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Trends in 1029 trauma deaths at a level 1 trauma center: Impact of a bleeding control bundle of care

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ABSTRACT

Background: Over the last decade the age of trauma patients and injury mortality has increased. At the same time, many centers have implemented multiple interventions focused on improved hemorrhage control, effectively resulting in a bleeding control bundle of care. The objective of our study was to analyze the temporal distribution of trauma-related deaths, the factors that characterize that distribution and how those factors have changed over time at our urban level 1 trauma center.

Methods: Records at an urban Level 1 trauma center were reviewed. Two time periods (2005–2006 and 2012–2013) were included in the analysis. Mortality rates were directly adjusted for age, gender and mechanism of injury. The Mann-Whitney and chi square tests were used to compare variables between periods, with significance set at 0.05.

Results: 7080 patients (498 deaths) were examined in 2005–2006, while 8767 patients (531 deaths) were reviewed in 2012–2013. The median age increased 6 years, with a similar increase in those who died. In patients that died, no differences by gender, race or ethnicity were observed. Fall-related deaths are now the leading cause of death. Traumatic brain injury (TBI) and hemorrhage accounted for >91% of all deaths. TBI (61%) and multiple organ failure or sepsis (6.2%) deaths were unchanged, while deaths associated with hemorrhage decreased from 36% to 25% ($p < 0.01$). Across time periods, 26% of all deaths occurred within one hour of hospital arrival, while 59% occurred within 24 h. Unadjusted mortality dropped from 7.0% to 6.1 ($p = 0.01$) and in-hospital mortality dropped from 6.0% to 5.0% ($p < 0.01$). Adjusted mortality dropped 24% from 7.6% (95% CI: 6.9–8.2) to 5.8% (95% CI: 5.3–6.3) and in-hospital mortality decreased 30% from 6.6% (95% CI: 6.0–7.2) to 4.7 (95% CI: 4.2–5.1).

Conclusions: Over the same time frame of this study, increases in trauma death across the globe have been reported. This single-site study demonstrated a significant reduction in mortality, attributable to decreased hemorrhagic death. It is possible that efforts focused on hemorrhage control interventions (a bleeding control bundle) resulted in this reduction. These changing factors provide guidance on future prevention and intervention efforts.

Background

The federal government supports research to improve the general health of the nation and outcomes after disease and injury. As a result, life expectancy has increased by 11% from 70.8 to 78.8 (1970–2012) [1,2], cancer mortality decreased (1991–2009) by 20% [3] and heart disease declined (2000–2010) by 31% [4]. However, during similar periods, injury-related mortality has risen. The past decade (2000–2010) has seen an increase in trauma-related mortality in the US by 22.8% [5] and worldwide (1990–2010) by 24% [6]. An increase in patient age, motor vehicle collisions by 46% and an increase in falls by 55% likely contributed to the global rise in trauma mortality [7].

Internationally, injury-related mortality accounts for 1 in 10 deaths [6,7]. In the United states, trauma-related injuries (unintentional + suicides + drug overdose) is the 3rd leading cause of death [2]. Between 2000 and 2010, traumatic injury increased from the leading cause of death among individuals younger than 43 years to the leading cause in those younger than 46 [5]. Likewise, traumatic injury increased from the leading cause of life-years lost up to age 65 to the leading cause up to age 75 [8]. Additionally, the mean age of trauma patients has increased [9].

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Past studies have shown head injuries (42–52%) and hemorrhage (30–39%) to be leading causes of trauma-related deaths while multiple organ failure (MOF) trails at 7–11% [9,10].

Keeping with the tenants of a learning health care system [11] the objective of our study was to analyze mortality rates, the temporal distribution of the causes of trauma-related deaths, the factors that characterize that distribution and how those factors have changed over time at our urban level I trauma center. Since 2008, our center has focused on optimal resuscitation and stopping bleeding, employing multiple methods in the prehospital and hospital areas of care, resulting in a bleeding control bundle of care. We hypothesized that from 2005–2006 in comparison to 2012–2013, the percentage of deaths would change, the distribution of cause-specific mortality would be different and that the time to death for trauma patients would be dissimilar.

Methods

The trauma registry, weekly Morbidity & Mortality reports, autopsy reports and electronic medical records at Memorial Hermann Hospital in Houston, TX were reviewed. The Memorial Hermann Hospital is one of two level 1-trauma centers serving the greater Houston area and admits greater than 6000 injured patients a year.

Two time periods (2005–2006 and 2012–2013) were included in the analysis. These periods of time represent two years before and after implementation of major changes in control of bleeding and early resuscitation procedures [12]. Studies from our center and others have documented specific interventions for improved bleeding control, such as the use of pelvic binders, hemostatic dressings, extremity and junctional tourniquets, balloon occlusion of the aorta, minimizing crystalloid resuscitation, coagulation monitoring by TEG [13], use of TXA in patients with increased fibrinolysis and prehospital and hospital balanced transfusion (damage control resuscitation) and rapid delivery of patients to the operating and interventional radiology suites. These interventions are usually performed concurrently, but often analyzed separately. Few papers have examined the overall effects on hemorrhage related mortality of these often concurrent interventions.

Patients with primary burn injuries and pediatric age (<16) patients were excluded. Only patients declared dead in the hospital were included in this analysis. For each patient, data was collected on baseline characteristics, which included age, sex, mechanism of injury, cause of death, time of hospital arrival and time of death (same as discharge time). The time to death was calculated from time of hospital arrival to physician pronouncement of death or discharge time. At our weekly M&Ms, the trauma team, many of whom were involved in the patient's care, reviewed each patient's medical records to determine the primary cause of death. Autopsy data were also reviewed, but these were often not available at the time of the M&M conference. These data were recorded in each patient's M&M report and entered into the trauma registry. Patients were classified into one of several groups: (1) head injuries—fatal brain injury; (2) hemorrhage—uncontrolled bleeding; (3) multiple organ failure and/or systemic infection (MOF+ Sepsis); (4) Respiratory Failure—inadequate exchange of gases by the lungs (Respiratory Fail); (5) Cardiac—sudden cardiac arrest [6]; Comorbid—presence of a significant secondary disease contributing to mortality [7]; Pulmonary Embolism—embolus lodging in pulmonary arteries (PE); (8) Other—primary cause of death not described by previous primary categories; (9) Unknown—missing sufficient data to determine cause of death (UNK). For patients with more than one factor contributing to death, each cause was counted separately. This more accurately represents the fact that multiple etiologies may have contributed to a patient's death.

Penetrating injuries were defined as traumatic wounds that were a primary result of an object puncturing the skin and entering the underlying tissue. Blunt injuries were defined as injuries primarily resulting from the application of a non-penetrating mechanical force.

In hospital mortalities excludes all patients that were dead on arrival. Mortality rates were directly adjusted for age, gender and mechanism of injury using direct standardization.

Results are expressed comparing 2005–2006 with 2012–2013. The Mann-Whitney rank sum and chi square tests were used to compare variables between periods, with significance set at 0.05. Data is presented as medians and intra-quartile ranges (IQR). Analysis was conducted using STATA 13.1.

Results

We reviewed 15,874 and 1029 deaths from the 4-year study period. 7080 patients including 498 deaths were examined in the early time period (2005–2006), while 8767 patients including 531 deaths were reviewed in the recent period (2012–2013). There was a 23% increase in the number of admissions in the recent period. The overall trauma population showed differences in age and gender overtime but were similar in race/ethnicity distribution (Table 1). The median age of all patients increased by 6 years, 38 (24–52) to 44 (28–62) ($p < 0.01$) years. The percent of male trauma patients seen at the trauma center decreased from 72% to 68% ($p < 0.01$). In patients that died, no differences by gender, race or ethnicity were observed, however they differed in age. The median age of patients that died increased by 7 years from 46 (28–67) to 53

Table 1
Patient characteristics.

	Total N = 1029	2005–2006 N = 498	2012–2013 N = 531	p
Age				
All Trauma Patients, median (IQR)	41 (26–57)	38 (24–52)	44 (28–62)	<0.01
Trauma Deaths, median (IQR)	50 (30–69)	46 (28–67)	53 (32–73)	<0.01
Gender–Male				
All Trauma Patients, n (%)	11008/15847 (69.5)	5068/7080 (71.6)	5940/8767 (67.8)	<0.01
Trauma Deaths, n (%)	737/1029 (71.6)	364/498 (73.1)	373/531 (70.2)	0.35
Race/Ethnicity (Trauma Deaths)				
Black, n (%)	141/1029 (13.7)	66/498 (13.3)	75/531 (14.1)	0.75
Hispanic/Latino, n (%)	211/1029 (20.5)	102/500 (20.5)	109/531 (20.5)	1.00
Other, n (%)	57/1029 (5.54)	25/498 (5.02)	32/531 (6.03)	0.57
White, n (%)	620/1029 (60.3)	305/498 (61.2)	315/531 (59.3)	0.57
Injury Severity Score, median (IQR)	26 (25–38)	26.5 (25–43)	26 (25–36)	0.09

IQR, Interquartile Ratio; ISS, Injury Severity Score.