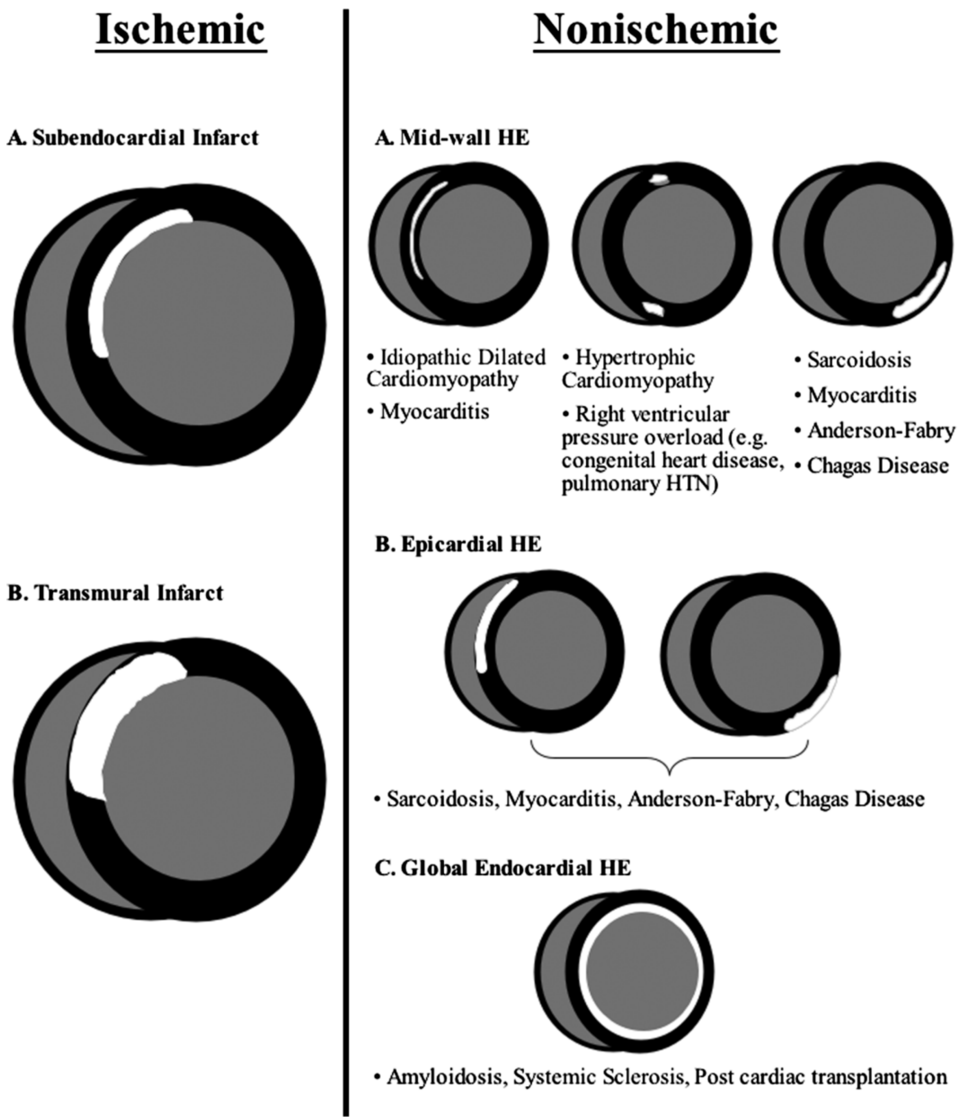
SMC-VT 2016 2016년 10월 29일(토)
Session C. Ablation techniques of scar-based VT
세션시간: 15:20~16:00
발표시간: 15:40~16:00

Ablation techniques of scar-based VT : Non-ischemic VT ablation

Asan Medical Center

Gi-Byoung Nam MD

HYPERENHANCEMENT PATTERNS



Vascular territory

Endocardial

Peri-annular

Diverse

European Heart Journal (2005) 26, 1461–1474

Table 1 Baseline Characteristics of the Population Depending on the Substrate

	Ischemic CMP (n = 51)	Idiopathic Dilated CMP (n = 39)	ARVC (n = 14)
Percentage of epicardial access compared with the global population of VT ablation (n = 722)	16%	35%	41%
Age (yrs)	63 ± 11	59 ± 15	42 ± 13
Men	48 (94%)	32 (82%)	9 (64%)
Left ventricular ejection fraction (%)	31 ± 11	33 ± 12	59 ± 9
Patients with previous endocardial VT ablation	46 (90%)	33 (85%)	9 (64%)
Patients with epicardial mapping and ablation	42 (82%)	36 (92%)	14 (100%)

ARVC = arrhythmogenic right ventricular cardiomyopathy; CMP = cardiomyopathy; VT = ventricular tachycardia.

J Am Coll Cardiol 2010;55:2366–72

Patient Name: H-SJ, Sex/Age: M/64, Procedure Date: 28/May/2015

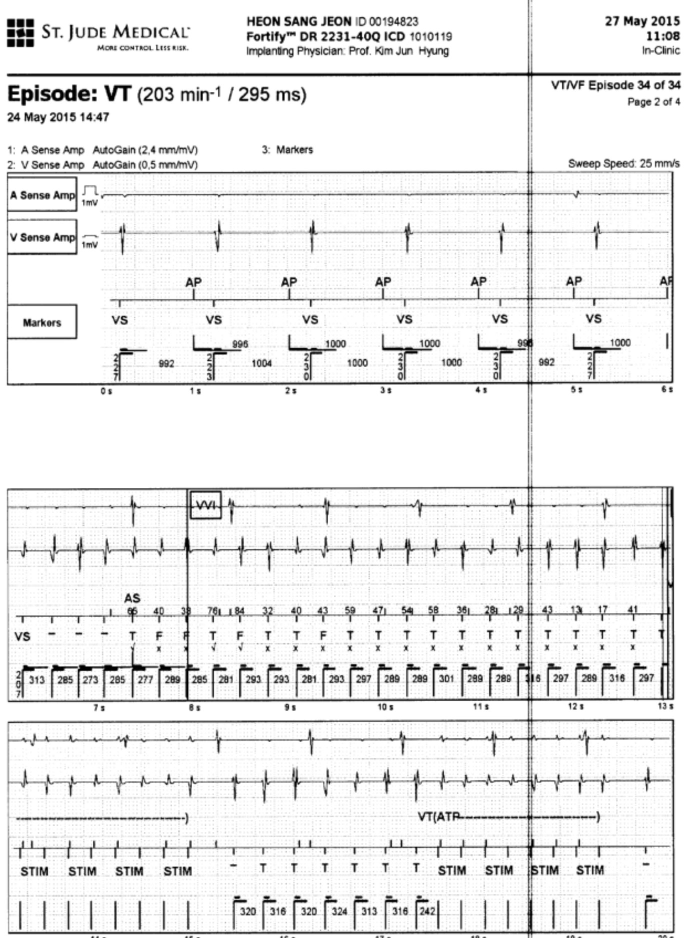
Clinical Diagnosis:

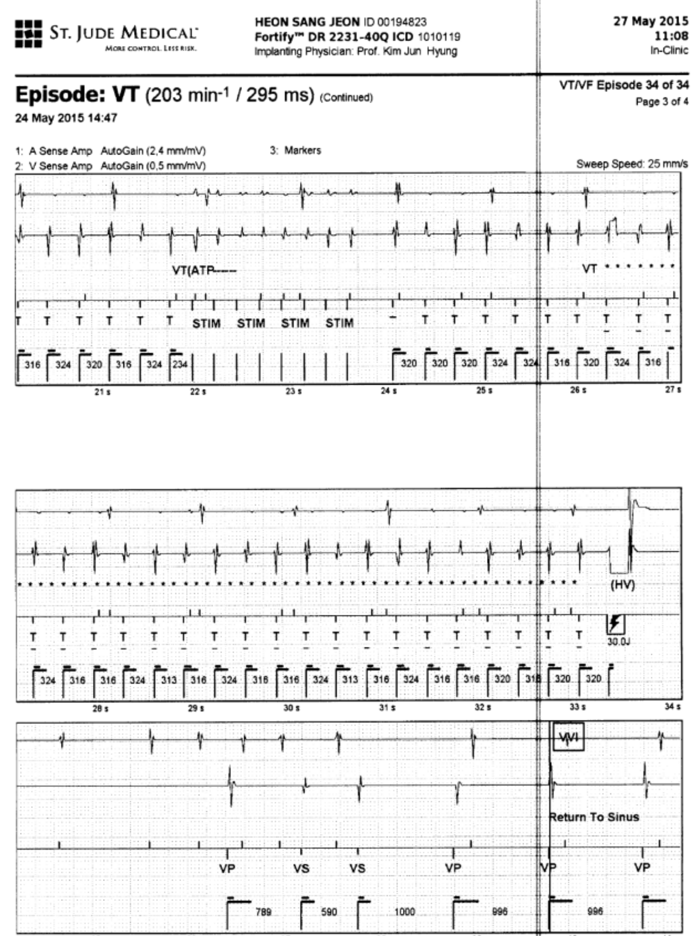
Hypertension

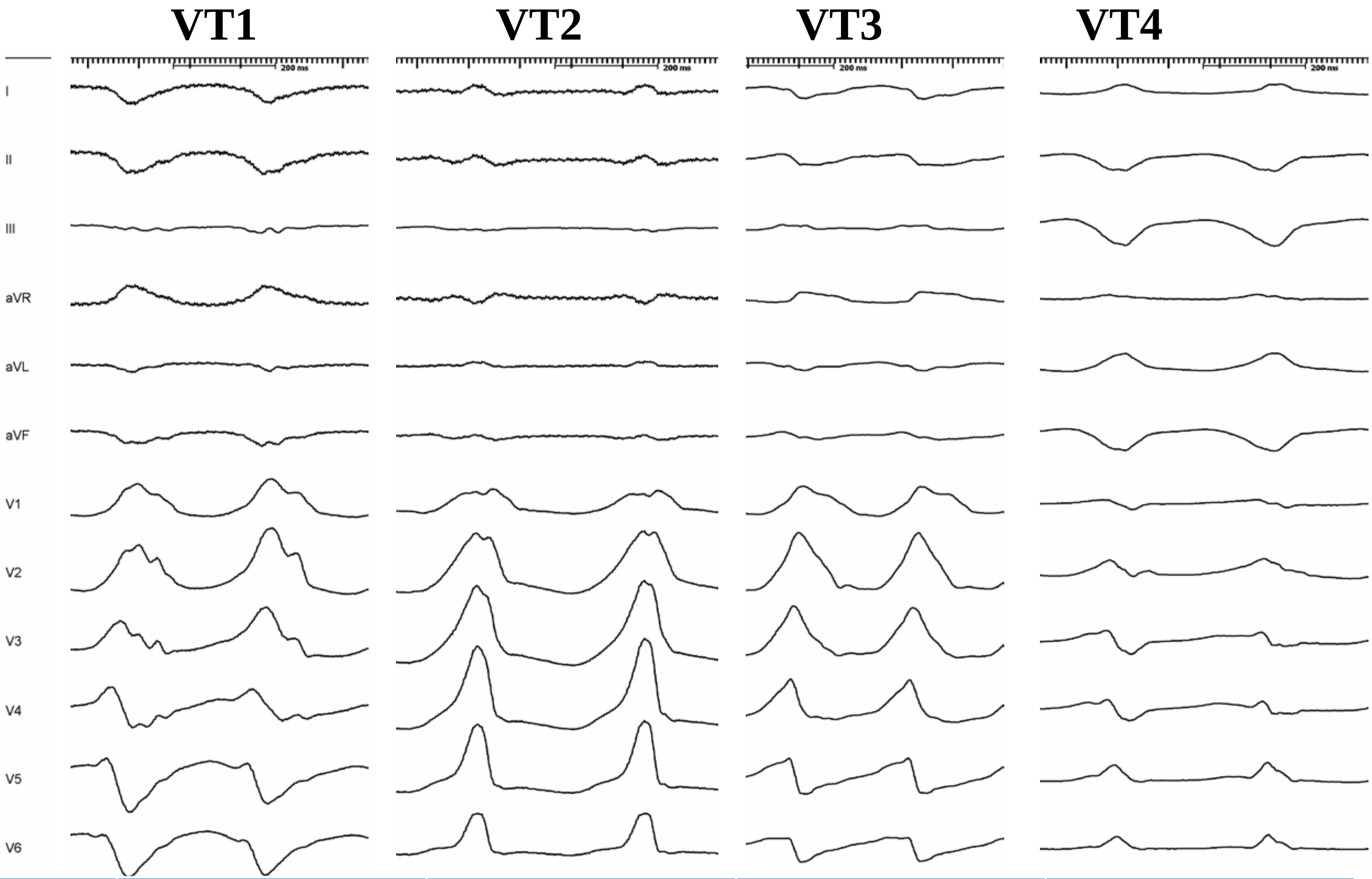
2002, Idiopathic CM, moderate LV dysfunction (EF, 42%)

2012, Sustained VT, NSVT……s/p ICD implantation

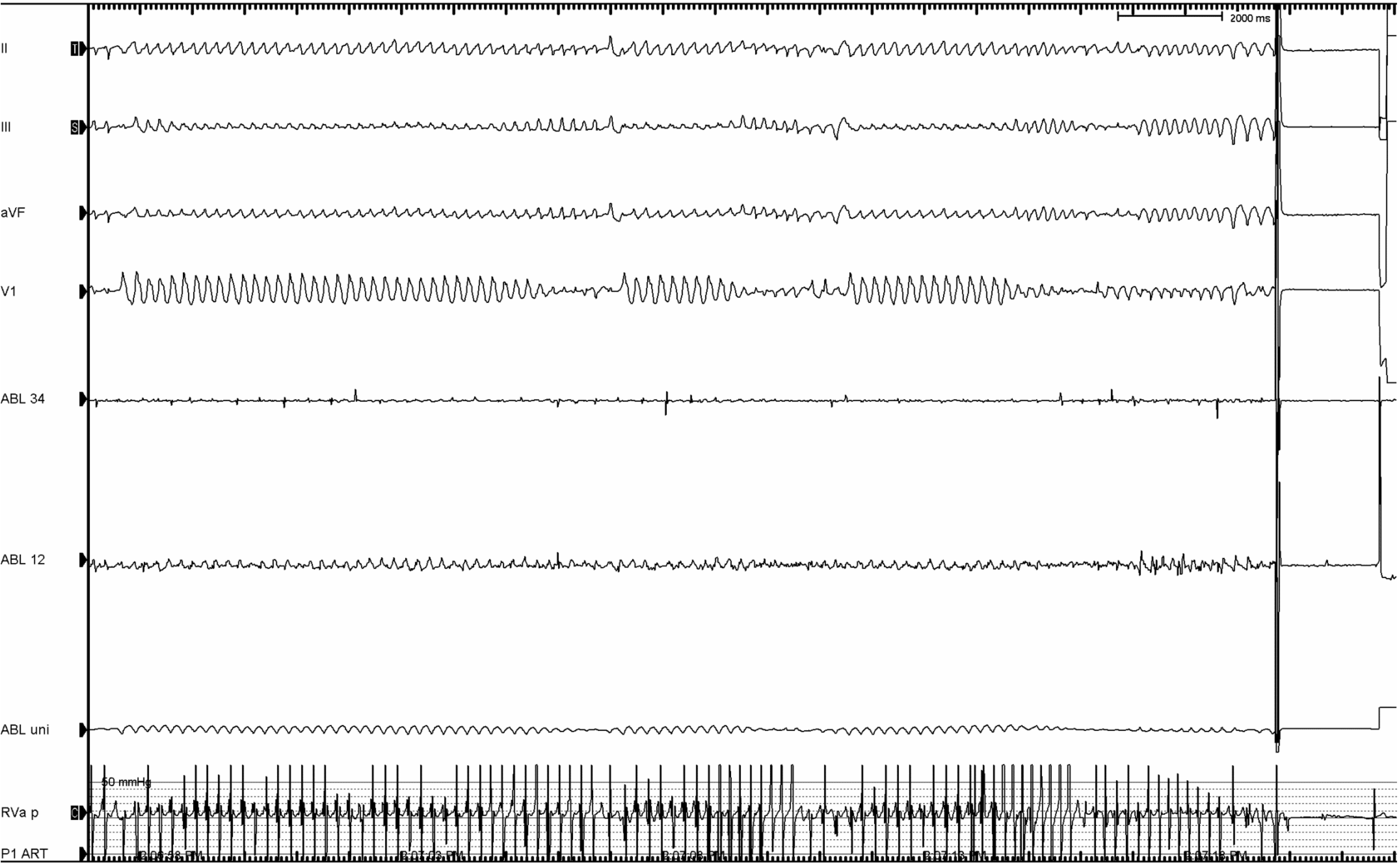
Ventricular tachycardia storm



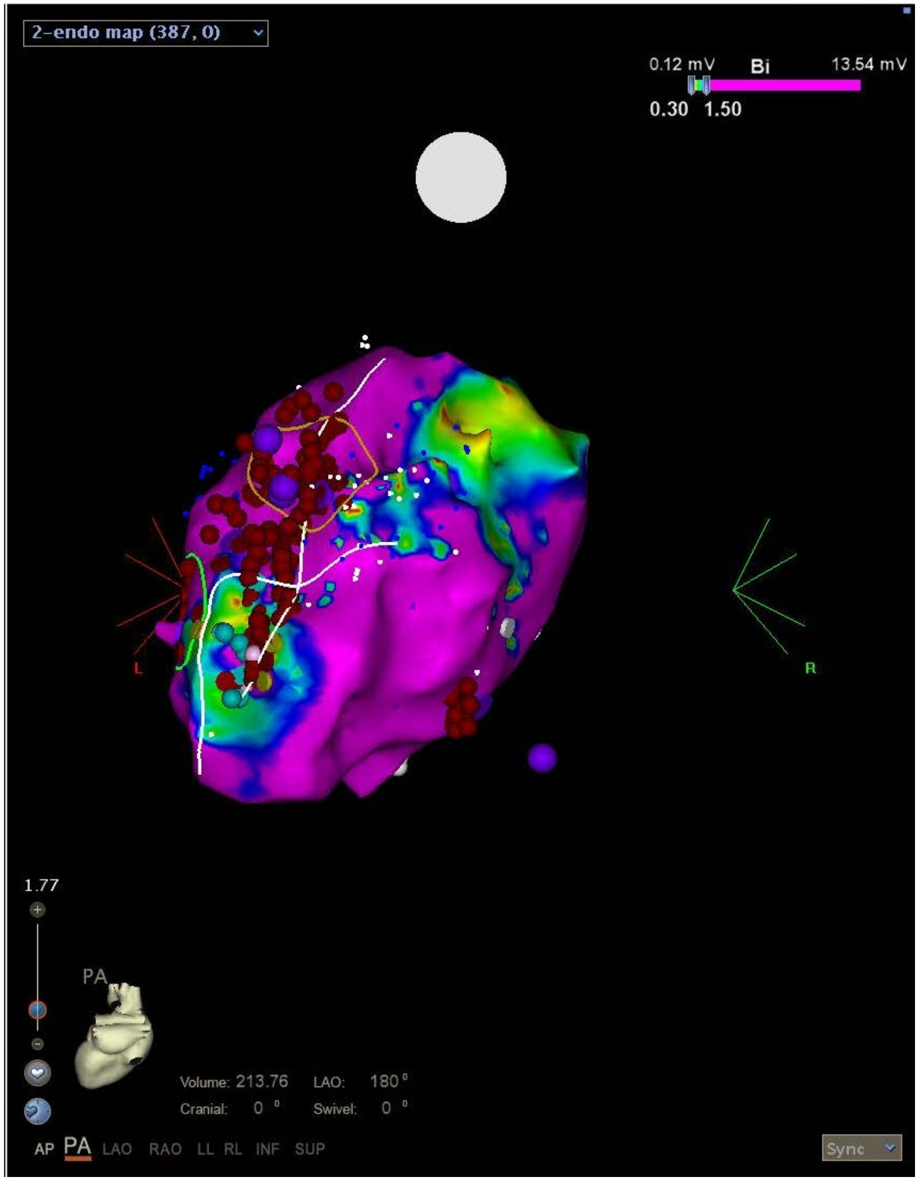


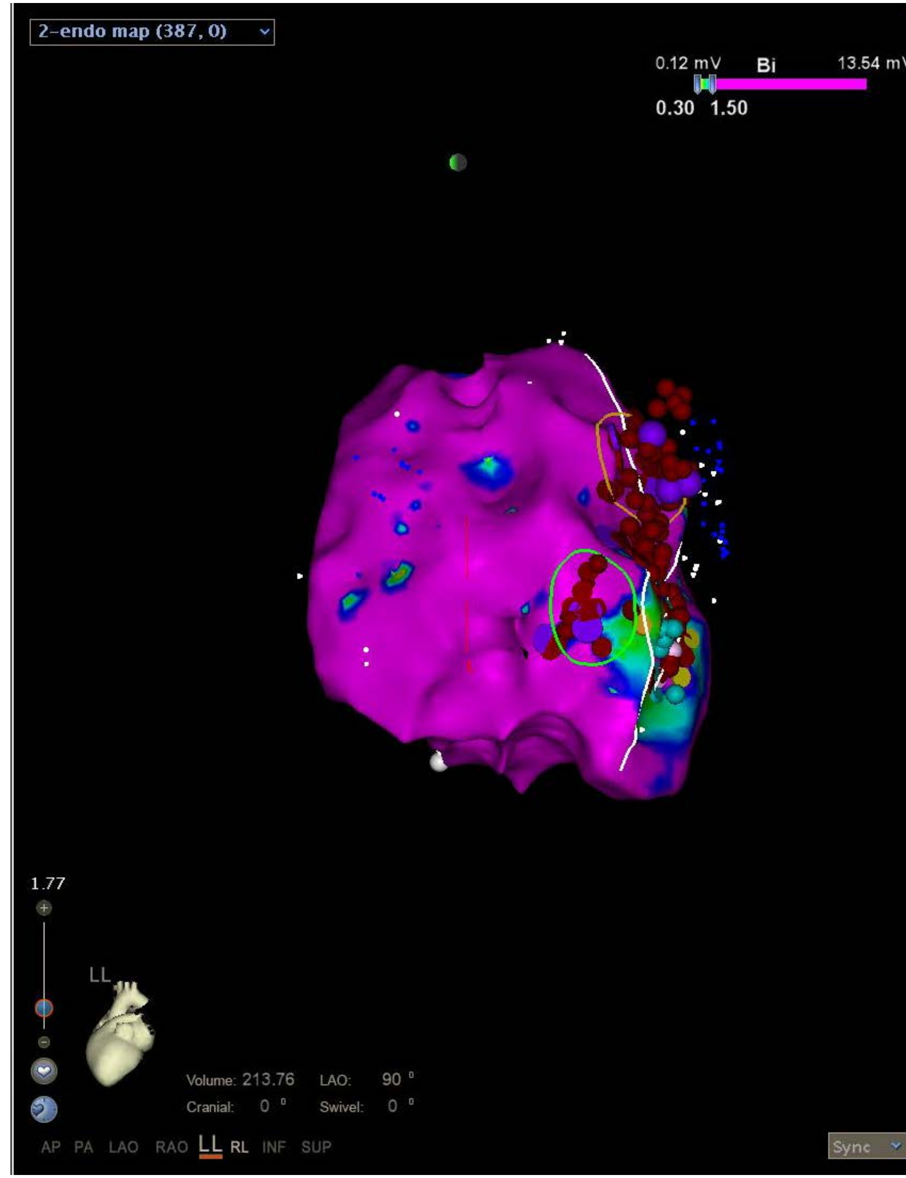


	VT 1	VT2	VT3	VT4
Isuprel	(-)	(-)	(-)	(+)
TCL	260	320	230	270
QRS duration	160	175	170	160
V1	RBBB	RBBB	RBBB	RBBB
I	QS	qRs	rS	R
V5, V6	rS	Monophasic R	rS	R



2000 ms
II
III
aVF
V1
ABL 34
ABL 12
ABL uni
50 mmHg
RVa p
P1 ART

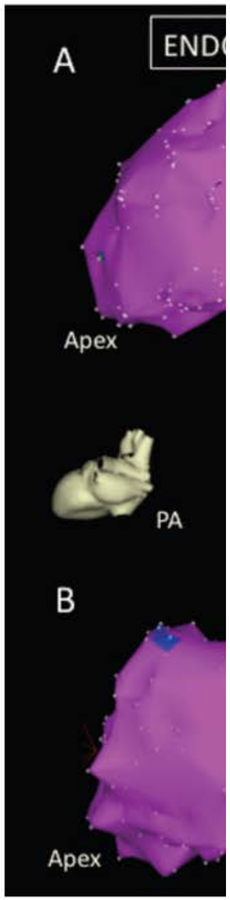

2-endo map (387, 0)
0.12 mV
Bi
13.54 mV
0.30 1.50
L
R
1.77
PA
Volume: 213.76
LAO: 180°
Cranial: 0°
Swivel: 0°
AP PA LAO RAO LL RL INF SUP
Sync

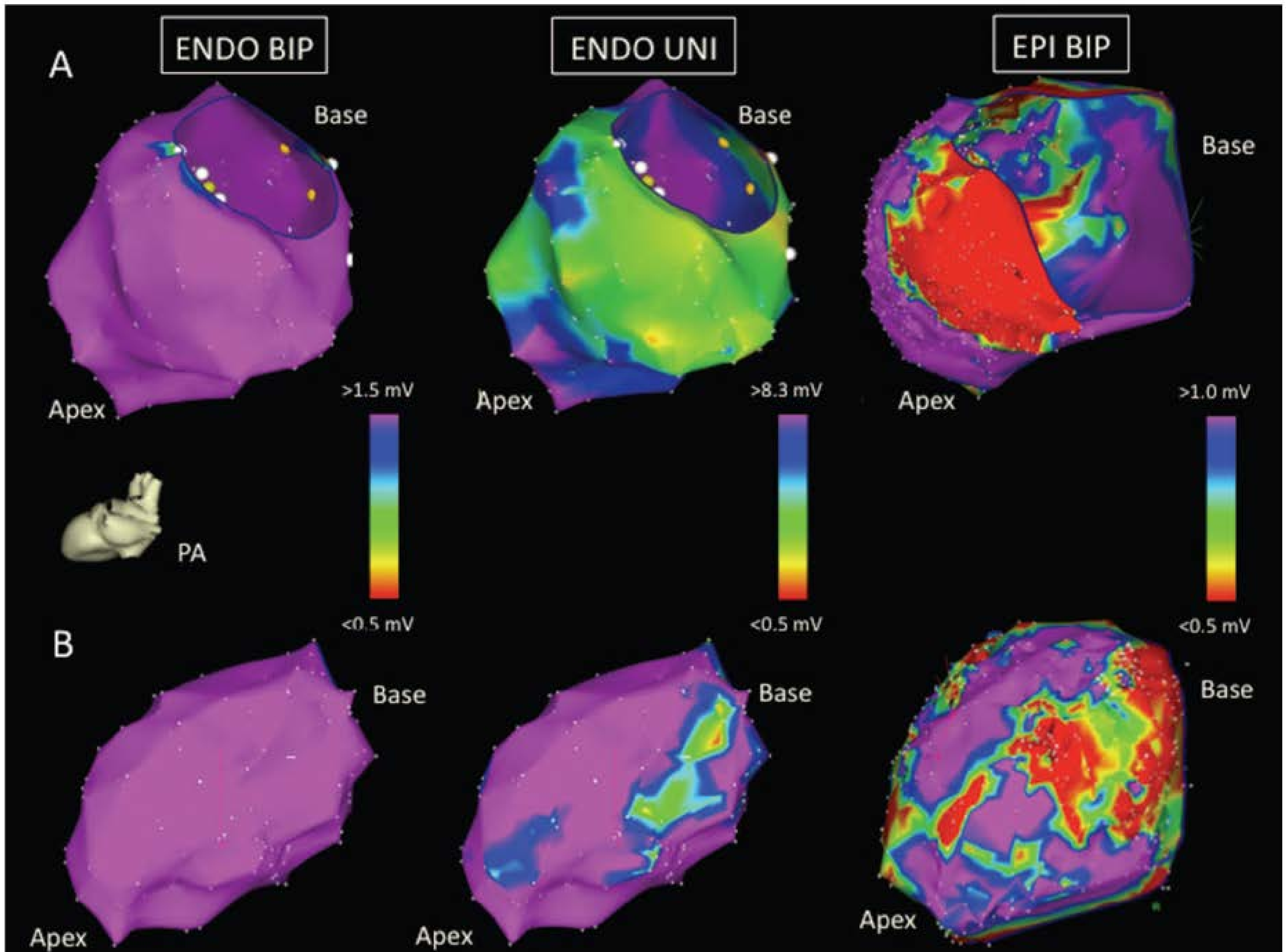

2-endo map (387, 0)
0.12 mV
Bi
13.54 mV
0.30 1.50
1.77
LL
Volume: 213.76
LAO: 90°
Cranial: 0°
Swivel: 0°
AP PA LAO RAO LL RL INF SUP
Sync

Endocardial Unipolar Voltage Mapping to Detect Epicardial Ventricular Tachycardia Substrate in Patients With Nonischemic Left Ventricular Cardiomyopathy

Mathew D. Hutchinson, MD; Edward P. Gerstenfeld, MD; Benoit Desjardins, MD, PhD; Rupa Bala, MD; Michael P. Riley, MD, PhD; Fermin C. Garcia, MD; Sanjay Dixit, MD; David Lin, MD; Wendy S. Tzou, MD; Joshua M. Cooper, MD; Ralph J. Verdino, MD; David J. Callans, MD; Francis E. Marchlinski, MD

Unipolar Reference Values
95% of LV ENDO unipolar signals > 8.27 mV (mean, 19.6±6.9 mV), defined as the value of normal LV ENDO UNI signal amplitude.



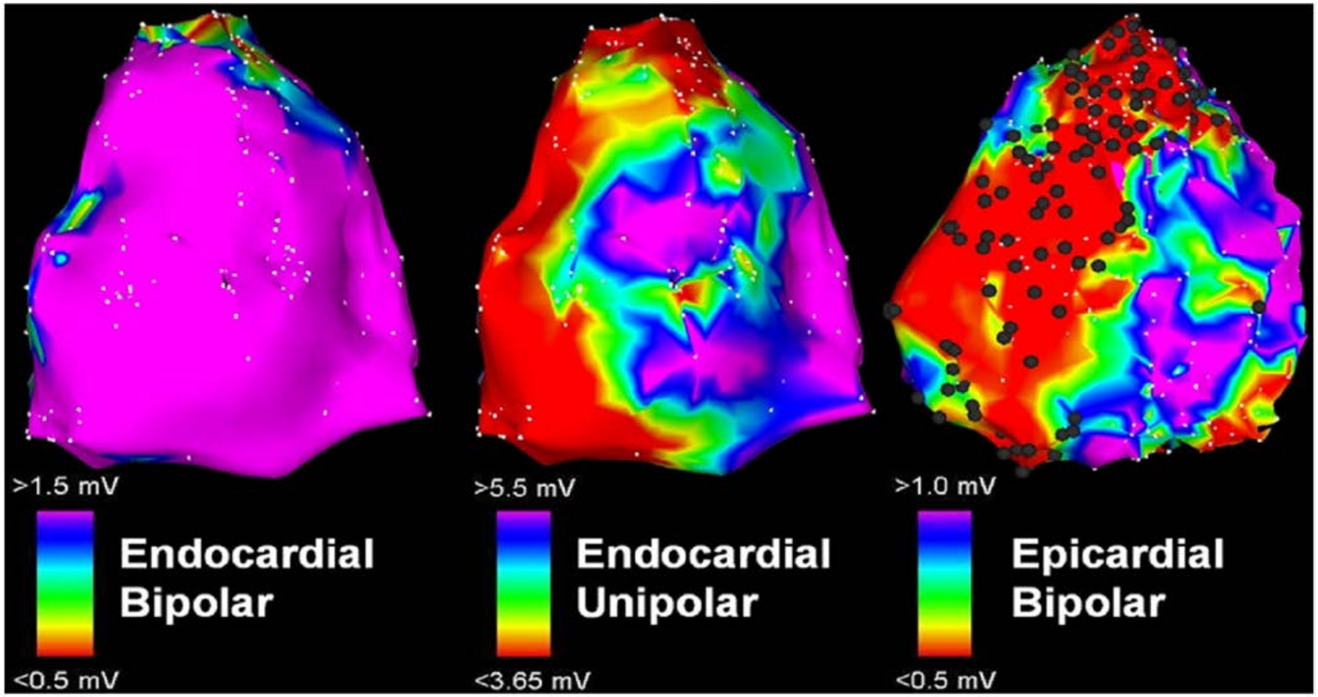


Circ Arrhythm Electrophysiol. 2011;4:49-55

Unipolar voltage mapping in RV

Endocardial unipolar voltage mapping to identify epicardial substrate in arrhythmogenic right ventricular cardiomyopathy/dysplasia

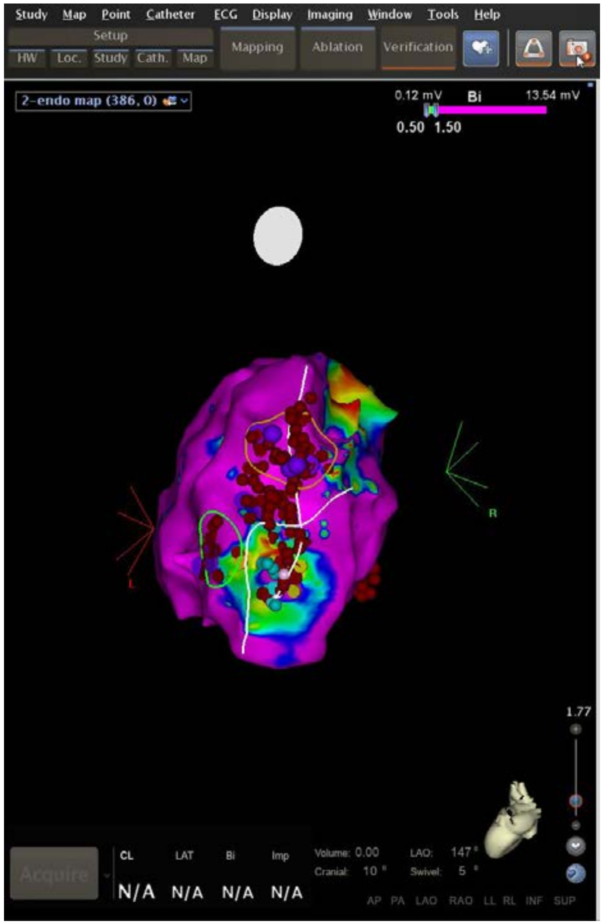
Glenn M. Polin, MD, Haris Haqqani, MBBS, PhD, Wendy Tzou, MD, Mathew D. Hutchinson, MD, Fermin C. Garcia, MD, David J. Callans, MD, FHRS, Erica S. Zado, PA-C, FHRS, Francis E. Marchlinski, MD, FHRS



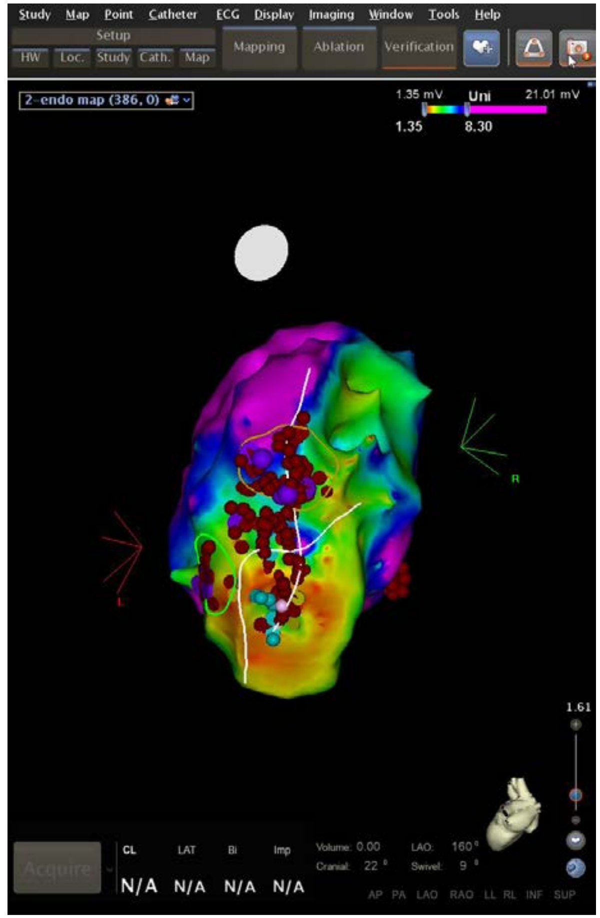
Normal unipolar electrogram
95% of unipolar signals had an amplitude >5.5 mV and defined a normal unipolar electrogram amplitude.

Heart Rhythm 2011;8:76–83

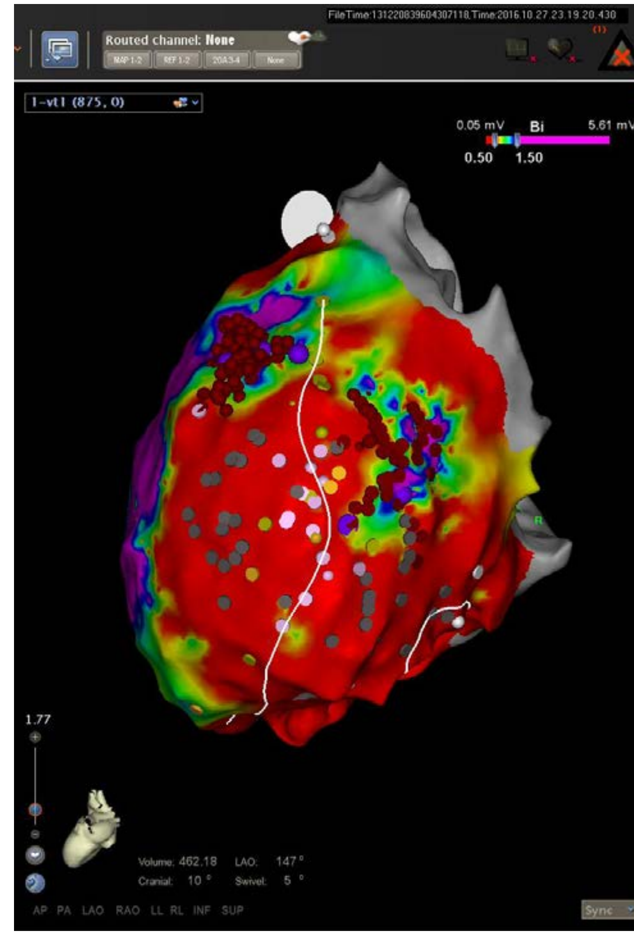
Endo, Bipolar



Endo, Unipolar



Epi, Bipolar



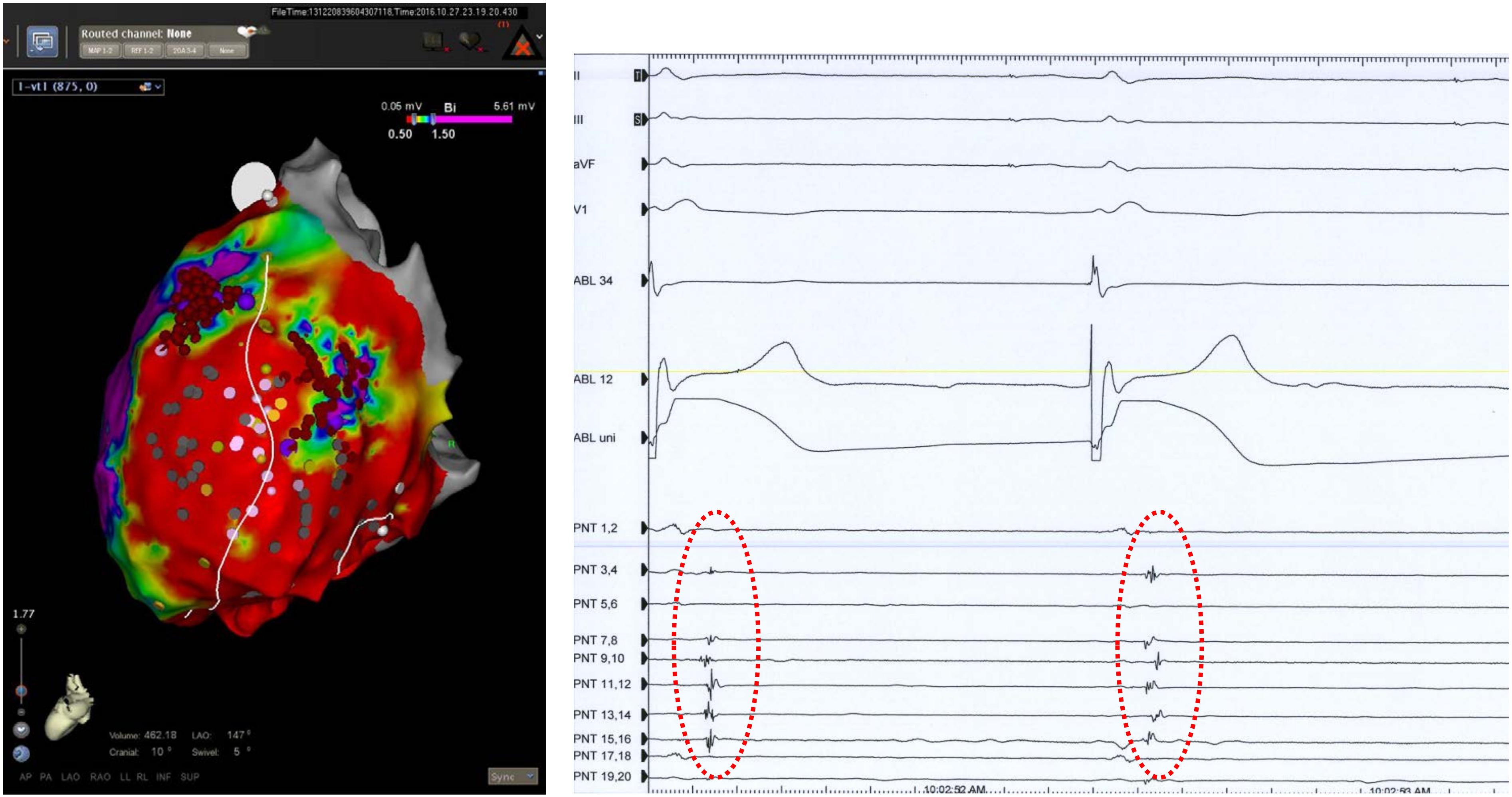
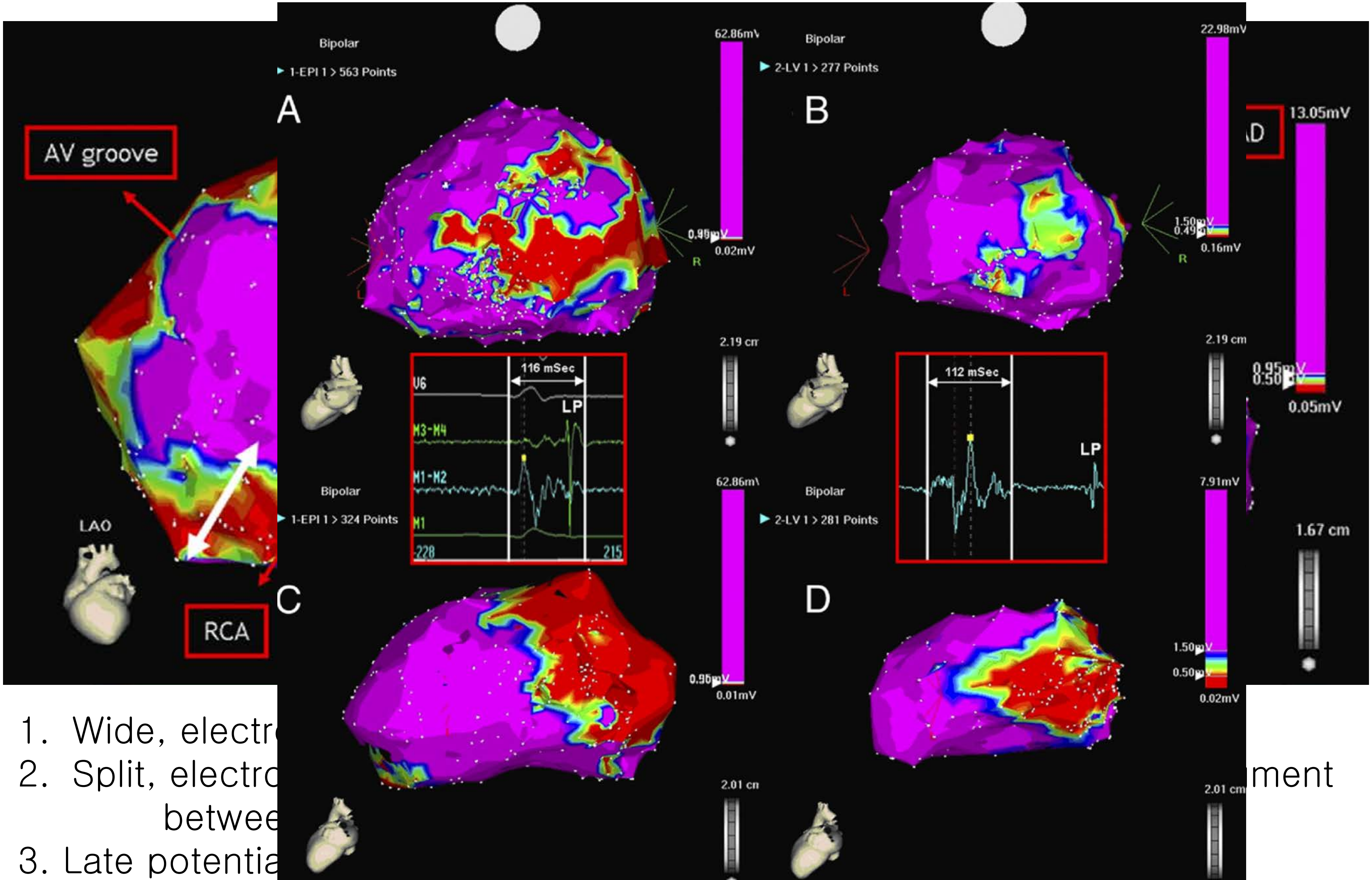


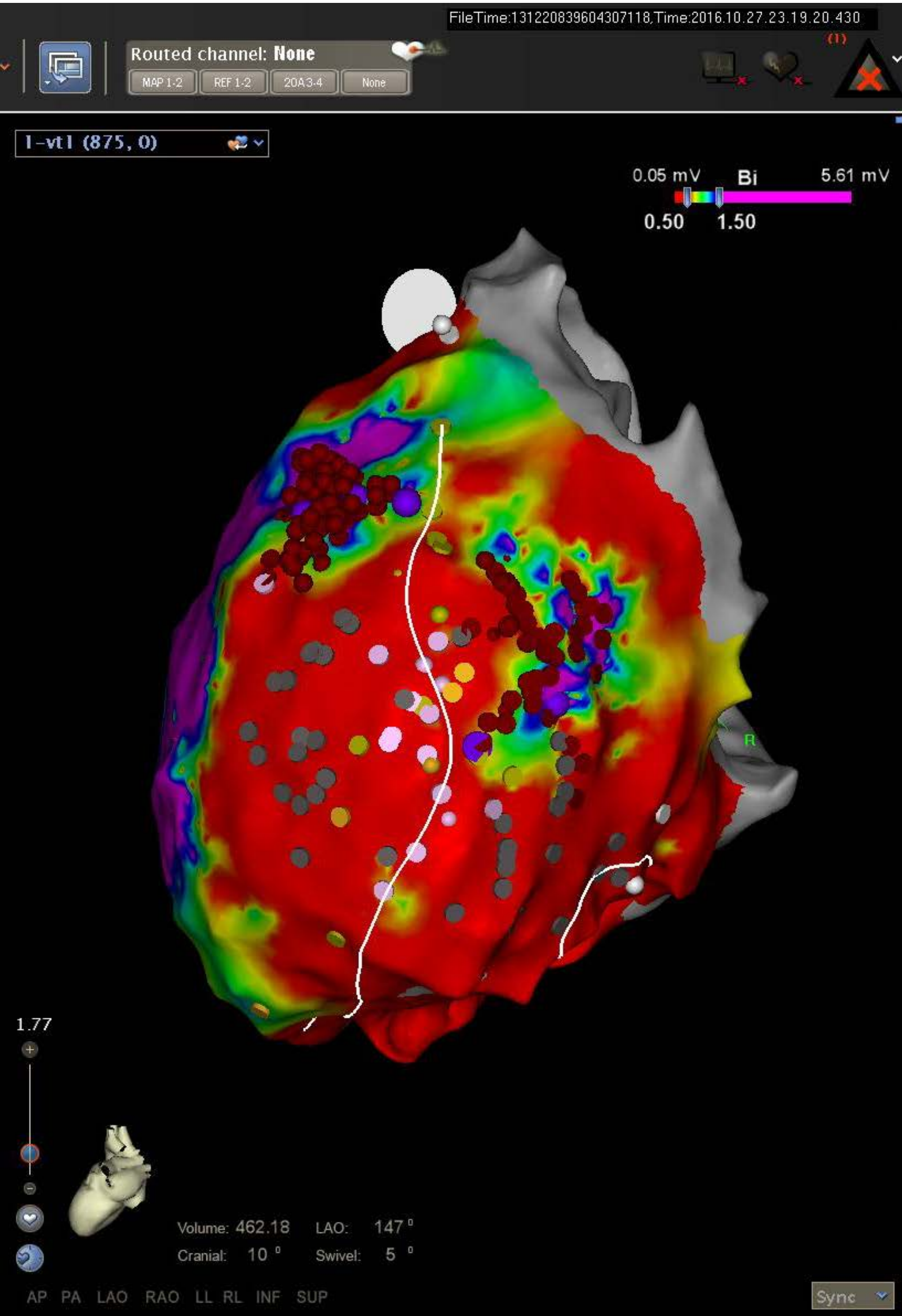
Figure 2. Substrate voltage mapping and RFCA images
Gray dots denote scar
Pink dots denote delayed potentials
Red dots denote ablation points (target of circuit exits and isthmus)
Sky blue dots denote fractionate potentials
Yellow dots and white lines denote phrenic nerve captured points
Purple dots denote good pace mapping points

Bipolar egm voltage (perivascular, AV groove)

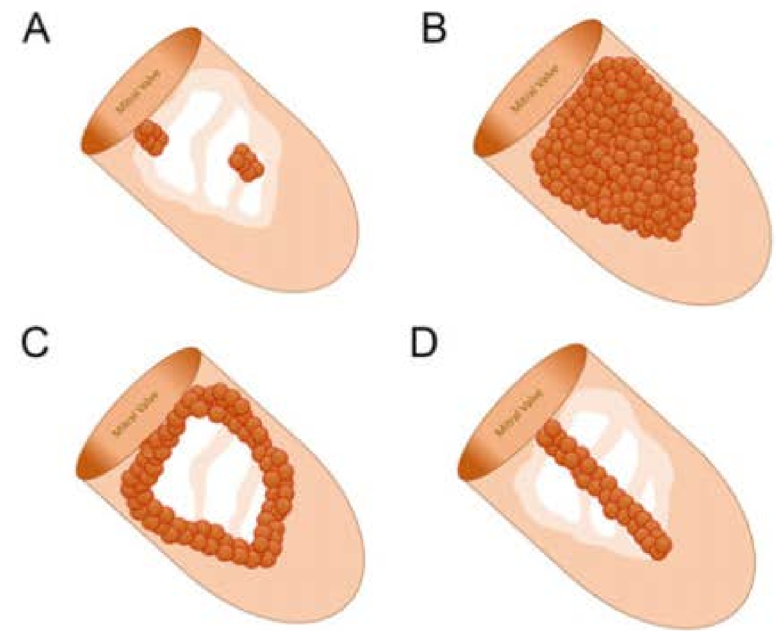


1. Wide, electr
2. Split, electro ... ment
   betwee
3. Late potentia

J Am Coll Cardiol 2009;54:799–808



rategy



Linear lesion connecting dense scar to normal myocardium (Marchlinski)

Short linear ablation parallel to the border zone (Soejima)

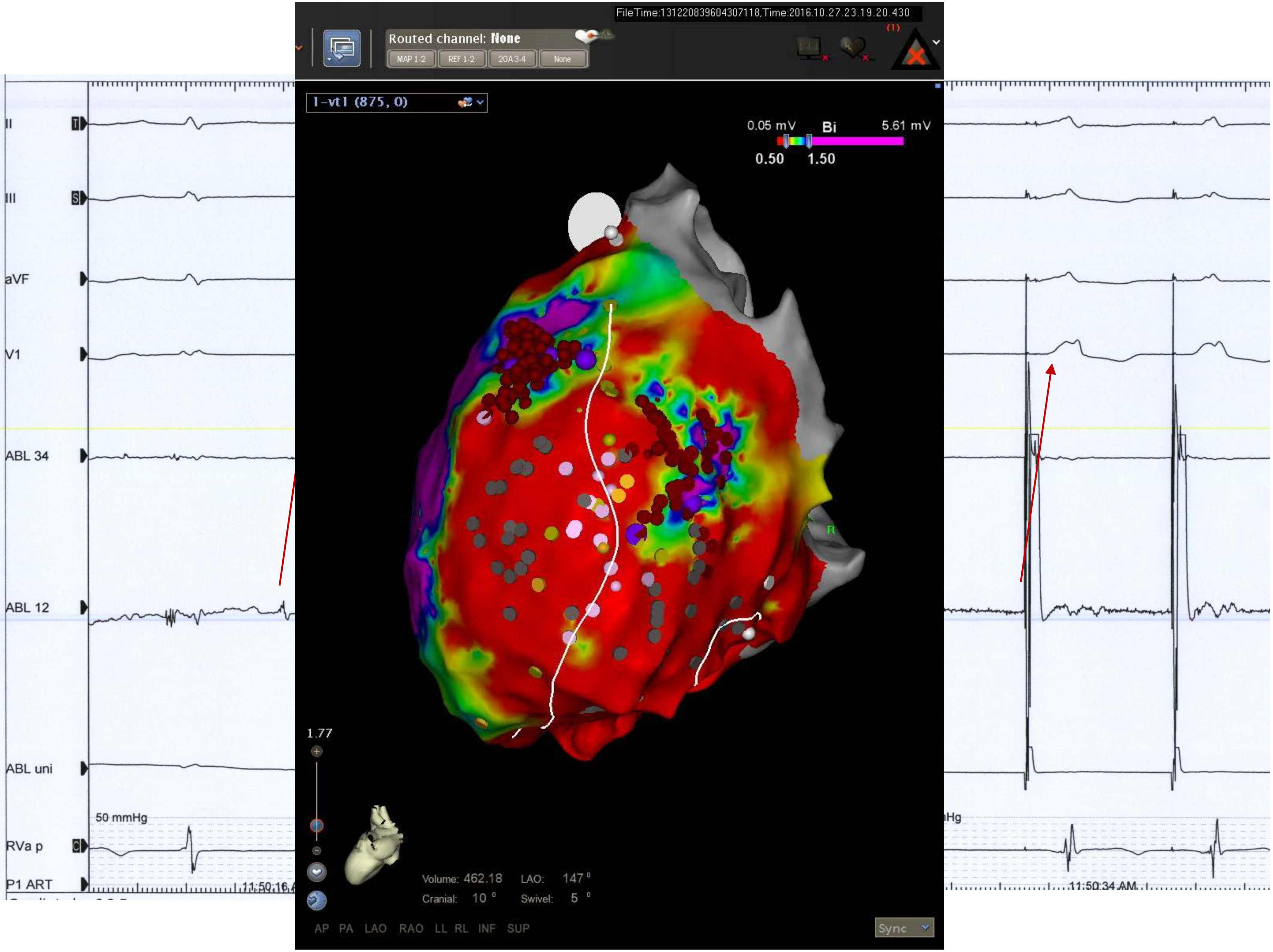
Channels ablation – EUS(Soejima), voltage-define CC (Arenal)

LAVA (local abn. Ventricular activity) ablation (Jais)

Scar dechanneling (Berruezo)

Circumferential scar isolation (Tilz)

Scar homogenization (Di Biase)



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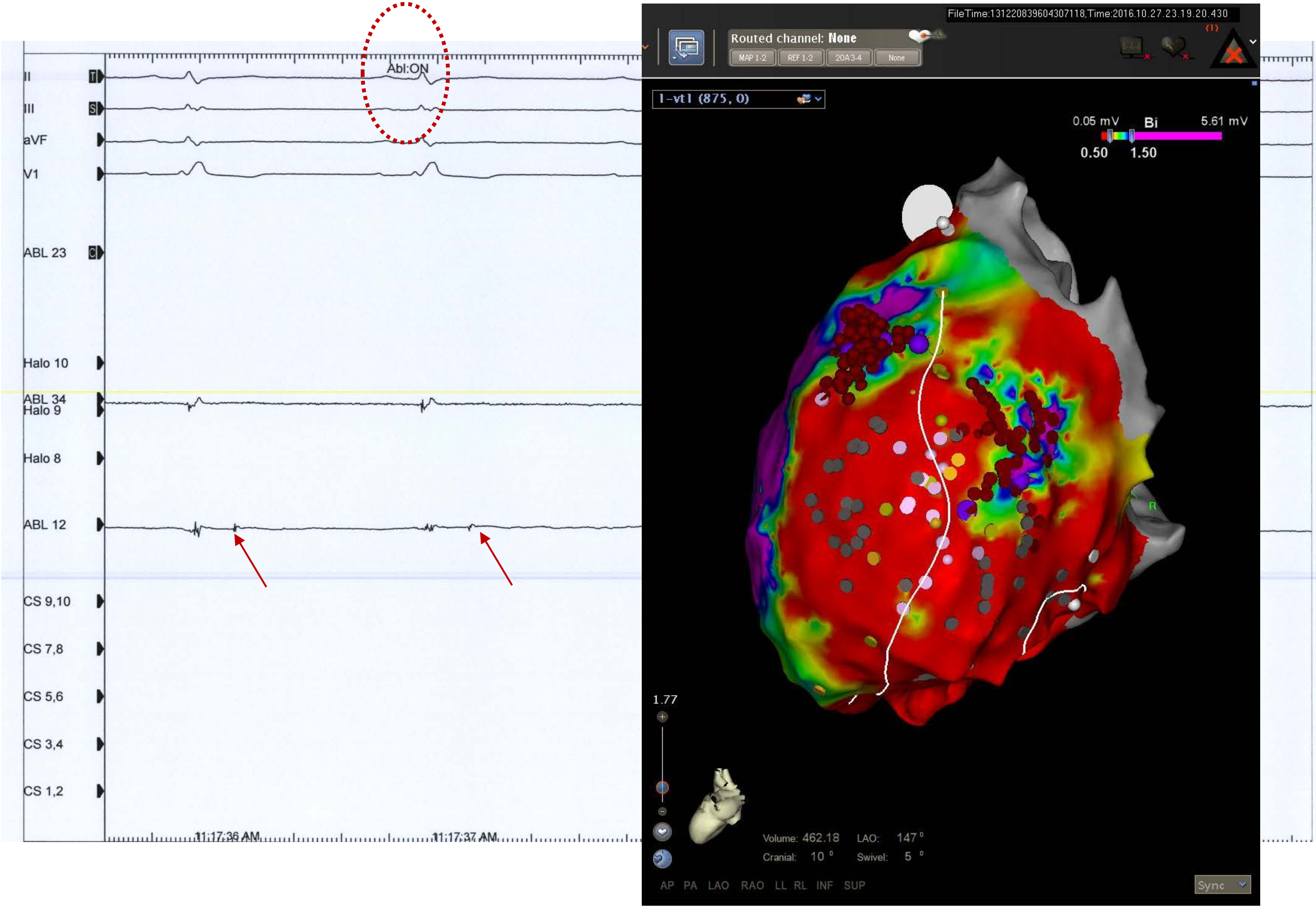
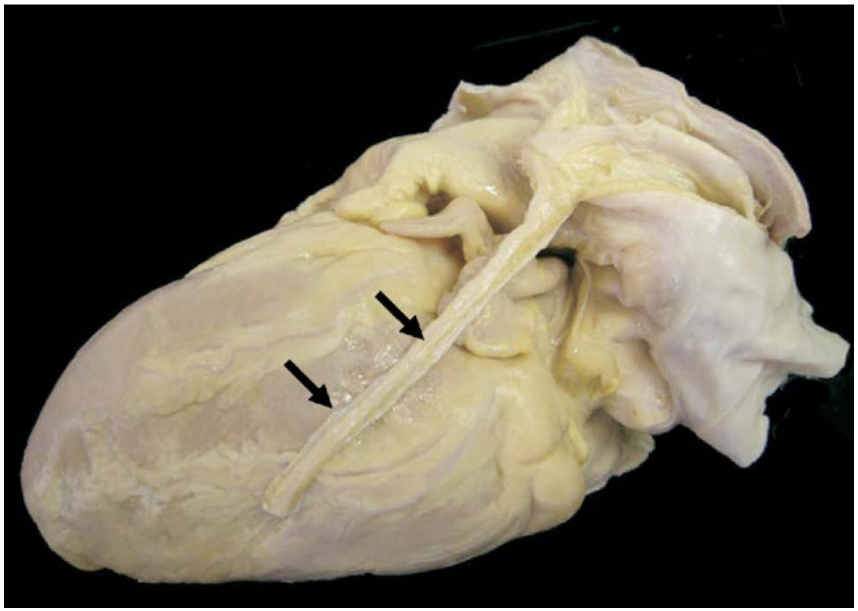
REF 1-2
20A3-4
None
1-vt1 (875, 0)
0.05 mV
Bi
5.61 mV
0.50
1.50
1.77
Volume: 462.18
LAO: 147°
Cranial: 10°
Swivel: 5°
AP PA LAO RAO LL RL INF SUP
Sync
II
III
aVF
V1
ABL 34
ABL 12
ABL uni
50 mmHg
RVa p
P1 ART
11:50:34 AM



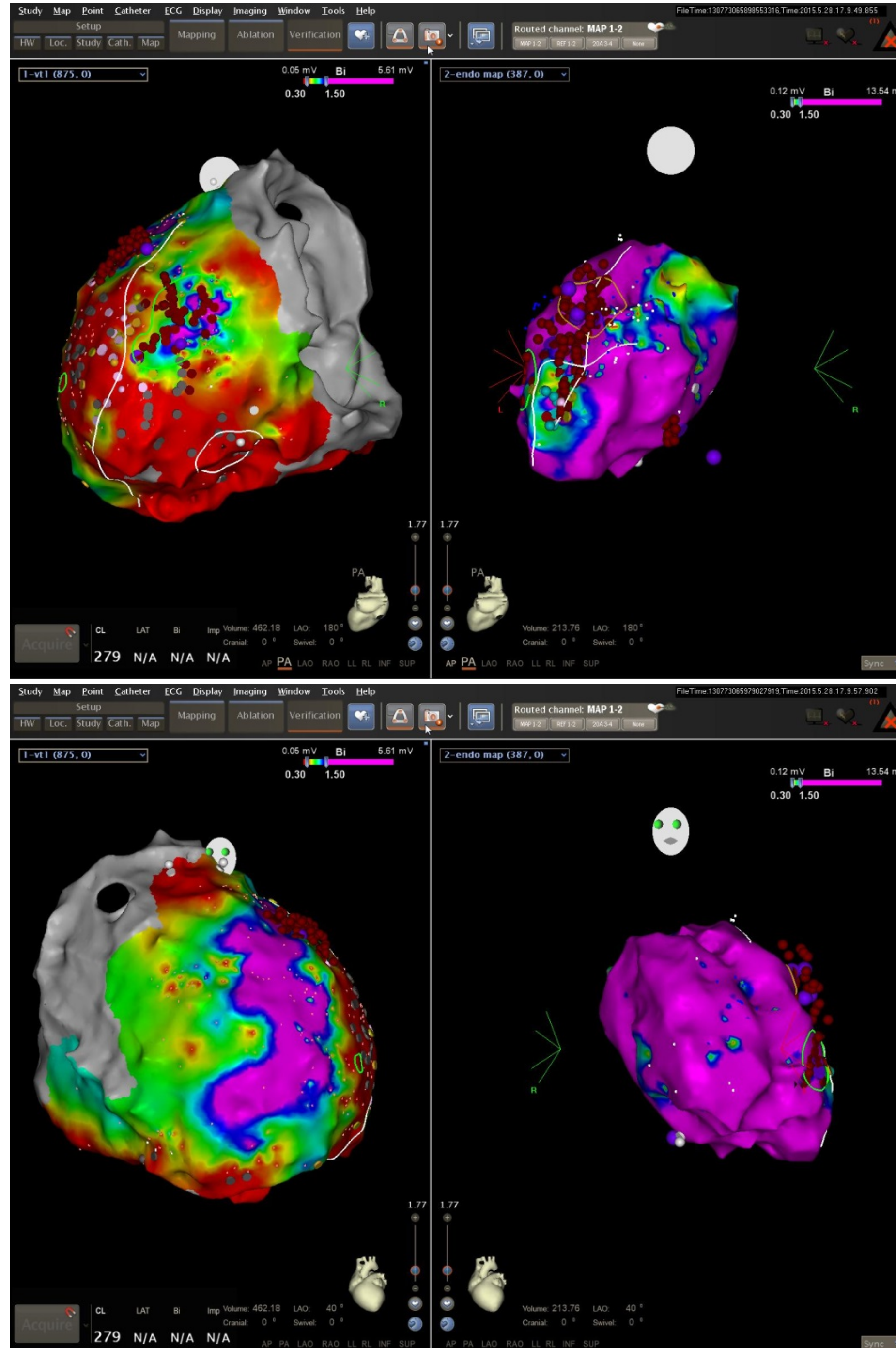
Abl:ON
II
III
aVF
V1
ABL 23
Halo 10
ABL 34
Halo 9
Halo 8
ABL 12
CS 9,10
CS 7,8
CS 5,6
CS 3,4
CS 1,2
11:17:36 AM
11:17:37 AM
FileTime:131220839604307118,Time:2016.10.27.23.19.20.430
Routed channel: None
MAP 1-2
REF 1-2
20A3-4
None
1-vt1 (875, 0)
0.05 mV
Bi
5.61 mV
0.50
1.50
1.77
Volume: 462.18
LAO: 147 °
Cranial: 10 °
Swivel: 5 °
AP PA LAO RAO LL RL INF SUP
Sync

Phrenic N course within the epicardial substrate of patients with non-ischemic CM and VT



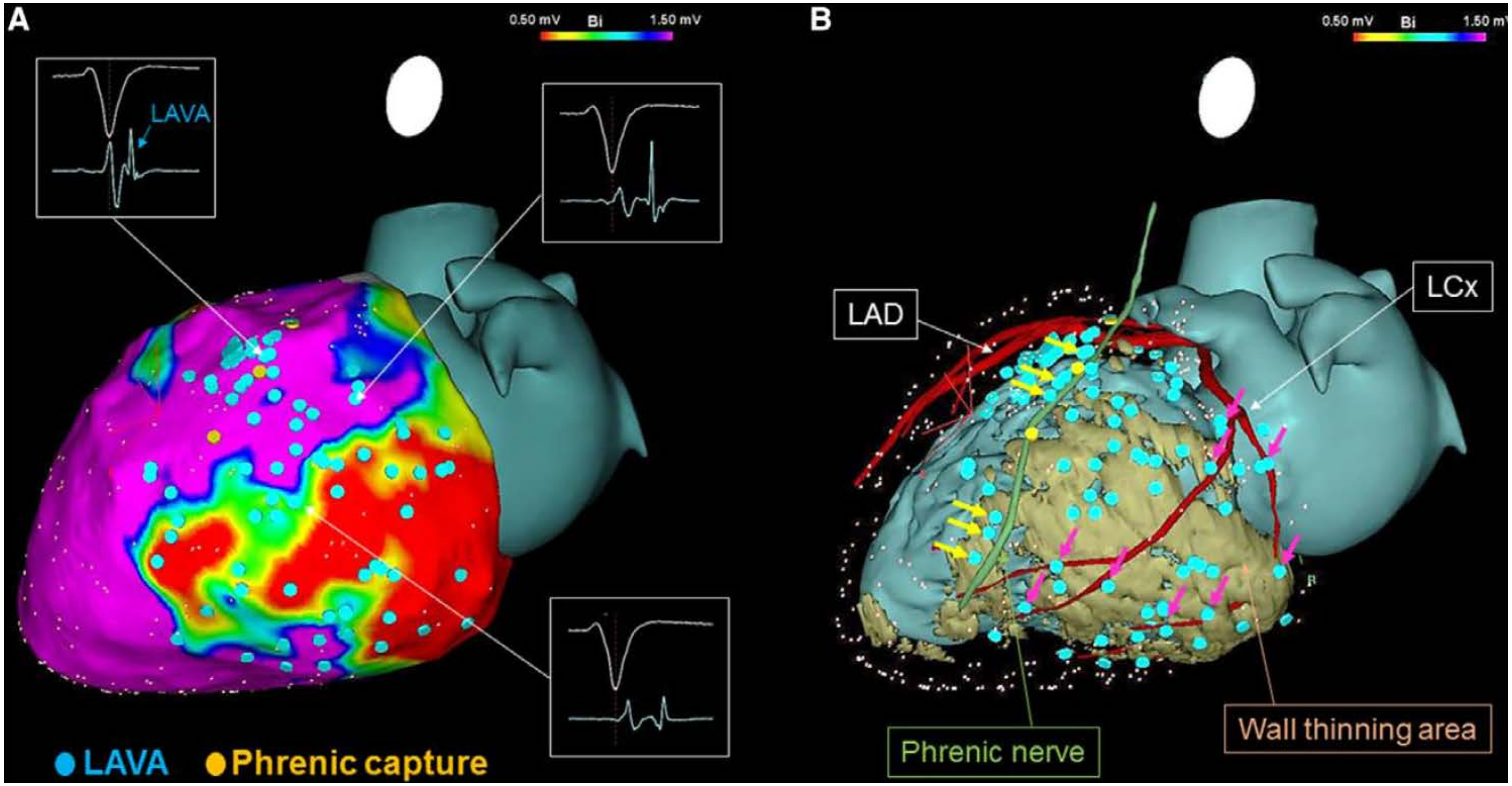
Eight of 10 patients had low-voltage areas involving the lateral epicardial LV, and 7 of these 8 patients had sites of phrenic capture within these areas.

Heart Rhythm 2009;6:59–64

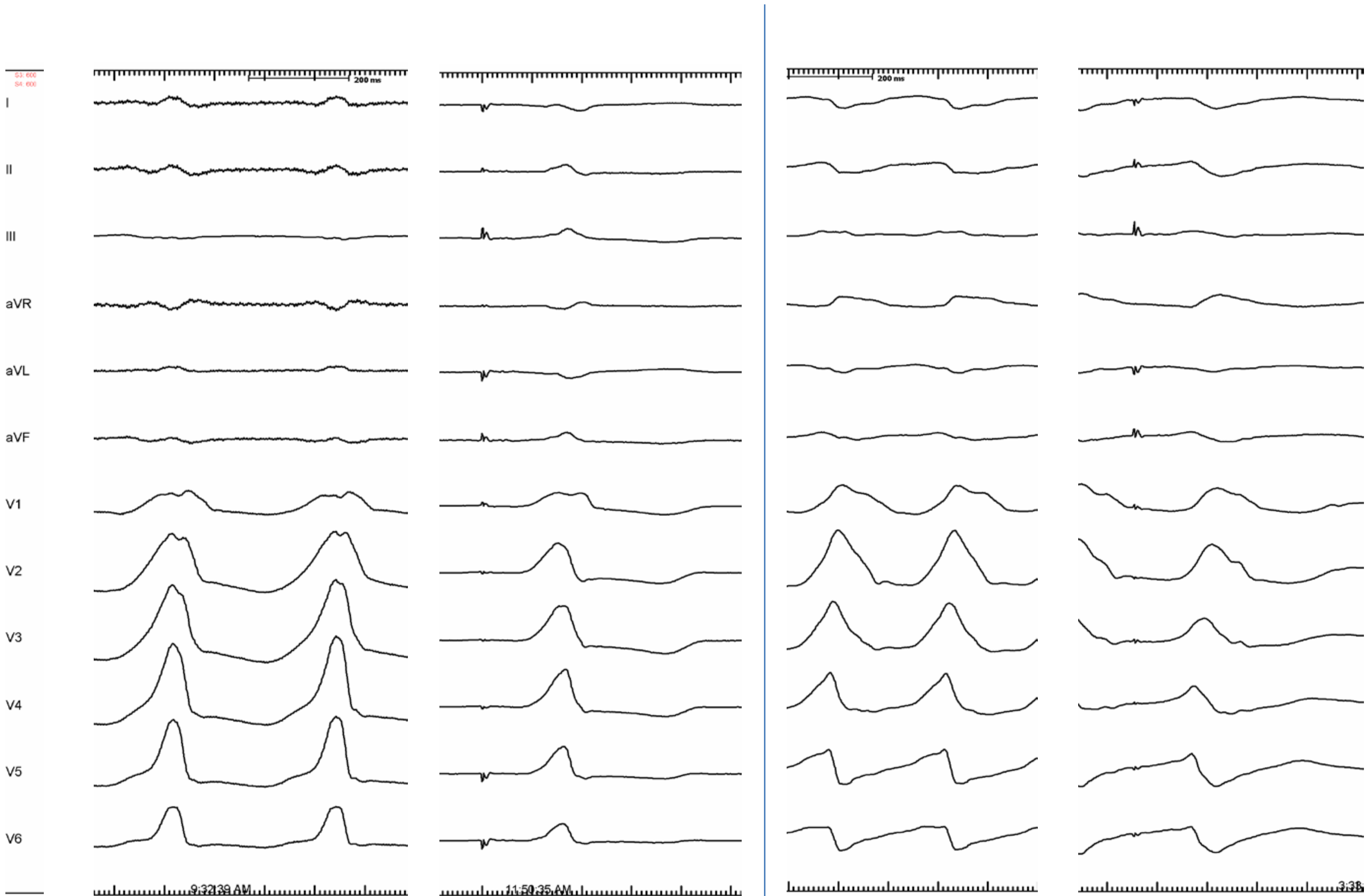


Role of High-Resolution Image Integration to Visualize Left Phrenic Nerve and Coronary Arteries During Epicardial Ventricular Tachycardia Ablation

Seigo Yamashita, MD, PhD; Frédéric Sacher, MD, PhD; Saagar Mahida, MBChB, PhD; Benjamin Berte, MD; Han S. Lim, MBBS, PhD; Yuki Komatsu, MD; Sana Amraoui, MD; Arnaud Denis, MD; Nicolas Derval, MD; François Laurent, MD; Michel Montaudon, MD, PhD; Méléze Hocini, MD; Michel Haïssaguerre, MD, PhD; Pierre Jaïs, MD, PhD; Hubert Cochet, MD, PhD

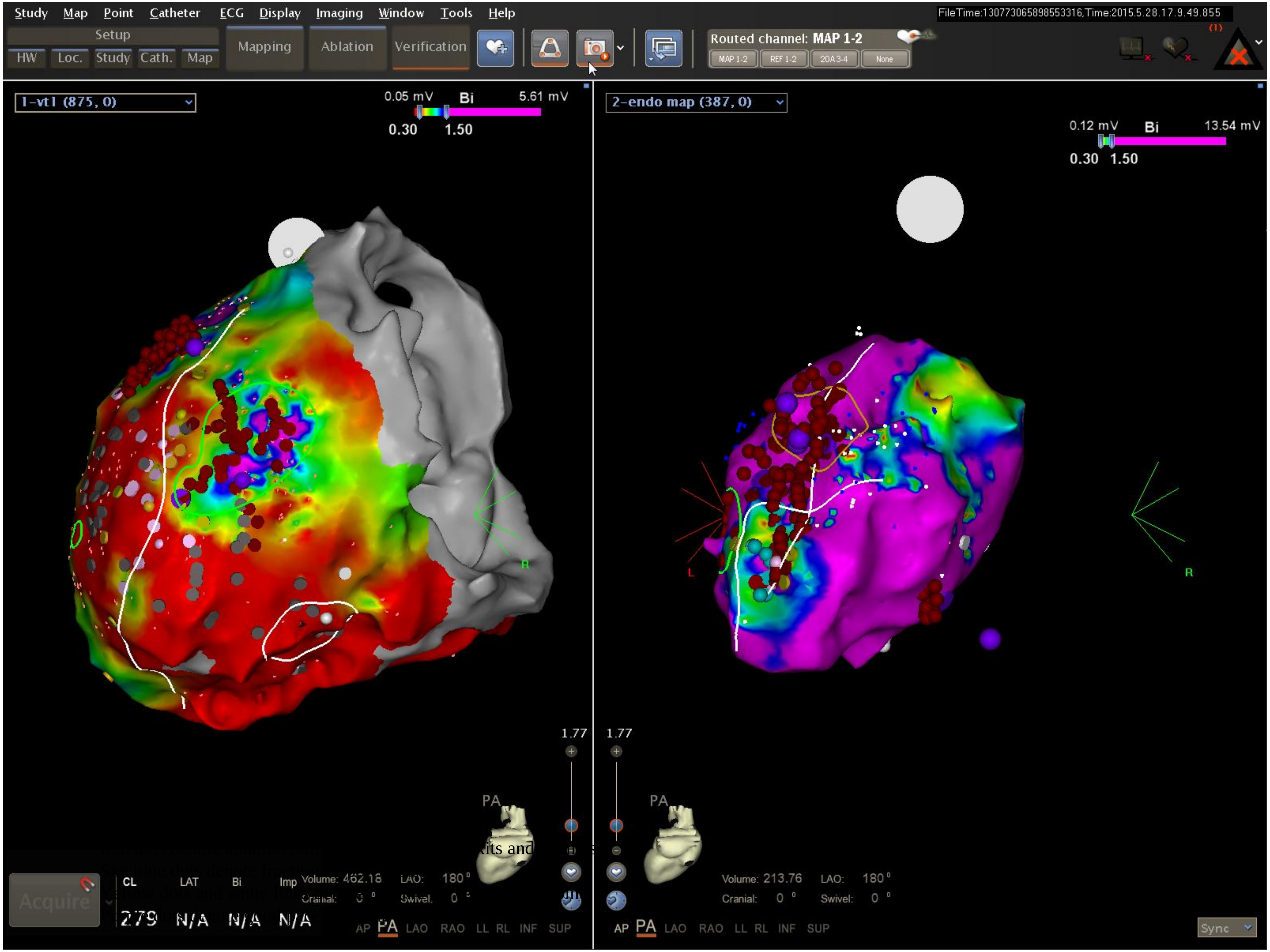


Multidetector CT detected PN in 81 patients (85%). LAVAs were located within 1 cm from CAs and PN in 35 (80%) and 18 (37%) patients, respectively.



VT2-pace map

VT3- pace map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Ablation
Verification
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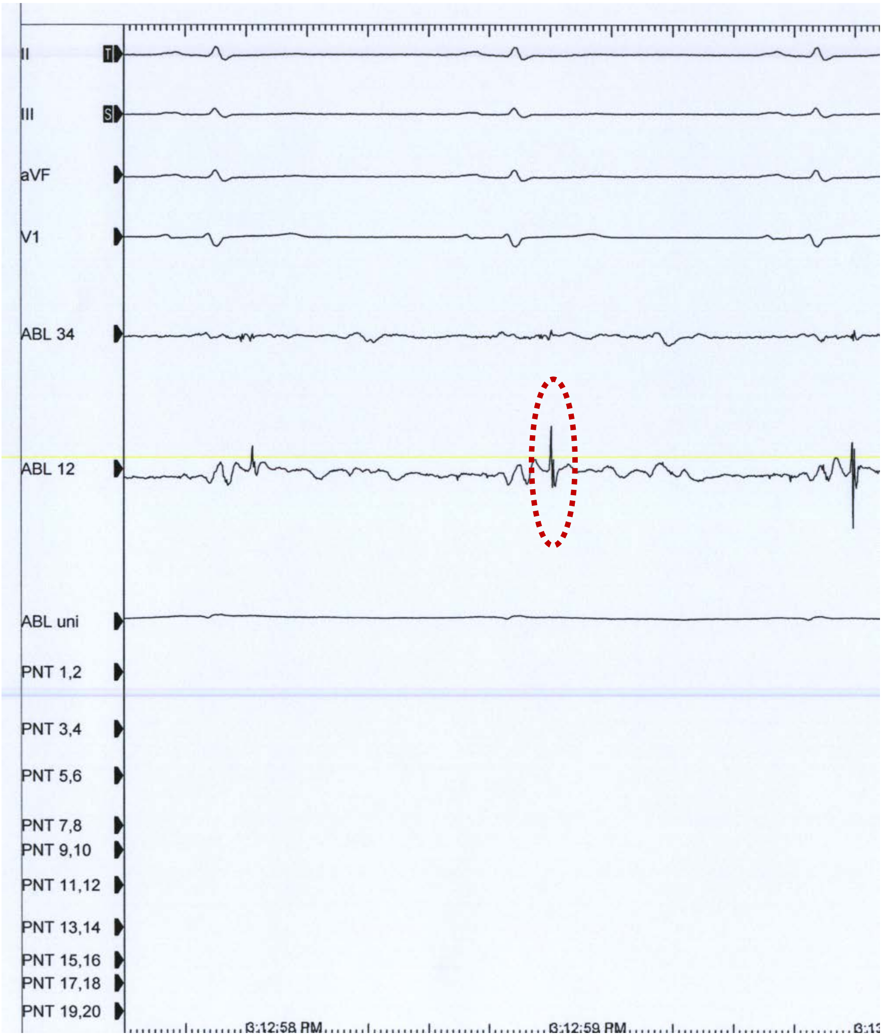
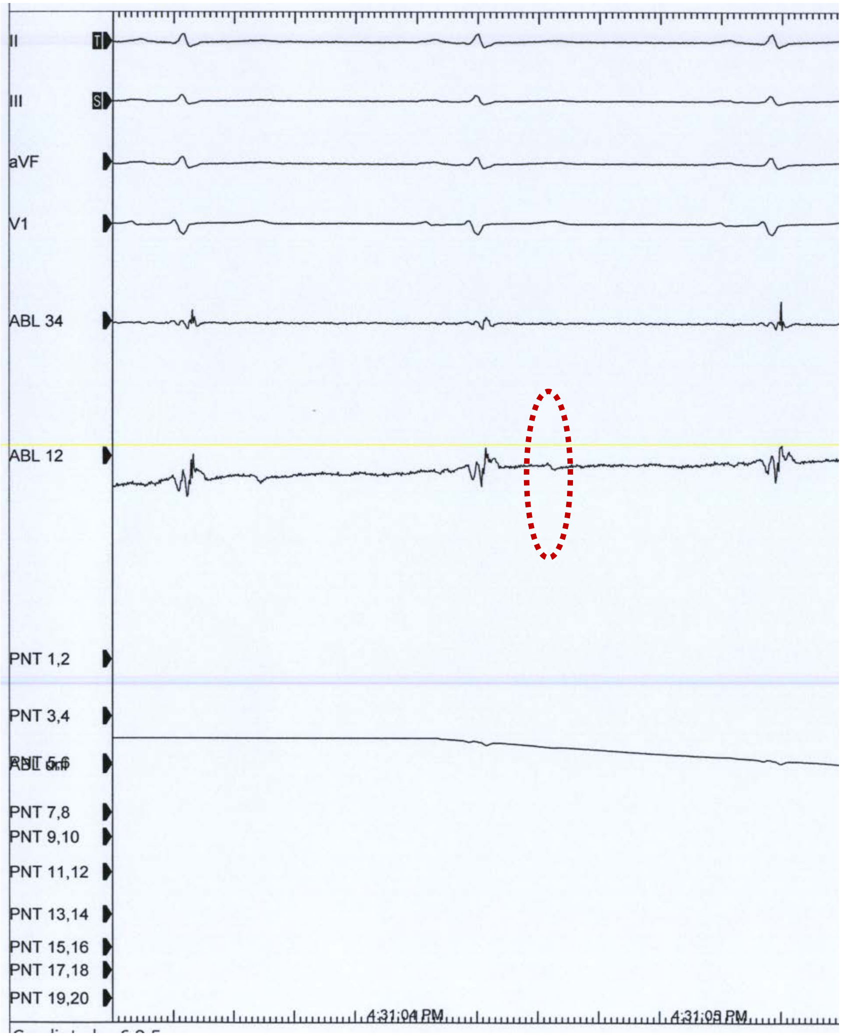
MAP 1-2 REF 1-2 20A3-4 None
1-vt1 (875, 0)
0.05 mV Bi 5.61 mV
0.30 1.50
2-endo map (387, 0)
0.12 mV Bi 13.54 mV
0.30 1.50
L
R
1.77
1.77
PA
PA
Acquire
CL LAT Bi Imp
279 N/A N/A N/A
Volume: 462.18 LAO: 180 °
Cranial: 0 ° Swivel: 0 °
Volume: 213.76 LAO: 180 °
Cranial: 0 ° Swivel: 0 °
AP PA LAO RAO LL RL INF SUP
AP PA LAO RAO LL RL INF SUP
Sync

Elimination of epicardial delayed potential after endocardial VT exit ablation





DCM VT ablation

Multiple VTs are common,
Hemodynamically unstable, unmappable

Threshold for epicardial access should be low.
- ECG,
- small (bi) abn. egm area, large (uni) abn. area

Epicardial egm interpretation
- normal value (1.5mV in endo, 1.0mv in epi)
- overlying fat vs low voltage zone: DDx

Ablation strategy
- isthmus, LAVA, de-channeling, circumferential, transection, homogenization,
- Endocardial ablation for epicardial delayed potentials

Arrhythmogenic RV dysplasia

predominantly genetically determined
estimated prevalence, 1 in 2,000 to 1 in 5,000,

replacement of myocytes by adipose and fibrous tissue
RV failure, arrhythmias, and SCD

AD disease with reduced penetrance and variable expression,
genes encoding cardiac desmosome

Dx: FHx, ECG, cardiac imaging, endomyocardial biopsy

Tx: limited because of the progressive nature of ARVC/D.

Sotalol proved to be highly effective in pts with ARVC/D VT
The role of EPS and VT ablation: palliative for refractory VT.

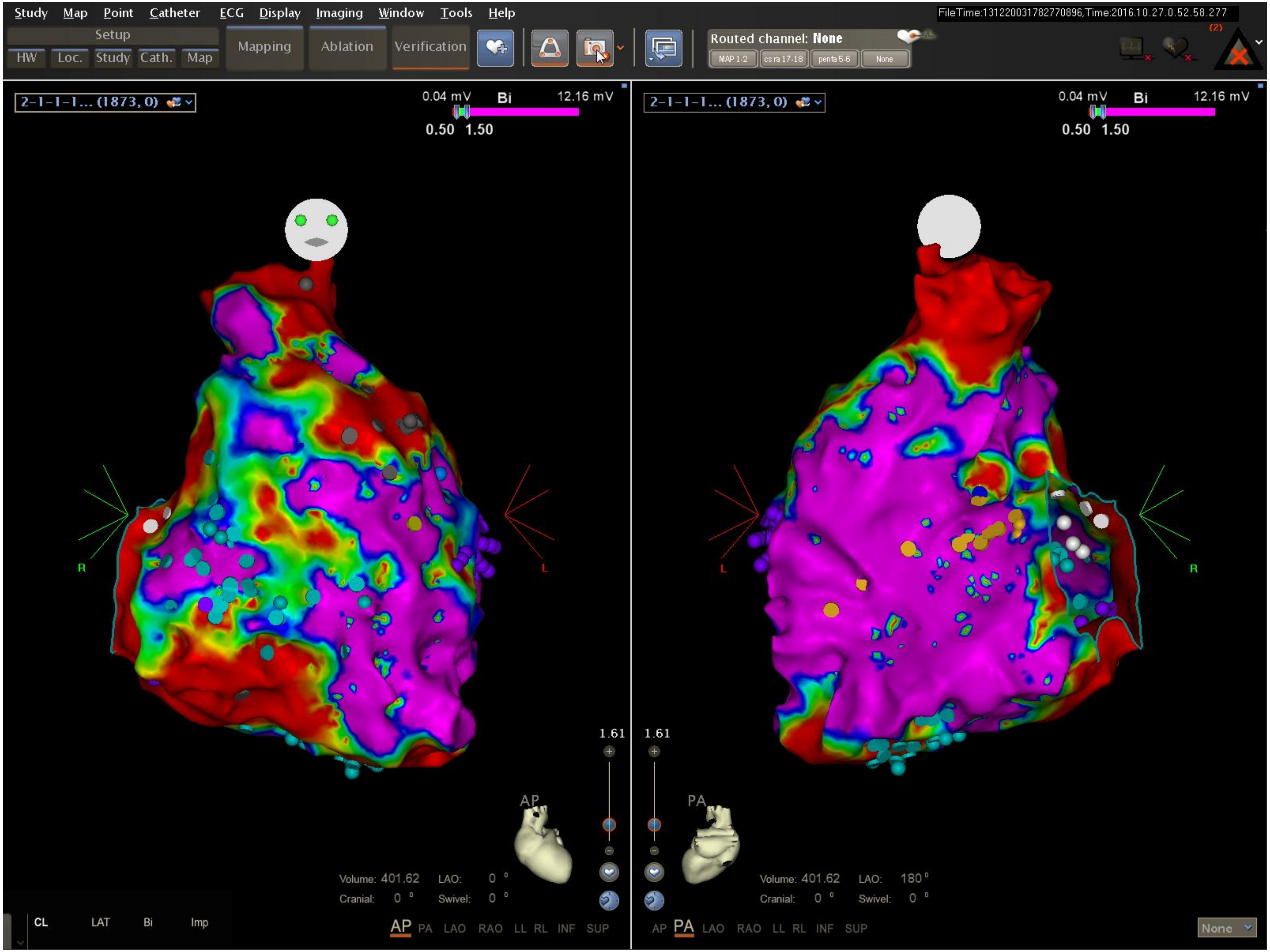
Clin Res Cardiol (2011) 100:383–394

Patient Name: K BH, Sex/Age: M/55
Procedure Date: 26/Jul/2016

2009년 ICD 삽입
최근 수개월 간 shock 7회 가량 발생함.
운동하거나 스트레스 받을 때 주로 발생하였으며
2014년 경 수면 중에도 증상 발생하고
2016년 5월, 6월 증상 연속해서 나타나
2016/6/22 amiodarone 투여함.

최근 식사하기만 해도 증상 발생하여 거의 식사하지 못하고
지내어 체중 4kg 감소--상기 증상으로 ablation 위해 입원함.

RV
Epicardial
Triangle of dysplasia
(*RV* inflow, diaphragmatic area,
the *apex* and the infundibulum



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Verification
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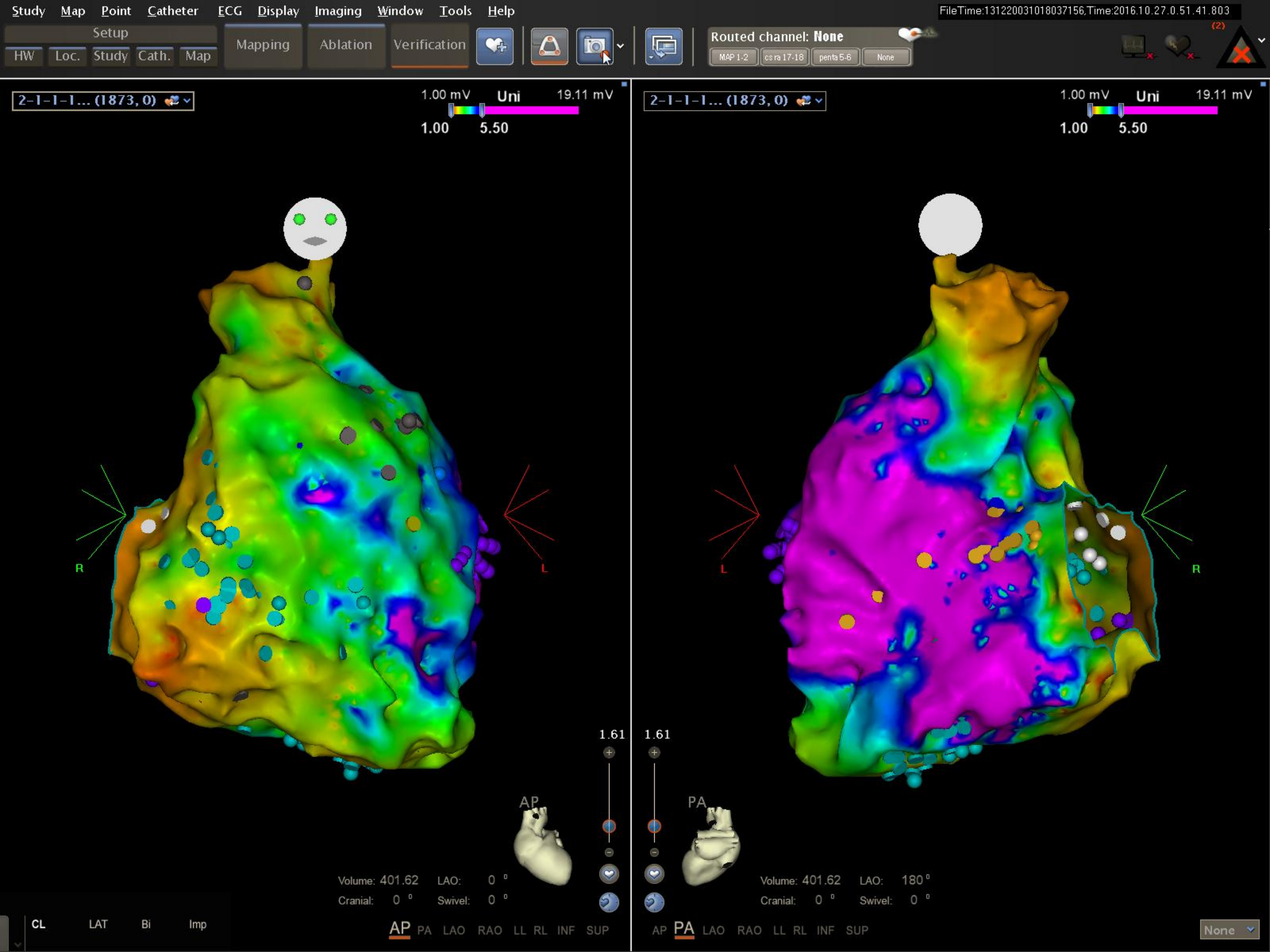
cs ra 17-18
penta 5-6
None
2-1-1-1... (1873, 0)
0.04 mV
Bi
12.16 mV
0.50 1.50
R
L
1.61
AP
Volume: 401.62
LAO: 0 °
Cranial: 0 °
Swivel: 0 °
CL
LAT
Bi
Imp
AP PA LAO RAO LL RL INF SUP
2-1-1-1... (1873, 0)
0.04 mV
Bi
12.16 mV
0.50 1.50
L
R
1.61
PA
Volume: 401.62
LAO: 180 °
Cranial: 0 °
Swivel: 0 °
AP PA LAO RAO LL RL INF SUP
None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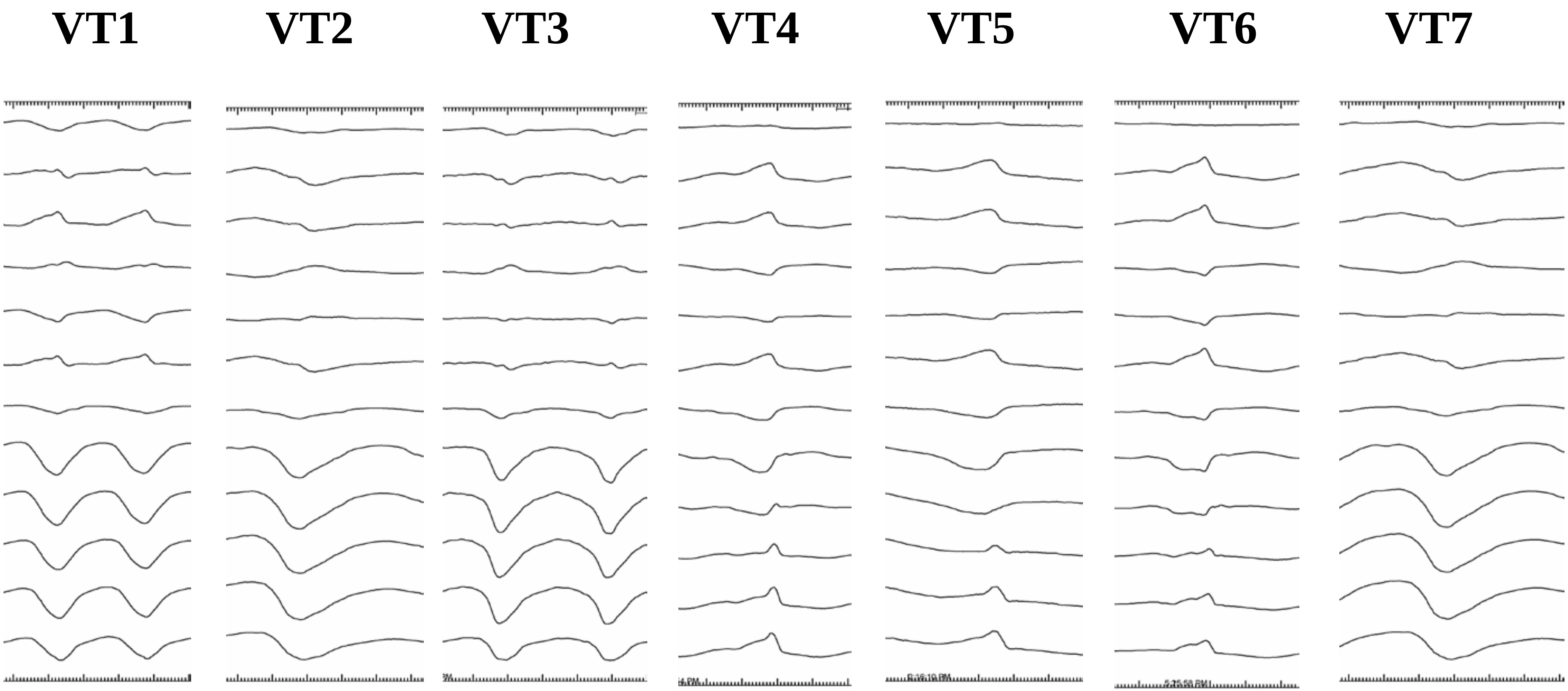
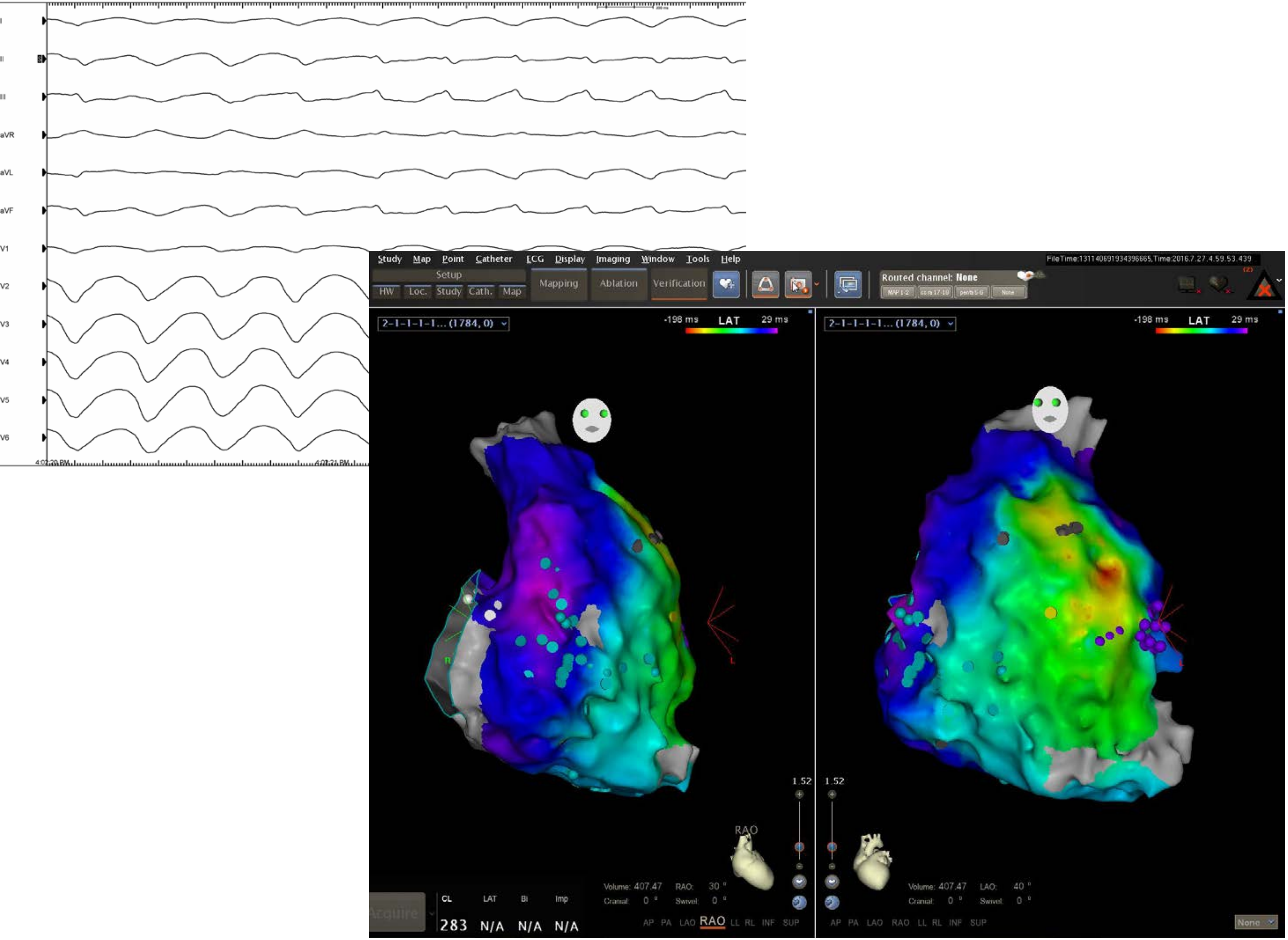
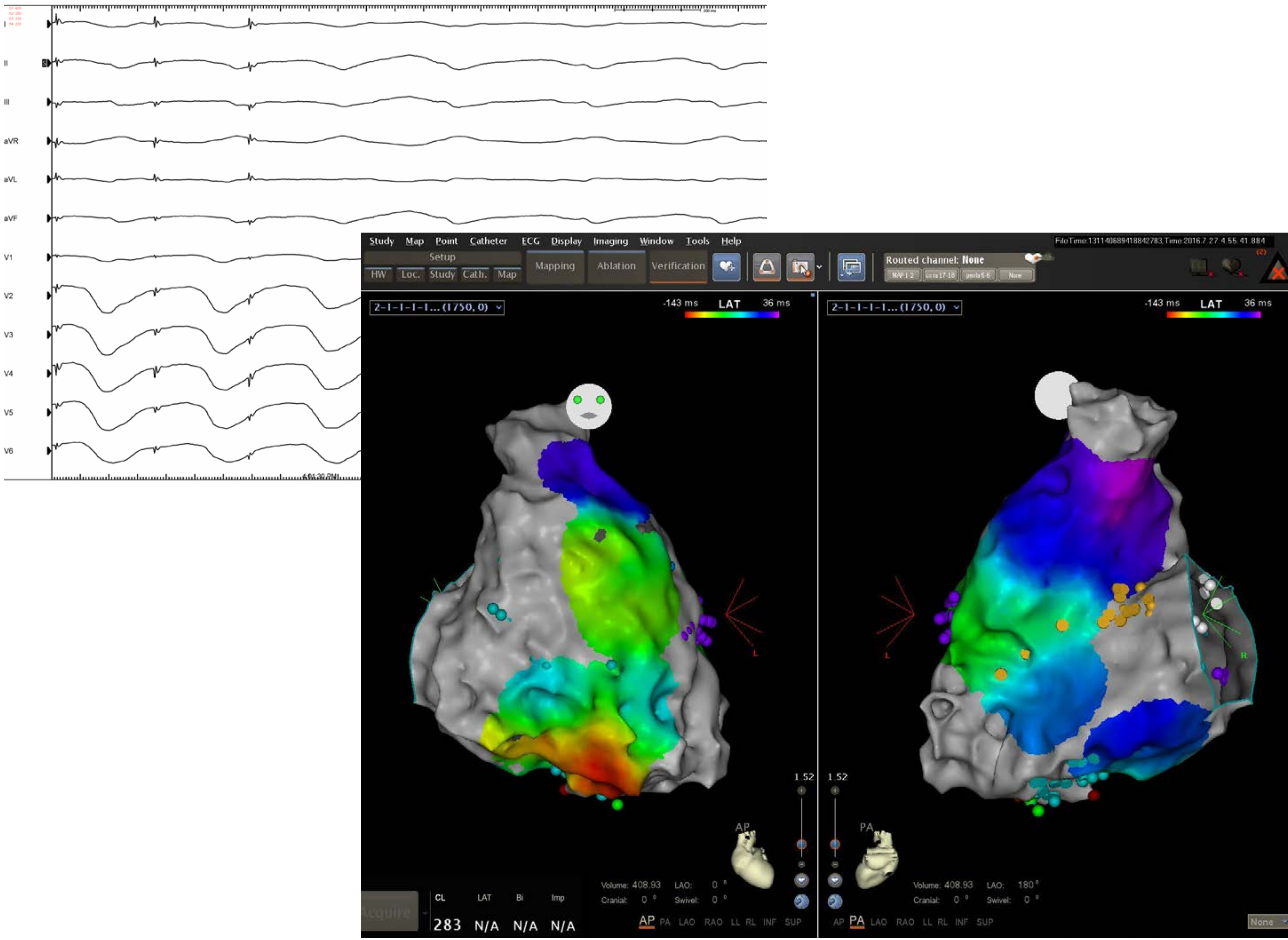
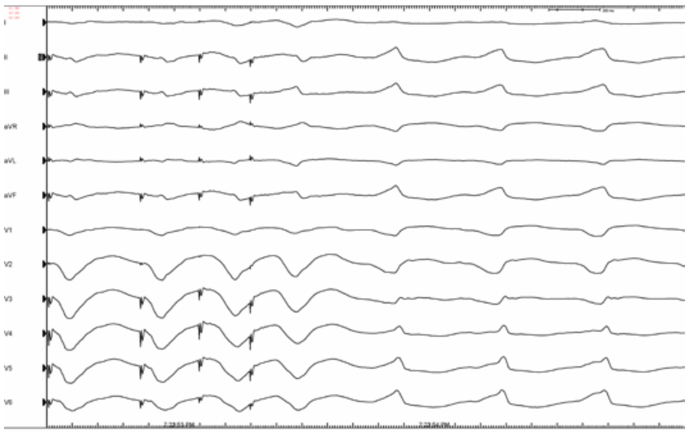
Ablation
Verification
Routed channel: None
MAP 1-2
cs ra 17-18
penta 5-6
None
(2)
2-1-1-1... (1873, 0)
1.00 mV
Uni
19.11 mV
1.00
5.50
R
L
1.61
AP
PA
Volume: 401.62
LAO: 0 °
Cranial: 0 °
Swivel: 0 °
LAO: 180 °
CL
LAT
Bi
Imp
AP PA LAO RAO LL RL INF SUP
None

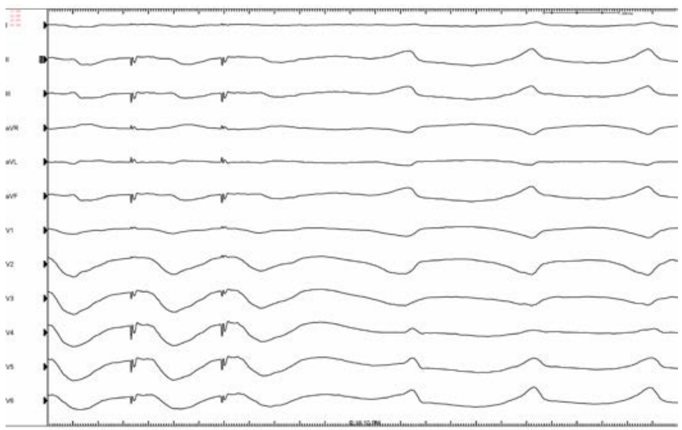

VT1
VT2
VT3
VT4
VT5
VT6
VT7

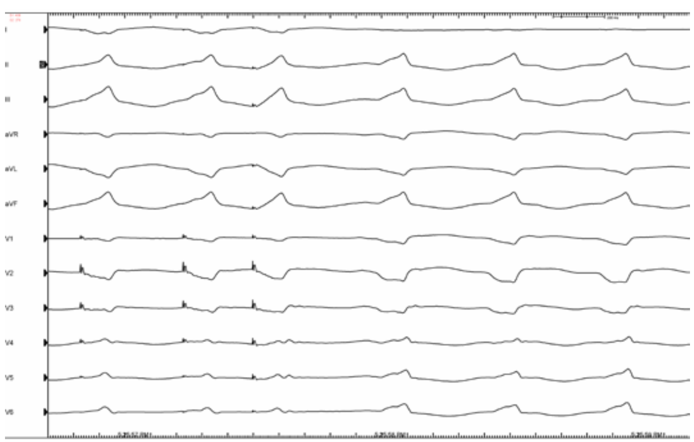

I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
Study Map Point Catheter ECG Display Imaging Window Tools Help
Setup
HW Loc. Study Cath. Map
Mapping
Ablation
Verification
Routed channel: None
2-1-1-1-1... (1784, 0)
-198 ms LAT 29 ms
2-1-1-1-1... (1784, 0)
-198 ms LAT 29 ms
1.52
1.52
RAO
Volume: 407.47 RAO: 30 °
Cranial: 0 ° Swivel: 0 °
Volume: 407.47 LAO: 40 °
Cranial: 0 ° Swivel: 0 °
CL LAT Bi Imp
283 N/A N/A N/A
AP PA LAO RAO LL RL INF SUP
AP PA LAO RAO LL RL INF SUP
None

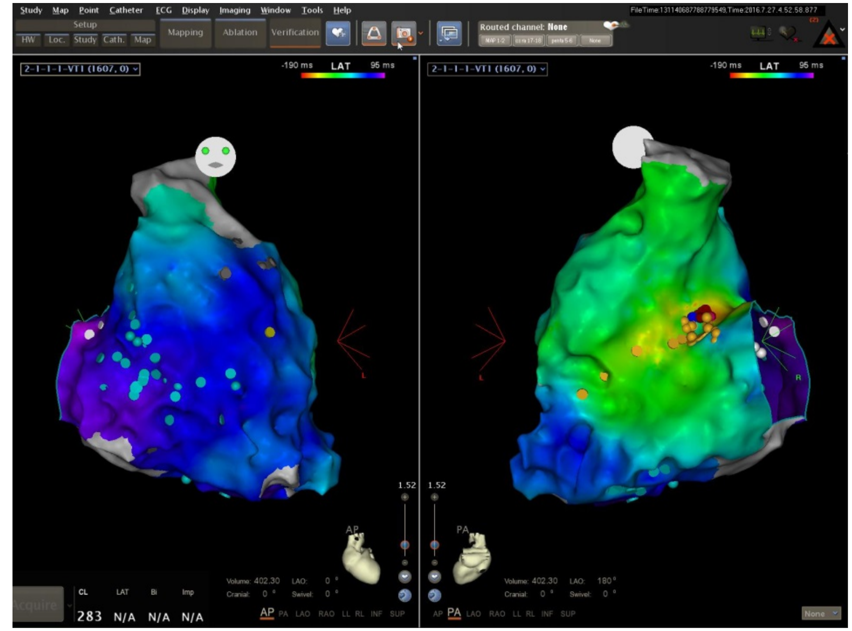

I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
Study Map Point Catheter ECG Display Imaging Window Tools Help
Setup
HW Loc. Study Cath. Map
Mapping
Ablation
Verification
Routed channel: None
2-1-1-1-1... (1750, 0)
-143 ms LAT 36 ms
1.52
AP
PA
Volume: 408.93 LAO: 0 °
Cranial: 0 ° Swivel: 0 °
Volume: 408.93 LAO: 180 °
Cranial: 0 ° Swivel: 0 °
CL LAT Bi Imp
283 N/A N/A N/A
AP PA LAO RAO LL RL INF SUP
None


-1-1... (1873, 0)
0.04 mV
Bi
12.16 m
0.50 1.50
R
L
AP
Volume: 401.62
LAO: 0
2-1-1-1... (1873, 0)
-189 ms
LAT
68 ms
R
L
1.46
Volume: 401.74
RAO: 24
Cranial: 16
Swivel: 4
CL
LAT
Bi
Imp
AP PA LAO RAO LL RL INF SUP





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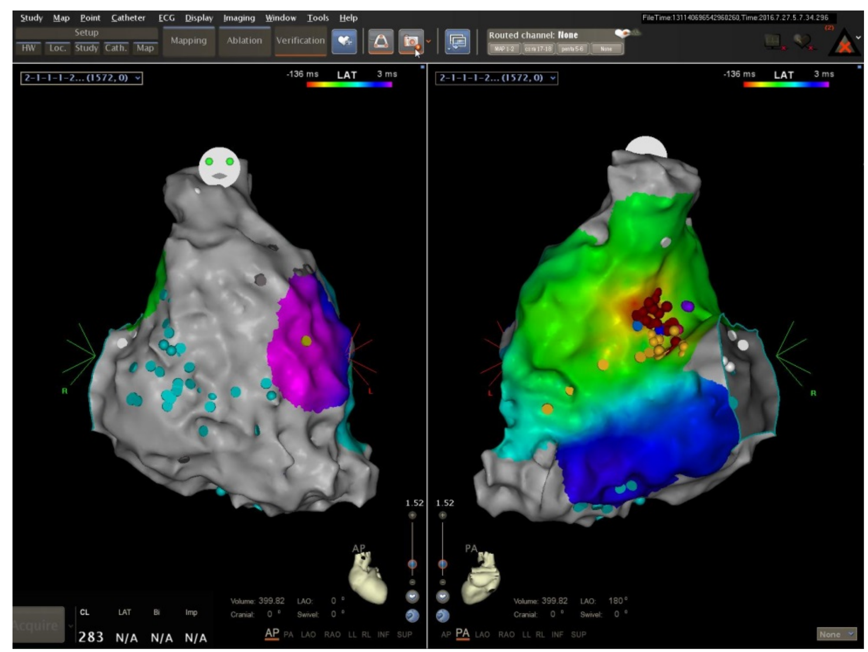
-190 ms LAT 95 ms
1.52
AP
PA
CL LAT Bi Imp
283 N/A N/A N/A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Mapping Ablation Verification
Routed channel: None
2-1-1-1-2... (1572, 0)
-136 ms LAT 3 ms
1.52
AP
PA
CL LAT Bi Imp
283 N/A N/A N/A

Case summary: ARVC

VT
- focal from anterior wall, inferior wall
- multiple, focal from proximal HPS
- reentry in the antero-lateral RV wall

Importance of epicardial substrate
- ECG criteria?
- Endocardial unipolar voltage map

RF ablation
- Endocardial ablation alone: longterm?
- combine endo, epi ablation

Short- and Long-Term Success of Substrate-Based Mapping and Ablation of Ventricular Tachycardia in Arrhythmogenic Right Ventricular Dysplasia

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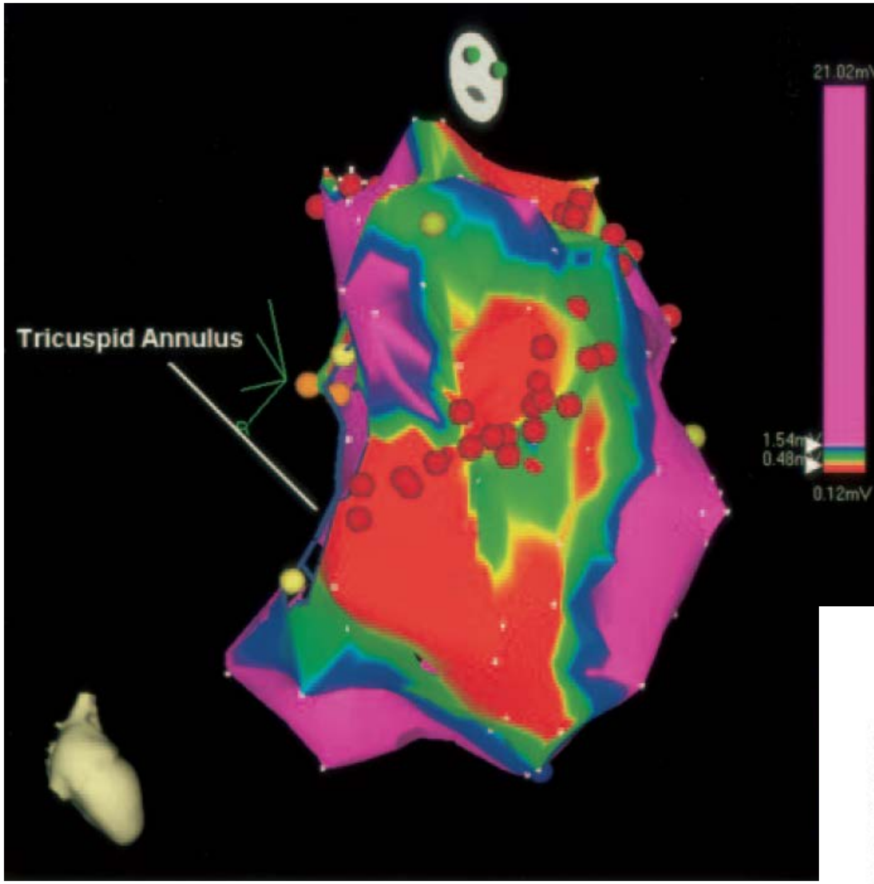
Background—Multiple morphologies, hemodynamic instability, or noninducibility may limit ventricular tachycardia (VT) ablation in patients with arrhythmogenic right ventricular dysplasia (ARVD). Substrate-based mapping and ablation may overcome these limitations. We report the results and success of substrate-based VT ablation in ARVD.

Methods and Results—Twenty-two patients with ARVD were studied. Traditional mapping for VT was limited because of multiple/changing VT morphologies (n=14), nonsustained VT (n=10), or hemodynamic intolerance (n=5). Sinus rhythm CARTO mapping was performed to define areas of "scar" (<0.5 mV) and "abnormal" myocardium (0.5 to 1.5 mV). Ablation was performed in "abnormal" regions, targeting sites with good pace maps compared with the induced VT(s). Linear lesions were created in these areas to (1) connect the scar/abnormal region to a valve continuity or other scar or (2) encircle the scar/abnormal region. Eighteen patients had implanted cardioverter defibrillators, 15 had implanted cardioverter defibrillator therapies, and 7 had sustained VT (6 with syncope). VTs (3±2 per patient) were induced (cycle length, 339±94 ms), and scar was identified in all patients. Scar areas were related to the tricuspid annulus, proximal right ventricular outflow tract, and anterior/inferior-apical walls. Lesions connected abnormal regions to the annulus (n=12) or other scars (n=4) and/or encircled abnormal regions (n=13). Per patient, a mean of 38±22 radiofrequency lesions was applied. Short-term success was achieved in 18 patients (82%). VT recurred in 23%, 27%, and 47% of patients after 1, 2, and 3 years' follow-up, respectively.

Conclusions—Substrate-based ablation of VT in ARVD can achieve a good short-term success rate. However, recurrences become increasingly common during long-term follow-up. (*Circulation*. **2005;111:3209-3216.**)



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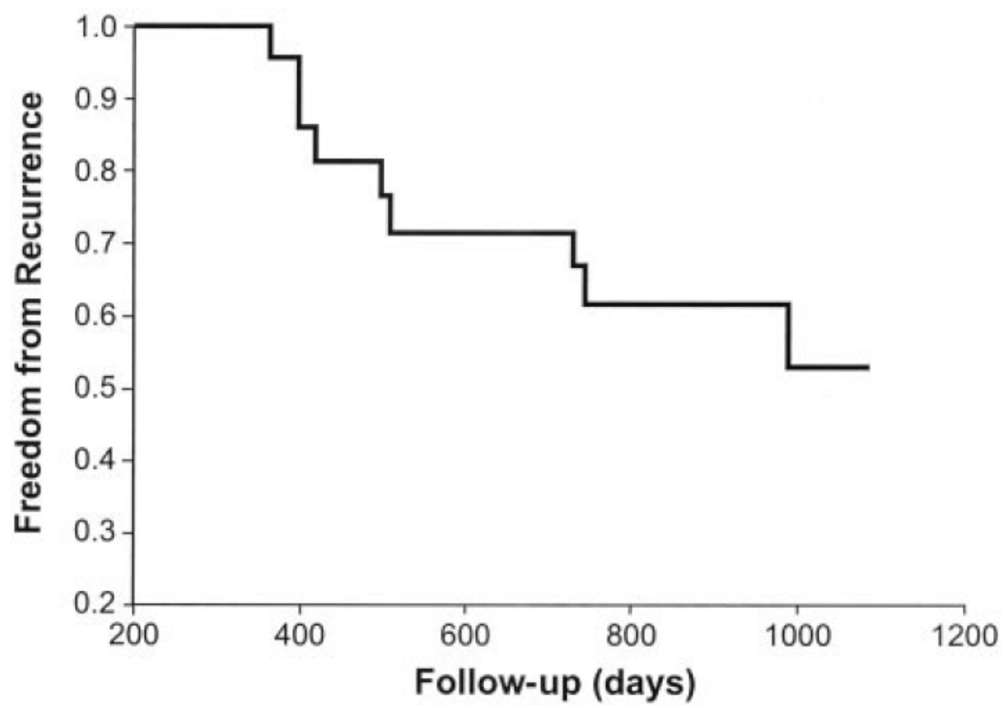

Circulation. 2005;111:3209–3216

Combined Endocardial and Epicardial Catheter Ablation in Arrhythmogenic Right Ventricular Dysplasia Incorporating Scar Dechanneling Technique

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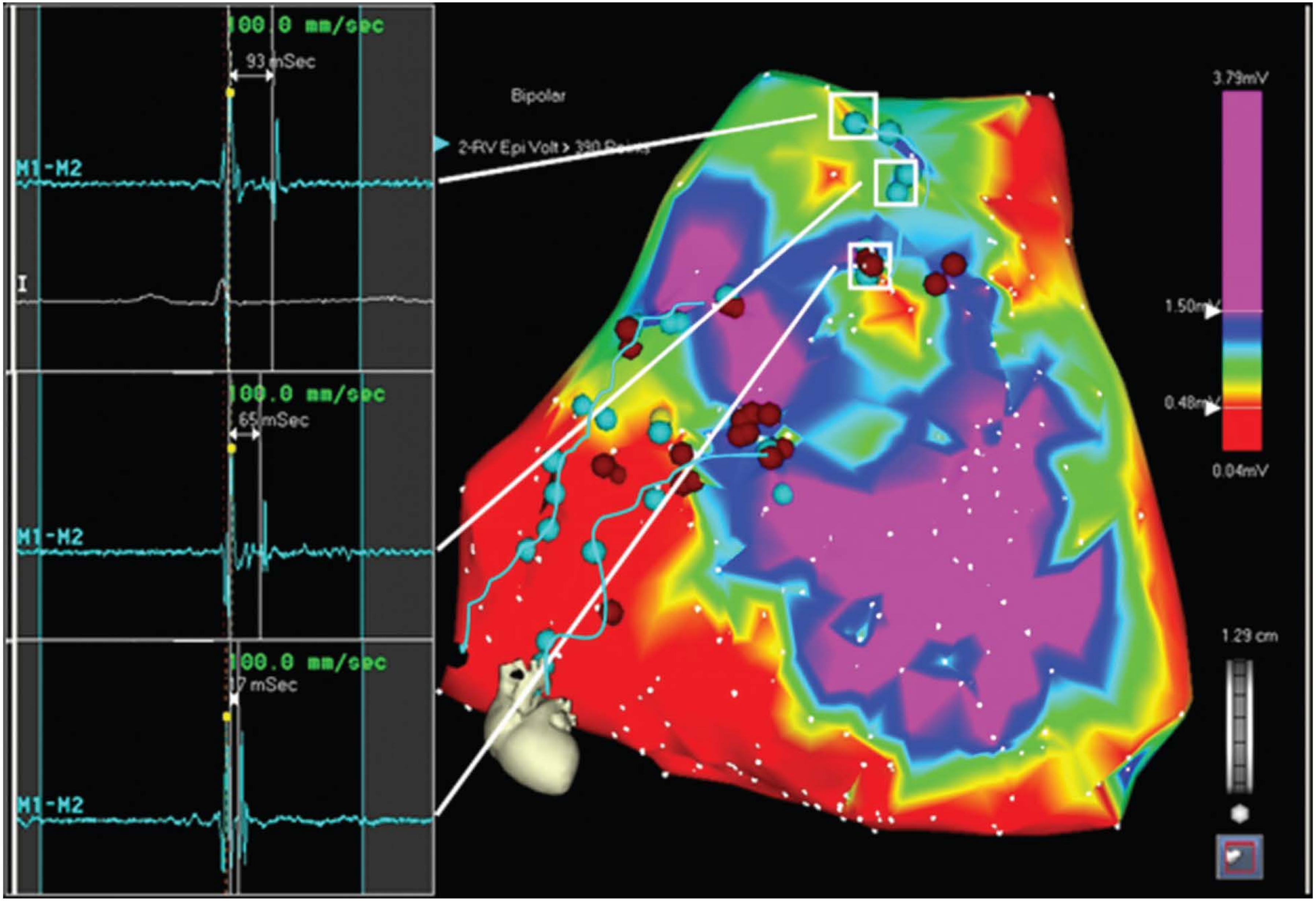
Background—Ventricular tachycardia (VT) ablation in patients with arrhythmogenic right ventricular dysplasia/cardiomyopathy (ARVD/C) has a low success rate. A more extensive epicardial (Epi) arrhythmogenic substrate could explain the low efficacy. We report the results of combined endocardial (Endo) and Epi VT ablation and conducting channel (CC) elimination.

Methods and Results—Eleven consecutive patients with ARVD/C were included in the study. A high-density 3D Endo (321±93 sites mapped) and Epi (302±158 sites mapped) electroanatomical voltage map was obtained during sinus rhythm to define scar areas (<1.5 mV) and CCs inside the scars, between scars, or between the tricuspid annulus and a scar. The end point of the ablation procedure was the elimination of all identified CCs (scar dechanneling) and the abolition of all inducible VTs. The mean procedure and fluoroscopy time were 177±63 minutes and 20±8 minutes, respectively. Epi scar area was larger in all cases (26±18 versus 94±45 cm^2, $P<0.01$). The combined Endo and Epi VT ablation eliminated all clinical and induced VTs, and the addition of scar dechanneling resulted in noninducibility in all cases. Seven patients continued on sotalol. During a median follow-up of 11 months (6–24 months), only 1 (9%) patient had a VT recurrence. There was a single major bleeding event that did not preclude a successful procedure.

Conclusions—Combined Endo and Epi mapping reveals a wider Epi VT substrate in patients with ARVD/C with clinical VTs. As a first-line therapy, combined Endo and Epi VT ablation incorporating scar dechanneling achieves a very good short- and midterm success rate. (***Circ Arrhythm Electrophysiol*. 2012;5:111-121.**)

Key Words: arrhythmogenic right ventricular dysplasia ■ ventricular tachycardia ■ ablation ■ pericardium



(Circulation. 2012;5:111)

Cardiac sarcoidosis

Systemic inflammatory disease of unknown cause

Formation of non-caseating granulomas and tissue scarring involving lung, eye, heart, etc.

Clinical manifestations of CS: CHF, VT, SVT, AV block, and sudden cardiac death.

Myocardial involvement is associated with widespread multi-organ disease and carries a 40% mortality at 5 years.

Circ AE. **2014;7:407-413**

Ventricular Tachycardia in Cardiac Sarcoidosis

Characterization of Ventricular Substrate and Outcomes of Catheter Ablation

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Background—Cardiac sarcoid–related ventricular tachycardia (VT) is a rare disorder; the underlying substrate and response to ablation are poorly understood. We sought to examine the ventricular substrate and outcomes of catheter ablation in this population.

Methods and Results—Of 435 patients with nonischemic cardiomyopathy referred for VT ablation, 21 patients (5%) had cardiac sarcoidosis. Multiple inducible VTs were observed with mechanism consistent with scar-mediated re-entry in all VTs. Voltage maps showed widespread and confluent right ventricular scarring. Left ventricular scarring was patchy with a predilection for the basal septum, anterior wall, and perivalvular regions. Epicardial right ventricular scar overlay and exceeded the region of corresponding endocardial scar. After ≥1 procedures, ablation abolished ≥1 inducible VT in 90% and eliminated VT storm in 78% of patients; however, multiple residual VTs remained inducible. Failure to abolish all inducible VTs was because of septal intramural circuits or extensive right ventricular scarring. Multiple procedure VT-free survival was 37% at 1 year, but VT control was achievable in the majority of patients with fewer antiarrhythmic drugs compared with preablation (2.1±0.8 versus 1.1±0.8; $P<0.001$).

Conclusions—Patients with cardiac sarcoidosis and VT exhibit ventricular substrate characterized by confluent right ventricular scarring and patchy left ventricular scarring capable of sustaining a large number of re-entrant circuits. Catheter ablation is effective in terminating VT storm and eliminating ≥1 inducible VT in the majority of patients, but recurrences are common. Ablation in conjunction with antiarrhythmic drugs can help palliate VT in this high-risk population. (***Circ Arrhythm Electrophysiol*. 2015;8:87-93. DOI: 10.1161/CIRCEP.114.002145.**)

Key Words: arrhythmias, cardiac ■ catheter ablation ■ radiofrequency catheter ablation ■ tachycardia, ventricular

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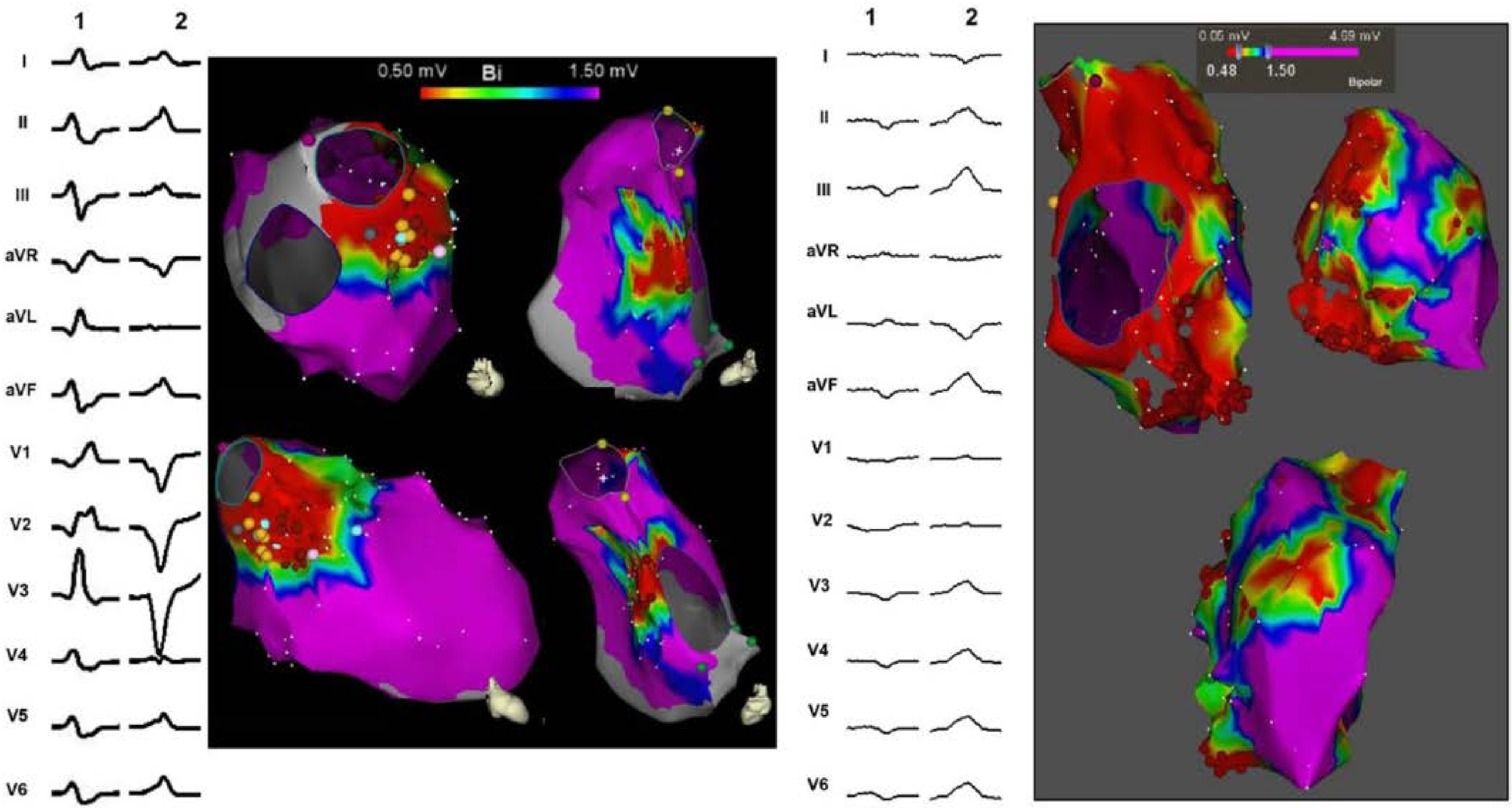

1
2
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
0.50 mV
Bi
1.50 mV
1
2
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
0.05 mV
4.69 mV
0.48
1.50
Bipolar

Systematic Treatment Approach to Ventricular Tachycardia in Cardiac Sarcoidosis

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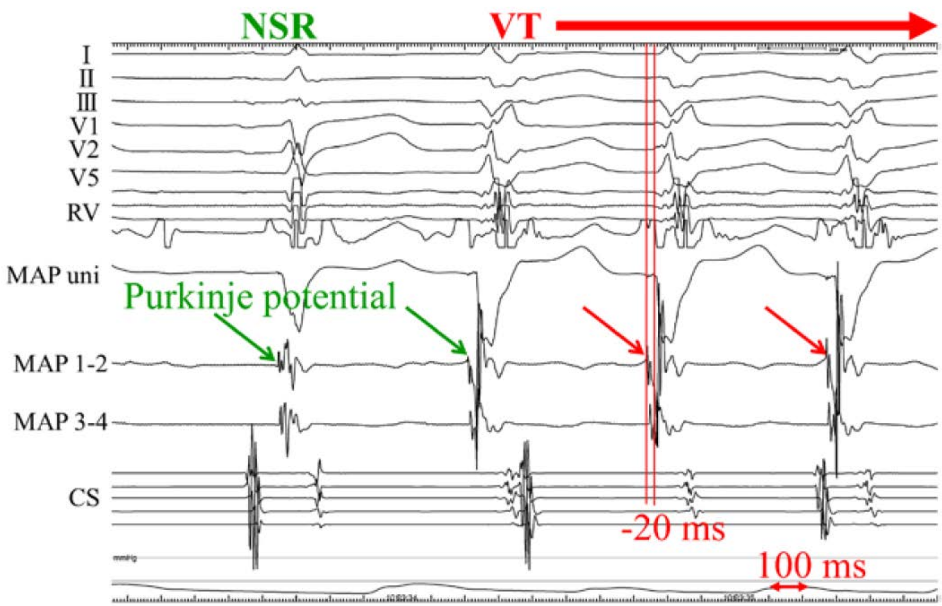
Background—Fatal arrhythmia is commonly observed in cardiac sarcoidosis, but clinical effects of a systematic treatment approach are still uncertain. This study sought to describe both clinical and electrophysiological characteristics and outcomes of systematic treatment approach to ventricular tachycardia (VT) associated with cardiac sarcoidosis.

Methods and Results—We enrolled 37 consecutive patients (11 men; age, 56±11 years) with a diagnosis of sustained VT associated with cardiac sarcoidosis. Clinical effects of a systematic treatment approach including medical therapy (both steroid and antiarrhythmic agents), in association with radiofrequency catheter ablation, were evaluated. All patients received antiarrhythmic agents, and 34 received steroid therapy. During a 39-month follow-up, 23 (62%) patients were free from any VT episodes with medical therapy. Multivariable Cox regression analyses revealed that the absence of gallium-67 myocardial uptake was an independent predictor for VT recurrence (hazard ratio, 7.51; 95% confidence interval, 1.65–34.26; *P*<0.01). Fourteen patients who experienced VT recurrences even while on drug therapy underwent radiofrequency catheter ablation. Electrophysiological study revealed that the mechanisms of VTs could be classified into 2 subgroups: Purkinje-related or scar-related VT. The QRS duration of VT was narrower in Purkinje-related than in scar-related VTs (157±23 versus 183±22 ms; *P*<0.05). After a 33-month follow-up subsequent to the radiofrequency catheter ablation, 6 of 14 patients experienced VT recurrence. The number of VTs sustained during electrophysiological study was higher in the patients with VT recurrence than in those without (3.7±1.4 versus 1.9±0.8; *P*<0.01).

Conclusions—A systematic treatment approach to cardiac sarcoidosis with VT successfully suppressed VT recurrences in the majority of patients studied. (*Circ Arrhythm Electrophysiol*. **2014;7:407-413.**)

Key Words: ablation, catheter ■ anti-arrhythmia agents ■ sarcoidosis ■ tachycardia, ventricular



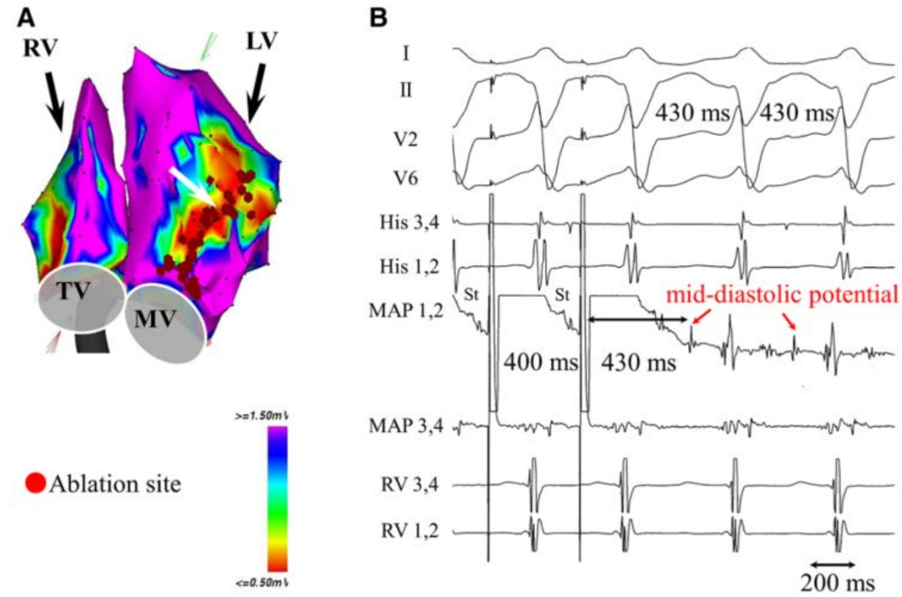


Table 3. Electrophysiological Characteristics of Purkinje-Related and Scar-Related VT

	Total (n=37)	Purkinje-Related VT (n=6)	Scar-Related VT (n=31)	*P* Value
VT-QRS duration, ms	173±27	157±23	183±22	0.016
VT cycle length, ms	400±97	454±97	385±92	0.134

Circ AE 2014;7:407-413

Substrates/ablation strategy in NICM

ICM	D-CM	ARVC	Sarcoidosis	HCM
vascular	Peri-valvular	Peri-valvular (triangle)	Peri-valvular, Basal, septal	Basal/RV-LV Apical,
Endo	Epicardial (collateral damage: CA, PhN, lung)			
Scar-related reentry Non-scar-related, non-reentrant (RVOT, HPS, BBRVT)				
linear exit, LAVA, scar isolation, scar-dechanneling homogenization				

Conclusion

1. **Multiple VTs are common. Majority of them are un-mappable.**
2. **Threshold for epicardial access should be low in ablation of NICM.**
3. **Ablation strategy is diverse. Anatomic approach is important.**

   (linear exit, LAVA, scar isolation, scar-dechanneling, homogenization)
4. **Reentry (Focal, esp, HPS origin, BBRVT possible)**
5. **Irrigation catheter is necessary.**
6. **Collateral damage (coronary artery, phrenic nerve) – CAG, balloon**
7. **Sarcoidosis, ARVD, HCM**