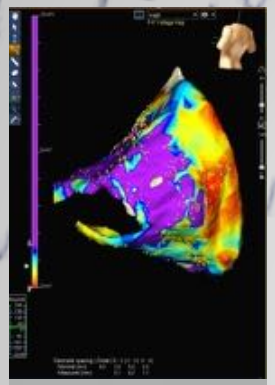
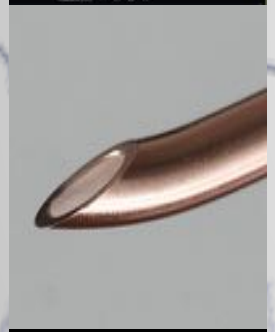
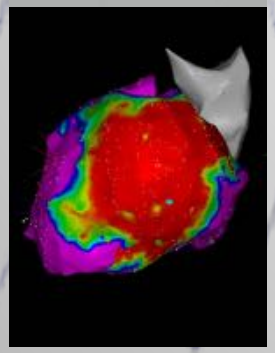






EPICARDIAL ABLATION AROUND THE WORLD:
WHAT HAVE WE LEARNED AFTER 20 YEARS PERFORMING EPICARDIAL MAPPING AND ABLATION OF CARDIAC ARRHYTHMIAS?

A EUROPEAN VIEW

PAOLO DELLA BELLA
CATERINA BISCEGLIA
San Raffaele Hospital
Milan, Italy

CONFLICTS OF INTEREST

Research grants:
Biosense Webster
St. Jude Medical
Biotronik
Boston Scientific

Fellowship support:
Biosense Webster
St. Jude Medical
Biotronik
Boston Scientific
Medtronic

Consultant fee:
St. Jude Medical

INDICATIONS TO EPICARDIAL APPROACH: GUIDELINES AND CONSENSUS DOCUMENTS

Catheter ablation for the treatment of sustained monomorphic ventricular tachycardia

Recommendations	Class[a]	Level[b]	Ref.[c]
Urgent catheter ablation is recommended in patients with scar-related heart disease presenting with incessant VT or electrical storm.	I	B	183
Catheter ablation is recommended in patients with ischaemic heart disease and recurrent ICD shocks due to sustained VT.	I	B	184–186
Catheter ablation should be considered after a first episode of sustained VT in patients with ischaemic heart disease and an ICD.	IIa	B	184–186

ICD = implantable cardioverter defibrillator; VT = ventricular tachycardia.
[a]Class of recommendation.
[b]Level of evidence.
[c]Reference(s) supporting recommendations.

ogenization, can be used.[202–205] Epicardial mapping and ablation are more often required in patients with dilated cardiomyopathy (DCM)[206] or ARVC[207] undergoing VT ablation. Potential complications of epicardial puncture and ablation are damage to the coronary vasculature or inadvertent puncture of surrounding organs, left phrenic nerve palsy or significant bleeding resulting in pericardial tamponade.

2015 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death

Eur **Heart** J. 2015; Europace **2015**

Epicardial mapping and ablation is needed more often in patients with SMVT associated with dilated, non-ischaemic cardiomyopathy than in patients with prior infarction, although only a small number of patients are reported[86,135,166,251,288,292] Voltage maps consistently demonstrate areas of scarring that are often more extensive on the epicardium than on the endocardium.[86,87,251]

Small series and anecdotal reports have also reported successful ablation of epicardial VTs following a failed endocardial ablation in patients with idiopathic OT-VTs, VTs originating from the mitral annulus, the crux of the heart, idiopathic ventricular aneurysms, ARVD, and non-compaction of the LV.[86,135,166,251,288,292] Idiopathic OT-VTs that are epicardial in location may originate close to the anterior interventricular vein, great cardiac vein, and middle cardiac vein; and successful ablation from within these structures has been reported.[164,293,294]

Indications and outcomes. Patients with scar-related or idiopathic VT may benefit from an epicardial approach if endocardial ablation fails. Patients reported have generally been referred to specialized centres, often after failing endocardial ablation; thus, the incidence of epicardial VTs is unknown. In the majority of reported cases, epicardial ablation has been performed as a second, separate intervention following failure of an attempted endocardial approach.[86,251,262,266] Endocardial

CONSENSUS DOCUMENT

EHRA/HRS Expert Consensus on Catheter Ablation of Ventricular Arrhythmias

Developed in a partnership with the European Heart Rhythm Association (EHRA), a Registered Branch of the European Society of Cardiology (ESC), and the Heart Rhythm Society (HRS); in collaboration with the American College of Cardiology (ACC) and the American Heart Association (AHA)

Heart Rhythm, Vol 6, No 6, June 2009

opathy, a reduction in mortality has yet to be demonstrated.[150] Catheter ablation has also been successfully used in patients with non-ischaemic cardiomyopathy where the ablation target is often on the epicardial surface of the ventricles and the procedure may be more complex.[151–156] The long-term effectiveness of catheter ablation for non-ischaemic cardiomyopathies has been less well studied than for ischaemic cardiomyopathies.

EHRA/HRS/APHRS expert consensus on ventricular arrhythmias

Europace **2014**

Indications to epicardial mapping and ablation: Are there news?

- Idiopathic dilated cardiomyopathy, inferolateral vs anteroseptal scar

Catheter Ablation of Ventricular Arrhythmia in Nonischemic Cardiomyopathy: Anteroseptal Versus Inferolateral Scar Sub-Types

Teresa Oloriz, John Silberbauer, Giuseppe Maccabelli, Hiroya Mizuno, Francesca Baratto, Senthil Kirubakaran, Pasquale Vergara, Caterina Bisceglia, Giulia Santagostino, Alessandra Marzi, Nicoleta Sora, Carla Roque, Fabrizio Guarracini, Dimitris Tsiachris, Andrea Radinovic, Manuela Cireddu, Simone Sala, Simone Gulletta, Gabriele Paglino, Patrizio Mazzone, Nicola Trevisi and Paolo Della Bella

- VT related to Myocarditis

Imaging and epicardial substrate ablation of ventricular tachycardia in patients late after myocarditis

Giuseppe Maccabelli[1]*, Dimitris Tsiachris[1], John Silberbauer[1], Antonio Esposito[2], Caterina Bisceglia[1], Francesca Baratto[1], Caterina Colantoni[2], Nicola Trevisi[1], Anna Palmisano[2], Pasquale Vergara[1], Francesco De Cobelli[2], Alessandro Del Maschio[2], and Paolo Della Bella[1]

- Post-ischemic cardiomyopathy

Electroanatomical Voltage and Morphology Characteristics in Postinfarction Patients Undergoing Ventricular Tachycardia Ablation

Pragmatic Approach Favoring Late Potentials Abolition

Dimitris Tsiachris, MD; John Silberbauer, MD; Giuseppe Maccabelli, MD; Teresa Oloriz, MD; Francesca Baratto, MD; Hiroya Mizuno, MD; Caterina Bisceglia, MD; Pasquale Vergara, MD; Alessandra Marzi, MD; Nicoleta Sora, MD; Fabrizio Guarracini, MD; Andrea Radinovic, MD; Manuela Cireddu, MD; Simone Sala, MD; Simone Gulletta, MD; Gabriele Paglino, MD; Patrizio Mazzone, MD; Nicola Trevisi, MD; Paolo Della Bella, MD

Infarct transmurality as a criterion for first-line endo-epicardial substrate–guided ventricular tachycardia ablation in ischemic cardiomyopathy

Juan Acosta, MD,* Juan Fernández-Armenta, MD,* Diego Penela, MD,* David Andreu, MSc, PhD,* Roger Borras, MSc,* Francesca Vassanelli, MD,* Viatcheslav Korshunov, MD,* Rosario J. Perea, MD, PhD,† Teresa M. de Caralt, MD, PhD,† Jose T. Ortiz, MD, PhD,* Guillermina Fita, MD, PhD,* Marta Sitges, MD, PhD,* Josep Brugada, MD, PhD,* Lluis Mont, MD, PhD,* Antonio Berruezo, MD, PhD*

- Arrhythmogenic right ventricular dysplasia

Epicardial Substrate and Outcome With Epicardial Ablation of Ventricular Tachycardia in Arrhythmogenic Right Ventricular Cardiomyopathy/Dysplasia

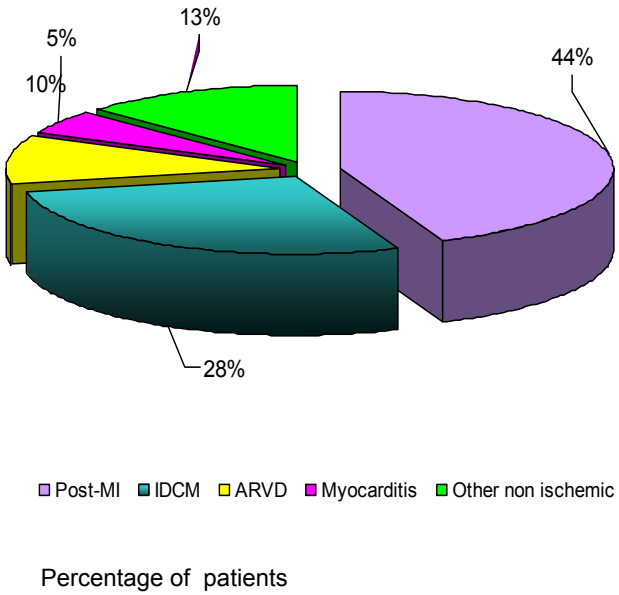
Fermin C. Garcia, MD; Victor Bazan, MD; Erica S. Zado, PA-C; Jian-Fang Ren, MD; Francis E. Marchlinski, MD

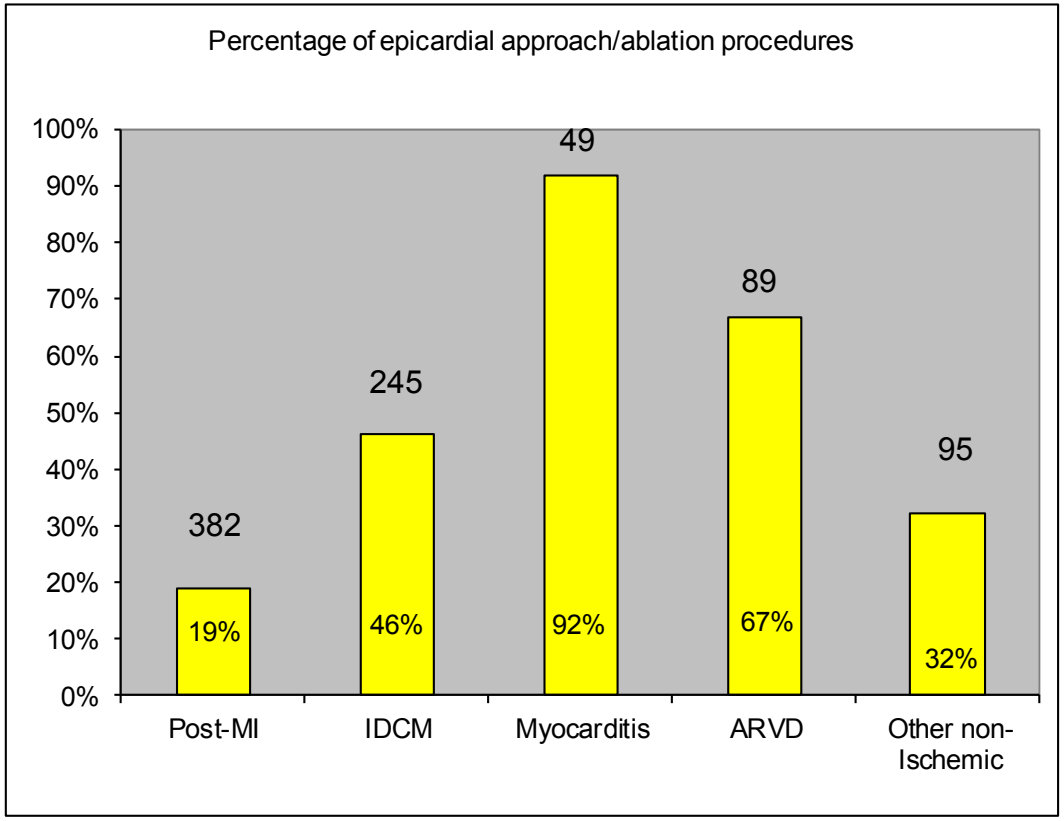
Outcomes and ventricular tachycardia recurrence characteristics after epicardial ablation of ventricular tachycardia in arrhythmogenic right ventricular dysplasia/cardiomyopathy

Binu Philips, MD,*† Anneline S.J.M. te Riele, MD,†‡§ Abhishek Sawant, MD, MPH,† Vishnupriya Kareddy,† Cynthia A. James, ScM, PhD,† Brittney Murray, MS,† Crystal Tichnell, MGC,† Bina Kassamali,† Saman Nazarian, MD, PhD,† Daniel P. Judge, MD,† Hugh Calkins, MD, FHRS,† Harikrishna Tandri, MD†

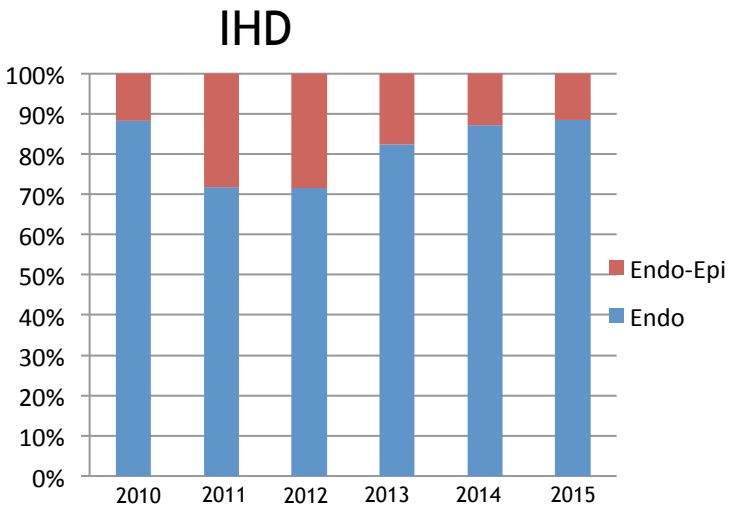
860 VT ablation procedures in 683 pts in the setting of structural heart disease Jan 2010- Sept 2015

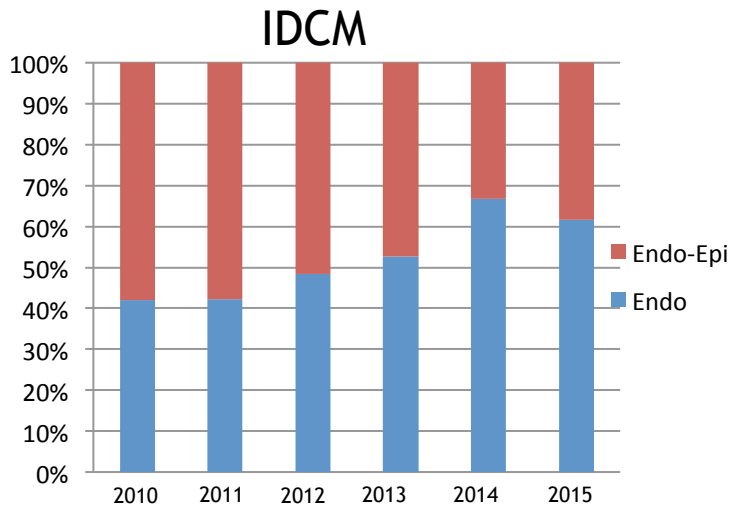
Rate of epicardial approach/ablation procedures according to VT etiology

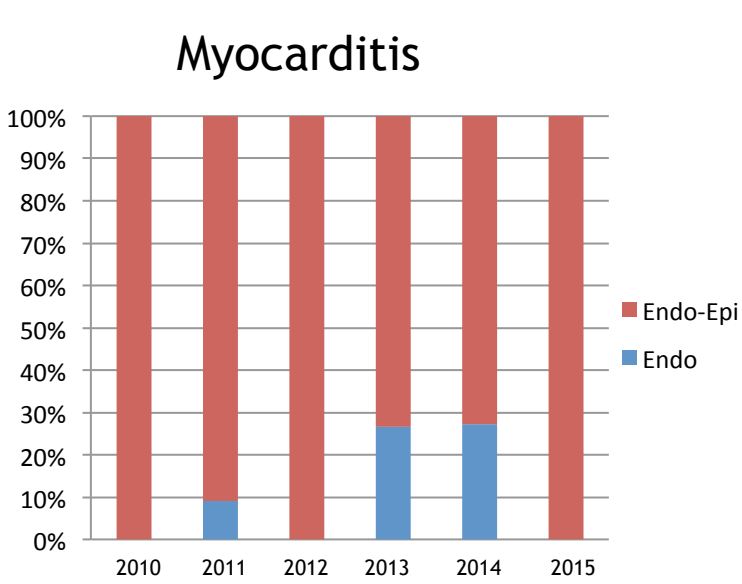


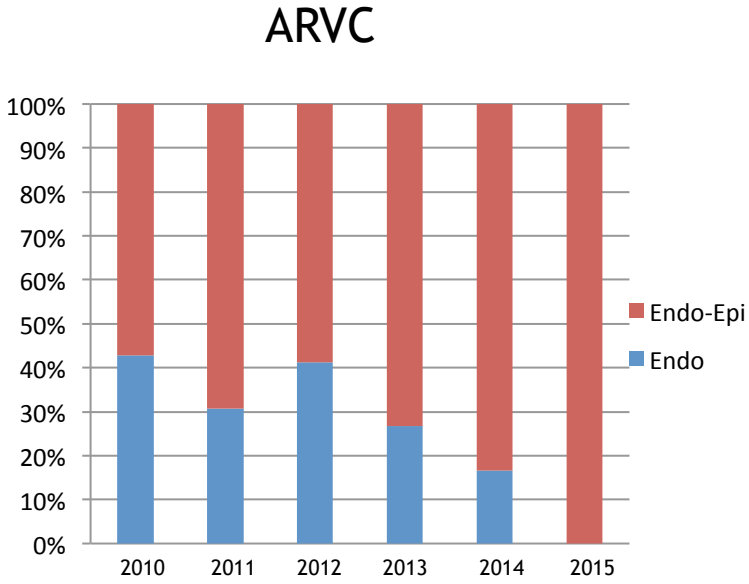


Epicardial/endocardial approach according to VT etiology

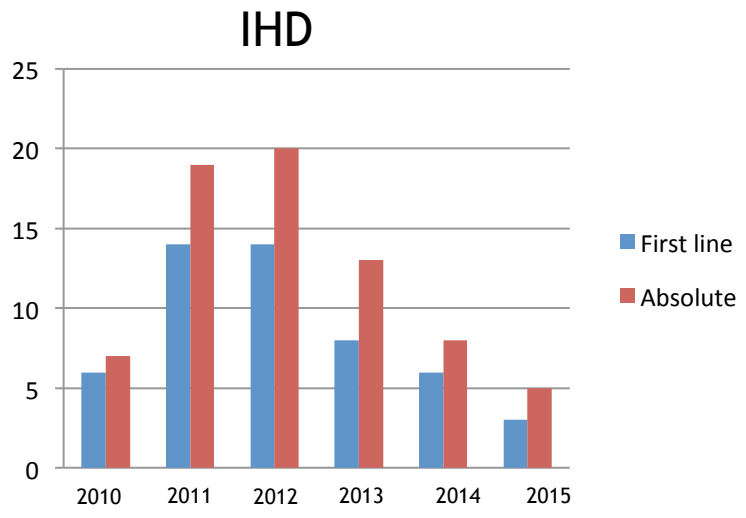


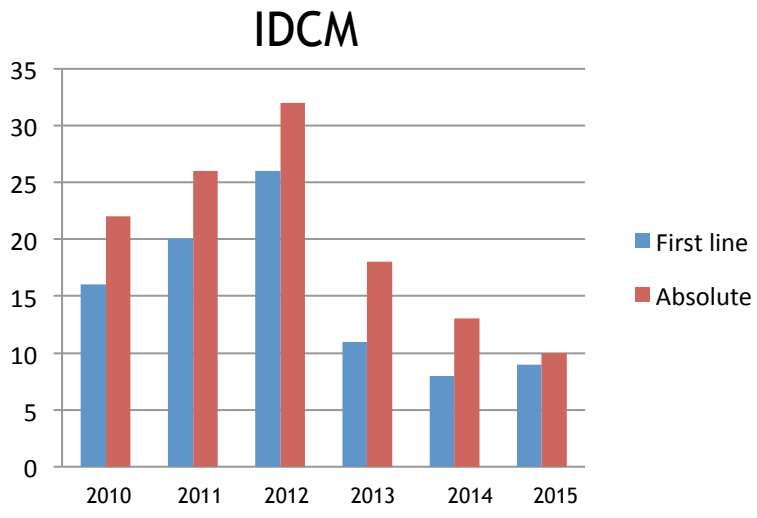


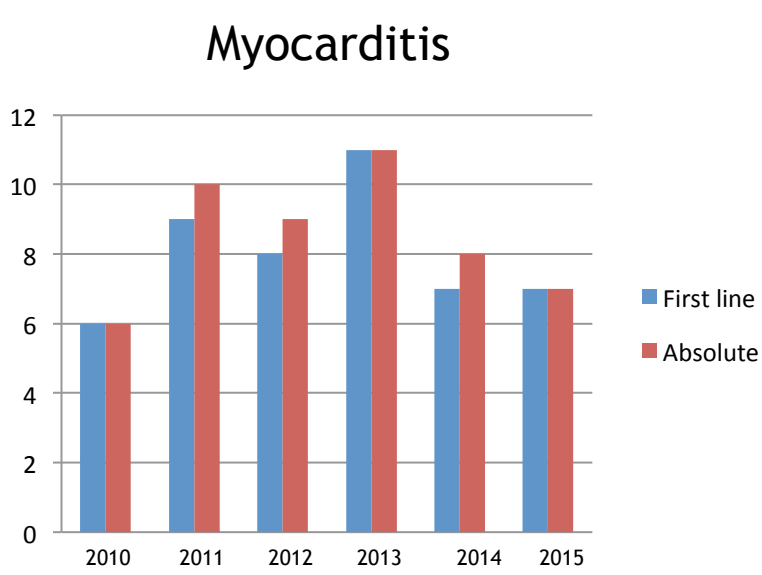


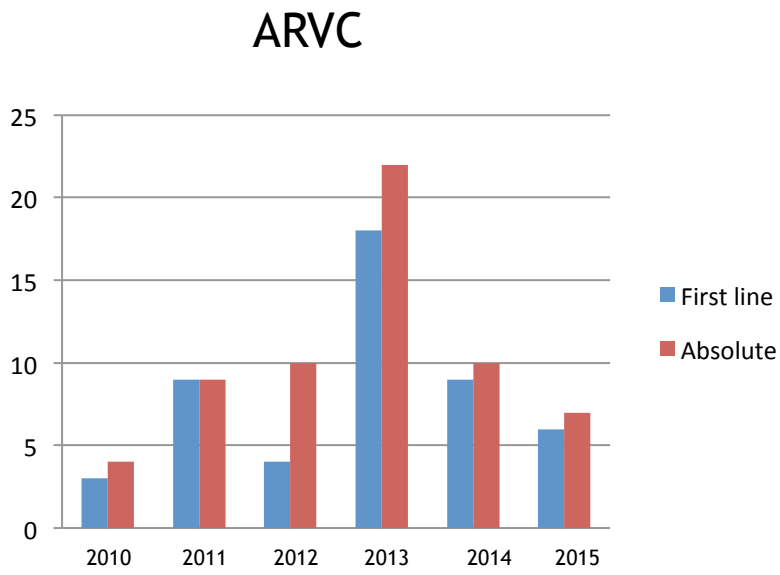


Epicardial approach as a first line strategy according to VT etiology







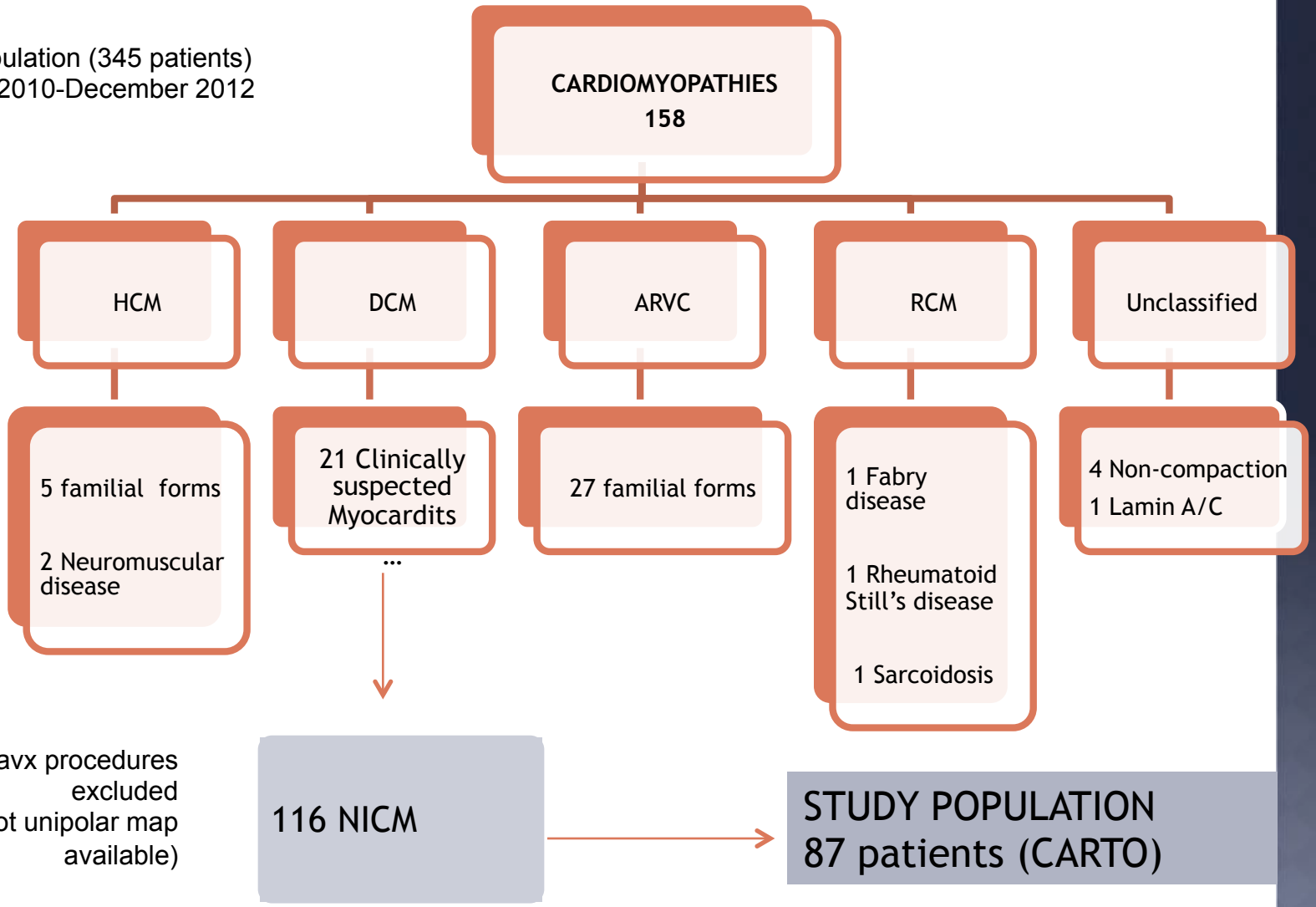


Different arrhythmic substrates in NIDC patients

Catheter Ablation of Ventricular Arrhythmia in Nonischemic Cardiomyopathy: Anteroseptal Versus Inferolateral Scar Sub-Types
Teresa Oloriz, John Silberbauer, Giuseppe Maccabelli, Hiroya Mizuno, Francesca Baratto, Senthil Kirubakaran, Pasquale Vergara, Caterina Bisceglia, Giulia Santagostino, Alessandra Marzi, Nicoleta Sora, Carla Roque, Fabrizio Guarracini, Dimitris Tsiachris, Andrea Radinovic, Manuela Cireddu, Simone Sala, Simone Gulletta, Gabriele Paglino, Patrizio Mazzone, Nicola Trevisi and Paolo Della Bella

160	16	4	7
Ischemic cardiomyopathy	Valvular disease	Hypertensive cardiomyopathy	Congenital disease

Methods
Total population (345 patients)
January 2010-December 2012
OSR



Methods

STUDY POPULATION
87 patients (CARTO)

28 Early-Cardiomyopathy
LV volume: normal or mildly dilated
EF ≥45

59 Dilated-Cardiomyopathy
LV volume: moderate or severe dilatation
EF ≤45

The endocardial LV EAM was segmented using the standardized 17-segment model with the aorta, mitral valve annulus and apex as references.

Patients were categorized as predominant Anteroseptal or Inferolateral scar type based on the majority percentage of endocardial segments (eight segments each) displaying a unipolar voltage less than 8mV, excluding the apex.

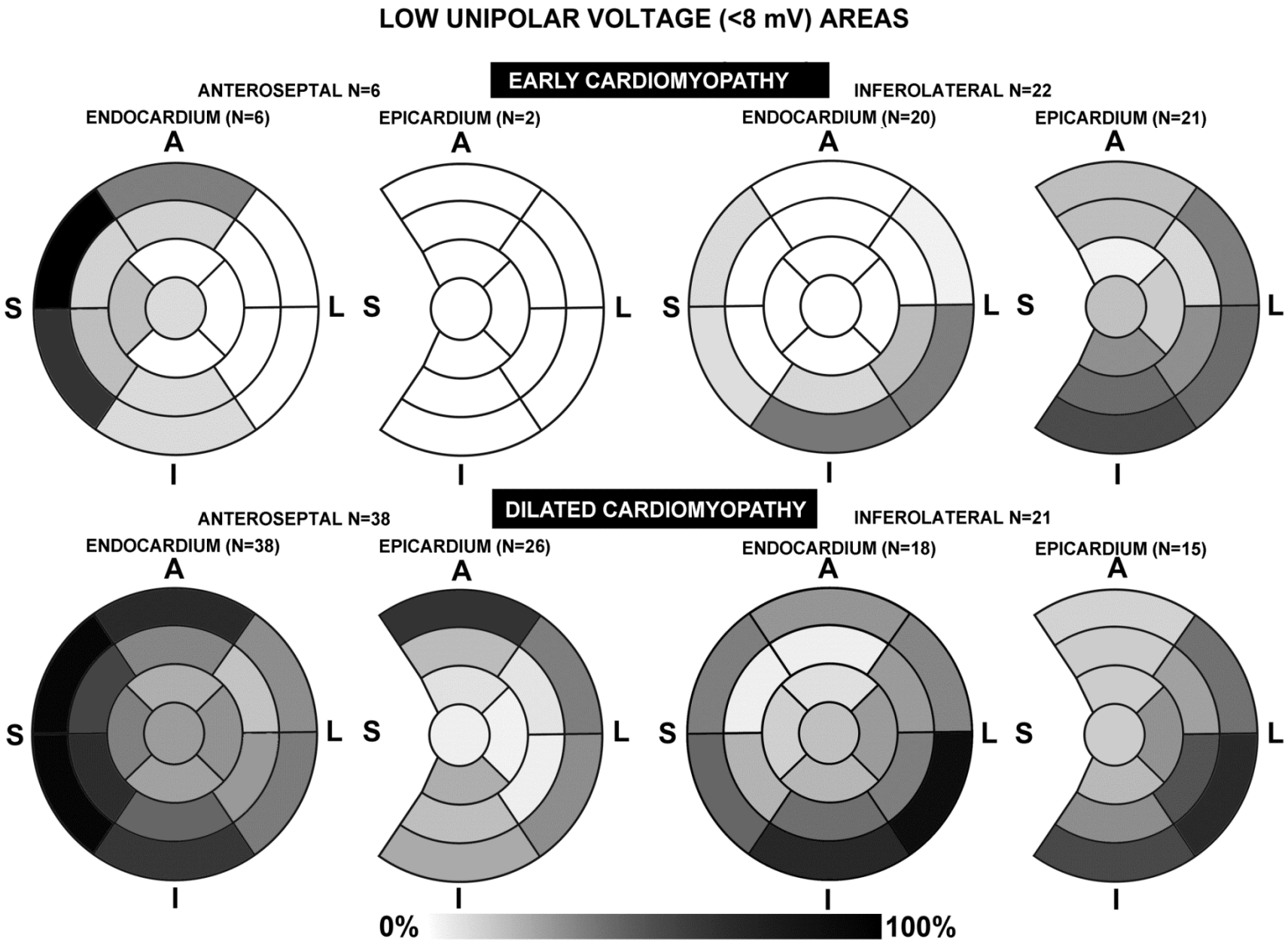
6 Anteroseptal ECM

22 Inferolateral ECM

38 Anteroseptal DCM

21 Inferolateral DCM

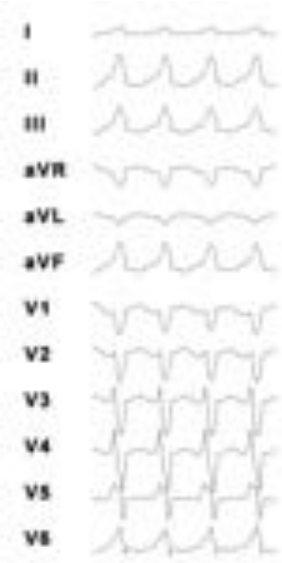
Results. Unipolar scar distribution in the 17 segment model.

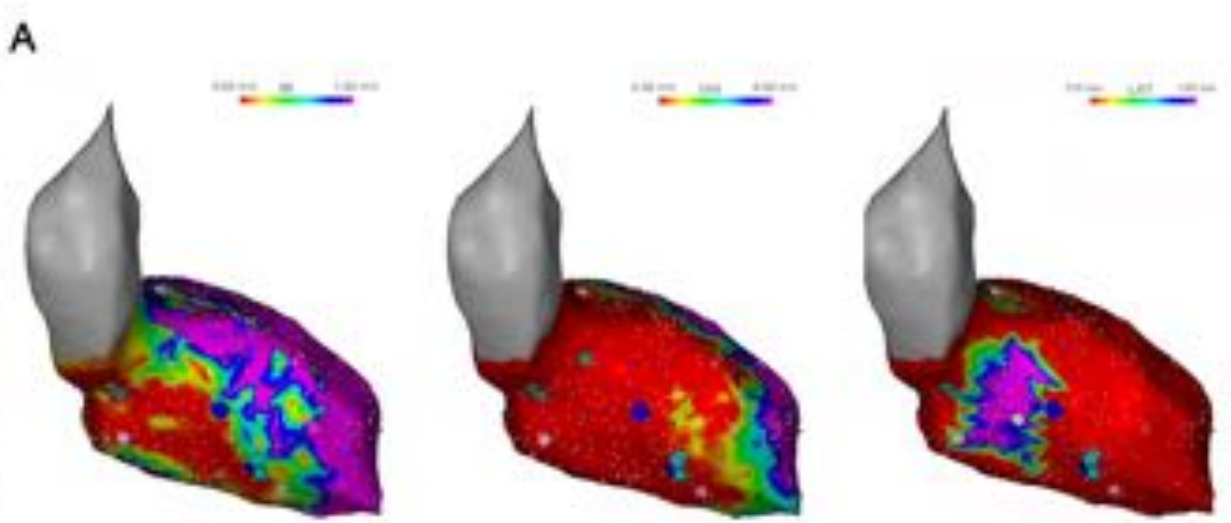


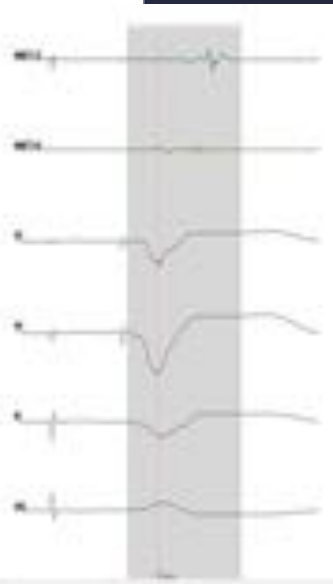
VT morphology:
Left inferior axis

ENDOCARDIAL ELECTROANATOMIC MAP
ANTEROSEPTAL SCAR PATTERN

Sinus rhythm: complete AV block



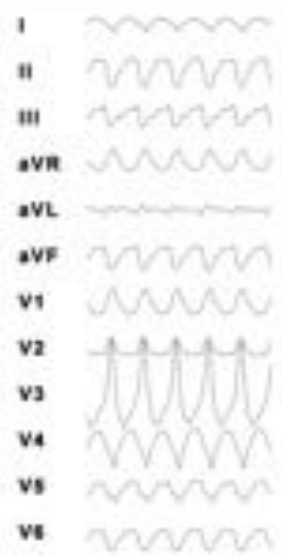


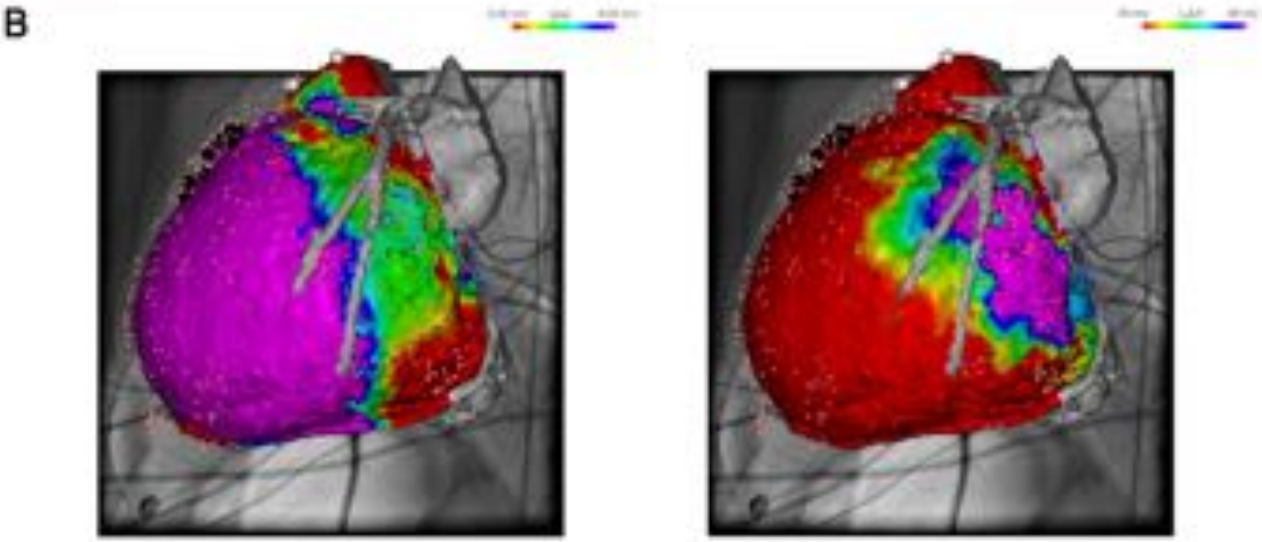


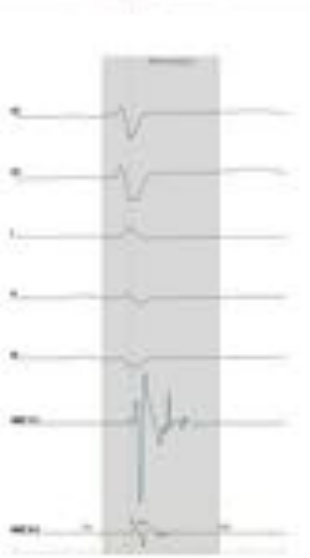
VT morphology: Right superior axis

EPICARDIAL ELECTROANATOMIC MAP
INFEROLATERAL SCAR PATTERN

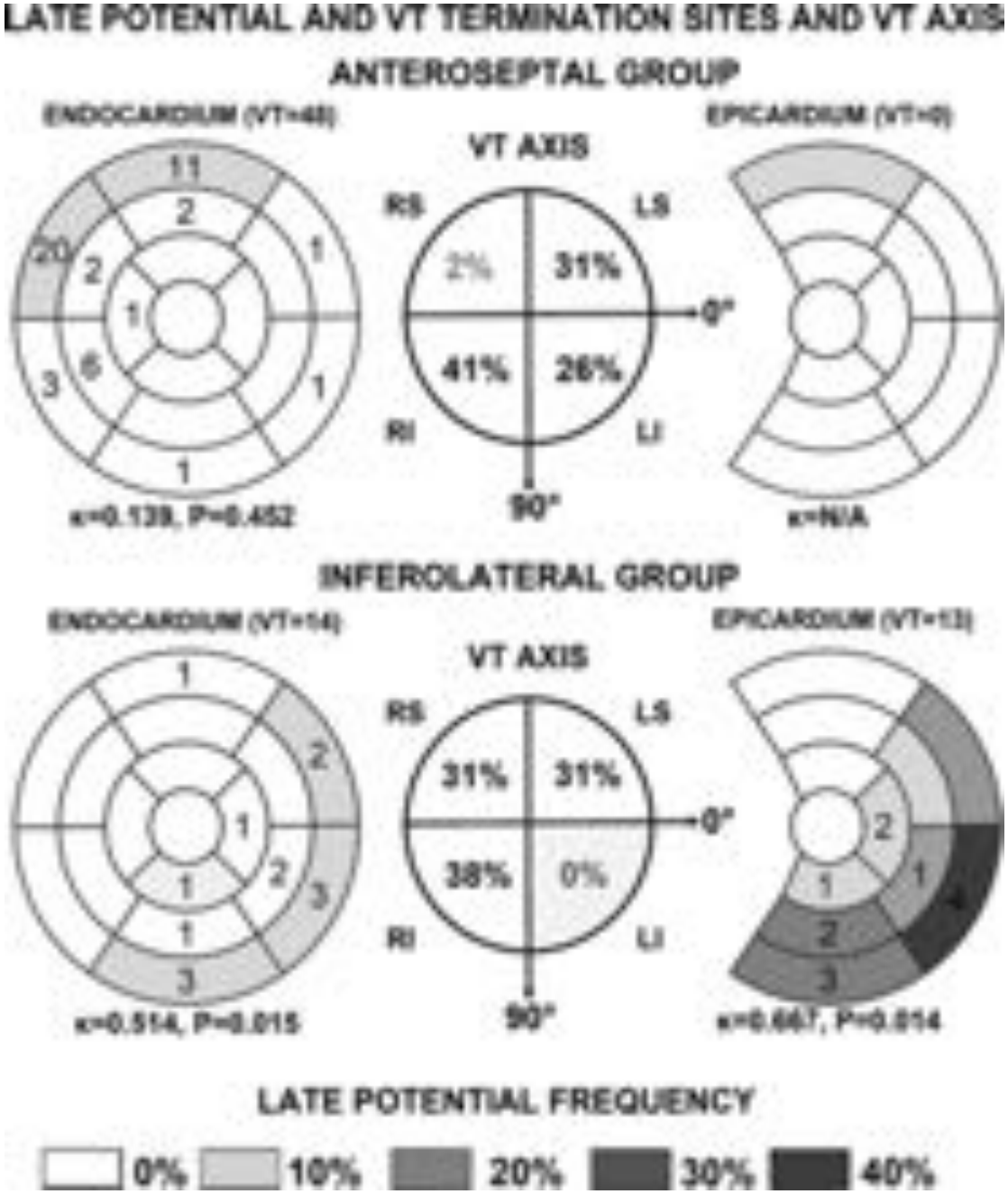
Sinus rhythm: narrow QRS







Results

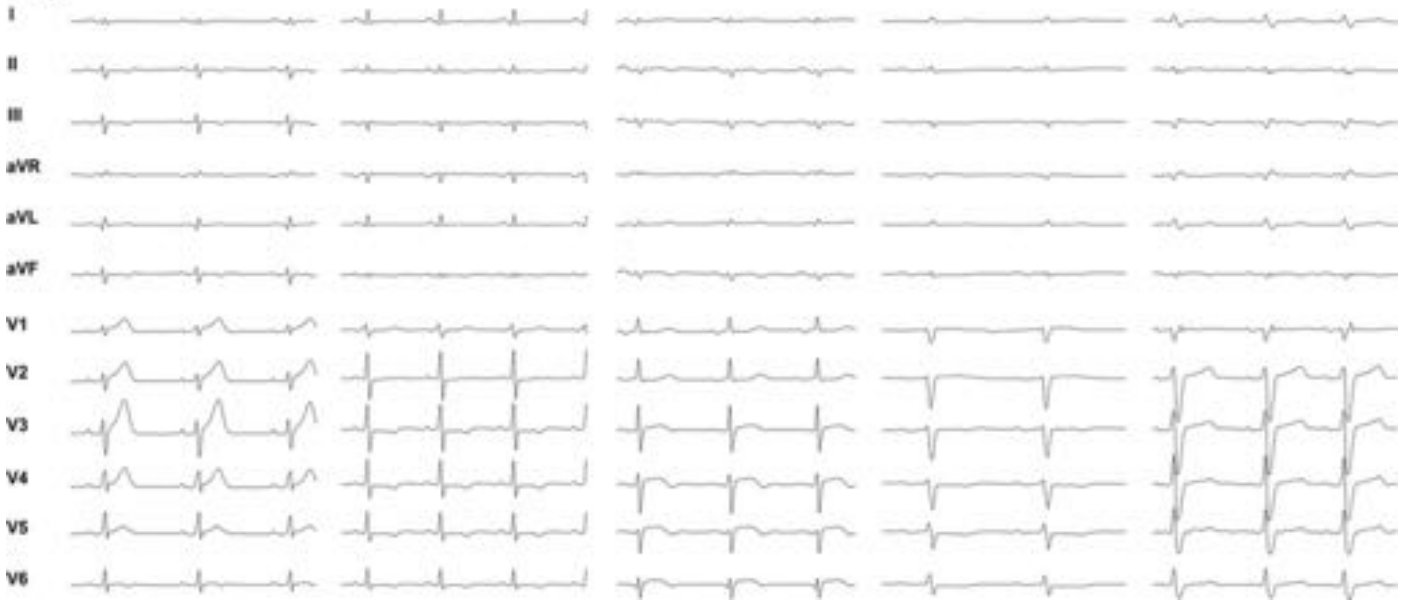

LATE POTENTIAL AND VT TERMINATION SITES AND VT AXIS
ANTEROSEPTAL GROUP
ENDOCARDIUM (VT=48)
VT AXIS
EPICARDIUM (VT=0)
11
2
20
2
1
1
3
6
1
1
RS
LS
2%
31%
0°
41%
26%
RI
LI
90°
κ=0.139, P=0.452
κ=N/A
INFEROLATERAL GROUP
ENDOCARDIUM (VT=14)
VT AXIS
EPICARDIUM (VT=13)
1
2
1
1
2
3
1
3
RS
LS
31%
31%
0°
38%
0%
RI
LI
90°
κ=0.514, P=0.015
κ=0.667, P=0.014
LATE POTENTIAL FREQUENCY
0%
10%
20%
30%
40%

A

ECG – ANTEROSEPTAL SCAR PATTERN

B

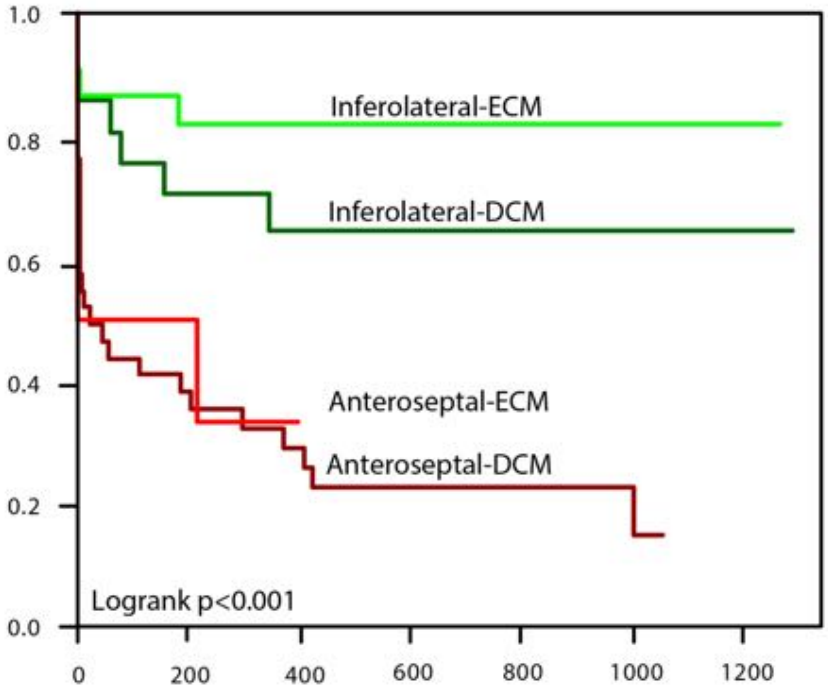
ECG – INFEROLATERAL SCAR PATTERN



SR ECG and VT morphology as predictors of scar pattern

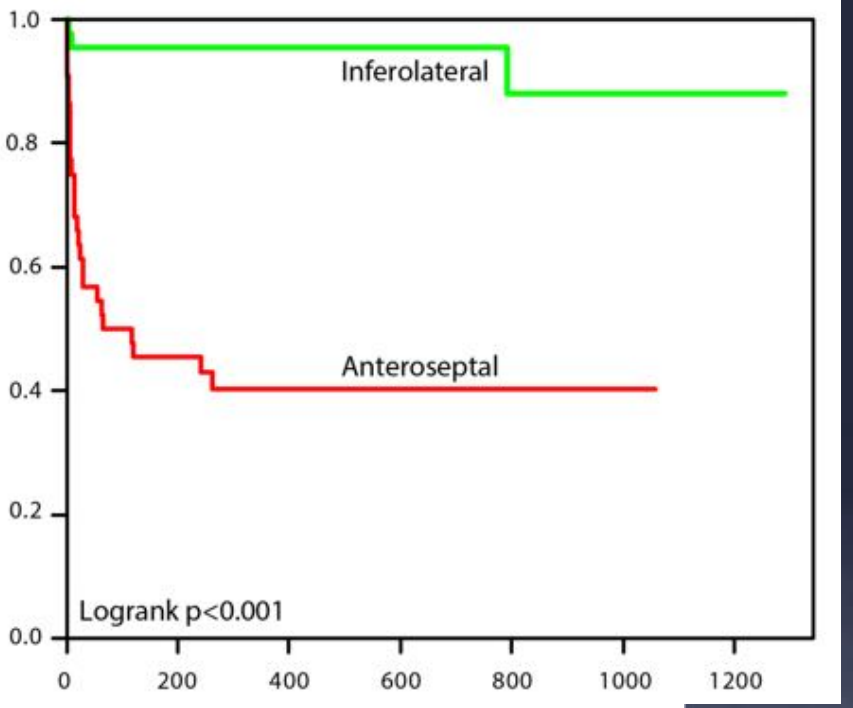
Non-ischemic cardiomyopathy. Outcome post VT ablation.

VT recurrence free survival



Under Risk	Time in Days					
Inferolateral-ECM	18	14	12	7	4	2
Inferolateral-DCM	15	12	8	5	2	1
Anteroseptal-ECM	3	0	0	0	0	0
Anteroseptal-DCM	15	9	5	3	3	0

Redo VT ablation free survival



Under Risk	Time in Days					
Inferolateral	40	31	21	12	6	3
Anteroseptal	20	11	8	4	3	0

Europace (2014) 16, 1363–1372
doi:10.1093/europace/euu017

CLINICAL RESEARCH
Electrophysiology and ablation

Imaging and epicardial substrate ablation of ventricular tachycardia in patients late after myocarditis

Giuseppe Maccabelli[1]*, Dimitris Tsiachris[1], John Silberbauer[1], Antonio Esposito[2], Caterina Bisceglia[1], Francesca Baratto[1], Caterina Colantoni[2], Nicola Trevisi[1], Anna Palmisano[2], Pasquale Vergara[1], Francesco De Cobelli[2], Alessandro Del Maschio[2], and Paolo Della Bella[1]

26 patients (mean age 47.5 yy)
Preserved systolic function (median LVEF 54.5%, range 40-65%)
Previous Myocarditis: (Biopsy proven 7/26 pts).

- Sustained VTs: 24/26 pts
- Non tolerated VTs: 13/26 pts
- PVCs and NSVTs: 2/26 pts
- ICD: 8/26 pts (3/8→ ES presentation)
- IMAGING:
  - -MRI→ 19 pts
  - -CT scan→7 pts
  - -MRI+CT scan→ 1 pt

- *Endocardial EAM*
  - -Low voltage bipolar scar (0,5-1,5 mV) in 1 segment / 1 pt
  - -No LPs

- *Epicardial EAM*
  - -***Bipolar border zone scar (cutoff value 1 mV) :*** 14/19 pts
    - → in 12 correspondence with LE imaging (Sensitivity 63.2%)
  - -***Bipolar border zone scar (cutoff value 1,5 mV):*** 16/19 pts
    - → in 14 correspondence with LE imaging (Sensitivity 73.7%)
    - → Segment per segment corrrspondence with LE: 39.8%
  - -***Unipolar scar*** correspondence with LE imaging in 18/19 pts (Sensitivity 94.7%)
    - → Segment per segment correspondence with LE: 66.2%
  - - ***LP:*** 15/19 pts (78.9%)

Increased sensitivity

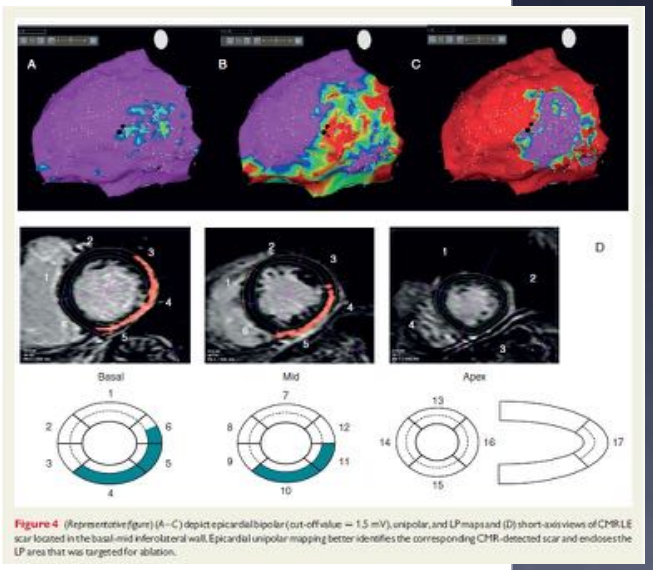


Figure 4 (Representative figure) (A–C) depict epicardial bipolar (cut-off value = 1.5 mV), unipolar, and LP maps and (D) short-axis views of CMR LE scar located in the basal-mid inferolateral wall. Epicardial unipolar mapping better identifies the corresponding CMR-detected scar and encloses the LP area that was targeted for ablation.

A detailed subset analysis focused on segment per segment **correspondence of LE scar localization with EAM** was undertaken in 19 pts with endocardial and epicardial uni/bipolar voltage maps. (MRI in 15 pts, CCT in 4 pts).
The majority of patients had scar localizing to the ***basal-mid inferolateral walls***

Europace (2014) 16, 1363–1372
doi:10.1093/europace/eus017

Imaging and epicardial substrate ablation of ventricular tachycardia in patients late after myocarditis

Giuseppe Maccabelli[1]*, Dimitris Tsiachris[1], John Silberbauer[1], Antonio Esposito[2], Caterina Bisceglia[1], Francesca Baratto[1], Caterina Colantoni[2], Nicola Trevisi[1], Anna Palmisano[2], Pasquale Vergara[1], Francesco De Cobelli[2], Alessandro Del Maschio[2], and Paolo Della Bella[1]

Correlation between MRI Extension and Electroanatomical Mapping Scar Thickness:

Table 2 Prevalence of electroanatomical scar detection according to the extension pattern based on LE imaging

	Mid-wall and subepicardial scar	Subepicardial scar	*P*
Endocardial bipolar scar (1.5 mV), %	10	0	0.33
Endocardial unipolar scar (8 mV), %	80	44.4	0.10
Epicardial bipolar dense scar (0.5 mV), %	70	22.2	0.037
Epicardial bipolar scar (1 mV), %	100	44.4	0.006
Epicardial bipolar scar (1.5 mV), %	100	77.8	0.11
Epicardial unipolar scar (8 mV), %	90	100	0.33

- Accuracy of endo unipolar mapping in providing identification of epicardial substrate is related to the thickness of scar area (80% of segments with midwall LE versus 44.4% of segments with subepicardial LE)
- Accuracy of Bipolar Epicardial mapping dense in providing scar identification was also related to the tickness of scar tissue and to the voltage cut-off (sensitivity in detection of subepicardial scar from 22.2% to 77.8%).
- Epicardial unipolar scar was the most accurate in identification of subepicardial scar (100% of segments)

Ablation of VT in the setting of previous myocarditis: 43/639 patients (7%)

Age, years, M±SD	62±14
Male, N, %	42 (98%)
LVEF, %, M±SD	37±15
ICD, N, %	23 (53%)
Electrical Storm, N, %	5 (11%)
Imaging, N, %:	
•MRI	25 (58%)
•CT	6 (14%)

Ablation Strategy:

-Primary endpoint: Late/fragmented potentials abolition

-Secondary endpoint non inducibility of VT

- First line Endo-epicardial EAM: 40 (93%)
- Endocardial EAM: 3 (7%) – endo ablation 2 (basal EP study→ morphology consistent with septal VTs)

Targets for substrate modification:

-Epi LPs: 30/43 (70%)

Epi LPs complete abolition after ablation: 20/43 (46%)

Epi LPs incomplete abolition after ablation: 10/43 (23%)

Overall absence of substrate / LPs: 13 (30%)

-Endo: 3 (7%)

-Epi:10 (22%)

•*BaselineVT Inducibility: 27/43 (61%)*

-Activation mapping of VT: 21/27 pts(78%)

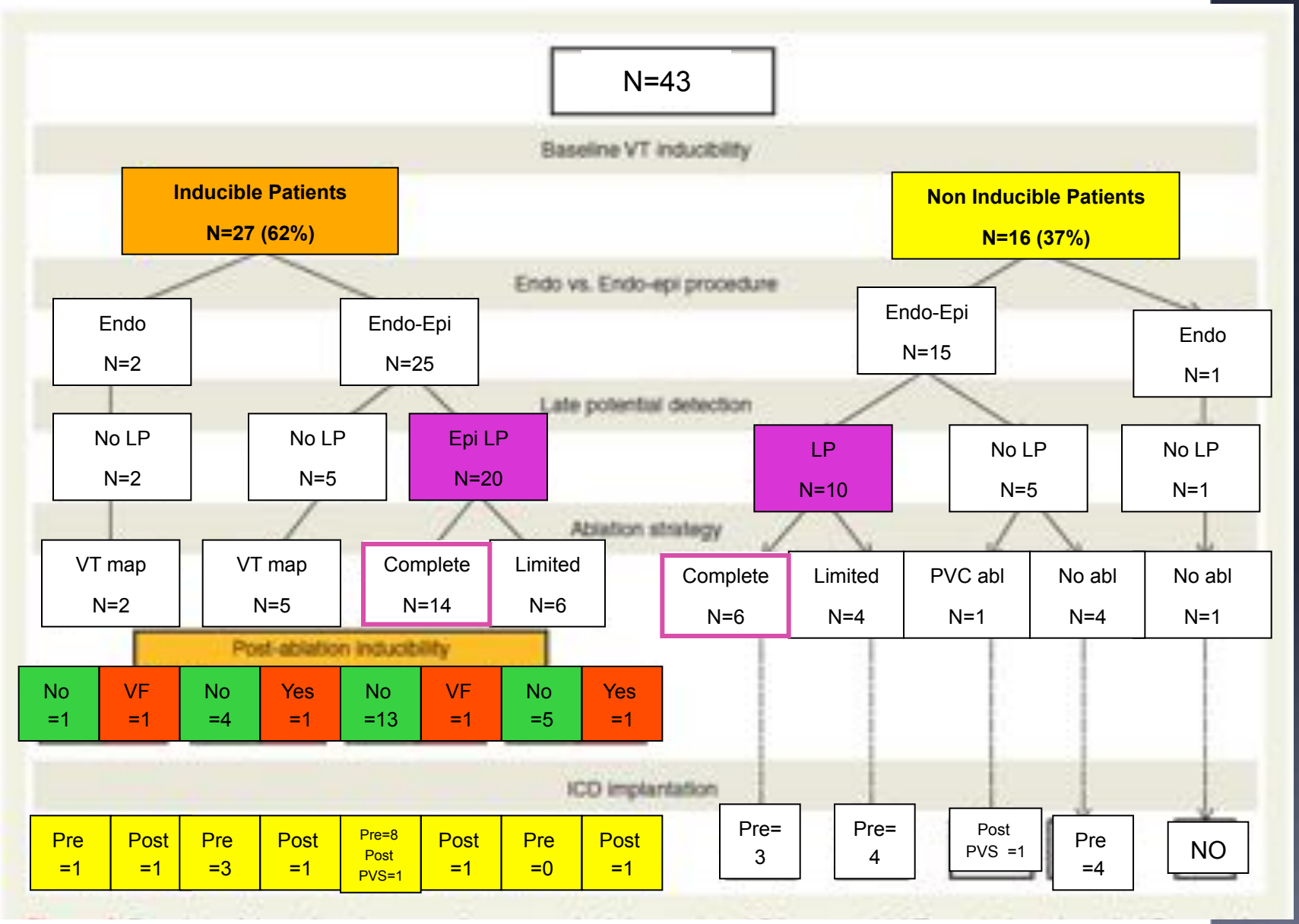
- Overall LP absence: 7/27 pts (26%)

-Epi LP presence: 20/27 pts (74%)

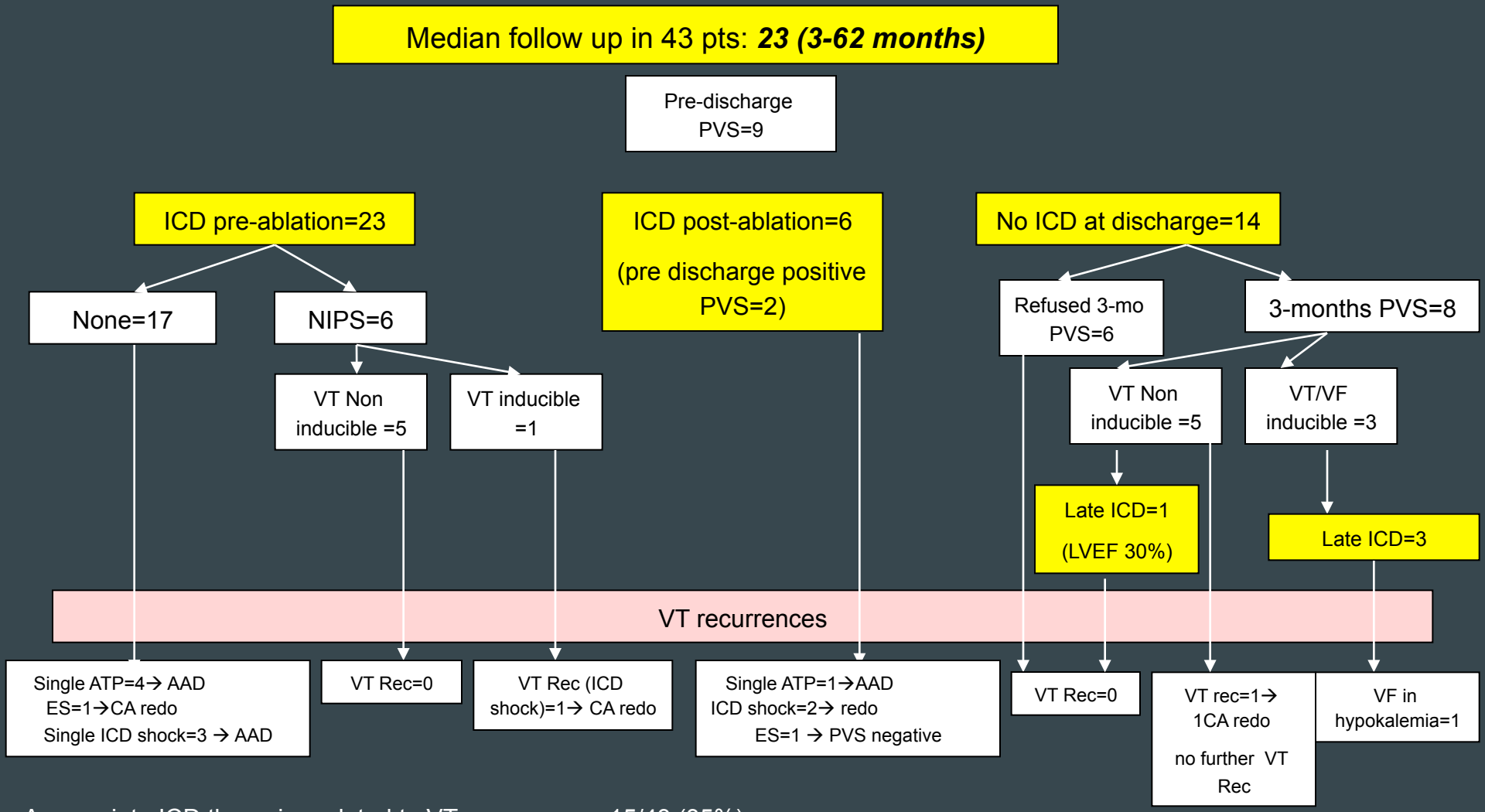
→abolition: 14/20 pts (70%)

→limited (coronary, phrenic nerve): 6/20 pts (30%)

VT Ablation in the setting of previous myocarditis: 43 patients (2010-2015)



No major CA-related complications



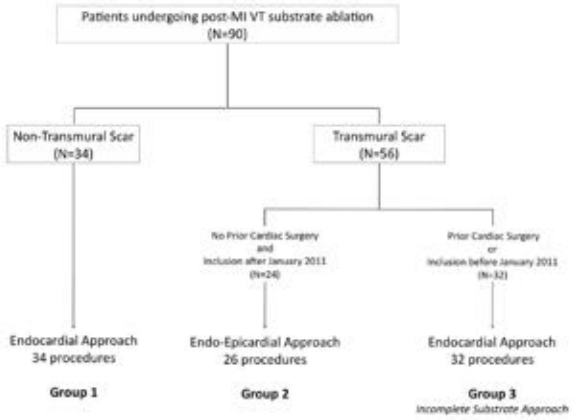
- Appropriate ICD therapies related to VT recurrences: 15/43 (35%)
  - →ATP: 5 (12%)
  - →ICD shock: 6 (14%)
  - →ES: 2 (5%)
  - →REDO procedures: 5 pts (12%)
  - amio-related thyrotoxicosis=1
  - -Hypokalemia=1

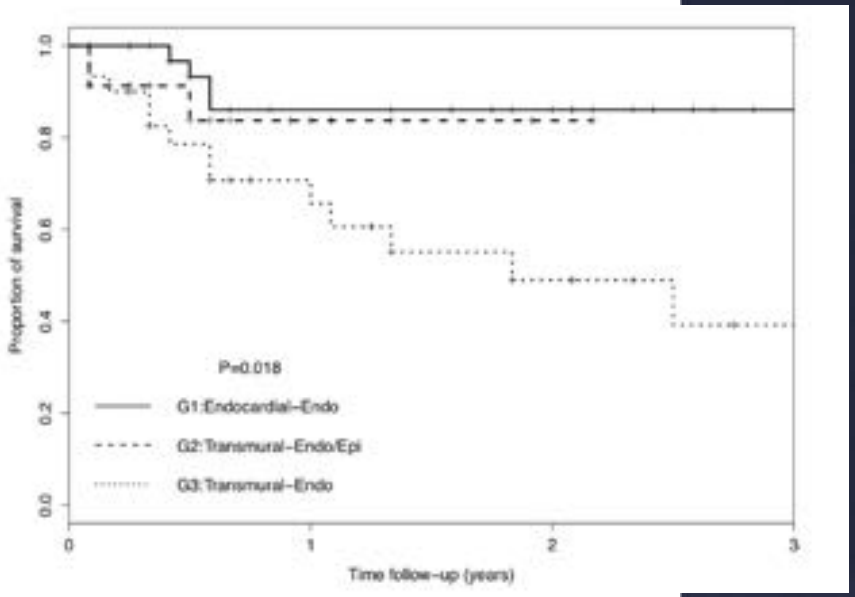
Infarct transmurality as a criterion for first-line endo-epicardial substrate–guided ventricular tachycardia ablation in ischemic cardiomyopathy

Acosta J; Heart Rhythm 2015

90 patients (92.2% men; mean age 67.4 ± 9.8 years) undergoing VT substrate ablation
IT was assessed by
contrast-enhanced MRI (LE ≥75% of the wall thickness in ≥1 segment)

Echo (dyskinesia/akinesia + hyperrefringency + wall thinning)
CT scan (wall thinning)
SPET (transmural necrosis)
"scar dechanneling" technique





No differences in acute noninducibility rate were observed between groups: 29 patients in group 1 (85.2%), 22 patients in group 2 (91.6%), and 24 patients in group 3 (75%)

Table 2 Substrate mapping data: comparison by procedure type

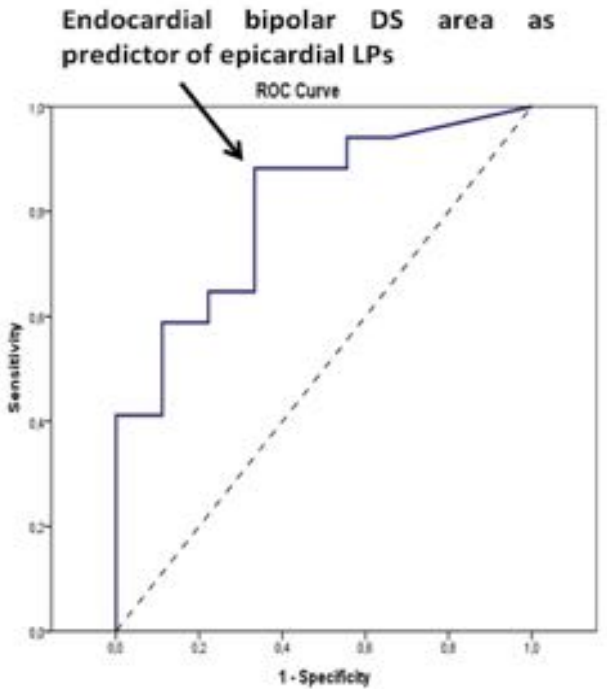
Characteristic	Group 1 (n = 34)	Group 2 (n = 24)	Group 3 (n = 32)	P
No. of points				
Endocardial	521 ± 202.9	473.5 ± 158.4	553.4 ± 205.2	.335
Epicardial	—	478.6 ± 257.5	—	NA
Scar area < 1.5 mV (cm^2)				
Endocardial	60.4 ± 33.2	63.5 ± 34.6	72.4 ± 34.1	.465
Epicardial	—	48.2 ± 31.6	—	NA
No. of E-DCs				
Endocardial	57.1 ± 31.5	73.8 ± 31.5	75.7 ± 45.3	.096
Endocardial	—	46.3 ± 25.9	—	NA
No. of RF applications				
Endocardial	23.5 ± 15.4	18.2 ± 10.8	27.6 ± 15.1	.065
Epicardial	—	7.7 ± 7.2	—	NA
Complete CC-EG elimination	32 (94.1)	20 (83.3)	25 (78.1)	.170

Clinical and mapping characteristics predicting presence of epicardial LPs

Electroanatomical Voltage and Morphology Characteristics in Post-Infarction Patients Undergoing Ventricular Tachycardia Ablation: A Pragmatic Approach Favoring Late Potentials Abolition

Tsiachiris D; Circ Arrhythm Electrophysiol. 2015

Study population: 100 pts with post-MI VT
Anterior: 36 pts,inferolateral: 64 pts
Epicardial mapping: 26 pts



➢Endocardial bipolar dense scar area **≥ 7cm2** was the best predictor of the presence of epicardial LPs

(sens: 0.88 – spec: 0.67).

➢Endocardial bipolar dense scar area **≥ 38cm2** predicted the presence of epicardial LPs with a specifity of 100%

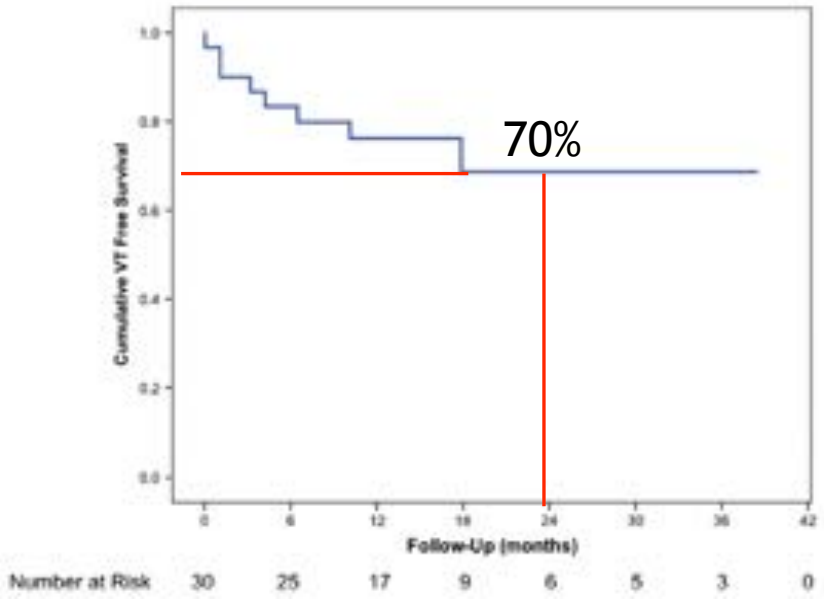
VT ablation in ARVC patients: results

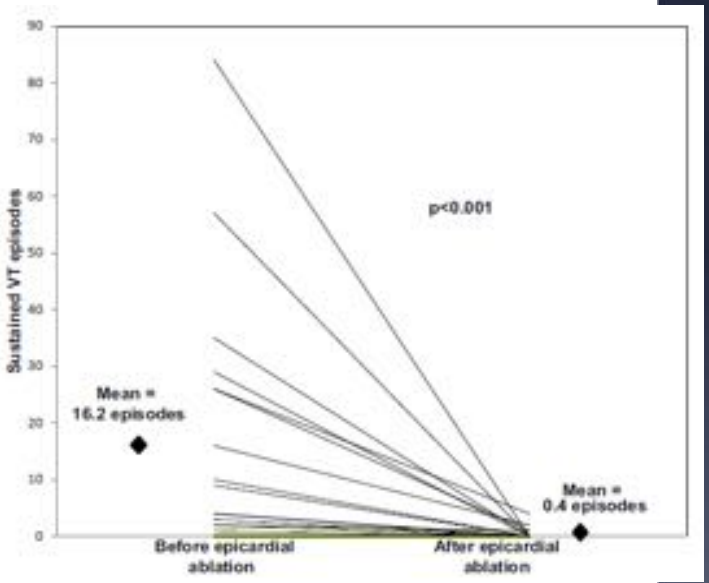
Outcomes and ventricular tachycardia recurrence characteristics after epicardial ablation of ventricular tachycardia in arrhythmogenic right ventricular dysplasia/cardiomyopathy

Philips B; Heart Rhythm 2015

Single-center study
30 ARVC pts undergoing endo-epicardial mapping
Previous endo failed ablation in 50% of pts
8 patients (27%) experienced VT recurrence (mean FU 19,7±11,7 months)

VT burden significantly decreased among all patients





Complications in epicardial VT ablation

	Pts	Minor complications	Major complications	Pericardial Effusion/ Tamponade	Death
Epicardial Ablation for Ventricular Tachycardia **A European Multicenter Study** Della Bella P. Circ Arr EP. 2011	222	7.8%	4.1%	Tamponade: 3.7%	-
Epicardial Ventricular Tachycardia Ablation **A Multicenter Safety Study** Sacher F., JACC 2010	134	RV puncture: 17% Pleural lesion 1.5%	7 %-§	Effusion 4.5%	-
Epicardial Ablation of Ventricular Tachycardia in Ischemic Heart Disease Sarkozy A., Circ Arrh Electrophysiol, 2013	56 (57 proc)		8 pts- 14%	4 Minor (<200 ml) pericardial effusion, 3 tamponade	1 fatal pulmonary embolism 2 cardiogenic shock after intraprocedure ES
Epicardial ablation of ventricular tachycardia: An institutional experience of safety and efficacy Tung R, Heart Rhythm 2013	95	3.1%	8.8%	Effusion: 6.7%	-

-§: related to epicardial approach

Complications of Epicardial Approach-OSR experience
Jan 2010- Sept 2015

345 procedures (11 failed percutaneous puncture; 5 surgical approach)

	Patients, N
In Hospital Outcome	
Abdominal Haematoma (subdiafragmatic damage)	2
Cardiac Tamponade requiring surgery	3
Cardiac Tamponade requiring drainage	2
Retroperitoneal Haematoma	1
Phrenic nerve Injury (without sequelae)	3
Coronary artery damage	0
Liver damage	1
Stroke	0
Pericarditis (anti-inflammatory agents)	20
In Hospital death (complications after surgery for tamponade)	1 (0.2%)

Major complications related to epicardial approach/ablation : 3,4%
Transient pericarditis: 5.8%

CONCLUSION

- Epicardial approach is useful and efficient in many types of non-ischemic VT etiologies and can be considered at first line ablation attempt
- Imaging provides a substantial guide to drive decision in specific settings (post-MI; IDCM)
- The whole safety profile of epicardial approach is high, provided a proper physician training and a specific operative network to deal with complications