Mid-Myocardial Septal Substrate for Ventricular Tachycardia in Nonischemic Cardiomyopathy

Haris M. Haqqani

MBBS(Hons) PhD FRACP FCSANZ FHRS FACC

Associate Professor of Medicine, The University of Queensland
Senior Consultant Electrophysiologist, The Prince Charles Hospital
Brisbane, Australia
Disclosures

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<table>
<thead>
<tr>
<th>Company Name</th>
<th>Relationship</th>
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<tbody>
<tr>
<td>Biosense Webster</td>
<td>Research grant</td>
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<td></td>
<td>Speaking honoraria</td>
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<tr>
<td>Boston Scientific</td>
<td>Scientific advisory board</td>
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<td>Abbott</td>
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</table>
Usual pattern of macroscopic basolateral endocardial scar in NICM

Bipolar LV Voltage Map

Hsia, Marchlinski Circ 2003

Waller et. al. AJC 1998

Soejima, Stevenson JACC 2004
Pathologic correlation

Periannular Low Voltage Area

LV

RV

Periannular Endocardial Scarring

LV

RV

Mitral annulus

Tricuspid annulus

>1.5 mV

<0.5 mV

Courtesy of Dr Marchlinski

KHRS Scientific Sessions 2018, Seoul

8 June 2018
Epicardial substrate in NICM

Basal lateral (56.7 ± 33.1 cm²) confluent EPI scar (< 1.0mV) away from coronaries

Versus 22.9 ± 32.4 cm² ENDO scar

Electrogram Characteristics

- Wide Egms > 80ms - 27.5%
- Split Egms – 33.0%
- Late Potentials – 25.8%
- Wide, Split or Late - 50%

Cano, Marchlinski et al JACC 2009
What about NICM patients who don’t have this typical pattern of basolateral involvement?
266 consecutive UPenn NICM* pts with SMVT undergoing VT ablation (1999 to 2010)

31/266 (11.3%) patients had isolated septal substrate on EAM and/or imaging with no lateral wall involvement

*Excluded secondary causes of NICM including sarcoid, VHD, ACHD, HCM, EtOH, TMC etc.
<table>
<thead>
<tr>
<th><strong>Baseline characteristics</strong></th>
<th><strong>n = 31</strong></th>
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<tbody>
<tr>
<td>Age</td>
<td>59 ± 12 years</td>
</tr>
<tr>
<td>Males</td>
<td>26 (84%)</td>
</tr>
<tr>
<td>LV ejection fraction</td>
<td>30 ± 14%</td>
</tr>
<tr>
<td>LV EDD</td>
<td>62 ± 11 mm</td>
</tr>
<tr>
<td>Amiodarone use</td>
<td>24 (77%)</td>
</tr>
<tr>
<td>LBBB</td>
<td>10 (32%)</td>
</tr>
<tr>
<td>Complete AV block</td>
<td>8 (26%)</td>
</tr>
<tr>
<td>RV / BiV pacing</td>
<td>6 (19%) / 6 (19%)</td>
</tr>
<tr>
<td>ICD in situ</td>
<td>26 (84%)</td>
</tr>
<tr>
<td>Prior procedures</td>
<td>10 (32%) – 1.7</td>
</tr>
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</table>
### Endocardial Mapping

<table>
<thead>
<tr>
<th></th>
<th>n = 31</th>
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</thead>
<tbody>
<tr>
<td>LV endocardial points</td>
<td>305 ± 121</td>
</tr>
<tr>
<td>Septal bipolar voltage &lt;1.5mV</td>
<td>22/31 (71%)*</td>
</tr>
<tr>
<td>LV area of bipolar low voltage</td>
<td>63 ± 41cm²</td>
</tr>
<tr>
<td>Prop. of LV with low Bi voltage</td>
<td>26 ± 13%</td>
</tr>
<tr>
<td>RV mapping performed</td>
<td>17 (57%)</td>
</tr>
<tr>
<td>RV endocardial points</td>
<td>188 ± 130</td>
</tr>
<tr>
<td>RV area of bipolar low voltage</td>
<td>23 ± 27cm²</td>
</tr>
<tr>
<td>Proportion of RV with low voltage</td>
<td>14 ± 16%</td>
</tr>
</tbody>
</table>

*Of the 9 patients with normal bipolar voltage, all had extensive septal areas of low unipolar voltage (<8.3mV) with lateral wall spared in all (80 ± 36cm² or 40 ± 16% of LV surface area)
Epicardial mapping performed in 14 (45%) patients had a normal epicardial substrate map. 5 patients had patchy fractionation at LV summit.

CMR performed in 9 patients (29%) [ICDs] had 8 patients had septal DGE.

Haqqani, Marchlinski et. al. HRJ 2011
33 yo man with NICM, SMVT and LVEF 40%
<table>
<thead>
<tr>
<th>VT characteristics</th>
<th>n = 151</th>
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<tbody>
<tr>
<td>Cycle length</td>
<td>396 ± 90ms</td>
</tr>
<tr>
<td>VT QRS duration</td>
<td>186 ± 34ms</td>
</tr>
<tr>
<td>Mappable VTs</td>
<td>54 (36%)</td>
</tr>
<tr>
<td>LBBB configuration</td>
<td>57 (38%)</td>
</tr>
<tr>
<td>Inferior limb lead discordance</td>
<td>24 (16%)</td>
</tr>
<tr>
<td>$V_2$ transition pattern break</td>
<td>26 (17%)</td>
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</table>
Precordial transition ‘pattern break’

Adapted from Haqqani et. al. *JCE* 2009

8 June 2018
Outcomes of Catheter Ablation of Idiopathic Outflow Tract Ventricular Arrhythmias With an R Wave Pattern Break in Lead V2: A Distinct Clinical Entity

Hayashi et al. JCE 2017
VT ablation results | n = 50
--- | ---
Acute success | 33 (66%)  
Partial success | 10 (20%)  
Failure | 7 (14%)  
Complete AV block | 5 (10%)*  
New LBBB | 2 (4%)  

* Including during septal transcoronary ethanol ablation in 1

Complications | n = 50
--- | ---
LAD spasm | 1  
Pericardial bleeding during epicardial access | 1  
Cardiogenic shock | 1

Late outcomes | n = 31
--- | ---
Median follow up | 12 mo  
VT recurrence | 10 (32%)  
Death | 8 (26%)  
Heart transplant | 5 (16%)
Characterization of Trans-septal Activation During Septal Pacing

Criteria for Identification of Intramural Ventricular Tachycardia Substrate in Nonischemic Cardiomyopathy

Gp 1: n=14 with no septal scar
Gp 2: n=26 with septal scar

Betensky et. al. Circ AE 2013
UNI VOLT

LV ACT

Control

NICM

RAO

RAO

RV pacing catheter (stationary)

LV mapping catheter (roving)

“DIRECT”

“DISRUPTED”

Betensky et. al. Circ AE 2013
Catheter Ablation of Ventricular Arrhythmia in Nonischemic Cardiomyopathy
Anteroseptal Versus Inferolateral Scar Sub-Types

87 idiopathic NICM patients with SMVT undergoing VT RFA

44 patients had predominant anteroseptal unipolar scar distribution

43 patients had predominant inferolateral unipolar scar distribution

- AS substrate patients had more endocardial unipolar low voltage (41 vs 9cm²)
- Left inferior axis VT predicted AS substrate (PPV=100%)
- Right superior axis VT predicted IL substrate (PPV=89%)

Oloriz et. al. Circ AE 2014
Catheter Ablation of Ventricular Arrhythmia in Nonischemic Cardiomyopathy
Anteroseptal Versus Inferolateral Scar Sub-Types

Oloriz et. al. Circ AE 2014
SR ECG features of AS vs. IL substrate
Clear association with outcome

Oloriz et al. Circ A&E 2014
Non-idiopathic NICM case

- 35yo man
- short history of palpitations, cough, dyspnea and syncope secondary to VT
- ECG: SR with normal conduction
- LVEF 35%; normal coronary angiogram
- bilateral perihilar and mediastinal adenopathy
- PET: extensive RV and septal FDG uptake consistent with sarcoidosis
- i/o dcICD and Rx glucocorticoids and HF therapy
- represented with ongoing appropriate ICD shocks for MMVT despite treatment with amiodarone and mexilite
VT 2: clinical VT

Right Ventricle

Left lateral projection

Entrance site: ECF; PPI=TCL; long S-QRS = egm-QRS

Exit site: ECF; PPI=TCL; short S-QRS = egm-QRS
Termination in 9 seconds with RF
Extensive substrate ablation for other unmappable morphologies

…but still inducible for 2 nonclinical VTs at case end
n=21 patients with cardiac sarcoid and VT catheter ablation

Ventricular Tachycardia in Cardiac Sarcoidosis
Characterization of Ventricular Substrate and Outcomes of Catheter Ablation

Kumar et al. Circ AE 2015
Multicenter Experience With Catheter Ablation for Ventricular Tachycardia in Lamin A/C Cardiomyopathy

n=25 patients with cardiac LMNA and VT catheter ablation

Kumar et al. Circ AE 2016
Clinical disease presentation and ECG characteristics of LMNA mutation carriers

![Graph showing survival analysis with different groups: LMNA mutation, DCM control, LMNA mutation-censored, and DCM control-censored. The log-rank test p-value is 0.005.]

<table>
<thead>
<tr>
<th>No. at Risk</th>
<th>Age (years)</th>
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<tbody>
<tr>
<td>LMNA mutation carrier</td>
<td>27</td>
</tr>
<tr>
<td>DCM control</td>
<td>78</td>
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![ECG images showing different waveforms labeled A to E.]

![Images of heart with RV and LV labels.]

Ollila et. al. *Open Heart* 2017
Clear association with outcome
Conclusions

• Basal septal substrate represents an important pattern of involvement in NICM and frequently has a substantial intramural component
• Bipolar endo-epicardial voltage mapping may be entirely normal in these patients
• NICM septal substrate may affect the sinus rhythm ECG with a high prevalence of conduction system disease and leads to characteristic septal VT morphologies
• Multimodality imaging is an important diagnostic modality for defining septal involvement
• This group of patients has a worse prognosis than the basolateral group and ablation is challenging