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The Association Between Stroke Mortality and Time of Admission and Participation in A Telestroke Network

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The Association between Stroke Mortality and Time of Arrival and Participation in a Telestroke Network Abstract

Objectives—Acute ischemic stroke is one of the leading causes of death. Patient outcomes, such as in-patient mortality, may be impacted by the time of arrival to the hospital. Telestroke networks have been found to be effective and safe at treating acute ischemic strokes. This paper investigated the association between mortality and time of arrival and hospital's participation in a telestroke network.

Methods—Data were collected on ischemic stroke patients who arrived at 15 non-teaching hospitals in Georgia's Paul Coverdell Acute stroke registry from 2009 to 2016. After controlling for patient and hospital characteristics, multivariate logistic regression was conducted to assess whether time of arrival and telestroke participation was associated with in-hospital mortality. Subgroup analysis was conducted based on hospital bed size.

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Author Contributions

BW conceptualized the study, interpreted the results and wrote the first draft of the manuscript; DZ did the data analysis participated in the study design and revised the manuscript for publication; JS and DH revised the manuscript; LS supervised the data analysis and study design, and substantially revised the manuscript.

Declaration of Conflicting Interests

None.

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Results—Overall, a total of 19,759 admissions for acute ischemic stroke were included in this analysis. The odds of dying in the hospital when arriving during the nighttime are 1.22 times the odds of dying when arriving during the day (95% CI: 1.04–1.45) and the odds of dying at a telestroke hospital are 53% lower than at a non-telestroke hospital (OR 0.47, 95% CI 0.31 – 0.71). The associations were more prominent in large hospitals.

Conclusions—Our study found that the hour of arrival for acute ischemic stroke is linked with in-hospital mortality in large hospitals, with patients more likely to die if they arrive during the nighttime hours as compared to the daytime hours. Telestroke participation is linked with lower odds of hospital mortality in all hospitals.

Keywords

Telestroke; Mortality; Time metrics; Stroke

Introduction

Over the past few decades, acute ischemic stroke has been one of the leading causes of death and disability in the United States, with approximately 795,000 individuals suffering from stroke each year (1). Unfortunately, this trend is likely to continue, with an expected 20.5% increase in stroke prevalence by 2030 (2). Better patient outcomes for acute ischemic stroke victims can be achieved by early recognition and up-to-date, evidence-based treatment (2) (3). Currently, the only drug approved by the Food and Drug Administration for acute ischemic stroke is the intravenous tissue plasminogen activator (IV tPA), which is most effective if administration takes place within the first 4.5 hours of event (3) (4) (5). Although these recommendations are well known nationwide, proper use of tPA remains low, particularly in rural areas and healthcare centers without access to neurological expertise (6).

Telestroke is able to broaden the range of neurovascular specialists into rural, underserved geographic areas to provide high quality stroke care for more patients (1). Telestroke is a “network of audio-visual communication and computer systems which provide the foundation for a collaboration, interprofessional care model focusing on acute stroke patients” (7). Telestroke networks are designed in a hub and spoke system in which the stroke center (hub) provides high quality stroke care to distance sites that do not have a stroke center (spokes). For example, the Remote Evaluation for Acute Ischemic Stroke (REACH) telestroke network is a telehealth program aimed at improving stroke outcomes in rural hospitals of Georgia and South Carolina through more efficient diagnosing and treatment for acute ischemic stroke patients (8). There is an increasing amount of evidence that suggests that telestroke is feasible, safe, and effective in treating acute ischemic strokes (6) (9) (10). Stroke mortality rates in hospitals that utilize telestroke are similar to those at specialized stroke centers (11). Furthermore, the use of telestroke can dramatically increase the number of patients treated with tPA in non-specialist settings especially in the critical 4.5-hour window (10).

International studies have found that the patients time of arrival of stroke victims can have a major impact on the quality of care the patients receive and the discharge disposition. Studies in Japan (12), Canada (13), and Sweden (14) found that patients who are admitted

during the weekend have higher mortality than patients admitted during the weekday. Furthermore, studies in United Kingdom found that patients admitted during the off hours are less likely to receive a brain scan and less likely to receive tPA (15) (16). However, the “weekend effect” has been inconsistent in studies conducted in the United States. Rose and colleagues (17) found that patients admitted during the off hours had to wait on longer for a CT scan and Reeves et al. (18) found that patients were less likely to receive tPA. Conversely, other studies have found that patients during the off hours are actually more likely to receive tPA(19) and that there was not a difference in mortality or hospital discharge disposition (20).

The purpose of this paper was to evaluate the association between in-hospital mortality and time of arrival and whether or not the hospital participated in a telestroke network. Additionally, we determined the marginal differences between in-hospital mortality by time of arrival for hospitals who did and did not participate in a telestroke network. Assessing this link will provide further insight into the “weekend” effect and the impact of telestroke on stroke care.

Methods

Data Source

In this observational study, data were obtained retrospectively from Georgia’s Paul Coverdell Acute Stroke Registry. We analyzed the selected study sample to assess the association between patient time of arrival at the hospital and mortality and if that association was impacted by the hospital’s participation in a telestroke network. Georgia’s Paul Coverdell Acute Stroke Registry was developed in 2001 to improve the care of acute stroke patients in the hospital and pre-hospital settings by addressing quality improvement in stroke care, preventative efforts, and rehabilitation services (21). In this study, data was collected on ischemic stroke patients who arrived at 15 hospitals from 2009 to 2016. All the hospitals were non-teaching hospitals, located outside of the Atlanta metropolitan area. Four of the 15 hospitals began participating in the REACH telestroke program in 2009. Details of hospital selection, sample description, and ethical review exemptions can be found from a previous publication (22).

Variables

We collected demographic information, discharge disposition, medical information and history, initial National Institutes of Health Stroke Scale (NIHSS) (23), arrival mode and status, and hospital bed size. The primary outcome variable for this study was in-hospital mortality, as identified by the discharge disposition of the patient. The primary predictor of interest, nighttime arrival, was defined as arriving to the hospital between 6:00 PM to 6:00 AM. It is important to note that this arrival time, the time when the patient arrives at the hospital (usually at the Emergency Department), is not the same as the admission time when the patient is moved to the inpatient unit. For example, a patient arriving at the hospital at 11 am and getting admitted to the inpatient unit at 9 pm would be coded as 0 for our variable of nighttime arrival.

Demographic information included the age, gender, race/ethnicity, and insurance status (Private vs Medicare vs Medicaid vs Uninsured) of the patient. Relevant documented medical history, such as diabetes, atrial fibrillation, dyslipidemia, and hypertension, were collected from patient records recorded as a binary event on whether the patient had a history of them or not. Patient's arrival mode (EMS vs Private Vs Transfer) and ambulatory status prior to the event (Walking independently vs Walking with assistance vs Unable to walk) were also obtained from patient records. The NIHSS variable was recoded into three categories: 0–6 as low, 7–15 as medium, and 16 as high. Due to missing 33.6% of NIHSS data on patients, we used multiple imputation by chained equations to impute the missing data. Please refer to a previous publication for more detailed information about the imputation process and why it was necessary (Table 1 in the [data supplement](#)) (22). Hospitals were categorized based on the number of beds, with less than 100 beds classified as small, those who had between 100 and 350 classified as medium, and those with greater than 350 beds classified as large.

Statistical Analysis

First, we conducted descriptive analysis on the study sample by exploring demographic information, medical history, clinical information, and hospital bed size. Frequency and percentage were reported for categorical variables and mean and standard deviations for normally distributed variables. We compared baseline differences between patients who arrived during the daytime and the nighttime using Pearson Chi-square test for categorical variables and t test for continuous variables with normal distribution.

Second, we conducted multivariable logistic regression to assess the association between time of arrival and patient mortality and whether or not hospital participated in a telestroke network. Due to the fact that data on health outcomes has a multilevel structure and that patients arriving at a hospital may resemble each other but will differ from those arriving at another hospital, we conducted patient-level logistic regression analysis while adjusting for the within hospital clustering effect (24). Based on the literature, two individual-level groups of variables, patient characteristics and medical characteristics, and hospital level variables were identified as being related to stroke outcomes and were controlled for in the analysis. Patient characteristics included age (25) (26), gender (27), race/ethnicity (26), and insurance (28). Medical characteristics included arrival mode (29), ambulatory status prior to the event (30), stroke severity (31), and medical history of atrial fibrillation (32), dyslipidemia (33), diabetes mellitus (34), and hypertension (35). Hospital level characteristics included bed size and telestroke participation. Additional subgroup analysis was conducted based on hospital bed size (large vs medium/small). We also estimated the marginal effects of nighttime or daytime arrival in hospitals that did and did not participate in a telestroke network. These analyses were stratified by hospital bed size.

All analyses were conducted using Stata software (version 15.1, StataCorp, College Station, TX) and statistical significance was determined at a p level of 0.05.

Results

The baseline characteristics of patients who arrived during the nighttime and the daytime are presented in Table 1. Overall, there were a total of 19,759 admissions for acute ischemic stroke between 2009 and 2016 at the 15 hospitals included in this analysis. Of those admissions, almost one third (32.05%) arrived during the nighttime hours. Those who arrived during the nighttime hours were more likely to be younger African American males with a mean age of 66.9 (14.0 Standard Deviation (SD)) as compared with 68.2 (13.7 SD) for those who arrived during the day. Additionally, patients who arrived during the nighttime hours were more likely to be transferred from another facility and having a medical history of atrial fibrillation.

Table 2 presents the adjusted odds ratio of mortality in patients who arrived during the nighttime hours as compared to the daytime hours. Overall, the crude mortality rate for patients who arrived during the nighttime hours was greater than the rate for patients who arrived during the daytime (5.07% vs 3.80%, $p<0.001$). When controlling for covariates listed above, the odds of dying in the hospital when arriving during the nighttime hours are 1.22 times as large as the odds of dying when arriving during the day (95% Confidence Interval (CI): 1.04–1.45, $p<0.05$) and the odds of dying at a telestroke hospital are 53% lower than at a non-telestroke hospital (OR 0.47, 95% CI 0.31 – 0.71, $p<0.001$). For hospitals with over 350 beds, the adjusted odds of dying in the hospital when admitted during the nighttime is 1.34 times the odds of dying when admitted during the daytime (95% CI 1.12 – 1.60, $p<0.01$) and the odds of dying at a telestroke hospital are 79% lower than at a non-telestroke hospital (OR 0.21, 95% CI 0.15 – 0.31, $p<0.001$). For hospital with less than 350 beds, the odds of dying during the nighttime was not significantly different from the odds of dying during the daytime (OR 1.05; 95 % CI 0.87–1.28) but the odds of dying in a telestroke hospital were 47% lower than at a non- telestroke hospital (OR 0.53, 95% CI 0.35–0.83, $p<0.01$).

Table 3 shows the predicted probabilities as well as the marginal differences in the predicted probabilities among those who were admitted during the nighttime and the daytime for both telestroke and non-telestroke hospitals. Among large telestroke hospital (350+ beds), the predicted probability of dying in the hospital was 0.61 (95% CI 0.54 – 0.68) for those admitted during the nighttime hours and 0.41 (95% CI 0.36 – 0.56) for those admitted during the day. Thus, there was a 0.15 marginal difference, meaning that being admitted during the night was significantly associated with a 15% (95% CI 0.07 – 0.23) increase in the probability of dying at a large telestroke hospital. Among large non-telestroke hospitals, there was a 0.64 (95% CI 0.13– 1.15) marginal difference, with a 2.70 (95%CI 1.89 – 3.51) probability of dying when admitted during the nighttime versus a 2.06 (1.65–2.47) probability of dying if admitted during the day. Therefore, being admitted during the night was significantly associated with a 64% increase in the probability of dying at a large non-telestroke hospital as compared with being admitted during the day. Among small/medium telestroke hospital (<350 beds), the predicted probability of dying in a telestroke hospital was 1.63 (95% CI 1.24 – 2.03) for patients admitted at night and 1.56 (95% CI 1.13 – 1.98) when admitted during the day. The marginal difference was 0.08 (95% CI –0.21 – 0.37) but was not statistically significant. For small non-telestroke hospitals, the predicated probability

of dying was 2.91 (95% CI 1.89 – 3.93) when admitted at night and 2.77 (95% CI 1.74 – 3.81) when admitted during the day. The marginal difference was 0.13 (95% CI –0.36 – 0.63) but was not statistically significant.

Discussion

In the current study of 15 hospitals from Georgia's Paul Coverdell Acute Stroke Registry, we found that even when adjusting for known covariates and telestroke participation, patients who arrived at hospitals during the nighttime hours had higher odds of dying than patients who arrived during the day. The overall impact is similar to other studies that have found that patients who arrived during nighttime hours had worse outcomes than patients who arrived during the day (13) (36) (37). However, our results were much higher than previous studies, especially those restricted to just North American countries, even when controlling for NIHSS scores (37). This suggests that there are other factors besides stroke severity that contribute to the higher mortality during the nighttime hours. Part of the difference could be due the fact that the hospitals in our study are located in the Stroke Belt, which has higher stroke mortality and incidence rates than in other areas of the country (38).

When assessing the impact of telestroke on mortality, we found that participation in a telestroke network significantly decreases the odds of dying as compared to non-telestroke hospitals. Telestroke participation also appears to lessen the impact of time of admission on mortality, with a smaller marginal difference in telestroke hospitals compared to non-telestroke hospitals for the predicted risk of death when admitted during the nighttime vs the daytime. This is consistent with what was found in Bavaria, Germany and supports the hypothesis that telestroke participation can have an impact on clinical outcomes of stroke patients by decreasing stroke mortality (39).

Altogether, the size of the hospital appears to have major impact on the association between in hospital mortality and time of arrival and telestroke participation. Patients admitted to small/medium hospitals had a higher probability of death, regardless of time of arrival or telestroke participation. Furthermore, the impact of telestroke participation was lower in small/medium hospitals compared to larger hospitals. Telestroke networks are designed to increase the reach of specialist to all spoke hospitals in the network (1) but the impact appears to be greater in larger hospitals. This suggests that the differences in hospital staff, resources, and structure between larger hospitals and small/medium hospitals has an impact on the clinical outcomes of stroke patients and that telestroke networks do not impact all hospitals in the same way.

Our study has several limitations. First, there were several variables that might affect mortality that were not available in this dataset. For example, we were not able to get information on time from stroke event to arrival at the hospital or patient lifestyle, which might affect stroke outcomes. Second, in-hospital mortality does not reflect a hospital's capacity to treat a stroke patient, which may be related with a likelihood of transferring severe patients to large stroke centers, particularly for small and medium hospitals. In future studies, we will look at additional outcomes such as risk-adjusted 30-day mortality, risk-

adjusted 30-day rehospitalization, and discharge to nursing homes, which can also indicate poor clinical outcomes.

In conclusion, our study found that the hour of arrival for acute ischemic stroke is linked with in-hospital mortality in large hospitals, with patients more likely to die if they arrive during the nighttime hours as compared to the daytime hours. The telestroke participation is linked with lower odds of hospital mortality in all hospitals, although this pattern of association is stronger in larger hospitals. Future studies will need to identify specific roles of hospital resource allocation and clinical practice behind this temporal pattern of stroke mortality.

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Table 1.**Characteristics of Stroke Patients Who Arrived During the Day and Night**

	Daytime Arrival (n=13,427)	Nighttime Arrival (n=6,332)	P value
Age, mean $\pm$ SD	68.15 $\pm$ 13.69	66.93 $\pm$ 14.01	<0.000
Admitted to a telestroke hospital, N (%)	3,257 (24.26)	1,583 (25.00)	0.257
Age Strata, N (%)			<0.000
18–44	570 (4.25)	350 (5.53)	
45–64	4,870 (36.27)	2,406 (38.00)	
65+	7,987 (59.48)	3,576 (56.48)	
Gender, N (%)			0.218
Male	6,528 (48.62)	3,138 (49.56)	
Race, N (%)			0.055
White	8,402 (62.58)	3,853 (60.85)	
African American	4,812 (35.84)	2,381 (37.60)	
Other	213 (1.59)	98 (1.55)	
Insurance, N (%)			0.025
Private	3,067 (22.84)	1,487 (23.48)	
Medicare	7,413 (55.21)	3,416 (53.95)	
Medicaid	1,653 (12.31)	743 (11.73)	
No Insurance	1,294 (9.64)	686 (10.83)	
Arrival Mode, N (%)			<0.000
EMS	6,924 (51.57)	3,145 (49.67)	
Private	5,396 (40.19)	1,899 (29.99)	
Transfer	1,107 (8.24)	1,288 (20.34)	
Prior Ambulatory Status, N (%)			0.326
Walking independently	12,032 (89.61)	5,686 (89.80)	
Walking with assistance	739 (5.50)	320 (5.05)	
Unable to Walk	656 (4.89)	326 (5.15)	
Stroke Severity, N (%)			<0.000
Low	8,802 (65.55)	3,829 (60.47)	
Medium	2,966 (22.09)	1,577 (24.91)	
High	1,659 (12.36)	926 (14.62)	
Bed Categories			0.007
Small (< 100)	813 (6.05)	313 (4.94)	
Medium (101–349)	4,670 (34.78)	2,221 (35.08)	
Large (> 350)	7,944 (59.16)	3,798 (59.98)	
Medical History			
Atrial Fibrillation	1,866 (13.90)	944 (14.91)	0.058
Dyslipidemia	6,075 (45.24)	2,769 (43.73)	0.046
Diabetes mellitus	5,383 (40.09)	2,564 (40.49)	0.591
Hypertension	11,294 (84.11)	5,332 (84.21)	0.867

Table 2:

Adjusted odds ratio of mortality in nighttime arrival vs daytime arrival

Model Description	Model 1 (N=19,759) ¹		Model 2 (N=11,742) ²		Model 3 (N=8,017) ³	
	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI
Night arrival	1.22 *	1.04 – 1.42	1.34 **	1.12 – 1.60	1.05	0.87 – 1.28
Telestroke	0.47 ***	0.31 – 0.71	0.21 ***	0.15 – 0.31	0.53 **	0.34 – 0.83

*
P<0.05**
p< 0.01***
p<0.001¹Model 1 adjusted for telestroke participation, age group, gender, race, insurance, arrival mode, ambulatory status before event, stroke severity, bed size, and medical history of atrial fibrillation, dyslipidemia, diabetes, and hypertension²Model 2 was a subgroup analysis utilizing the sample of large hospitals (350+ beds)³Model 3 was a subgroup analysis utilizing the sample of small/medium hospitals (<350 beds)

Table 3:

Predicted Risk of Death for Ischemic Stroke Patients admitted in Telestroke vs. Non-Telestroke Hospitals in nighttime arrival vs daytime arrival stratified by Hospital bed size

	Night arrival		Day arrival		Marginal Difference	
	Predicted mortality <i>I</i>	95% CI	Predicted mortality <i>I</i>	95% CI	Marginal difference ²	95% CI
Large Hospitals (N=11,742)						
Telestroke Hospitals	0.61 ***	0.54 – 0.68	0.46 ***	0.36 – 0.56	0.15 ***	0.07 – 0.23
Non-Telestroke Hospitals	2.70 ***	1.89 – 3.51	2.06 ***	1.65 – 2.47	0.64 *	0.13 – 1.15
Small Hospitals (N=8,017)						
Telestroke Hospitals	1.63 ***	1.24 – 2.03	1.56 ***	1.13 – 1.98	0.08	–0.21 – 0.37
Non-Telestroke Hospitals	2.91 ***	1.89 – 3.93	2.77 ***	1.74 – 3.81	0.13	–0.36 – 0.63

* P<0.05

** p< 0.01

*** p<0.001

¹ Predicted probability was computed from the logit regression while adjusting for age group, gender, race, insurance, arrival mode, ambulatory status before event, stroke severity, bed size, and medical history of atrial fibrillation, dyslipidemia, diabetes, and hypertension

² Marginal difference refers to risk difference, measuring the difference between the predicted mortality for night vs. day arrival with and without participation in a telestroke network