Nuclear imaging and semi-invasive electrocardiography in CRT

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1.4 Nuclear imaging and semi-invasive electrocardiography in CRT

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Abstract
Cardiac resynchronisation therapy (CRT) is a promising treatment option in patients with chronic heart failure. In this article the roles of semi-invasive esophageal left-heart electrocardiography and functional cardiac nuclear imaging in the field of CRT are highlighted, as the combination of both could be a favourable diagnostic approach in special cardiac situations. Also original esophageal left heart electrogram data of exemplary CRT patients is presented.

Introduction
During the last 15 years cardiac resynchronisation therapy (CRT) has made a huge step forward from experimental pacing to a routine and evidence-based treatment option in patients with chronic heart failure, who have ischemic or non-ischemic cardiomyopathy at NYHA III or IV, sinus rhythm, a left-bundle branch block and a left ventricular ejection fraction below 35% [1, 2].

The relatively young field of biomedical engineering has also found a rapid and promising development in the two medical imaging disciplines radiology and nuclear medicine as well as semi-invasive electrocardiographic methods and thus strengthened modern medicine.

The role of nuclear imaging
Nuclear medicine diagnostic instruments provide various opportunities to help the patient in the battle against his or her disease. In cardiovascular diseases, electrocardiogram (ECG)-triggered myocardial perfusion single-photon-emission-computed-tomography (SPECT) or ^{18}F-fluorodeoxy-D-glucose (FDG) positron emission tomography (PET) have become routine tools to detect viable myocardium, to study heart motility and to define the ejection fraction, the left-ventricular or right-ventricular function.

Although CRT is a promising treatment option, some patients do not respond to it [1]. van Campen et al., 2007, therefore, studied the relationship between viable myocardial tissue assessed by FDG PET and the improvement after CRT in 39 patients with ischemic cardiomyopathy, ejection fraction 27±9% and a wide QRS complex [3]. They found a correlation between the extent of viable myocardium and the hemodynamic response to CRT (assessed by the cardiac index measured by Doppler echocardiography) and concluded that FDG PET imaging may be a useful predicting tool to distinguish between responders and non-responders. Siegrist et al., 2008, studied the role of left-ventricular phase histograms of radionuclide ventriculography (RNV) for optimizing atrioventricular delay setting for CRT in 17 patients with heart failure and could show that RNV is a helpful instrument for the optimization of pacing parameters in CRT [4]. Looking at radiological tools, selection of pacing sites can be improved e.g. by cardiac computer tomography of the cardiac veins. In addition to PET imaging, candidates with large myocardial scars can be excluded also by magnetic resonance tomography [5].

The role of semi-invasive left-heart electrocardiography
Recently, esophageal left heart electrogram was demonstrated to be a simple but useful semi-invasive method in the field of CRT [6, 7]. It could be utilized to increase responder rate (Figure 1.4-1). Performed preoperatively, this approach provides more direct quantification of the left ventricular conduction delay than QRS width in surface ECG. Duncan et. al. found an underestimation of duration of ventricular activation by the 12-lead ECG compared with pacemaker device electrogram measurements [8]. Previously measured esophageal left ventricular conduction delay can be used, intraoperatively, as valuable target interval to guide positioning of the left ventricular electrode. Missing this target interval should encourage the seeking for another pacing position in order to decrease the amount of nonresponders (Figure 1.4-2).

Furthermore, postoperatively, esophageal left atrial electrogram recording enables measurement of implant-related interatrial conduction intervals. The latter mainly determine individual duration of the hemodynamically optimal AV delay programming.

Actually, the semi-invasive esophageal left heart electrogram is a feature of the Biotronik ICS3000 (Biotronik GmbH, Berlin, Germany) standard programmer, solely. Applying, perorally, a TOslim esophageal electrode (Osypka AG,

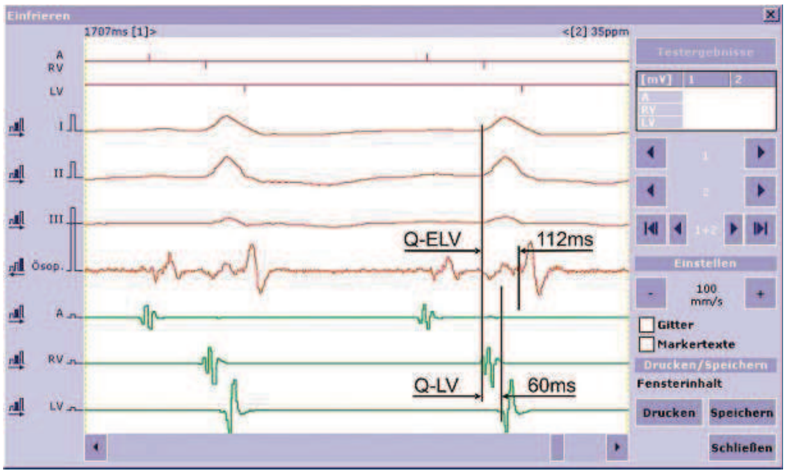

Fig. 1.4-1: *Example of CRT patient presenting distinct esophageal left ventricular conduction delay Q-ELV of 112 ms. In contrast to that, the left ventricular electrode is placed in unfavourable region with left ventricular electrode delay Q-LV of 60 ms, only. Intraoperatively, this suboptimal situation should encourage the seeking for another left ventricular electrode position in order to avoid nonresponders*

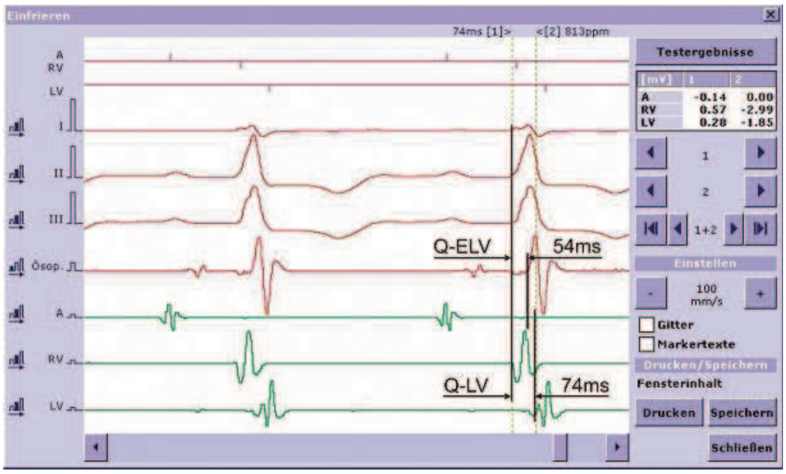

Fig. 1.4-2: *Example of CRT patient demonstrating the esophageal left ventricular conduction delay Q-ELV of 54 ms as minimal target interval for left ventricular electrode positioning. In this constellation with Q-LV of 74 ms, response to CRT could be expected*

Rheinfelden-Herten, Germany) connected to the PK199 programmer cable, depending on esophageal electrode position, filtered esophageal left ventricular or left atrial electrograms can be recorded simultaneously with three-channel surface ECG in patients without or with pacing systems irrespective of their make and model.

Conclusion

Nuclear imaging as well as semi-invasive left-heart electrogram studies in CRT are still rare, and the number of patients studied is low. Both methods, however, can help CRT in special situations. Therefore, further clinical studies combining the two disciplines may be a favourable approach.

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