

ORAL PRESENTATION

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Phantom validation of 4D flow: independent validation of flow velocity quantification using particle imaging velocimetry

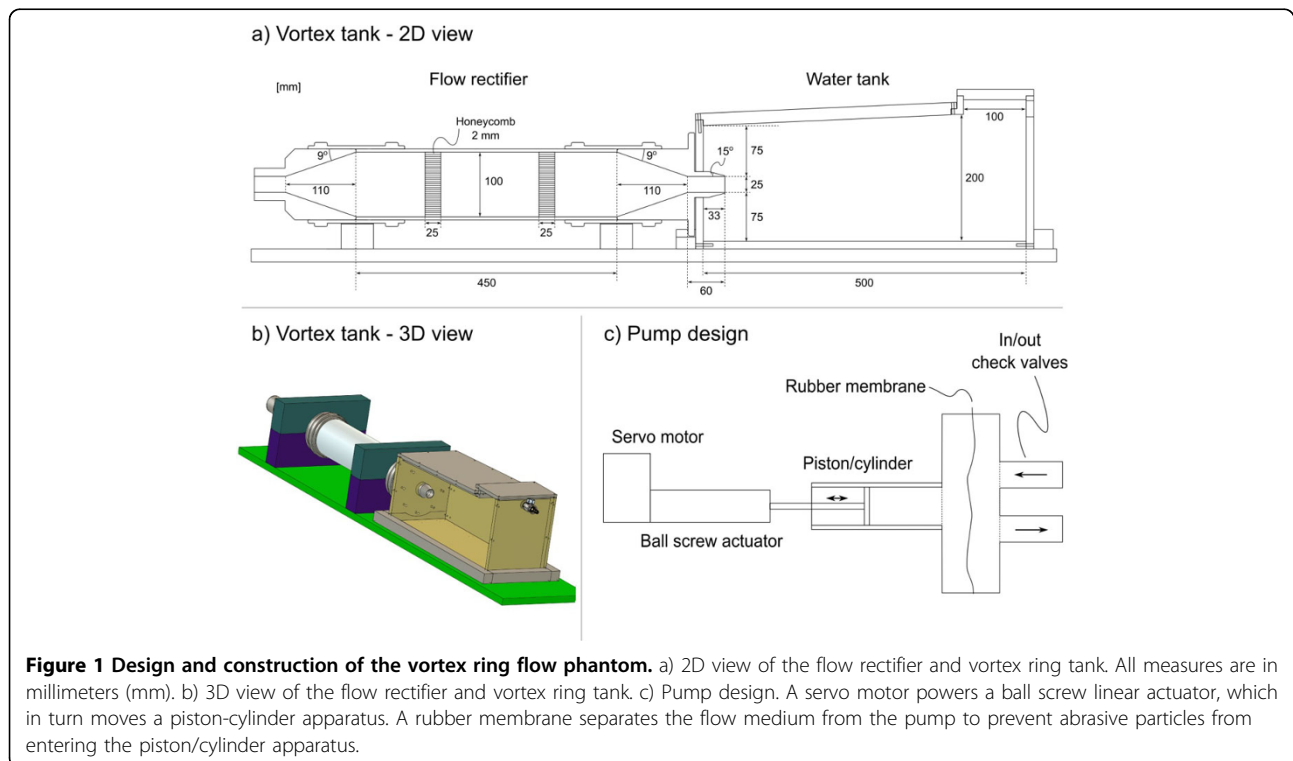
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Background

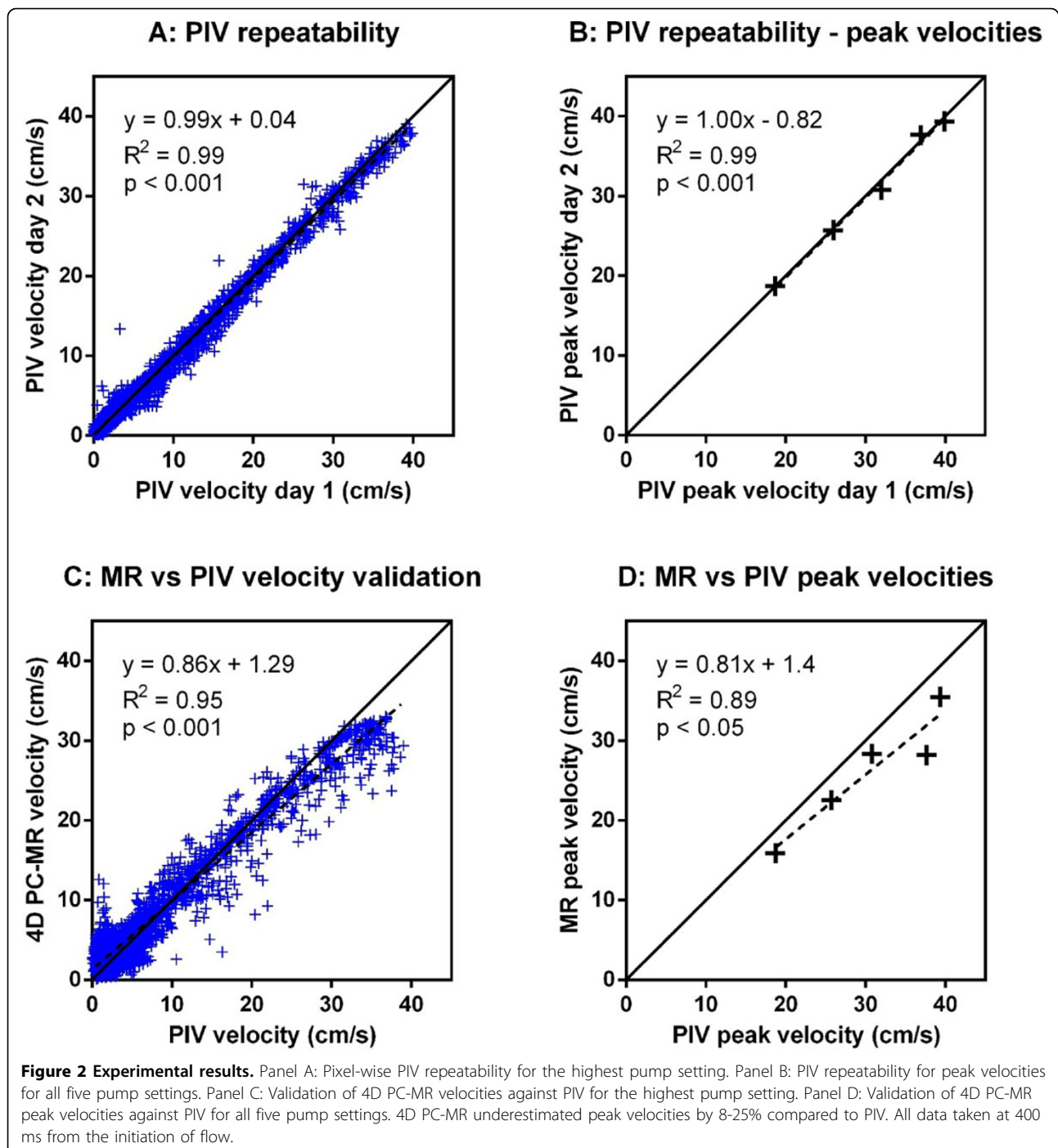
4D phase contrast magnetic resonance blood flow measurements (4D PC-MR) is a promising tool for clinical assessment of cardiac function, but lack of independent validation may limit clinical adoption. Previous validation

studies are limited by lack of pulsatility [1,2] or by the need of a post hoc correction factor to compensate for differences in experimental setup between 4D PC-MR and reference imaging [3]. Therefore, we aimed to validate 4D PC-MR velocity measurements with particle



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imaging velocimetry (PIV) as the reference standard in a phantom setup based on vortex ring formation, which has previously shown excellent repeatability [4].

Methods

We constructed a pulsatile pump and a water tank with a 25mm nozzle (Figure 1). Five different pump settings

were used. PIV measurements with spatial resolution 1.5x1.5 mm were obtained on two consecutive days to evaluate phantom stability. Nozzle stroke volumes were measured using 2D PC-MR (voxel size 2.4x2.4x6 mm, VENC 50 cm/s). 4D PC-MR (3x3x3 mm voxels, temporal resolution 50 ms, VENC 100 cm/s) was acquired at 1.5T using a 32-channel cardiac coil and SENSE=2. The 4D

PC-MR velocity measurements were interpolated to the PIV resolution, and compared to PIV pixel-by-pixel after semi-automatic registration.

Results

Stroke volumes ranged from 12-37 ml and peak nozzle velocities from 19-40 cm/s. PIV velocities showed excellent agreement between days, both for the pixel-wise comparison (Figure 2A, $R^2=0.99$, bias -0.04 ± 0.72 cm/s) and for peak velocities (Figure 2B, $R^2=0.99$, bias $-1\pm 2\%$). Validation of 4D PC-MR against PIV showed good pixel-wise agreement (Figure 2C, $R^2 = 0.95$, bias 0.17 ± 2.31 cm/s), but peak velocities were underestimated by 8-25% (Figure 2D, $R^2=0.89$, bias $-14\pm 7\%$).

Conclusions

This study shows that 1) the proposed vortex ring flow phantom can be used for validation of 4D PC-MR measurements, 2) 4D PC-MR shows good overall agreement in velocity for the pixel-wise comparison, but underestimates peak velocities by 8-25% compared to PIV.

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