Patient-Specific Injury Profiles Predict Organ Failure in Multiply Injured Patients

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Background/Purpose: Multiply injured patients (MIPs) sustain a composite of mechanical tissue damage, ischemic tissue damage, and hemorrhage-associated hypoperfusion that is specific to the individual injury. Metabolic response to injury is also highly variable and patient-specific. Collectively, individual injury and response characteristics affect complications and outcomes. While some MIPs demonstrate an uneventful recovery, other MIPs with seemingly similar injuries develop complicated clinical courses punctuated by wound problems (coagulopathy, infection, poor wound healing), systemic inflammatory response syndrome (SIRS), multiple organ failure (MOF), and death. Early identification of MIPs at risk for complicated clinical trajectories remains a diagnostic challenge. Current injury scoring systems are granular and do not account for patient-specific injury characteristics. In addition, these systems do not quantify patient response. They are of limited value in stratifying clinical trajectories and guiding treatment, including subsequent orthopaedic interventions. In this study, we explore a new paradigm by quantifying early (within 48 hours of trauma) individualized critical components of injury including mechanical tissue damage, magnitude and duration of shock, and acute metabolic response to establish a Patient-Specific Injury (PSI) score. We hypothesized that PSI scores would accurately stratify patient risk for MOF.

Methods: 72 consecutive adult (18-65 years) MIPs (ISS >18) admitted to the intensive care unit (ICU) for a minimum of 7 days were studied retrospectively. We collected vital signs and laboratory values during ICU admission, and accessed all admission imaging studies. Total body patient-specific mechanical tissue damage was quantified using a novel index (Tissue Damage Volume Score [TDVS]). TDVS calculates a volume (cm3) of every injury sustained by a patient based on measurements made from admission CT scans and radiographs. Total body TDVS was subdivided by tissue type and body region (head/neck, chest, abdomen, pelvis, extremities). Hypoperfusion was calculated by integrating elevated values of shock index (SI) (SI = heart rate/systolic blood pressure; SI >0.9 is a validated marker of hypoperfusion) over time to yield a patient-specific metric termed Shock Volume (SV). Patient-specific metabolic response was measured by calculating the difference of mean pH for the first 48 hours after injury from normal (7.40). TDVS, SV, and pH deviation were integrated into a PSI score. PSI scores were compared to Sequential Organ Failure Assessment (SOFA) scores with linear regression to determine correlation between PSI profiles and organ failure. The SOFA score is a validated outcome instrument that measures organ failure in trauma patients and was utilized as the primary outcome in this study.

Results: Total body PSI scores (Figure 1a) correlated well with organ dysfunction over the entire population. Pelvic PSI scores (Figure 1b) and abdominal PSI scores (Figure 1c) correlated more closely with organ dysfunction. Chest PSI scores corresponded to organ dysfunction, but the variability was greater (Figure 1d). There was minimal correlation between extremity and head/neck PSI scores and organ dysfunction (not shown).

See pages 47 - 108 for financial disclosure information.

Conclusion: It has been postulated that the magnitude of mechanical and ischemic tissue injury and resuscitation dictate patient response and orchestrate clinical trajectories in MIPs. Our data demonstrated that patient-specific indices measured early during the injury period (mechanical tissue damage, hypoperfusion, metabolic response) collectively predicted subsequent organ dysfunction on an individual basis. PSI scores in patients sustaining axial trauma (chest, abdomen, and pelvis) were more accurate in predicting subsequent organ dysfunction. Such information could prove to be clinically relevant in timing interventions, including major orthopaedic operations. Although preliminary, this research offers a novel approach of applying personalized medicine to trauma patients.

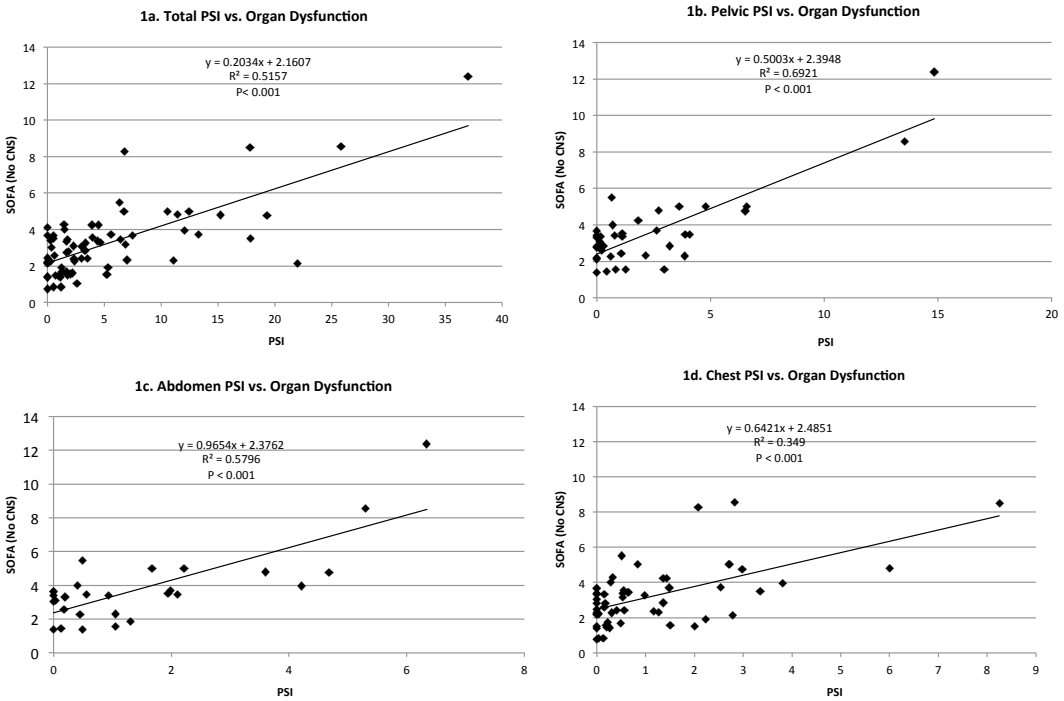

Figure 1: PSI Scores vs. organ dysfunction. Organ dysfunction was measured by SOFA scores. The CNS component was purposefully omitted from SOFA scores to improve clinical accuracy in an ICU patient population. Organ dysfunction correlated to PSI scores calculated from total body TDVS (Fig 1a), pelvis TDVS (Fig 1b), abdominal TDVS (Fig 1c), and chest TDVS (Fig 1d). PSI was most predictive of organ dysfunction in patients sustaining pelvic ($R^2 = 0.69$) and abdominal trauma ($R^2 = 0.58$).