

Passive Leg Raise (PLR) Test as a Predictor of Tolerance to Lower Body Negative Pressure (LBNP)

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Introduction: Fluid responsiveness (FR) is reported to be the ability to increase stroke volume (SV) in response to fluid administration¹. Passive leg raising (PLR) creates a transient increase in biventricular preload and has shown the capability to predict fluid responsiveness². LBNP creates a reversible hypovolemic state by sequestering blood in the lower extremities³. This study sought to examine the ability of stroke volume percent change during (PLR) to predict the extent of tolerance to hypovolemia during Lower body negative pressure (LBNP).

Methods: With IRB approval 12 subjects underwent PLR at 45° angle for 2 min followed by progressive LBNP protocol at -15 mmHg, -30 mmHg, -45 mmHg, -60 mmHg, -75 mmHg and -85 mmHg. Each patient was monitored for heart rate (HR), continuous noninvasive arterial blood pressure (CNAP) (CNSystems, Austria), Noninvasive CO monitor (NICOM) (Cheetah medical, MA, USA) streaming stroke volume (SV), cardiac index (CI) noninvasively at 8s intervals. These parameters were measured at baseline, during LRT and during progressive LBNP, Subjects were classified as high tolerance (HT) and low tolerance (LT) based upon the development of symptoms of hypovolemia such as lightheadedness, nausea, diaphoresis and shortness of breath at LBNP -75 mmHg or earlier. Unpaired t-test was used to assess the difference in the mean percent change in SV ($\Delta SV\%$), CI ($\Delta CI\%$) and HR ($\Delta HR\%$) with PLR between the HT and LT groups, p -value of < 0.05 was accepted statistically significant. ROC curve was constructed to examine the accuracy of SV change in response to PLR in predicting tolerance to LBNP.

Results: During LBNP 6 out of 12 were (LT) and 6 were (HT). There was a statistically significant difference between the HT and LT groups in terms of $\Delta CI\%$ and $\Delta SV\%$ during PLR, while difference in $\Delta HR\%$ wasn't significant (table-1). Using $\Delta SV\%$ ROC curve (figure-1) yielded cut-off of ($\Delta SV\% = 12.8\%$) with 100% sensitivity, 95% CI (54-100%) and 83% specificity, 95% CI (36-99%). AUC is 0.89, 95% CI (0.67-1.1) ($p = 0.025$) to predict tolerance to LBNP-induced hypovolemia.

Discussion: LRT is associated with 300 cc of auto transfusion⁴. Thus, even small volume of fluid will have a great impact on CI attributed to changes in SV and not the HR. A threshold of $\geq 12.8\%$ increase in SV with PLR predicted with great sensitivity the tolerance to central hypovolemia induced by the LBNP model.

References:

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2. Monnet X, Rienzo M, Osman D, Anguel N, Richard C, Pinsky MR, Teboul JL: Passive leg raising predicts fluid responsiveness in the critically. Crit Care Med. 2006 May;34(5):1402-7.
3. Cooke, W.H., K.L. Ryan, and V.A. Convertino, Lower body negative pressure as a model to study progression to acute hemorrhagic shock in humans. J Appl Physiol (1985), 2004. 96(4): p. 1249-61.
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Figure 1:

Table 1	HT	LT	<i>p-value</i>
ΔCI% mean \pmSD	9.4 \pm 8.8	21.8 \pm 6.3	0.018
ΔSV% mean \pmSD	8.8 \pm 7.6	19.1 \pm 6.7	0.046
ΔHR% mean \pmSD	0.8 \pm 3.5	1.9 \pm 3.3	0.58