Signal averaging transesophageal left heart ECG software to evaluate left atrial conduction delay and left ventricular conduction delay in heart failure patients with dilated and ischaemic cardiomyopathy

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Abstract
Cardiac resynchronization therapy with biventricular pacing is an established therapy for heart failure patients with electrical left ventricular desynchronization. The aim of this study was to evaluate left atrial conduction delay, intra left atrial conduction delay, left ventricular conduction delay and intra left ventricular conduction delay in heart failure patients using novel signal averaging transesophageal left heart ECG software.

Methods: 8 heart failure patients with dilated cardiomyopathy (DCM), age 68 ± 9 years, New York Heart Association (NYHA) class 2.9 ± 0.2, 24.8 ± 6.7 % left ventricular ejection fraction, 188.8 ± 15.5 ms QRS duration and 8 heart failure patients with ischaemic cardiomyopathy (ICM), age 67 ± 8 years, NYHA class 2.9 ± 0.3, 32.5 ± 7.4 % left ventricular ejection fraction and 167.6 ± 19.4 ms QRS duration were analysed with transesophageal and transthoracic ECG by Bard LabDuo EP system and novel National Intruments LabView signal averaging ECG software.

Results: The electrical left atrial conduction delay was 71.3 ± 17.6 ms in ICM versus 72.3 ± 12.4 ms in DCM, intra left atrial conduction delay 66.8 ± 8.6 ms in ICM versus 63.4 ± 10.9 ms in DCM and left cardiac AV delay 180.5 ± 32.6 ms in ICM versus 152.4 ± 30.4 ms in DCM. The electrical left ventricular conduction delay was 40.9 ± 7.5 ms in ICM versus 42.6 ± 17 ms in DCM and intra left ventricular conduction delay 105.6 ± 19.3 ms in ICM versus 128.3 ± 24.1 ms in DCM.

Conclusions: Left heart signal averaging ECG can be utilized to analyse left atrial conduction delay, intra left atrial conduction delay, left ventricular conduction delay and intra left ventricular conduction delay to improve patient selection for cardiac resynchronization therapy.

1 Introduction
Cardiac resynchronization therapy with biventricular pacing is an established therapy for heart failure patients with electrical left ventricular (LV) desynchronization. The aim of this study was to evaluate electrical left atrial (LA) conduction delay, intra LA conduction delay, LV conduction delay and intra LV conduction delay in heart failure patients using novel signal averaging transesophageal left heart ECG software [1-4].

2 Methods
Eight heart failure patients with ischaemic cardiomyopathy, age 67 ± 8 years, New York Heart Association functional class 2.9 ± 0.3, 32.5 ± 7.4 % LV ejection fraction and 167.6 ± 19.4 ms QRS duration were analysed with transesophageal and transthoracic ECG by Bard LabDuo EP system and novel National Intruments LabView SA ECG software [5, 6]. TO Osypka catheter was used for LA and LV ECG recording with 1000-Hz sampling rate.

2.1 Transesophageal left atrial and left ventricular electrocardiography
Electrical LA conduction delay und LV conduction delay were measured by bipolar filtered transesophageal LA ECG and LV ECG recording with hemispherical electrodes TO catheter with distal 10 mm cylindrical electrode and three (TO4 catheter) or seven 6 mm hemispherical electrodes (TO8 catheter) with 15 mm electrode distance (TO, Osypka AG, Rheinfelden, Germany) (Fig. 1).
2.2 Electrical left atrial and left ventricular conduction delay analysis

Electrical LA conduction delay was measured between onset of P-wave in the signal averaging surface ECG and onset of LA deflection in the signal averaging LA ECG. Electrical intra LA conduction delay was measured between onset and offset of LA deflection in the signal averaging LA ECG. Electrical LV conduction delay was measured between onset of QRS in the signal averaging surface ECG and onset of LV deflection in the signal averaging LV ECG. Electrical intra LV conduction delay was measured between onset and offset of LV deflection in the signal averaging LV ECG (Fig. 2).

Statistical analysis was performed by Origin® 8.5 software (OriginLab Corporation, Northampton, MA, USA) using paired and unpaired t-tests, as appropriate, with a statistical significance of p<0.05.

3 Results

QRS triggered signal averaging transesophageal LA ECG recording was possible with high-resolution posterior LA potential in the left heart ECG in all heart failure patients with dilated and ischaemic cardiomyopathy (100%). QRS triggered signal averaging transesophageal LV ECG recording was possible with high-resolution posterior LV potential in the left heart ECG in all heart failure patients with dilated and ischaemic cardiomyopathy (100%).

3.1 Left atrial conduction delay in dilated and ischaemic cardiomyopathy

The electrical LA conduction delay was 71.3 ± 17.6 ms in ischaemic cardiomyopathy versus 72.3 ± 12.4 ms in dilated cardiomyopathy. The electrical intra LA conduction delay was 66.8 ± 8.6 ms in ischaemic cardiomyopathy versus 63.4 ± 10.9 ms in dilated cardiomyopathy. The left cardiac atrioventricular delay was 180.5 ± 32.6 ms in ischaemic cardiomyopathy versus 152.4 ± 30.4 ms in dilated cardiomyopathy with PQ duration 210.9 ± 25.9 ms in ischaemic cardiomyopathy versus 178.0 ± 24.5 ms in dilated cardiomyopathy (Fig. 3).
3.2 Left ventricular conduction delay in dilated and ischaemic cardiomyopathy

The electrical LV conduction delay was 40.9 ± 7.5 ms in ischaemic cardiomyopathy versus 42.6 ± 17 ms in dilated cardiomyopathy. The electrical intra LV conduction delay was 105.6 ± 19.3 ms in ischaemic cardiomyopathy versus 128.3 ± 24.1 ms in dilated cardiomyopathy (Fig. 4, Fig. 5).
4 Conclusions

Signal averaging transesophageal left heart ECG can be utilized to analyse electrical LA conduction delay, intra LA conduction delay, LV conduction delay and intra LV conduction delay to improve patient selection for cardiac resynchronization therapy.

Signal averaging ECG software may be a useful novel technique in the time domain, frequency domain and 3-dimensional vector loop domain to evaluate electrical LA conduction delay and electrical LV conduction delay in heart failure patients with dilated and ischaemic cardiomyopathy.

5 References


