Ablation Strategy for VT Storm in Patients with Non-Ischemic Cardiomyopathy

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Agenda

Reversible cause
Hemodynamic status
Role of VT ablation in electrical storm
Trigger PVC in NICM
Substrate characteristics
  – patchy, scattered, epicardial/intramural
Challenging cases
Reversible causes

Electrolytes
Drug.....TdP
Transient aggravation of CHF
Infection, Fever,
Acute ischemia
Hyperthyroidism
65/F, Kim MS

Adrenal insufficiency
Steroid-induced DM
Idiopathic dilated CM (EF 42%)
Sick sinus syndrome, AT and paroxysmal AF
  frequent VPC, NSVT
Pulseless VT (RBBB pattern VT, documented)
  => CPR survivor, s/p ICD insertion (2013.7.18)

At OPD, pAF into peAF – warfarin and VVIR
2014.5.30 VT storm (270 appropriate shock)
Battery depletion (ERI)
V pacing ---- caused aggravation of CHF triggered sustained VT/VF
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Hemodynamic status

BP drop with VT/VF induction
- Difficult activation/entrainment mapping
- Poor organ perfusion–ischemic brain/kidney injury
  multi-organ failure

ECMO, LVAD – team approach
  (HF/EP/surgeon)

Insurance coverage in Korea?
M/49 W S.H.

2012. Dx w ARVD – ICD

first shock during running

only infrequent shocks.
Sustained VT with hemodynamic compromise for the past several days.

Adm at other hospital -- Amiodarone loading was not effective.

ATP was not effective, degenerated VT intoVF.

Terminated only by shock, VT every 5 min.
First session (2017.4/28): Pace-mapping and RF ablation
4/28 2AM-7AM, first RF

4/28 1PM  recurrent VT

continued amiodarone loading
Lidocaine, added

4/29 3PM, second RF

“VT, more hemodyn stable !!! “

Extensive, dense scars in the epi. Activation was later than in the epi.
Activation mapping for the 4 VTs showed earliest activation site at the apex, RVOT and RV anterior area. There was associated mid-diastolic potentials on the free wall/apical scar area. Ablation at the earliest activation, and adjacent areas with diastolic potentials successfully suppressed induction of VTs.
Prophylactic use of percutaneous LVAD in high-risk pts undergoing RFCA of scar-related VT

PAINESD risk score

Incorporating clinical/procedural variables may help identify patients at high risk of peri-procedural acute HD decompensation who may benefit from prophylactic LVAD - **COPD**, age>60y.o, Ischemic CM, **NYHA III/IV**, EF<25%, **VT storm**, Diabetes
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Challenging cases
Long-Term Outcome after Catheter Ablation of VT in Patients with Non-ischemic DCM

282 pt with nonischemic D-CM who underwent CA

Circ Arrhythm Electrophysiol. 2016;9:e004328
Outcome after RFCA of Electrical storm

267 consecutive patients with
- NIDCM (n = 71)
- ICM (n = 196)

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Challenging cases
Successful Catheter Ablation of Focal VF in a Pt with Nonischemic DCM

A 64-year-old man with known DCM and a biventricular ICD presented to our institution with multiple ICD shocks due to VF. Interrogation of his ICD revealed **10 episodes of VF, nine terminated with 30-J shocks** and one terminated spontaneously. Activation mapping demonstrated the origin of the PVC to be **near the LVOT** toward the mitral valve ring.

*PACE 2011; 34:e38–342*
Catheter Ablation of Freq. Recurring VF after AV Repair

Recurrent VF was observed in a 17-year-old pt after AV repair. Recurrent VF with a maximum of 14 external defibrillations over a 24 Hr. At EP study, frequent short runs of VF initiated by VPB originating from anteroseptal and inferoseptal areas of the LV. VPBs were preceded by distinct Purkinje potentials preceding QRS by 68 ms and 30 ms, respectively.
Catheter Ablation of VF Storm in Pts w Infiltrative Amyloidosis

Two patients with repetitive VF associated with cardiac amyloidosis. VF, preceded by monomorphic PVCs, with the earliest activation localized within the LV (LPF) in the absence of significant scar tissue.

(J Cardiovasc Electrophysiol, 17-426, 2006)
## Trigger PVCs in non-ischemic CM

<table>
<thead>
<tr>
<th>Author</th>
<th>Dx</th>
<th>PLP-QRS</th>
<th>Earliest activation</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLCOHOVA</td>
<td>Amyloidosis (2 cases)</td>
<td>-68m</td>
<td>Apical inferolateral prox. LPV</td>
<td><em>JCE</em> 2006; 17:426</td>
</tr>
<tr>
<td>KIRUBAKARAN</td>
<td>DCM (1 case)</td>
<td></td>
<td>LVOT near the MV ring</td>
<td><em>PACE</em> 2011; 34:e38</td>
</tr>
<tr>
<td>Li</td>
<td>AVR (1 case)</td>
<td>-68ms</td>
<td>LV, anteroseptal</td>
<td><em>JCE</em> 2004, 15:90,</td>
</tr>
<tr>
<td>Sinha</td>
<td>DCM (4 cases)</td>
<td>-15 to -42ms</td>
<td>Posteroseptal (1) Posterolateral (3)</td>
<td><em>PACE</em> 2009; 32:286</td>
</tr>
</tbody>
</table>

Trigger PVCs from Purkinje fibers may be important not only in IVF/BS/LQTS, ischemic CM (or acute ischemia), but also in patients with non-ischemic CM.
Limitation of Trigger PVCs ablation

Available data - HPS trigger, near scar border zone

However,

- VF occurrence, infrequent, unpredictable
- PVC easily degenerates into unstable VT, VF
- Trigger PVC ablation may not be sufficient
- Late recurrence
Reversible cause
Hemodynamic status
Role of VT ablation in electrical storm
Trigger PVC in NICM
Substrate characteristics in NICM
  – patchy, scattered, epicardial/intramural
Challenging cases
# Characteristics of Scars: Ischemic vs. Non-ischemic DCM

<table>
<thead>
<tr>
<th></th>
<th>Ischemic CM</th>
<th>Non-ischemic CM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>Larger</td>
<td>Patchy, Scattered, Smaller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heterogenous</td>
</tr>
<tr>
<td><strong>Predilection</strong></td>
<td>Near coronary</td>
<td>Near annulus</td>
</tr>
<tr>
<td><strong>Epi, vs endo</strong></td>
<td>Endo-</td>
<td>Both epi, endo</td>
</tr>
<tr>
<td><strong>Mid-myocardial</strong></td>
<td>Less frequent</td>
<td>Frequent</td>
</tr>
<tr>
<td><strong>Transmural</strong></td>
<td>Frequent</td>
<td>Less frequent</td>
</tr>
<tr>
<td><strong>Recurrence</strong></td>
<td>30-40%</td>
<td>50-60%</td>
</tr>
</tbody>
</table>

_Circulation_. 2005 112(18): 2821–2825
Outcome after RFCA of Electrical storm: ICM vs NICM

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hazard Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiomyopathy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICM</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>NICM</td>
<td>1.534 (1.081-2.178)</td>
<td>0.017</td>
</tr>
<tr>
<td>HTN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0.723 (0.503-1.037)</td>
<td>0.078</td>
</tr>
<tr>
<td>PES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical VTs inducible</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Nonclinical VTs inducible</td>
<td>0.252 (0.140-0.453)</td>
<td>0.000</td>
</tr>
<tr>
<td>No inducible VTs</td>
<td>0.231 (0.138-0.386)</td>
<td>0.000</td>
</tr>
<tr>
<td>Not tested</td>
<td>0.533 (0.271-1.048)</td>
<td>0.068</td>
</tr>
<tr>
<td>LVEF</td>
<td>0.977 (0.964-0.991)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Heart Rhythm 2018;15:48–55

Table 5  Odds of a recurrence of ventricular arrhythmia and death after ablation in relation to underlying heart disease

<table>
<thead>
<tr>
<th>Disease group comparison</th>
<th>Death</th>
<th>Recurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds ratio (95% CI)</td>
<td>P-value</td>
</tr>
<tr>
<td>ICM vs. DCM</td>
<td>0.51 (0.22–1.22)</td>
<td>0.13</td>
</tr>
<tr>
<td>ICM vs. ARVD + others</td>
<td>0.69 (0.24–2.01)</td>
<td>0.50</td>
</tr>
<tr>
<td>DCM vs. ARVD + others</td>
<td>1.36 (0.43–4.2)</td>
<td>0.60</td>
</tr>
</tbody>
</table>

ICM, ischaemic cardiomyopathy; DCM, dilated cardiomyopathy; ARVD, arrhythmogenic right ventricular dysplasia; CI, confidence interval.

Conducting Channels Using Contrast-Enhanced MRI in Patients with Chronic MI
Impact of Electrode Type on Mapping of Scar-Related VT

Heart Rhythm 2015;12:1927–1934

J Cardiovasc Electrophysiol, Vol. 26, pp. 1213
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.
When LAVAs < 1 cm from PN on MDCT, PN capture was confirmed by pacing with 25 mA.
If it failed to eliminate epicardial LAVAs, 100 to 300 mL saline in the pericardium.
When LAVAs were < 5 mm from the Cas, a coronary angiography was performed.
His-Purkinje-related Tachycardias

Bundle branch reentry
Inter-fascicular reentry
His-Purkinje related VT
Systematic Tx Approach to VT in Cardiac Sarcoidosis

37 consecutive patients with sustained VT
37 w AAD, and 34 w steroid therapy.
During a 39-month F/U, 23 (62%) pts free from VT w med Rx.
14 patients - RFCA
EPS - mechanisms of VTs classified into 2 subgroups
  : Purkinje-related (5pts) or scar-related VT (10pts)

EPS of Purkinje-Related VTs
The Purkinje system was involved in 6 VTs.
Origin of the 6 Purkinje-related VTs
  : LAF (2), LPF (2), RBB (2).
Mechanism of VTs
  : BBR (1), micro–Re (3), non–Re (2) VTs.

Circ Arrhythm Electrophysiol. 2014;7:407-413
Challenging cases: new methods

Intramural or deep substrate
- bipolar RF
- trans-coronary, trans-venous ethanol
- infusion needle ablation

Separation of CA or epi fat
- surgical access and cryo-ablation, epi window

Neuraxial modulation
- Thoracic Epidural Anesthesia
- LSG Blockade
- Surgical Cardiac Sympathetic Denervation
- Renal Sympathetic Denervation

Non-invasive Cardiac Radiation Therapy
Coronary targets for transcoronary ethanol ablation

Surgical cryoablation targets

Circ Arrhythm Electrophysiol. 2015;8:606-615
Noninvasive Cardiac Radiation for Ablation of VT
stereotactic body radiation therapy (SBRT)

Failed AAD/RFCA
Contralx to catheter placement
Too Frail

CT or MRI
ECGI
volumetric target
- the first 10 msec of VT
25 Gy in a single fraction
Conclusions

1. Electrical storm – correctable cause/HD support

2. Substrate in NICM – patchy, scattered, heterogenous, diverse
   (deep, epicardial, near PhN or CA)

3. RFCA – Refined (imaging/mapping)

4. Challenging cases
   new tool-bipolar/needle ablation, trans-coron ethanol, surgcial cryoablation/epicardial window stereotactetic body RT
Role of LV Scar and Purkinje-Like Potentials During Mapping and Ablation of VF in D-CM

PACE 2009; 32:286–290
Retrograde Coronary Venous Ethanol Infusion for Refractory VT

Trans-coronary ethanol ablation

Circ Arrhythm Electrophysiol. 2016;9:e004352

Circ Arrhythm Electrophysiol. 2017;10:e003676
Surgical cryoablation for refractory VT in patients with non-ischemic cardiomyopathy

Typically through a **midline sternotomy**, or via partial lower sternotomy, and CP bypass. In select cases, endocardial exposure through the AoV via an aortotomy above the S of Valsalva or through the LV apex in patients undergoing LVAD placement. No additional EP mapping was performed during the surgical procedure. Cryothermy, applied to the targets (**prev RF lesions/3D map, visible scars, VT exit on ECG**). Typical cryo applications extended for 3 min (including the thawing phase), achieving a minimum temperature of -150 C.
Surgical cryoablation in a pt with prominent epicardial fat prohibiting effective RF ablation

M/59 with non-ischemic CM (EF 45-50%)
Substrate mapping: normal endocardial bipolar RV voltage
Extensive RV free wall scar extending from base to apex.
Substrate modification (x2) failed.

Mapping in the OR revealed prominent epicardial fat.

Epicardial fat was divided and dissected down to the myocardial surface parallel to the acute marginal (AM) branch of the RCA.

Cryoablation lesions were delivered to the basal segment of the RV 2cm above the AM, rendering the VT noninducible.

Circ Arrhythm Electrophysiol. 2015;8:606-615
Rescue procedure for an electrical storm using robotic non-invasive cardiac radio-ablation: case report

A 75-year-old man, w severe DCM since 2009, (ICD in 2013) - ICU d/t ES
Previous RF ablation in December 2015, (a first ES due to VT from IVS)
MRI in 2013 – Gd enhancement (posterior-anterior segment of the basal IVS)
4 VTs – 2 successfully treated by CA, 2 recurred within minutes.
Because of severe hypotension during VT, RFCA was stopped after 4 h of attempt.
During the following days, the ES remained uncontrolled with multiple ICD shocks requiring general anesthesia and intubation. (LVEF from 30% to 15% after the ES)
Organs at risk (lungs, esophagus, stomach, and coronary a) were delineated.
The whole treatment was catheter-free, and the right ventricular ICD lead was used as fiducial marker for real time tracking.

25 Gy, delivered to the VT substrate (volume of 21 cc) in a single 45-min procedure.
No ICD shocks since SBRT, --extubated 3 days after SBRT. --discharged after 2 mon.
The LVEF returned to its 30% baseline value.
M/49 W S.H. with ARVC

Importance of hemodynamic stability during ablation

Extensive (predominant) involvement of epicardium in ARVC – threshold for epicardial access should be low in NICM

Patchy, scattered scar characteristics
- Multi-electrode mapping catheters
- Use of imaging studies (MRI, CT)