Integrated bioptome technology with multielectrode high-density mapping system for guided ultraselective endomyocardial biopsy

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Introduction

Cardiac biopsy procedures demand accurate targeting of myocardial sites to obtain representative tissue samples for diagnostic evaluation.[1] This is even more relevant for focal myocardial abnormalities. Integrating bioptome devices in an electroanatomic mapping system is a novel approach to perform cardiac biopsies with enhanced precision.[2] In this case report, ultraselective endomyocardial biopsy is guided by a multielectrode high-density mapping system integrated with bioptome technology.

Principles of bioptome and CARTO integration

Bioptome devices are usually navigated within the cardiac chambers under fluoroscopic or intracardiac echocardiographic guidance to obtain myocardial tissue samples. CARTO 3-dimensional mapping (Biosense Webster Inc., Irvine, CA) using multielectrode uses electromagnetic navigation and high-density 3-dimensional mapping to guide catheter navigation during electrophysiological procedures.[3] Integrating bioptome technology with CARTO mapping provides real-time visualization of bioptome location within the cardiac chambers, facilitating precise targeting of myocardial regions for tissue sampling.[4,5]

Technical considerations and workflow

A 75-year-old man was referred to our institution for left symptomatic sustained ventricular tachyarrhythmias. Left ventricular ejection fraction was preserved and proximal right coronary artery disease was treated 2 years earlier with percutaneous coronary angioplasty.

KEY TEACHING POINTS

- Integrating bioptome technology with the CARTO high-density mapping system (Biosense Webster Inc., Irvine, CA) allows for real-time visualization and precise targeting of myocardial regions. This significantly improves the accuracy of tissue sampling, especially in areas with focal myocardial abnormalities, enhancing diagnostic yield. and procedural outcomes.
- Using a combined bipolar and unipolar mapping approach with a 20-pole steerable multielectrode catheter increases the sensitivity of detecting diseased myocardial areas. Unipolar signals, which can reveal larger areas of pathology even when bipolar maps appear normal, contribute to more comprehensive and effective identification of myocardial abnormalities.
- The integration of advanced mapping systems and multielectrode catheters not only enhancesthe precision of biopsies, but also reduces the time and fluoroscopy exposure required during the procedure. This approach minimizes radiation risks for both patients and health careproviders, while maintaining high procedural efficiency and accuracy.

In another center, coronary angiography excluded progression of coronary disease and cardiac magnetic resonance images revealed only small areas of doubtful late gadolinium enhancement in the left ventricle (LV). In addition, conventional cardiac biopsy was also performed. Three myocardial samples were obtained from the interventricular septum to

KEYWORDS Cardiac biopsy; Bioptome; Electroanatomic mapping system; Tissue sampling accuracy; Procedural guidance
(Heart Rhythm Case Reports 2024;10:872–874)

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https://doi.org/10.1016/j.hrcr.2024.08.017

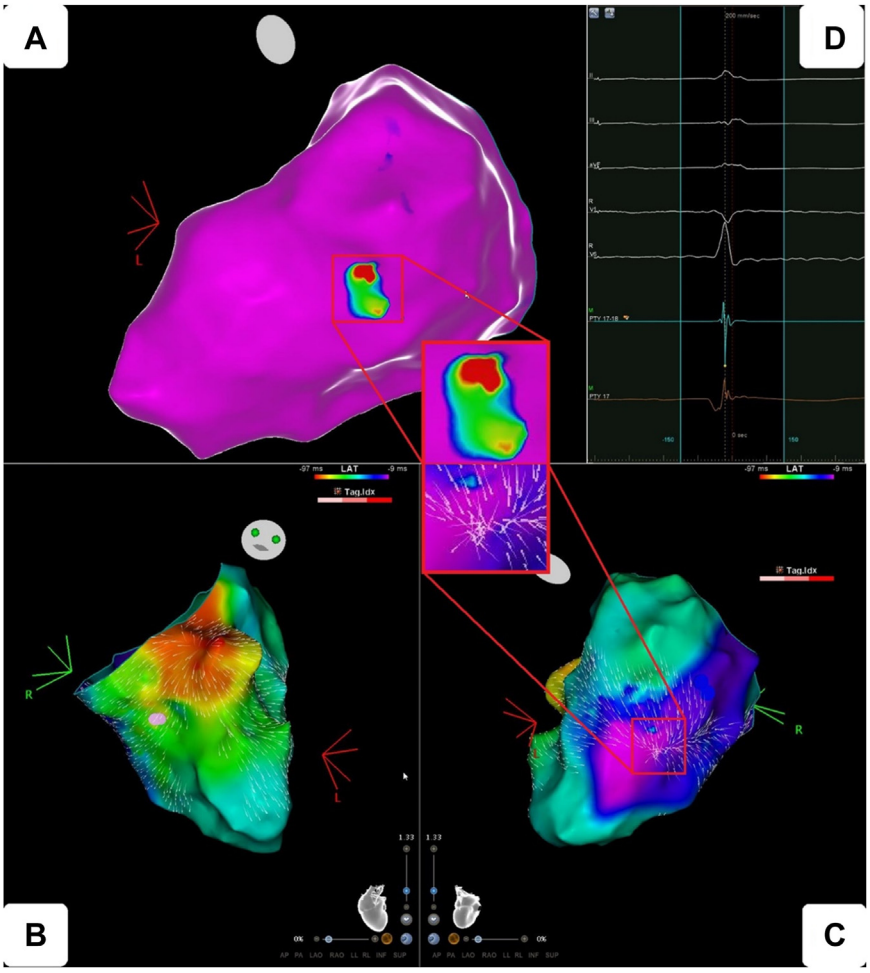

Figure 1 **A:** A 3-dimensional (3D) electroanatomical unipolar voltage map of the left ventricle, depicted from a posterior view. The color bar ranges from 3.5 mV to 5.5 mV. The low voltage area is discernible on the map, indicated by the red and green areas. A 3D electroanatomical activation map of the left ventricle in anterior (**B**) and posterior views constructed during the clinical ventricular tachycardia (**C**). The activation map shows a delayed activation corresponding to the low-voltage area. Arrows indicate the direction of propagation of the expanding wavefront (coherent mapping). **D:** Electrocardiogram and electrogram signal corresponding to unipolar low-voltage area shown in (**A**).

minimize the risk of perforation. However, specific myocardial abnormalities were not found.

In our center, considering the small areas in the LV shown on magnetic resonance imaging, we decided to repeat a cardiac biopsy in a more targeted manner. Under general anesthesia, after transseptal puncture, an LV electroanatomic mapping voltage map (CARTO 3 system, version 7) was constructed during sinus rhythm by mapping with a 20-pole steerable mapping catheter arranged in 5 soft radiating spines covering a diameter of 3.5 cm (Pentaray, Biosense Webster; interelectrode spacing 2-6-2 mm; multielectrode mapping). A Vizigo steerable sheath (Biosense Webster) was used to facilitate maneuvering of the mapping catheter inside the left ventricular cavity. Catheter–tissue contact was verified with fluoroscopy, signal characteristics, and transesophageal echocardiogram. Points acquired with the Pentaray catheter were filtered using the tissue proximity indicator algorithm. The resulting voltage map consisted of 3030 mapping points. Areas with potential voltages smaller than a predetermined threshold of 0.5 mV were labeled as low-voltage areas (LVAs). However, all bipolar potentials had a peak-to-peak amplitude larger than the upper threshold of 1.5 mV.

In contrast, the unipolar LV voltage map revealed a small LVA in the posterior wall defined by a signal amplitude of <4 mV, as shown in Figure 1. Moreover, conduction within this area was delayed (Figure 1). As also indicated by the surface electrocardiogram of the ventricular tachycardia, the ventricular tachycardia most likely originated from the epicardium.

A bioptome (Biopsy Forceps, Cordis, Santa Clara, CA) was connected to the CARTO 3 visualization system, which displayed the bioptome catheter in real time. We put a small screw into the adapter of the bioptome handle and pinched it with alligator clips, creating an electric dipole. The end of the electric cables was then connected to the CARTO system and visualized in the system. A picture of this setup has been published previously.[6] The screw-attached bioptome was carefully introduced into the LV, guided by both fluoroscopy and the CARTO visualization system. Real-time

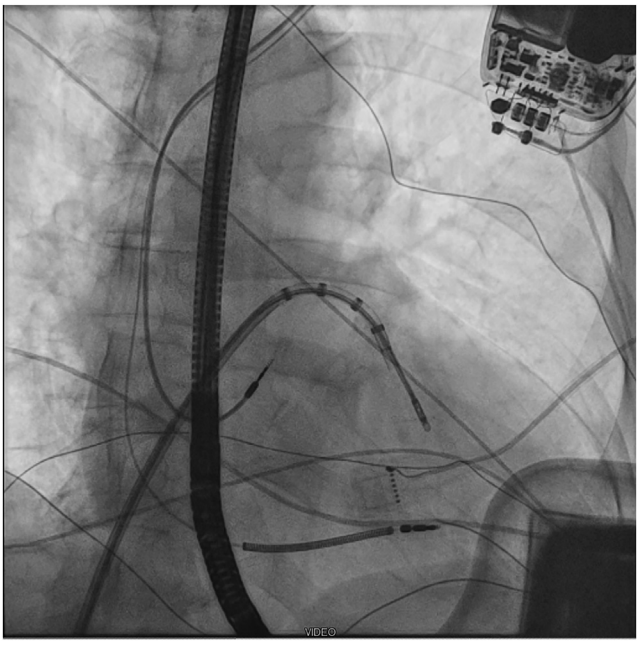

Figure 2 Fluoroscopy monitoring during myocardial tissue sampling from the low voltage are using the bioptome system.

visualization facilitated precise navigation toward the unipolar LVA. This dynamic 3-dimensional representation of the LVA aided in optimal positioning of the bioptome for targeted biopsy. Once positioned at the LVA, 3 samples were taken using the Cordis bioptome. The bioptome jaws were opened, capturing small sections of myocardial tissue. This procedure was monitored continuously using both fluoroscopy (Figure 2) and the CARTO system to ensure accurate sampling from the small circumscriptive LVA (Figure 1).

Following the biopsy, the obtained tissue samples were processed for histologic analysis to diagnose underlying myocardial abnormalities. For histology, samples are fixed in formalin and embedded in paraffin. Serial sections were obtained, which were stained with hematoxylin and eosin for morphologic analysis and with Masson's trichrome for visualization of fibrosis and Congo red for amyloidosis. Histologic analysis confirmed the initial development of LV arrhythmogenic cardiomyopathy, which was then also confirmed by genetic testing.

Clinical implications and outcomes

Integrating bioptome technology with CARTO high-density mapping enhances tissue sampling accuracy, procedural guidance, and patient safety in cardiac biopsy procedures. CARTO high-density mapping with multielectrode catheter, instead of using an open irrigation linear catheter with a 3.5-mm distal electrode, enables more precise targeting of myocardial areas of interest, improving diagnostic yield and facilitating therapeutic decision making in patients with cardiac abnormalities.[3,7] The use of combined bipolar and unipolar maps potentially increases the diagnostic yield of endomyocardial biopsy for diseases that are frequently epicardial or intramyocardial.[6] The increased sensitivity for diagnostic findings can be explained by the fact that unipolar diseased areas are significantly larger than bipolar areas. Unipolar signals can reveal areas of diseased myocardium even when the bipolar electroanatomic mapping is completely normal or minimally affected.

Furthermore, the use of a 20-pole steerable multielectrode catheter for mapping can improve mapping resolution within LVAs and allow for a considerable reduction in time and use of fluoroscopy, lowering exposure toward the patient and physicians.

Future directions

Advancements in bioptome technology and CARTO high-density mapping system with multielectrode catheter may further optimize guidance and precision in cardiac biopsy procedures. The integration of advanced imaging modalities and artificial intelligence algorithms could automatically identify areas for cardiac biopsy, detecting intra- and epicardial involvement with increased sensitivity.

Conclusion

Use of a combined multielectrode high-density bipolar and unipolar maps and integration of bioptome devices with the CARTO mapping system offers a promising approach to enhance guidance and accuracy in cardiac biopsy procedures, improving diagnostic yield and patient care.

Acknowledgments

All authors are grateful to Fondazione Cardimed ETS for supporting the publication of this article.

Funding Sources: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Disclosures: The authors have no conflicts of interest to disclose.

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