergency medical services; TIA, transient ischemic attack; JCPSC, Joint Commission Primary Stroke Center.

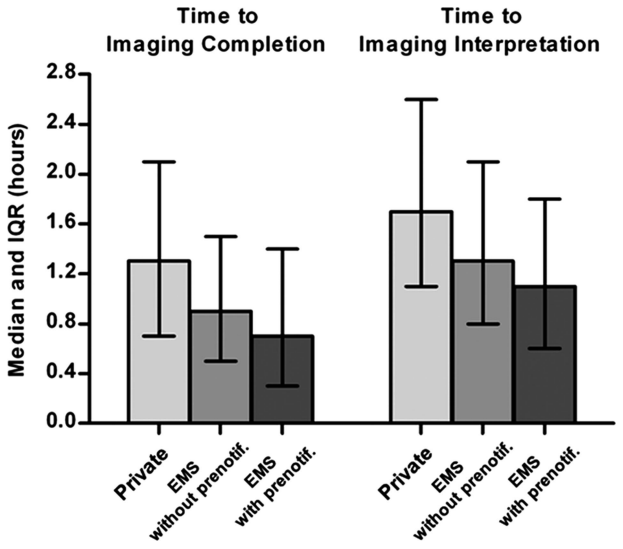

Figure. Median in-hospital delay times (and interquartile range [IQR]) by arrival mode, North Carolina Stroke Care Collaborative, 2008 to 2009.

(relative risk, 1.5; 95% CI, 1.1 to 1.9). Moreover, EMS arrival with prenotification (versus no prenotification) was significantly associated with higher tPA administration (relative risk, 1.6; 95% CI, 1.4 to 2.0).

Discussion

The immediate evaluation of patients with stroke 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, approximately one fifth of patients with suspected stroke 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 <25 minutes.[4] Still, they estimated a 0.1-hour annual decline in CT scan delays from 1994 to 2005. When compared with CT delays reported in a similar North Carolina patient population from 2005 to 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. Furthermore, the proportion of patients with suspected stroke having a brain imaging study completed and interpreted in a timely manner was higher with hospital prenotification by EMS. This is consistent with a previous study that found shorter times to CT with EMS prenotification.[25] To illustrate the public health impact of our findings, given approximately 28 000 stroke discharges from North Carolina hospitals per year,[29] an estimated 15 400 would arrive by EMS, and according to our number needed to treat analysis, prenotification would increase the number of patients having imaging completed within 25 minutes from 4216 to 4957, or by 741 patients. Similarly, the number of patients having imaging interpreted within 45 minutes would increase from 4478 to 5321, or by 843. Therefore, incorporating prenotification in large populations could increase timely evaluation in a substantial number of patients with stroke.

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 1 other study that has reported on this end point.[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. Although interpretation time was missing for approximately 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.

Table 2. Associations Between Meeting Brain Imaging Target Times and Arrival Mode, North Carolina Stroke Care Collaborative, 2008 to 2009

	Brain Imaging Completed Within 25 Min			Brain Imaging Interpreted Within 45 Min		
	Risk	RR	95% CI	Risk	RR	95% CI
Crude						
EMS with prenotification	0.32	2.9	(2.1–3.9)	0.34	2.5	(2.1–3.1)
EMS without prenotification	0.22	1.9	(1.5–2.5)	0.24	1.8	(1.4–2.3)
Private (reference)	0.11	1		0.13	1	
Adjusted*						
EMS with prenotification	0.32	3.0	(2.1–4.1)	0.35	2.7	(2.3–3.3)
EMS without prenotification	0.21	1.9	(1.6–2.3)	0.22	1.7	(1.4–2.1)
Private (reference)	0.11	1		0.13	1	

RR indicates risk ratio; CI, confidence interval; EMS, emergency medical services.

*Adjusted for age, sex, race, health insurance, time of day of arrival, weekend arrival, documented history of stroke/transient ischemic attack, presumptive stroke diagnosis, ambulatory status at admission, patient location at onset, Joint Commission Primary Stroke Center certification, teaching hospital, and hospital beds.

Table 3. Associations Between Meeting Brain Imaging Target Times and Arrival Mode Among Patients Arriving Within 2 Hours of Stroke Onset, North Carolina Stroke Care Collaborative, 2008 to 2009

	Brain Imaging Completed Within 25 Min			Brain Imaging Interpreted Within 45 Min		
	Risk	RR	95% CI	Risk	RR	95% CI
Crude						
EMS with prenotification	0.55	2.3	(1.8–2.8)	0.57	1.8	(1.5–2.1)
EMS without prenotification	0.34	1.4	(1.1–1.8)	0.43	1.3	(1.1–1.7)
Private (reference)	0.25	1		0.32	1	
Adjusted*						
EMS with prenotification	0.52	1.9	(1.6–2.3)	0.53	1.5	(1.3–1.7)
EMS without prenotification	0.34	1.2	(1.0–1.6)	0.43	1.2	(1.0–1.5)
Private (reference)	0.27	1		0.35	1	

RR indicated rate ratio; CI, confidence interval; EMS, emergency medical services.

*Adjusted for age, sex, race, health insurance, time of day of arrival, weekend arrival, documented history of stroke/transient ischemic attack, presumptive stroke diagnosis, ambulatory status at admission, patient location at onset, Joint Commission Primary Stroke Center certification, teaching hospital, and hospital beds.

However, we could not adjust for stroke severity because it was not adequately measured. Because 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, in which 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 emergency department 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 transient ischemic attack regardless of final diagnosis. To show that our results are robust to the exclusion of transient ischemic attacks, we performed a stroke-only analysis and found slightly stronger associations between arrival mode and imaging delay times at the same time as observing the same relationships as with the overall study population.

Our assessment of EMS prenotification 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 patients with potential stroke with implications for policies that influence the role of EMS in stroke systems of care. Our results suggest that implementing hospital prenotification in EMS protocols may significantly reduce delays in the evaluation of patients with acute stroke. Additional analyses suggest a similar impact of EMS prenotification 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 to 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 prenotification to the hospital experienced the most rapid evaluation. Nevertheless, the proportion of patients who met recommended target times was only approximately 20%. Patients arriving soon after symptom onset were more likely to meet these targets, although there were still reductions in hospital delays with EMS prenotification. These findings support the practice of prenotification by EMS personnel when transporting patients with suspected stroke to the hospital.

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Disclosures

None.

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