PW2-9

Development and validation of a novel automated learning based algorithm for quantification of MRI right ventricular volume in Tetralogy of Fallot

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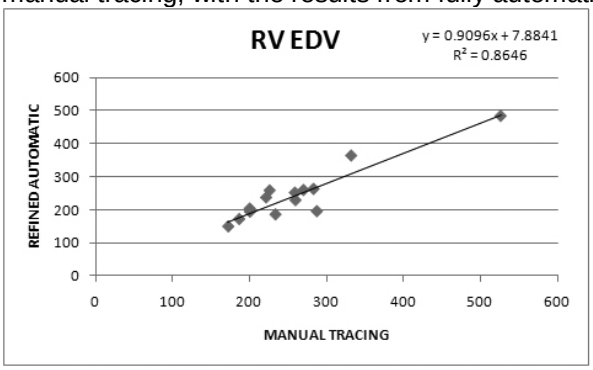
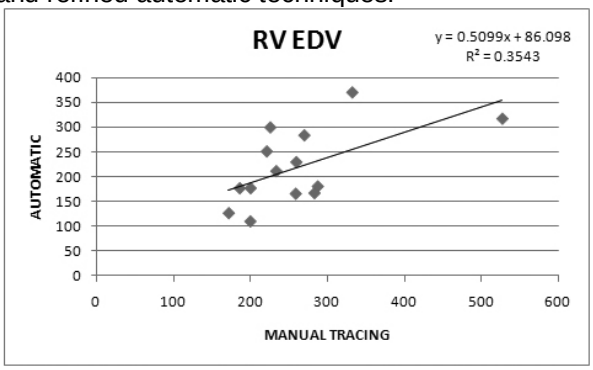
Introduction or Basis or Objectives: Quantification of right ventricular volume (RVV) and ejection fraction (EF) in patients with complex congenital heart disease is essential and currently requires manual time consuming endocardial tracing. We compare the accuracy and post processing time of a novel automated learning-based algorithm (LBA) with current methods.

Methods: LBA relies on robust machine learning methods to capture complex statistics of right ventricular shape and appearance in cine steady-state free precession or gradient images. The LBA, previously trained on 114 patients with Tetralogy of Fallot (TOF), is applied to automatically estimate the three-dimensional RV boundary from images of unseen patients. To validate the LBA method, we examined 15 additional patients with TOF and compared three methods blindly in measuring RVV and EF: current standard manual tracing (M-TRACE), fully automated LBA (AUTO), and LBA with manual boundary refinement of fully automated tracings (R-AUTO). Using linear regression, right ventricular systolic (RVESV) and diastolic volumes (RVEDV) and EF were compared between manual and automated methods. Average processing time per patient was compared between techniques.

Results:
Mean processing time (minutes) per patient was significantly reduced using the fully automated method but not when adding the overhead of manual correction: M-Trace, 5.7±0.9; AUTO, 0.7 ($p<0.001$); and R-AUTO, 16.2±2.0 ($p< 0.002$). Results from manual tracing demonstrated poor correlation with diastolic volumes (RVEDV AUTO 0.595; R-AUTO, 0.930); good correlation with systolic volumes (RVESV AUTO, 0.874; R-AUTO, 0.918), and superior EF measures (AUTO, 0.854; R-AUTO, 0.633). LBA volume inaccuracy was most commonly due to incorrect identification of the tricuspid and pulmonary annuli. The figure below displays the relationship of RVEDV as measured by manual tracing, with the results from fully automatic and refined automatic techniques.





Conclusions:
Our fully automated LDA method markedly reduces the time necessary to complete volumetric assessment of right ventricular function but due to failure to delineate accurately the tricuspid and pulmonary valve annuli, underestimates predominately diastolic right ventricular volume. With additional case training, LBDA offers the opportunity to develop fully automatic volumetric measures to overcome the complexity of right ventricular function assessment of congenital heart disease and thereby reduce operator variability.