Shock Volume May Serve as an Early Predictor of Organ Dysfunction in Orthopaedic Polytrauma

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Purpose: The timing of fracture surgery in orthopaedic polytrauma patients is driven by resuscitation status and acidosis. Shock Volume is a patient-specific index of cumulative hypoperfusion that integrates serial vital signs and has shown improved correspondence to adverse short-term outcomes compared to traditional surrogates of acidosis (lactate, base deficit, and pH). The purpose of this study was to compare the association between Shock Volume, lactate, and pH against development of organ dysfunction.

Methods: This is an a priori planned secondary analysis of the multicenter PRECISE prospective observational trial of polytrauma patients (18-55 years, ISS>15) with pelvis, acetabulum, femur, and/or tibia shaft fractures across 10 Level I North American trauma centers from 2018-2022. The primary outcome was the Marshall Organ Dysfunction Score averaged from days 2-5 (aMODS2-5). Sequential measurements of shock index (heart rate/systolic blood pressure) above a hypoperfusion threshold of 0.9 were integrated into distinct 3, 6, 12, and 24-hour periods post-injury to quantify Shock Volume. Patients were stratified into quartiles based on Shock Volume and Kaplan-Meier survival analysis assessed time to complete resolution of organ dysfunction. Logistic regression was used to establish the predictive accuracy of Shock Volume, lactate, and pH to discriminate patients with high (aMODS2-5 ≥3) and low (aMODS2-5 <3) organ dysfunction.

Results: 230 polytrauma patients were enrolled (146 with low aMODS2-5 and 84 with high aMODS2-5). The high aMODS2-5 group had a greater Shock Volume at all time points (3-hour 20.3 vs 2.6, 6-hour 41.7 vs 9.3, 12- hour 77.4 vs 17.3, 24-hour 81.9 vs 15.0; P<0.001 for all). Kaplan-Meier analysis demonstrated that a lower probability of organ dysfunction resolution was associated with higher Shock Volume quartiles (P<0.001).
Receiver operating characteristic (ROC) curve analysis revealed that Shock Volume provided good discrimination in predicting high vs low aMODS2-5 (3-hour area under the ROC curve [AUC] = 0.84; 6-hour AUC = 0.86; 12-hour AUC = 0.87, 24-hour AUC = 0.84), outperforming admission lactate (AUC = 0.67; P = 0.022) but not admission pH (AUC = 0.78; P = 0.253).

Conclusion: Shock Volume is a patient-specific index that risk-stratifies organ dysfunction as early as 3 hours post-injury. Identification of patients at risk of organ dysfunction, in conjunction with measures of acidosis, may help inform clinical decisions surrounding fracture fixation timing in polytrauma patients.