Predictors of mortality in nontraumatic subdural hematoma

Clinical article

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Object. Subdural hematoma (SDH) is a common diagnosis in neurosurgical and neurocritical practice. Comprehensive outcome data are lacking for nontraumatic SDH. The authors determined which factors are associated with in-hospital mortality in a large sample of patients with nontraumatic SDH.

Methods. Using the Nationwide Inpatient Sample, the authors selected adults who had been hospitalized in the US between 2007 and 2009 and in whom a primary diagnosis of nontraumatic SDH (ICD-9-CM code 432.1) had been made. Demographics, comorbidities, surgical treatment, and discharge outcomes were identified. Univariate and multivariate analyses were performed to identify predictors of in-hospital mortality.

Results. Among 14,093 patients with acute nontraumatic SDH, the mean age was 71.4 ± 14.8 (mean ± standard deviation). In addition, 22.2% of the patients were admitted during the weekend. Surgical evacuation was performed in 51.4% of the patients, and 11.8% of all patients died during hospitalization. In multivariate analyses, patient age (adjusted OR 1.02, 95% CI 1.012–1.022), congestive heart failure (adjusted OR 1.42, 95% CI 1.19–1.71), warfarin use (adjusted OR 1.41, 95% CI 1.17–1.70), coagulopathy (adjusted OR 2.14, 95% CI 1.75–2.61), mechanical ventilation (adjusted OR 16.85, 95% CI 14.29–19.86), and weekend admission (adjusted OR 1.19, 95% CI 1.02–1.38) were independent predictors of in-hospital mortality. Race (Hispanic: adjusted OR 0.65, 95% CI 0.51–0.83; black: adjusted OR 0.78, 95% CI 0.63–0.96), urban hospital location (adjusted OR 0.69, 95% CI 0.54–0.89), and surgical SDH evacuation (adjusted OR 0.52, 95% CI 0.45–0.60) were strong independent predictors for decreased mortality.

Conclusions. One in 9 patients with nontraumatic SDH dies during hospitalization. Among the several predictors of in-hospital mortality, the weekend effect and treatment with surgical evacuation are potentially modifiable factors. Further investigation may lead to improvements in management and outcomes.

KEY WORDS • subdural hematoma • subdural hemorrhage • weekend effect • in-hospital mortality • surgical evacuation

Subdural hematoma is one of the most common diagnoses in neurointensive care units and in neurosurgical practice. Traditionally, SDH is divided into traumatic and nontraumatic types. A distinction is also made between acute and chronic SDH. While acute traumatic SDH remains one of the most lethal head injuries, with reported mortality rates between 50% and 90%,21 acute nontraumatic and chronic SDHs are often considered to be rather benign entities. However, mortality rates as high as 13% are reported in the literature for chronic SDH2,21,29,30 underscoring the relatively high morbidity and mortality of the disease. In addition, hematoma recurrence is documented in as much as 20% of patients after evacuation, with an incomplete understanding of the contributing factors and thus warranting further advances in our understanding of SDH formation and treatment strategies.1,23

For nontraumatic SDH, several factors, such as patient age, presence of cortical atrophy, and mechanism of injury, play a role in determining acute, subacute, or chronic presentations.10 Elderly patients often suffer from minor trauma (for example, falls) that is often unrecognized and may result in a more insidious onset of symptoms.3 With the aging population, the prevalence of nontraumatic SDH has increased over the past decade and is expected to increase.8 Nonetheless, SDH remains an understudied entity, and few advances in its treatment have been made.30 Comprehensive data for nontraumatic SDH are especially lacking. In the present study, we aimed to determine which factors were associated with in-hospital mortality among patients with nontraumatic SDH who had been admitted to a large sample of hospitals in the US.
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Methods

Patient Population

Using the NIS, we reviewed nationwide hospitalizations for adults (age > 18 years) in whom nontraumatic SDH had been diagnosed between 2007 and 2009. The NIS, a prospectively collected set of databases, is the largest all-payer inpatient care database containing data from admissions at 1050 hospitals in 44 states in the US, approximating a 20% stratified sample of US hospitals (http://www.hcup-us.ahrq.gov/nisoverview.jsp). The NIS database provides demographic information, primary and secondary diagnoses, and procedures—all provided through ICD-9-CM codes and discharge dispositions. Hospitalizations for SDH (as a primary diagnosis) were identified using the ICD-9-CM code 432.1 (nontraumatic SDH).

Data Collection

Collected demographic variables included patient age, sex, race (categorized as white, black, Hispanic, Asian, Pacific Islander, and other/unknown in the NIS), and insurance payer information. Comorbidities, diagnoses, and treatments were abstracted based on diagnosis codes, procedure codes, or V codes as available. Comorbidities referred to hypertension, congestive heart failure, diabetes mellitus, coagulopathy, liver disease, valvular disease, renal failure, use of antiplatelets or anticoagulants, and whether mechanical ventilation had been used within the first 4 days of admission. Hospitalizations were further characterized by admission type (emergency, urgent, or elective admission, trauma center admission, or other), hospital characteristics (urban vs rural location; teaching status), and admission day (that is, weekday or weekend admission). Surgical interventions associated with treatment for acute SDH (incision and excision of CNS, Clinical Classifications Software, Procedure Code 1) were recorded. Repeat evacuations (if more than 1 procedure was listed as occurring on subsequent days following admission) as well as the time to procedure were noted.

Outcome Variables

The primary outcome measure was in-hospital death. Mortality data and duration of stay were abstracted directly from the NIS.

Statistical Analysis

We assessed associations between independent risk factors and in-hospital death using bivariate analyses. For categorical variables, both chi-square analysis and Fisher exact test were applied as appropriate. For continuous variables, the Student t-test was applied. A probability value < 0.05 was regarded as significant. For multivariate analysis, a GEE model of logistic regression was used to account for the hospital clustering effect. All variables significant at p < 0.05 in a univariate analysis were included in the multivariate model. To determine the effect of surgical evacuation in different age groups, we assessed the odds ratio for mortality associated with surgical evacuation in separate multivariate GEE models for the following age groups (in years): 18–59, 60–69, 70–79, and > 80. Odds ratios and 95% confidence intervals for multivariate analyses are reported as well. Statistical analysis was performed with IBM SPSS software, version 19.0 (IBM SPSS Inc.).

Results

Between 2007 and 2009, 14,093 patients, ages ≥ 18 years, were hospitalized with nontraumatic SDH nationwide. The mean age was 71.4 ± 14.8 years (mean ± standard deviation); 62% of the patients were male; 68% were white; 69.1% were admitted emergently; and 22.2% (3130 patients) were admitted on the weekend. Table 1 provides an overview of demographics and characteristics in patients overall and between those who did and those who did not die in the hospital. Overall, 11.8% (1664) of patients died during hospitalization. For weekday admissions, the mortality rate was 11.2% versus 13.9% on weekends (p < 0.001).

Among all admitted patients, 51.4% underwent surgical evacuation of the SDH, and 7.4% required repeat evacuation during the hospitalization (16.8% of the patients undergoing surgical evacuation). Most patients were treated with evacuation on the day of admission (Day 0) or on Day 1 of admission (Fig. 1). The mean time to evacuation was 1.23 days for patients with a weekday admission and 1.32 days for patients with a weekend admission (p = 0.180). A surgical evacuation performed the same day the patient was admitted occurred less often for weekend admissions than for weekday admissions (43.2% vs 46.8%, p < 0.023).

In multivariate analyses, patient age (adjusted OR 1.02 per year, 95% CI 1.012–1.022), congestive heart failure (adjusted OR 1.42, 95% CI 1.19–1.71), warfarin use (adjusted OR 1.41, 95% CI 1.17–1.70), coagulopathy (adjusted OR 2.14, 95% CI 1.75–2.61), mechanical ventilation (adjusted OR 16.85, 95% CI 14.29–19.86), and weekend admission (adjusted OR 1.19, 95% CI 1.02–1.38) were independent predictors of in-hospital mortality. Race (adjusted ORs 0.65 and 0.78, 95% CIs 0.51–0.83 and 0.63–0.96 for Hispanic and black, respectively), urban hospital location (adjusted OR 0.69, 95% CI 0.54–0.89), and surgical SDH evacuation (adjusted OR 0.52, 95% CI 0.45–0.60) were strong independent predictors for decreased mortality (Table 2). The observed benefit for surgical evacuation was higher in older patients (Table 3).

Discussion

In this study, we identified factors associated with in-hospital mortality in patients hospitalized with nontraumatic SDH. Among these factors, 2 stand out, as they are potentially modifiable factors: weekend effect and treatment with surgical evacuation.

We found that admission with nontraumatic SDH during the weekend carried a 19% higher risk of in-hospital mortality than a weekday admission. A weekend effect with a similar (20%) increased risk of death for weekend admissions was recently described for pulmonary embolism, with the authors suggesting that delayed access to interventional procedures during off hours might be a contributing factor. Furthermore, a weekend effect has recently been documented for the admission treatment.
of patients requiring surgery for metastatic spine disease; that is, patients admitted during weekends were less likely to receive early intervention, although there was no difference in in-hospital mortality. Similarly, a weekend effect was found for urgent surgery in patients with diverticulitis, pointing out the problem of the influence of available surgical expertise on outcomes for a common disease. Lack of access to specialized care was also proposed as a factor contributing to significantly higher 90-day mortality in stroke patients admitted to non–stroke center hospitals during weekends. Similarly, off hour deliveries were associated with increased perinatal mortality, especially when involving specific emergency delivery procedures. While only a slight delay in the time to craniotomy was noted, our data raise the question of whether patients admitted during the weekend are less likely to be treated with, or have delays in, surgical evacuation as compared with patients admitted during the week. A difference in the timeliness of diagnosis and treatment between weekday and weekend admissions, as well as between the presence or absence of subspecialty staff, might play another role. Furthermore, hospital staffing in general, usually with fewer ancillary support staff, may contribute to a higher number of adverse outcomes. Our findings indicating lower in-hospital mortality when patients are admitted to an urban, as opposed to a rural, hospital concord with the fact that rural hospitals are less often staffed with subspecialty personnel. Additionally, the association of an urban hospital location with a lower risk of in-hospital mortality could be related to provider volume, subspecialty training, and experience of the medical personnel; hospitals with a low volume of surgeries have been shown to have worse outcomes than those with a high volume of surgeries. The month of admission, which has been found to have an impact on outcomes in spine surgery, did not affect mortality in our study.

### TABLE 1: Summary of demographics, characteristics, and treatment in 14,093 patients with nontraumatic SDH*

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. (%)</th>
<th>In-Hospital Death</th>
<th>In-Hospital Survival</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>age in yrs</td>
<td>71.4 ± 14.8</td>
<td>74.42</td>
<td>70.98</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>male sex</td>
<td>8,729 (62.0)</td>
<td>55.3%</td>
<td>62.9%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>race†</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>white</td>
<td>7,635 (68.4)</td>
<td>73.6%</td>
<td>67.7%</td>
<td></td>
</tr>
<tr>
<td>black</td>
<td>1,418 (12.7)</td>
<td>10.6%</td>
<td>13.0%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1,071 (9.6)</td>
<td>7.1%</td>
<td>9.9%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>other</td>
<td>1,032 (9.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>comorbidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>congestive heart failure</td>
<td>1,711 (12.1)</td>
<td>17.9%</td>
<td>11.2%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>hypertension</td>
<td>9,168 (65.1)</td>
<td>60.9%</td>
<td>65.6%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>diabetes, uncomplicated</td>
<td>3,072 (21.8)</td>
<td>22.9%</td>
<td>21.7%</td>
<td>0.255</td>
</tr>
<tr>
<td>liver disease</td>
<td>364 (2.6)</td>
<td>3.9%</td>
<td>2.4%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>renal failure</td>
<td>1,207 (12.0)</td>
<td>17.2%</td>
<td>11.3%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>valvular disease</td>
<td>1,034 (7.3)</td>
<td>8.8%</td>
<td>7.1%</td>
<td>0.017</td>
</tr>
<tr>
<td>anticoagulation w/ warfarin</td>
<td>1,502 (10.7)</td>
<td>15.7%</td>
<td>10.0%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>antiplatelet treatment</td>
<td>570 (4.0)</td>
<td>3.2%</td>
<td>4.2%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>coagulopathy</td>
<td>1,331 (9.4)</td>
<td>16.5%</td>
<td>8.5%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>admission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>1,170 (8.3)</td>
<td>8.1%</td>
<td>8.5%</td>
<td>0.538</td>
</tr>
<tr>
<td>weekend</td>
<td>3,130 (22.2)</td>
<td>26.1%</td>
<td>21.7%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>insurance: Medicare or HMO</td>
<td>3,597 (25.5)</td>
<td>21.6%</td>
<td>26.1%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>hospital size</td>
<td></td>
<td></td>
<td></td>
<td>0.084</td>
</tr>
<tr>
<td>small</td>
<td>935 (6.7)</td>
<td>8.0%</td>
<td>6.5%</td>
<td></td>
</tr>
<tr>
<td>medium</td>
<td>2,680 (19.2)</td>
<td>18.6%</td>
<td>19.3%</td>
<td></td>
</tr>
<tr>
<td>large</td>
<td>10,325 (74.1)</td>
<td>73.5%</td>
<td>74.1%</td>
<td></td>
</tr>
<tr>
<td>urban hospital location</td>
<td>13,163 (94.4)</td>
<td>92.0%</td>
<td>94.8%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>teaching hospital</td>
<td>8,546 (61.3)</td>
<td>55.8%</td>
<td>62.0%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mechanical ventilation</td>
<td>1,049 (7.4)</td>
<td>38.1%</td>
<td>3.3%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>surgical evacuation</td>
<td>7,243 (51.4)</td>
<td>31.1%</td>
<td>54.1%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>repeat evacuation</td>
<td>1,047 (7.4)</td>
<td>6.3%</td>
<td>7.6%</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* HMO = health maintenance organization.
† Coding missing for 2937 patients.
Our data also indicated that patients treated with surgical evacuation have a dramatically lower risk of in-hospital death (48%) than those who do not undergo surgical evacuation. These results are similar to the findings of Frontera et al.,8 who reported 30% and 20% decreased mortality with bur hole drainage and craniotomy, respectively. Another study including patients with acute SDH and a presentation Glasgow Coma Scale score < 9 also showed that nonoperative management was associated with significantly higher mortality.12 However, a single-center study evaluating elderly patients with a primary diagnosis of SDH revealed that craniotomy carried a 2.6-fold OR for in-hospital mortality.22 The high proportion (42%) of patients older than 80 years of age may have been an important contributor to this surprising result. Another study of patients with acute traumatic SDH showed that craniotomy for those older than 65 years remains controversial, with significant postoperative morbidity, mortality, and adverse outcomes.28 In our study, the observed benefit of surgical evacuation was higher for older patients—probably because in younger patients with nontraumatic SDH, different entities such as hematological disorders play a larger role.

Criteria for patients with acute SDH who can be safely treated conservatively have been proposed,13,32 but there is no Class I evidence about the optimal treatment and its timing, and comprehensive outcome data for conservative versus surgical treatment are lacking. Because imaging data and information on individual clinical decisions are not available in the NIS, we could not assess characteristics that may be associated with the decision for or against surgical treatment (such as size and location of the SDH, and mass effect or midline shift). While our data suggest that mortality after nontraumatic SDH can be lowered with surgical treatment, the lack of well-defined criteria and guidelines for surgical evacuation calls for further research.

Our mortality rate of 11.8% is similar to rates reported for chronic SDH (up to 13%)2,21,29,30 and, as expected, lower than the rates for traumatic SDH. However, a direct comparison of studies is difficult given the different patient populations and SDH subcategories evaluated in the various studies. While our data suggest that more than 1 in 10 patients with nontraumatic SDH do not survive hospitalization, we cannot comment on death occurring after discharge and therefore probably underestimate the intermediate-term and long-term mortality rates in nontraumatic SDH. Interestingly, in our study, Hispanic or black race was an independent predictor for decreased mortality, even after accounting for the effect of hospital location.23,26 A possible explanation could be differences in disease severity and mechanisms of SDH by race, but other unknown residual confounders and interactions may play a larger role. Because of the structure of the NIS, certain factors such as imaging characteristics or neurological status on admission cannot be evaluated, and further studies are required.

The effect of patient age on mortality in the present study is consistent with findings in previous studies indicat-
ing worse outcomes in older patients with brain injury.\textsuperscript{4,24} It is also not surprising that mechanical ventilation is a strong predictor of a poor outcome, as it is a good surrogate for severity of disease. The association between severity of disease and poor outcome has been described in numerous other studies on SDH.\textsuperscript{10,19,24,34,35} Similarly, comorbidities such as cardiac and renal disease and coagulopathy have been associated with worse outcomes as well.\textsuperscript{4,20}

Our study has several limitations. While the NIS offers a large sample size with reliable national representation, it is an administrative database that does not assess certain factors, including several clinical factors that may impact mortality (for example, mechanism of injury or neurological condition on presentation). Moreover, the NIS cannot provide data on imaging findings and physician assessments and thus does not offer information on the decision process for or against surgical treatment. However, ascertaining significant factors from a large representative database such as the NIS may be useful for hypothesis generation for future research. A further limitation of an analysis based on ICD-9 codes is the potential lack of accuracy with which diagnoses are made. However, studies examining ICD-9 code accuracy have demonstrated high predictive values and specificity.\textsuperscript{3,8,10,11} More importantly, the ICD-9 coding system does not allow separation of different acuity grades for SDH, which has an important effect on surgical versus nonsurgical treatment, as therapeutic strategies differ for acute or acute-on-chronic versus subacute or chronic SDH. Despite these limitations to the NIS, this large database allowed comprehensive assessment, whereas most studies on SDH, which are based on single centers, may suffer from selection bias. Lastly, our outcome measures do not include long-term functional or neurological components.

Conclusions

Data in this study revealed important factors associated with in-hospital mortality in patients with nontraumatic SDH. Our findings indicated a national in-hospital mortality rate of 11.8\% for acute nontraumatic SDH. For patients admitted during the weekend, the risk of mortality was considerably higher than for patients admitted during the week. Among those factors associated with an increased or a decreased risk of in-hospital mortality, the weekend effect and treatment with surgical evacuation are potentially modifiable factors, and a better understanding of these factors could improve patient management and decrease mortality.

Disclosure

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

Author contributions to the study and manuscript preparation include the following. Conception and design: Busl. Acquisition of data: both authors. Analysis and interpretation of data: both authors. Drafting the article: Busl. Critically revising the article: both authors. Reviewed submitted version of manuscript: both authors. Approved the final version of the manuscript on behalf of both authors: Busl. Statistical analysis: both authors. Study supervision: Prabhakaran.

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Accepted April 25, 2013.
Please include this information when citing this paper: published online June 7, 2013; DOI: 10.3171/2013.4.JNS122236.
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