TOP 10

Assessment of diastolic dysfunction markers in hypertrophic cardiomyopathy patients with 4D flow magnetic resonance imaging and Doppler echocardiography

Filip Lončarić[1,2*],
Xabier Morales Ferez[3],
Gaspar Delso[4],
Ana Garcia-Alvarez[2,4],
Jordi Mill Tena[3],
Adelina Doltra[2,4],
Marta Sitges[2,4],
Oscar Camara[3],
Bart Bijnens[3]

[1]University Hospital Centre Zagreb, University of Zagreb School of Medicine, Zagreb, Croatia
[2]August Pi i Sunyer Biomedical Research Institute (IDIBAPS), Barcelona, Spain
[3]Universitat Pompeu Fabra, Department of information technologies and communication, Simulation, Imaging and Modelling for Biomedical Systems, Barcelona, Spain
[4]Cardiovascular Institut, Hospital Clínic, University of Barcelona, Barcelona, Spain

RECEIVED:
March 26 2023
ACCEPTED:
March 29, 2023

KEYWORDS: 4D Flow, magnetic resonance imaging, echocardiography, hypertrophic cardiomiopathy.
CITATION: Cardiol Croat. 2023;18(5-6):168-9. | https://doi.org/10.15836/ccar2023.168

***ADDRESS FOR CORRESPONDENCE**: Filip Lončarić, Klinički bolnički centar Zagreb, Kišpatićeva 12, HR-10000 Zagreb, Croatia. / Phone: +385-91-2220-480 / E-mail: loncaric.filip@gmail.com

ORCID: Filip Lončarić, https://orcid.org/0000-0002-7865-1108 • Xabier Morales Ferez, https://orcid.org/0000-0003-1349-2457
Gaspar Delso, https://orcid.org/0000-0003-0438-8244 • Ana Garcia-Alvarez, https://orcid.org/0000-0002-1718-2424
Jordi Mill Tena, https://orcid.org/0000-0003-0087-7489 • Adelina Doltra, https://orcid.org/0000-0003-3539-6917
Marta Sitges, https://orcid.org/0000-0003-1300-4732 • Oscar Camara, https://orcid.org/0000-0002-5125-6132
Bart Bijnens, https://orcid.org/0000-0003-3130-6937

Introduction: Transthoracic echocardiography (TTE) is the gold standard in the assessment of diastolic dysfunction, however, measurement of diastolic markers such as the pulmonary vein (PV) inflow velocities is often challenging. 4D flow cardiac magnetic resonance imaging (CMR) enables quantification of velocities in any target volume without the constraints faced by TTE. We explored the use of 4D flow CMR in generating Doppler-like velocity spectrograms of mitral and PV inflow and comparing them to actual echo-based pulsed-wave (PW) Doppler velocity curves.

Patients and Methods: A total of 6 HCM patients were included (P1-6). TTE was performed with a GE E95 system. Mitral and PV inflow PW Doppler was performed in the apical 4-chamber view by placing the sample volume at the level of the leaflet tips and at the inflow of the PV. The CMR data was acquired through a GE SIGNA Architect 3.0T scanner. The left atrium (LA), ventricle and outflow tract (LVOT) were segmented from a 4D flow phase contrast angiogram. The sample volume of PW Doppler was imitated using spheres of 4 mm radius placed in the same positions as in TTE. Velocities were projected in the direction typically captured by the echo transducer generating Doppler-like images. The duration of the pulmonary Ar and the mitral A wave was measured using both methods.

Results: Figure 1 shows volumetric renderings of velocity at mid-systole. Compared to P1 and P2, P3-6 present an accelerated LVOT flow due to obstruction caused by systolic anterior motion, causing posterolateral mitral regurgitation disrupting LA hemodynamics. **Figure 2** demonstrates the mitral and pulmonary inflow patterns obtained with TTE and CMR. Peak velocities and the duration of the A/Ar waves were comparable when quantified using both modalities (**Table 1**). Ar wave duration could be quantified in all CMR studies, showing heterogeneity between the four PVs, whereas AR could be measured in only 3/6 of the echo studies.

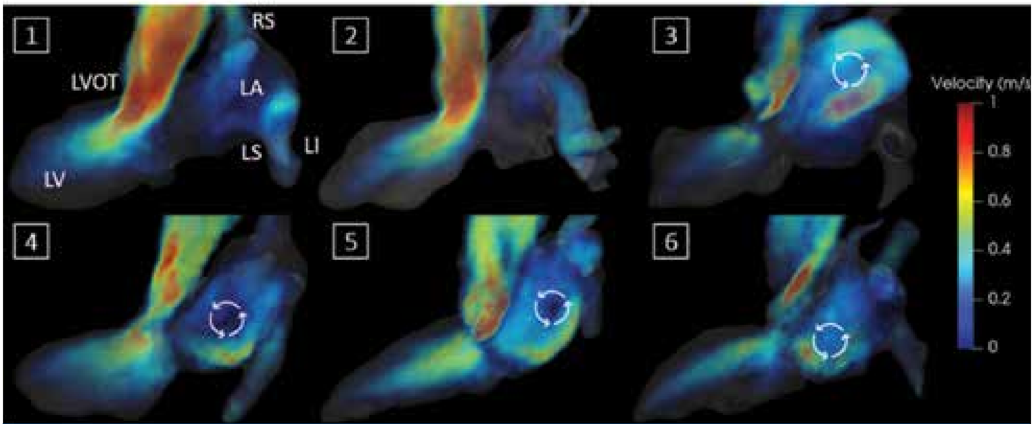

FIGURE 1. Volumetric rendering of the 4D flow MRI velocity fields mid-systole, including arrows pointing in the direction of the blood flow. A clear LVOT obstruction can be observed in patients 3-6 caused by systolic anterior motion. The distinctive rotational flow pattern in the LA is a consequence of the mitral regurgitation jet.

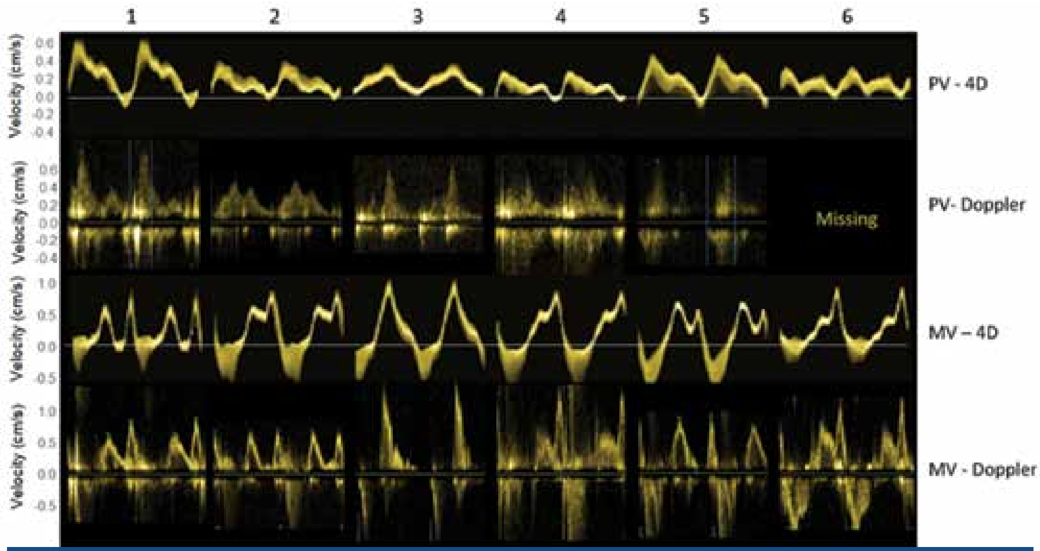

FIGURE 2. The synthetic 4D flow derived PW Doppler velocity curves alongside the authentic PW Doppler. The sample volume for the PV acquisitions was located in the right superior PV, while the mitral valve profiles were extracted from the leaflet tips.

TABLE 1. AR and A wave duration measurements performed from cardiac magnetic resonance and transthoracic echocardiography images, respectively.

Patient		1	2	3 (AF no A wave)	4	5	6
Ar Duration	RS-4D (ms)	198	136	–	188	180	260
	RI-4D (ms)	168	97	–	229	193	200
	LS-4D (ms)	168	58	–	229	138	260
	LI-4D (ms)	137	233	–	313	346	421
	RS-Echo (ms)	185	206	–	–	220	–
Mitral A Duration	MV-4D (ms)	150	191	–	123	136	158
	MV-Echo (ms)	145	181	–	140	156	166

RS - right superior PV; RI – right inferior PV; LS – left superior PV; LI – left inferior PV

Conclusion: 4D CMR shows potential for blood flow assessment previously feasible only via TTE. CMR could provide a more reproducible assessment of PV inflow velocities, relevant in assessing diastolic function, and potentially reveal new insights about LA hemodynamics.