Compensatory Reserve Index Detects Subclinical Phases of Shock and More Expeditiously Predicts the Need for Life-Saving Interventions: Comparison with Vital Signs and Arterial Lactate Metrics

Michael C Johnson, MD¹, Victor Convertino, PhD², Kevin Chung, MD², Jeffrey Howard, PhD², Alicia Schiller, PhD², Abdul Alarhayem, MD¹, Ronald Stewart, MD¹, David Wampler, PhD¹, Mark DeRosa¹, Brian Eastridge, MD¹
¹ UT Health San Antonio, San Antonio, Texas
² US Army Institute of Surgical Research, San Antonio, Texas

Background:

Hemorrhage is the leading cause of preventable death after injury on the battlefield and in the civilian environment. Prehospital providers attempt to identify bleeding by clinical cues, but the early stages of hemorrhagic shock may be occult at the time of assessment and difficult to identify with clinical skills and rudimentary tool sets available in the field. Hypotension identified by standard vital signs is a latent manifestation of decompensation secondary to hemorrhage. The prompt identification of shock expedites resuscitation and treatment strategies and is associated with improved casualty outcomes. Identification of shock in the subclinical phase could potentially facilitate improved clinical decision making and accelerate the provision of life-saving interventions (LSI). We hypothesized the Compensatory Reserve Index (CRI) would more readily identify patients at risk to progress to shock and/or need life-saving intervention when compared to standard assessment metrics.

Methods:

A prospective observational study was performed analyzing CRI during the acute resuscitation phase of injured patients evaluated at a level I trauma facility. The analysis consisted of 205 injured patients with requisite inclusion measures of continuous CRI, arterial lactate, and systolic blood pressure (SBP) at admission and concurrent with blood lactate measurement. The composite outcome measurement included blood transfusion, procedural LSI, and mortality. LSI was defined as
intubation, tube thoracostomy or hemorrhage control procedures (tourniquet, operation, and/or angiography). Discrete measures assessed as abnormal were SBP <90 mmHg, CRI <0.60, and lactate >2.0. The graded categorization of shock was defined as follows: no shock (normal SBP, CRI and lactate); subclinical shock (normal SBP, abnormal CRI, normal lactate); occult shock (normal SBP, abnormal CRI and abnormal lactate or normal SBP, normal CRI, abnormal lactate); and overt shock (abnormal SBP, CRI, and lactate). Descriptive statistics and odds ratios (OR) from multivariable ordinal and binary logistic regression models assessed associations between initial SBP and CRI, and subsequent measurements of deterioration to shock, positive lactate, and the composite outcome.

Results:

The sample population was substantively male (65%) with a mean age of 46. The analysis demonstrated that 86 (41.9%) patients manifest no shock, 25 (12.2%) patients were classified as subclinical shock, 91 (44.4%) patients were classified as occult shock, and 3 (1.5%) were characterized as overt shock. Proportional analysis of each shock subcategory revealed a graded increase in those requiring LSI and transfusion. Rates of LSI and transfusion for each category were developed as follows: no shock (7% and 3%), subclinical shock (13% and 9%), occult shock (26% and 20%), and overt shock (100% and 67%). Logistic regression models showed initial SBP was not associated with progression to overt shock (OR=1.00; p=0.60) or abnormal lactate (OR=1.00; p=0.67) but was associated with the composite outcome (OR=0.98; p=0.02). Initial CRI was associated with progression to shock (OR=0.97; p<0.001), abnormal lactate (OR=0.97; p<0.001) and the composite outcome (OR=0.97; p<0.001).

Conclusions:
Initial measures of CRI were significantly associated with progression to shock, abnormal lactate, and the composite outcome. These data suggest CRI could be used to more expeditiously identify injured patients likely to deteriorate to shock, require blood transfusion, or require lifesaving intervention.