Ventricular arrhythmia III
Ventricular tachycardia in ischemic heart disease

Paolo Della Bella
Arrhythmia Department and Clinical Electrophysiology Laboratory.
Ospedale S Raffaele - Milano
Post-MI VT ablation: limitations of activation mapping guided procedure

Non tolerated VTs in 252/405 (62%)* of cases

Multiple VT documented before ablation in 92/405 pts (22 %)*

Lack of 12 lead ECG morphology: in 99/405 (24%)*
pts only data from ICD –EGMs are available to document the occurrence of VT

Unpredictable VT inducibility at pre-ablation EP study

(*): Data from 405 patients with VT and structural heart disease treated by RFCA (2007- 2009 Centro Cardiologico, since 2010 San Raffaele Hospital – Milan)
Which procedural endpoint?

The traditional paradigm:

RF on

VT termination

VT non inducible

But....
Immediate reproducibility of an induced sustained ventricular tachycardia:
reproducibility according to VT cycle and morphology

Table 2. Differences in Rate and Morphology Between the First and Second Induced Ventricular Tachycardia (n = 104)

| Similar rate and morphology | 65 (63%) |
| Different morphology only   | 19 (18%) |
| Different rate and morphology | 13 (13%) |
| Different rate only         | 7 (7%)  |

Overall reproducibility: 104/106 patients (98%)
Reproducibility of VT inducibility is related to the induction protocol

<table>
<thead>
<tr>
<th>Response at first study</th>
<th>Response at second control study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inducible with 1 or 2 extrastimuli: 41 pts</td>
<td>Inducible: 39 (95%)</td>
</tr>
<tr>
<td>Inducible with 3 or more extrastimuli: 25 pts</td>
<td>14 (56%)</td>
</tr>
<tr>
<td>Not inducible: 11 pts</td>
<td>1 (9%)</td>
</tr>
</tbody>
</table>

Overall reproducibility: 66/77 pts (80%)
Is post-ablation VT inducibility abolition really predictive of absence of VT recurrence at long term f.u.?

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>STUDY POPULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Number of Patients: 124; mean age: 64±8 yrs)</td>
</tr>
<tr>
<td>n° Pts</td>
<td>%</td>
</tr>
<tr>
<td><strong>Prior myocardial infarction(s)</strong></td>
<td></td>
</tr>
<tr>
<td>• Anterior</td>
<td>37</td>
</tr>
<tr>
<td>• Inferior</td>
<td>68</td>
</tr>
<tr>
<td>• Multiple</td>
<td>19</td>
</tr>
<tr>
<td><strong>LV ejection fraction ≥ 30 %</strong></td>
<td>87 (68.4%)</td>
</tr>
<tr>
<td><strong>&lt; 30 %</strong></td>
<td>97 (31.6%)</td>
</tr>
<tr>
<td><strong>Mean ejection fraction</strong></td>
<td>(range 15 - 67)</td>
</tr>
<tr>
<td><strong>Number of diseased coronary arteries</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;2</td>
<td>57</td>
</tr>
<tr>
<td>&gt;=2</td>
<td>63</td>
</tr>
<tr>
<td><strong>Syncope at VT presentation</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;3</td>
<td>29</td>
</tr>
<tr>
<td>&gt;=3</td>
<td>30</td>
</tr>
<tr>
<td><strong>Uneffective AADs</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;3</td>
<td>93</td>
</tr>
<tr>
<td>&gt;=3</td>
<td>29</td>
</tr>
<tr>
<td>(range 0-5)</td>
<td></td>
</tr>
<tr>
<td><strong>Previous ventricular aneurysmectomy/freezing + peeling</strong></td>
<td>15</td>
</tr>
</tbody>
</table>

LV: left ventricular
VT: ventricular tachycardia
AAD: antiarrhythmic drugs

P. Della Bella et al, Eur Heart J, 2002
Unreliable predictive value of post-ablation VT inducibility abolition

Figure 1. Event-free survival function according to class (recurrences—including sudden death). ——— = class A: complete success; ——— = class B: partial result; •••• = class C: failure.
New targets for VT ablation

Late potentials during sinus rhythm are found in area critically involved in reentry maintainance during VT

The efficacy of the ablation may be easily assessed by remapping during sinus rhythm after ablation
Alternative means to assess substrate modifications following ablation of VT

Non contact mapping
Ultra - high density contact mapping
Electroanatomical mapping
Performing post-MI VT ablation…

First step: 12 lead ECG morphology assessment

*When available!*

It provides information on:
Reentry circuit location (Endocardium or epicardium)
VT Exit point
Second step: substrate characterization during sinus rhythm

Identification of conducting channels

Delayed activation during sinus rhythm (late potentials)

Pacemapping techniques to define functional role of any site of interest
Effect of scar voltage definition on identification of CCs.


scar definition set at 0.5 mV  
scar definition set at 0.2 mV
Third step: VT activation mapping and ablation

Activation mapping during VT (stable VT)

Mode of VT induction

Analysis of electrogram characteristics (amplitude, fragmentation, timing with respect to QRS onset) during VT

Functional assessment of any diastolic activity by pacing manoeuvres (entrainment)
<table>
<thead>
<tr>
<th>Location</th>
<th>Concealed Fusion</th>
<th>PPI-VTCL &lt;30 ms</th>
<th>S-QRS as % of VTCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance</td>
<td>Yes</td>
<td>Yes</td>
<td>&gt;70%</td>
</tr>
<tr>
<td>Central Isthmus</td>
<td>Yes</td>
<td>Yes</td>
<td>30% - 70%</td>
</tr>
<tr>
<td>Exit</td>
<td>Yes</td>
<td>Yes</td>
<td>&lt;30%</td>
</tr>
<tr>
<td>Outer Loop</td>
<td>No</td>
<td>Yes</td>
<td>Variable</td>
</tr>
</tbody>
</table>

PPI: post-pacing interval; VTCL: ventricular tachycardia cycle length

Anatomic characterization of endocardial substrate for hemodynamically stable reentrant ventricular tachycardia: Identification of endocardial conducting channels

Henry H. Hsia, MD, David Lin, MD, William H. Sauer, MD, David J. Callans, MD, Francis E. Marchlinski, MD
When to perform epicardial ablation in post-MI VT ablation

- Failure of a previous endocardial procedure
- VT morphology suggesting epicardial circuit
- LV thrombus
- Results of activation mapping suggesting epicardial reentry (“pseudo-focal” VT)
MDI: interval from the earliest ventricular activation to the peak of the largest amplitude deflection in each precordial lead (taking the shortest time) divided by the QRS duration

Pseudo-delta: interval from the earliest ventricular activation to the onset of the earliest fast deflection in any precordial lead

ECG Criteria to Identify Epicardial Ventricular Tachycardia in Nonischemic Cardiomyopathy
Ermengol Vallès, Victor Bazán and Francis E. Marchlinski
Circ Arrhythm Electrophysiol 2010;3;63-71; originally published online Dec 11, 2009;
How to perform post-MI VT ablation? Clinical case - 1

- P.U. male, 71 yrs
  Previous inferoposterolateral MI and severe LV dysfunction (EF: 25%). Two-vessel coronary artery disease (Previous PTCA and stent on LAD artery)

Dual chamber ICD implantation (2006).

2011, january: Referred from another Institution for refractory paroxysmal VT causing arrhythmic storm
Clinical case I: post MI VT ablation
First step: VT morphology evaluation

A) Apical inferoseptal
B) Basal inferoseptal
C) Basal inferolateral
D) None correct

Q1
Clinical case I - Second step
scar characterization: voltage maps – endocardium

Identification of scar border and transition zone (1.5-0.5 mV)

Discrimination of channels and dense scar by high density voltage mapping (0.5-0.1 mV)
Second step
scar characterization: map of late potentials endocardium

Suggest the site of recording of this EGM
Second step

**scar characterization: map of late potentials endocardium**

Late potential map: strict correlation between LP and dense scar distribution
Pacemapping and VT induction
VT is induced by pacing-from:
The S-QRS and QRS morphology analysis and the timing of the EGM recorded by mapping catheter suggest:

A) Exit site
B) Outer loop (near entrance) site
C) Proximal loop site
The timing of recording during VT from LV mapping catheter (arrow) and RV apex (RVa d) suggest:

A) VT Exit site is inferoseptal
B) VT exit is lateral
C) VT exit is in the right ventricle

Q4
Diastolic potential during activation mapping. Suggest the location
Same Diastolic potential. Late potential map during sinus rhythm. Suggest the correct location
Slowing and termination during RF – late potential at ablation site during SR
Final Endpoint:

substrate modification (complete abolition of late potentials)

No VT inducible
Clinical case - 2

- B.F. male, 75 yrs

2010, august: Referred from another Institution for refractory incessant VT causing hemodynamic decompensation (NYHA 3)
Based on 12 lead VT ECG morphology, where do you believe the exit point may be located?

Q7

a) LV apex

b) LV basal (perimitral) anterior wall

c) RV inflow

d) None correct
Which of these considerations regarding VT circuit location is correct?

a) Absence of Q wave in D1 suggest endocardial location
b) MDI is borderline for epicardial location
c) MDI suggests endocardial location
d) ECG is unconclusive
e) a+c correct
f) None correct
Electroanatomic LV Bipolar voltage map
Two different sites during activation mapping
A) Site 1: proximal; site 2: bystander
B) Site 1: bystander, site 2: exit
C) Site 1: proximal, site 2: outer
D) Site 1: bystander, site 2: outer
E) Site 1: proximal, site 2: exit
F) None correct
Clinical case - 3

Male. 62 years.
- Previous Anterior MI that evolved in LV aneurysm and moderate LV dysfunction (FE: 40%).
- Previous ICD implant for refractory smVTs.
- Iterative ICD shocks caused by sustained tolerated VT.
- 2 previous ineffective conventional RFCA attempt.
Circuit location from 12 lead ECG:

A) Endocardium  
B) Epicardium  
C) Unconclusive
Activation mapping

Recording during VT from LV endocardium (green) and from 2 multipolar catheters in anterior interventricular (red) and anterolateral (violet) ventricular branches of CS are shown. Comment as true or false these considerations:

A) clear diastolic activity (1) suggest epicardial anterolateral or anterior location

B) No clear diastolic activity in CS catheters is found, but the activation on epicardial catheters preceeds the earliest endocardial activation, thus suggesting epicardial circuit

C) The VT is probably intramyocardial

Q11
Activation mapping

A) clear diastolic activity (1) suggest epicardial anterolateral or anterior location: **False**

B) No clear diastolic activity in CS catheters is found, but the activation on epicardial catheters precedes the earliest endocardial activation, thus suggesting epicardial circuit **True**

C) The VT is probably intramyocardial: **False**.
The 12 leads ECG traces during Entrainment from epicardial (2) and endocardial (1) site

A Concealed entrainment from endocardium is demonstrated

B Both sites of entrainment are suitable for ablation

C Epicardial location of circuit is demonstrated

Q12
Surface and intracavitary recording of S-QRS and return cycle after epicardial entrainment suggest:

A  Outer loop site
B  Exit site
C  Bystander site
D  Entrance site
Epicardial ablation site

-107 ms

Epicardial ablation site
VT termination
Clinical case - 4

• P.L., 65 years old

• Previous infero-posterior myocardial infarction with residual moderate LV dysfunction (EF = 38%)

• Previous surgical revascularization and Dual Chamber ICD implantation after spontaneous VT occurrence

• Amiodarone withdrawal after one year of therapy because of thyroid side effect

• Referred to catheter ablation because of excessive ICD therapy on VT
The LAT map:
Surface ECG recording of VT morphology.

Identification of exit site:

A) Endocardium, mid-posterolateral
B) Epicardium, inferobasal
C) Septal
LV Scar activation pattern recorded by the same high density catheter during an induced VT. The timing of diastolic activity recorded suggest...

A) The whole activation of critical istmus can be recognized  
B) only partial activation of the isthmus can be mapped  
C) The mapping result is consistent with epicardial circuit  
D) A Bystander site can be identified in some electrodes  
E) A+D
Clinical case - 5

Multiple unmappable VT morphologies

B. C., male, 70 yrs

Previous anterior MI; severe LV disfunction (EF: 38%).

Dual chamber ICD.

Frequent VT episodes causing excessive ICD therapy.
VT induction by pacing from a...
A) entrance site
B) Central Isthmus site
C) Exit site
D) Outer loop site

VT morphology suggest:
A) Apical anterior
B) Apical Inferior
C) Basal

Q16
VT c.l.: 340 ms

Q17
This electrogram is most probably recorded in:

A) Site 1
B) Site 2
C) Site 3
VT morphology changes during RF delivery
Multiple unmappable (unstable or untolerated) VT possible strategy: endo-epicardial substrate modification by late potentials ablation

Epicardial voltage and LP map
Abolition of late potential at remapping after RF
No further VT induction after late potential ablation
The correlation between late potentials during sinus rhythm and VT circuit:

Evidence from non contact mapping

G. C., male, 61 yrs

Previous inferoposterior MI and ACBPG; severe LV disfunction (EF: 32%). Long-standing antiarrhythmic therapy with amiodarone.

ICD implantation after E.R. admission for sustained VT causing hemodynamic derangement.

Frequent VT episodes both self-terminating and requiring ATP.
Clinical untreated VT 12 lead ECG
Voltage map (Peak negative Value of local virtual unipolar EGM) by DSM during sinus rhythm: abnormal substrate demonstrated at inferoposterior mid-basal LV corresponding to scarred tissue.
Propagation of activation wave during sinus rhythm: lines of segmental block of propagation at lateral and septal borders of the infarct are shown. White arrow and white line: slow and delayed spreading of activation wave within the scar. Orange arrows: Low amplitude and late potentials within the scar recorded by ablation catheter (not shown) facing virtual EGM 13
Propagation analysis during VT: diastolic pathway entering scar near lateral border; exit on posterior basal border.
Propagation analysis – Pacemapping from near-entrance site: complete overlap with VT diastolic pathway
RF linear ablation on the diastolic pathway
Propagation of activation wave during sinus rhythm after ablation: same HP filter setting (2Hz), vEGMs location and timing. Modification of propagation after ablation: no late spreading of activation is detectable at vEGM 11 to 13, corresponding to VT channel.
“Pseudofocal” VT: an example

- N. S., male, 62 y.o.
- CAD, EF 44% (1995, inferior myocardial infarction)
- 2000: PTCA on circumflex artery and ICD implantation due to recurrent episodes of Ventricular Tachycardia
- April 2009: Electrical Storm (multiple ICD shocks on LBBB inferior axes VT)
VT 12 lead ECG

Virtual unipolar maximum amplitude map – sinus rhythm-
VT Propagation: exit point and 20 ms of diastolic pathway at basal inferoposterior MI.
Epicardial mapping

Pacemapping suggesting near entrance site followed by VT induction
Endocardial ablation site

Epi

-180 ms

Endo

-30 ms

Epicardial ablation site

Endocardial ablation site