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Age-related mortality in blunt traumatic hemorrhagic shock: the killers and the life savers

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ABSTRACT

Background: There are sparse data on the association between age and mortality in hemorrhagic shock (HS). We examined this association in this study.

Materials and methods: The Glue Grant database was analyzed. Patients aged ≥16 y with blunt traumatic HS were stratified into eight age groups (16–24, 25–34, 35–44, 45–54, 55–64, 65–74, 75–84, and ≥85 y) to identify the mortality inflection point. Subsequently, patients were restratified into young age (16–44 y), middle age (45–64 y), and elderly (≥65 y). Multivariate analysis was used to determine predictors of mortality by group.

Results: A total of 1976 patients were included, with mortality of 16%. Mortality by initial age group is as follows: 16–24 (13.0%), 25–34 (11.9%), 35–44 (11.9%), 45–54 (15.6%), 55–64 (15.7%), 65–74 (20.3%), 75–84 (38.2%), and ≥85 y (51.6%), delineating 65 y as the mortality inflection point. Overall, 55% were young, 30% middle age, and 15% elderly. Predictors of mortality in the young include multiple-organ dysfunction score (MODS; odds ratio [OR]: 1.93, confidence interval [CI]: 1.62–2.30), emergency room lactate (OR: 1.14, CI: 1.02–1.27), injury severity score (OR: 1.06, CI: 1.03–1.09), and cardiac arrest (OR: 10.60, CI: 3.05–36.86). Predictors of mortality in the middle age include MODS (OR: 1.38, CI: 1.24–1.53), cardiac arrest (OR: 12.24, CI: 5.38–27.81), craniotomy (OR: 5.62, CI: 1.93–16.37), and thoracotomy (OR: 2.76, CI: 1.28–5.98). In the elderly, predictors of mortality were age (OR: 1.07, CI: 1.02–1.13), MODS (OR: 1.47, CI: 1.26–1.72), laparotomy (OR: 2.04, CI: 1.02–4.08), and cardiac arrest (OR: 11.61, CI: 4.35–30.98). Open fixation of nonfemoral fractures was protective against mortality in all age groups.

Conclusions: In blunt HS, mortality parallels increasing age, with the inflection point at 65 y. MODS and cardiac arrest uniformly predict mortality across all age groups. Craniotomy and thoracotomy are associated with mortality in the middle age, whereas laparotomy is associated with mortality in the elderly.

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1. Introduction

Hemorrhagic shock (HS) is the leading cause of trauma-related deaths in civilian patients surviving to the trauma center, accounting for about 40% of trauma deaths globally [1]. On the battle field, it is the leading cause of death in potentially survivable cases, where it accounts for as much as 80% of these cases [2]. Fluid resuscitation, hemorrhage control, correction of coagulopathy, and rapid transport to the trauma center are key tenets of care for the traumatic HS patient which have been associated with improved outcome [3].

The effect of host factors such as age, gender, and inflammatory response on trauma outcomes has been studied extensively. In spite of this, the exact relationship between age and trauma outcomes is far from settled. Several investigators have documented increasing mortality with age after blunt or penetrating injury. Hollis *et al.* [4] studied 65,743 patients from the database of the United Kingdom Trauma Network and showed that there was an increase in mortality with increasing age at all levels of injury severity. Morris *et al.* [5] examined 199,737 trauma patients in the state of California and showed that mortality in the entire cohort increased starting at the age of 40 y, with the mortality rates becoming higher in the elderly at the age of ≥65 y in patients with minor injuries. They also showed that in patients with moderate injury severity, mortality increased in both the middle age (40–64 y) and elderly groups (≥65 y). They found that the presence of preexisting medical disease or injury to the head or abdomen was related to increased mortality in middle-aged patients at all injury severity levels. In contrast, Bhullar *et al.* [6] studied 539 hemodynamically stable patients with blunt splenic trauma who underwent nonoperative management and concluded that age had no effect on outcomes, the outcome in this case being failure of nonoperative management.

Most studies examining the relationship between trauma outcomes and age seem to reach one conclusion as age increases and mortality increases. The specific factors that predict mortality in different age groups are seldom examined. In traumatic HS in particular, there are very sparse data examining the association between age and mortality. This is important because there is some evidence from preclinical studies showing that animals of different ages have different optimal resuscitation blood pressures after uncontrolled hemorrhage and these resuscitation pressures influence both survival time and 24-h survival rate [7].

Therefore, the need to identify the specific determinants of survival or mortality in different age groups after HS remains valid. We therefore hypothesized that (1) there is a distinct mortality inflection point, that is, the age at which there is a sharp rise in mortality after blunt traumatic HS, and (2) the determinants of survival after blunt traumatic HS vary from one age group to the other. We sought to examine the relationship between age and mortality as well as identify the predictors of mortality in multiple age group cohorts.

2. Materials and methods

2.1. *Study design and patient selection*

This is a retrospective analysis of the Inflammation and the Host Response to Injury trauma relational database (Glue Grant database), a large scale collaborative program that involved multiple level I trauma centers in the United States and established to study the inflammatory changes accompanying trauma and burns. The criteria for patient inclusion in the original database development have been published previously [8]. Briefly, these were patients aged ≥16 y who sustained blunt trauma; were in HS as evidenced by a base deficit ≥6 or systolic blood pressure (SBP) <90 mm Hg within 60 min of emergency room (ER) arrival; were transfused with blood within 12 h of injury; and had no evidence of severe traumatic brain or spinal cord injury, that is, Glasgow coma scale (GCS) ≤8 after intensive care unit (ICU) admission and brain computerized tomography scan abnormality within first 12 h after injury. Patients with anticipated survival of <24 h from injury or anticipate survival <28 d because of a preexisting medication were excluded. In our present study, all patients with complete clinical and laboratory data points were included.

2.2. *Patient stratification*

Patients were initially stratified into eight age groups (16–24 y, 25–34 y, 35–44 y, 45–54 y, 55–64 y, 65–74 y, 75–84 y, and ≥85 y) to identify the mortality inflection point, that is, the age group at which there is a sharp or sudden change in mortality on a curve showing the relationship between mortality and age group. This initial classification into eight age groups (referred to in this study as age group I) was used solely for determination of the mortality inflection point. For subsequent analyses, patients were restratified into young age (16–44 y), middle age (45–64 y), and elderly (≥65 y), using definitions from the US Census Bureau [9]. For clarification purposes, this second stratification into three age groups is referred to as age group II.

2.3. *Data variables and outcome measures*

The variables analyzed include demographics (age, gender, and ethnicity), injury severity score (ISS), preinjury comorbidities, inhospital complications, Marshall's multiple-organ dysfunction score (MODS), ER serum lactate level, volume of resuscitative fluids (crystalloids, colloids, and blood products), and operative interventions. The primary outcome measure was inhospital mortality. Hospital length of stay and ICU length of stay were the secondary outcome measures.

2.4. *Statistical analysis*

Continuous variables were described with summary statistics, whereas proportions were used to describe categorical