Comparison of Left Ventricle Late Activation Zones Determined Using Noninvasive Electrophysiological Mapping with Sequential Computed and Magnetic Resonance Tomography

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Abstract

Nowadays, non-invasive electrophysiological mapping (NEM) is being introduced into clinical practice. The diagnostic accuracy of the application of the NEM in combination with computed tomography (CT) was previously determined. On the other hand, the question of validating the technique with the use of magnetic resonance imaging (MRI) was not solved. In this article the method of comparison of left ventricle late activation zones determined using NEM and sequential CT and MRI is shown. The reconstructed three-dimensional CT and MRI models of the ventricles were merged using custom written software with Python. The accuracy of the comparison of the zones of late activation was: 12.5 (7; 13.1) mm - median (LQ; UQ). Minimal dimension was 1.4 mm. Maximum measurement was 19.7 mm. This study is the first to validate the accuracy of determining the zone of late activation with NEM and MRI.

1. Introduction

Non-invasive mapping is a modern diagnostic direction in arrhythmology, based on solving the inverse problem of electrocardiography. A number of methods are known in this direction [1-4]. The technique we use is called non-invasive electrophysiological mapping (NEM). It implies a combined application of multichannel electrocardiography and computer (CT) or magnetic resonance imaging (MRI) data. The diagnostic accuracy of the application of the NEM in combination with CT was previously determined [5]. The isopotential map, constructed from unipolar electrograms, demonstrated quite accurately the early activation zone on the three dimension CT model of the heart. The concept of assessing the late activation zone with this map is the same. We consider the use of the same map on the CT model also to allow to have a reliable determination of the zone of late activation. In clinical practice preference is given to MRI as not associated with radiation exposure. In this regard, the issue of validation of the use of NEM and MRI has arisen. In our opinion, one of such validation methods can be comparison of left ventricle late activation zones determined using NEM with sequential CT and MRI.

2. Materials

In Figure 1, we show the workflow of the project, described in this Section.

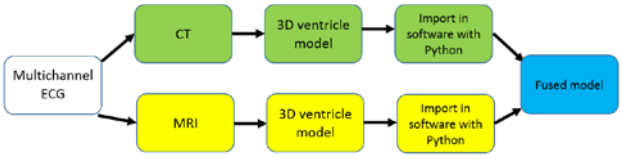

Figure. 1. Workflow of the project.

2.1. Patient data

The study population consisted of 11 consecutive patients scheduled for CRT device implantation. The age was 67 (55; 78) – median (min; max) years. All the examined had sinus rhythm and complete left bundle branch block activation pattern (n=10) or a left anterior bundle branch block (n=1). The participants signed informed consent before the procedure. The study was approved by the local ethic committee.

2.2. ECG recording

A maximum of 240 unipolar body surface mapping electrodes compatible with CT and MRI were placed onto the patients' torsos. Body surface ECG were recorded during sinus rhythm on Amycard 01C EP LAB system (EP

Solutions SA, Switzerland).

2.3 Tomography imaging

Firstly, torso and cardiac CT scan were performed. We used Somatom Definition 128, Siemens AG. Low dose scan revealed positions of body surface electrodes and individual torso anatomy. ECG gated scan of the heart was accomplished using automated intravenous injection of a non-ionic contrast (Ultravist 100ml) during breath hold. In addition to scientific data the patients received CT conclusion about anatomy of coronary sinus.

Torso and cardiac MRI scan (MAGNETOM Trio A Tim 3 T, Siemens AG, Germany) were implemented 2 hours after CT. Torso MRI scan revealed the same as torso CT scan. MRI scan of the heart was accomplished using intravenous injection of a contrast (Gadovist 15 ml). In addition to scientific data the participants obtained MRI conclusion about structural changes (scar, post inflammatory fibrosis) of left ventricle.

2.4 Data analysis

Individual epicardial models of the heart ventricles were reconstructed, using MRI and CT data separately. The activation of the LV epicardium was evaluated using software of Amycard 01C EP LAB system. Late activation zone was determined based on isopotential maps. We marked the center of late zone using the black dot (fig. 1, fig. 2).

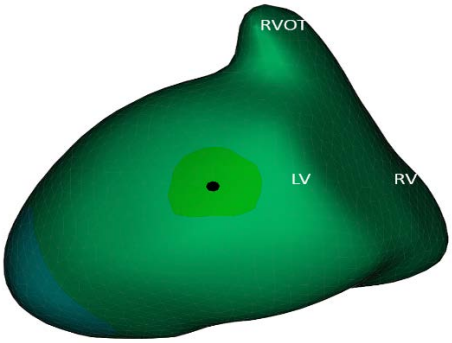

Figure. 2. Reconstructed epicardial polygonal model using computed tomography. Isopotential map. Black dot – central marker of late activation zone. LV and RV- left and right ventricles. RVOT – right ventricular outflow track.

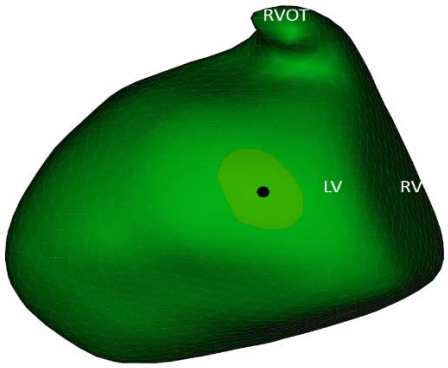

Figure. 3. Reconstructed epicardial polygonal model using magnetic resonance tomography. Isopotential map. Black dot – central marker of late activation zone. LV and RV- left and right ventricles. RVOT – right ventricular outflow track.

Reconstructed polygonal epicardial models based on CT and MRI were imported in text format into custom written software with Python (Python Software Foundation) (fig. 3, fig. 4).

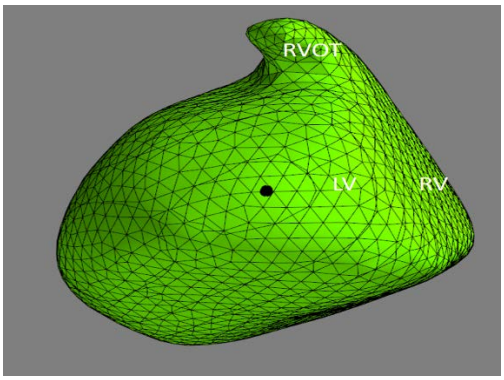

Figure. 4. Epicardial polygonal MRI model imported into custom written software with Python. Black dot – central marker of late activation zone.

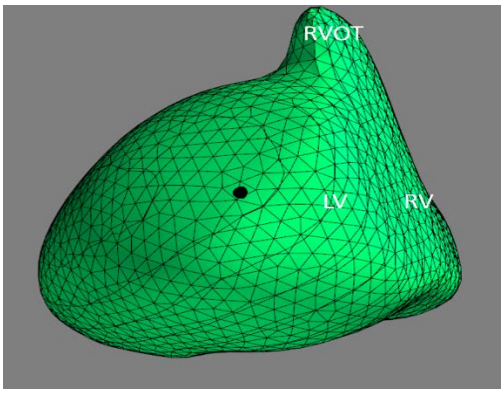

Figure. 5. Epicardial polygonal CT model imported into custom written software with Python. Black dot – central marker of late activation zone.

The CT and MRI model were fused using the iterative closest point algorithm. Quantitative coincidence of late activation zones on fused model was assessed by measuring the distance between the black dots (fig. 6).

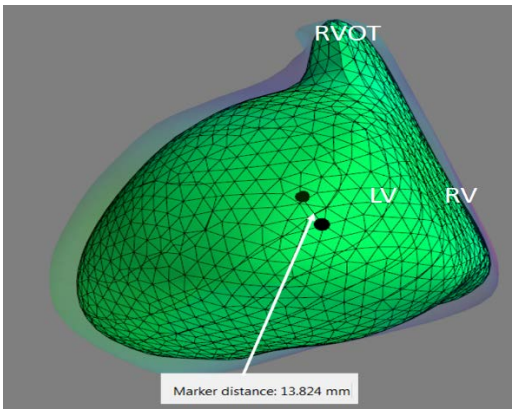

Figure. 6. Epicardial merged model with Python. Black dot – center marker of late activation zone on CT and MRI model. Marker distance = 13.8 mm.

2.5 Statistics

The statistical analysis was performed using the statistical software package STATISTICA v.12 (StatSoft Inc., USA). The median, quartiles (LQ; UQ), min and max values were calculated for continuous variables.

3. Results

Clinical and instrumental data of the examined patients (table 1).

Table 1. Participants' data

Parameters	Value
CHD/DCM	8/3
QRS, ms	195(165;215)
LV EF, %	25(20;29)
LVEDD, mm	72(67;83)
LVESD, mm	66(60;75)
LVEDV, ml	262(200;395)
LVESV, ml	202(160;281)

CHD – congestive heart disease; DCM – dilated cardiomyopathy, LV EF – ejection of fraction left ventricular; EDD and EDV – end diastolic diameter and volume; ESD and ESV – end systolic diameter and volume

On the fused models distance between black dots was calculated automatically and equaled 12.5 (7; 13.1) mm - median (LQ; UQ). Minimal distance was 1.4 mm. Maximum distance was 19.7 mm.

4. Conclusion

Implementation of merged model of CT and MRI data revealed absence of significant difference between marked centers of late activation zones. Inaccuracy between CT and MRI models didn't exceed 20 mm. This study is the first to validate the accuracy of determining the zone of late activation with NEM and MRI.

Acknowledgements

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References

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