Penetrating brain injury carries a high lethality and an uncertain recovery. While it has been suggested that withholding treatment in the setting of a GCS of 3-5 leads to improved resource utilization, aggressive hemostatic resuscitation has recently been associated with improved outcomes and increased organ donation. Determining which patients might benefit from this aggressive resuscitation will continue to refine the management of these devastating injuries. An immediate question is whether or not patients with penetrating brain injuries undergoing cardiopulmonary resuscitation (CPR) during their trauma resuscitation have the potential for either recovery or organ donation. This question has been answered in penetrating torso trauma, with evidence-based recommendations being available to guide resuscitative thoracotomy.

In a five-year retrospective analysis at our center, we identified 13 patients who had gunshot wounds to the brain and had CPR during their initial resuscitation. In spite of aggressive hemostatic resuscitation, none of these patients survived to discharge or organ donation. Based on this, we have proposed an algorithm that recommends cessation of resuscitative efforts in patients with isolated gunshot wound to the brain who undergo field or trauma bay CPR. That said, we recognize the perils of implementing such a practice without a greater number of patients to support this incomplete experience. An additional caveat is that resuscitative practices differ across centers, and it may be that other centers are incorporating measures that will lead to survival and enhanced organ donation among these critically injured patients. Understanding the limitations of aggressive resuscitation in patients with penetrating brain injury should guide resuscitative efforts in these patients and improve resource utilization. To that end, an evaluation of patients with penetrating brain injury presenting in extremis is warranted.

The primary aim of this study is to evaluate the rate of survival in patients with isolated gunshot wound to the brain requiring CPR at referring hospital, in the field, or in the trauma resuscitation room.

Secondary aims of this study are to:

1. Determine the rate of organ donation in patients with isolated gunshot wounds to the brain requiring CPR at referring hospital, in the field, or in the trauma resuscitation room.
2. Evaluate factors associated with survival in patients with isolated gunshot wounds to the brain requiring CPR at referring hospital, in the field, or in the trauma resuscitation room.
3. Evaluate factors associated with successful organ donation in patients with isolated gunshot wounds to the brain requiring CPR at referring hospital, in the field, or in the trauma resuscitation room.
4. To determine the costs associated with the treatment of patients with isolated gunshot wounds to the brain requiring CPR at referring hospital, in the field, or in the trauma resuscitation room.

Patients will be included if presenting with isolated gunshot wound to the brain and requiring CPR at referring hospital, in the field, or in the trauma resuscitation room. Patients will be included if sustaining associated injuries to the face or neck (dates inclusive of June 1, 2011-December 31, 2017).

Patients will be excluded if they meet any of the following criteria:

1. Significant injuries to the torso or extremities (AIS≥2 for thorax, abdomen, spine, upper or lower extremities, or unspecified)
2. Pregnancy at the time of shooting.

The primary outcome measure will be survival rate, as determined by the number of patients surviving hospitalization divided by the total number of patients presenting with this injury.

Secondary outcomes will be:

1. Organ donation rate in this population, as determined by the number of patients donating at least one organ divided by the number of patients eligible for organ donation less the number of survivors to hospital discharge.

2. Establishment of factors associated with survival to hospital discharge, based on a multivariate logistic regression utilizing collected variables.

3. Establishment of factors associated with successful organ donation among eligible donors, based on a multivariate logistic regression utilizing collected variables.

4. Establishment of factors associated with either survival to hospital discharge or successful organ donation, based on a multivariate logistic regression utilizing collected variables.

5. Determination of costs associated with the treatment of patients with isolated gunshot wound to the brain and requiring CPR in the referring hospital, in the field, or in the trauma resuscitation room.

6. Determination of costs associated with successful survival among patients with isolated gunshot wound to the brain and requiring CPR at referring hospital, in the field, or in the trauma resuscitation room.

7. Determination of costs associated with successful organ donation among patients with isolated gunshot wound to the brain and requiring CPR at referring hospital, in the field, or in the trauma resuscitation room.

Variables:

- Age
- Sex
- Race
- Mechanism (E-code)
- Diagnosis (ICD 9 or 10)
- Transfer to Trauma Center (Y/N)
- Referral Center Cardiac Arrest (Y/N/NA)
- Referral Center PRBC (Units)
- Referral Center Plasma (Units)
- Referral Center Platelet (Units)
- Referral Center Cryoprecipitate (Units)
- Referral Center Crystalloid (Volume in mL)
- Referral Center TXA (Y/N/NA)
- Referral Center Factor VII (Y/N/NA)
- Referral Center PCC (Y/N/NA)
- Prehospital Cardiac Arrest (Y/N/NA)
- Prehospital PRBC (Units)
- Prehospital Plasma (Units)
- Prehospital Crystalloid (Volume in mL)
- Prehospital TXA (Y/N/NA)
- Trauma Center ED Signs of Life (Y/N)
- Admit BD
Admit SBP
Admit HR
Trauma Center Cardiac Arrest (Y/N)
Trauma Center Resus Thoracotomy (Y/N)
Trauma Center REBOA (Y/N)
Trauma Center PRBC (Units)
Trauma Center Plasma (Units)
Trauma Center Platelet (Units)
Trauma Center Cryoprecipitate (Units)
Trauma Center Crystalloid (Volume in mL)
Trauma Center TXA (Y/N)
Trauma Center Factor VII (Y/N)
Trauma Center PCC (Y/N)
Procedures (CPT)
ED Disposition
ISS
AIS Head
T3/T4 Given (Y/N)
Methylprednisolone Given (Y/N)
Vasopressin Given (Y/N)
Insulin Given (Y/N)
LOS
Vent Days
ICU Days
Organ Request (Y/N)
Suitable for organ donation (Y/N)
Organ Consent (Y/N)
Organ Donor (Y/N)
DC Status (Alive/Dead)
DC Disposition (Home, Inpatient Rehab, SNF, LTAC, Acute Care Hospital, Morgue)
Total hospital charges

Data collection and statistical analysis:
Participating sites will obtain the requested data via their trauma registry and medical record review. Data will be recorded onto an Excel spreadsheet at each site and then sent to the coordinating site, where the data will be compiled for analysis. Overall survival and organ donation rates will be calculated as outlined above. Bivariate analysis will be utilized to establish significant relationships between variables measured and the outcomes of survival and organ donation. Significant variables identified on bivariate analysis will be utilized in a multivariate logistic regression to establish factors associated with the outcomes of survival and organ donation. Hospital charges will be considered in total as well as averages or median values (dependent on preliminary assessment of data distribution) for all patients, survivors, and organ donors.

Consent Procedures:
As this study represents no more than minimal risk to subjects and no PHI will be collected, we are seeking waiver of consent.

Risk/Benefit Analysis:
This study is a retrospective analysis of trauma registries and medical records. As such, it is of no more than minimal risk to participants. There would be a small risk of breach of confidentiality during the identification of subjects and medical record review; however, this will be minimized by only allowing study personnel to access records and destroying any identifying links between collected data and PHI identifiers at the earliest possible moment at each participating site. To avoid inadvertent transmission of PHI from participating site to coordinating center, patients with age ≥ 89 years will be recorded as 89. No other potential PHI will be transmitted to the coordinating center. There will be no direct benefit to participants in this study. The potential benefit to future patients with gunshot wounds to the brain undergoing CPR and those who treat them is the establishment of informed guidance on therapies that may enhance survival in these patients. The potential benefit to society is improved resource utilization in the care of trauma patients as well as the provision of evidence for therapies that may improve survival or increase the potential for organ donation.

Data Dictionary:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Patient's Age in Years</td>
</tr>
<tr>
<td>Sex</td>
<td>Patient's Sex (Male, Female, Unknown)</td>
</tr>
<tr>
<td>Race</td>
<td>Patient's Race (White, Black or African American, Native Hawaiian or other Pacific Islander, American Indian or Alaska Native, Asian, Other, Unknown)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Patient's Ethnicity (Hispanic or Latino, Not Hispanic or Latino, Unknown)</td>
</tr>
<tr>
<td>Mechanism</td>
<td>The mechanism of injury E-code</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>The ICD 9 or 10 code(s) corresponding to the patient's injuries</td>
</tr>
<tr>
<td>Transfer to Trauma Center</td>
<td>Was the patient transferred from another hospital? (Yes/No)</td>
</tr>
<tr>
<td>Referral Center Cardiac Arrest</td>
<td>Did the patient arrest at the referring facility (Yes, No, N/A)</td>
</tr>
<tr>
<td>Referral Center PRBC</td>
<td>The nearest whole number of units of packed red blood cells transfused at the referral facility</td>
</tr>
<tr>
<td>Referral Center Plasma</td>
<td>The nearest whole number of units of plasma transfused at the referral facility</td>
</tr>
<tr>
<td>Referral Center Platelet</td>
<td>The nearest whole number of units of platelets</td>
</tr>
<tr>
<td>Referral Center Cryoprecipitate</td>
<td>The nearest whole number of units of cryoprecipitate</td>
</tr>
<tr>
<td>Referral Center Crystalloid</td>
<td>The total volume of crystalloid transfused at the referral facility</td>
</tr>
<tr>
<td>Referral Center TXA</td>
<td>Was TXA given at the referral facility (Yes, No, N/A)?</td>
</tr>
<tr>
<td>Referral Center Factor VII</td>
<td>Was Factor VII given at the referral facility (Yes, No, N/A)?</td>
</tr>
<tr>
<td>Referral Center PCC</td>
<td>Was Prothrombin Complex Concentrate given at the referral facility (Yes, No, N/A)?</td>
</tr>
<tr>
<td>Prehospital Cardiac Arrest</td>
<td>Did the patient arrest in the field (Yes/No)?</td>
</tr>
<tr>
<td>Prehospital PRBC</td>
<td>The nearest whole number of units of packed red blood cells transfused in the field</td>
</tr>
</tbody>
</table>
Prehospital Plasma: The nearest whole number of units of plasma transfused in the field.

Prehospital Platelet: The nearest whole number of platelets transfused in the field.

Prehospital Crystalloid: The total volume of crystalloid transfused in the field, in milliliters.

Prehospital TXA: Was TXA given in the field (Yes, No, N/A)?

Trauma Center ED Signs of Life: Did the patient have signs of life (electrical activity on EKG with or without pulse; evidence of pupillary, corneal, or gag reflexes; GCS >3) on arrival to the trauma center (Yes, No)?

Trauma Center Cardiac Arrest: Did the patient arrest while in the trauma center (Yes, No)?

Trauma Center Resus Thoracotomy: Did the patient undergo resuscitative thoracotomy (Yes, No)?

Trauma Center REBOA: Did the patient undergo REBOA (Yes, No)?

Trauma Center PRBC: The nearest whole number of units of packed red blood cells transfused at the trauma center during initial resuscitation.

Trauma Center Plasma: The nearest whole number of units of plasma transfused at the trauma center during initial resuscitation.

Trauma Center Platelet: The nearest whole number of units of platelets transfused at the trauma center during initial resuscitation.

Trauma Center Cryoprecipitate: The nearest whole number of units of cryoprecipitate transfused at the trauma center during initial resuscitation.

Trauma Center Crystalloid: The total volume of crystalloid transfused in the trauma center, in milliliters.

Trauma Center TXA: Was TXA given in the trauma center (Yes, No)?

Trauma Center Factor VII: Was Factor VII given at the trauma center (Yes, No)?

Trauma Center PCC: Was Prothrombin Complex Concentrate given at the trauma center (Yes, No)?

Procedures: The CPT code(s) corresponding to procedures performed on the patient.

ED Disposition: Where did the patient go after initial resuscitation (OR, Interventional Radiology, ICU, Ward, Morgue, ED Discharge)?

ISS: The patient's injury severity score.

AIS Head: The patient's abbreviated injury scale score for head.

T3/T4 Given: Was triiodothyronine (T3) or thyroxine (T4) given during the patient's care at the trauma center?

Methylprednisolone Given: Was methylprednisolone given during the patient's care at the trauma center?

Vasopressin Given: Was vasopressin given during the patient's care at the trauma center?

Insulin Given: Was insulin given during the patient's care at the trauma center?
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What was the patient's hospital length of stay, in days?</td>
<td></td>
</tr>
<tr>
<td>How many days did the patient spend at least some time on mechanical ventilation?</td>
<td></td>
</tr>
<tr>
<td>Was the patient's surrogate decision maker contacted regarding organ donation (Yes, No)?</td>
<td></td>
</tr>
<tr>
<td>Was the patient a suitable candidate for organ donation (Yes, No)?</td>
<td></td>
</tr>
<tr>
<td>Did the patient's surrogate provide consent for organ donation (Yes, No)?</td>
<td></td>
</tr>
<tr>
<td>Did the patient donate at least one organ (Yes, No)?</td>
<td></td>
</tr>
<tr>
<td>Was the patient Alive or Dead at discharge?</td>
<td></td>
</tr>
<tr>
<td>What was the patient's disposition at the end of their hospital stay (Home, Inpatient Rehabilitation, SNF, LTAC, Acute Care Hospital, Morgue)?</td>
<td></td>
</tr>
<tr>
<td>What were the total hospital charges for the patient's stay at the trauma center?</td>
<td></td>
</tr>
</tbody>
</table>