Patient-Specific Injury Score Is a Better Predictor of Outcome Than ISS in Multiply Injured Patients

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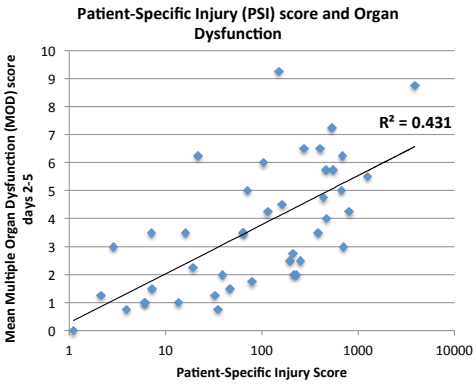
Purpose: Current injury scoring systems in trauma have limited prognostic value and are relatively nonspecific. The most frequently employed method to estimate injury burden is the ISS. The ISS has been criticized for underestimating multiple injuries within the same region and offers no guidance in treatment due to the retrospective nature of its calculation. Multiply injured patients (MIPs) sustain both mechanical and ischemic components of tissue injury. Precise methods of quantifying the injury burden may allow clinicians to better predict clinical trajectories, complications, and aid in guiding treatment such as the timing of staged orthopaedic interventions. Several recent retrospective studies of critically injured patients employing patient-specific injury measurement techniques found significant correlations between the initial magnitude of both mechanical and ischemic tissue injury and subsequent organ dysfunction. This investigation expands on this concept and evaluates the utility of a Patient-Specific Injury (PSI) score, which incorporates mechanical and ischemic tissue injury, in predicting organ dysfunction in a prospective cohort of multiply injured patients. We hypothesized that PSI scores, in comparison to ISS, would demonstrate improved correlation to organ dysfunction, multiple organ failure (MOF), and nosocomial infection (NI).

Methods: 54 consecutive MIPs ages 18-55 admitted to the ICU or taken straight to the operating room were evaluated. 4 patients declined participation and 2 additional patients had incomplete imaging, leaving 48 patients eligible for the study. Whole-body patient-specific mechanical tissue damage was quantified using a novel index termed the Tissue Damage Volume (TDV) score. TDV score calculates a volume (cm^3) of every injury sustained by a patient based on measurements made from admission CT scans of the head/neck, chest, abdomen, pelvis/retroperitoneum, and axial skeleton. Ischemic tissue injury was characterized by integrating elevated values of shock index (SI) (SI = HR/SBP [heart rate/systolic blood pressure]; SI >0.9 is a validated marker of hypoperfusion) over the initial 24 hours after injury to yield a patient-specific metric termed Shock Volume (SV). Patient-specific metabolic response was measured by calculating the difference of the minimum pH for 0-24 and 24-48 hours after injury from normal (7.40). TDV, SV, and pH deviation were integrated into a PSI score (TDV + [SV x 5] x pH deviation). The primary outcome was organ dysfunction as depicted by mean Marshall Multiple Organ Dysfunction (MOD) score on days 2- 5 (predictive of prolonged ICU admission). We also determined the presence of MOF using the MOD score criteria and the presence of NI (CDC [Centers for Disease Control and Prevention] criteria). PSI scores were compared to ISS for correspondence to mean MOD scores with linear regression. Student's *t* test was employed to compare PSI scores and ISS between groups that did or did not develop MOF and NI.

See pages 49 - 106 for financial disclosure information.

Results: PSI scores demonstrated better correlation to organ dysfunction (r^2 = 0.431) in comparison to ISS (r^2 = 0.151) as measured by the MOD score on days 2 through 5 (Fig. 1a and 1b). Mean PSI was elevated 4.7 times in patients who developed MOF versus those who did not (755.3 vs 159.7; P <0.01) (Fig. 1c). Mean PSI was 3 times higher in patients who acquired an NI (459.6 vs 143.7; P = 0.03) (Fig. 1d). There was no difference in the mean ISS of patients who developed MOF and those who did not. (34.8 vs 28.5; P = 0.13). Patients who developed NI had a higher mean ISS (35.9 vs 25.2; P <0.01).



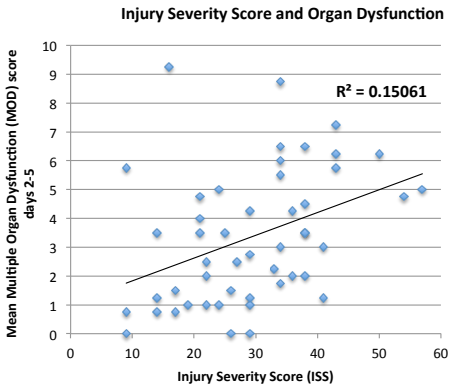


Figure 1a and 1b. The PSI score demonstrated better correlation with organ dysfunction (days 2-5) compared to ISS (r^2= 0.431 vs. r^2= 0.151).

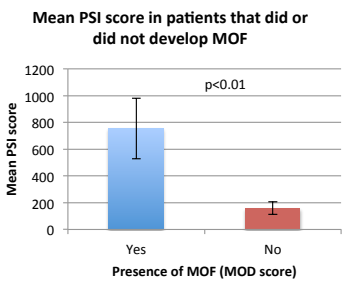


Figure 1c. The mean PSI score was nearly 4.7 times higher in patients that developed MOF (MOD score) compared to those that did not develop MOF.

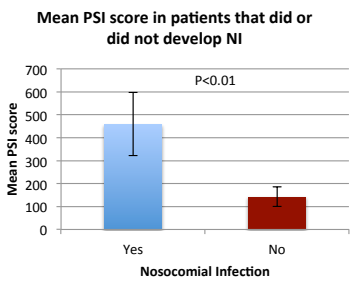


Figure 1d. The mean PSI score was over 3 times higher in patients that acquired NI compared to those that did not acquire NI.

Conclusion: This prospective investigation demonstrates that patient-specific metrics of tissue injury better determine how the overall injury burden affects meaningful clinical phenotypes compared to traditional measures such as ISS. PSI provides early identification of patients at risk of complications such as NI and MOF. This prospective study outlines a novel approach to injury assessment via precision medicine techniques in MIPs in an attempt to stratify patients at risk of complicated clinical courses. The described techniques continue to be refined and require more rigorous study in a larger population of trauma patients before clinical application. Future studies should analyze and incorporate immunologic dysregulation after trauma.