Comparison of 4D flow and 2D PC MRI Blood Flow Quantification in Children and Young Adults with Congenital Heart Disease

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Introduction

- **Echocardiography is the primary imaging modality for assessment of aortic and pulmonary blood flow velocities.**

- **2D phase contrast (PC) MRI provides better access to all segments of the aortic and pulmonary system and is considered the standard for quantifying blood flow.**

- **Both techniques are limited by velocity analysis in 2D planes and by single-direction velocity measurement which may be inadequate to characterize the complex 3D hemodynamics in congenital heart disease (CHD).**

- **4D flow MRI provides simultaneous assessment of 3D blood flow characteristics of all vessels within a 3D volume and offers the ability to retrospectively quantify blood flow parameters at selectable regions of interest.**

- **<u>PURPOSE:</u> To determine the accuracy of 4D flow for quantification of aortic and pulmonary flow parameters compared to the reference standards 2D PC MRI and echo in children and young adults with CHD.**

Methods

- **50 patients with CHD (mean age: 13.1 ± 6.4 years) who underwent simultaneous 4D flow and 2D PC MRI (N=50) and echo (N=36) within 9 months of MRI (mean time interval: 2.9 ± 2.3 months) were retrospectively included (Table 1).**

- **2D PC MRI flow studies (1 mm in-plane spatial res, 30 true phases/cardiac cycle temp res) of the aortic root (Ao), pulmonary trunk (PT), and right and left pulmonary arteries (RPA, LPA) were analyzed (Medis, Leiden, The Netherlands).**

- **4D flow (2.5 mm in-plane spatial res, 80 ms temp res) analysis included calculation of a 3D- PC-angiogram (Figure 1) which was used to position analysis planes in the Ao, PT, LPA and RPA (EnSight, CEI, Apex, NC).**

- **4D flow and 2D PC MRI net flow, regurgitant fractions, and peak velocities were calculated. Ao and MPA peak velocities were obtained by echo.**

- **Linear regression analysis comparison of 4D flow and 2D PC MRI data was performed. Pearson's correlation coefficient (r) was calculated. $p<0.05$ was considered significant.**

Results

Table 1: Patient population characteristics

Number of patients	Patient Diagnosis
12	TOF/DORV, post repair
7	d-TGA, post arterial switch
5	post Ross procedure
3	Coarctation
3	post Fontan
4	ASD +/- VSD
16	Other CHD

Abbreviation key: TOF, tetralogy of Fallot; DORV, double outlet right ventricle; d-TGA, d-transposition of the great arteries; ASD, atrial septal defect; VSD, ventricular septal defect.

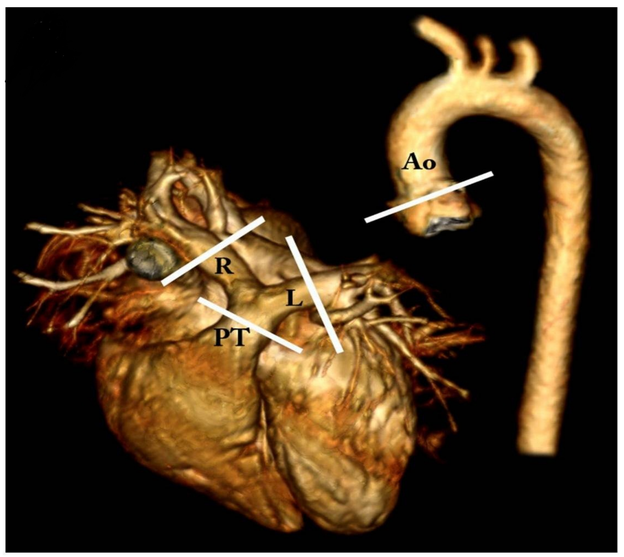

Figure 1. Location of analysis planes in the aorta and pulmonary system used for flow quantification based on 2D CINE PC and 4D flow MRI. *Ao: Aorta, PT: Pulmonary trunk, R/L: right/left pulmonary artery.*

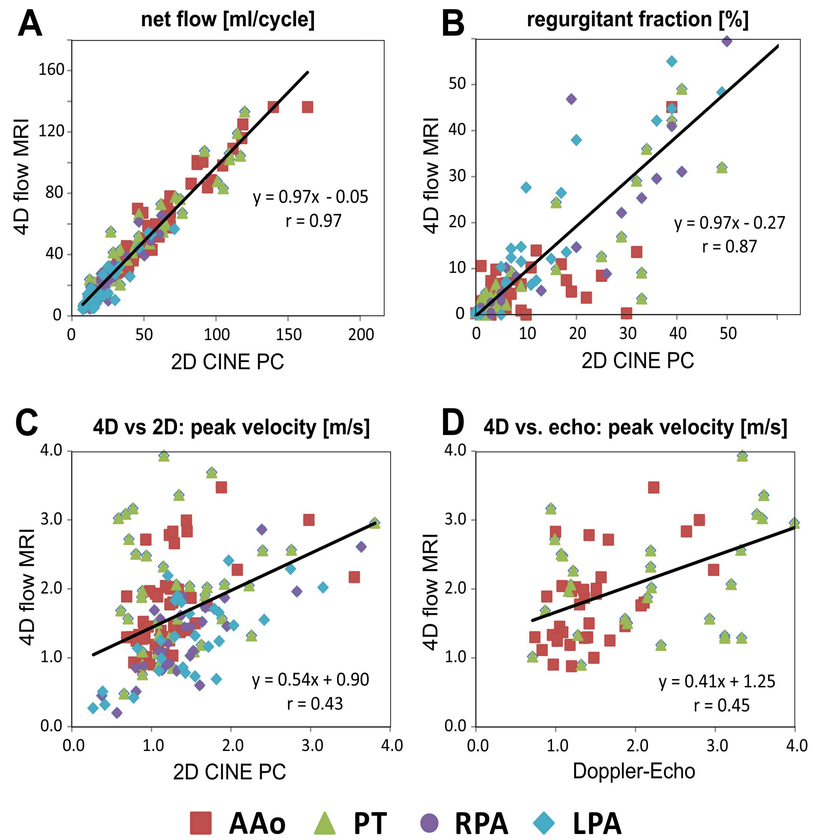

Figure A - **Net flow analysis.** Excellent agreement between 4D flow and 2D PC MRI ($r=0.97$, $p<0.001$).

Figure B - **Regurgitant fraction analysis**. Excellent agreement between 4D flow and 2D PC MRI ($r=0.87$, $p<0.001$).

Figure C - **Peak velocity analysis 4D vs 2D.** Moderate relationship between 4D flow and 2D PC MRI ($r=0.43$, $p<0.001$).

Figure D - **Peak velocity analysis 4D vs echo.** Moderate relationship between 4D flow and echo ($r=0.45$, $p<0.001$).

Conclusions

- 4D flow MRI quantification showed good-excellent correlation for flow parameters used to characterize CHD including Ao and PT net flow and regurgitant fractions, and a moderate relationship with Ao and PT peak velocities compared to the standards of 2D PC MRI and echo.