

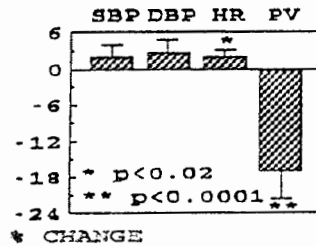
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### Early Noninvasive Detection of Hypovolemia Secondary to Acute Blood Loss Using Pulse Volume Analysis

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Hypovolemic shock is difficult to recognize in its early stages because clinically significant changes in heart rate (HR), blood pressure (BP), and urine output occur late in its course. This study was conducted to determine if changes in peripheral pulse volume (PV) occur early in acute blood loss, prior to clinically significant changes in HR or BP. PV is defined as the maximum change in volume of a limb segment (e.g. calf) occurring during the cardiac cycle and is measured noninvasively with a digitally enhanced admittance plethysmograph. HR, systolic BP (SBP), diastolic BP (DBP), and calf PV (in microliters,  $\mu\text{L}$ ) were measured in 35 male blood donors (age =  $38.7 \pm 11.1$  [sd] yrs, weight =  $97.7 \pm 15.3$  [sd] kg) before and after donating a unit of whole blood (the average blood loss was  $5.3 \pm 0.9$  [sd] ml/kg). Pre and post donation measurements were compared using paired Student's t-test. The results (mean  $\pm$  se) are tabulated below and illustrated above:

	Pre-Donation	Post-Donation	Change	Significance
HR (/min)	$68.5 \pm 1.5$	$69.8 \pm 1.5$	$1.4 \pm 0.6$	$p < 0.02$
SBP (mmHg)	$143.1 \pm 2.5$	$145.8 \pm 3.1$	$2.9 \pm 2.3$	n.s.
DBP (mmHg)	$73.2 \pm 2.0$	$75.7 \pm 1.7$	$1.9 \pm 1.5$	n.s.
PV ( $\mu\text{L}$ )	$1151 \pm 64$	$954 \pm 39$	$-197 \pm 53$	$p < 0.0001$



There were no significant changes in either SBP or DBP. The HR increased significantly, but by only 2.0% ( $p < 0.02$ ). The PV decreased by 17.1% ( $p < 0.0001$ ), which is 8.6 times greater than the percent change in heart rate ( $p < 0.01$ ). The PV decrease correlated with the blood loss per kg ( $r = 0.46$ ,  $p < 0.01$ ). We conclude that a significant change in PV occurs with relatively minor blood loss. Pulse volume analysis may therefore provide an early indication of hypovolemia due to acute blood loss.

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