Autopsies and death certification in deaths due to blunt trauma: What are we missing?

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Objectives: To determine the frequency, body region and severity of injuries missed by the clinical team in patients who die of blunt trauma, and to examine the accuracy of the cause of death as recorded on death certificates.

Design: A retrospective review.

Setting: London Health Sciences Centre, London, Ont.

Patients: One hundred and eight deaths due to blunt trauma occurring during the period Apr. 1, 1991, to Mar. 31, 1997. Two groups were considered: clinically significant missed injuries were identified by comparing patient charts only (group1) and more detailed injury lists from the autopsies and charts of the patients (group 2).

Outcome measures: Chart and autopsy findings.

Results: Of the 108 patients, 78 (72%) were male, and they had a median age of 39 years (range from 2 to 90 years). The most common cause of death was neurologic injury (27%), followed by sepsis (17%) and hemorrhage (15%). There was disagreement between the treating physicians and the causes of death listed on the death certificate in 40% of cases and with the coroner in 7% of cases. Seventy-seven clinically significant injuries were missed in 51 (47%) of the 108 patient deaths. Injuries were missed in 29% of inhospital deaths and 100% of emergency department deaths. Abdominal and head injuries accounted for 43% and 34% of the missed injuries, respectively.

Conclusions: The information contained on the death certificate can be misleading. Health care planners utilizing this data may draw inaccurate conclusions regarding causes of death, which may have an impact on trauma system development. Missed injuries continue to be a concern in the management of patients with major blunt trauma.

Objectifs : Déterminer la fréquence, la région du corps et la gravité des traumatismes non repérés par l'équipe clinique chez les patients qui meurent à cause de traumatismes fermés et examiner l'exactitude de la cause du décès inscrite sur le certificat de décès.

Conception : Étude rétrospective.

Contexte : Centre des sciences de la santé de London, London (Ont.).

Patients : Cent huit décès causés par un traumatisme fermé survenus entre le 1er avril 1991 et le 31 mars 1997. On a étudié les cas en deux groupes : traumatismes non repérés significatifs sur le plan clinique identifiés par comparaison des dossiers des patients seulement (groupe 1); listes plus détaillées de traumatismes tirées des autopsies et des dossiers des patients (groupe 2).

Mesures de résultats : Constatations inscrites au dossier et conclusions de l'autopsie.

Résultats : Sur les 108 patients, 78 (72 %) étaient de sexe masculin. L'âge médian des patients était de 39 ans (intervalle de 2 à 90 ans). La cause la plus fréquente de décès était un traumatisme d'ordre neurologique (27 %), suivi d'une infection (17 %) et d'une hémorragie (15 %). Il y avait divergence entre les médecins traitants et les causes de décès inscrites sur les certificats de décès dans 40 % des cas et avec le coroner, dans 7 % des cas. On n'a pas repéré 77 traumatismes significatifs sur le plan clinique chez 51 (47 %) des 108 patient décédés. On a raté des traumatismes dans 29 % des décès survenus à l'hôpital et 100 % de ceux qui

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sont survenus à l'urgence. Les traumatismes à l'abdomen et à la tête ont représenté 43 % et 34 % respectivement des traumatismes non repérés.

CONCLUSIONS : Les renseignements figurant sur le certificat de décès peuvent être trompeurs. Les planificateurs de services de santé qui utilisent ces données peuvent tirer, au sujet des causes des décès, des conclusions erronées qui peuvent avoir une incidence sur l'évolution du système de traumatologie. Les traumatismes non repérés continuent de préoccuper dans la prise en charge des patients victimes de traumatismes fermés graves.

Trauma is a leading cause of morbidity and mortality in the Canadians under the age of 45 years, and it is the third highest overall cause of death.[1] Despite planned and aggressive strategies for injury prevention, the number of deaths due to trauma in the Province of Ontario has increased by 2% since 1990, with 60% of deaths being secondary to falls and motor vehicle accidents.[1] The management of these seriously injured patients is a clinical challenge. Injuries, potentially fatal or trivial, may be missed at any stage of management, including intraoperatively. Missed injuries are unfortunately a component of trauma care, and the reported rates of missed injuries in trauma patients vary from 2% to 50%.[2–4] Blunt trauma yields higher rates of missed injuries than penetrating trauma.[5] To date, only one autopsy assessment of missed injuries has been reported: Albrektsen and Thomsen[6] reported a 34% missed injury rate but included only clinical-ly insignificant injuries (abbreviated injury score [AIS] less than 4).[7] Retrospective clinical reviews without autopsy evaluation do not estimate the true magnitude of these missed injuries.

An important source of information on injury deaths could include the death certificate completed by the treating physician or coroner subsequent to a trauma death. Not dissimilar to missed injuries, information given on death certificates can have inaccuracies with respect to the cause(s) of death, reportedly as high as 30% in the absence of an autopsy.[8,9] Death certificate information within epidemiologic databases is used for such purposes as tracking the health of the population, designing health care promotion and injury prevention programs, as well as guiding the allocation of resources for clinical, research and other health related programs. Therefore, these data must be accurate. The cause of death assigned by a clinician on the basis of autopsy findings in combination with clinical data is likely the best estimation of the true cause of death.

The purpose of this review was twofold. Based on a consecutive series of autopsies of patients who died of blunt trauma, we attempted to determine the frequency, body region and severity of injuries missed by the clinical team. Also, we examined the accuracy of the death certificates filed on these trauma deaths by comparing the cause of death as completed by either the attending physician or the coroner with that determined during our review process.

MATERIAL AND METHODS

Data

The study population consisted of the health records and autopsies of 108 patients who were treated and died as a result of blunt trauma at the London Health Sciences Centre (LHSC) between Apr. 1, 1991, and Mar. 31, 1997. The LHSC is the leading tertiary hospital for trauma care, serving southwestern Ontario. The hospital provides acute trauma services for nearly one million people with a radial referral area of over 150 km, much of which is rural. Of the 1939 nonpenetrating injuries during this period there were 263 deaths, but autopsy was performed in only 44% (117) of cases. An autopsy is performed at the request of the coroner and includes cases involving motor vehicle drivers, children and any case in which the cause of death is unknown. Of the 117 cases, full autopsy results and complete health record documentation was available at the time of study in 108 (92%) cases.

Detailed data were collected on each patient including demographic, injury and treatment information from the injury scene and during prehospital care, through the entire acute care hospital stay until the patient's death. Each patient's injury severity score (ISS) was calculated twice, using TRI-CODE 5.0 Personal Computer Injury Coding Software (Tri-Analytics, Inc., Bel-Air, Calif.). First, the ISS was calculated on the basis of injury descriptions from clinical records, and radiology, operative and pathology reports. This data set made up the "chart alone" group (group 1). The reviewer (N.F.H.) who entered the injury data was blinded to the autopsy results. Next, the autopsies of individual patients were reviewed and used to update the injury list. Any new injuries were entered and the severity of previous injuries was updated when greater detail was supplied in the autopsy report. The ISS was then recalculated and the data assigned to the a chart plus autopsy group (group 2).

A missed injury was defined as one that escaped detection during resuscitative, radiologic, operative and pathologic investigation but was identified through autopsy. Missed injuries were identified manually by comparing the injury list of patients in group 1 with the more detailed injury lists of the patients in group 2. The missed

injuries were totalled for all patients and for the patients who died in the Emergency Department (ED deaths), with only clinically significant (AIS 4 or greater, i.e., severe, critical and maximum injuries[7]) missed injuries recorded. The cause of death was determined from the chart and autopsy and placed in 1 of 8 categories (Table I[10–12]). The cause of death was confirmed by a second reviewer, the medical director (M.J.G.) of the LHSC trauma program. It was then determined if this cause of death was correctly identified on the death certificate and if it was specified by the coroner in the autopsy report.

Statistical analysis

For the analysis of nominal variables, frequencies and percentages were calculated. For the numerical and ordinal variables, medians and ranges were calculated, since it was determined that none of these data were normally distributed. Population differences in median ISS values between groups 1 and 2 were examined by the nonparametric Wilcoxon rank-sum test[13] for all deaths and for ED deaths.

RESULTS

From Apr. 1, 1991, until Mar. 31, 1997, 108 deaths caused by nonpenetrating trauma were reviewed. The study population was 72% male with a median age of 39 years (range from 2 to 90 years). The cause of the 108 deaths included 64 (59%) motor vehicle crashes, 20 (19%) falls, 8 (7%) intentional suicides or homicides and 16 (15%) deaths from other causes. The temporal distribution from the time of injury to death is presented in Fig. 1. Of the 108 deaths, 56% occurred in the acute phase (less than 48 hours after injury), 25% in the early phase (2 to 7 days after injury) and 19% in the late phase (more than 7 days after injury).

There were statistically significant differences in the population ISS medians of the 2 groups, for both all deaths and ED deaths, with group 2 having a higher ISS (Table II). The ISS differences of 13 and 23.5 points for all deaths and ED deaths respectively are also clinically significant, since they represent additional serious, moderate and severe injuries. The most common cause of death was neurologic injury (27%), followed by sepsis (17%) and hemorrhage (15%) (Table I).

Table I

Definitions and Study Values for the 8 Cause-of-Death Categories[10–12]

Cause of death	Definition	No. (%) in study
Neurologic — head trauma	Death due to intracranial abnormality, including the anatomic injury itself (e.g., contusion) or a secondary consequence of the injury (e.g., severe cerebral edema)	29 (27)
Cardiac failure	Death due to cardiac failure, including myocardial infarction or contusion, arrhythmia, congestive heart failure or pulmonary embolism	7 (6)
Respiratory failure	Death due to respiratory failure, including respiratory arrest, adult respiratory distress syndrome, inhalation injury, any pulmonary or ventilation insufficiency	7 (6)
Hemorrhage	Death due to uncontrolled bleeding, regardless of organ, but exclusive of the brain (e.g., a massive subdural hemorrhage should be coded to neurologic — head trauma).	16 (15)
Spinal cord trauma	Death due to spinal cord injury, usually an atlanto-occipital dislocation	1 (1)
Other	Death due to any other cause not listed above. (12 of the 20 "other" cases were the result of "multiple trauma".)	20 (19)
Sepsis/systemic inflammatory response syndrome (SIRS)	Death due to the systemic inflammatory response to infection caused by the presence of microorganisms in the host (sepsis) or the a variety of noninfectious pathologic causes, including multiple trauma and tissue injury or hemorrhagic shock. The response is manifested by 2 or more of the following: 1. temperature > 38 °C or < 36 °C 2. heart rate > 90 bpm 3. respiratory rate > 20 bpm or $Paco_2$ < 32 mm Hg 4. Leukocyte count > 12.0×10^9/L, < 4.0×10^9/L or > 10% immature forms. Severe forms may also include hypotension or hypoperfusion abnormality (e.g., lactic acidosis, oliguria, acute alteration of mental status).	18 (17)
Multiple organ dysfunction syndrome (MODS)	Death due to altered organ function in an acutely ill patient such that homeostasis cannot be maintained without intervention. May be primary, a direct result of a well-defined insult (e.g., trauma/pulmonary contusion) in which organ dysfunction occurs early and can be directly attributable to the insult itself; or secondary, as a consequence of a host response and is identified within the context of sepsis/SIRS.	10 (9)

Missed injuries

A summary of the injuries and their severity for all cases, as well as the missed injuries for the inhospital and ED deaths, is presented in Table III. There were 77 clinically significant (AIS 4 or greater) injuries missed. Not surprisingly, the majority of missed injuries (64%) occurred in the ED deaths group. In total, 51 (47%) of the 108 patient deaths studied had missed injuries, 23 (29%) of 80 patients in the inhospital deaths subgroup and all 28 patients (100%) in the ED deaths subgroup. Abdominal injuries were the leading type of missed injury (Table IV). There were 33 undiagnosed abdominal injuries, 43% of all missed injuries. Most of these (23 cases) occurred in the ED deaths subgroup. Both hepatic and splenic ruptures were frequently missed in this group, whereas intestinal and mesenteric injuries were missed equally in the inhospital and ED subgroups. Interestingly, other major intra-abdominal vascular injuries, such as laceration of the inferior vena cava (IVC), were missed intraoperatively in 2 patients who survived initial resuscitation.

Head injuries were the second most common type of missed injury, making up 34% of the missed injuries. The frequency with which these injuries were missed before autopsy was equal in the ED and inhospital subgroups. Subdural hematomas were the most commonly missed head injury (10 cases), followed by diffuse axonal injury (8 cases).

Of the chest injuries, a large number of cardiac injuries were missed including 4 atrial ruptures, 2 pericardial tears and 2 myocardial contusions. All missed aortic lacerations and other serious vessel injuries were in the ED deaths subgroup. A large number of rib fractures without complications and pulmonary contusions were undiagnosed in both subgroups. These were excluded from this report, since they were defined as clinically insignificant (AIS 2 or 3). Musculoskeletal injuries were less frequently missed (4%) and, as with the other body region injuries, the majority were in the ED deaths subgroup. There were also 2 missed femoral fractures and 1 missed tibia-fibula fracture. Again, these were excluded because they were considered clinically insignificant (AIS less than 4).

The influence of the ED deaths subgroup in terms of missed injuries appears obvious. Because of our large geographic referral area, it seemed appropriate to determine if the referral pattern ("off the street" versus transferred) was associated with increased missed injuries. To examine this, all the ED deaths files were reviewed to determine the percentage of patients who were transferred from a peripheral centre. Nine (32%) of the 28 ED patients were transferred from a peripheral hospital. A surprisingly high rate of clinically significant intra-abdominal visceral and vascular injuries were missed in this group. All cases of splenic and renal missed injuries occurred in these referred patients. Two cases of hepatic rupture, as well as 2 aortic lacerations were missed before transport, making these cases potentially preventable hemorrhagic deaths.

Death certificate information

Based on the examination by 2 reviewers of the clinical charts and autopsy reports, there was disagreement

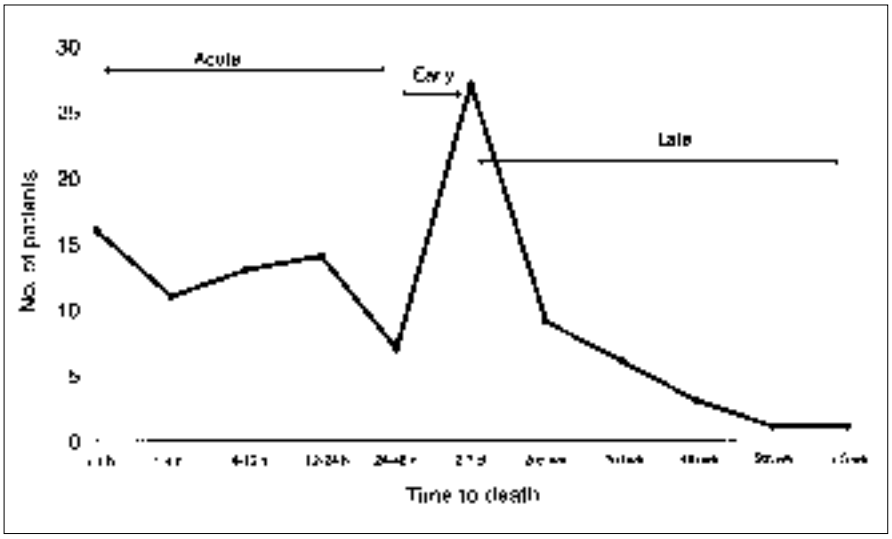

FIG. 1. Temporal relationship of the time from injury to death for acute (less than 48 hours), early (48 hours to 7 days) and late (more than 7 days) deaths due to blunt trauma in 108 cases at the London Health Sciences Centre from 1991 to 1997.

Table II

Comparison of the Median and Range Injury Severity Scores for Patients With Injuries Scored From the Chart Alone (Group 1) Versus Chart and Autopsy (Group 2)

Death subgroup	Group 1	Group 2	*p* value
All deaths	30 (5–75)	43 (14–75)	0.0001
Emergency department deaths	33.5 (10–75)	57 (19–75)	0.0001

with the treating surgeons and physicians in 43 (40%) of cases and with the coroner in 8 (7%) of cases with respect to the causes of death listed on the death certificate. The causes of death felt to be misclassified by the coroner included sepsis or multiple organ dysfunction syndrome (MODS), 4 cases inaccurately classified as neurologic injury, intestinal ischemia, 1 case in which death was inaccurately classified as "secondary to neurologic injury" and hemorrhage, and 3 cases inaccurately classified as multitrauma.

Table III

Number of Missed Injuries by Body Region for Inhospital and Emergency Department Deaths

Body region	AIS score	Total no. of cases	Missed injuries: Inhospital deaths	Missed injuries: ED deaths
Head				
Subdural hematoma	4	20	3	7
Epidural hematoma	5	3	1	0
Cerebral laceration	4	11	2	5
Diffuse axonal injury	5	20	7	1
Chest				
Cardiac injury	4–5	12	2	6
Aortic laceration	4	8	0	3
Subclavian artery laceration	4	1	0	1
Flail chest	4	8	2	1
Abdomen				
Hepatic rupture	5	10	0	2
Hepatic laceration (grade IV)	4	14	3	8
Splenic rupture	5	4	0	3
Splenic laceration (grade IV)	4	12	1	5
Intestinal or mesenteric laceration	4	13	2	2
Renal injury	4	16	2	3
Inferior vena caval laceration	4	2	2	0
Musculoskeletal				
Pelvic fracture	4	18	1	2

AIS = abbreviated injury score, ED = emergency department.

Table IV

The Numbers and Percentages by Body Region of the 77 Clinically Significant Missed Injuries for Inhospital and Emergency Department Deaths

Body region	Missed injuries, no. (%): Inhospital deaths	ED deaths	Total
Head	13 (17)	13 (17)	26 (34)
Chest	4 (5)	11 (14)	15 (19)
Abdomen	10 (13)	23 (30)	33 (43)
Musculoskeletal	1 (1)	2 (3)	3 (4)
Total	28 (36)	49 (64)	77 (100)

DISCUSSION

The problem of missed injuries in trauma patients is not well documented in the surgical literature. Injuries are commonly missed in blunt trauma patients because of the need for simultaneously rapid assessment and resuscitation (including immediate access to an operating room) in what are often complex cases. Unrecognized injuries in these cases can have a negative impact on patient outcomes. Clinically significant missed injuries, especially abdominal or cervical spine injuries, can lead to complications, high morbidity and even death.[14] Autopsies are an important source of additional injury information in this population of patients and assist the clinical team (surgeons, intensivists, emergency physicians and family physicians) in addressing this problem of missed injuries that are of clinical significance. As part of any local quality medical program, regular review and discussion of such information with clinicians involved in treating these patients is mandatory.

In our study population the majority of the deaths occurred in the acute phase, less than 48 hours after the injury. This finding is comparable to other inhospital trauma death profiles.[15–17] In this analysis, the significantly higher ISS in group 1 for both all deaths and ED deaths indicates that the autopsy report contained either additional injuries or more detailed injury severity descriptions than was present in the clinical chart. There were 77 clinically significant (AIS 4 or greater) missed injuries in 51 patients; of these, 49 injuries (64%) were missed in the 28 patients who made up the ED deaths subgroup. A recent prospective evaluation of missed injuries and the role of

the tertiary trauma service indicated a 14.5% incidence of clinically significant missed injuries, and autopsies on 12 deaths revealed new injuries (8%) that were clinically insignificant.[14]

In our review, there was a high incidence of missed abdominal and head injuries, 43% and 34%, respectively. On initial examination of these data, it is reassuring that the majority of these missed injuries occurred in the ED deaths subgroup (30% abdominal and 17% head trauma). Their significantly higher ISS and multiple injuries were indicative of a severe injury pattern incompatible with life. Accurate documentation of the injury pattern in any patient who died in the Emergency Department would be heavily influenced by the lack of diagnostic, particularly radiologic, information, which would be available for the in-hospital patients who died.

There were a number of potentially salvageable hemorrhagic ED deaths as a consequence of missed abdominal injuries in patients transferred from another institution. This discovery strongly argues for immediate general surgical intervention, if available, rather than transfer to the trauma hospital regardless of the extent of the neurologic injuries, which are the major reason for transfer to the LHSC. Such findings beg the question Should we be increasing the general surgical support network in peripheral hospitals? As part of our continuing trauma outreach program, referring hospitals are visited regularly by the trauma program team (medical director, clinical nurse specialist and emergency nurse coordinator). During these educational visits, cases referred to the LHSC by the local physicians are presented and discussed, as are issues of communication and coordination of transfers. These have been extremely helpful in understanding the management of trauma in rural Canada. Educational sessions such as these, in addition to changes in clinical assessment and investigative procedures can help to minimize the occurrence of missed injuries. The implementation of a tertiary trauma survey within 24 hours of admission, in addition to established Advanced Trauma Life Support primary and secondary survey guidelines, may aid in decreasing the incidence of missed injuries.[14,18]

This study once again confirms that the information contained in the death certificate, if completed by the treating physician, suffers from major inaccuracies. Any health policies, prevention programs or resource allocation based on such information must be regarded as suspect. It is clear that in the absence of major chart reviews by experienced clinical teams, the death certificate, if completed by the coroner, is the most appropriate and easily accessible data upon which such decisions and policies should be based. It is recognized that in many instances surgical house staff would be the medical individuals responsible for completing the death certificate. As a result of this study, an educational program in association with the local coroner's office has been undertaken to assist the members of the house staff in accurately completing death certificates. Such information has also been shared with all of the attending surgeons at the LHSC.

The incidence of MODS and systemic inflammatory response syndrome as a cause of death in this population (26%) is consistent with previous reports.[16] This seems to suggest that despite aggressive resuscitation, advanced diagnostic techniques and treatments, and early access to surgical resources continuing directed research is needed into the underlying causes and mechanisms of these syndromes in trauma patients. Any suggestion that there is a declining requirement for intensive care resources for trauma patients is not supported by the results of this study.

This study has potential drawbacks. Due to limited resources, the coroner's office was not able to undertake autopsy on all patients with trauma who died at the LHSC. Hence, the real incidence of missed injuries and inaccuracies in the death certificate information is still an estimation, based on autopsy criteria established by the coroner. With the use of new vehicle safety measures such as airbags and pre-tensioned seatbelts, new mechanisms of injury may occur, and autopsy evaluation will aid in defining the patterns and severity of these injuries. It is essential that the clinical community continue to pressure the coroner's office to undertake autopsy in as many trauma cases as possible to avoid these identifiable patterns of injury and death when new "safety" devices are introduced into either our automobiles or our homes.

This study adds to the body of surgical literature that indicates that missed injuries continue to be a concern in the management of the major blunt trauma patient. Several suggestions and actions, including regular reviews of patient deaths with autopsy results, aggressive outreach education programs, the addition of a tertiary trauma survey within 24 hours of admission and enhanced working relationships with the coroner's office are necessary to reduce these occurrences to a minimum. In addition, accurate death information is a requirement for the appropriate planning of health care policies (research and clinical), and, in our case, the planning of injury prevention programs with the public at large and with corporate Canada.

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