Predictors of outcome in civilian gunshot wounds to the head

Clinical article

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Object. Civilian gunshot wounds to the head (GSWH) are often deadly, but some patients with open cranial wounds need medical and surgical management and are potentially good candidates for acceptable functional recovery. The authors analyzed predictors of favorable clinical outcome (Glasgow Outcome Scale scores of 4 and 5) after GSWH over a 24-month period.

Methods. The authors posited 2 questions: First, what percentage of civilians with GSWH died in the state of Maryland in a given period of time? Second, what were the predictors of favorable outcome after GSWH? The authors examined demographic, clinical, imaging, and acute care data for 786 civilians who sustained GSWH. Univariate and logistic regression analyses were used to analyze the data.

Results. Of the 786 patients in this series, 712 (91%) died and 74 (9%) completed acute care in 9 trauma centers. Of the 69 patients admitted to one Maryland center, 46 (67%) eventually died. In 48 patients who were resuscitated, the Injury Severity Score was 26.2, Glasgow Coma Scale (GCS) score was 7.8, and an abnormal pupillary response (APR) to light was present in 41% of patients. Computed tomography indicated midline shift in 17%, obliteration of basal cisterns in 41.3%, intracranial hematomas in 34.8%, and intraventricular hemorrhage in 49% of cases. When analyzed for trajectory, 57.5% of bullet slugs crossed midcoronal, midsagittal, or both planes. Two subsets of admissions were studied: 27 patients (65%) who had poor outcome (25 patients who died and 2 who had severe disability) and 15 patients (35%) who had a favorable outcome when followed for a mean period of 40.6 months. Six patients were lost to follow-up.

Univariate analysis indicated that admission GCS score (p < 0.001), missile trajectory (p < 0.001), surgery (p < 0.001), APR to light (p = 0.002), patency of basal cisterns (p = 0.01), age (p = 0.01), and intraventricular bleed (p = 0.03) had a significant relationship to outcome. Multivariable logistic regression analysis indicated that GCS score and patency of the basal cistern were significant determinants of outcome. Exclusion of GCS score from the regression models indicated missile trajectory and APR to light were significant in determining outcome.

Conclusions. Admission GCS score, trajectory of the missile track, APR to light, and patency of basal cisterns were significant determinants of outcome in civilian GSWH.

(key words) • trauma • gunshot wound • traumatic brain injury • penetrating brain injury • Glasgow Outcome Scale • decompressive craniectomy

M ore than 30 years ago, Hernesniemi wrote that in the management of civilian gunshot wounds to the head (GSWH) neurosurgeons come across only the tip of the iceberg.21 Up to 71% of patients with civilian GSWH die at the scene of accident.16,30,32,30,52,58 Fewer than half of the civilians admitted to trauma centers alive and who survive benefit from neurosurgical care involving debridement, structural repair, and decompressive craniectomy.11,21,26,27 There is emerging evidence from Operation Iraqi Freedom and from reports on civilian GSWH that uncontrollable intracranial hyperten-
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...ision resulting from primary and secondary blast injuries and diffuse brain swelling may be amenable to ultrafast decompressive craniectomy (Rosenfeld JV, personal correspondence, 2007). There is further evidence that vascular injuries may be responsive to endovascular therapy. A limited number of retrospective and prospective studies indicate that patients with GSWH who make it through acute care management have better Glasgow Coma Scale (GCS) scores and their injuries are more lobar without involvement of the central gray structures dubbed as zona fatalis. In Graham and colleagues’ prospective studies of 100 patients with civilian GSWH, 59% died, only 8 were severely disabled or remained in a vegetative state, and 33 made good recovery. Zafonte et al. prospectively studied the survivors among 442 patients with GSWH and confirmed that survivors able to participate in an inpatient rehabilitation program had good potential for functional improvement.

We hypothesized that only a significant minority of patients with civilian GSWH in the state of Maryland could benefit from neurosurgical intervention, and we further hypothesized that the majority of those who survived might have a good outcome. We therefore propose that knowing the predictors of good outcome is of utmost importance for neurosurgeons so that they can identify which patients have the best favorable long-term outcome and offer the best possible medical, surgical, and endovascular management, including decompressive craniectomy, at the earliest time possible.

Methods

Null Hypothesis

Nearly half of patients with civilian GSWH have a favorable outcome.

Participants

Participants in this 2-year retrospective study of prospectively collected data were the Office of the Chief Medical Examiner in Baltimore and the following 9 trauma centers in Maryland: 1) Shock Trauma Center, 2) The Sinai Hospital, 3) The Johns Hopkins Hospital, 4) Johns Hopkins Bayview Medical Center in Baltimore, 5) Suburban Hospital in Bethesda, 6) Prince George’s Hospital Center in Cheverly, 7) Peninsula Regional Medical Center in Salisbury, 8) Western Maryland Health System in Cumberland, and 9) Washington County Hospital in Hagerstown.

Specific Aim 1

The first goal of the study was to determine the proportion of patients who died in the state of Maryland as a result of civilian GSWH in a 2-year period.

Specific Aim 2

The second goal of the study was to identify variables predictive of good outcome after civilian GSWH in patients admitted to the Shock Trauma Center (STC).

Inclusion Criteria

Criteria for inclusion in the study were as follows: 1) age 16 years or older; 2) admission to any of the aforementioned 9 trauma centers and being alive at discharge; and 3) being a registered victim whose primary cause of death was civilian GSWH and who underwent autopsy at the state of Maryland Office of the Chief Medical Examiner.

Exclusion Criteria

Criteria for exclusion from the study were as follows: 1) victims of civilian GSWH aged 15 years or younger; 2) military personnel with war injuries; 3) victims whose cause of death was not related to GSWH; and 4) penetrating brain injury not caused by small firearms.

Primary End Point

The primary end point of the study was a Glasgow Outcome Scale (GOS) score with at least 3 months of follow-up. A favorable outcome was indicated by a GOS score of 4 or 5.

This study was approved by the institutional review boards of the University Of Maryland School Of Medicine, the Johns Hopkins Medical institutions, and Prince George’s Hospital Center. Neither local institutional review board nor ethics committee approval was needed to include the de-identified data submitted from the Office of the Chief Medical Examiner and the rest of the Level II and Level III trauma centers in the state of Maryland.

Cohort

Patients Who Died at the Scene of Accident. The Office of the Chief Medical Examiner data registry in Baltimore was searched for patients who died primarily from GSWH during the study period. It is the state law in Maryland that whoever dies at the scene of an accident from GSWH should have an autopsy unless the offending slug to the head is found at the scene of accident. For this reason, the numbers in Table 1 may not be entirely representative of all those who died of GSWH in the state of Maryland.

Scene Resuscitation and Evacuation. Field resuscitation was performed by emergency medical technicians of the Maryland Institute for Emergency Medical Services Systems, in accordance with the guidelines for Management and Prognosis of Penetrating Brain Injury recommended by AANS/CNS.

Emergency Department Resuscitation. All patients admitted to the 9 Level I–III trauma centers in the state of Maryland had uniform emergency department resuscitation and primary and secondary surveys as recommended by the AANS/CNS guidelines for Management and Prognosis of Penetrating Brain Injury.

Imaging Studies. When hemodynamically stable, patients underwent head CT to establish definition of where the bullet entered, involvement of the air sinuses, trajectory of the bullet, presence of retained bone and metal...
fragments, presence of intracranial and intraventricular hematomas, and the exit wound in the case of perforating injuries. The degree of shift of the midline structures and the obliteration of the basal cisterns were also defined by CT scans of the head. Both CT angiography and conventional angiography were performed in patients in whom there were risk factors for a traumatic aneurysm.2

**Maximum Medical Management.** Critical care management was initiated as soon as the patient was in stable condition, and this included intracranial pressure monitoring in 15 patients (placement of a parenchymal sensor in 2 and/or intraventricular cannula in 13) and osmotherapy to maintain the intracranial pressure below 20 mm Hg. To keep the intracranial pressure at that level, 5 patients required decompressive craniectomy.4

**Surgical Intervention.** We followed the AANS/CNS-mandated guidelines when surgery was contemplated in the management of GSWH.3 Surgical intervention was part of the management in 28 (58%) of 48 resuscitated patients. Operative intervention was simple wound debridement and closure of skin in 9 patients (19%) and craniotomy or decompressive craniectomy in 19 (40%).4,11,36,47 Indications for decompressive craniectomy in 5 patients (10%) were preoperative and intraoperative brain swelling in 3 patients (preemptive decompressive craniectomy) or intractable intracranial hypertension following primary debridement not responsive to maximum medical management in 2 patients (secondary decompressive craniectomy). Maximum medical management included sedation, short-term paralytics, placement of an intraventricular cannula for external ventricular drainage, and osmotherapy.4,11,36,47

**Acute and Rehabilitative Care Management.** Critical, intermediate, and rehabilitative care of patients with civilian GSWH followed the AANS/CNS guidelines.3

**Statistical Analysis**

Continuous variables are presented as the mean ± SD for normally distributed data. For continuous variables that were not normal, medians and IQRs (that is, the 25th–75th percentile) are reported. Comparisons of continuous variables between subjects with poor outcome (GOS score < 4) and those with good outcome (GOS = 4 or 5) were made using the Student t-test for normally distributed variables and using the Wilcoxon’s rank-sum test for nonnormal data. Categorical variables were compared between groups using the Wald chi-square test or the Fisher’s exact test for contingency tables containing cells with small numbers. A p value less than 0.05 was suggestive of statistical significance.

As an exploratory method to analyze relationships between possible risk factors for outcome, individual logistic regression models were constructed to determine univariate predictors of favorable outcome in terms of odds ratios and their 95% confidence intervals.

Statistically significant variables (p < 0.05 or 95% confidence interval of the odds ratios does not include 1.00) were analyzed for inclusion in multivariable logistic regression models for prediction of a favorable outcome. With many independent variables available for analysis but few patients and events (that is, GOS score of 4 or 5) in the cohort, correlations between variables were computed and evaluated to reduce the number of covariates

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**TABLE 1: Approximate number of patients who sustained GSWH in the state of Maryland stratified by trauma center and acute care outcome**

<table>
<thead>
<tr>
<th>Institution or Factor</th>
<th>Inpatient Mortality Rate (%)†</th>
<th>Survived Acute Care &amp; Discharge (%)‡</th>
<th>Sum GSWH (% of Maryland total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STC, University of Maryland</td>
<td>46 (66.7)</td>
<td>23 (33.3)</td>
<td>69 (9)</td>
</tr>
<tr>
<td>Prince George’s Hospital Center, Cheverly</td>
<td>25 (54.3)</td>
<td>21 (45.7)</td>
<td>46 (6)</td>
</tr>
<tr>
<td>Johns Hopkins Medical institutions§</td>
<td>25 (62.5)</td>
<td>15 (37.5)¶</td>
<td>40 (5)</td>
</tr>
<tr>
<td>Sinai Hospital of Baltimore, Baltimore City</td>
<td>8 (44.4)</td>
<td>10 (55.6)</td>
<td>18 (2)</td>
</tr>
<tr>
<td>Washington County Hospital, Hagerstown</td>
<td>5 (62.5)</td>
<td>3 (37.5)</td>
<td>8 (1)</td>
</tr>
<tr>
<td>Peninsula Regional Medical Center, Salisbury</td>
<td>6 (85.7)</td>
<td>1 (14.3)</td>
<td>7 (0.9)</td>
</tr>
<tr>
<td>Suburban Hospital, Bethesda</td>
<td>2 (66.7)</td>
<td>1 (43.3)</td>
<td>3 (0.4)</td>
</tr>
<tr>
<td>Western Maryland Health System, Memorial Campus</td>
<td>1 (100)</td>
<td>0</td>
<td>1 (0.1)</td>
</tr>
</tbody>
</table>

| Overall | 118 (61.5) | 74 (38.5) | 192 (24.4) |
| Overall GSWH in the state of Maryland | — | — | 786 (100) |

* From February 1, 2000, to January 31, 2002.
† The value represents the number (%) of patients who died in the respective trauma center.
‡ The value represents the number (%) of patients who survived acute care and were discharged from the respective trauma center.
§ The Johns Hopkins Hospital and the Bayview Medical Center.
¶ One patient’s disposition unknown.
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for inclusion in a multivariate model in an effort to avoid multicollinearity and model overfit, yet still allow for replicability and validity. The remaining variables with a p value less than 0.10 were selected for inclusion in the regression models; those with a p value less than 0.05, following adjustment by covariates, were considered to be statistically significant. Median unbiased estimates of odds ratios were reported for predictor variables having unbounded right-sided confidence intervals (that is, infinity) due to small cell samples.5

Results

From February 1, 2000, to January 31, 2002, 786 individuals were civilian victims of GSWH in the state of Maryland; of these, 594 died at the scene of accident and 192 were triaged to 9 trauma centers (Table 1).

Demographics

The mean age of 713 of the 786 patients with GSWH was 38.2 ± 18 years (age was not recorded for 73 patients). Race was identified for 716 patients: 360 (50.3%) were white; 339 (47.3%) were African American; and 17 (2.4%) were other races. The mean age of 68 of 69 patients admitted to the STC was 33.9 ± 15 years (range 16–85 years). Information about age was not available for 1 patient. In the same group of patients, 84.1% (58 of 69) were male.

Imaging Studies

Detailed information was not available about the imaging studies for those who underwent autopsy at the Office of the Chief Medical Examiner or those who were admitted to any trauma center other than the STC. The site of penetration was parietal in 17 patients, frontal and occipitotemporal each in 9 cases, facio-orbito-cranio-ce-rebral in 7, and frontoparietal in 5. The site of penetration was not available in 1 patient. The mode of injury was penetrating (that is, fragment entered the brain through soft tissues of the posterior fossa in 3 patients, face in 2, and supratentorial calvaria in 7, and frontoparietal in 5. The site of penetration was not available in 1 patient. The mode of injury was penetrating (that is, fragment entered the cranium but did not leave it [Fig. 1C]) in 23 patients, perforating (that is, the bullet went through the cranium [Fig. 1D]) in 16, tangential (that is, the bullet bounced off the cranium) in 7, and indirect in 1 patient. Computed tomography indicated that only 17% of patients had more than a 5-mm shift of the midline structures, and obliteration of basal cisterns was noted in 41%. The incidence of intraventricular (Fig. 1B), track (Fig. 1A), intracerebral, subdural, and epidural hematomas was 49%, 26%, 4%, 2%, and 0%, respectively. Subarachnoid hemorrhage was seen in 59% of victims. The trajectory of the projectile transgressed the x, y, and z planes in 58% of the patients (Fig. 1).

Clinical Characteristics

In the 48 patients who were resuscitated at the STC, the mean Injury Severity Score (ISS) was 26.2 ± 9.4, abnormal pupillary response (APR) to light was seen in 41%, and the mean GCS score was 7.8 ± 4.8. Postresuscitation GCS scores were 3–5 in 20 patients, 6–8 in 8, 9–12 in 4, and 13–15 in 13 patients. The GCS score was not known in 3 patients. The baseline GCS score was determined after reversal of all the neuromuscular blocking agents such as vecuronium and when the sedating and hypnotic effects of propofol or short-acting benzodiazepines such as midazolam had completely disappeared.

Neurosurgical Intervention

Superficial Wound Care. In 9 patients (mean age 37 years, all male), operative intervention was limited to wound care and a short-term course (3–5 days) of antibiotics and no craniotomy. Among these, small fragments entered the brain through soft tissues of the posterior fossa in 3 patients, face in 2, and supratentorial calvaria in 4. Of the 9 patients, 4 were lost to follow-up, 3 died, and 2 made a good recovery at a mean of 65 months after trauma.

Craniotomy. Fifteen patients underwent craniotomy and debridement of skin, skull, dura, and brain in association with removal of easily accessible retained bone

![Fig. 1](image-url). Axial CT scans obtained at the level of injury in 4 different victims of GSWH who did not survive their injuries. The scans demonstrate the projectile traversing multiple lobes (A), crossing the sagittal (Z) plane (B), coronal (X) plane (C), and both sagittal and coronal planes (D) of intracranial structures. Track (A, B, and D) and intraventricular (B and D) hematomas indicate vascular injuries.
and metal fragments. In these patients watertight closure of the dura and the scalp was performed and postoperative antibiotics were administered. Complications in this group of patients included 1 CSF rhinorrhea that was managed by re-exploration and repair of base dura and 1 frontal epidural and subdural empyema that needed wound wash out.

Decompressive Craniectomy. Five (10%) of 48 resuscitated patients (3 males), whose mean age was 23 years, underwent either preemptive (3 patients) or secondary (2 patients) decompressive craniectomy when maximum medical management failed to keep intracranial pressure below 20 mm Hg. Decompressive craniectomy was frontal-toparietotemporal in 3, frontal in 1, and occipital in 1. These patients were followed for a mean of 49 months (range 3–136 months). The GOS score was favorable in 3 patients, but 2 patients had severe disability.

Outcome

The numbers of patients admitted to each of the 9 trauma centers and their outcomes are summarized in Table 1. Of 192 patients transported from the scene of the accident, 118 (61.5%) were dead on arrival to the facility or died during critical care and neurosurgical management at 1 of the 9 trauma centers; 74 (38.5%) survived acute care and were discharged to have traumatic brain injury (TBI) rehabilitation. Thirty of 74 patients (40.5%) underwent neurosurgical management. Overall, 712 (91%) of the 786 patients in this series eventually died. Of the 69 patients who were admitted to the STC, 46 (66.7%) died; 21 were dead on arrival; and 25 died during their acute care. Of the 23 patients discharged, 6 were lost to follow-up and 17 had a follow-up of at least 3 months (mean 40.6, range 3–136 months). Among 20 patients who were admitted to the STC with a GCS score of 3–5, 19 died (95%) and 1 was severely disabled 4 months after discharge. Among 8 patients with GCS score of 6–8, 1 died, 1 was severely disabled, and 3 had mild to moderate disability. In this group of patients, 2 patients were lost to follow-up. All of the 4 patients with admission GCS scores of 9–12 had a GOS score of 4. Among 13 patients with a postresuscitation GCS score of 13–15, 2 died, 4 were lost to follow-up, and 7 had a GOS score of 4. Two of 3 patients with an unknown admission GCS score died, and 1 had a mild disability at 60 months of follow-up. Follow-up GOS scores were available for all 42 patients analyzed in this report. Fifteen (35.7%) of these 42 patients had a GOS score of 4, 2 (4.8%) had a GOS score of 3, and the remaining 25 (59.5%) had a GOS score of 1. The mortality trend at the STC has remained fairly stable during the past 10 years. From 2003 to 2012, there were 578 patients admitted to the STC of whom 351 died, a mortality rate of 61% during acute care hospitalization.

Statistical Analysis

Univariate analysis of 11 independent variables of interest (Table 2) indicated that admission GCS score (p < 0.001); transgression of x, y, and z planes (p < 0.001); surgical intervention (p < 0.001); an APR to light (p = 0.002); age (p < 0.01); obliteration of basal cisterns (p = 0.01); and intraventricular hematoma (p = 0.03) were predictors of outcome. Intracranial hemorrhage was marginally significantly associated with outcome (p = 0.08). Sex, ISS, and > 5-mm shift of the midline structures did not predict outcome.

All 15 patients with a GOS score of 4 underwent surgery, whereas only 32% of those with GOS score of less than 4 underwent surgery, yielding an unbounded confidence interval for the odds ratio of surgical intervention (Table 2). Surgery was also significantly less likely to be performed in individuals with the following: a) GCS score of 3–8 rather than a GCS score of 9–15 (27% vs 100%, respectively), b) an APR to light rather than a normal pupillary reaction (11% vs 90%, respectively), c) intraventricular hematoma rather than its absence (19% vs 90%, respectively), and d) x, y, and z transgression rather than no transgression (24% vs 94%, respectively). Therefore, due to such high correlations, surgery was not selected for inclusion in the final regression model. Similarly, subjects with a GCS score of 3–8 were highly likely to have an APR to light (68%), intraventricular hematoma (72%), and transgression of the x, y, and z planes (85%). Thus, we decided to construct 4 regression models, each containing the 3 variables that were significant (p < 0.10) in the univariate analysis: age, obliteration of basal cisterns, and intracranial hemorrhage. The fourth variable in each model was rotated between each of 4 highly associated clinical and imaging variables (GCS score 9–15, normal pupillary reaction to light, no intraventricular hematoma, and little transgression of the x, y, and z planes) (Table 3).

For the logistic regression model containing GCS score, only GCS score (p = 0.002) was highly predictive of a favorable outcome, with an odds ratio of 16.18 for a GCS score of 9–15 relative to a GCS score of 3–8; the presence of open basal cisterns was a borderline predictor (p = 0.055). When GCS score was excluded from the regression models, normal pupillary reaction to light and lack of transgression of x, y, and z planes were statistically predictor of favorable outcome, as GCS
score was highly associated with those 2 factors. Among patients with a poor outcome (GOS score < 4), 100% of those with an APR to light and 94% of those with a bullet transgressing the x, y, and z planes had a GCS score between 3 and 8 (Table 2).

**Discussion**

One fundamental unresolved question perplexes every neurosurgeon confronting patients with GSWH: How well can these patient be managed to achieve the most favorable functional outcome?5,7,12,19,22,36,40 Evidence has indicated that a limited number of postresuscitation variables play a major role in favorable functional outcome of victims of GSWH.5,7,19,20,22,30,38,40,49,57 Univariate analysis (Table 2) in several published series, including ours, indicated that younger patients, those who have a better level of consciousness and pupillary reaction to light, and those who have less structural destruction of the brain parenchyma do better functionally over the long term.5,7,22,38,44,49

Among the clinical variables, postresuscitation GCS score seems to be the strongest variable predicting mortality and favorable outcome.5,7,12,14,17,19,22,28,29,35,36,38,49,58 When we analyzed the variables in multiple regression models, a GCS score greater than 8 was the most important predictor of favorable outcome (Table 3). When GCS score was excluded from the regression model, APR to light reached statistical significance (Table 3). The significance of APR to light differs in various reports.20,24,29,53,54

Besides GCS score and APR to light, several imaging findings on CT scan at the time of admission were important in univariate analysis, including the trajectory of the slug, obliteration of basal cisterns, and intraventricular hematoma. However, in regression analysis, trajectory of the bullet in crossing the x, y, and z planes was more significant than the other 2 variables. The predictive value in risk analysis of transventricular and transhemispheric missile injuries has been reported before.14,20,30,31,34,48,49,53

The emerging concept of damage control by preemptive decompressive craniectomy in patients with penetrating blast injuries encountered in Operation Iraqi Freedom supports the notion that, in a minority of patients with GSWH, the degree of swelling may not be alleviated by focal debridement and maximum medical management.
This was true in the 5 patients (10%) in our series who underwent decompressive craniectomy to control intractable intracranial hypertension resistant to maximum medical management or to reverse significant midline shift or impending brainstem compression. Long-term outcome was a GOS score of 4 in 3 patients and a GOS score of 3 in 2 of them.

The current literature and the findings in this study suggest there is an overwhelming chance of death following civilian GSWH. A surprising finding is the survival of a minority of patients with an acceptable postresuscitation GCS score (6–15) and the prospects of good functional outcome. The odds of a functional survival are even greater if the bullet does not cross the coronal or sagittal planes, and there is no APR to light and the basal cisterns are shown to be open on CT.

Neurosurgeons should remember that civilian GSWH are open wounds, and, depending on the type of injury, one has to tailor the surgical approach accordingly. First, it is important to keep in mind that entrance of small pellets into the brain through a small entrance wound does not need extensive surgical intervention other than local wound care, antibiotic administration, and appropriate skin closure. Second, significant local injuries with no evidence of intracranial hypertension, midline shift, or obliteration of basal cisterns need craniotomy, superficial debridement, and watertight closure of the dura and scalp. Third, more extensive injuries associated with regional swelling, shift of the midline structures, and obliteration of basal cisterns require intracranial pressure monitoring, debridement, maximum medical management, and, if there is evidence of intractable intracranial hypertension, decompressive craniectomy.

There are several key limitations to this study. One is that we were unable to obtain detailed follow-up of the discharged patients from trauma centers other than STC. Another is that several key variables important in closed head injury, such as intracranial hematomas and midline shift, were not among the significant statistical variables. The reason for this might be the low overall number of patients who survived. We also recognize that inclusion of a large number of variables within a small cohort can negatively affect the statistical evaluation in a regression model, inducing large odds ratios and wide confidence intervals. Thus, the number of variables selected for model inclusion had to be limited. Finally, death due to GSWH is so common there is a small number of patients for whom one can evaluate intervention.

Conclusions
In the current investigation only 9% of 786 patients with GSWH survived their injury and were discharged from 9 trauma centers after receiving acute care management. A postresuscitation GCS score greater than 8 was highly predictive of favorable outcome. When GCS score was excluded from our models, an APR to light, obliteration of basal cisterns, and trajectory of the projectile inside the cranium were major predictors of outcome.

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