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The influence of respiration on blood flow in children – validation by realtime MR velocity mapping at 3 Tesla

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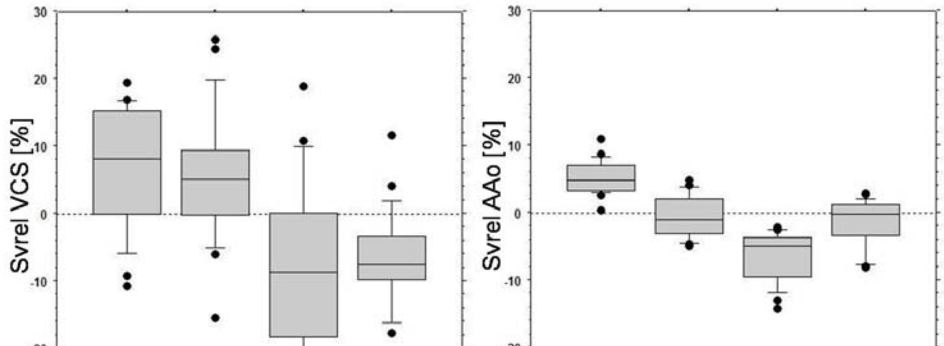
Introduction: Respiration can strongly influence cardiac preload which is especially important for children with CHD. We investigated realtime quantitative flow (QF) in healthy children with high temporal resolution to get unique hemodynamic information during respiratory phases.
Methods: QF was recorded on a 3T-TXMR scanner (Philips) using a non-triggered, free-breathing, real-time phase-contrast EPI sequence (RT-QF,In-plane resolution 2.7x2.7 mm^2, slice thickness 6 mm, acquisition time 12s). Temporal resolution below 25 ms was achieved using a SENSE factor of 4 combined with half-Fourier. Measurements were performed in the ascending aorta (AAo) and vena cava superior (VCS) in 23 healthy kids (13 male, age=13.6±3.6y) and compared with a validated conventional QF sequence (Ref-QF). Respiratory volumes were assessed using a Spirostik (Fa Geratherm) simultaneously.
Results: High agreement was observed comparing "mean" SV provided by RT-QF and Ref-QF in AAo (mean±SD; limits-of-agreement: 3.0±11%; -18.9 to 25, r=0.934), whereas some higher overestimation was found for RT-QF in VCS (10.0±10.6%; -11.1 to 31.1, r=0.882) using Bland Altmann statistics. RT-QF SV varied much more in the VCS than in the AAo during respiration (mean±SD [%]; deep expiration, inspiration, deep inspiration and expiration. VCS: 6.7 ± 8.9; 5.6 ± 9.6; -7.3 ±12.5; -6.7 ± 7.6, AAo: -5.4 ± 2.4; -0.6 ± 3.1; -6.5 ± 3.6; -1.2 ± 3.4). ANOVA demonstrates that all volumes belonging to the various respiratory phases are statistically different of each other for VCS and AAo (p < 0.001) except the relation "deep expiration/inspiration" (p= 0.69, VCS), "deep inspiration/expiration" (p=0.85, VCS) and "inspiration/expiration" (p=0.52, AAo). With forced in- and expiration this differences in respiration-dependent flow augmented parallel to the respiratory volumes.



Conclusions: The impact of the dynamics of respiration on blood flow pattern in thoracic vessels can precisely be quantified in healthy children using RT-QF. This may especially be important for the assessment of children with a Fontan´s circulation. Furthermore it raises the question to what extent flow in the great thoracic vessels is attenuated by breath-holding if fast flow mapping methods are applied. Using RT-QF, no respiratory gating or ECG triggering are needed. Furthermore, cardiac arrhythmia should no longer preclude safe and reliable flow measurements.