AUTOMATED EVALUATION OF LEFT VENTRICULAR DIASTOLIC FUNCTION USING VELOCITY-ENCODED MAGNETIC RESONANCE IMAGING: CONVENTIONAL AND NEW PARAMETERS

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Introduction

Since diastolic dysfunction is an early sign of heart failure, its early detection is crucial for patient management. In clinical routine, this evaluation is performed using Doppler echocardiography imaging. This technique enables the estimation of conventional diastolic parameters: the transmitral flow early peak (E) and late peak (A) velocities and the deceleration time (DT), as well as the myocardial early peak (Ea) longitudinal velocity at the mitral annulus. Despite recent developments in Magnetic Resonance (MR) velocity encoding, using phase-contrast (PC) imaging, MR evaluation of diastolic function in clinical routine is not established yet. This limitation is mainly due to technical issues, such as the lack of automated methods designed for the analysis of PC images. Accordingly, a primary goal of our study was to develop a robust segmentation technique to automatically delineate the transmitral flow and the myocardium throughout the cardiac cycle. We hypothesized that the excellent quality of PC images, combined with an accurate segmentation, would allow the estimation of new diastolic parameters, in addition to the conventional parameters.

Methods

We studied 25 healthy volunteers (13 men, 12 women, age: 31 ± 10 years). Each subject had a transmitral flow sequence (velocity encoding Ve = 180 cm/s) and a myocardial longitudinal velocity sequence (Ve = 15 cm/s) at the level of the mitral annulus. To analyze these data, we developed an automated process, including: 1) a connectivity-based automated segmentation of the transmitral and aortic flows, 2) a temporal k-means clustering-based automated segmentation of the myocardium, and 3) a velocity and flow curves automated analysis to derive both conventional and new diastolic parameters. These new parameters were: 1) the isovolumetric relaxation time (IVRT), which is evaluated in echocardiography but, to our knowledge, was never assessed in MR, and 2) new filling flow-related parameters, such as Ef/Af and SV/Ef ratios (Ef and Af in ml/s being the early peak and late peak filling flow rates and SV in ml, the stroke volume). These latter parameters are specific to MR data and are, by definition, less sensitive to data noise than the commonly-used maximal velocities. Results were compared to those previously described in the echocardiographic and MR literature, when available, or were correlated with those known to have a high prognosis value.

Results

The segmentation and the parameters extraction steps were successfully performed on the whole database, resulting in conventional diastolic parameters, which were consistent with those previously presented in the echocardiographic [1] and MR [2] literature (Table 1). Considering the new parameters: 1) IVRT mean value was 69 ± 18 ms and was consistent with value previously described in the echocardiographic study [1] (IVRT = 76 ms (54-98 ms)), 2) comparison of the flow rate parameter Ef/Af (1.8 ± 0.8) and the conventional parameter E/A resulted in a correlation coefficient of r = 0.95 (Figure 1.A), and 3) comparison of the parameter SV/Ef and DT resulted in a correlation coefficient of r = 0.85 (Figure 1.B).

Discussion and conclusions

Our new parameters are well related to parameters with high prognosis value. Their evaluation on a population including pathological subjects should be carried out to further demonstrate their diagnosis value. However, this preliminary study was a necessary step to test our new technique and its ability to reproduce the established diastolic values. The addition of our fast and operator-independent developments to MR tools may prove clinically useful.

Transmitral flow	Present study (n = 25)	Echocardiographic literature (n = 61)	MRI literature (n = 10)
Age (years)	31 ± 10	21-49	33 ± 9
E (cm/s)	62 ± 17	72 (44-100)	70.6 ± 20
A (cm/s)	43 ± 7.9	40 (20-60)	45.1 ± 18.8
E/A	1.5 ± 0.5	1.9 (0.7-3.1)	1.8 ± 0.8
DT (ms)	177 ± 48.1	179 (139-219)	175 ± 40.7
E/Ea	6.2 ± 2	*Within normal range*	

Table 1: Comparison of conventional diastolic parameters (mean values and standard deviations) obtained in the present study against those previously described in echocardiographic and MRI literature. Numbers between brackets represented study populations. Studies in which population mean ages were the closest to those of our database were used in this comparison.

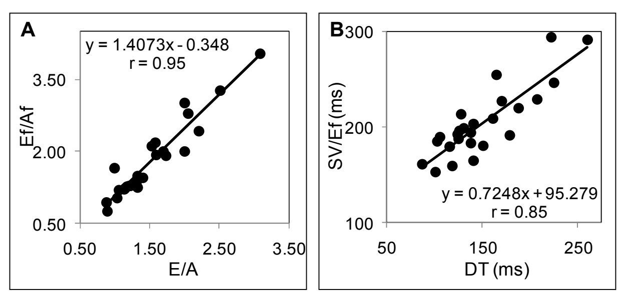

Figure 1: Comparison between new and conventional parameters.

References

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