The American Journal of Surgery 212 (2016) 1101–1105

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.ajconline.org

Southwestern Surgical Congress

Time is the enemy: Mortality in trauma patients with hemorrhage from torso injury occurs long before the "golden hour"

A.Q. Alarhayem [a], J.G. Myers [a], D. Dent [a], L. Liao [a], M. Muir [a], D. Mueller [a], S. Nicholson [a], R. Cestero [a], M.C. Johnson [a], R. Stewart [a], Grant O'Keefe [b], B.J. Eastridge [a, *]

[a] The University of Texas Health Science Center at San Antonio, Department of Surgery, Division of Trauma, Critical Care, and Acute Care Surgery, United States
[b] University of Washington, Department of Surgery, Division of Trauma and Acute Care Surgery, United States

ARTICLE INFO

Article history:
Received 30 March 2016
Accepted 24 August 2016

Keywords:
Prehospital
Time
Injury
Trauma
Abdomen
Survival

ABSTRACT

Introduction: The concept of the "Golden Hour" has been a time-honored tenet of prehospital trauma care, despite a paucity of data to substantiate its validity. Non-compressible torso hemorrhage has been demonstrated to be a significant cause of mortality in both military and civilian settings. We sought to characterize the impact of prehospital time and torso injury severity on survival. Furthermore, we hypothesized that time would be a significant determinant of mortality in patients with higher Abbreviated Injury Scale (AIS) grades of torso injury (AIS $\geq$ 4) and field hypotension (prehospital SBP $\leq$ 110 mmHg) as these injuries are commonly associated with hemorrhage.

Methods: Data for this analysis was generated from a registry of 2,523,394 injured patients entered into the National Trauma Data Bank Research Data Set from 2012 to 2014. Patients with torso injury were identified utilizing Abbreviated Injury Scale (AIS) for body regions 4 (Thorax) and 5 (Abdomen). Specific inclusion criteria for this study included pre-hospital time, prehospital SBP $\leq$110 mmHg, torso injury qualified by AIS and mortality. Patients with non-survivable torso injury (AIS = 6), severe head injuries (AIS $\geq$ 3), no signs of life in the field (SBP = 0), interfacility transfers, or those with any missing data elements were excluded. This classification methodology identified a composite cohort of 42,135 adult patients for analysis.

Results: The overall mortality rate of the study population was 7.9% (3326/42,135); Torso AIS and prehospital time were noted to be strong independent predictors of patient mortality in all population strata of the analysis ($P < 0.05$). The data demonstrated a profound incremental increase in mortality in the early time course after injury associated with torso AIS $\geq$4.

Conclusion: In patients with high-grade torso injury, AIS grades $\geq$4, the degree anatomic disruption is associated with significant hemorrhage. In our study, a precipitous rise in patient mortality was exhibited in this high-grade injury group at prehospital times <30 min. Our data highlight the critical nature of prehospital time in patients with non-compressible torso hemorrhage. However, realizing that evacuation times $\leq$30 min may not be realistic, particularly in rural or austere environments, future efforts should be directed toward the development of therapies to increase the window of survival in the prehospital environment.

1. Background

In 1966, the National Academy of Sciences (NAS) published "Accidental Death and Disability: The Neglected Disease of Modern Society" perceiving injury to be one of the most significant public health problems faced by our nation.[1] At the same point in history, the surgical community was taking note of significant successes in trauma care on the battlefields of Vietnam such as advanced

* Corresponding author. Department of Surgery, Division of Trauma and Emergency Surgery, Jocelyn and Joe Straus Endowed Chair in Trauma Research, University of Texas Health Science Center at San Antonio, University Health System, 7703 Floyd Curl Drive (MC 7740), San Antonio, TX, 78229-3900, United States.
E-mail address: eastridge@uthscsa.edu (B.J. Eastridge).

http://dx.doi.org/10.1016/j.amjsurg.2016.08.018
0002-9610/

resuscitation practices and refined aeromedical evacuation capabilities.[2] The timely coevolution of these historical events generated the impetus to develop formal trauma systems to improve injury care across the nation. One pioneer in the genesis of the early trauma system concepts was Dr. R. Adams Cowley, who conceptualized the notion of the "golden hour ". In defining the emergency medical system for the State of Maryland, Dr. Cowley noted that " the first hour after injury will largely determine a critically injured persons chances for survival," an assertion which focused trauma care providers on the critical importance of time between injury and definitive care.[3–5] Whether driven by his prominence and authority in the field, the need to fill a critical void in trauma system development, to serve as a guiding principle to emergency medical systems providers or just a captivating marketing phrase, the concept of the "golden hour" has become firmly engrained in the lexicon of injury management for the last four decades. During the nascence of trauma systems in the US, achieving the 60-minute window to deliver the patient from point of injury to a hospital capable of managing severe trauma would have been a laudable objective. As trauma centers and systems have matured and become much more sophisticated within the last forty years, several have challenged the validity of the "golden hour" principle.

The development of structured trauma systems both in civilian settings and on the battlefield has been instrumental to decreasing delays in time to definitive care.[6] However, within the same context, the discrete relationship between prehospital time and its impact upon on survival has not been fully developed.[6] In addition, the impact of prehospital time intervals in injured civilians has not been consistently demonstrated, potentially secondary to heterogeneous populations and environments.[7,8,6,9,10] Even with the paucity of substantiating evidence to support the "golden hour", expedited response times continue to be utilized as surrogates for the quality of care provided to trauma patients.[11,12] Likewise, many contemporary EMS agencies have fostered the "scoop and run" paradigm, choosing to minimize time to definitive care while concurrently administering "treatment en route".[13]

Even with the inconsistent evidence to support a true "golden hour", the degree of cultural penetrance remains pervasive and was prominently evidenced by the 2009 mandate by then Secretary of Defense, Robert Gates, which obligated the aeromedical evacuation of critically injured combat casualties to a military treatment facility within 60 min.[14]

Ultimately however, there is little evidence to definitively support a true "golden hour", much less any ubiquitous prehospital time which improves trauma outcomes. However, intuitively, minimizing time to definitive care, particularly in patients with time sensitive pathology, should be effective in the context of survival benefit. The purpose of this study was to examine the mortality outcome association between prehospital time and torso injury severity. We hypothesized that patients with more severe torso injuries, particularly those manifest with non-compressible hemorrhage, that longer prehospital times would be associated with decreased survival.

2. Methods

This was a retrospective study of 2,523,394 patient records derived from the National Trauma Data Bank Research Datasets (NTDB-RDS) 2012 to 2014. The NTDB is compiled annually from participating trauma centers nationwide and is the largest aggregation of U.S. trauma registry data.

Patients with torso injury were identified utilizing Abbreviated Injury Scale (AIS) for body regions 4 (Thorax) and 5 (Abdomen). Torso injury morphology was ascribed utilizing the six digit pre dot AIS code. Injury severity was assessed utilizing the single digit post dot code. Patients with severe head injuries (AIS $\geq$ 3), non-survivable injuries (AIS = 6), no signs of life at the field (EMS SBP = 0), prehospital SBP greater than 110 mm Hg, transfers, or those with missing data elements were excluded. Specific inclusion criteria of pre-hospital time, torso injury and mortality identified a cohort of 42,135 adult patients for analysis.

We categorized prehospital times into 15 min intervals. Additional variables considered in the analysis included age, sex, mechanism of injury, field and emergency department vital signs, Abbreviated Injury Scale Score, and Injury Severity Score.

SPSS software, Version 22 (SPSS, Chicago, IL, USA) was used for all statistical analyses with a p value of <0.05 regarded as significant. Continuous numerical variables were analyzed by a two-sample *t*-test or one-way analysis of variance (one-way ANOVA). Categorical variables were analyzed by the $\chi 2$ test or Fischer's exact test. All numerical data were expressed as the mean $\pm$ standard deviation (SD).

3. Results

The mean age of our sample population was 37.4 years, median ISS was 14, 67.6% of the patients were male, and 73.3% of patients sustained blunt trauma. Motor vehicle collisions (MVC) accounted for 75.6% of blunt injuries, while firearm related injuries accounted for 55.2% of penetrating trauma.

The overall mortality in this analysis was 7.9% (3326/42,135); 7.4% (2371/32,077) with blunt mechanisms, 3.3% (143/4325) with stab wounds, and 14.2% (812/5733) with firearm injuries. Of the 3, 326 fatalities, 1022 (30.7%) of patients expired in the emergency department.

As expected, the risk of death was significantly influenced by the prehospital systolic blood pressure. Overall mortality in patients with mild hypotension (pSBP 90–110 mm Hg) was 5.0% (1364/27,241). The mortality in patients with moderate hypotension (pSBP 61–90 mm Hg) was 12.1% (1521/12,557), and 21.5% (502/2337) in those with severe hypotension (pSBP >0 but $\leq$ 60 mm Hg).

In patients with an Injury Severity Score (ISS) less than or equal to 15, 3.5% died. The mortality rate in patients with an ISS of 15–45 was 11.4%, and 34.2% in those with an ISS >45.

Overall median total prehospital time was 37 min, 40 min for blunt trauma and 28 min for penetrating injury.

The risk of death increased with longer prehospital times, and was most prominent within the first 30 min. The rise in mortality is

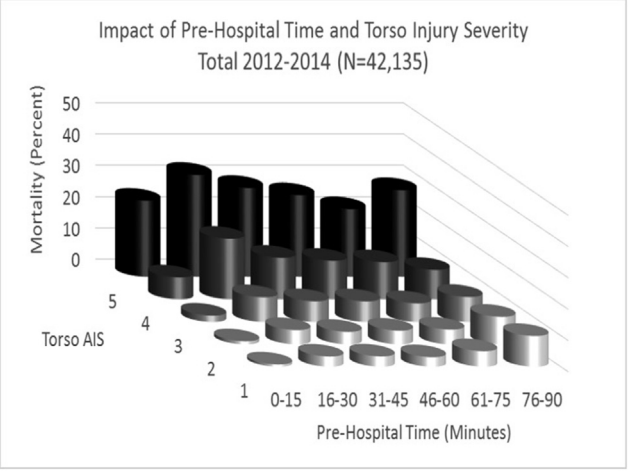

Fig. 1. Mortality Impact of prehospital time and torso injury severity for composite population 2012–2014 (N = 42,135).