

Can Comprehensive Stroke Centers Erase the ‘Weekend Effect’?

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Key Words

Stroke · Weekend · Mortality · Outcomes research · Quality of healthcare

Abstract

Background: Prior epidemiological work has shown higher mortality in ischemic stroke patients admitted on weekends, which has been termed the ‘weekend effect’. Our aim was to assess stroke patient outcomes in order to determine the significance of the ‘weekend effect’ at 2 comprehensive stroke centers. **Methods:** Consecutive stroke patients were identified using prospective databases. Patients were categorized into 4 groups: intracerebral hemorrhage (ICH group), ischemic strokes not treated with IV t-PA (intravenous tissue plasminogen activator; IS group), acute ischemic strokes treated with IV t-PA (AIS-TPA group), and transient ischemic attack (TIA group). Weekend admission was defined as the period from Friday, 17:01, to Monday, 08:59. Patients treated beyond the 3-hour window, receiving intra-arterial therapy, or enrolled in nonobservational clinical trials were excluded. Patient demographics, NIHSS scores, and admission glucose levels were examined. Adverse events, poor functional outcome (modified Rankin scale, mRS, 3–6), and mortality were compared. **Results:** A total of 2,211 patients were included

(1,407 site 1, 804 site 2). Thirty-six percent (800/2,211) arrived on a weekend. No significant differences were found in the ICH, IS, AIS-TPA, or TIA groups with respect to the rate of symptomatic ICH, mRS on discharge, discharge disposition, 90-day mRS, or 90-day mortality when comparing weekend and weekday groups. Using multivariate logistic regression to adjust for site, age, admission NIHSS, and blood glucose, weekend admission was not a significant independent predictive factor for in-hospital mortality in all strokes (OR = 1.10, 95% CI 0.74–1.63, $p = 0.631$). **Conclusions:** Our results suggest that comprehensive stroke centers (CSC) may ameliorate the ‘weekend effect’ in stroke patients. These results may be due to 24/7 availability of stroke specialists, advanced neuroimaging, or ongoing training and surveillance of specialized nursing care available at CSC. While encouraging, these results require confirmation in prospective studies.

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Introduction

Efficient and effective emergency health care should be readily available, irrespective of day or admission time. For 23 of the 100 leading causes of death, prior epidemio-

logical work has shown higher mortality rates for weekend admissions compared with weekday admissions [1]. Recent work by Kostis et al. [2] found that patients with myocardial infarction have higher mortality rates and lower numbers of invasive cardiac procedures performed when admitted on weekends, suggesting that improving access to care on weekends could improve patient outcome. This difference in outcomes related to patient admission during the weekend has come to be known as the 'weekend effect.'

More recently, Saposnik et al. [3] found the 'weekend effect' to have a significant negative impact on discharge disposition, 7-day case fatality, and in-hospital mortality in ischemic stroke patients. Analysis of the Swedish Hospital Discharge Register and the Nationwide Inpatient Sample of Healthcare Cost and Utilization Project data confirmed this excess mortality for weekend admissions [4, 5]. Using the Get with the Guidelines data, Reeves et al. [5] recently reported increased in-hospital mortality in weekend admissions for both patients with infarct and intracerebral hemorrhage [6]. Though patients treated in hospitals with stroke units have improved outcome, evidence from the UK suggests that stroke patients admitted on weekends were less likely to be admitted to stroke units and less likely to receive the same quality of care when compared to weekday admissions [7–12].

Contrary to these findings, Ensminger et al. [13] found no statistically significant difference in hospital mortality between weekend and weekday admissions when examining an 8-year cohort of general ICU patients admitted to a tertiary care academic medical center. This study differed from previous studies in that the facility was staffed by fellows and residents 24 h a day, 7 days a week, and intensivists were available at all times. Further, the authors suggested that this level of staffing and the continuous availability of diagnostic and therapeutic modalities may be responsible for preventing the weekend effect.

Given these contradictory findings, we hypothesized that centers with continuous availability of expert stroke teams, necessary diagnostic and therapeutic modalities, and stroke-nursing expertise could modify the 'weekend effect' in acute ischemic stroke (AIS) patients. Our aim was to examine both the individual and combined experiences of 2 comprehensive stroke centers (CSC) in the USA, and determine the presence and significance of a 'weekend effect' in AIS patients treated with IV t-PA (intravenous tissue plasminogen activator). Acute ischemic stroke patients treated with IV t-PA were chosen, as these

patients require the highest need for immediate services and immediate intervention. In addition, it is often the post-t-PA AIS patients that are at greatest risk of adverse events.

Methods

Site 1

As previously described, a dedicated stroke pager is carried by all members of the stroke team (i.e. fellows, faculty, research nurses, ultrasonographers) [14]. The emergency department (ED) or the transfer center page the dedicated stroke pager, activating the stroke team. The page is answered by a stroke fellow or stroke attending 24 h a day, 7 days a week. The physician answering the page then enters a series of codes or a text message into the pager, notifying the rest of the team that the call has been answered and providing information on the patient's location, need for urgent treatment, possible research protocol enrollment, and the need for transcranial Doppler. Using this dedicated stroke pager system, IV t-PA treatment rates for patients arriving at the ED range from 20 to 30%. While the majority of patients present to our ED directly, about 1/3 are originally taken to outside facilities before transfer to our center.

Site 1: Discharge Adverse Events and Functional Outcomes

To examine the relationship between weekend admissions and discharge outcome, a retrospective review of all stroke patients admitted from June 2004 to June 2006 was performed. Patients were categorized into 4 groups based on their stroke: intracerebral hemorrhage (ICH), ischemic strokes not treated with IV t-PA (IS), acute ischemic strokes treated with IV t-PA (AIS-TPA), and transient ischemic attack (TIA). Those patients treated with IV t-PA beyond 3 h after onset, treated with intra-arterial therapy, enrolled in a clinical trial, or with incomplete admission time data were excluded. In a retrospective chart review, we collected patient demographics, admission NIHSS scores, admission glucose, and time to treatment. Patients meeting inclusion criteria were divided into 2 groups: weekend and weekday admissions. Weekend admission was defined as the period from Friday, 17:01 to Monday, 08:59. All other admissions were classified as weekday admissions.

Primary outcome measures included symptomatic intracerebral hemorrhage (sICH), hospital length of stay, discharge disposition (home or inpatient rehabilitation favorable vs. skilled nursing facility, long-term care facility or death unfavorable), and functional outcome on discharge, as measured by the modified Rankin Scale (mRS; 0–2 favorable vs. 3–6 poor). The primary outcome measures were compared in the weekend and weekday groups. Having found no 'weekend effect' at site 1, we chose a second CSC with a different patient population to confirm our findings.

Site 2

An expedited code stroke protocol is activated by ED personnel (associated with one of the 6 site-2-affiliated hospitals) or any emergency medical service's transport team, calling a single centralized pager system. Specified protocols call for activation of a stroke code for all patients with signs or symptoms of acute stroke or TIA pre-

Table 1. Patient demographics by site

	Site 1	Site 2	p value
Weekend admissions, %	37 (521/1407)	34.7 (279/804)	0.290
Age, years	64 (17–100)	72 (17–99)	<0.001
Ethnicity, %			
African American	36.0 (503/1,399)	11.3 (91/804)	<0.001
Hispanic	18.4 (257/1,399)	12.8 (103/804)	
Caucasian	43.1 (603/1,399)	66.2 (532/804)	
Asian	2.3 (32/1,399)	7.3 (59/804)	
Other	0.3 (4/1,399)	2.4 (19/804)	
NIHSS score	7 (0–40)	6 (0–42)	0.047
Admission glucose, mg/dl	124 (6–633)	117 (12–533)	0.001

Values in parentheses are numbers of patients or ranges.

senting within 24 h of symptom onset, as previously described [15, 16]. Once the stroke code pager is activated, a multidisciplinary team is mobilized, including a neurology resident, stroke fellow, stroke attending, study nurse coordinator, pharmacist, radiologist, and CT technician. The stroke fellow or attending on call evaluates the patient at the specified hospital's ED for purposes of potential thrombolytic administration in patients who present within the first 3 h. Using this community stroke code model, the IV t-PA treatment rate has been most recently estimated at 19%. Details regarding tertiary referral were unavailable at the time of this publication, though likely account for approximately 5% of the acute stroke codes evaluated for both standard and research therapies.

Site 2: 90-Day Mortality and Functional Outcomes

To examine the relationship between weekend admissions and 90-day outcome, a retrospective review of all stroke patients admitted from June 2004 to August 2007 (dates are different for 2 institutions) was performed. Patients were categorized into 4 groups based on their stroke: ICH, IS, AIS-TPA, and TIA. Patients treated with IV t-PA beyond 3 h after onset, receiving intra-arterial therapy, enrolled in a nonobservational clinical trial, or with incomplete admission time data were excluded. Patient demographics, admission NIHSS score, admission glucose levels, and time to treatment were examined. Patients meeting inclusion criteria were similarly divided into 2 groups: weekend and weekday admissions, as previously defined. Primary outcome measures, 90-day mRS (0–2 favorable vs. 3–6 poor) and 90-day mortality were compared in the weekend and weekday groups.

Site 1 and 2 Combined: In-Hospital Mortality

As in-hospital mortality data were available for both sites, data from site 1 and site 2 were combined to examine the effect of weekend admission on in-hospital mortality. The inclusion and exclusion criteria described above were utilized. Patients were dichotomized based on time and date of arrival as described above. The primary outcome measure was in-hospital mortality. As age, admission NIHSS score, and admission glucose have previously been shown to affect outcome, it was predetermined that adjustment would be made for these variables.

Statistical Analysis

Categorical variables were compared using χ^2 or Fisher's exact tests, as appropriate. Continuous variables were compared using two-sample t tests or Wilcoxon rank-sum tests, as appropriate. The in-hospital mortality rate was compared between weekend admissions and weekday admissions using the Cochran-Mantel-Haenszel χ^2 test stratified by site (site 1/site 2). In addition, in-hospital mortality rate was compared between arrival groups using multivariate logistic regression, controlling for site, admission NIHSS, age, and admission glucose.

Results

Site 1: Discharge Adverse Events and Functional Outcomes

A total of 1,407 patients met the inclusion criteria in the site 1 cohort (376 ICH, 648 IS, 200 AIS-TPA, 183 TIA). Comparison demographics for patients at sites 1 and 2 are shown in table 1; demographics for weekday and weekend patients are shown in table 2.

There was no significant difference in IV t-PA treatment rates on weekends when compared to weekdays [22.3% (140/629) vs. 20.1% (221/1097), $p = 0.314$]. After excluding patients with TIA, there remained no significant differences in weekend and weekday groups [26.0% (140/539) vs. 24.7% (221/896), $p = 0.580$]. Adverse events and functional outcome at the time of discharge for each stroke category are shown in table 3. No significant differences were found in the ICH, IS, AIS-TPA, or TIA groups with respect to the rate of sICH, mRS on discharge, or discharge disposition when comparing weekend and weekday groups (table 3). Interestingly, ICH and IS patients arriving on a weekday appeared to have an increased length of stay ($p = 0.02$, $p = 0.04$).

Site 2: 90-Day Mortality and Functional Outcomes

A total of 804 patients met the inclusion criteria in the site 2 cohort (109 ICH, 426 IS, 161 AIS-TPA, 111 TIA). Patient demographics are shown in table 1. As illustrated in table 4, 90-day mortality and functional outcome data were available for 242 patients (9 ICH, 99 IS, 100 AIS-TPA, 34 TIA). There was no significant difference in either 90-day functional outcome or mortality at 90 days in any of the stroke categories.

Sites 1 and 2 Combined: In-Hospital Mortality

A total of 2,211 patients met inclusion criteria for the combined cohort, 1,407 from site 1 and 804 from site 2, as previously described. Patient demographics comparing site 1 to site 2 are shown in table 2. In total, 36.2%

Table 2. Patient demographics for weekend and weekday admissions for both sites

	Weekend	Weekday	p value
IV t-PA treatment rate, % (AIS-TPA/all strokes – ICH)	22.3 (140/629)	20.1 (221/1,097)	0.314
IV t-PA treatment rate, % (AIS-TPA/all strokes – ICH – TIA)	26.0 (140/539)	24.7 (221/896)	0.580
Age, years	67 (19–100)	67 (17–100)	0.644
Ethnicity, %			0.003
African American	30.8 (246/798)	24.8 (348/1,405)	
Hispanic	17.2 (137/798)	15.9 (223/1,405)	
Caucasian	46.6 (372/798)	54.3 (763/1,405)	
Asian	3.9 (31/798)	4.3 (60/1,405)	
Other	1.5 (12/798)	0.8 (11/1,405)	
NIHSS score	6 (0–42)	6 (0–40)	0.398
Admission glucose, mg/dl	122 (12–441)	121 (6–633)	0.800

Values in parentheses are numbers of patients or ranges.

Table 3. Site 1: Discharge adverse events and functional outcomes

	Symptomatic ICH		Poor outcome (mRS 3–6)		Discharge disposition (home/rehab)		Length of stay	
	weekend	weekday	weekend	weekday	weekend	weekday	weekend	weekday
All strokes, %	1.0 (5/521)	0.6 (5/886)	56.8 (294/518)	52.8 (464/879)	68.1 (353/518)	68.8 (605/879)	5 (0–63)	5 (1–79)
	p = 0.51		p = 0.81		p = 0.81		p = 0.06	
ICH, %	0 (0/139)	0 (0/237)	79.9 (111/139)	76.3 (180/236)	50.4 (70/139)	44.5 (105/236)	6 (0–63)	7 (1–77)
	n/a		p = 0.44		p = 0.29		p = 0.02	
IS (without IV t-PA), %	0.4 (1/246)	0 (0/402)	51.0 (124/243)	50.7 (203/400)	74.1 (180/243)	75.5 (302/400)	5 (0–38)	6 (1–79)
	p = 0.38		p = 1.0		p = 0.71		p = 0.04	
AIS (with IV t-PA), %	5.1 (4/79)	4.1 (5/121)	62.0 (49/79)	53.8 (64/119)	60.8 (48/79)	71.4 (85/119)	5 (2–38)	5 (2–50)
	p = 0.74		p = 0.31		p = 0.13		p = 0.89	
TIA, %	0 (0/57)	0 (0/126)	17.5 (10/57)	13.7 (17/124)	96.5 (55/59)	91.1 (113/124)	3 (1–18)	3 (1–12)
	n/a		p = 0.51		p = 0.23		p = 0.84	

Values in parentheses are numbers of patients or ranges.

(800/2,211) of patients arrived on a weekend. As illustrated in table 1, there was no significant difference in age, NIHSS score or admission glucose levels in the weekend and weekday admission groups. The overall median age was 67 years (range 17–100), with site 2 patients being significantly older ($p < 0.001$). In the combined group, the majority of patients were Caucasian (51.5%, 1,135/2,203), followed by African American (27%, 594/2,203), and Hispanic (16.3%, 360/2,203). Caucasians represented 66.2% of patients at site 2 as compared to 43.1% at site 1 ($p < 0.001$). The overall median NIHSS score, including TIA, was 6 (range 0–42), with patients at site 1 having a

significantly higher median NIHSS score ($p = 0.047$). The median admission glucose was 122 mg/dl (range 6–633), with patients at site 1 exhibiting more severe hyperglycemia ($p = 0.001$).

Weekend versus weekday in-hospital mortality for sites 1 and 2 combined is shown in table 5. There was no significant difference found for in-hospital mortality in any stroke category when comparing weekend to weekday admissions; results for all strokes adjusted using Cochran-Mantel-Haenszel for site are: OR = 1.01, 95% CI 0.74–1.39, $p = 0.936$. Using multivariate logistic regression to adjust for site, age, admission NIHSS score, and

Table 4. Site 2: 90-day mortality and functional outcome

	90-day poor outcome (mRS 3–6)		90-day mortality	
	weekend	weekday	weekend	weekday
All strokes, %	48.6 (35/72)	45.3 (77/170)	16.7 (12/72)	17.6 (30/170)
	p = 0.67		p = 1.0	
ICH, %	66.7 (2/3)	66.7 (4/6)	33.3 (1/3)	33.3 (2/6)
	p = 1.0		p = 1.0	
IS (without IV t-PA), %	40.7 (11/27)	38.9 (28/72)	14.8 (4/27)	11.1 (8/72)
	p = 1.0		p = 0.73	
AIS (with IV t-PA), %	58.8 (20/34)	65.2 (43/66)	17.6 (6/34)	30.3 (20/66)
	p = 0.66		p = 0.23	
TIA, %	25.0 (2/8)	7.7 (2/26)	12.5 (1/8)	0 (0/26)
	p = 0.23		p = 0.24	

Values in parentheses are numbers of patients or ranges.

Table 5. Sites 1 and 2 combined: in-hospital mortality

	In-hospital mortality	
	weekend	weekday
All strokes, %	8.2 (65/788)	8.2 (114/1,392)
	p = 0.94	
ICH, %	22.5 (38/169)	22.1 (69/312)
	p = 0.87	
IS (without IV t-PA), %	3.8 (15/391)	3.5 (23/661)
	p = 0.88	
AIS (with IV t-PA), %	8.7 (12/138)	10.1 (22/218)
	p = 0.84	
TIA, %	0 (0/90)	0 (0/201)
	n/a	

Values in parentheses are numbers of patients or ranges.

blood glucose, weekend admission was not a significant independent predictive factor for in-hospital mortality in all strokes (OR = 1.10, 95% CI 0.74–1.63, $p = 0.631$).

Discussion

In this cohort, patients admitted on weekends did not have a higher rate of in-hospital mortality or 90-day mortality when compared to weekday admissions. Patients

admitted on weekends also did not have worse functional outcome (mRS 3–6) at discharge or at 90 days. Further, patients admitted and treated with IV t-PA on weekends did not have higher rates of sICH when compared with their weekday counterparts. The lack of a weekend effect cannot be attributed to baseline variables that affect outcome, as there were no significant differences in weekday and weekend groups with respect to age, NIHSS scores, and admission glucose levels. Further, IV t-PA treatment rates were not significantly different in patients treated on weekends, as compared to their weekday counterparts.

The weekend effect was absent when the data from site 1 was investigated. This result then prompted us to assess the weekend effect at a separate CSC. A significant concern is that of the disparate populations at site 1 and site 2. Despite the differences noted in demographics at the 2 sites, the weekend effect was still not observed in the second dataset. Although a homogeneous patient sample may be desirable, the lack of a weekend effect seen even in these differing patient populations may support generalizability to the population as a whole. Further, when outcomes common to both sites were combined to generate an even larger sample, no significant differences in in-hospital mortality were observed.

The acute coronary literature has shown that patients with more severe disease tend to present on weekends [17]. It has been suggested that the increased mortality previously seen in weekend stroke patients may be due to the different level of severity of disease [18].

Our study found no significant differences in NIHSS scores, age, race, or admission glucose levels when comparing the weekend and weekday groups. In addition, we found no significant difference in IV t-PA treatment rates.

Previous studies have also reported the rate of weekend admissions in certain disease processes to be higher than that which would be expected (2/7 or 28.6%) [1]. While our study did not find the rate of weekend admissions for AIS-TPA to be significantly different between the 2 sites (37, 35%), it did find the weekend stroke rate to be greater than the expected 28.6% (2/7). This increased incidence of stroke on the weekends is consistent with previous reports of an increased incidence of stroke on holidays and weekends [19].

Given the above results, it is important to point out that this study is limited by its small sample size and should therefore be interpreted with caution. Our design is also limited by its retrospective analysis of prospectively collected data. Future prospective designs may lend additional support to these findings. Each database was designed independently; thus, not all outcome variables were available at each site. Site 1 provided in-hospital adverse events and discharge functional outcome, while site 2 provided functional outcome and mortality at 90 days, thus limiting the number of patients of which every variable was collected. Fortunately, both sites had in-hospital mortality data available; thus, we were able to combine the datasets for this important outcome variable. Patient data collection time periods were slightly different at each site. Similarly, practice patterns may have been different at individual institutions. In spite of these differences, our data did not show a statistically significant difference for in-hospital mortality.

While this study is limited by its small sample size, our results suggest that CSC may erase the previously reported 'weekend effect' in acute ischemic stroke patients. Compared to other reports, the absence of the weekend

effect in our study may be the result of the 24/7 availability of stroke specialists, trained stroke-nursing expertise, or advanced neuroimaging capabilities at CSC, as previously described by the Brain Attack Coalition [3, 20].

The Brain Attack Coalition described a CSC as a facility with the necessary personnel, infrastructure, expertise, and programs to diagnose and treat stroke patients requiring a high intensity of medical and surgical care, specialized tests, or interventional therapies. This coalition further suggested that an additional function of a CSC would be to act as a resource center for other facilities in their region, such as primary stroke centers [20]. If CSC were intended to parallel trauma centers, this raises the question as to whether weekend stroke patients should bypass local facilities and be brought directly to a CSC in locations where this is an option. Another option would be to establish 'drip and ship' relationships with noncomprehensive stroke centers where acute ischemic stroke patients arriving on a weekend could be treated with IV t-PA when appropriate, and then immediately transferred to a comprehensive stroke center where the resources are available 24/7.

Our data did not confirm recent reports which showed that both ischemic and hemorrhagic stroke patients had higher mortality when presenting on the weekend [3–5]. In those studies, patients were primarily treated at primary stroke centers or community hospitals without dedicated university-affiliated stroke programs. It is possible that formation of comprehensive stroke centers and appropriate network strategies may ameliorate or prevent the weekend phenomenon. Additional study is warranted to further investigate these promising findings.

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