Epidemiology of Trauma Deaths: A Reassessment

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Abstract

Recognizing the impact of the 1977 San Francisco study of trauma deaths in trauma care, our purpose was to reassess those findings in a contemporary trauma system.

Cross-sectional.

All trauma deaths occurring in Denver City and County during 1992 were reviewed; data were obtained by cross-referencing four databases: paramedic trip reports, trauma registries, coroner autopsy reports and police reports.

There were 289 postinjury fatalities; mean age was 36.8 +/- 1.2 years and mean Injury Severity Score (ISS) was 35.7 +/- 1.2. Predominant injury mechanisms were gunshot wounds in 121 (42%), motorvehicle accidents in 75 (38%) and falls in 23 (8%) cases. Seven (2%) individuals sustained lethal burns. Ninety eight (34%) deaths occurred in the pre-hospital setting. The remaining 191 (66%) patients were transported to the hospital. Of these, 154 (81%) died in the first 48 hours (acute), 11 (6%) within three to seven days (early) and 26 (14%) after seven days (late). Central nervous system injuries were the most frequent cause of death (42%), followed by exsanguination (39%) and organ failure (7%). While acute and early deaths were mostly due to the first two causes, organ failure was the most common cause of late death (61%).

In comparison with the previous report, we observed similar injury mechanisms, demographics and causes of death. However, in our experience, there was an improved access to the medical system, greater proportion of late deaths due to brain injury and lack of the classic trimodal distribution.

Key Words: Trauma, trauma death, organ failure, MOF, trauma epidemiology.

Fifteen years ago, Baker et al. [1] did a comprehensive study of trauma deaths that occurred over a 1-year period in the city and county of San Francisco. This seminal report, as well as others from this era, served to focus efforts to further improve civilian trauma care. [2-7] Indeed, these efforts resulted in improved patient outcome. [8] Recognizing the profound impact of this study on trauma system development, we believed that a reassessment of this issue in a contemporary trauma system was necessary. The Denver trauma system has been in effect for over two decades, and throughout this time period, it has been continually studied and restructured to optimize trauma care. Consequently, our global purpose was to characterize the epidemiology of all trauma deaths occurring in the city and county of Denver to update the observations made in San Francisco. Our specific aims were to: (a) document the predominant injury mechanisms, demographic factors, and ultimate causes of trauma deaths; (b) determine the temporal relationship between these factors and the time from injury; and (c) compare these findings with those observed in San Francisco, as well as elsewhere. We believe this data will assist us in future resource allocations and research priorities.

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MATERIAL AND METHODS

All traumatic deaths occurring in Denver City and County during the year ending December 1992 were reviewed; drownings and hangings were excluded. The Denver Emergency Medical System (EMS) has been in effect since 1972. Prehospital care is provided by the Paramedic Division of the Department of Health and Hospitals (DHH) based at the Denver General Hospital (DGH). The City Dispatch Center is activated by a 911 call and, requests for emergency medical assistance are referred to DHH emergency medical dispatchers who initiate a modified tiered response. Ambulance coverage for Denver County is based on a zone system, whereby ambulances are assigned to a specific area; as ambulances are mobilized for transport, the remaining vehicles relocate to provide maximum coverage with the shortest possible response time. All DHH ambulances are staffed with two paramedics and provide advanced life support. The Fire Department is also activated for blunt trauma, while police protection is sent for penetrating. The Paramedic Division consists of 75 full-time paramedics with a full-time physician director (P.T.P.). On-line medical control is provided by the Emergency Medicine attending staff in the Emergency Department (ED) at DGH via radio or cellular telephone. Denver paramedics can provide the following routine Advanced Trauma Life Support (ATLS) interventions by protocol prior to base station contact: endotracheal intubation, intravenous line access, and fluid administration. One paramedic obtains vital signs, while the other begins the appropriate field interventions. Ambulance response time for penetrating wounds in Denver averages 5 minutes, whereas time spent on the scene by the paramedics is just under 10 min and return to the hospital, 6 minutes. [9] Level I trauma centers in Denver County are the DGH, University Hospital, and Saint Anthony Hospital. Code 10 (emergent return) trauma--including all gunshot wounds (GSWs), all stab wounds (SWs), all multisystem trauma, and all trauma accompanied by shock--returns to DGH. Code 9 (nonemergent return) trauma is transported to the closest level I trauma center. Hospital evaluation and therapy are governed by ATLS protocols that ensure rapid control of airways, aggressive resuscitation, and early operative intervention.

For the purposes of this study, four data bases were cross-referenced: paramedic trip reports, trauma registries of the level I trauma centers, Denver County coroner autopsy reports, and police reports. Autopsies were performed at the request of the County Coroner (Colorado Revised Statutes 30-10-606) by board-certified forensic pathologists and were performed in 195 (68%) of the 289 traumatic deaths. Trauma case autopsies included a detailed description of injuries, organ weights, and microscopic examinations. Eighty-one patients who died in the hospital did not have an autopsy, because cause of death was believed clear based on operative and other clinical information. The remaining 11 patients died outside the hospital; seven patients sustained a GSW that transversed the head, whereas in six patients the cause of death was not precisely defined. Demographic data, injury mechanism, transportation time, primary diagnosis and injuries, ethanol levels at the time of the injury, and major septic and nonseptic complications were obtained from trauma registry, chart review, and autopsy reports. Injury severity was quantitated by the Injury Severity Score (ISS; American Association of Automotive Medicine--1990 guidelines). Data to calculate the ISS was available in 278 (96%) of the 289 patients; the remaining 11 (4%) were patients who died outside the hospital and did not have autopsies. Injury severity scoring for in-hospital patients was performed by trauma registries trained personnel and reviewed by the trauma research fellow (A.S.) who also scored prehospital deaths. Organ failure was defined according to our previously described score. [10] Briefly, dysfunction of four organs (lung, liver, kidney, and heart) was graded from 0 to 3, based on objective data. Adult respiratory distress syndrome (ARDS) was defined as a lung dysfunction grade greater than or equal to4. Multiple organ failure (MOF) was defined as a sum of the four organ dysfunction grades greater than or equal to4.

Cause of death, as determined by the county forensic pathologist, was subsequently classified by three of the authors (A.S., F.A.M., E.E.M.) into six categories: (a) CNS--predominantly lethal injury of brain, brain stem, and high cervical spine; (b) exsanguination--predominantly from uncontrolled bleeding; (c) central nervous system (CNS) + exsanguination--combination of categories (a) and (b); (d) organ failure--MOF or ARDS; (e) other--other lethal injuries (e.g., airway injuries) or secondary complications (e.g., pulmonary embolism, myocardial infarction, etc.); and (f) undetermined. Fatalities were then grouped according to time from injury to death. Deaths that occurred out of the hospital (prehospital) were subcategorized into ``found dead,'' which consisted of patients who were found by the police and whose time from injury of death could not be precisely determined, or ``death at scene'' that consisted of patients who were declared dead upon the paramedics arrival. Hospital deaths were classified as acute (within 48 hours), early (within 3 to 7 days after injury), and late (>7 days).

The probability of survival (PS) was calculated by the Trauma and Injury Severity Score methodology--which considers age, trauma score, ISS, and injury mechanism (blunt or penetrating)--and converted to percentage. [11] Data for calculating the PS was applicable in only 146 (76%) of the 191 in-hospital deaths, because respiratory rate data obtained in intubated patients was not accurate. Hospital deaths were judged nonpreventable, potentially preventable, or frankly preventable, based on the guidelines of Shackford et al. [12] All cases were categorized by the trauma team, including neurosurgery service, in weekly morbidity and mortality conferences in the respective hospitals, and subsequently reverified at monthly trauma committee meetings. Briefly, nonpreventable deaths consisted of anatomic injuries considered to be nonsurvivable with optimum care as outlined by ATLS and, when available, a PS <25%. Care is not suspected to compromise the possibility of survival. Potentially preventable deaths consist of very severe anatomic injuries, but survivable under optimal conditions with the patients physiologic state unstable or minimally responsive to treatment and, when available, a PS between 25% and 50%. Evaluation and management conformed to ATLS guidelines, but care was possibly implicated in the patients' demise. Frankly preventable deaths consisted of anatomic injuries considered survivable with patient physiologic state stable or responsive to treatment and, when available, a PS >50%. Evaluation and management were judged suspect. Questionable care of potentially and frankly preventable deaths was further qualified as resuscitative phase, operative phase, or critical care phase.

Comparisons between continuous variables were performed by analysis of variance (ANOVA), followed by the Bonferroni multiple comparisons test. The^2 test with Yates correction was used for categorical variables. Correlation between ISS, age, and time from injury to death was assessed by the Spearman rank correlation. A level of significance of 0.05 was applied. Data are reported as mean +/- SE. For the purposes of statistical comparisons, individuals who were found dead were not included, because time from injury to death could not be determined, and no attempt was made to access the medical system.

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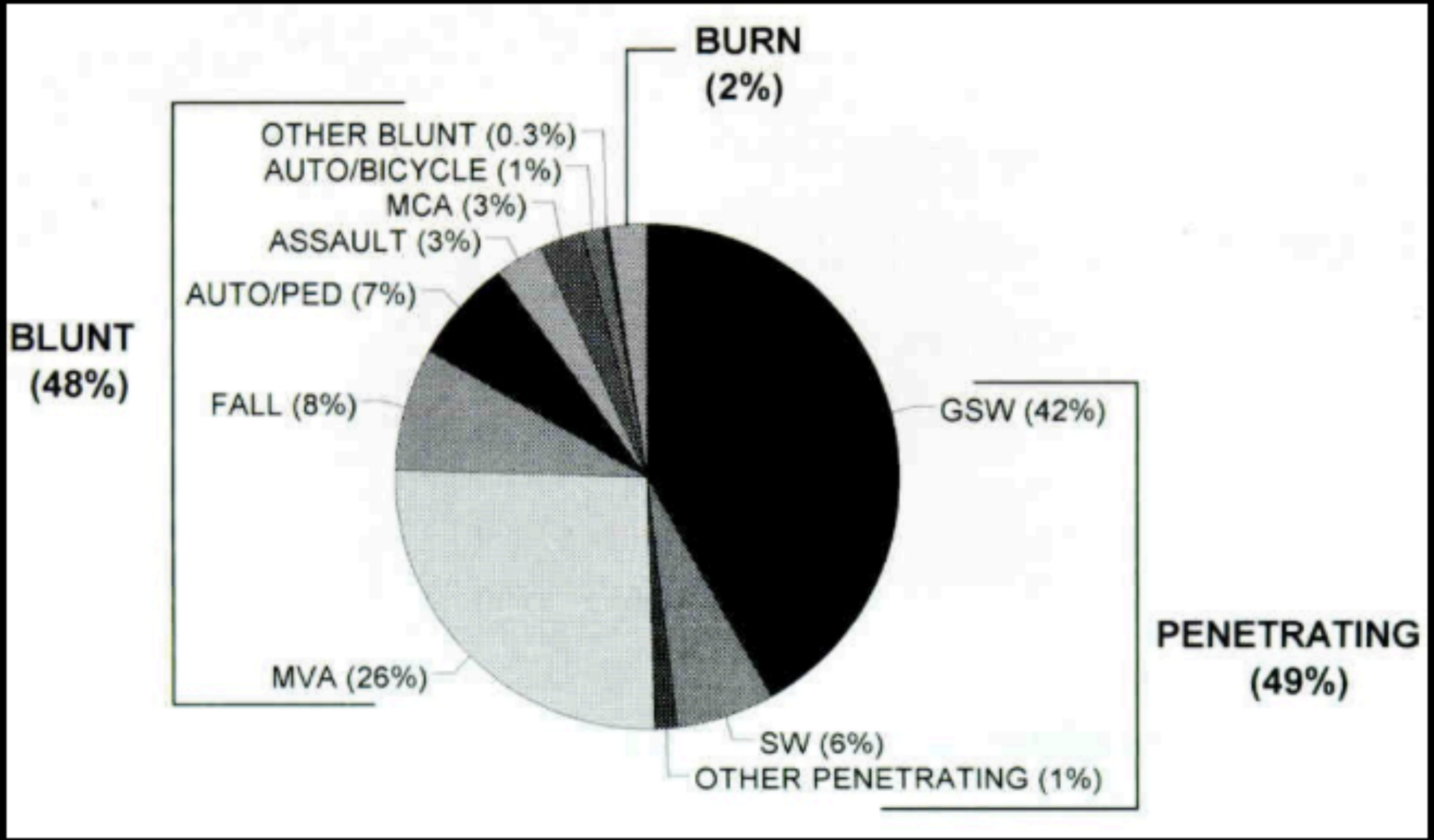
RESULTS

During the study period, there were 289 deaths attributed to injury, 225 (79%) of these individuals were men. Mean age was 36.8 +/- 1.2 years (range, 6 months to 92 years), and 190 (66%) were younger than 40 years of age. Injury mechanism is illustrated in Figure 1; 143 (49%) patients were victims of penetrating injuries (GSWs in 121, SWs in 18, a combination of both in 3, and a hatchet wound in 1), 139 (48%) had blunt trauma (motor vehicle collisions in 75, falls in 23, auto-pedestrians in 19, assault in 9, motorcycle in 8, auto-bicycle in 4, and train-pedestrian in 1), whereas the remaining 7 (2%) sustained lethal burns. ISS ranged from 9 to 75 (mean, 35.7 +/- 1.2). Blood ethanol levels were elevated in 80 (43%) of the 187 patients in whom it was measured. Of interest, there were no significant differences between blunt and penetrating trauma (38% vs. 48%).



Injury mechanism in 289 traumatic deaths in Denver, 1992. MCA = motorcycle accident; PED = pedestrian; MVA = motor vehicle accident; SW = stab wound; GSW = gunshot wound.

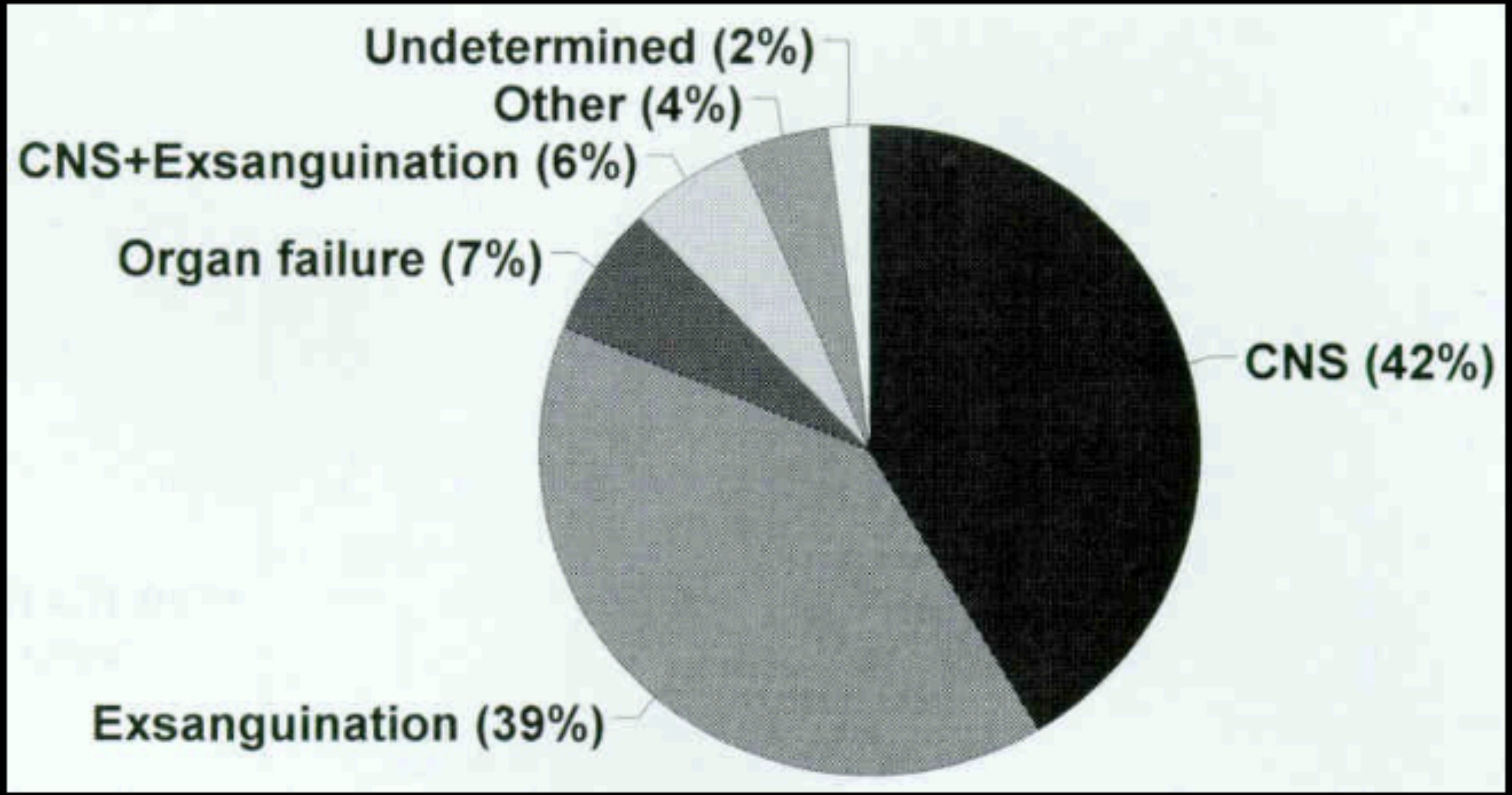
Distribution by time from injury to death, demographic data, injury mechanism, and ISS are shown in Table 1. Of the 289 traumatic deaths, 98 (34%) occurred in the prehospital setting: 52 (53%) people were found dead by police and 46 (47%) were declared death at the scene by paramedics. The remaining 191 (65%) patients died in the hospital: 180 (94%) were transported to the hospital by ambulance or helicopters (accessed via 911) and 11 (6%) were taken to the hospital by private means. Mean time from injury to ED arrival was 1.4 +/- 3.4 hours (range, 12 minutes to 24 hours), with 85% of these patients arriving in the ED in <1-hour postinjury. Of the 191 hospital deaths, 154 (81%) occurred in the first 48 hours after injury (acute), 11 (6%) in the period from 24 hours to 7 days (early), and 26 (14%) after 7 days (late). We observed significant differences among the dead at scene, acute, early, and late trauma death groups in regards to age (ANOVA, $p < 0.0001$) and ISS (ANOVA, $p = 0.001$). There was a trend toward increasing age (Spearman $r = 0.23$, $p = 0.001$) and lower ISS (Spearman $r = -0.20$, $p = 0.005$), with longer time from injury to death. A significant inverse correlation was observed between age and ISS (Spearman $r = -0.24$, $p = 0.0006$). Not surprising, penetrating injuries occurred in 90% of the patients who were found dead by the police (70% of these were GSWs), whereas blunt mechanism was more prevalent in the other groups. Interestingly, 73 of the 77 (95%) in hospital penetrating injury deaths occurred acutely (i.e., within 48 hours), whereas only 80 of the 110 (73%) blunt trauma deaths occurred in the same period (sup 2 , $p = 0.0003$). In addition, the probability of survival was significantly different among the three in hospital groups [acute = 0.23 +/- 0.03; early = 0.64 +/- 0.11; late = 0.74 +/- 0.07 ($p < 0.0001$, ANOVA)], with a trend toward higher values with longer time from injury to death.

	Prehospital (n = 98)		In-Hospital (n = 191)		
	Found Dead (n = 52)	Scene (n = 46)	Acute (n = 154)	Early (n = 11)	Late (n = 26)
Age (yr)[a]	37.5 ± 2.5	38.0 ± 3.0	33.2 ± 1.5	40.0 ± 4.8	52.0 ± 4.3
Male	39 (75%)	32 (70%)	122 (79%)	9 (82%)	23 (88%)
Mechanism					
Blunt	5 (10%)	24 (52%)	80 (52%)	11 (100%)	19 (73%)
Penetrating	47 (90%)	19 (41%)	73 (47%)	0	4 (15%)
Burns	0	3 (7%)	1 (1%)	0	3 (12%)
ISS*	34.9 ± 2.9	44.4 ± 3.8	37.6 ± 1.7	29.0 ± 5.8	24.3 ± 3.0

Values are mean ± SE.
[a] $p < 0.05$ (ANOVA); comparing scene, acute, early, and late.

Distribution by time, demographics, injury mechanism, and ISS of 289 traumatic deaths occurring in Denver, 1992.

Causes of death for all study patients are depicted in Figure 2. Overall, injuries to the CNS were the most prevalent (42%), followed by exsanguination (39%). Organ failure was the third most common cause of death, accounting for 7% of these patients. ``Other'' causes of death included severe airway injury in 4, severe burns in 4 (3 found dead and 1 died 12 hours after hospital admission), pulmonary embolism in 2 (air embolism in 1 and clot embolism in 1), cardiac failure in 2 (preexisting cor pulmonale in 1 and combination of coronary artery disease plus bilateral fat emboli in 1), and bilateral adrenal hemorrhage in 1. The causes of death as they relate to time from injury to death are shown in Table 2.



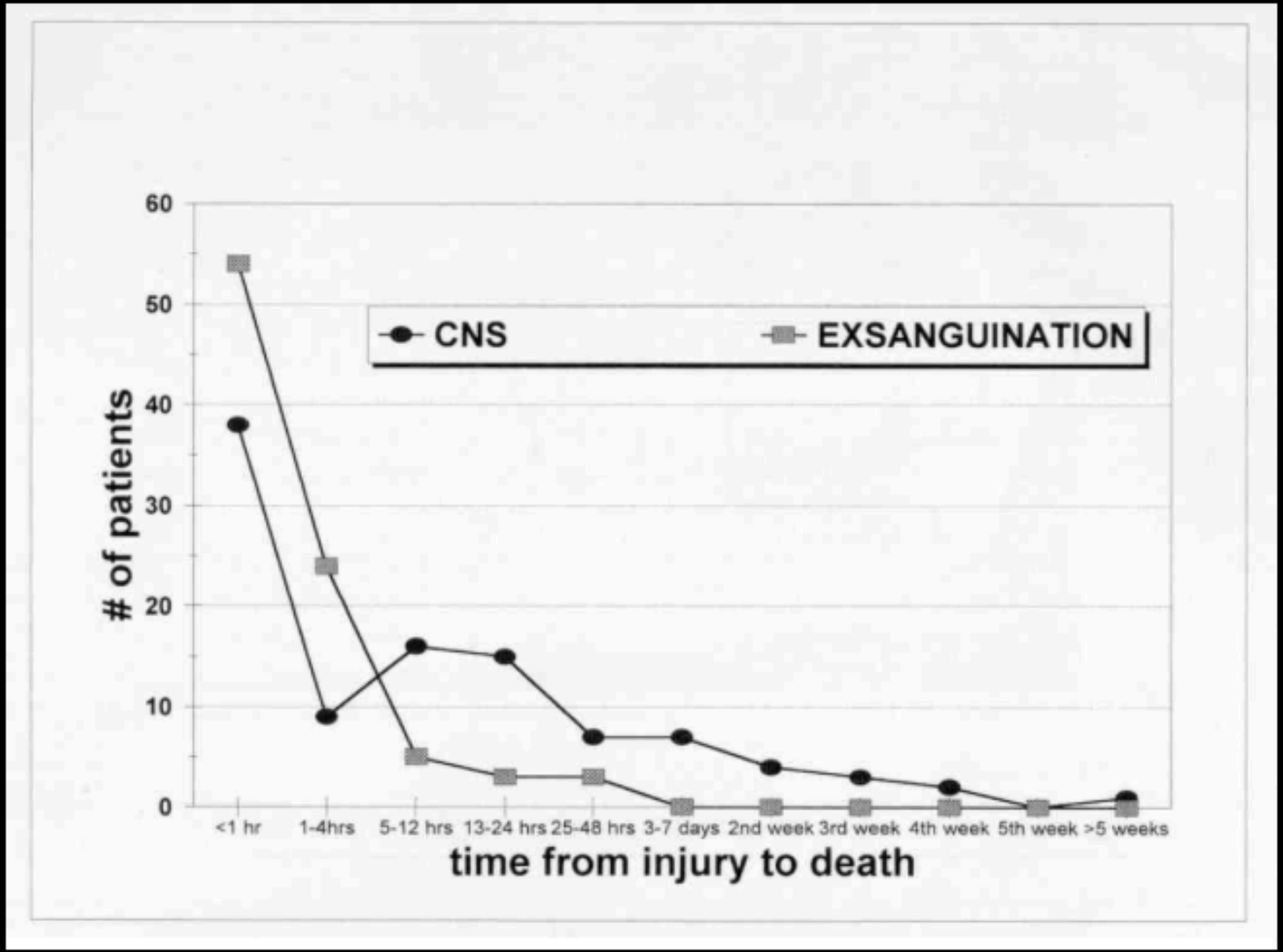
Etiology of postinjury deaths in Denver, 1992.

Cause of Death	Prehospital (n = 98)		In-Hospital (n = 191)		
	Found Dead (n = 52)	Scene (n = 46)	Acute (n = 154)	Early (n = 11)	Late (n = 26)
CNS	19 (36%)	23 (50%)	62 (40%)	7 (64%)	10 (39%)
Exsanguination	24 (46%)	11 (24%)	78 (51%)	0	0
CNS + exsanguination	5 (10%)	4 (9%)	7 (4%)	1 (9%)	0
Organ failure	0	0	1 (1%)	2 (18%)	16 (61%)
Other	2 (4%)	4 (9%)	6 (4%)	1 (9%)	0
Undetermined	2 (4%)	4 (9%)	0	0	0

Refer to "Materials and Methods" for cause of death definitions.

Causes of 289 traumatic deaths occurring in Denver, 1992.

Exsanguination was the most common cause of death among those who were found dead, whereas CNS injuries were implicated in the majority of those declared dead at the scene. Among those who were transported to the hospital, there were significant differences in the cause of acute, early, and late deaths. Exsanguination was the most frequent cause of the acute deaths (51%), 72 (92%) of these 78 patients had severe isolated or combinated injuries of the liver (n = 30), heart (n = 28), and major vessels (n = 24). Forty-six (59%) of these were caused by penetrating injuries (39% or 85% were GSWs). Central nervous system injuries were the second most frequent cause of acute deaths, and these occurred as a result of isolated or combinated brain lacerations (n = 23), brain contusions (n = 25), and subdural hematomas (n = 24). Gunshot wounds caused 43% of these acute CNS-related deaths in 43%. Central nervous system injuries were by far the most frequent cause of early death (64%); most of these were the result of brain contusions with or without subdural hematomas (n = 6). All were caused by blunt trauma. In the group of patients who died late, organ failure was the most common cause (61%); two of these patients had ARDS, whereas the others had MOF. Of note, there was a significantly higher prevalence of organ failure among blunt mechanism deaths (14 of 110, 13%), compared with penetrating injury deaths (2 of 77, 3%) (p = 0.03,[2]). Central nervous system was the second most frequent (39%) cause of late deaths (80% blunt, 20% penetrating). Figure 3 illustrates the temporal pattern of in-hospital deaths caused by exsanguination and CNS injuries. Although exsanguination deaths followed a curve with a rapid descending phase in the first 12 hours, the CNS deaths had a peak in the first 4 hours, followed by a more gradual decrease.



Temporal distribution of trauma deaths caused by CNS injuries and exsanguination, excluding individuals who were found dead by police.

In addition, we analyzed how cause of death relates to the severity of the anatomic injury as quantitated by the ISS (Table 3). Overall, CNS and exsanguination were the most frequent causes of death in patients with an ISS less than or equal to 20, 20 < ISS less than or equal to 35, and ISS greater than or equal to 36; however, of the 42 patients who had an ISS less than or equal to 20, 10 (24%) died of organ failure, compared with 8 (9%) in the group with a 20 < ISS less than or equal to 35 (p = 0.06,[2]) and 1 (1%) among patients with an ISS greater than or equal to 36 (p = 0.002,[2]). Of note, in those patients with ISS less than or equal to 20, organ failure was triggered by a major infection in 8 (80%) of the cases. We also observed a significant difference with respect to age (ANOVA, p = 0.0003); patients with less severe injuries (ISS less than or equal to 20) were significantly older than patients with 20 < ISS = less than or equal to 35 and ISS greater than or equal to 36 (45.2 +/- 3.8, 37.1 +/- 2.1, 28.9 +/- 1.9, p < 0.05; ANOVA and Bonferroni multiple comparisons test). Also, 70% of the patients with an ISS less than or equal to 20 who died of organ failure were older than 55 years.

	ISS		
	≤20 (n = 42)	21–35 (n = 91)	≥36 (n = 58)
Cause of death			
CNS	16 (38%)	40 (44%)	23 (40%)
Exsanguination	13 (31%)	36 (40%)	29 (50%)
CNS + exsanguination	0	3 (3%)	5 (9%)
Organ failure	10 (24%)	8 (9%)	1 (1%)
Other	3 (7%)	4 (4%)	0

Values are mean ± SE. Refer to “Materials and Methods” for cause of death definitions.

Cause of death by ISS in 191 in hospital trauma deaths.

Overall, 181 (95%) of the 191 hospital deaths were judged to be nonpreventable, whereas 6 (3%) were considered potentially preventable and 4 (2%) were judged frankly preventable. Table 4 depicts these latter deaths in greater detail. Six (60%) of these questionable management errors occurred at the resuscitative phase, whereas the other 4 (40%) were related to the critical care phase.

Resuscitative Phase	
Frankly Preventable	**Potentially Preventable**
Multisystem trauma delayed intubation/ventilatory support	Delayed resuscitative thoracotomy in two patients; died of exsanguination
Delayed pelvic fracture fixation; died of cardiac failure combined with fat emboli	Inadequate resuscitation; developed small bowel ischemia; died of MOF
	Delayed recognition of bilateral pulmonary contusion; died of ARDS
Critical Care Phase	
Frankly Preventable	**Potentially Preventable**
Premature extubation; aspirated; died of anoxic encephalopathy	Pulmonary embolism and deep venous thrombosis; no prophylaxis
Delayed laparotomy for postoperatory small bowel obstruction; died of MOF	Unrecognized bilateral adrenal hemorrhage; died of MOF

Errors in the four frankly preventable and six potentially preventable traumatic deaths.

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DISCUSSION

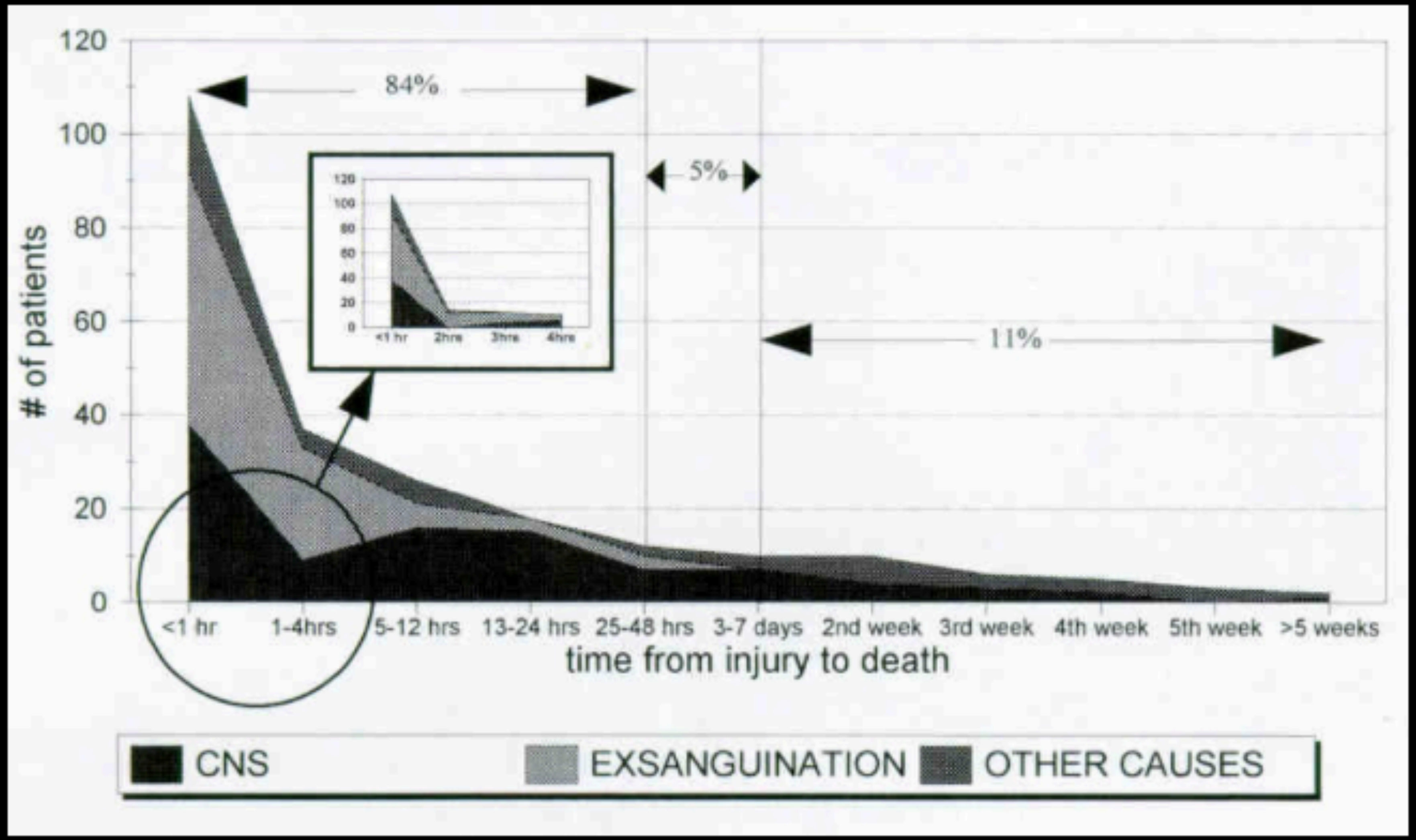
The study of trauma care originated from military experience; but, in 1955, a report by Zollinger [13] initiated a series of studies addressing civilian trauma care. [1-8] These early reports focused primarily on motor vehicle crashes. The first comprehensive review of all trauma deaths occurring in a geographic area was published by Baker et al. [1] in 1980. This was a retrospective autopsy study of 437 deaths that occurred in San Francisco during 1977. This seminal report, as well as others of this era, provided the impetus for the design and implementation of regional trauma systems (e.g., Orange County, San Diego). [14,15] These systems have been evaluated, and the results have consistently shown that regional trauma systems decrease the number of preventable deaths by ensuring prompt access to prehospital care and triage to trauma centers capable of providing emergent operative intervention. [14-21] Virtually all of these studies, however, focused on specific types of injury or were limited to hospital admissions. Recognizing the importance of the comprehensive epidemiologic investigation done by Baker et al. in 1977, we used a similar methodology to evaluate a contemporary trauma system.

San Francisco and Denver are similar geopolitical areas, in that the boundaries of the city and county are the same. As a result, both cities have one paramedic dispatch center based at the city hospital that is activated by 911 calls. Comparing the epidemiology of trauma deaths occurring in San Francisco during 1977 with those in Denver in 1992, the predominant injury mechanisms, demographic factors, and ultimate causes of death were not drastically different. Blunt fatalities predominated in San Francisco (53%), whereas penetrating injuries accounted for 40% and burns for 7% of postinjury deaths. In our community, penetrating wounds were present in 49% of the traumatic deaths, blunt trauma in 48%, and burns in 2%. San Francisco had more falls (San Francisco = 28% vs. Denver = 8%), whereas we seem to have more GSWs (San Francisco = 32% vs. Denver = 42%). CNS injuries (San Francisco = 50% vs. Denver = 42%) and exsanguination (San Francisco = 31% vs. Denver = 39%) were the primary causes of death in both communities. In both cities, roughly three-fourths of the dead were men, and the age distribution seemed similar (data not shown). We found that our mean ISS was lower (San Francisco = 43.0 +/- 0.8 vs. Denver = 35.7 +/- 1.2). There are several explanations for this discrepancy. First, Baker et al. assigned an ISS of 36 for isolated neurologic injury, whereas the majority of our fatal head injuries were scored as 25, and their report included ISSs exceeding 75. Second, we encountered more penetrating wounds in our series, and

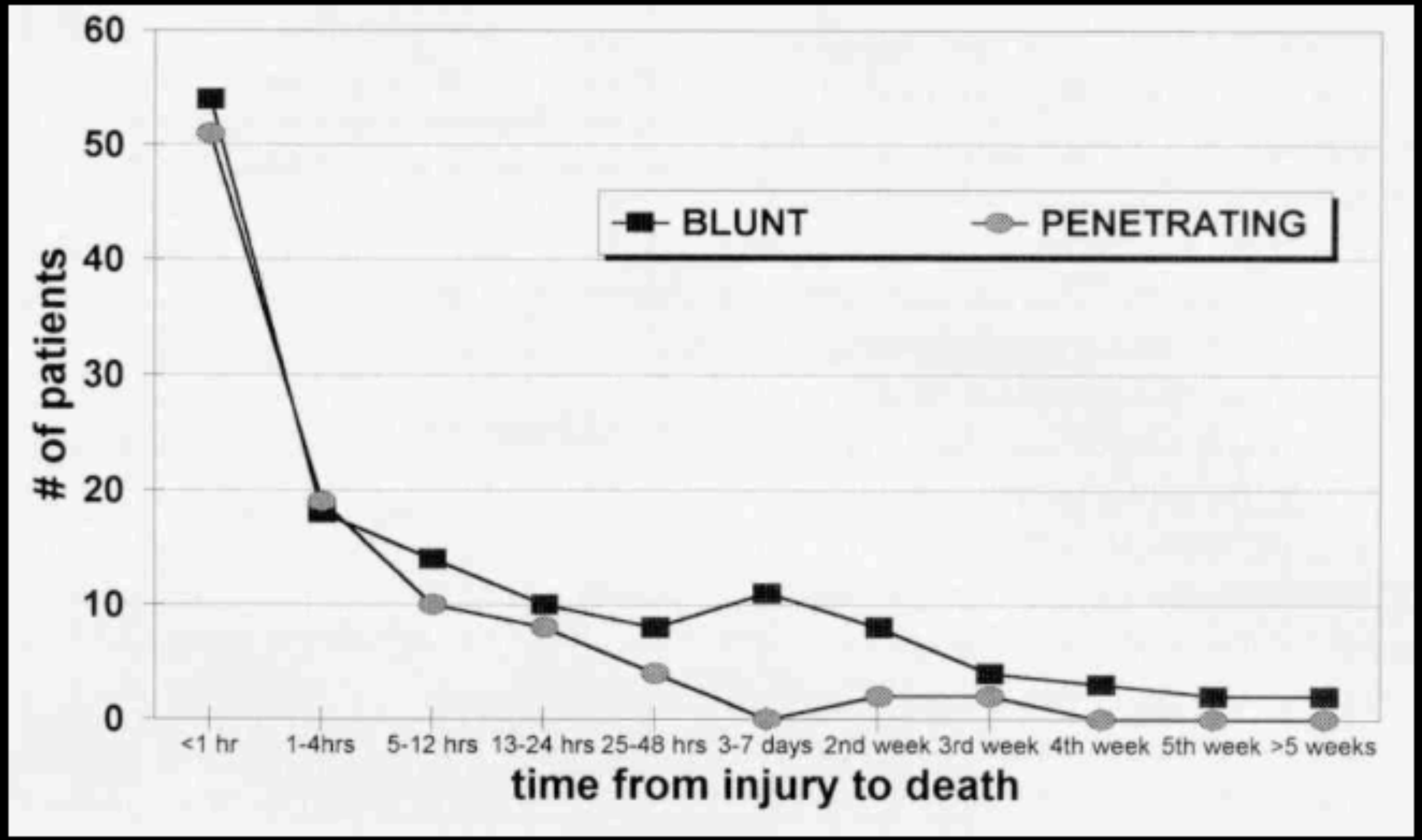
ISS does not consider multiple injuries within one body region. Patients sustaining life-threatening penetrating injuries to the head, chest, or abdomen will have an inappropriately low ISS in regards to their PS. Indeed, in a recent review of hospital trauma deaths occurring in New York during 1987 to 1989, Cayton et al. [22] observed the same discrepancy (penetrating: 31.8 +/- 1.1 vs. blunt: 37.2 +/- 1.2; p <0.05). ISS is an anatomic index that does not take into consideration age or physiologic derangement. [23] Dove et al., [3] studying postinjury deaths at the Metropolitan Hospital Center during 1974 to 1978, observed that patients presenting in shock did not necessarily have higher ISSs. To assess this issue better, we looked more closely at patients who died with less severe injuries (i.e., ISS less than or equal to 20). These patients were significantly older (mean age = 45.2). This inverse relationship between ISS and age had been previously observed by other investigators. [1,24] These patients had a higher incidence of organ failure (24%). The higher incidence of MOF among older patients is probably related to their diminished physiologic reserve. [10] Similarly, Cayton et al. [22] observed that patients who died because of low falls (which produces a low ISS) were significantly older and had a higher comorbidity rate. They observed that roughly 45% of the trauma deaths in this group were caused by sepsis-related MOF.

When analyzing the temporal distribution of the trauma deaths, we observed several interesting differences. The percentage of prehospital deaths (San Francisco = 53% vs. Denver = 34%) and acute hospital deaths (San Francisco = 29% vs. Denver = 53%) were significantly different ($p < 0.05,^2$), whereas the number of early (San Francisco = 5% vs. Denver = 4%) and late (San Francisco = 13% vs. Denver = 9%) were not. In a subsequent review article, Trunkey and Blaisdell [25] combined data from the 1977 Baker et al. [1] study with those of a 1974 epidemiology study also done by their group to derive the often-cited ``trimodal distribution of trauma deaths.'' [25] The first peak included immediate deaths (approximately 45%) that are primarily the result of CNS and major vascular trauma. The second peak included the early hospital deaths (roughly 34%) that occurred within a few hours after injury, principally caused by CNS injuries and exsanguination. The third peak (roughly 20%) constituted the late deaths, three-fourths of which were caused by sepsis-related MOF. We did not observe this trimodal pattern (Figure 4). One probable reason is that Denver has a more efficient EMS than San Francisco had in 1977, and, therefore, we are prolonging the survival of some unsalvageable patients.

Another possible explanation could be a difference in injury mechanism, however, as shown in Figure 5, we observed no obvious differences between blunt and penetrating injury deaths in the first 48 hours. On closer review, however, we found that 41% of ``dead-at-scene'' patients had sustained penetrating injuries (95% GSWs), and virtually all victims of penetrating wounds transported to the hospital died within 48 hours (90% GSWs). In contrast, only 73% of the hospitalized blunt-injured patients died in the same period. These differences in the temporal distribution of deaths caused by blunt and penetrating injuries were also observed by Cayton et al., [22] as well as by Baker et al. [1] Collectively, these findings raise several points for discussion. As in most urban settings, Denver has a major problem with GSWs. [26,27] Despite our advanced EMS, 43% of GSW deaths occurred in the field (half of these people were found dead), and 55% occurred within 48 hours of hospitalization. It is difficult to believe that we will reduce this problem by improving either 911 access or triage to a capable trauma facility. The only recourse is to prevent humans from being shot (e.g., stricter gun control laws). Second, there is a concern that more aggressive field care will result in early survivors who will eventually die after extensive and costly trauma care. Our data indicate that survival with penetrating torso injuries is declared within 48 hours. On the other hand, an increasing percentage of patients with CNS trauma are surviving the acute postinjury period, only to be later declared brain dead. This issue deserves further study to determine guidelines to identify brain-injured patients who should not be resuscitated. Definitions of futile care are needed for those patients who, following resuscitation, have devastating brain injuries, but are not clinically brain dead. This issue raises the question further of whether trauma centers can expend prolonged efforts to recover organs for transplantation. In 1992, only 12 (6%) of our hospitalized trauma victims were organ donors, despite a committed institutional effort to recover organs.



Temporal distribution of trauma deaths, excluding individuals who were found dead by police.



Temporal distribution of trauma deaths caused by blunt and penetrating injuries, excluding individuals who were found dead by police.

Over the last 8 years, the San Diego group has published a series of thoughtful studies evaluating the 1984 implementation of their trauma system. [12,15,17-20] In 1986, they introduced a formal medical audit committee, which uses the format of a surgical morbidity and mortality conference to assess the quality of trauma care. [12] Subsequently, in 1987, they published a study that demonstrated that severely injured patients (i.e., Trauma Score less than or equal to 8), triaged to 1 of 6 regional trauma centers (one level I, four level II, and one pediatric), had a better outcome than that observed in the major trauma outcome study. [17] In their second 1987 publication, they showed that the incidence of frankly preventable deaths in patients admitted to nontrauma hospitals was 8%, compared with 2% in trauma centers ($p < 0.001$). [12] They observed that virtually all preventable deaths in non-trauma hospitals were the result of failure by the evaluating physician to appreciate the severity or multiplicity of injuries. On the other hand, in a trauma center, the most common mistakes were errors in judgment or errors in technique. Admittedly, our preventable deaths were not as rigorously assessed, but our incidence of frankly preventable deaths (which are much easier to define than potentially preventable) was 2%; all involved error in judgment. According to Shackford et al., this rate represents the limit of improvement one can expect in a trauma system. In a 1992 follow-up report, the San Diego group used the medical audit committee to evaluate the relative frequency of common errors in various phases of hospital care and assess their relationship to preventable deaths. [20] Of the 1032 errors identified over 4 years, roughly one-half occurred during the resuscitative phase, one-fourth in the operative phase, and one-fourth in the critical care phase. Errors, however, in critical care were responsible for 50% of the preventable deaths; a finding similar to ours, as well as Cayton et al. [22] It would thus seem that, if trauma centers are to further reduce hospital deaths, they need to focus on the later phases of therapy delivered in the intensive care unit. [28] Finally, this group has published two epidemiologic studies of traumatic deaths. [18,29] The first study focused on in-hospital deaths that occurred in a level I trauma center, whereas the second study (published subsequent to our submission) was a comprehensive review of all trauma deaths occurring in their regional trauma system. In comparison, a similar percentage of people died in the prehospital setting (40%). Again, three-fourths of the dead were male, and their mean age was similar to our experience. However, the predominant mechanism of injury was blunt (71%); motor vehicle crashes accounted for 55% of their deaths, compared with 26% in our study. The distribution of deaths in San Diego over time was similar to ours; however, their percentage of organ failure deaths was lower than ours (4% of the hospitalized patients). In our experience, if we exclude burns, 9% of hospitalized patients died of organ failure. In 1992, we studied 394 trauma patients admitted to DGH with an ISS > 15 and, when using our standard organ failure score, we documented a 13% incidence of MOF; one-half of these patients died. [10] This is similar to the 8% postinjury MOF reported by Faist et al. [30] in 1983. Although the San Diego group contends that MOF is disappearing, this has not been our experience. A possible explanation is a difference in the definition of organ failure. In fact, their patients who were reported to have died of pneumonia, most likely had organ failure by our definition. [31]

In summary, GSWs represent a major cause of premature death in our community and should represent a primary focus in prevention. Brain injuries remain the predominant cause of postinjury death, whereas organ failure is still the leading cause of late trauma deaths. In comparison with the 1977 San Francisco 1977 experience, we observed improved access to the medical system, greater percentage of late deaths caused by brain injury, and lack of the classic trimodal distribution of mortality.

By combining experiences, we can identify similarities and, consequently, make decisions that may have the greatest positive influence. Conversely, discrepancies underscore the importance of examining local differences. Ultimately, a National Trauma Registry with a large contemporary data base is essential to determine priorities and ascertain the impact of policy changes.

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