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Failure to rescue in trauma: Coming to terms with the second term

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ABSTRACT

Introduction: The failure to rescue (FTR) rate is the probability of death after a major complication and was defined in elective surgical cohorts. In elective surgery, the precedence rate (proportion of deaths preceded by major complications) approaches 100%, but recent studies in trauma report rates of only 20–25%. We hypothesised that use of high quality data would result precedence rates in higher than those derived from national datasets, and we further sought to characterise the nature of those deaths not preceded by major complications.

Methods: Prospectively collected data from 2006 to 2010 from a single level I trauma centre were used. Patients age >16 years with AIS ≥2 who survived beyond the trauma bay were included. Complications, mortality, FTR, and precedence rates were calculated. Chart abstraction was performed for registry deaths without recorded complications to verify the absence of complications and determine the cause of death, after which outcomes were re-calculated.

Results: A total of 8004 patients were included (median age 41 (IQR 25–75), 71% male, 82% blunt, median ISS 10 (IQR 5–18)). Using registry data the precedence rate was 55%, with 132/293 (45%) deaths occurring without antecedent major complications. On chart abstraction, 11/132 (8%) patients recorded in the registry as having no complication prior to death were found to have major complications. Complication and FTR rates after chart abstraction were statistically significantly different than those derived from registry data alone (complications 16.5% vs. 16.3, FTR 12.3 vs.13, $p = 0.001$), but this difference was unlikely to be clinically meaningful. Patients dying without complications predominantly (87%) had neurologic causes of demise.

Conclusions: Use of data with near-complete ascertainment of complications results in precedence rates much higher than those from national datasets. Patients dying without precedent complications at our centre largely succumbed to progression of neurologic injury. Attempts to use FTR to compare quality between centres should be limited to high quality data.

Level of evidence: Level III.

Retrospective cohort study: Outcomes.

Introduction

Historically reported outcome metrics after trauma include mortality and adverse occurrence rates, but recent work has examined the role of the failure to rescue (FTR) in trauma. This metric was originally described by Silber et al. in a cohort of patients undergoing elective surgery[1] and refers to the conditional probability of death after an adverse occurrence. Mathematically, this concept can be considered as the probability

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of death occurring after an adverse occurrence ($p(d|a)$) multiplied by the probability of an adverse occurrence ($p(a)$) plus the chance of dying after no adverse occurrence ($p(d|\text{no } a)$) multiplied by the probability of not having an adverse occurrence ($1 - p(a)$), or:

$$p(d) = [p(d|a) \times p(a)] + [p(d|\text{no } a) \times (1-p(a))].$$

In this equation, the first term describes the fraction of death attributable to dying after an adverse occurrence, while the second term describes the fraction of death attributable to dying without an adverse occurrence. In the elective surgical population, it is highly unlikely that a death would occur without a preceding serious adverse occurrence, and so the second term of the equation should reduce to zero. For this reason, any deaths that occur without a coded antecedent adverse occurrence are highly suspect for incomplete ascertainment of adverse occurrences and the "precedence rate", or percentage of deaths that are preceded by a serious adverse occurrence should approximate 100%. Under these conditions, variations in mortality between centres are due to variations in adverse occurrence rates, variations in FTR rates, or both.

While FTR rates have great potential to inform trauma care, application of the original FTR metric to the trauma population is clouded by the second term in the equation above [$p(d|\text{no } a) \times (1 - p(a))$], which, unlike in elective surgical populations, is not expected to approach zero. Many trauma patients who die will do so secondary to progression of disease or through changes in level of the aggressiveness of care and not as result of an adverse occurrence. This is problematic because when the precedence rate is not 100%, those deaths in the second term of the equation (deaths not preceded by an adverse occurrence, or "non-precedence" deaths) could represent progression of disease, a decision to withdraw care, or a misclassified case of FTR secondary to an unrecorded adverse occurrence. Deaths secondary to progression of disease or withdrawal of care will not impact the FTR rate, but misclassification of FTR cases clearly influences FTR rates and hence estimates of the quality of care between centres.

Previous work has used data from the United States National Trauma Data Bank (NTDB) to examine FTR rates in the trauma population [2–5]. While more granular than administrative data, these registry data do not ensure complete ascertainment of adverse occurrences. In our analysis, we used institutional registry data along with chart review to ensure a detailed understanding of the hospital course. We hypothesised that the precedence rate using this granular data would not approach 100% but would be much higher the 20–25% rates that have been previously reported using NTDB data [2,3]. Using chart abstraction, we also sought to characterise the nature, cause of, and circumstances surrounding non-precedence deaths.

Patients and methods

This retrospective review was conducted in accordance with the ethical standards of the Perelman School of Medicine at the University of Pennsylvania and was approved by the Institutional Review Board.

The Hospital of the University of Pennsylvania is an academic level 1 trauma centre located in urban Philadelphia which participates in the Pennsylvania Trauma Outcomes Study (PTOS), a state-wide data registry. This database is maintained by the Pennsylvania Trauma Systems Foundation (PTSF), which is responsible for accreditation and quality of trauma centres in Pennsylvania. To ensure the quality of data collection at the centre-level, specially trained registrars at each trauma centre prospectively abstract detailed data from the medical chart of each patient meeting inclusion criteria into the PTOS registry. These data are collected according to standardised definitions put forth by the PTSF and a subset of charts is re-reviewed to ensure inter-rater reliability by registrars. Centrally, the PTSF assures the quality of the data by submitting it to range, logic, and missingness checks. Additionally, subsets of submitted data are re-abstracted by the PTSF during site accreditation visits to verify accuracy. As data quality is linked to accreditation, centres are strongly incentivised to accurately report data and rates of missing data are low. We performed a 5-year query of our institutional PTOS data from 1 January 2006 to 31 December 2010. Demographic data, presenting vital signs, mechanism of injury, Abbreviated Injury Scale (AIS) scores, Injury Severity Scores (ISS), serious adverse occurrences, and morality were abstracted. Patients were included if they were >16 years of age and were admitted to an inpatient setting. Patients who died in the trauma bay, died in the operating room after resuscitation in the trauma bay, had a maximum AIS of <2, were less than 16 years of age, were pregnant, or were prisoners were excluded. Patients were considered to have unstable vital signs if they presented with a systolic blood pressure of <90 mmHg or a pulse rate of >100 beats per minute.

The mortality rate and the serious adverse occurrence rate were calculated for the included population. Adverse occurrences were defined in accordance with the PTOS data definitions (available online at http://www.ptsf.org/upload/2014_PTOS_Manual_Tab_1_through_4_Final.doc). Consistent with the original FTR work, we used the definition of serious adverse occurrences that captured the greatest fraction of overall deaths [1,6]. Adverse occurrences were considered serious adverse occurrences if they were included by definitions initially put forth by Silber et al. or if they were found in univariate logistic regression analysis to be associated with mortality ($p < 0.1$). The failure to rescue rate, defined as the probability of death after serious adverse occurrence, was calculated. Non-precedence deaths, defined as those patients who died without recorded adverse occurrences were then isolated. The medical records of this subset of patients were abstracted to determine the proportion who did in fact have an adverse occurrence prior to death (false negative FTR), the proportion who presented with pre-existing Do-Not-Resuscitate (DNR) orders, the proportion undergoing withdrawal of care, and the proportion expiring due to progression of disease. Death secondary to progression of disease was defined as the occurrence of a brain death examination consistent with brain death or death that occurred in the setting of unsuccessful ongoing resuscitative efforts. Mortality rates, adverse occurrences, and FTR were recalculated after excluding patients who died in less than 48 h in order to examine the impact of early deaths.

Categorical variables were compared between the FTR and non-FTR groups using Fisher's exact test. Continuous variables were assessed for normality using Shapiro–Wilk test. Those that were found to be non-normally distributed were compared using Mann–Whitney (2 groups) or Kruskal–Wallis test (more than 2 groups). Continuous variables that were normally distributed were compared between groups using *t*-test. Mortality, serious adverse occurrence, and FTR rates were compared before and after chart abstraction using one or two sample test of proportions as appropriate, with 95% exact confidence intervals. Two-tailed statistical significance was set at $p = 0.05$. All statistical analyses were conducted using Stata v13.1 (College Station, TX).

Results

A total of 14,120 patients were seen at our centre over the study period, of which 5680 were excluded for a maximum AIS of <2. An additional 436 patients were excluded for death in trauma bay or death in the OR immediately after the trauma bay leaving 8004 patients for analysis (Fig. 1). Patients had a mean age of