Carotid Doppler ultrasonography: A novel method to predict fluid responsiveness in mechanically ventilated children

Thalita Belato de Souza, MD\textsuperscript{a}; Aline Junqueira Rubio, MD\textsuperscript{a}; Marcelo B. Brandão, MD, PhD\textsuperscript{a}; Roberto J. N. Nogueira, MD, PhD\textsuperscript{a, b} and Tiago H. de Souza, MD, PhD\textsuperscript{a}

Affiliations:

\textbf{a.} Pediatric Intensive Care Unit, Department of Pediatrics, Clinics Hospital of the State University of Campinas (UNICAMP), Campinas, SP, Brazil.

\textbf{b.} Department of Pediatrics, School of Medicine São Leopoldo Mandic, Campinas, SP, Brazil

\textbf{Objective:} The aim of this study was to investigate whether respiratory variations in carotid and aortic blood flows measured by Doppler ultrasonography could accurately predict fluid responsiveness in critically ill children.

\textbf{Methods:} This was a prospective single-center study including mechanically ventilated children who underwent fluid replacement at the discretion of the attending physician. A response to fluid load was defined by a stroke volume increase of more than 15%. Doppler ultrasonographic measurements of velocity peaks (Vpeak) in carotid and aortic blood flows were performed before and after volume expansion. Maximum and minimum values of Vpeak were determined over one controlled respiratory cycle. Respiratory changes in Vpeak of the carotid (∆Vpeak\textsubscript{Ca}) and aortic (∆Vpeak\textsubscript{Ao}) blood flows were calculated as the difference between maximum and minimum values divided by the mean of the two values and were expressed as a percentage.

\textbf{Results:} A total of 24 patients were included with median age and weight of 28 months (IQR 9.5 – 68.5) and 10 kg (IQR 5.7 – 20.0). The volume expansion-induced increase in stroke volume was > 15% in 9 patients (responders) and < 15% in 15 patients (nonresponders). Before volume expansion, both ∆Vpeak\textsubscript{Ca} and ∆Vpeak\textsubscript{Ao} were higher in responders than in nonresponders (17.7% vs 4.6%; \(p < 0.001\) and 23.8% vs 4.7%; \(p < 0.001\), respectively). ∆Vpeak\textsubscript{Ca} could effectively predict fluid responsiveness (area under the ROC curve [AUC] 1.00, 95\%CI 0.86-1.00), as well as ∆Vpeak\textsubscript{Ao} (AUC 0.96, 95\%CI 0.78-0.99). The best cut-off values were 10.6\% for ∆Vpeak\textsubscript{Ca} (sensitivity, specificity, positive predictive value and negative predictive value of 100\%) and 18.2\% for ∆Vpeak\textsubscript{Ao} (sensitivity, 88.9\%; specificity, 93.3\%; positive predictive value, 88.9\%; negative predictive value, 93.3\%). Volume expansion-induced changes in stroke volume correlated with the ∆Vpeak\textsubscript{Ca} and ∆Vpeak\textsubscript{Ao} before volume expansion (Pearson correlation coefficient of 0.68 and 0.64, respectively; \(p < 0.001\) for both).

\textbf{Conclusion:} Analysis of respiratory changes in carotid and aortic blood flows are accurate methods for predicting the hemodynamic effects of volume expansion in children under invasive mechanical ventilation.