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TITLE: Omnipolar versus bipolar mapping to guide ventricular tachycardia ablation

Short title: Omnipolar mapping in ventricular tachycardia.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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DATA AVAILABILITY STATEMENT

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ABSTRACT

BACKGROUND Omnipolar technology (OT) was recently proposed to generate electroanatomical voltage maps with orientation-independent electrograms. We describe the first cohort of patients undergoing ventricular tachycardia (VT) ablation guided by OT.

OBJECTIVES The purpose of this study was to compare omnipolar and bipolar high-density maps regarding voltage amplitude, late potentials (LP) annotation, and isochronal late activation maps (ILAM) distribution.

METHODS A total of 24 patients (16 ischemic cardiomyopathy, 12 redo cases) underwent VT ablation under OT guidance. Twenty-seven sinus rhythm substrate maps and 10 VT activation maps were analyzed. Omnipolar and bipolar (HD Wave solution) voltages were compared. Areas of late potentials were correlated to the VT isthmuses areas and late electrograms misannotation was evaluated. Deceleration zones based on ILAM were analysed by 2 blinded operators and compared to the VT isthmuses.

RESULTS Omnipolar maps had higher points density (13.8 vs 8.0 points/cm2). Omnipolar points had 7.1% higher voltages than bipolar points within areas of dense scar and border zone. The number of misannotated points was significantly lower in omnipolar maps (6.8% vs 21.9%, p=0.01), showing comparable sensitivity (53% vs 59%) but higher specificity (79% vs 63%). The sensitivity and specificity of deceleration zones detection of the VT critical isthmus were respectively 75% and 65% for OT, and 35% and 55% for bipolar. At 8.4 months, 71% freedom from VT recurrence was achieved.

CONCLUSIONS OT is a valuable tool for guiding VT ablation, providing more accurate identification of late potentials and isochronal crowding due to slightly higher voltages.

KEYWORDS Ventricular tachycardia; Mapping; Omnipolar; Catheter ablation; Bipolar; Electrograms.

INTRODUCTION

Substrate-based catheter ablation (CA) has become the standard of care for the treatment of ventricular tachycardia (VT).[1] Electroanatomic mapping systems have evolved throughout the last decades, especially concerning their computational power and therefore their ability to acquire and analyze a large number of points in a short time. Electroanatomic voltage maps are usually acquired in a bipolar fashion: by subtraction of two neighboring electrodes, to reduce the influence of far-field signals. However, bipolar electrograms (EGMs) are strongly affected by the wavefront direction in relation to the bipole axis.[2] Omnipolar technology (OT) was designed to overcome this limitation. Using a group of electrodes to mathematically derive the myocardial electric field, OT has recently landed in routine clinical practice.[3] This could potentially allow for more accurate voltage estimation and improved annotation for the propagation maps and late potentials. OT applied to animal models was promising.[4] Yet, there is no prospective data in the literature concerning ventricular tachycardia ablation with the support of OT mapping in the clinical setting.

Specifically, it is unknown 1) what the correlation between omnipolar and bipolar voltage is. 2) if a clearer signal will result in improved activation maps, late potential maps, and isochronal crowding identification.

The objective of our study is to compare the efficacy of OT with that of traditional bipolar mapping in delineating the functional substrate implicated in sinus rhythm (SR) and potential ventricular tachycardia (VT) circuits among patients receiving VT ablation.

METHODS

STUDY DESIGN AND PATIENT SELECTION

This is a prospective observational study of VT-ablated patients after substrate mapping with the OT. From October 2021 to February 2023, 24 consecutive patients referred for catheter ablation of scar-related sustained VT at the University Hospital of Bordeaux underwent mapping with an HD grid catheter (HD Grid, Abbott, Abbott Park, IL) with Ensite X mapping system and incorporated OT algorithm. The procedures were performed either under general anesthesia or conscious sedation, and epicardial mapping was performed as clinically indicated. All patients had previous episodes of recurrent, sustained VT requiring ICD interventions or external cardioversion. Written informed consent was obtained from all patients before ablation, according to institutional guidelines. The research was approved by the local ethics committee.

OMNIPOLAR

Omnipolartechnology has been previously described.[3,5] Local unipolar signals obtained from a group of 3 electrodes (clique) are used to derive a traveling wave (TW) along the myocardial surface. A TW produces an electric field, that can be derived by the OT and permits the determination of the wave's direction. Moreover, electrode orientation-independent omnipolar electrograms are recorded, from

which the maximal voltage OT signal can be selected. The OT signal's characteristics are projected on the myocardial geometry at the center of these cliques. EGMs were filtered at 30–300 Hz.

EP STUDY

5-French decapolar and quadripolar catheters were placed in the CS and the right ventricle (RV), respectively. The LV endocardium was accessed using either a transseptal or retrograde arterial approach. Pericardial access, if required, was obtained before systemic heparinization, via a percutaneous subxiphoid puncture. A long steerable sheath (Agilis, St Jude Medical, Saint-Paul, MN, USA) was used in all cases. Activation and voltage maps were created in sinus rhythm (SR) or RV pacing, with the EnSite X system (voxel mode) using the Advisor HDG Mapping Catheter, Sensor Enabled. All maps were evaluated in OT mode. The internal and external projection setting was set at 7 mm with 7-mm interpolation. We performed meticulous substrate mapping focusing on low-voltage regions and regions of wall thickness heterogeneity based on preprocedural CT imaging, if present. Voltage mapping was performed using established voltage settings of <0.5 mV for dense scar and <1.5 mV for border zone.[6] Local activation time maps were obtained with automatic annotation on the last deflection with a window of interest set at >500ms from reference and a minimum of 0,06 mV. Late potentials (LPs) were depicted as signals automatically annotated after the end of the QRS complex.[7] Local abnormal ventricular activities (LAVAs)were manually annotated in areas with coexisting LAVA and far-field activity. Isochronal late activation mapping (ILAM) areas were automatically displayed in zones of color crowding with 8 equally distributed isochrones of activation, as described in a previous publication.[8] The inducibility of VT was evaluated using two drive trains (600 and 400ms) and a maximum of 3 extra stimuli. Pace mapping was performed to assess correlation with the target VT morphology. The "critical isthmus" was identified on the electroanatomic map for each inducible VT, when possible, by considering the presence of diastolic potentials, entrainment with a post-pacing interval (PPI) minus tachycardia cycle length (TCL) of less than 30 ms, termination by ablation, or the most suitable pace-map location with the longest stim-to-QRS interval in cases where entrainment could not be achieved. Ablation was carried out by leveraging the information presented on the OT map. To target a specific zone, we employed a combination of all the aforementioned techniques, integrating their unique strengths to optimize the overall approach. Radiofrequency ablation was used in all patients except for one who underwent ultra-cryo ablation (Adagio Medical, Laguna Hills, California; vCLAS(TM) ULTC System). Unfractionated heparin was administered throughout the procedure to maintain an activated clotting time of 250–350 seconds.

OFFLINE ANALYSIS

To evaluate the OT algorithm's detail detection capacity, electro-anatomical maps (EAM) were replayed offline with bipolar fashion, using the HD wave solution algorithm. The HD wave identifies and displays the local EGM with the largest amplitude among all orthogonal pairs of electrodes (along the spline vs. across the splines). As the HD wave solution has shown to be superior in scar zone evaluation in comparison to standard bipolar,[9] is considered the benchmark for bipolar mapping in this study. Consequently, throughout this text, we will refer to the HD wave solution simply as "bipolar." Voltages, late potentials automatic annotation distribution, and ILAMs were compared between the bipolar and OT mapping methods. For each map, 100 random points annotated as LPs were randomly selected and automatic annotation was evaluated by an expert blinded operator. ILAMs and LPs were evaluated in the 10 cases in which VT diastolic signals could be mapped. LPs areas were correlated to the VT diastolic pathways of the VT circuit. Automated isochronal late

activations in omnipolar and bipolar maps were evaluated by 2 different operators, blinded both on the utilized mapping algorithm and the VT diastolic potentials localization.

STATISTICAL ANALYSIS

Continuous variables are given as mean ± SD or median [interquartile range]. Comparisons between groups were made with parametric (Student t) or nonparametric (Mann-Whitney U) tests, respectively. Comparison between categorical variables was performed with the χ^2 test and Fisher exact test. Event-free survival was estimated by the Kaplan-Meier method. SPSS 23.0 (IBM Corp, Armonk, NY) was used for all statistical analyses.

RESULTS

PATIENT CHARACTERISTICS

The baseline characteristics of the 24 patients are shown in Table 1. Twenty (83%) patients were male, with a median age of 59±16 years and a median ejection fraction (EF) of 41±14%. Twenty-three patients had an ICD and 5 presented with VT storm. Twelve patients were redo procedures. Sixteen cases (66%) were VT due to ischemic cardiomyopathy. Among the non-ischemic cardiomyopathy group, 6 patients had arrhythmogenic right ventricular cardiomyopathy, one laminopathy, one valvular induced cardiomyopathy, and one peripartum cardiomyopathy. Epicardial access was performed in 7 patients.

CATHETER ABLATION

High density mapping was performed in the LV for 15 patients, in the RV for 5 patients, and in the epicardial space for 7 patients, with a median mapping time of 42 min (32–46). Monomorphic VTs were induced mechanically or by programmed pacing in 21 patients and 13 had at least 2 VT morphologies. Substrate-based ablation was performed with the goal of LP and/or LAVA abolition. For ischemic patients, CT scan WT channels were also targeted. Additional ablations were also performed for patients with non-mappable VTs based on pace-map to identify the VT's isthmus exit. In 12 patients it was possible to obtain a complete or partial map of the diastolic isthmus of the clinical VT, confirmed by entrainment maneuvers. In 2 of these patients, the VT was incessant, therefore no voltage map was obtained before ablation. In these cases, after ablating the critical isthmus either in VT or SR, a substrate-based modification was performed. The median total RF time was 32.8 min (22.3–41.7). One patient also received ethanol infusion in a coronary sinus' septal branch for an intra-septal VT involving the midmyocardium between LV and RV. The median total procedural time was 210 min (170–250).

SUBSTRATE MAPS

The number of points acquired and used with OT appeared higher than HD WAVE (23940 vs 15921 and 3334 vs 2257, respectively). Also, the density of points per cm2 was significantly higher for OT (14.2 vs 9.5 points/cm^2; $p<0.01$). The median areas, number of points, and points density with

voltages lower than 1.5 mV, lower than 0.5 mV, between 1.5 and 0.5 mV, 0.5 and 0.3 mV, 0.3 and 0.1 mV, and lower than 0.1 mV are displayed in table 2.

OT identified higher mean voltages when compared with bipolar mapping in all patients (Figure 1). The global mean voltages of the left ventricles, right ventricles, and epicardial space were significantly higher with OT when compared with bipolar (LV: 1.82 mV vs 1.75 mV; P < 0.01; RV: 2.07 mV 2.15 mV; P < 0.01; EPI: 1.62 mV vs 1.49 mV; P < 0.01). Median values for the single maps are displayed in the supplement (data supplement, table 1). The relative voltage difference was 7.14% (0.81 mV [0.28-2.05] vs 0.76 mV [0.27-1.95], p<0.01) (Supplementary Figure 1).

AUTOMATED LATE POTENTIALS MAPS.

Areas with LPs accounted for a median of 20.5 cm^2 (11.3-54.3 cm^2) of the myocardium mapped with the OT. At offline analysis using a bipolar mapping technique, the median area with automatically annotated LPs points was 66 cm^2 (31.6-138.5 cm^2; p < 0.01 compared to the omnipolar LP area). Furthermore, the automatic annotation for each map was evaluated after randomly selecting 100 points that were annotated as LPs. Bipolar maps had 21.9% of points falsely annotated on noise, while only 6.8% were misannotated in omnipolar (p<0.01).

The diagnostic performance of LPs was analyzed in the 10 patients in whom the critical isthmus was mapped during VT. For both omnipolar and bipolar there was the presence of LPs in 8 of the 10 VT isthmuses (Figure 2). In terms of covered areas, the sensitivity of LP in the sinus map for identifying areas with mid-diastolic activation in VT was 53% for OT and 59% for bipolar. However, the specificity of LPs with OT mapping (79%) was higher compared to bipolar mapping (63%).

ISOCHRONAL LATE ACTIVATION MAPPING

The sensitivity and specificity of ILAMs detection of the critical isthmus were respectively 75% (56–94%) and 65% (44–86%) for OT, and 35% (14–56%) and 55% (33–77%) for bipolar. The positive predictive value for OT vs bipolar was 68% vs 44%, while the negative predictive value was 72% vs 46% (Figure 3).

ACUTE AND LONG-TERM CLINICAL OUTCOMES

An induction protocol was performed at the end of the procedure for 21 patients, with nonclinical VT induced in 3 patients including 1 with polymorphic VT, resulting in an acute success rate of 86%. The following complications were observed: 1 groin arterio-venous fistula and 2 pericardial effusions treated with immediate drainage due to tamponade; there were no periprocedural deaths. The follow-up was available for all the patients. After a median of 251 days (111-337 days) from the initial ablation procedure, there was no VT recurrence in 16 patients, indicating a long-term success rate of 71% (Figure 4). One patient died of heart failure and another patient underwent a cardiac transplant during the follow-up.

DISCUSSION

Our study is the first prospective evaluation of OT to guide VT ablation in the clinical setting. Our main findings are as follows:

1. OT maps in VT patients have a higher density of points and higher voltages, with scar areas that appear non-significantly smaller.
2. Automatic annotation (both for late potentials and ILAM) is more accurate on OT maps.
3. VT ablation based on OT opens new clinical perspectives.

High density mapping has become widely utilized, and several multipolar catheters have been developed to support it.[10] The Advisor HD grid allows the presence of bipoles on perpendicular axes. The HD wave algorithm considers 2 orthogonal bipoles and annotates the one with the highest voltage, while the OT uses fix triangular groups of electrodes, called cliques.[3] OT derives the electric field passing in the area enclosed by the clique and mathematically derives the signal with the maximal possible voltage.

Preliminary studies have shown promising results for ventricular mapping with OT, however, there is an important need for clinical data.[4] We present here the first human cohort of VT patients ablated using OT multipolar mapping.

VOLTAGE MAPS

The different electrode arrangement provides 36 potential mapping points with OT, in comparison to only 12 with HD WAVE.[11] This gives a higher number and density of points in all the maps evaluated. In our experience, OT maps have a significantly higher density of points, both overall and in diseased tissue.

Another important difference concerns the voltage itself: The angle of incidence of an electric wavefront with a bipole affects local EGM, leading to low-amplitude signals when activation is orthogonal to the electrode axis.[2] The OT works on the assumption that the real voltage of a given point is the highest of all the potential bipoles scanning the surface. Consequently, OT identified an overall higher maximum voltage for endocardial and epicardial maps. Our study found an overall voltage difference of 7.14%, with the scar accounting for 61.6% in OT and 62.9% in bipolar mapped areas. this data is in agreement with that previously published in preclinical experience and atrial fibrillation patients.[4,12] Although significant, this difference is mitigated by the fact that in the set of normal mapping, the catheter can rove and change the angulation in relation to the myocardial surface. Moreover, the system is designed to only use the point with the highest voltage, called “the best duplicate”, and so the mean OT voltages appear only moderately higher.

Areas classified as scar were also minimally smaller in OT. A possible explanation for this phenomenon could be that the significantly higher density of OT points increases the definition of the border zones and shows the actual voltage in locations where in bipolar maps points are only interpolated.

Generating a baseline map can be a time-consuming task, especially for patients undergoing VT ablation, with unstable hemodynamic compensation. In those cases, having a significantly higher number of points without the necessity to map from different angles can be beneficial. These advantages could be crucial when assessing fibrotic areas that are difficult to access. Furthermore, the improvement in scar discrimination in low voltage areas could help identify isthmuses, that could be overlooked or displayed as homogeneously silent on bipolar maps.

LOCAL ACTIVATION TIME ANNOTATION ON LAST DEFLECTION

For homogeneous myocardium, the initial peak of a filtered bipolar signal coincides with depolarization beneath the recording electrode and appears to correlate most consistently with LAT.[13] At sites with continuous and fractionated activity this may not be true and of more difficult to evaluate. Choosing the offset of the local EGM appears more reliable and reproducible approach.[14] Ensite system's automatic annotation of LAT on the last deflection enables quicker LAT map creation, providing a standardized visualization of late potentials and ILAMs.

The presence of Late Potentials (LPs) or continuous fractionated ventricular signals with an HD-grid catheter in bipolar mode has been shown to be associated with the VT isthmus.[15] Areas of late potentials in our data were smaller for OT when compared to bipolar maps. This can be caused by misannotation of the last deflection on noise in bipolar maps, as seen in our study. A possible explanation for this could be that maximization of the voltages in OT permits a better signal-to-noise ratio, and so annotation on true late signals. Furthermore, the less distinct wavefront shape in bipolar maps generally results in slightly later activations, contributing to the identified discrepancies. When LPs areas are compared to partial or complete VT isthmuses, LPs using OT had a slightly lower sensitivity for the detection of VT isthmus, but significantly higher specificity.

Isochronal late activation maps (ILAM) have shown a good level of correlation between deceleration zones and critical VT isthmuses.[16] Lately, automatic last deflection annotation has been proposed for faster ILAMs detection, appearing to have a good prediction level.[8] We analyzed automatically annotated ILAMs in areas where a complete or partial VT isthmus was displayed, and in the OT maps correspondence was more accurate than in bipolar maps. In OT, isochronal lines seemed more homogenous, hence there were fewer speckles of erroneously annotated activation and therefore a cleaner overall impression. As for LPs areas, this is probably due to the more accurate annotation capacity on the last deflection for the OT algorithm.

CLINICAL IMPLICATIONS

In our study, all ablations were performed on the base of omnipolar technology. While it is challenging to determine whether the ablation strategy or extent would have varied if guided by conventional bipolar voltage, the enhanced visualization of substrate and functional maps provided by the OT approach suggests that in some instances, bipolar maps might have failed to identify crucial targets.All patients except 2 had inducible VT using PVS or spontaneously at the beginning of the procedure, 86% of cases had non-inducible VT at the end of the procedure after targeted functional substate VT ablation, which is promising comparing with recent and older trials (46-82%).[17–19] At 8.3 months of median follow-up, the rate of VT-free survival was 71%. These results appear encouraging, also considering that half of the population (n=12) had previous ablation.

LIMITATIONS

This is a prospective non-randomized cohort of 24 patients. The relatively low number of patients is due to the novelty of this approach. Larger cohorts are required to evaluate its outcomes. There is a bias towards OT maps since only OT was used to guide ablation. The retrospective evaluation of the bipolar maps might have underestimated its potential, as it was applied to points previously collected in OT modality. Non-inducibility was used as an endpoint, although suboptimal, it is one of the more commonly utilized acute endpoints for a VT ablation. Only a small number of ventricular tachycardias

were stable enough to obtain a detailed mapping of the diastolic pathway of the VT circuit, therefore it was impossible to map all the potential VT circuits. As detailed histopathological information was unavailable, we could not provide pathology validation of the electroanatomic-derived information, in particular concerning the voltage. Contact force-sensing ablation catheters were not used consistently.

CONCLUSIONS

Omnipolar technology appears to be a reliable method to analyze electrical signals and allows precise annotation on voltage and activation maps. Given the complexity and unique features of each VT, omnipolar maps, with their higher density of points and overall higher voltages, can help discriminate signals in heterogeneous areas, as scar borders. Automatic local activation time annotation on the last deflection is more accurate in omnipolar than in bipolar. Substrate-based ablation performed under the guidance of an OT derived map is feasible, with good acute and mid-term outcomes.

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TABLES

Patients	**24**
Age	59.5±16.4 y
Male	20 (83)
BMI	27.8±4.6
EF %	41.5±13.8
Ischemic heart disease	16 (66)
Hypertension	8 (33)
AF	7 (29)
DM	2 (92)
eGFR	80.6±27.4 ml/min

ICD	19 (79)
CRT-D	4 (17)
VT CL	370±101 ms
Electric storm	5 (20)
ICD shock	14 (83)
B-Blockers	20 (83)
Amiodarone	10 (42)
Previous VT ablation	12 (50)

Table 1: Patients' baseline characteristics. Values are given as n (%), or mean ± SD. BMI, body mass index; EF, ejection fraction; AF, atrial fibrillation; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; ICD implantable cardioverter-defibrillator; CRT cardiac resynchronization therapy; VT CL, ventricular tachycardia cycle length.

	Omnipolar	Bipolar	p
total area, cm^2	192.4 (163.8-283.4)	197.6 (166.3-293.3)	0.799
Used points	2601 (1862-4033)	2009 (1226-2978.5)	**0.027**
Total density, points/cm^2	13.8 (10.2-18.1)	8 (7.3-12.6)	**<0.01**
Total area voltage, mV	0.81 (0.28-2.05)	0.76 (0.27-1.95)	**<0.01**
<1.5 mV area, cm^2	120.1 (77.1-198.6)	129.3 (78.5-214.1)	**<0.01**
<1.5 mV points	1651 (1250-2373)	1160 (926-1853)	**<0.01**
<1.5 mV density, points/cm^2	14.8 (11.1-20.3)	8.5 (7.1-13.4)	**<0.01**
<1.5 mV voltage, mV	0.418 (0.114-0.379)	0.412 (175-0.811)	**0.01**

1.5-0.5 mV area, cm^2	57.9 (41.8-41.8)	64.5 (41.2-99.2)	0.810
1.5-0.5 mV points	904 (529-1122)	609 (341-765)	**0.021**
1.5-0.5 mV density, points/cm^2	15 (9.9-19.9)	8.1 (6.2-13.1)	**<0.01**
1.5-0.5 mV voltage, mV	0.886 (0.674-1.146)	0.879 (0.669-1.140)	**0.049**
<0.5 mV area, cm^2	61.3 (34.8-97.0)	71.8 (35.0- 108.5)	**<0.01**
<0.5 mV points	935 (545-1399)	735 (366-1165)	**<0.01**
<0.5 mV density, points/cm^2	15.1 (11.9-21.8)	10.2 (8.2-13.7)	**<0.01**
<0.5 mV voltage, mV	0.202 (0.074-0.190)	0.199 (0.106-0.326)	**.0324**
0.5-0.3 mV area, cm^2	19.7 (14.5-33.9)	19.7 (14.9-36.7)	0.692
0.5-0.3 mV points	263 (223-388)	179 (140.5-266)	0.073
0.5-0.3 mV density, points/cm^2	13.4 (11-17.7)	7.9 (6.4-12.1)	**<0.01**
0.5-0.3 mV voltage, mV	0.392 (0.345-0.445)	0.392 (0.344-0.443)	0.29
0.3-0.1 mV area, cm^2	29.8 (14.2-46.9)	32.5 (15-56.8)	0.669
0.3-0.1 mV points	412 (275-703)	325 (187-548.5)	0.148
0.3-0.1 mV density, points/cm^2	16.6 (12.2-25.5)	9.9 (7.5-15.2)	**<0.01**
0.3-0.1 mV voltage, mV	0.189 (0.141-0.240)	0.187 (0.140-0.237)	**<0.01**
<0.1 mV area, cm^2	6.9 (2.4-16.1)	8.5 (1.5-22.8)	0.708
<0.1 mV points	94 (47-344)	97 (28-297)	0.352
<0.1 mV density, points/cm^2	15.8 (12.7-26)	12.2 (9.6-15.7)	0.255
<0.1 mV voltage, mV	0.061 (0.041-0.080)	0.063 (0.044-0.081)	**<0.01**

Table 2: Areas, number of points, points density and median voltages in total areas and in scar areas with voltages lower than 1.5 mV, lower than 0.5 mV, between 1.5 and 0.5 mV, 0,5 and 0,3 mV, 0,3 and 0,1 mV, and lower than 0,1 mV. Values are given as median (IQR).

FIGURES

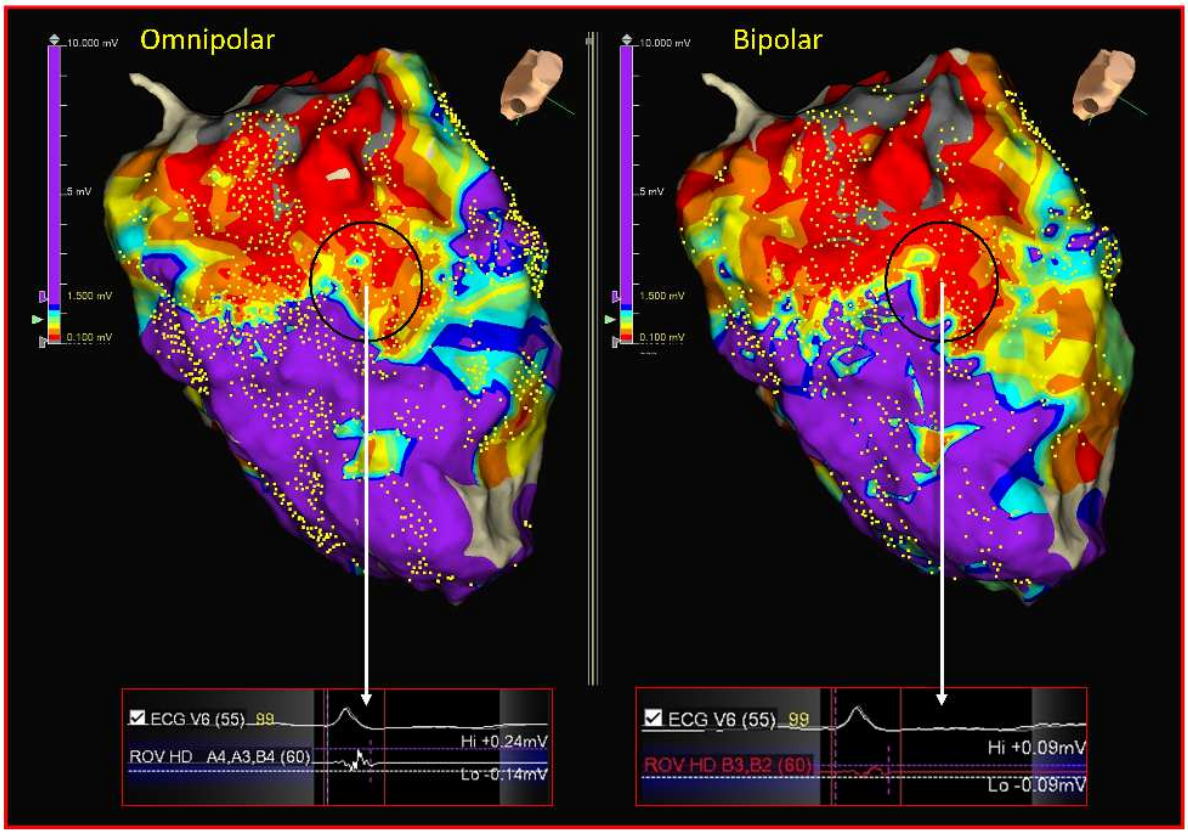


Figure 1: Omnipolar and bipolar voltage maps, obtained in sinus rhythm with the same mapping sequences, in a patient with ischemic cardiomyopathy. The point distribution inside the critical area (Black circle) shows higher mapping accuracy, more tissue heterogeneity, and higher voltages in OT. Two example points collected in the same area show the voltage difference. The maximal voltage was 0.38 mV in omnipolar mapping while the corresponding bipolar point showed 0.18 mV. This trend was also observed throughout the study.

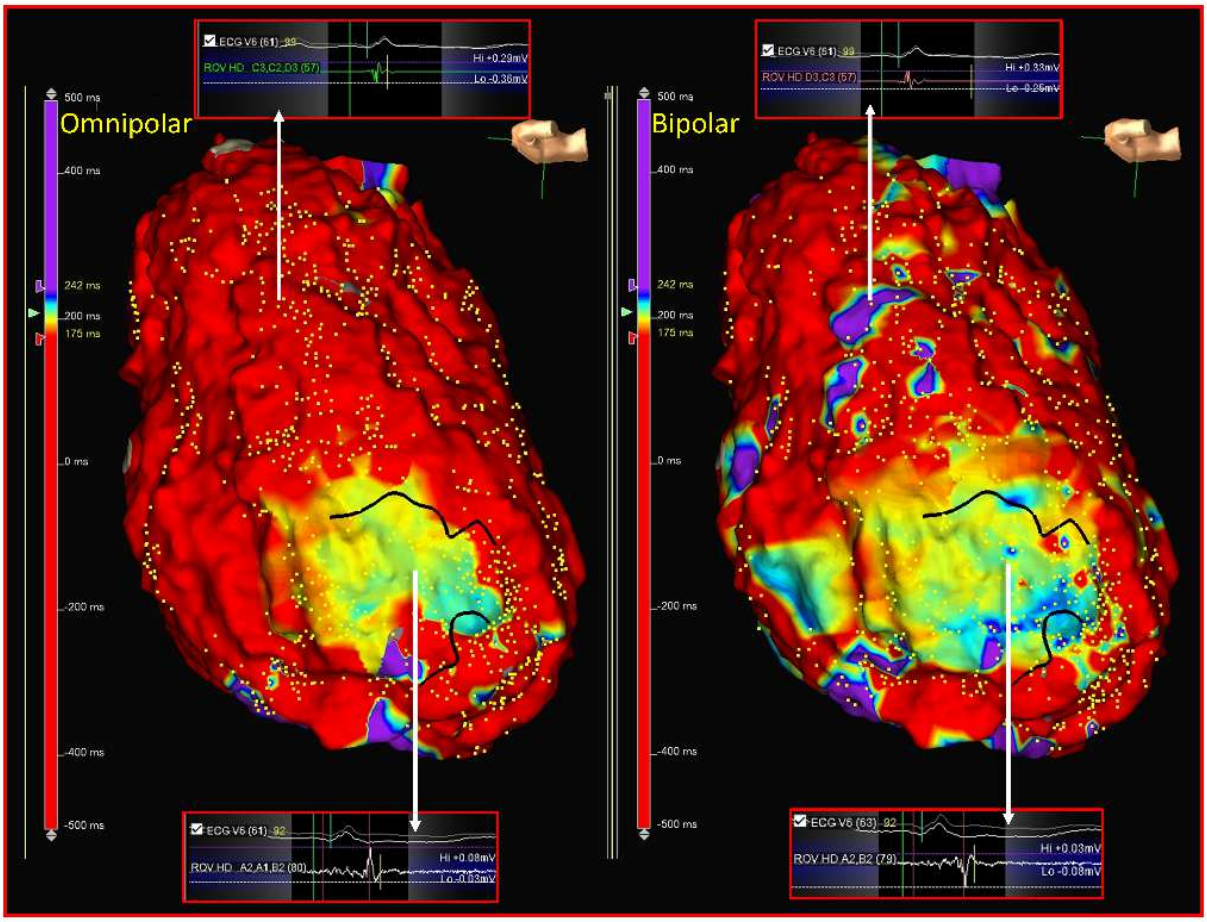


Figure 2: Omnipolar and bipolar late potentials maps, obtained in sinus rhythm with automatic annotation on the last deflection, in a patient with ischemic cardiomyopathy. The black markers delineate the borders of a VT isthmus. The automatic LAT annotation is marked with the yellow line. A correctly annotated late potential is depicted inside the isthmus in both omnipolar and bipolar maps. The bipolar map shows islands of LPs outside the isthmus that are falsely annotated due to noise. The VT activation map can be found in the supplement, figure 2.

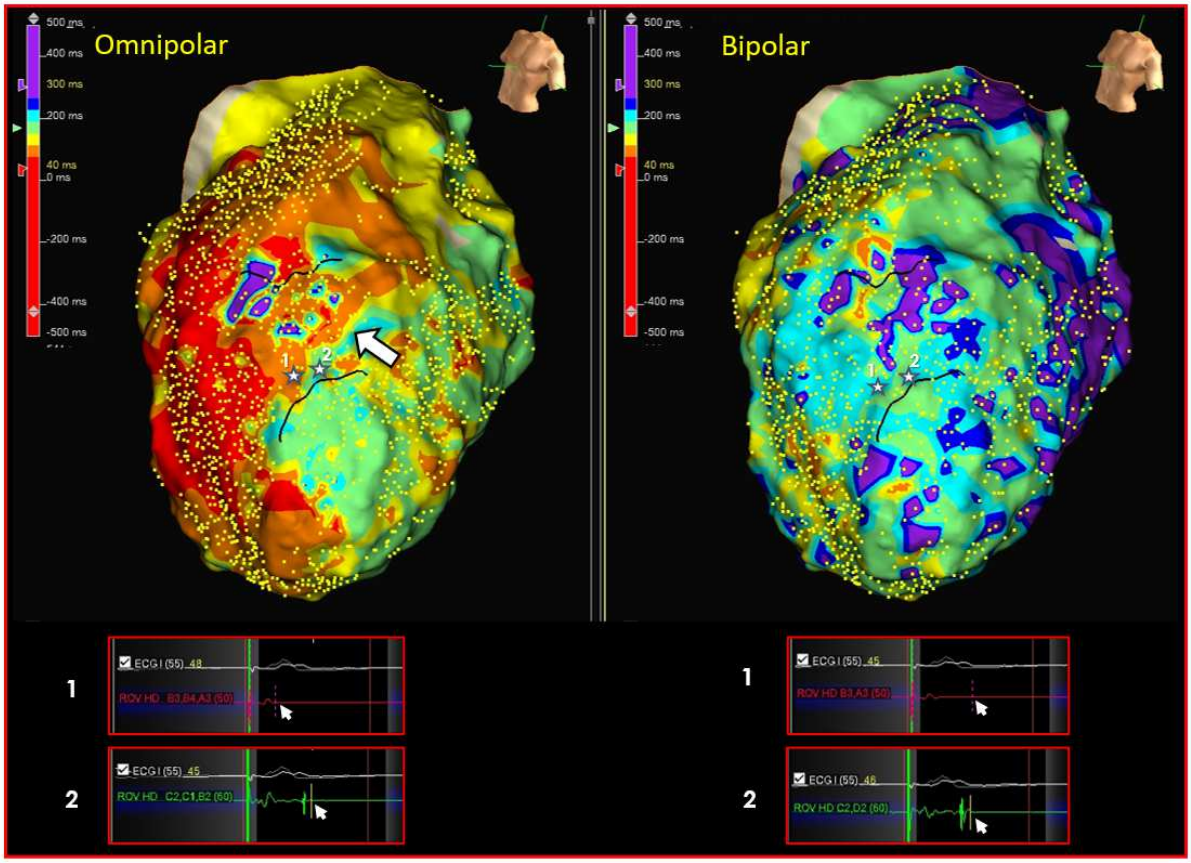


Figure 3: Omnipolar and bipolar isochronal maps, obtained with automatical annotation on the last deflection, in a patient with ischemic cardiomyopathy. The black markers delineate the borders of a VT isthmus. Omnipolar isochronal crowding areas appear to have a more homogeneous wavefront (white arrow) and have a good correlation with the VT isthmus, while in the bipolar map there are no clear deceleration zones. For each map, two electrograms (EGMs) from adjacent areas are presented, demonstrating that accurate annotation in the omnipolar map results in a more homogeneous wavefront (arrowheads). In the bipolar map, the first EGM is annotated on noise, leading to an absence of a temporal gap. he VT The activation map can be found in the supplement, figure 3.

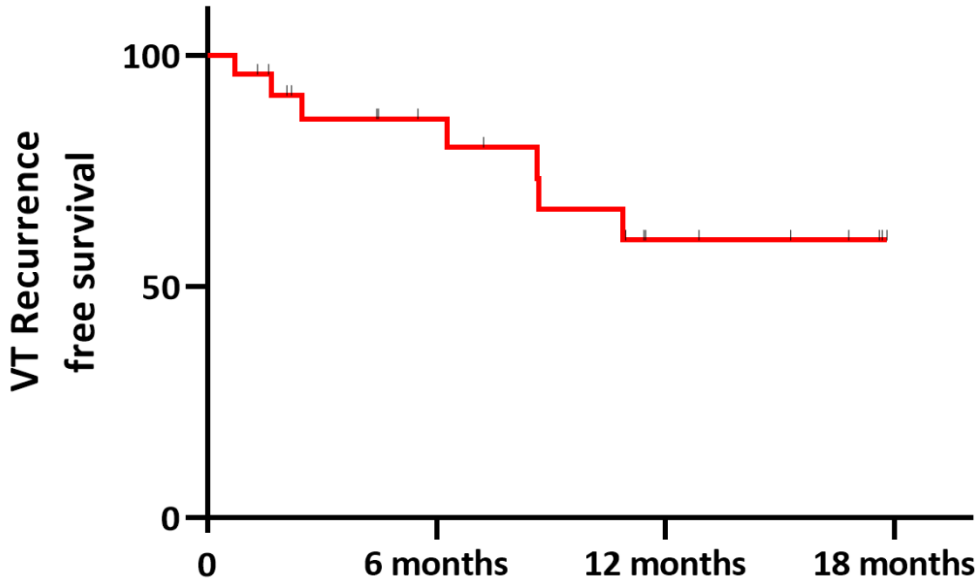


Figure 4: Kaplan Meier curve showing freedom from sustained ventricular tachycardia (VT) for the duration of 18 months after ablation.

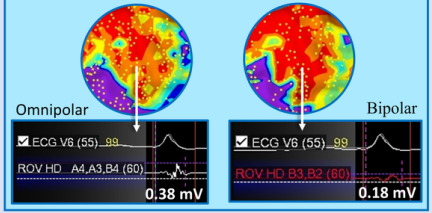
OMNIPOLAR VERSUS BIPOLAR MAPPING TO GUIDE VENTRICULAR TACHYCARDIA ABLATION

Mapping capacity

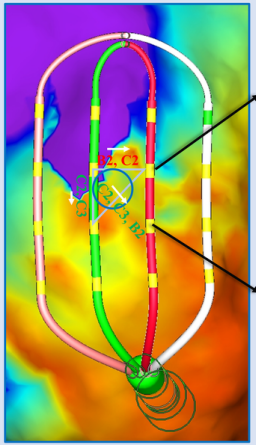
7.1% higher voltages for omnipolar.

Higher points density for omnipolar (13.8 vs 8.0 points/cm^2).

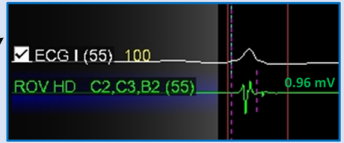
Smaller scar areas for omnipolar.



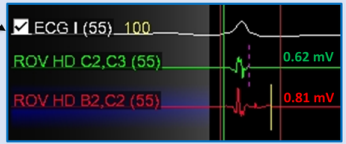
24 patients



OMNIPOLAR



BIPOLAR



Last deflection annotation

Less misannotated points for omnipolar (6.8% vs 21.9%).

Higher deceleration zones detection of the VT critical isthmus for omnipolar.

Higher late potentials specificity for omnipolar.

