The effect of weekend and after-hours surgery on morbidity and mortality rates in pediatric neurosurgery patients

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OBJECT Several studies have indicated that the 30-day morbidity and mortality risks are higher among pediatric and adult patients who are admitted on the weekends. This “weekend effect” has been observed among patients admitted with and for a variety of diagnoses and procedures, including myocardial infarction, pulmonary embolism, ruptured abdominal aortic aneurysm, stroke, peptic ulcer disease, and pediatric surgery. In this study, morbidity and mortality outcomes for emergency pediatric neurosurgical procedures carried out on the weekend or after hours are compared with emergency surgical procedures performed during regular weekday business hours.

METHODS A retrospective analysis of operative data was conducted. Between December 1, 2011, and August 20, 2014, a total of 710 urgent or emergency neurosurgical procedures were performed at Texas Children’s Hospital in children younger than 18 years of age. These procedures were then stratified into 3 groups: weekday regular hours, weekday after hours, and weekend hours. By cross-referencing these events with a prospectively collected morbidity and mortality database, the impact of the day and time on complication incidence was examined. Outcome metrics were compared using logistic regression models.

RESULTS The weekday regular hours and after-hours (weekday after hours and weekends) surgery groups consisted of 341 and 239 patients and 434 and 276 procedures, respectively. There were no significant differences in the types of cases performed (p = 0.629) or baseline preoperative health status as determined by American Society of Anesthesiologists classifications (p = 0.220) between the 2 cohorts. After multivariate adjustment and regression, children undergoing emergency neurosurgical procedures during weekday after hours or weekends were more likely to experience complications (p = 0.0227).

CONCLUSIONS Weekday after-hours and weekend emergency pediatric neurosurgical procedures are associated with significantly increased 30-day morbidity and mortality risk compared with procedures performed during weekday regular hours.

http://thejns.org/doi/abs/10.3171/2015.6.PEDS15184

KEY WORDS patient safety; pediatric neurosurgery; surgical outcomes
analyze the effect of time of the day and weekend status on the outcomes of emergency pediatric neurosurgical procedures.

Methods

Patient Population

Clinical data were retrospectively collected from medical records. Patients were identified from our institutional pediatric neurosurgical database and operating room records. A total of 710 procedures were posted by the pediatric neurosurgery service as “urgent” (within 12 hours) or “emergency” (within 30 minutes) between December 1, 2011, and August 20, 2014, at Texas Children’s Hospital. All surgical cases were performed with the attending neurosurgeon—a board-certified pediatric neurosurgeon—present throughout the entirety of the procedure. All pediatric patients who underwent neurosurgery during the study period were eligible for inclusion. This study was completed at a single tertiary-care children’s hospital where there is high patient acuity and complex cases.

Definition of “Complication”

As the leader of our clinical team, our American Board of Pediatric Neurosurgery–approved fellow participates in the majority of the surgical cases and provides oversight on most admissions and consultations to our service; hence, he or she is made aware of nearly every adverse event or unexpected outcome.10 Our fellow subsequently brings forth these cases to the morbidity and mortality conference for discussion. Based on the morbidity and mortality data—where consensus between a panel of 6 fellowship-trained pediatric neurosurgery faculty members attending the morbidity and mortality conference is reached for each procedure performed within the last week and any unexpected outcomes or readmission within 30 days of discharge, as identified by our fellow—all perioperative medical adverse events defined as “complications” were included in our assessment. Our process for determining a complication is further detailed in our prior publication.17 Multiple and unrelated complications following the same procedure were not recorded as separate events. Complications were classified as death, infection, CSF leakage, postoperative hemorrhage, new neurological deficits, or other.

Definition of “Regular Hours,” “After Hours,” and “Weekend Hours”

The weekday regular-hours group was defined as patients who underwent surgery Monday through Friday between 7:20 AM and 7:00 PM. The weekday after-hours group was defined as patients who underwent surgery Monday through Thursday between 7:01 PM and 7:19 AM, Monday between 12:00 AM and 7:19 AM, and Friday between 7:01 PM hours and 11:59 PM. The weekend group was defined as patients who underwent surgery from Saturday 12:00 AM to Sunday 11:59 PM hours. The time stamp used to stratify patients into “regular-hours,” “after-hours,” or “weekend-hours” groups was based on the time the patient entered the operating room.

Complications Analysis

Patient-identifying information was generated from our retrospective chart review of urgent and emergency procedures over a 33-month period (December 1, 2011 through August 20, 2014). This database was then cross-referenced with patient information in our prospectively maintained morbidity and mortality database. The intersection of these 2 disparate databases was defined as patients who underwent both urgent and emergency procedures and developed perioperative adverse outcomes. This subset of patients formed the basis for the further analysis of quantity and quality of complications within the 3 patient subpopulations: regular hours, after hours, and weekend hours.

Statistical Analysis

Patients were stratified into groups based on the start time of the surgical procedures: weekday regular hours, weekday after hours, or weekend hours. Intergroup comparisons were made in terms of 30-day morbidity and mortality.

Descriptive statistics, including mean, standard deviation, standard error, and confidence intervals, were computed for all measurements. Comparisons of outcome metrics were analyzed with a logistical regression model. For the purposes of our regression analyses, patient age was left as a continuous variable, while other categorical variables were dichotomized, including level of urgency, whether the surgery was performed after hours, procedure type, and American Society of Anesthesiologists (ASA) classification (class ≤ III vs > III). Variables with a p value < 0.2 in the univariate analysis were included in the multivariate logistic regression model. In this study, p values were considered significant at < 0.05.

Results

Patient Demographics and Operative Data

Overall, 580 patients who underwent 710 urgent or emergency procedures were followed in the immediate postoperative period (30 days after surgery) during the study period.

In the weekday regular-hours group, there were 341 patients who underwent 434 urgent or emergency procedures. The median age of this patient group was 8 years with an interquartile range of 4 to 14 years. In this weekday regular-hours group, 65.7% of the procedures were classified as a CSF-diversion procedure.

In the after-hours group (weekday after hours and weekends), there were 239 patients who underwent 276 urgent or emergency procedures. The median age of this patient group was 6 years with an interquartile range of 2 to 12 years. In this after-hours group, 63.8% of the procedures were classified as a CSF-diversion procedure.

The children in the regular-hours group were significantly older than those in the after-hours group, and the operating room time for the regular-hours cases was significantly longer than the after-hours cases. In the after-hours group, 48 of 276 cases (17.4%) were children younger than 1 year. In the regular-hours group, only 7 of 434 urgent or emergency procedures (1.6%) were performed.
in children younger than 1 year. There were no other significant demographic or clinical differences between the 2 groups (Table 1).

Complications Rates

Perioperative factors, such as patient age, urgent versus emergency case posting, time of day and weekend status, CSF-diversion procedure versus other procedures, and ASA classification of ≤ III versus > III were included in the univariate regression analysis. None of the factors analyzed reached statistical significance, except patient age (p < 0.0001) (Table 2). After multivariate regression analysis, only age and surgery performed after hours remained statistically significant (p = 0.0001 and 0.0227, respectively) (Table 3). Moreover, the odds of a complication in a procedure performed after hours was approximately 1.8 times that of a procedure performed during regular work hours (OR 1.79; 95% CI 1.083–2.961).

Overall, 73 procedures (10.3%) had at least 1 complication that prompted inclusion in the morbidity and mortality database. In the weekday regular-hours group, 38 procedures (8.8%) were included in the morbidity and mortality database. In the after-hours group, 35 procedures (12.7%) were included in the morbidity and mortality database. Table 4 summarizes the complications analyzed in our study, including CSF leakage, infection, hematoma, early return to the operating room, death, and other complications. More than 1 complication may be categorized per procedure.

Discussion

The Weekend and After-Hours Effect on Complication Incidence in Pediatric Surgery and Neurosurgery Patients

The correlation between performing emergency surgery after hours and on the weekend and perioperative complications has not been defined in pediatric neurosurgery. Recently, an effort was made to explore this relationship in a wide spectrum of common pediatric surgical procedures. In that study, the authors conducted a review of the Nationwide Inpatient Sample and Kids’ Inpatient Database for children who were admitted with emergency surgical problems, and 439,457 pediatric patients were included. The authors found that children who underwent common urgent surgical procedures during a weekend admission have a higher adjusted risk of death, blood transfusion, and procedural complications compared with those admitted on other days of the week, suggesting patient-related or systems-based deficiencies that are detrimental to pediatric surgical care.

To the best of our knowledge, only 1 similar study was performed in neurosurgery patients to examine the influence of weekend versus weekday hospital admission on mortality following subarachnoid hemorrhage. The authors retrospectively reviewed a cohort of adult patients included in the Nationwide Inpatient Sample for 2004. They found that of the 5667 patients with subarachnoid hemorrhage, 27.5% were admitted on the weekend. Weekend admission was not a statistically significant independent predictor of death in the subarachnoid hemorrhage study population at 7, 14, or 30 days.

Results of The Present Study

Over the study period, 580 patients underwent 710 urgent or emergency pediatric neurosurgical procedures at a single children’s hospital. In this study, 64.9% of the procedures were classified as a CSF-diversion procedure. In addition, there was a marked discrepancy between the 2 groups in the proportion of children younger than 1 year who underwent urgent or emergency procedures. Children younger than 1 year comprised 17.4% of cases in the after-hours group versus 1.6% in the regular-hours cohort. This discrepancy may represent our subconscious inclination as physicians to respond more expeditiously to younger patients, regardless of the time of day or night. On the same note, caretakers may have a lower threshold to come...
to the emergency room when infants are in distress, without regard to the time of day or night.

Patients with pediatric neurosurgical problems share many characteristics with the complex patients from other studies who were found to have an increased mortality risk due to surgery occurring after hours and on the weekend. Our overall complication rate of 10.3% was slightly lower than the rates reported in previously published studies that focused on complications in pediatric neurosurgery (15.0%–16.4%).10,17 After multivariate analysis, we found that cases performed after hours were more likely to have a complication than those performed during regular hours (p = 0.0227).

The perception that hospitals are understaffed after hours and on weekends is not new.9 There are fewer physicians and nurses in house during these times, with a concomitant increase in individual workload for those health care providers.3,21 Moreover, physicians who are working after hours and on the weekends are often less experienced than those available during regular hours during the weekdays, and they will often cover patients and disease processes with which they are less familiar.18,22

Lack of experience is not exclusive to surgeons and physicians. More often than not, members of the operating room nursing staff who are on duty after hours have less skill in and knowledge of pediatric neurosurgical procedures than their counterparts who usually compose the neurosurgical team during regular hours. The after-hours operating room staff is typically drawn from an on-call general operating room pool, as is the case at our institution; these nurses and scrub technicians are frequently cross-trained over the spectrum of surgical specialties. Few, if any, attain proficiency in any one surgical specialty such as neurosurgery. Cross-training ancillary operating room staff may increase flexibility for the purposes of call coverage and may be more cost-effective than training in a single surgical specialty. Unfortunately, it may also be a contributor to poorer patient outcomes in neurosurgical procedures performed after hours and on weekends.

### Possible Solutions

When patients are referred to tertiary and quaternary medical centers, they should undergo protocol-driven perioperative care, which should be the same regardless of the day of the week or time of day. Protocols help not only to ensure standardization and the best outcomes possible for patients, but also maintain this standard throughout the day and week. A basic tenet of quality improvement is the elimination of unexplained clinical variance and its attendant obligatory betterment of patient outcomes.

Our data also seem to support the notion that specialized pediatric neurosurgical teams should cover the operating rooms not only during regular hours but also after hours. This calls for the elimination of the generalist (“jack of all trades, master of none”) cross-trained model of operating room coverage. On-call neurosurgical operating room teams should be inclusive of both surgeons and, perhaps more importantly, neurosurgical operating room nurses and scrub technicians; these teams should manage all acute neurosurgical patients.

### Limitations

Our study includes many inherent opportunities for bias. First, despite the fact that all practicing health care providers experience and deal with complications, a consistent definition of “complication” still lacks agreement or standardization. One of the challenges facing the medical profession is to record and compare complications in a reproducible manner. Unfortunately, this is a difficult and often contentious task. Historically, complications have been assessed on an anecdotal or case-by-case basis, as in the weekly “morbidity and mortality” format used in our present study. However, this approach tends to focus only on the most dramatic of complications and does not always generate reproducible recommendations. Subjective judgments are likely employed to define when a complication has occurred. While some complications may be relatively easy to quantify, such as the surgical infection rate, other scenarios are open to interpretation.

### Table 2. Univariate odds ratio for morbidity and mortality occurrence

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (continuous variable)</td>
<td>1.075 (1.033–1.119)</td>
<td>0.0003</td>
</tr>
<tr>
<td>Level (urgent, emergency)</td>
<td>0.709 (0.409–1.282)</td>
<td>0.2566</td>
</tr>
<tr>
<td>After hrs (Saturday, Sunday, or 7 pm–7 am)</td>
<td>1.513 (0.927–2.463)</td>
<td>0.0949</td>
</tr>
<tr>
<td>Weekend (Saturday, Sunday)</td>
<td>1.327 (0.735–2.298)</td>
<td>0.3275</td>
</tr>
<tr>
<td>Night (7 pm–7 am)</td>
<td>1.306 (0.748–2.208)</td>
<td>0.3318</td>
</tr>
<tr>
<td>Procedure type (CSF diversion vs other)</td>
<td>1.487 (0.881–2.604)</td>
<td>0.1490</td>
</tr>
<tr>
<td>ASA class (&gt; III)</td>
<td>1.037 (0.535–2.215)</td>
<td>0.9203</td>
</tr>
</tbody>
</table>

### Table 3. Multivariate odds ratio for morbidity and mortality occurrence

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (continuous variable)</td>
<td>1.083 (1.040–1.128)</td>
<td>0.0001</td>
</tr>
<tr>
<td>After hrs (Saturday, Sunday, or 7 pm–7 am)</td>
<td>1.790 (1.083–2.961)</td>
<td>0.0227</td>
</tr>
<tr>
<td>Procedure type (CSF diversion vs other)</td>
<td>1.521 (0.894–2.684)</td>
<td>0.1328</td>
</tr>
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</table>

### Table 4. Comparison of complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>After Hrs (n = 276)</th>
<th>Monday–Friday Daytime Hrs (n = 434)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>10 (3.6)</td>
<td>9 (2.1)</td>
<td>0.238</td>
</tr>
<tr>
<td>CSF leakage</td>
<td>6 (2.2)</td>
<td>11 (2.5)</td>
<td>1</td>
</tr>
<tr>
<td>Early return to OR</td>
<td>13 (4.7)</td>
<td>14 (3.2)</td>
<td>0.321</td>
</tr>
<tr>
<td>Postop hemorrhage</td>
<td>4 (1.5)</td>
<td>3 (0.7)</td>
<td>0.44</td>
</tr>
<tr>
<td>Other</td>
<td>7 (2.5)</td>
<td>6 (1.4)</td>
<td>0.268</td>
</tr>
<tr>
<td>Death</td>
<td>3 (1.1)</td>
<td>0 (0)</td>
<td>0.058</td>
</tr>
</tbody>
</table>

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Second, our pediatric patient population was complex. The tertiary care population subjected to this assessment may not be representative of the general pediatric neurosurgical population. Therefore, our results may not be applicable to the pediatric neurosurgery community as a whole. In terms of patient-related factors, those patients who present after hours or on weekends may, indeed, be more severely ill and thus must resort to emergency services. The acuity of a patient’s disease processes were not accounted for in this study beyond the ASA grade, which is inherently a crude measure of the severity of a patient’s illness.

Third, we did not perform a chart review on every urgent or emergency case that occurred during the study time period as part of the retrospective validation process. For example, a review of the charts of the urgent and emergency surgeries was not performed to ensure that complications were not missed in our morbidity and mortality database. This lack of a validation process could have resulted in an underreporting of complications.

Fourth, the time stamp of when the patient entered the operating room was used to categorize each case as regular hours, after hours, or weekend hours. For example, a 5-hour tumor operation starting at 6:00 PM would be included in the regular-hours group, even though the majority of the procedure and its most critical portions may have been done after hours. This peculiarity in our methodology may have contributed to inaccuracies when determining the complication rates for the regular-hours, after-hours, and weekend-hours cohorts.

In addition, our cohort was defined by the case posting to the operating room rather than specific surgery types. While the “emergency” category denotes the need for immediate surgery, the “urgent” category may be influenced by a variety of surgeon, staffing, scheduling, and operating room availability issues.

Finally, our study is also subject to sources of bias due to its retrospective nature. Future assessments of clinical outcome in pediatric neurosurgery may seek to prospectively examine the effect of complication occurrence during weekday regular hours, weekday after hours, and weekends.

Conclusions

The concept that pediatric patients with certain diagnoses may have worse outcomes if they undergo emergency surgery after hours or on the weekend is concerning for physicians, patients, and parents alike. Pediatric neurosurgical patients, specifically, often require immediate attention and treatment if they are to receive the best chance of recovery from their affliction. This study provides data suggesting that emergency pediatric neurosurgical cases performed after hours are at higher risk for suffering a complication than those performed during regular hours. Complications due to surgery occurring after hours and on weekends may be ameliorated with the use of protocol-driven perioperative care and the utilization of specialized on-call operating teams dedicated to pediatric neurosurgery.

References

18. Petersen LA, Brennan TA, O’Neil AC, Cook EF, Lee TH: Does housestaff discontinuity of care increase the risk for

Disclosure
The authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions
Conception and design: Jea. Acquisition of data: Gonda, Briceño, Syed. Analysis and interpretation of data: Ryan, Syed. Drafting the article: Jea, Desai. Critically revising the article: Jea, Gonda, Lam, Luerssen. Reviewed submitted version of manuscript: Jea, Gonda. Approved the final version of the manuscript on behalf of all authors: Jea. Administrative/technical/material support: Luerssen. Study supervision: Jea.

Supplemental Information
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