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The intermountain risk score predicts mortality in trauma patients ☆

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ABSTRACT

Purpose: Intermountain Risk Score (IMRS) uses the admission complete blood count and basic metabolic profile to predict mortality. Intermountain Risk Score has been validated in medical patients but has not been evaluated in trauma. This study tested whether IMRS is predictive of mortality in a trauma population at a level I trauma center.
Methods: Admitted trauma patients with complete blood count and basic metabolic profile from October 2005 to December 2011 were evaluated. Thirty-day and 1-year IMRS were calculated using multivariable modeling. Mortality was determined using the medical record and Social Security Administration death data.
Results: Three thousand six hundred thirty-seven females and 5901 males were evaluated. Intermountain Risk Score was highly predictive of death at 30 days (c-statistics, c = 0.772 for females; c = 0.783 males) and 1 year (c = 0.778 for females; c = 0.831 males). Cox regression analysis, adjusted for injury severity score, blunt vs penetrating, and length of stay, showed increased mortality risks among patients in the moderate- and high-risk IMRS-defined groups at both 30 days and 1 year, with hazard ratios ranging from 4.96 to 57.88 (all $P < .001$).
Conclusion: Intermountain Risk Score strongly predicts mortality in trauma patients at this single level I trauma center. The ability to accurately determine a patient's mortality risk at admission makes IMRS a potentially clinically important tool.

1. Background

Risk stratification is necessary to predict patient outcomes after trauma. Many outcome prediction models exist for trauma patients. Some of the most commonly used prediction methodologies, including the Injury Severity Score (ISS) [1,2] and the Trauma and Injury Severity Score (TRISS) [3], can be cumbersome and require trained trauma registrars and the use of valuable resources to abstract the data necessary to calculate a score. The limitations of both have been extensively documented [4,5] in the literature. Furthermore, it is nearly impossible to calculate either score while the patient is still in the emergency department (ED). For this reason, neither ISS nor TRISS is useful for acute clinical decision making. To date, there is no mortality prediction model that can be calculated almost immediately after patient arrival or has the potential to be useful in the acute trauma setting.

The Intermountain Risk Score (IMRS) is a tool developed and validated [6,7] at Intermountain Healthcare among all patients regardless of diagnosis to evaluate individual mortality risk. Intermountain Risk Score is calculated using components of the complete blood count (CBC) and basic metabolic profile (BMP) on admission, along with patient age and sex. The values needed to calculate IMRS are clinically relevant to physicians and are obtained on nearly every trauma patient admitted to the hospital. These elements make IMRS potentially useful for first-line risk stratification, not just post hoc analysis.

Although IMRS has previously been shown to be an exceptional predictor of mortality and morbidity in general medical patients [8], the general population [6], and various cardiac patient populations [7], it has never been evaluated specifically in trauma patients. The purpose of this study was to test whether IMRS, calculated at the time of admission, is predictive of mortality in admitted trauma patients at a single level I trauma center.

2. Methods

This study took place at Intermountain Medical Center in Murray, UT, an American College of Surgeons–verified level I trauma center. All trauma patients who were at least 18 years old and were enrolled in the trauma registry (Traumabase 7; Clinical Data Management, Genesee, CO) were reviewed, as long as they had a CBC and BMP performed at the time of admission. Deaths were determined using 3 methods: (1) the Intermountain electronic medical record, which covers a system of 22 acute care hospitals and many clinics and physician offices throughout Utah and Idaho, (2) electronic Utah death certificates from

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Table 1
Basic demographic and injury information for study population

Male, sex (% of total)	5923 (62.1%)
Age (y)	48 ± 22
ISS	10.9 ± 8.6
Blunt mechanism (% of total)	8851 (92.1%)
Hospital stay (d)	4.8 ± 6.0

the Utah Department of Health, and (3) the US Social Security Administration death records. If a patient was not found to be a decedent in one of these sources, he was presumed to be alive (censored). All-cause, 30-day and 1-year mortality were the primary end points, with 1-year mortality evaluated using landmark analysis in which deaths up to 30 days were excluded from the analysis. The Intermountain Healthcare Institutional Review Board approved this study.

2.1. Laboratory testing

The admission BMP and CBC measurements were performed at the time that the patient presented to the ED. For patients who arrived as full trauma team activations, these were drawn immediately upon arrival. For patients who were admitted as consults through the ED, the time to draw the laboratories was variable. Basic metabolic profile testing used the VITROS 950 platform (Ortho Clinical Diagnostics, Rochester, NY) to measure sodium, potassium, chloride, bicarbonate, blood urea nitrogen, creatinine, glucose, and calcium. Chloride and blood urea nitrogen are not used in the calculation of the IMRS because of collinearity with other factors. Complete blood count testing was done using the COULTER Gen-S Hematology Analyzer (Beckman Coulter Corp, Hialeah, FL). Hemoglobin (HGB) level, hematocrit, red cell distribution width (RDW), mean corpuscular volume, red blood cell count, platelet count, mean platelet volume, mean corpuscular hemoglobin (MCH), MCH concentration, and total white blood cell count were measured (MCH, red blood cell, and HGB were excluded due to collinearity). All CBC and BMP components were categorized into quintiles, and the 30-day and 1-year IMRS were calculated from these values, producing a scalar risk score, using a previously described and validated method [6]. The Appendix provides the values for each quintile for each variable that is used to calculate the IMRS.

2.2. Statistical analysis

For baseline characteristics, variables are summarized as mean ± SD for continuous variables. For nonnormally distributed variables, values are reported as mean ± SEM. Discrete variables are reported as percentages.

Sex-specific 30-day and 1-year IMRS were calculated using multivariable modeling of components of the CBC, BMP, and age, as described above. Three risk thresholds were established based on IMRS (high, medium, and low). The divisions between each risk threshold are based on previous work done by one member of our group (BDH) [6]. The actual divisions for the IMRS risk thresholds are as follows: females, 30-day mortality: low risk, IMRS less than 15; moderate risk, 15 to 19; high risk, 20 or more. Males, 30-day mortality: low risk, IMRS less than 15; moderate risk, 15 to 18; high risk, 19 or more. Females, 1-year mortality: low risk, IMRS less than 9; moderate risk, 9 to 14; high risk, 15 or more. Males, 1-year mortality: low risk, IMRS less than 11; moderate risk, 11 to 16; high risk, 17 or more. Cox regression analysis adjusted for age, ISS, hospital length of stay, and blunt vs penetrating trauma was performed to calculate hazard ratios and 95% confidence intervals.

Receiver operating characteristic curves were used to determine the area under the curve c-statistic from IMRS data. The c-statistic measures the ability of a predictive variable to correctly classify those with and without a study outcome as true-positives or true-negatives. It ranges from 0.5, which would mean completely random or no predictive ability to 1.0, an exact prediction. All analyses were performed in SPSS (version 21.0, IBM; SPSS Inc., Chicago, IL).

3. Results

Overall, 9538 patients (3637 female, 5901 male) met all study criteria and are included in the analysis. Basic demographic and injury information for the study population are summarized in Table 1. There were 2324, 2235, and 1342 male patients in the low-, medium-, and high-risk 30-day IMRS groups, respectively and 1472, 1360, and 805 in the female 30-day groups. In the 1-year analysis, there were 2350, 2752, and 626 males in the low-, medium-, and high-risk groups and 975, 1499, and 1037 in the female groups. This information and overall 30-day and 1-year mortality rates are summarized in Table 2A to D.

At 30 days, admission IMRS strongly predicted mortality in both males and females, with c-statistics of 0.783 in males, and 0.772 in females (Fig. 1a and b). Similarly, at 1 year, IMRS also strongly predicted mortality, with c-statistics of 0.831 in males and 0.778 for females (Fig. 2a and b).

Sex-specific Cox regression analysis, adjusted for age, ISS, hospital length of stay, and blunt vs penetrating trauma, showed higher mortality risks in the moderate- and high-risk IMRS groups as compared with the low-risk groups at both 30 days and 1 year (Table 2). In males, the hazard ratios at 30 days were 4.96 for the moderate vs low group and 13.72 for the high vs low group ($P < .001$). At 1 year, the hazard ratios were 12.64 and 57.88 for the respective group comparisons ($P < .001$). In females, hazard ratios at 30 days were 6.15 for moderate vs low and 14.95 for high vs low ($P < .001$). At 1 year, hazard ratios were 4.95 and 19.00 for the respective group comparisons ($P < .001$).

4. Discussion

This study demonstrates that sex-specific IMRS at the time of hospital admission is an excellent predictor of all-cause mortality in trauma patients at both 30 days and 1 year after injury. This is the first time that the IMRS has been used in a trauma patient population.

Table 2
Sample sizes and overall mortality

Risk level	Total N	Deaths	Mortality
A. 30 d—males			
Low	2324	11	0.5%
Medium	2235	56	2.5%
High	1342	106	7.9%
Total	5901	173	2.9%
B. 30 d—females			
Low	1472	8	0.5%
Medium	1360	50	3.7%
High	805	68	8.4%
Total	3637	126	3.5%
C. 1 y—males			
Low	2350	4	0.2%
Medium	2752	52	1.9%
High	626	53	8.5%
Total	5728	109	1.9%
D. 1 y—females			
Low	975	6	0.6%
Medium	1499	44	2.9%
High	1037	111	10.7%
Total	3511	161	4.6%