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Research article



# Preoperative Prediction of Optimal Method and Site of Left Ventricular Electrode Implantation

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We present a clinical case of cardiac resynchronization device implantation in a patient with a zone of late left ventricular activation in the area of the anterior coronary sinus vein, which, however, was unsuitable for endovascular implantation and stable electrode placement in it. This anatomical feature was diagnosed at the outpatient stage using a noninvasive mapping technique. Using this approach, we were able to understand that an epicardial electrode implantation, instead of traditional endovascular implantation of the left ventricular electrode through the coronary sinus vein, is indicated for the patient. Targeted implantation of an epicardial electrode in the area of interest on the epicardial surface of the left ventricle in the basal part of the anterolateral wall allowed achieving a complete clinical response to resynchronization therapy.

**Keywords:** Left ventricular lead implantation; noninvasive mapping; cardiac resynchronization therapy; case report.

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Научная статья

## Предоперационное прогнозирование оптимального способа и места имплантации левожелудочкового электрода

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Приведен клинический случай имплантации сердечного ресинхронизирующего устройства пациенту с зоной поздней активации левого желудочка в области передней вены коронарного синуса, которая при этом была непригодна для эндоваскулярной имплантации и устойчивого нахождения в ней электрода. Эта анатомическая особенность была диагностирована на догоспитальном этапе с помощью методики неинвазивного картирования. Данный подход позволил понять, что пациенту показана имплантация эпикардимального электрода вместо традиционной трансвенозной имплантации левожелудочкового электрода через вену коронарного синуса. Проведенная целевая имплантация эпикардимального электрода в зону интереса на эпикардимальной поверхности левого желудочка в базальном отделе передне-боковой стенки позволила добиться полного клинического ответа на ресинхронизирующую терапию.

**Ключевые слова:** имплантация левожелудочкового электрода; неинвазивное картирование; сердечная ресинхронизирующая терапия; клинический случай.

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## BACKGROUND

Cardiac resynchronization therapy (CRT) has been proven to be a method for treating patients with chronic heart failure (CHF) and complete left bundle branch block (CLBBB) in addition to optimal drug therapy [1]. Classically, the coronary sinus (CS) has branches, namely, the posterior interventricular vein (or middle cardiac vein) and the posterior vein [3] (or posterolateral vein [2]). Also, there may be one or several lateral veins. The great cardiac vein is a continuation of the CS at the level of the anterior part of the mitral valve. It bypasses the aortic root and is called the anterior vein (anterior interventricular vein) as soon as it passes to the anterior surface where it passes in the anterior interventricular sulcus. The anterolateral vein usually ends in the anterior vein at the level of the left ventricle (LV) basal segments [2]. In some sources, the great cardiac vein and the anterior vein throughout are called the great cardiac vein [3]. Endovascular implantation of left ventricular lead is considered classical; it is inserted into one of the CS veins, preferably into the lateral, posterior, or anterolateral vein [3]. This choice of a vein for implantation is based on the fact that, as a rule, the late activation zone in CLBBB is located in the basal region on the border of the LV lateral and posterior walls.

Modern medicine tends to develop personalized approaches for treatment. One of these is the use of the noninvasive mapping system Amycard developed originally in Russia. The previous work revealed that the system can be used to detect a late activation zone, which, as it turned out, can have a diverse location in the LV [4]. In addition, this system enables us to compare the noninvasive activation map and the CS anatomy during the preoperative diagnostics on the same three-dimensional model [5].

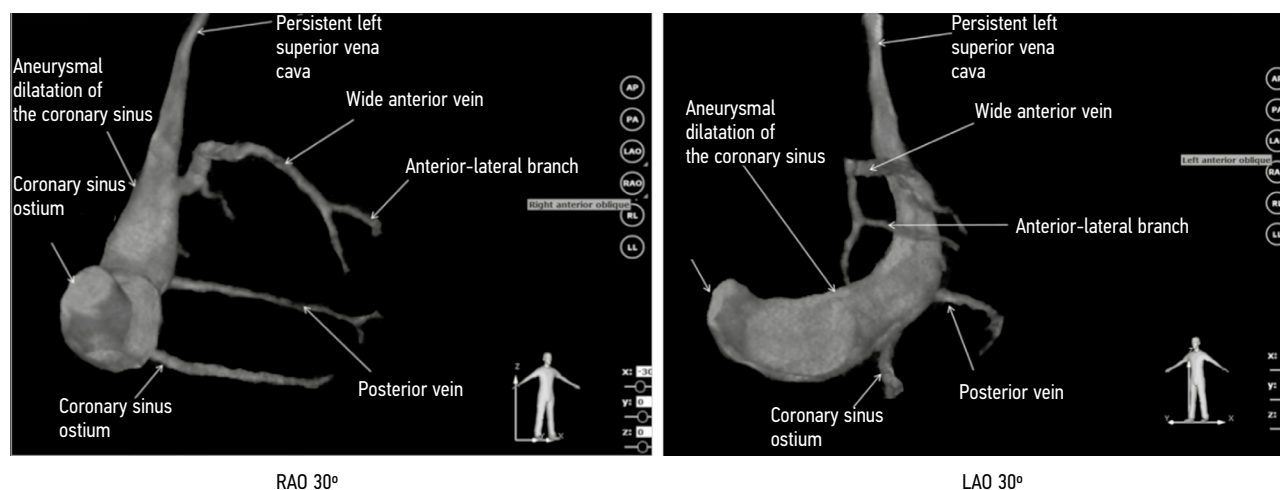
The clinical case presented demonstrates the feasibility of using noninvasive mapping for the correct choice of the method and place of implantation of the left ventricular lead in CRT.

## CASE REPORT

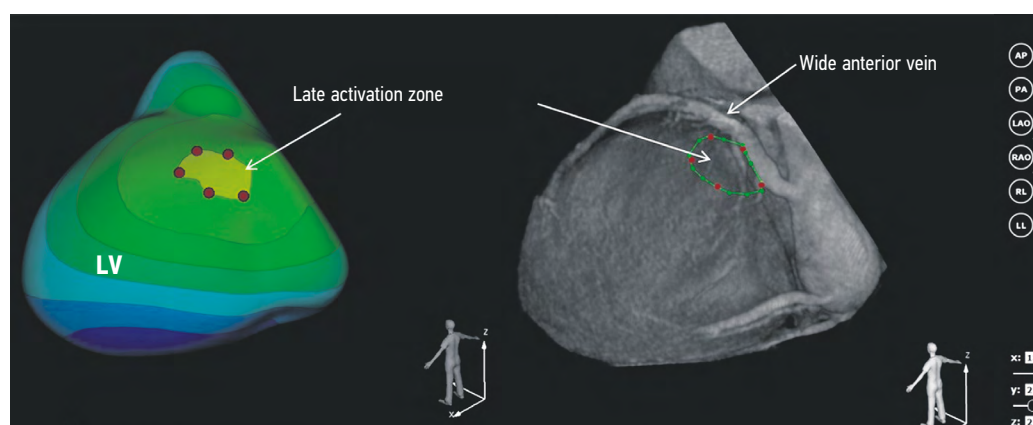
A 70-yr-old man complained of dyspnea when minimal physical exertion, and swelling of the lower legs. The 6-min walk distance was 100 m. Dyspnea appeared after a recurrent myocardial infarction. The past medical history showed that the patient had arterial hypertension for more than 15 yr; the target level of arterial pressure was achieved during therapy. Previously, he had a myocardial infarction of the LV lower wall (2015) and myocardial infarction with damage to the LV anterior septal region (2018). The risk factors for cardiovascular diseases include smoking, dyslipidemia, and type 2 diabetes mellitus. It is known that after heart attacks, stenting of the anterior interventricular artery, circumflex artery, and right coronary artery was performed using drug-eluting stents with the effect of complete revascularization.

The patient was given therapy that included 100 mg/day of metoprolol, 10 mg/day of enalapril, 75 mg/day of clopidogrel, 1,000 mg/day of metformin, 10 mg/day of torasemide, and 50 mg/day of spironolactone. The ejection fraction (EF) of the LV remained within 26%–29%, despite the drug therapy at the specified volume and optimal revascularization. Subsequently, the drug therapy was corrected, and sacubitril/valsartan was prescribed instead of enalapril. The dose was titrated to the maximum possible, considering hypotension associated with CHF, namely, 51.4 mg of valsartan and 48.6 mg of sacubitril twice a day. Dapagliflozin was also prescribed at a dose of 10 mg/day. During the corrective therapy for 3 months, the patient noted an improvement in the form of a decrease in dyspnea with minimal physical exertion; however, the distance of a 6-min walk was 160 m, and the patient corresponded to the III functional class of CHF. According to echocardiography, the LV EF was 32%, and the end systolic volume (ESV) was 178 ml. Considering the intraventricular conduction disorders in the patient in the form of CLBBB with a QRS complex duration of 160 ms, as well as clinically pronounced CHF with LV EF less than 35% during optimal drug therapy, indications for implantation of a resynchronizing device were determined.

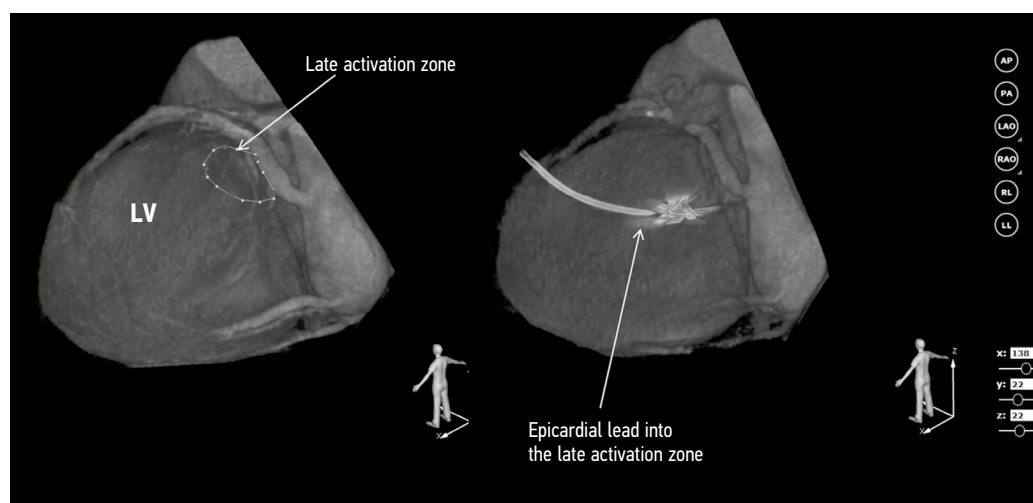
Within the preparation for surgery, noninvasive mapping was performed, which was multichannel (up to 240 unipolar leads) electrocardiography using the Amycard 01C EP LAB noninvasive mapping complex (EP Solutions SA, Switzerland) along with multislice computed tomography (MSCT) of the chest and heart in the device Somatom Definition 64 (Siemens, Germany) with intravenous contrast (Ultravist 370, 100 ml) [6]. The multichannel ECG and MSCT data obtained were imported into the Amycard 01C EP LAB software to construct a three-dimensional model of the heart ventricles and to conduct a detailed reconstruction of the CS and its branches, as well as compile an isopotential map of the ventricles based on the reconstructed unipolar endograms and compare the isopotential map with the anatomical model. The study revealed that the CS trunk was aneurysmically dilated up to 26 mm due to the confluence of the persistent left superior vena cava into it. Other branches of the CS were also visualized, namely, a large posterior interventricular vein, posterior vein with an ostial angle of 90°, wide anterior vein, and anterior-lateral branch distal to the anterior vein (Fig. 1). The zone of the latest activation of the intact myocardium was visualized in the basal part of the LV anterior-lateral wall. It was noteworthy that in the projection of this zone, there was no target vein suitable for standard endovascular implantation, since the anterior vein was too wide, and the anterolateral tributary branched off from the anterior vein only in the middle segments, while the late zone was located basally (Fig. 2). As a result, preoperative diagnostics enabled to schedule immediately to the patient the epicardial lead implantation to the basal segments of the LV anterior-lateral wall. It should also be noted that the absence of an ischemic scar in the target zone of late activation of the intact



**Fig. 1.** Three-dimensional anatomical model of the coronary sinus with branches, obtained after processing in the Amycard system



**Fig. 2.** Noninvasive mapping of the left ventricle. An isopotential map of the left ventricle is presented on the left. The late zone is indicated with red markers. Interpolation of the late zone on a three-dimensional anatomical model with coronary sinus veins are presented on the right. LV, left ventricle



**Fig. 3.** Left ventricular lead was implanted epicardially in the region of the initial late activation zone of the intact myocardium. LV, left ventricle

myocardium was confirmed by the results of earlier magnetic resonance imaging.

During the surgery, the right atrial and right ventricular leads were first implanted with transvenous access, then the epicardial unipolar lead was implanted through the left

lateral mini-thorascopic approach into the basal segment of the LV anterior-lateral wall in the late activation zone (Fig. 3). The leads were connected to the device Syncra CRT-P (Medtronic, USA). When programming the device, it was revealed that the QRS complex shortest duration is

determined in the p-controlled biventricular pacing mode with an interventricular delay of 0 ms. The atrioventricular delay after intrinsic P wave was 100 ms, and the atrioventricular delay after a paced atrial event was 140 ms.

The patient noted clinical improvement in the form of a decrease in dyspnea when walking along the corridor in the early postoperative period. The duration of the QRS complex decreased from 160 to 110 ms. After 12 months of follow-up, the patient's response to CRT was confirmed. The distance of the 6-min walk test was 400 m, which corresponds to the functional class II of CHF (the class decreased from III to II). The echocardiography results showed that LV EF was 45% (increase by 13% from the baseline), and ESV was 145 ml (decrease by 19% from the baseline). Consequently, both clinical and echocardiographic responses to CRT were registered.

## DISCUSSION

The standard approach to implanting an LV lead is positioning it in the posterior or posterolateral, lateral, or anterolateral veins, as far as possible in the basal regions. The posterior interventricular and anterior veins are not recommended as veins for implantation of the LV lead [3]. According to a previous study using the described noninvasive mapping technique in CRT candidates, the late zone on the LV epicardial surface had a heterogeneous location. Most often, it was determined between the inferolateral and anterolateral LV basal segments [4]. At the same time, in 23% of cases, the zone was determined in the anterolateral basal segment, as in our patient. This work suggests that a personalized approach to determining the zone of late activation of the intact myocardium and subsequent implantation of the lead in this area is more reasonable than empirical surgery.

However, in the present clinical case, the anterolateral and anterior veins could not be used for endovascular

implantation in the required LV segment due to their anatomical characteristics. Thus, the anterolateral vein in this patient was visualized in the mid-apical sections of the LV wall of the same name, and the late posture was located basally. Additionally, the anterior vein was too wide and not suitable for the stable presence of the left ventricular lead in it. In this regard, the planning of epicardial implantation immediately enabled to avoid a repeated surgery, unreasonable expenditure of a CS contrast kit, a delivery system for the LV lead, and the endocardial LV lead itself.

## CONCLUSION

The noninvasive mapping technique enables us to identify a patient at the outpatient stage, in whom, targeted implantation of the LV lead cannot be performed using the traditional transvenous method due to the anatomical characteristics of the CS, and to schedule immediately alternative implantation methods in this case. By using this clinical case as an example, we strived to demonstrate that an attempt of standard LV lead implantation would have been unsuccessful without a preoperative study in the scope of noninvasive mapping, including CT angiography of the CS and determination of the late zone in the LV.

## ADDITIONAL INFORMATION

**Patient consent.** The patient voluntarily signed an informed consent to publish personal medical information in anonymized form in the journal *Cardiac Arrhythmias*.

**Conflict of interest.** The authors declare no conflict of interest.

**Competing interests.** The authors declare that they have no competing interests.

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## REFERENCES

1. Glikson M, Nielsen JC, Kronborg MB, et al. 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy. *Eur Heart J*. 2021;42(35):3427–3520. DOI: 10.1093/eurheartj/ehab364.
2. Ellenbogen KA, Kay GN, Wilkoff BL, editors. *Device therapy for congestive heart failure*. 2nd ed. USA: Saunders, 2004. P. 157–158.
3. Gras D, Leon AR, Fisher WG, Abraham WT. *The road to successful CRT implantation*. USA: Blackwell Futura, 2004. P. 27–31. DOI: 10.1002/9780470751411
4. Zubarev S, Chmelevsky M, Potyagaylo D, et al. Noninvasive electrocardiographic imaging with magnetic resonance tomography in candidates for cardiac resynchronization therapy. *Comput Cardiol*. 2019;46:397. DOI: 10.23919/CinC49843.2019.9005803
5. Stepanova VV, Stovpyuk OF, Karev EA, et al. Cardiac resynchronisation therapy in an adult patient with long-term right ventricular pacing due to congenital complete atrioventricular block. *Annals of arrhythmology*. 2021;18(3):154–161. (In Russ.). DOI: 10.15275/annaritm.2021.3.4
6. Revishvili AS, Wissner E, Lebedev DS, et al. Validation of the mapping accuracy of a novel non-invasive epicardial and endocardial electrophysiology system. *Europace*. 2015;17(8):1282–1288. DOI:10.1093/europace/euu339

## СПИСОК ЛИТЕРАТУРЫ

1. Glikson M., Nielsen J.C., Kronborg M.B., et al. 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy // *Eur Heart J*. 2021. Vol. 42, No. 35. P. 3427–3520. DOI: 10.1093/eurheartj/ehab364.
2. Ellenbogen K.A., Kay G.N., Wilkoff B.L., editors. Device therapy for congestive heart failure. 2nd ed. USA: Saunders, 2004. P. 157–158.
3. Gras D., Leon A.R., Fisher W.G., Abraham W.T. The road to successful CRT implantation. USA: Blackwell Futura, 2004. P. 27–31. DOI: 10.1002/9780470751411
4. Zubarev S., Chmelevsky M., Potyagaylo D., et al. Noninvasive electrocardiographic imaging with magnetic resonance tomography in candidates for cardiac resynchronization therapy // *Comput Cardiol*. 2019. Vol. 46. ID 397. DOI: 10.23919/CinC49843.2019.9005803
5. Степанова В.В., Стовяк О.Ф., Карев Е.А., и др. Ресинхронизирующая терапия у взрослого пациента с длительным стажем правожелудочковой стимуляции вследствие врожденной полной атриовентрикулярной блокады // *Анналы аритмологии*. 2021. Т. 18, № 3. С. 154–161. DOI: 10.15275/annaritm.2021.3.4
6. Revishvili A.S., Wissner E., Lebedev D.S., et al. Validation of the mapping accuracy of a novel non-invasive epicardial and endocardial electrophysiology system // *Europace*. 2015. Vol. 17, No. 8. P. 1282–1288. DOI:10.1093/europace/euu339

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