Impact of Different Breathing Patterns on Peripheral Venous Pressure (PVP)

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Introduction: It has been suggested that peripherally transduced venous pressure (PVP) from a standard intravenous correlates well with central venous pressure and thus they could be used interchangeably.[1-4] The PVP is also interesting because unlike the CVP, it is independent of the direct impact of changes in thoracic pressure. Our study sought to explore the physiology of different breathing maneuvers [Muller, Valsalva and Incentive Spirometry (IS)] using the PVP waveforms. Muller maneuver consists of forced inspiratory effort against an obstructed airway. The sudden imposition of negative intrathoracic pressure leads to an abrupt decrease in left atrial volume and a decrease in left ventricular systolic performance. These changes reflected an increase in left ventricular afterload.[5] Valsalva maneuver consists of an expiratory effort against a closed glottis; the resulted increased intrathoracic pressure reduces venous return and results in a transient drop in average blood pressure and in pulse pressure.[6] Taking deep breaths through incentive spirometry will increase the lung volume quickly and results in reduction of right atrial preload as well as an increase in afterload of the right ventricle.[7]

Methods: With IRB approval, 11 healthy volunteers were recruited. Breathing pattern protocol consists of Muller breathing, Valsalva maneuver and taking deep breaths through the incentive spirometer for 12 breaths (encouraging the subjects to move 3 balls), with spontaneous breathing preceding each maneuver. PVP signals were recorded from a transduced intravenous catheter at the hand at 100 Hz with GE S/5 Collect system and analyzed with LabChart 7.3.7 (ADInstruments). Data were summarized as mean ±SD and analyzed using a paired t-test. P value <0.05 were considered statistically significant.

Results: In comparison to the preceding spontaneous breathing, Muller, Valsalva and IS breathing showed significant increase in mean PVP (3.1 mmHg ±1.4 vs.1.2±0.5), (7.1 mmHg ±3.8 vs.1.3±0.5) and (4.7 mmHg ±2.7 vs. 1.3±0.4) respectively. The percent change of PVP height were 151.8%, 446% and 254% during Muller, Valsalva and IS breathing respectively figure (1).

Conclusion: The cardiopulmonary interaction of Muller, Valsalva maneuver and IS showed significant increase in the PVP amplitude (mean venous pressure) as a result of changes in preload and/or afterload of the heart. Characterization of the changes in the morphology of the PVP waveform may yield valuable information about a patient's cardiovascular status. One advantage of the IS over the other 2 breathing maneuvers is that the breaths are standardized and therefore were similar in flow rate and depth. We were surprised to discover that IS breathing appears to create a positive pressure 'venous shockwave' that has similar characteristics to that of positive pressure ventilation.

References:
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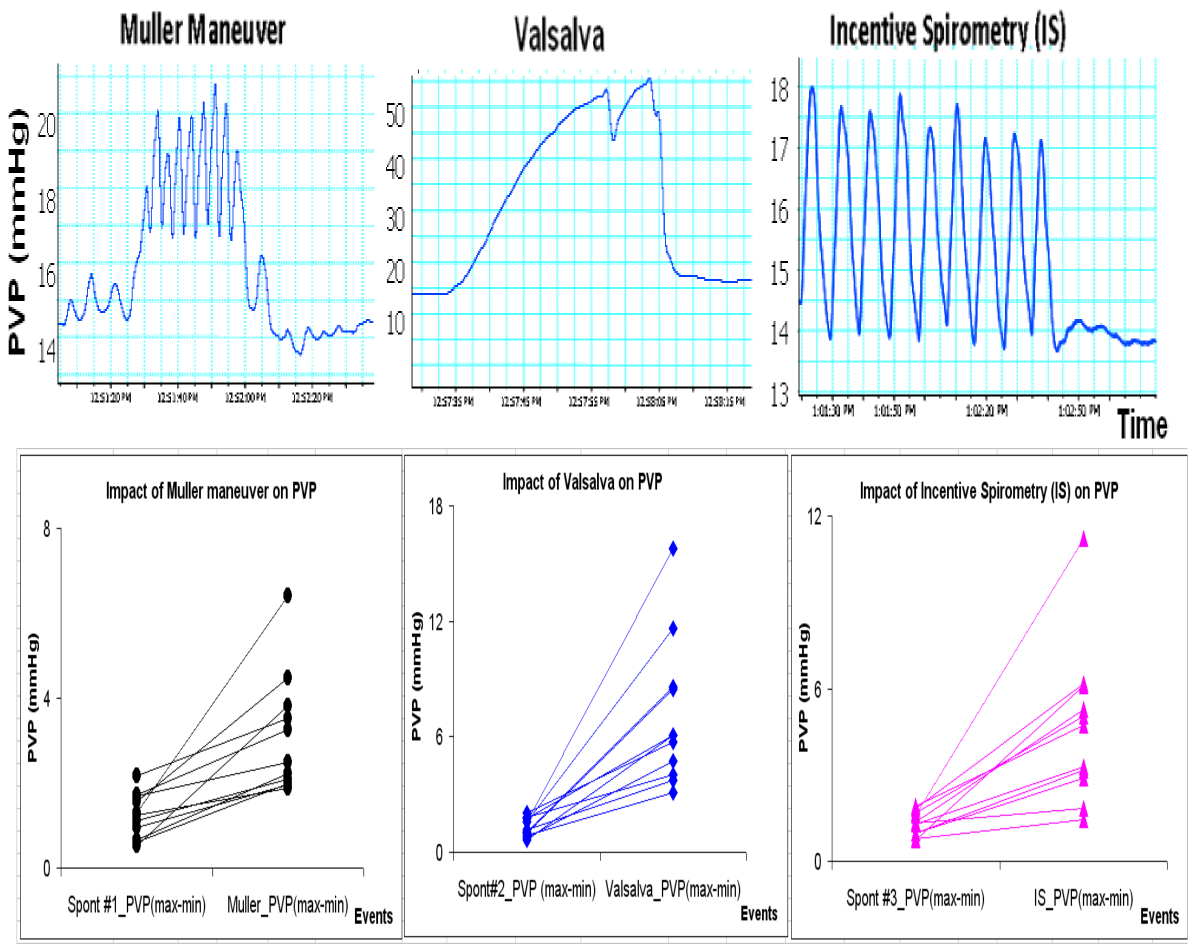

Figure (1): upper panel: An example of the peripheral venous pressure (PVP) waveform during different breathing patterns. The lower panel: graphs represent the impact of different breathing patterns on PVP