Title: Assessment of the "Weekend Effect" in Lower Extremity Vascular Trauma

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Abstract

Background: Studies suggest that patients admitted on weekends may have worse outcomes as compared to those admitted on weekdays. Lower extremity vascular trauma (LEVT) often requires emergent surgical intervention and might be particularly sensitive to this "weekend effect." The objective of this study was to determine if a weekend effect exists for LEVT.

Methods: The National and Nationwide Inpatient Sample Database (2005-2014) was queried to identify all adult patients who were admitted with a LEVT diagnosis. Patient and hospital characteristics were recorded or calculated and outcomes including in-hospital mortality, amputation, length of stay (LOS), and discharge disposition were assessed. Independent predictors of outcomes were identified using multivariable regression models.

Results: There were 9282 patients admitted with LEVT (2866 weekend admissions vs. 6416 weekday admissions). Patients admitted on weekends were likely to be younger than 45 years old (68% weekend vs. 55% weekday, $P< 0.001$), male (81% weekend vs. 75% weekday, $P<0.001$), and uninsured (22% weekend vs. 17% weekday, $P<0.001$) as compared to patients admitted on weekdays. There were no statistically significant differences in mortality (3.8% weekend vs. 3.3% weekday, $P= 0.209$), amputation (7.2% weekend vs 6.6% weekday, $P= 0.258$), or discharge home (57.4% weekend vs. 56.1% weekday, $P= 0.271$). There was no clinically significant difference in length of stay (median 7 days weekend vs. 7 days weekday), $P=0.009$. Upon multivariable regression analyses, there were no statistically significant outcome differences between the groups.

Conclusions: This study did not identify a weekend effect in LEVT patients in the United States. This suggests that factors other than the day of admission may be important in influencing outcomes after LEVT.

Introduction

Vascular trauma in the adult population accounts for 1.6% of traumatic injuries in the United States.[1] Vascular trauma cases can lead to detrimental consequences such as limb loss and mortality.[2,3] Therefore, a greater understanding of factors that may lead to worse patient outcomes is important in ensuring optimal overall outcomes for patients presenting with vascular trauma.

One such factor that may contribute to unfavorable outcomes is the "weekend effect." The weekend effect is a term coined to describe the differences in patient outcomes when admitted to the hospital on the weekends versus weekdays, where weekend admissions often demonstrate worse outcomes.[4,5,6] The root cause for the weekend effect is yet to be delineated. However, one possibility is that potentially reduced and less specialized staffing in hospitals on the weekends may be responsible for this observation. Numerous studies have observed a weekend effect in a number of diagnoses across multiple hospitals in various countries.[7,8,9] This phenomenon has been particularly notable amongst patients undergoing urgent procedures, such as emergency general surgery[4] and pediatric surgery,[10] where weekend operations have higher complications than weekday operations. The existence of the weekend effect has also been examined in vascular operations such as carotid endarterectomy and lower extremity bypass. Carotid endarterectomies performed on the weekends, in both asymptomatic and symptomatic patients, were associated with higher odds of stroke/death.[11] Furthermore, patients who underwent lower extremity bypass procedures on the weekends experienced higher 30-day rate of mortality and major amputation compared to patients undergoing bypass on weekdays.[12] It has also been noted that in ruptured abdominal aortic aneurysms (AAA's), patients transferred on the weekends demonstrated higher mortality rates as compared to those transferred during weekdays.[13] Although these studies attempted to homogenize the patients being compared, some may still argue that the urgency for intervention among these patients operated on

weekends is likely higher than those operated on weekdays which may, as a result, influence their outcomes.

Despite the increased awareness of the weekend effect, to date, only a paucity of studies have explored this phenomenon in trauma. In England, a study of all major trauma patients showed that the weekend effect was not observed in that patient population.[14] It is, however, unclear if this is true for all types of trauma. Although the weekend effect has not been seen in studies of patients with traumatic injuries, it has been shown in patients with urgent vascular conditions.[11,12,13] Therefore, we sought to evaluate if this phenomenon may be seen in patients with vascular trauma who require emergent surgical intervention, such as those presenting with lower extremity vascular trauma (LEVT). We sought to determine if there is a weekend effect in patients presenting with LEVT in the United States.

Methods

Data Source and Study Variables

The National Inpatient Sample and the Nationwide Inpatient Sample (NIS) is a 20% stratified sample of the United States inpatient population, which can be used to derive nationally representative estimates.[15] Patient data was retrieved from the NIS between the years 2005 to 2014. Using the *International Classification of Diseases – Clinical Modification, 9th Edition* (ICD-9-CM) diagnosis codes (904: 'Injury to blood vessels of lower extremity and unspecified sites'), patients 18 years and older who had a diagnosis of LEVT were identified. The specific ICD-9-CM codes included are listed in *Supplemental Table 1*. Patients were divided into groups based on admission during the weekend or the weekday. Because this was a retrospective study performed using deidentified data, an Institutional Review Board exemption was conferred. Accordingly, specific informed consent was not obtained.

The patient demographics included age, sex, race/ethnicity, insurance type, and median household income national quartile for patient zip code. Age was categorized using previously published groups into 18 – 44 years, 45 – 64 years, and ≥ 65 years old.[16,17] Race/ethnicity was classified as White, Black, Hispanic or Others. Insurance type was categorized into Private, Medicare, Medicaid, Uninsured/Self-Pay, and Other. "Other" insurance type included Worker's Compensation, Civilian Health and Medical Program of the Uniformed Services, Civilian Health and Medical Program of the Department of Veterans Affairs, Title V, other government programs, and no charge.[15]

Clinical characteristics derived for each patient included the Abbreviated Injury Scale (AIS) for different body regions, the Injury Severity Score (ISS), the Charlson Comorbidity Index (CCI) and whether the vessel injured was an artery or a vein. The AIS for each body region indicates the degree of severity of the injury to that body region and ranges from 1 (minor) to 6

(maximal).[18] The ISS is an aggregate score that uses the highest AIS from the three most injured body regions to obtain a score that has been shown to predict mortality after traumatic injury.[19, 20] AIS and ISS was calculated from ICD-9-CM diagnosis codes using the previously validated ICD Programs for Injury Categorization module in Stata.[21,22] ISS was categorized as <9, 9-15, 16-24, and ≥25.[23,24] CCI was calculated using the CHARLSON module in Stata.[25] Using information regarding 19 possible chronic conditions, the CCI has been validated to predict mortality and perioperative complications in longitudinal data.[26, 27] CCI was classified as <2 and ≥2 (higher being worse).[28, 29] Details of the specific vessels injured were derived from ICD-9-CM codes (*Supplemental Table 1)*. Some patients in the cohort had both arterial and venous injuries, while some patients' injuries were coded as unspecified. We also identified patients who got vascular operations and stratified by whether they procedures were open or endovascular. Information on hospital location and teaching status was categorized as rural, urban non-teaching, and urban teaching.

Assessment of Outcomes

The outcomes of interest included mortality, limb loss, hospital length of stay, and discharge disposition. Lower limb loss (major amputation) was defined using the ICD-9-CM procedure codes of 84.15-17. Discharge disposition was classified as discharge home versus any other disposition at discharge. Patients who died during the hospital admission were excluded from the assessment of discharge disposition.

Statistical Analyses

Differences in demographics, clinical, and hospital characteristics between patients admitted on weekends versus the weekdays were determined using Chi-square tests. The patterns of injury, including the specific vessels injured and/or the presence of lower limb fractures (ICD-9-CM diagnosis codes – 820.xx, 821.xx, 823.xx), were also compared between the two groups.

The outcomes of the two groups were compared using Chi-squared tests for the categorical variables and Wilcoxon rank sum tests for length of stay.

Factors associated with each outcome were determined using bivariate regression models built separately for each variable. Factors that were marginally significantly associated with the outcomes on the bivariate analysis ($P < 0.2$) were included in further multivariate analyses. It was pre-determined that the variable for day of admission and Charlson score would be included in the multivariate models regardless of the bivariate analyses because they were integral parts of the analyses. Multivariate logistic regression models were then fitted to identify independent associations with mortality, lower limb loss, and discharge disposition. To identify independent factors associated with length of stay, multivariate generalized linear models were constructed with gamma distributions and the mean predicted length of stay was calculated.

Because some of the outcomes observed may have been associated with other injuries present in the patients, we undertook sensitivity analyses using patients with isolated LEVT. Isolated LEVT was defined using methodology previously described by Kauvar et al.[2] Patients with ICD-9-CM codes noted in *Supplemental Table 1*, who had AIS scores of 0 in all body regions other than the "extremity" were considered "Isolated LEVT." Further sensitivity analyses were undertaken using patients treated at teaching hospitals and those at non-teaching hospitals to determine if the associations observed were modified by the different types of hospitals where patients were treated. Sensitivity analyses by type of vessel injured were also performed. All analyses were conducted using Stata Statistical Software: Release 14.2 (College Station, TX: StataCorp LLC) and the significance level was set as $P < 0.05$.

Results

There were 9282 patients admitted with LEVT (2866 admitted on the weekend versus 6416 admitted on the weekday). The volume of patients on the weekends were 1433 per day compared to 1283 per day on the weekdays, indicating slightly higher patient admission volumes on the weekends versus the weekdays. *Table 1* illustrates the cohort demographics obtained. Compared to patients admitted on the weekdays, patients admitted on the weekend were more likely to be younger than 45 years old (68% weekend vs. 55% weekday), male (81% weekend vs. 75% weekday), and uninsured (22% weekend vs. 17% weekday) [all $P < 0.001$]. The patterns of lower extremity injury among patients admitted on weekends and weekdays is shown in *Table 2*. The predominant vessel injured in both groups was the popliteal artery (21.6% weekend vs. 20.1% weekday, $P = 0.093$). A third of the patients had lower extremity fractures (33.7% weekend vs. 28.4% weekday, $P < 0.001$).

When patients admitted on weekends were compared to those admitted on the weekdays in the overall cohort, there were no significant differences in mortality (3.8% weekend vs. 3.3% weekday, $P = 0.209$), amputation (7.2% weekend vs 6.6% weekday, $P = 0.255$), or discharge home (57.4% weekend vs. 56.1% weekday, $P = 0.271$) as shown in *Table 3*. There was also no clinically significant difference in length of stay. The cohort had a median range of 7 days on both the weekend and weekday (interquartile range 3-16 weekend vs. 3-14 weekday, $P = 0.009$). This was also observed amongst patients with isolated LEVT, where no differences in mortality (2.1% weekend vs. 2.1% weekday, $P = 0.993$), amputation (6.2% weekend vs. 5.7% weekday, $P = 0.531$), discharge home (58.5% weekend vs. 58.3% weekday, $P = 0.911$), and length of stay (interquartile range 3-13 weekend vs. 3-12 weekday, $P = 0.002$) were seen as shown in *Table 3*.

Multivariate regression analyses were done controlling for race, insurance type, median household income national quartile for patient zip code, ISS, CCI, and location/teaching status of hospital. There were no statistically significant differences between the weekend and weekday groups in terms of mortality (adjusted odds ratio [aOR] 1.10, 95% confidence interval (CI) 0.84 to 1.47), amputation (aOR 1.03, 95% CI 0.85 to 1.25), discharge home (aOR 0.94, 95% CI 0.84 to 1.05), hospital LOS (predicted mean difference 0.33, 95% CI -0.34 to 1.00) (*Table 4*). There was, however, a notable association observed in the multivariate analyses. Compared to patients in rural hospitals, patients treated at urban hospitals had significantly higher odds of lower extremity amputation as well as longer lengths of stay.

Examination of the weekend effect by hospital type (rural/urban nonteaching and urban teaching) showed there was no weekend effect with any of the outcomes measured across all hospital types. Sub analyses of arteries and veins injured in patients with LEVT showed there were 6099 patients with arteries injured, 2951 with veins injured, and 1438 patients with both vessels injured. Examination of the weekend effect by vessel type showed no difference in the relationship in patients with arterial injury vs. those with venous injury (*Table 5).*

Sensitivity analyses including only patients with isolated LEVT showed similar patterns of associations as in the overall cohort (*Supplemental Table 2, 3).*

Compared to patients admitted on the weekday, patients admitted on the weekend were more likely to undergo vascular procedures (63.1% weekend vs. 57.7% weekday, $P<0.001$). When stratified by type of procedure, this difference was seen in rates of open procedures performed for LEVT (60.4% weekend vs 54.8% weekday, $P<0.001$) but not for endovascular procedures (4.3% weekend vs 4.9% weekday, $P=0.170$) (*Supplemental Table 4).*

When the outcomes of patients who underwent vascular operations for LEVT were compared on the weekends vs. the weekdays, there was no difference in mortality (4.3% weekend vs. 3.4% weekday, *P*= 0.090), amputation (5.6% weekend vs. 4.9% weekday, *P*= 0.251) or length of stay as shown in *Supplemental Table 5.*However, there was a slight difference in the proportion of patients discharged home (61.9% weekend vs. 58.6% weekday, *P*= 0.022).

Discussion

Our study did not identify a weekend effect in patients presenting with LEVT in the United States. Our study also revealed differences in patient populations who presented on the weekends versus the weekday. Compared to patients admitted on the weekdays with vascular trauma, patients admitted on the weekends with vascular trauma were more likely to be younger with a lower comorbidity index, but with higher injury severity scores and a more serious abbreviated injury scale for the extremity body region. Even after we adjusted for these differences, we still did not observe a weekend effect in patients with LEVT. The lack of a weekend effect in the trauma setting may be due to the nature of trauma and the practice of continuous coverage by a full complement of ancillary staff and trauma team members.[14,30] Since there are explicit requirements of trauma centers to be staffed and prepared to deliver optimal care independent of time of day and day of week, this may be the underlying factor which protects against increased mortality in traumatic injuries presenting on the weekends.[14,31]

While multiple studies have demonstrated this effect in vascular and general surgery,[4,11-13] some studies have not identified this phenomenon.[32-34] The finding of a “weekend effect” across a large range of patient groups has, understandably, raised significant concerns about these differences in outcomes.[9, 35-42] In vascular trauma, it was unknown whether such an effect existed. We believed it was important to determine if such an effect exists given the possibility of finding a target for potentially reducing preventable deaths and/or limb loss. Gratifyingly, our findings did not demonstrate evidence of a clinically significant weekend effect in the management of lower extremity vascular trauma. The likelihood of mortality, amputation, prolonged hospital stay, and being discharged home did not differ amongst this population of patients, based on weekend or weekday presentation. This suggests that there is little difference in patient outcomes regardless of whether they present on a weekend or during the

week. An earlier study in the United Kingdom did not identify the weekend effect in patients with severe trauma.[14] Our results were consistent with the findings of this study.

Previous studies performed to delineate the weekend effect postulate that the weekend effect may be due to reduced staffing levels[5,43], use of temporary clinical staff [5,44] or reduced access to various procedures[45] that are available on weekdays. Decreased staffing may cause clinical staff members to have an increased workload since they now have to manage multiple tasks, which can potentially lead to increased error.[13] It can also cause delayed communication, inability of staff to respond immediately[46], which can lead to delays in diagnosing the patient[13] or even mortality. Other possible reasons for the existence of the weekend effect may be due to personnel who have limited experience[5] or a decreased number of specialized physicians in the hospital on the weekends compared to the weekdays.[46] The absence of a weekend effect in transplant surgery[33,34] and trauma[14] may support these hypotheses. In the case of transplant, it is often the case that the transplant supporting team – i.e. nurses and technicians – come in to join the transplant surgeons to perform a transplant whether it is a weekend or weekday. Thus, the supporting team may be no different on weekends versus weekdays. Likewise, in trauma, the supporting team remains similar on weekends and weekdays ensuring that the outcomes are comparable. The weekend effect identified in carotid endarterectomy and leg bypass[11,12] may be attributable to the fact that the supporting vascular teams are available during the weekdays but not available during weekends so that less familiar staff are employed to support the vascular surgeon. In addition, since these procedures can usually be performed in a non-urgent fashion during routine hours, patients treated on the weekends in these studies were likely treated for more urgent indications, potentially confounding the results of these studies.

When looking at hospital type our study demonstrated decreased mortality in urban hospitals, both teaching and non-teaching, as compared to rural hospitals. Decreased mortality in urban

hospitals was accompanied by an increased incidence of amputation. Increased amputation in urban hospitals has been attributed to more complex cases at these hospitals.[47] It is also quite plausible that the decreased transport time in urban settings, compared to rural settings, allows for life-saving interventions including amputations early in the course of the injury.[48]

Limitations

There were some limitations to this study. We are unable to determine whether the vascular injuries were repaired by vascular surgeons or trauma surgeons. While some evidence suggests that trauma surgeons may have equivalent outcomes to vascular surgeons in repairing traumatic vascular injuries, this evidence is local and not nationwide in scope.[49] We were also unable to capture patients that were discharged early but subsequently died outside of the hospital. However, the weekend effect is typically an examination of in-hospital outcomes.[4,13,35] We did not enumerate all other injuries patients had in addition to their LEVT. These injuries could have presumably influenced the outcomes measured. However, we included ISS which should account for other injuries along with their severity. It is reassuring that sensitivity analyses on patients who had no injuries other than LEVT showed similar findings. There also remains the possibility of miscoding of diagnoses, procedures, and other variables, which is a limitation that is inherent to all studies using administrative data.[50]

In conclusion, our study did not identify a weekend effect in patients admitted with LEVT in the United States. This suggests that factors other than the day of admission may be important in influencing outcomes after LEVT. Further understanding of these factors would be beneficial in improving outcomes following LEVT.

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