Novel semi-invasive left-heart electrogram feature to select patients with atrial fibrillation for cardiac resynchronization

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Abstract

About 20% of those heart failure patients receiving cardiac resynchronization therapy (CRT) are in atrial fibrillation (AF). Current guidelines apply for patients in sinus rhythm only. Recent studies have shown again, that successful resynchronization is closely linked to a pre-existent ventricular desynchronization. In those studies, the interventricular conduction delay (IVCD) was determined prior to device implantation by ultrasound in patients with sinus rhythm (SR) only. In patients with AF this method’s use is limited.

To implement left-heart electrogram (LHE) into standard programmers and to simplify IVCD measurement in heart failure patients with AF, LHE was recorded in 11 AF patients with heart failure by Biotronik ICS3000 programmer via a 15Hz Butterworth high-pass filter. Therefore, TOslim esophageal electrode (Dr. Osypka GmbH, Rheinfelden, Germany) was perorally applied and fixed in position of maximal left ventricular deflection. IVCD was measured between onset of QRS in surface ECG and left ventricular deflection (LV) in LHE. In addition, intra-left ventricular conduction delay (ILVCD) was measured as duration of LV in LHE.

In all of the 11 AF patients, desynchronization was quantifiable by LHE. Mean QRS of 162 ± 27ms (120-206ms) was linked with IVCD of 62ms ± 27ms (37-98ms) and ILVCD of 110 ± 20ms (80-144ms), at mean. Correlation between IVCD and QRS was 0.39 (n. s.) with IVCD/QRS ratio of 0.38 ± 0.11 (0.22-0.81).

A 15Hz high-pass filtered LHE feature of the Biotronik ICS3000 programmer is feasible to quantify ventricular dyssynchrony in heart failure patients with AF in order to clearly indicate implantation of CRT systems. As relations between QRS duration, IVCD and ILVCD considerably differ interindividually, the predictive values of IVCD, ILVCD and IVCD/QRS ratio for individual CRT response or non-response shall be identified in follow-up studies.

Introduction

More than one third of heart failure patients receiving CRT systems fail to respond clinically. Guidelines for CRT ask for the following criteria before CRT-implantation: Sinus rhythm, left bundle branch block morphology in surface ECG/prolonged QRS-complex, heart failure with reduced left ventricular ejection fraction < 35% under optimal medical heart-failure treatment. Recent studies have shown again, that successful resynchronization is closely linked to a pre-existent ventricular desynchronization /1, 2/. Since studies had also shown, that ventricular desynchronization is not linked with QRS-width in surface ECG /3/, the interventricular conduction delay here (IVCD) was determined by ultrasound in patients with sinus rhythm (SR) prior to device implantation. In patients with AF, making up about 20% of patients receiving CRT-devices, this method is and has always been limited. Also, Ultrasound diagnostics are examiner-depending.

Methods

Anatomically, the esophagus is very close to the left heart. This closeness of the two organs has long been used as an advantage in ultrasound imaging of the heart. Also, ECG can be of higher definition transesophageally. The esophageal left heart electrogram(LHE) is a known diagnostic option to determine interatrial, atrioventricular and interventricular intervals /4, 5/.

In this diagnostic option, a bipolar electrode is perorally applied and connected with the Biotronik ICS3000 programmer. Using the special PK 199 cable, a three-channel surface ECG is recorded simultaneously. Interventricular conduction delay thus can be measured between the onset of QRS in the surface ECG and the onset of left ventricular deflection (LV) in LHE. The electrode is therefore positioned at the point of maximum left ventricular deflection and fixed for the measurements. The ventricular deflection in LHE is displaying left ventricular activity. QRS complex in surface ECG displays activity of both ventricles.

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As an advantage of LHE, the left ventricular deflection is clearly determinable and can be put into context with surface QRS-onset. The duration between QRS-onset in surface ECG and left-ventricular deflection in LHE is the esophageal interventricular conduction delay (IVCD) and reflects the degree of ventricular dysynchrony.

In this study IVCD was measured in patients with atrial fibrillation between onset of QRS in the 3-channel surface ECG and the onset of left ventricular deflection (LV) in the LHE. Intra-left ventricular conduction delay (ILVCD) was measured as the duration of left ventricular deflection in LHE (Figure 1).

Ventricular LHE was recorded in 11 of our heart failure patients that are in AF. The recording works via a 15Hz Butterworth high-pass filter and can be displayed in the Biotronik ICS3000 programmer.

Results

In all of the 11 patients with atrial fibrillation, desynchronization was quantifiable easily by left heart electrogram. The determined mean QRS of 162 ± 27ms (120-206ms) is in CRT criteria a fairly long one. It was in our study linked with an IVCD of 62ms ± 27ms (37-98ms) and ILVCD of 110 ± 20ms (80-144ms), at mean. The determined correlation between IVCD and QRS was 0.39 (n. s.). The IVCD/QRS ratio was determined to be of 0.38 ± 0.11 (0.22-0.81) at mean.

These findings again display, that QRS width in surface ECG is not a reliable criteria for ventricular dyssynchrony as it does not correlate with IVCD. QRS complexes of ‘normal’ width do not exclude the existence of ventricular desynchronization; vice versa, a wide QRS-complex does not necessarily prove ventricular dyssynchrony. European guidelines should thus include other signs of ventricular dyssynchrony as indicational criteria for CRT.

Conclusions

A 15Hz high-pass filtered LHE feature of the ICS3000 programmer is feasible to quantify ventricular dysynchrony in heart failure patients with atrial fibrillation in order to clearly indicate implantation of CRT systems. The method is easy, quick and of reasonable cost. But the most important advantage is, that LHE is not examiner-depending.

As relations between QRS duration, IVCD and ILVCD considerably differ interindividually, the predictive values of IVCD, ILVCD and IVCD/QRS ratio for individual CRT response or non-response shall be identified in follow-up studies.

References


Figure 1: Extracted screenshot of Biotronik ICS3000 programmer in heart-failure patient in atrial fibrillation with CRT-device. Three-channel surface ECG and LHE with IVCD and ILVCD.