Peak time of shortening predicts onset time of shortening in non-ischemic dilated cardiomyopathy with intraventricular conduction delay

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Purpose: The purpose of this work was to compare the propagation of the onset time of circumferential shortening (T_{onset}) with the propagation of the time to peak shortening (T_{peak}) in patients with dilated cardiomyopathy.

Background: Mechanical asynchrony is an important parameter for adequate selection of patients that are likely to respond to resynchronization therapy [1]. Echocardiographic measures of mechanical asynchrony consist mainly of time to peak displacement, peak velocity and/or peak longitudinal strain(-rate) [2]. However, the relation of peak times with onset times, which are more directly influenced by pacing, have not yet been studied.

Methods: Seventeen patients (56 ± 11 years, 10 male) with non-ischemic dilated cardiomyopathy (DCM) (NYHA class III-IV and EF < 45%) were studied. All patients underwent coronary angiography to exclude the presence of coronary artery disease, and delayed contrast enhancement (DCE) to exclude focal spots of fibrosis. High temporal resolution (14 ms) strain curves were obtained using steady state free precession imaging with tagging and HARP strain analysis [2], for five short axis slices. Imaging parameters for the tagging images were: voxel size 1.2 × 3.8 × 6.0 mm^3, flip angle 20º, TR/TE 4.7/2.3 ms, BW 369 Hz/pixel, matrix 256 x 78. For the DCE images, 10 to 15 min. after contrast injection an inversion-recovery gradient echo was applied with: voxel size 1.6 × 1.3 × 5.0 mm^3, flip angle 25º, TR/TE 9.6/4.4 ms, BW 130 Hz/pixel, and matrix 256 x 208.

T_{onset} was defined as the beginning of the downslope of the circumferential strain curve and determined by an automated routine [2] for 6 circumferential segments. T_{onset} was regarded as missing when the goodness of fit was less than 85% or when a region was akinetic (peak shortening less than 3%). T_{peak} was defined as the moment of first zero-crossing of the strain rate after T_{onset}, and was therefore also missing when T_{onset} was missing. This definition was used to deal consistently with multiple contraction waves often observed in septal segments of DCM patients. Seventeen healthy subjects served as control group.

Data was averaged per segment over all subjects (either DCM or controls) for linear regression analysis between T_{onset} and T_{peak}. The Pearson correlation coefficient was used to study the individual correlations between T_{onset} and T_{peak}. We investigated whether the (dis)similarity in T_{onset} and T_{peak} depended on the degree of mechanical asynchrony. For that purpose, we defined the mechanical asynchrony as the delay in T_{onset} between septum and lateral wall.

Results: For the mean patient data, a strong positive correlation was found between T_{peak} and T_{onset}: a segment with an early mean T_{onset} showed also an early mean T_{peak} (Fig. 1, Table 1). For the mean data of the healthy subjects, a weak but significant negative correlation was observed: (r = -0.50, P = 0.01, Table 1). Looking on an individual basis, we found that T_{peak} was only positively correlated with T_{onset} when the asynchrony between septum and lateral wall was larger than approximately 50 ms (lateral wall delayed compared to septum, Fig. 2).

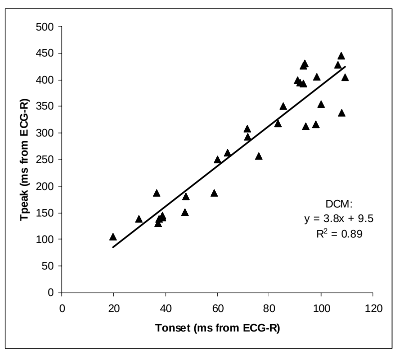

Fig 1. *Mean time to peak circumferential shortening (T_{peak}) is strongly correlated with time to onset of shortening (T_{onset}) in patients with DCM and asynchronous contraction. Each data point represents one segment of the LV averaged over all DCM patients.*

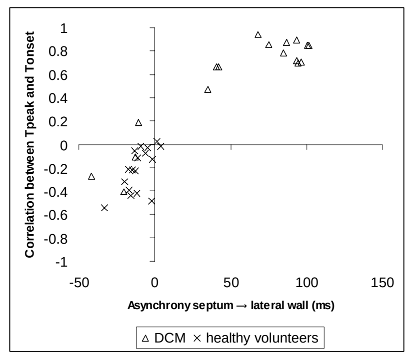

Fig 2. *Individual correlation coefficients between T_{peak} and T_{onset}. The individual correlations are plotted versus the delay between septum and lateral wall, which is a measure for the degree of mechanical asynchrony. T_{peak} correlates well with T_{onset}, only in the presence of considerable mechanical asynchrony (positive asynchrony: lateral wall later than septum).*

Discussion: The regression coefficient between the T_{peak} and T_{onset} of the patient data was considerably larger than unity: 3.9 ± 0.3 (Table 1). This means that asynchrony in T_{onset} returns amplified in T_{peak}, which makes T_{peak} a more sensitive parameter for the assessment of mechanical asynchrony. The amplification of the asynchrony in T_{peak} when compared to the asynchrony in T_{onset} may be due to the reduced load for the early activated regions, or because of a local Frank-Starling effect in the late activated regions, which are prestretched by the early activated regions. Both effects influence the duration of contraction [4].

Table 1. Regression coefficients for the relation between T_{peak} and T_{onset}.

Subjects	Constant (ms)	Regression coefficient (-)	R^2
DCM	9 ± 20	3.8 ± 0.3*	0.89
Healthy	529 ± 48*	-2.1 ± 0.7†	0.25

T_{peak}: time to peak circ. shortening; T_{onset}: time to onset of shortening; *$P \leq 0.001$; †$P < 0.01$.

Conclusion: Time to peak shortening is preferred to time to onset of shortening for the assessment of the mechanical asynchrony in non-ischemic patients with DCM, but only when considerable asynchrony exists.

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