One thousand consecutive in-hospital deaths following severe injury: Has the etiology of traumatic inpatient death changed in Canada?

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Summary

A wide range of factors have traditionally led to early in-hospital death following severe injury. The primary goal of this commentary was to evaluate the causes of early posttraumatic inpatient deaths over an extended period. Although early posttraumatic in-hospital death remains multifactorial, severe traumatic brain injuries are the dominant cause and have increased in proportion over time. Other traditional causes of death have also decreased owing to improved clinical care.

A wide range of factors have traditionally led to in-hospital death following severe injury. Although the most dramatic is ongoing hemorrhage and subsequent physiological exhaustion, other factors include severe neurological injuries, sepsis, multiorgan failure and the progression of preceding medical comorbidities.[1] It is also evident that the relative incidence of these causes has changed over time. More specifically, innovation and improvements in care have led to a reported decrease in deaths from acute respiratory distress syndrome (ARDS), multiorgan failure and sepsis. Advancements that have contributed to this improvement include lung-protective ventilation strategies, a reduction in crystalloid fluid usage, aggressive deep venous thrombosis prophylaxis, early antimicrobial therapy and source control for infection, and damage control resuscitation.[2,3]

The most relevant and recent literature discussing the etiology of posttraumatic inpatient death is a review of 813 patients by Kahl and colleagues.[4] Although this American group clearly outlines an increase in deaths related to pre-existing patient comorbidities, it remains unclear if these data are also relevant in Canada. More specifically, given differences in helmet laws, gun control, organized trauma systems and even health care itself, we conducted an ecological, ethically approved review of Canadian inpatient deaths after severe injury (1000 consecutive inpatient deaths [injury severity score (ISS) ≥ 12] at the Foothills Medical Centre in Calgary, Alta.). The dominant goal of this review was to elucidate the potential change in early mortality among severely injured patients. Detailed analyses of patient records, including the medical death certificates and coroner's reports, were completed by two experienced reviewers (C.H. and C.G.B.).

Between Feb. 21, 2005, and Dec. 31, 2013, a total of 9941 consecutive severely injured (ISS ≥ 12) patients were admitted to the Foothills Medical Centre. This cohort was typical of the admission profile for critically injured patients to our trauma service (Table 1). The overall early inpatient mortality was 10.1%. The primary causes of death included severe neurological trauma (traumatic brain injury [TBI], spinal cord injury); acute hemorrhagic shock/exsanguination; sepsis; sudden, unexpected inpatient events; and a multitude of other uncommon causes (e.g., medical events that immediately preceded the injury) (Table 2). Over the nearly 8-year study period, deaths due to ARDS and sepsis nearly disappeared (no patient died of ARDS or sepsis after

2010). The overall mortality decreased significantly among all patients, from 14.4% in 2005 to 8.7% in 2013 (p = 0.001). The mean patient age at the time of death increased over the study period from 56.6 years in 2005 to 61.4 years in 2013 (p = 0.041).

The precise time of death following admission varied significantly and was associated with the primary cause of record (Table 3). Overall, 212 patients (21.2%) also underwent withdrawal of care (WOC) irrespective of their primary injury. Although most (83%) of these patients had severe neurological injuries (Table 4) as the documented reason for WOC, there was no change in the rate of withdrawal over the study interval (p = 0.24). Also, WOC was more common when patients survived longer in hospital (> 48 hours) (p = 0.021). Overall, 90% of the WOC mechanisms of death were related to neurological and/or spine injuries. It should be noted that the potential impact of a donation after cardiac death (DCD) program on early mortality and the WOC process was not a practical concern as our institution did not use DCD until 2016.

Despite significant differences in traumatic mechanisms and age, patients who died following a severe injury in southern Alberta showed similar patterns to those reported by Kahl and colleagues.[4] More specifically, overall mortality decreased over time (mean 10%). Although the mean age of death increased, the occurrence of death caused by ARDS, sepsis, and therefore the specific sequelae of injury, decreased over time. This is a direct result of advances in

Table 1. Demographic characteristics of 1000 patients admitted to the Foothills Medical Centre trauma service who experienced early inpatient death

Characteristic	Mean (range)	No. of patients
Age, yr	59.7 (21–81)	—
Sex		
Male	—	720
Female	—	280
Injury characteristics		
ISS	29 (15–59)	—
Mechanism		
Blunt	—	943
Penetrating	—	57
Admission vital signs		
Heart rate, bpm	109 (66–150)	—
Systolic blood pressure, mm Hg	95 (64–151)	—
Respiratory rate, bpm	24 (10–36)	—
Glasgow Coma Scale score	11 (3–15)	—

bpm = beats/breaths per minute; ISS = injury severity score.

Table 2. Primary causes of inpatient death following critical injury (n = 1000)

Cause of death	No. of patients
Neurological (severe traumatic brain or spinal cord injuries)	770
Acute traumatic shock/exsanguination	183
Pelvic fracture	123
Abdominal source	123
Thoracic source	22
Extremity or other source	3
Sepsis/ARDS	24
Gastrointestinal	12
Pulmonary	11
Other	1
Sudden, unexpected inpatient events	21
Pulmonary embolus	12
Myocardial infarction	4
Cerebrovascular accident	3
Tension pneumothorax	1
Cardiac tamponade	1
Progression of preceding event	2
Myocardial infarction	1
Seizure/brain injury	1
Withdrawal of care	212

ARDS = acute respiratory distress syndrome.

Table 3. Primary cause of death, as related to the timing of admission

Time of death after admission	No. of patients
< 6 hours	130
Neurological	21
Exsanguination	104
Sepsis/ARDS	0
Unexpected event	5
6–24 hours	153
Neurological	62
Exsanguination	81
Sepsis/ARDS	4
Unexpected event	6
24–48 hours	163
Neurological	85
Exsanguination	66
Sepsis/ARDS	6
Unexpected event	6
> 48 hours	554
Neurological	461
Exsanguination	22
Sepsis/ARDS	50
Unexpected event	21

ARDS = acute respiratory distress syndrome.

Table 4. Underlying diagnosis in patients who underwent withdrawal of care (n = 212)

Injury-related cause of death	No. of patients
Severe neurological injury	
Traumatic brain injury	179
Severe spinal cord injury	13
Unexpected event	9
Progression of preceding event	8
Physiologic exhaustion/exsanguination	2
Sepsis/ARDS	1

ARDS = acute respiratory distress syndrome.

care. The benefits of pattern recognition in caring for elderly, injured patients on a more frequent basis owing to increased volumes also cannot be understated. This improvement applies not only to the clinicians, but also to the nursing staff and rehabilitation specialists.

It is clear that although the primary causes of death were varied, the most common causes were severe neurological injuries (TBI and spinal cord injury; 77.0%) and acute hemorrhagic shock/exsanguination within the torso (18.3%). Although our ability to maintain life in patients with severe neurological injury has improved significantly, we still lack treatments that improve functional recovery for all patients. This concept overlaps with the willingness to engage in the WOC process in many cultures.[5] Exsanguination secondary to ongoing hemorrhage also remains a significant challenge despite advancements such as damage control resuscitation, hybrid operating theatres and recognition of the urgency to arrest bleeding. Although some patients died of sudden, unexpected inpatient events (2.1%) and others died from medical events preceding their injuries (0.2%), these uncommon occurrences are considered much more difficult to prevent and predict from a public health point of view.

In summary, although the mean age of patients and the mean age at time of death are increasing over time, the causes of death that occured as a direct result of the injuries are decreasing. Severe neurological trauma and exsanguination remain the dominant causes of inpatient death and require enhanced efforts at injury prevention. These patterns echo those reported by Kahl and colleagues[4] in the United States. The impact of WOC in scenarios of perceived medical futility is substantial in Canada and must now be better elucidated in Canadian studies on posttraumatic inpatient mortality.

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