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## Comprehensive Stroke Centers and the “Weekend Effect”: The SPOTRIAS Experience

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### Abstract

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#### Conflict of Interest

The authors have no conflicts of interest relevant to this work.

**Background and Purpose**—Prior studies found mortality among ischemic stroke patients to be higher on weekends. We sought to evaluate whether weekend admission was associated with worse outcomes in a large comprehensive stroke center (CSC) cohort.

**Methods**—Consecutive ischemic stroke patients presenting within 6 hours of symptom onset were identified using the 8 CSC SPOTRIAS database. Patients who received intra-arterial therapy or were enrolled in a non-observational clinical trial were excluded. All patients meeting inclusion criteria were then divided into two groups: weekday admissions or weekend admissions. Weekend admission was defined as Friday 17:01 to Monday 08:59. The remainder were classified weekday admissions. Multivariate logistic regression was used adjusting for age, stroke severity on admission via NIHSS, and admission glucose to compare outcomes in the weekend vs. weekday groups.

**Results**—8581 subjects from the combined SPOTRIAS database were screened from 2002-2009. 2090 (24.4%) met inclusion criteria. There was no significant difference in t-PA treatment rates between weekday and weekend groups (58.5% vs. 60.4%,  $p=.397$ ). Weekend admission was not a significant independent predictor of in-hospital mortality (8.4% vs. 9.9%,  $p=.056$ ), LOS (4 days vs. 5 days,  $p=.442$ ), favorable discharge disposition (38.0% vs. 42.2%,  $p=.122$ ), favorable functional outcome at discharge (41.6% vs. 43.4%,  $p=.805$ ), favorable 90 day functional outcome (54.2% vs. 46.9%,  $p=.301$ ), or 90 day mortality (18.2% vs. 19.8%,  $p=.680$ ) when adjusting for age, NIHSS, and admission glucose.

**Conclusions**—In this large cohort of ischemic stroke patients treated at CSC's, we did not observe the “weekend effect.” This may be due to 24/7/365 access to stroke specialists, nurses with stroke experience, and the organized system for delivering care available at CSCs. These results suggest EMS protocol should be reexamined regarding preferential delivery of weekend stroke victims to hospitals that provide all levels of reperfusion therapy. This further highlights the importance of organized stroke care.

## Keywords

Acute Care; Acute Stroke; Emergency Medical Services; Epidemiology; Organized Stroke Care; Outcomes; Stroke Delivery; Thrombolytic RX

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Stroke requires emergency medical care that is continuous, coordinated, timely, and effective. In 2005, The Brain Attack Coalition (BAC) made recommendations for designation of comprehensive stroke centers (CSC) as those facilities with the necessary infrastructure, personnel, expertise, and programs to diagnose and treat stroke patients who require a high intensity of medical and surgical care, specialized tests, or interventional therapies.[1] While the BAC suggested that CSCs may parallel trauma centers in their ability to enhance treatment and improve patient outcome, little evidence with regards to patient outcome exists for CSCs.

Data from prior epidemiologic studies have raised concern that care for stroke patients may be inconsistent and perhaps even inferior during off-hours when compared to regular business hours.[2-14] This has since been dubbed the “weekend effect”. National data from Canada found worse discharge disposition, increased 7-day case fatality, and increased in-hospital mortality in ischemic stroke patients admitted on the weekend.[8] Similar results were reported in both a Swedish national sample and the U.S. Nationwide Inpatient Sample of Healthcare Cost and Utilization Project.[7,13] More recently, Reeves et al. reported increased in-hospital mortality in weekend admissions for AIS patients using Get with the Guidelines (GWTG) data.[10] It has been postulated that the “weekend effect” as observed in AIS, myocardial infarction, and other serious medical conditions, may be related to reduced staffing levels, decreased availability of resources, and diminished access to

subspecialty care on weekends.[15,16] Not all studies, however, have confirmed the “weekend effect” and further studies are needed to determine whether there truly is a reduced quality level after hours.

SPOTRIAS (Specialized Programs of Translational Research in Acute Stroke) is a national network of stroke centers developed and deployed with funding from the NIH/NINDS.[17] SPOTRIAS was designed to perform early phase clinical projects, collect and share registry level data, and promote new approaches to therapy for acute stroke. This network of academic tertiary care medical centers provides acute stroke therapies for thousands of patients, participates in cutting edge research for acute stroke, and provides the options for surgical and interventional management of patients above and beyond standard medical therapies. These SPOTRIAS network centers have the resources of CSCs, and thus provide a unique opportunity to explore the “weekend effect” in a CSC environment. In addition, most SPOTRIAS centers collect data from nearby community medical centers (‘spokes’) allowing a cross-representational study of a ‘weekend effect’ in a variety of medical settings.

Our prior work failed to find evidence of inferior outcomes associated with the ‘weekend effect’ in TIA (transient ischemic attack), AIS, or ICH (intracerebral hemorrhage) patients when two of the eight SPOTRIAS sites were examined.[18] Given Reeves’ estimation that 1/20 in-hospital stroke deaths could be avoided if the system were to eliminate the higher mortality associated with off-hours presentation[10], the aim of the current study was to assess patient outcomes in a multisite collaboration of CSCs and to determine if patients presenting on weekends indeed had worse outcomes, or if evaluation by CSC stroke specialists could help to erase the “weekend effect”. We hypothesized that centers with continuous availability of expert stroke teams, necessary diagnostic and therapeutic modalities, and stroke-nursing expertise would have consistent patient outcomes, regardless of the day of presentation.

## Materials and Methods

SPOTRIAS is a network of stroke centers from 8 different sites (in alphabetical order- Columbia University, Intramural National Institute of Neurological Disorders and Stroke (NINDS) Program, Partners at Massachusetts General, University of California Los Angeles, University of California San Diego, University of Cincinnati, University of Texas Houston, Washington University) who share data elements in a common SPOTRIAS clinical and neuroimaging database. SPOTRIAS stroke centers meet the comprehensive stroke center (CSC) criteria as outlined by the BAC. While sites may differ in their practice patterns, each site provides 24/7/365 access to stroke specialists and nurses with specialized training. In their role as CSCs, SPOTRIAS sites may serve as a hub for outlying spoke hospitals (e.g., primary stroke centers (PSCs), non-stroke centers (NSCs)).

Ischemic stroke patients arriving within six hours of symptom onset from the common SPOTRIAS database were identified, in an effort to eliminate patients with excessive delay in presentation. Patients who received intra-arterial therapy or who were enrolled in a non-observational clinical trial were excluded, as these interventions have an undetermined impact on outcomes. All patients meeting inclusion criteria were then divided into two groups: weekday and weekend admissions. Weekend admission was defined as the period from Friday, 17: 01 to Monday, 08: 59. All other admissions were classified as weekday admissions.

Patient age, gender, race/ethnicity, admission NIHSS score, and admission glucose levels were examined. Outcome measures included length of hospital stay, in-hospital mortality, discharge disposition (home favorable vs. all others unfavorable), and functional outcome on

discharge and at 90-day follow up, as measured by the modified Rankin Scale (mRS 0-2 favorable vs. mRS 3-6 poor), and 90 day mortality. All outcome measures were compared in the weekend and weekday groups.

Demographic and baseline characteristics between weekend admissions and weekday admissions were compared using the Fisher's exact test for categorical variables and the Wilcoxon Rank Sum test for continuous variables. Logistic regression or ANOVA, as appropriate, was used to test the interaction of site and weekend status. The binary outcome variables in-house mortality, discharge mRS, 90-day mortality and 90-day mRS, were compared between weekend admissions and weekday admissions using the multivariable logistic regression, adjusting for admission NIHSS, age, and admission glucose. Site was included as a covariate in the multivariable model if the Cochran-Mantel-Haenszel Chi-square test stratified by site comparing the outcome rates between weekend and weekday admissions was statistically significant at the 0.05 level. Length of hospital stay between the two groups was compared using the Wilcoxon Rank Sum test.

Since this was an exploratory analysis, no adjustments for multiple comparisons were made and a p-value of less than 0.05 was considered to be statistically significant. To assess the differences between groups for those outcome variables that did not show a statistical significance, we have chosen to use 95% confidence intervals instead of a post-hoc power calculation.[19] All statistical analysis was conducted using the statistical software R, version 2.6.2.

## Results

A total of 8,581 consecutive patients were screened from 2002 to 2009. Of those patients screened, 2,090 patients from the combined SPOTRIAS database met inclusion criteria (in random order- n=278 Site 1, n=99 Site 2, n=872 Site 3, n=268 Site 4, n=150 Site 5, n=348 Site 6, n=43 Site 7, n=32 Site 8). Patient demographics in the weekend and weekday admission groups are shown in Table 1. Overall, the mean age was 68.3 years (SD 15, n=2,085). Over half of the participants were male (52.7%, 1,094/2,077). There was no significant difference in the mean age or gender for patients admitted on weekends and weekdays (68.2 vs. 68.3,  $p=.972$ , 51.0% vs. 53.6%,  $p=.268$ ). The majority of patients were Caucasian/White (60.0%, 1254/2090), followed by African American/Black (22.2%, 463/2090), Hispanic non-Black (9.4%, 196/2090), other (5.7%, 119/2090), and Asian (2.8%, 58/2090) with no significant differences in race/ethnicity of patients arriving on the weekend vs. weekdays ( $p=.944$ ). The median NIHSS score was 8, ranging from 0-40 (IQR 4, 15; n=1892) and the mean admission glucose level was 141mg/dl (SD 64, n=1943). There was no significant difference in the median NIHSS score for patients admitted on weekends and weekdays (9 vs. 8,  $p=.157$ ) or the mean admission glucose levels for weekend vs. weekdays (143.5 vs. 139.8,  $p=.313$ ). Overall, 59.1% of patients arriving within six hours of symptom onset were treated with IV t-PA. There was no significant difference in IV t-PA treatment rates in patients presenting on a weekend when compared to those presenting on a weekday (60.4% vs. 58.5%,  $p=.397$ ).

Patient outcomes comparing the weekend and weekday admission groups are shown in Table 2. As specified a priori, all outcome analysis were adjusted for patient age, admission NIHSS, and admission glucose. In-hospital mortality overall was 9.3% (141/1,509). Patients admitted on weekends did not have a higher rate of in-hospital mortality; rather, there was a trend suggesting higher mortality in patients admitted on weekdays (8.4% vs. 9.9%,  $p=.056$ ). The median length of stay was 5 days, ranging from 0 to 111 days (IQR 3, 7). There was no significant difference in the median LOS in patients admitted on weekends as compared to those admitted on weekdays (4 days vs. 5 days,  $p=.442$ ). Over 40% of patients were

discharged home (40.7%, 851/2089) with no significant difference in favorable discharge disposition between the weekend and weekday groups (38.0% vs. 42.2%,  $p=.122$ ). Nearly 43% of patients had favorable functional outcome at discharge (42.7%, 645/1509) with no evidence of significant differences in favorable functional outcome at discharge when patients admitted on weekends were compared to those admitted on weekdays (41.6% vs. 43.4%,  $p=.805$ ) after adjusting for age, admission NIHSS, admission glucose, and site. Nearly half of patients had favorable 90 day functional outcome (49.3%, 369/748). No significant difference was found in favorable functional outcome at 90 days when controlling for age, NIHSS on admission, and glucose in weekend and weekday patients (54.2% vs. 46.9%,  $p=.301$ ). Mortality at 90 day follow up was 19.3% (144/748). Patients admitted on weekends had a similar 90 day mortality to their weekday counterparts (18.2% vs. 19.8%,  $p=.680$ ).

## Discussion

To the best of our knowledge, this is the largest study of comprehensive stroke centers examining the impact of day of presentation on patient outcomes. Our study found no evidence of the “weekend effect”. Ischemic stroke patients admitted on weekends did not have significant differences in LOS, in-hospital mortality, favorable hospital discharge, or functional outcome at discharge. Further, patients presenting on a weekend did not have inferior 90-day functional outcome or higher 90-day mortality.

Our results differ from previously published studies that reported increased length of stay, [13] inferior functional outcomes,[6] inferior discharge disposition,[7,10] and increased mortality rates[7,8,10-12] in ischemic stroke patients presenting on the weekend or during off hours. One possible explanation for this difference is the homogenous nature of our sample. While our study included only centers that met BAC criteria for CSCs, previous studies had included a heterogeneous sample of hospitals (e.g., state designated CSCs and PSCs, self-designated CSCs, The Joint Commission (TJC) PSCs, NSCs).

Our findings concur with those of Kazley et al. and Streifler et al. who found no statistically significant difference in stroke mortality based on day of admission.[20,21] As demonstrated in our previous work, analysis of this larger multicenter sample suggests that centers that focus on providing comprehensive care around the clock irrespective of day of the week may be less susceptible to the “weekend effect”.[18]

We have shown that by providing access to stroke specialists, stroke teams, and organized systems of care, we can reduce the “weekend effect”. Our findings have significant health policy implications. Using the calculation proposed by Reeves et al., use of CSCs might prevent 1/20 in-hospital stroke deaths by eliminating the higher mortality associated with off-hours presentation.[10] It is possible that the previously postulated causes of the “weekend effect”, such as reduced staffing levels, decreased availability of resources, and diminished access to subspecialty care on weekends is averted by the continuous availability of expert stroke teams, necessary diagnostic and therapeutic modalities, and stroke-nursing expertise afforded by CSCs.

Our study is not without limitations. While our data were collected prospectively, this study remains a retrospective analysis. As it was an exploratory analysis, we did not control for multiple comparisons. Low event rates may limit our ability to detect differences. In light of the International Stroke Trial, patients arriving within the 6-hour treatment window were selected. Our aim was to determine if the exposure of arriving on a weekend placed ischemic stroke patients at increased odds of having a poor outcome. To do this, we elected to limit our sample to patients arriving within 6 hours of symptom onset. Thus, our results



are not generalizable to other types of stroke (e.g., TIA, ICH) or to patients arriving more than 6 hours from symptom onset. Furthermore, since intra-arterial recanalization is yet to be fully proven to improve outcome or has yet to receive consensus on its benefits compared with IV t-PA, we also excluded this variable. Lastly, we did not include non-observational trials since by their very nature these approaches have not yet been proven to affect stroke outcome. While excluding patients arriving beyond 6 hours, patients receiving intra-arterial therapy, and patients enrolled in acute stroke therapy trials served to limit potential confounders of patient outcome, it may have resulted in our rather high weekend admission rate. While one cannot be certain, it is possible that a higher proportion of patients may have presented within 6 hours on the weekend. Another possibility is that a higher number of patients were enrolled on weekdays, thus making fewer weekday patients eligible for our study. A third possibility is that more patients were taken for intra-arterial therapy on weekdays, making them ineligible for our study.

Using SPOTRIAS data provides the benefits of a multi-site collaboration (e.g., nationally representative sample, increased sample size); however, practice patterns may vary at the eight individual institutions. While sites meet BAC criteria for CSCs, SPOTRIAS stroke specialists may admit patients to a primary stroke service, admit patients to a general neurology service, or simply serve as consultants in the acute management of stroke patients. Further, each site within the SPOTRIAS network may serve as a hub hospital to one or more spoke hospitals. Despite differences in practice patterns and the hub and spoke sub-network established at our sites, outcomes for weekend patients cared for by CSC stroke specialists appear to differ from the previously reported outcomes of patients admitted to NSCs and PSCs on the weekend.

To the best of our knowledge, this is the largest study examining the impact of day of presentation on the outcome of patients evaluated by CSC stroke specialists. Our results suggest that patients evaluated by CSC specialists do not experience the “weekend effect”. Our findings raise the important question of whether EMS policy on hospital selection for acute stroke victims should be modified to permit diversion to CSCs and/or CSC spoke hospitals on weekends. It may be advisable for centers that cannot provide around the clock acute stroke care to vigilantly seek help from centers that are able to do so, particularly on weekends and after hours, as this may help to prevent 1/20 unnecessary deaths[10] and potentially decrease long-term stroke morbidity.

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**Table 1**  
**Patient Demographics**

	<b>Weekend</b>	<b>Weekday</b>	<b>p value</b>
<b>Age</b>	68.2±15.2 n=722	68.3±14.9 n=1363	.972
<b>Gender, male</b>	51.0% (367/720)	53.6% (727/1357)	.268
<b>Ethnicity</b>			
<b>African American/Black</b>	22.4% (162/723)	22.0% (301/1367)	.944
<b>Hispanic non-Black</b>	9.8% (71/723)	9.1% (125/1367)	
<b>Caucasian/White</b>	59.2% (428/723)	60.4% (826/1367)	
<b>Asian</b>	3.0% (22/723)	2.6% (36/1367)	
<b>Other</b>	5.5% (40/723)	5.8% (79/1367)	
<b>NIHSS</b>	9 (0-40) IQR 4,16 n=659	8 (0-40) IQR 4,15 n=1233	.157
<b>Admission glucose</b>	143.5±66.2 n=671	139.8±63.1 n=1272	.313
<b>Treated with IV t-PA</b>	60.4% (432/715)	58.5% (788/1348)	.397



**Table 2**

## Patient Outcomes

	<b>Weekend</b>	<b>Weekday</b>	<b>p value</b>
<b>In-hospital mortality</b>	8.4% (45/534)	9.9% (96/975)	.056 <sup>†</sup>
<b>LOS</b>	4 (1-48) IQR 3,7 n=683	5(0-111) IQR 3,7 n=1312	.442 <sup>**</sup>
<b>Discharged home</b>	38.0% (275/723)	42.2% (576/1366)	.122 <sup>†</sup>
<b>Discharge mRS 0-2</b>	41.6% (222/534)	43.4% (423/975)	.805 <sup>*</sup>
<b>90 day mRS 0-2</b>	54.2% (137/253)	46.9% (232/495)	.301 <sup>†</sup>
<b>90 day mortality</b>	18.2% (46/253)	19.8% (98/495)	.680 <sup>†</sup>

<sup>†</sup> Adjusted for age, admission NIHSS, admission glucose

<sup>\*</sup> adjusted for age, admission NIHSS, admission glucose, and site

<sup>\*\*</sup> unadjusted