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Physiologic, demographic and mechanistic factors predicting New Injury Severity Score (NISS) in motor vehicle accident victims

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ABSTRACT

Background: Current literature on motor vehicle accidents (MVAs) has few reports regarding field factors that predict the degree of injury. Also, studies of mechanistic factors rarely consider concurrent predictive effects of on-scene patient physiology. The New Injury Severity Score (NISS) has previously been found to correlate with mortality, need for ICU admission, length of hospital stay, and functional recovery after trauma. To potentially increase future precision of trauma triage, we assessed how the NISS is associated with physiologic, demographic and mechanistic variables from the accident site.
Methods: Using mixed-model linear regression analyses, we explored the association between NISS and pre-hospital Glasgow Coma Scale (GCS) score, Revised Trauma Score (RTS) categories of respiratory rate (RR) and systolic blood pressure (SBP), gender, age, subject position in the vehicle, seatbelt use, airbag deployment, and the estimated squared change in vehicle velocity on impact ($(\Delta v)^2$). Missing values were handled with multiple imputation.
Results: We included 190 accidents with 353 dead or injured subjects (mean NISS 17, median NISS 8, IQR 1–27). For the 307 subjects in front-impact MVAs, the mean increase in NISS was −2.58 per GCS point, −2.52 per RR category level, −2.77 per SBP category level, −1.08 for male gender, 0.18 per year of age, 4.98 for driver vs. rear passengers, 4.83 for no seatbelt use, 13.52 for indeterminable seatbelt use, 5.07 for no airbag deployment, and 0.0003 per $(km/h)^2$ velocity change (all $p < 0.002$).
Conclusion: This study in victims of MVAs demonstrated that injury severity (NISS) was concurrently and independently predicted by poor pre-hospital physiologic status, increasing age and female gender, and several mechanistic measures of localised and generalised trauma energy. Our findings underscore the need for precise information from the site of trauma, to reduce undertriage, target diagnostic efforts, and anticipate need for high-level care and rehabilitative resources.

Introduction

Accurate pre-hospital triage of trauma victims is challenging. The long-established Guidelines for Field Triage of Injured Patients[1] utilise a two-level outcome variable, ''major trauma'' or not, to determine the adequate transport destination for a patient. This variable is generated by dichotomizing the scale of the Injury Severity Score[2] (ISS) at the value of 16. In a large general trauma population, the combination of the physiologic and anatomic criteria from the field triage guidelines only detected patients with major trauma (ISS $\geq$ 16) with a sensitivity of 46%.[1,3] Addition of mechanistic criteria (e.g. ejection from automobile) and special considerations (e.g. elderly patient) increased the cumulative sensitivity to 71% and 88%, respectively.[3] The use of mechanism of injury as a sole triage criterion has however been associated with high overtriage rates and a poor prediction of mortality in trauma victims.[1,4]

Studies of motor vehicle accidents (MVAs) have explored numerous mechanistic factors potentially predicting mortality, specific injuries, or injuries in specific body regions. However, the lack of standardised definitions of predictors and outcomes makes comparison of research findings difficult. Also, most MVA studies of mechanistic predictors have not considered simultaneous predictive effects of the subjects' on-scene physiologic status.

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Mechanistic criteria need to be regularly revised as motor vehicle (MV) technology and safety features improve.[1]

There are few reports of relationships between field prognostic criteria and the degree of injury severity. In studies utilising the full range of injury scores (0–75) as predictor, both ISS and the New Injury Severity Score[5] (NISS) have demonstrated associations with mortality after adult[6–10] and paediatric trauma,[11] length of hospital stay and ICU admission,[12,13] poor expression, feeding and locomotion at hospital discharge,[11] and functional recovery after musculoskeletal injury.[14] Thus, degree of injury severity broadly predicts trauma outcome and should be an interesting outcome variable in field trauma triage.

In the present study, we aimed to assess the simultaneous effects of physiologic, demographic and mechanistic factors on the degree of injury severity (NISS) in MVA victims. Only factors available to the emergency medical service (EMS) personnel at the accident site were explored. Our intent was that pre-hospital factors showing statistical associations with NISS later could be prospectively evaluated for their possible improvement of field triage precision after motor vehicle accidents.

Material and methods

Setting

This was an observational, cross sectional, multi-site study of injury severity in subjects involved in MVAs occurring in nine different counties in south-eastern Norway. Five emergency medical communication centre (EMCC) districts, eight local emergency medical centres and 21 hospitals provided data. Both ground and air ambulances were part of the EMS system. The ground ambulances were staffed with emergency medical technicians and/or paramedics. The air ambulances were staffed with a pilot, an experienced anaesthesiologist, and a rescue professional.

Data were collected prospectively from December 1, 2004 to January 31, 2006 in cooperation with the police and the Norwegian Public Roads Administration's regional accident analysis groups.[15,16] Based on the dispatch criterion, "MVA with suspicion of serious injury or death," the EMCC dispatched one of six research assistants (experienced paramedics) engaged in the project, in a car approved for light-and-siren responses. For each MVA, the research assistant compiled a detailed accident report, including photo documentation of the vehicles involved and accident surroundings. Police reports, including technical data and the identification of all involved subjects, were retrieved for all MVAs. Ground and air ambulance records, hospital or local emergency medical centre records, and relevant autopsy reports were also collected.

Data sources and measurements

Predictive factors

Physiologic data were the first-recorded, pre-interventional values of Glasgow Coma Scale (GCS) score, respiratory rate (RR), and systolic blood pressure (SBP) registered by ground or air ambulance personnel upon arrival on-scene.[1,15,17] RR and SBP values were recoded as Revised Trauma Score (RTS) categories (0–4).[18] When exact RR or SBP values were missing, RTS categories were coded from ambulance record check boxes and clinical descriptions if possible.[15] Demographic predictors were gender and age, because they have been found to contribute in both MVA studies and trauma survival prediction models.[8,10]

Mechanistic factors were subject position in vehicle, restraint use and trauma energy. Seatbelt use and airbag deployment was documented by the research assistants. A seatbelt was deemed to have been in use on impact if visible seatbelt load marks were present or the seatbelt emergency locking retractors (ELRs) had been activated. Correspondingly, a seatbelt was documented as not having been used when no visible seatbelt load marks were present on the seatbelt or subject, or the ELRs had not been activated. Indeterminable seatbelt use was reported for cases with inconclusive findings. Technical information regarding the presence of ELRs and airbags in various MV models was retrieved from the Crash Recovery System v. 4.0 (Crash Recovery System, Moditech Rescue Solution BV, Hoogwoud, Netherlands).[19]

The estimated change in vehicle velocity (Δv) on impact was computed for MVs involved in front-impact collisions. A front-impact collision for a given vehicle A included the following four possible scenarios: (1) vehicle A in a front-impact collision with vehicle B; (2) vehicle A going off the road and crashing head-on into an unyielding object (e.g., rock face, tree); (3) vehicle A hitting vehicle B squarely in the side (vehicle B was then defined as being involved in a side-impact collision); or (4) vehicle A hitting vehicle B in its rear end (vehicle B was then defined as being involved in a rear-impact collision).

The change in velocity during the collision was approximated assuming a conservation of momentum in the system and perfectly inelastic collisions ($\text{Mass}_A \times \text{Velocity}_A + \text{Mass}_B \times \text{Velocity}_B = (\text{Mass}_A + \text{Mass}_B) \times \text{Velocity}_{\text{Final}}$). The masses of the involved vehicles were retrieved from the MV factory specifications. Though vehicle telematics may prove a helpful tool in the future, there is currently no precise, objective way of estimating the velocities of vehicles on impact.[1] Therefore, the accident analysis groups approximated the velocity on impact using a combination of information from the MV speedometer, MV deformation, direction of impact, tire marks from the deceleration, on-scene speed limits, and EMS-documented witness observations (subjects involved in the accident). For MVs crashing head-on with an unyielding object, the final velocity was assumed to be zero, and consequently Δv was defined as the negative value of the MV's velocity on impact.

Initially, a univariate statistical analysis of the effect of Δv on NISS was conducted. For the final analyses, we chose $(\Delta v)^2$ as explanatory variable because the energy absorbed in a collision may be approximated by the change in kinetic energy, which is proportional to the square of the Δv experienced during the collision ($\Delta E = 1/2 \times \text{Mass} \times (\Delta v)^2$).

Injury data

Injuries were coded using the Abbreviated Injury Scale (AIS) 1998 catalogue[20] based on all available injury documentation.[15] The AIS is a consensus-derived, anatomically based injury scoring system that classifies individual injuries by body region on a 6-point ordinal severity scale ranging from 1 (minor) to 6 (maximum; currently untreatable). Subjects who did not fulfil the criteria for any AIS code were registered as uninjured. NISS was calculated as the sum of the squares of the patient's three highest AIS scores, regardless of body region.[5] AIS coding was performed by a nurse anaesthetist with broad trauma team experience and ten years of experience as a full-time Association for the Advancement of Automotive Medicine (AAAM)-certified trauma registrar at the Oslo University Hospital Trauma Registry.

Data analysis

Analyses were conducted using SPSS for Windows v.18 (IBM Corporation, Somers, NY, USA). Mosaic plots were generated with JMP 9 (SAS Institute Inc., Cary, NC, USA).

Data are presented as counts and percentages (%) for categorical data and medians and interquartile ranges (IQR) for continuous data. Although the distribution of NISS values was markedly