Potentially Preventable Trauma Deaths: A Challenge for Trauma Care Systems

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Key Points

- Death preventability is a major indicator of trauma system performance and adequacy.
- Death preventability is evaluated taking into account the type of error(s) performed during the patient's care in relation to the entity of suffered injuries.
- Potentially preventable deaths are based on three criteria, including non-lethal injury, suboptimal care, and management errors as a direct or indirect cause of death.
- Preventable deaths (potentially or frankly) usually occur early during the acute care of the patient and imply missed injuries sustaining haemodynamic instability and delayed bleeding control.
- The improvement of prehospital care, the introduction of new strategies for bleeding control on the field and in the emergency department, and the implementation of the transfer strategies within the trauma system may allow the reduction of preventable trauma death rate.

63.1 Introduction

The concept of death preventability was first introduced in the 1970s [1]. In the following decades, it became a marker for overall quality of care, and it can be used to evaluate care protocols and health care systems, and be a major indicator of performance and adequacy of management among trauma patients [2–4].

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63.1.1 Definition of Preventable Trauma Deaths (PTDs)

In general, preventable deaths after a traumatic injury have been defined as casualties whose lives could have been saved by appropriate and timely medical care, regardless of tactical, logistical, or environmental issues [5].

For purposes of categorisation, MacKenzie et al. [6] in the first 1990s classified trauma death as follows:

– *Preventable* (frankly or definite are sometimes added): deaths that occur when a care error is clearly the cause of deaths. They are anatomic injuries and sequelae clearly considered survivable if appropriate steps have been taken, including divergence from the standard of care that directly or indirectly caused the patient's death.
– *Potentially preventable*: deaths determined based on three criteria including non-lethal injury, suboptimal care, and management errors as a direct or indirect cause of death. They are represented by anatomic injuries that are severe but survivable under optimum prehospital and in-hospital care.
– *Non-preventable:* deaths that occur when there is a lethal injury. They include those with anatomical injuries of torso, catastrophic brain injury (i.e. brain avulsion, transcranial penetrating brain injury involving deep nuclei or critical vascular structures, and brain stem injury), cervical spinal cord transection (above cervical level 3), major airway transection within the thorax, perforating/penetrating cardiac injury (>1/2 inch), free bleeding from a thoracic aorta injury, major pulmonary artery injury with free bleeding, hepatic avulsion with free bleeding, and catastrophic abdominopelvic injury (lower extremity amputations with open pelvis and large tissue loss/traumatic hemipelvectomy) [7].

The evaluation of errors identified in the delivery of care is of the utmost importance when the survivability of the patients has to be assessed. Identified errors may pertain to five complementary root nodes, according to the Joint

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Commission on Accreditation of Healthcare Organizations (JCAHO) taxonomy [8–10]:

1. *Impact*: the outcome or effects of medical errors and system failure, usually identified as harm to the patient;
2. *Type*: visible processes that were faulty or failed (i.e. errors in diagnosis, treatment, prevention, equipment failure, communication failure, errors in transfer);
3. *Domain*: the setting(s) where the errors happened (emergency department, operating room, intensive care unit—ICU, ward);
4. *Cause*: agents that lead to an error. They can be subgrouped as *system failures* (errors in design, organisation, training, or maintenance that lead the operator to an error) or *human failures*. These ones are classified as follows: *input errors* (wrong action based on incorrect perceiving data); *intention errors* (correct input but wrong action due to incorrect intention); and *execution errors* (unintended or wrong action even though the intention was correct) [11].
5. *Prevention and mitigation*.

Several studies demonstrated that management errors occur even in mature trauma systems and may contribute to the patient's demise [12–14]. In a retrospective study, Ivatury et al. [15] observed that in 79% of cases management errors might have contributed to potentially preventable deaths, and in 21% of cases definitely contributed to deaths, judged as preventable. Human errors were common in the emergency department and operating room, pertaining prevailingly to the resuscitative phase.

No uniformity of opinion exists about how to determine the preventability of deaths [16]. Fallon et al. [17] multidisciplinary reviewed 104 deaths out of 1.868 trauma and stated that peer-review outcomes are at least as effective as the computed generated TRISS probability of survival data for evaluating the quality of trauma care, being more effective for analysis of potentially preventable outcomes. On the other hand, Shanti et al. [18] noted that in their cases a more accurate prediction of deaths came from TRISS, but that peer-review was more sensitive in identifying preventable deaths. These results were confirmed by other authors [19].

The role of autopsy data in improving peer-review is also controversial. Some authors [20] consider autopsy results useful in the analysis of late deaths but not early ones, whereas others [21] do not.

63.2 The Burden of the Problem

Although trauma systems have worked to improve the care of patients before, during and after hospitalisation [22], traumatic injury continues to be among the top five leading causes of death worldwide and the leading one for patients under 44 years of age [23]. The World Health Organization (WHO) projects that by 2030 trauma will be the third leading cause of disability-adjusted life loss [24]. Several studies performed both in in-hospital [25] and prehospital [26] settings, and accounting for both civilian [27] and military data [28], show that the rate of PTDs is between 20 and 27.5%, and of these preventable deaths 64–90% are due to haemorrhage [5]. Acosta et al. [29], in an analysis of trauma centre mortality, demonstrated that almost all traumatic deaths were haemorrhage related and occurred within 24 h from injury. In another review of mortality in an urban trauma centre. Stewart et al. [30] observed 37% of deaths attributable to acute haemorrhage. Chiara and coworkers [3], in an analysis of trauma deaths preventability in an Italian urban area, recorded that among 203 trauma deaths, 11% were definitively preventable and 32% possibly preventable, with the rate of preventability increasing from the field to the hospital and being higher for haemorrhage-related deaths. In particular, preventability was conditioned by errors in management and missed injuries causing haemodynamic instability. Drake et al. [31] in a large retrospective study of one-year trauma-related deaths observed that of preventable/potentially preventable deaths occurring prehospital 55% were due to haemorrhage, while of those in the acute care setting, 16.1% occurred at non-trauma centre. Evaluation of prehospital deaths [26] identified 29% as potentially preventable, with 64% of that attributed almost entirely to haemorrhage.

Historically, Trunkey described a trimodal distribution of deaths, identifying "immediate" deaths occurring within one hour of trauma considered unsurvivable because of catastrophic injury of the central nervous system, cardiac or great vessels injury, "early" deaths, within a few hours after injury attributed to the central nervous system and/or haemorrhage, and "late" deaths, after weeks from injury because of multiorgan failure [12]. Considering the characteristics of early deaths, the interval between injury and definitive bleeding control appeared, since the beginning, the most critical issue for these patients.

In more recent years, a reassessment of the temporal distribution of trauma deaths has been performed [32, 33]. Valdez et al. [32], comparing the distribution of deaths described by Trunkey [12] with the time distribution of National Trauma Data Bank (NTDB) 7.2 (2002–2006), found a gradual reduction in early deaths as time progresses, notwithstanding the majority of deaths within 24 h from trauma were still related to torso injuries. In the study of Oyeniyi et al. [33] overall haemorrhage-related mortality decreased significantly from 36 to 25% between two observation periods, 2005–2006 and 2012–2013. Moreover, a more in-depth analysis revealed that the rate of potentially preventable deaths from haemorrhage remained constant, suggesting that a large proportion of deaths in the second period were judged potentially preventable due to the advancement in diagnostic and management strategies.

63.3 How to Reduce Preventable Trauma Deaths to Zero

To reduce the rate of PTDs is an ambitious but achievable goal. Several mitigation strategies have to be implemented, either prehospital or in-hospital, across the continuum of care, targeting prevention, intervention, and treatments. On the field, the prompt identification of patient needs throughout an appropriate triage is a key factor that allows the severely injured to be treated in referral trauma centres, where all resources and professional skills are available for proper management. From this point of view, an organised trauma system is proven to be effective in reducing PTDs [16] and it is now accepted that a preventable death rate of less than 1–2% is ideal in a mature trauma system.

Taking into account that the vast majority of PTDs are haemorrhage-related it seems reasonable that the implementation of a multi-modal bleeding control bundle may be effective in improving patients' survival. To do this a systematic approach is needed, by using an iterative process of quality improvement (LHCS—learning health care system) [5]. Education plays a pivotal role, and best practices and innovations must be disseminated and applied in practice.

Options to stop truncal and junctional traumatic haemorrhage in prehospital are evolving, and several strategies have been translated from military experience, where simple lifesaving interventions have been implemented, mostly for compressible haemorrhages. Examples are the use of tourniquets for limb injuries, junctional tourniquets [34], or topical haemostatic agents if standard tourniquets are impractical or ineffective [35]. In the civilian setting, the "Stop the Bleed" campaign [36] is a valuable initiative to educate bystanders on the principle of preventing deaths from haemorrhage from extremity injuries.

On the other hand, non-compressible torso bleeding still remains the biggest challenge in prehospital trauma care. Several interventions/procedures have been developed [37]. Among them, some as pelvic circumferential binders in case of pelvis fracture can be applied by trained paramedics; for the performance of others, as prehospital Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) [38], or prehospital resuscitative thoracotomy, a physician-staffed prehospital team is necessary.

Future directions for prehospital bleeding patient management seem to be represented by the deployment of blood and blood products on the field, eventually lyophilised [39].

Once in the emergency department, only timely management of bleeding patients according to the damage control strategy may improve survivability. This strategy encompasses shortened surgical procedures, permissive hypotension, and haemostatic resuscitation through massive transfusion protocols in order to restore the patient's physiologic reserve and to prevent the onset of the triad of acidosis, hypothermia, and coagulopathy, contributing to postinjury haemorrhagic mortality [40].

Keeping in mind the aforementioned evidences, it is easy to understand as trauma education and a continuous quality assessment, even in mature systems, are mandatory in order to identify and correct errors that may contribute to trauma death preventability.

Self-assessment Test

1. A death can be defined as preventable if
   (a) A care error may contribute to death
   (b) A care error is clearly the cause of death
   (c) The death occurs in a non-trauma centre
   (d) All of the above
2. The vast majority of late deaths are due to
   (a) Lack of bleeding control
   (b) Multiorgan failure
   (c) System errors
   (d) Catastrophic brain injuries
3. Most of the preventable trauma deaths are related to
   (a) Torso haemorrhage
   (b) Primary brain injury
   (c) Sepsis
   (d) None of the above

Correct Answers

1. (b)
2. (b)
3. (a)

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