Mapping and Ablation of VT in Arrhythmogenic Right Ventricular Dysplasia Patients

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Case: ARVC RV-VT
**Electrophysiology**

<table>
<thead>
<tr>
<th>RVOT-T</th>
<th>Task Force (-) N=98, 78.4%</th>
<th>Task Force (+) N=27, 21.6%</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catheter mapping</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>RV ERP (msec)</td>
<td>215 ± 22</td>
<td>238 ± 32</td>
<td>0.016</td>
</tr>
<tr>
<td>Inducible sustained VT</td>
<td>24%</td>
<td>59%</td>
<td>0.001</td>
</tr>
<tr>
<td>Requirement of isoproterenol infusion</td>
<td>53%</td>
<td>26%</td>
<td>0.016</td>
</tr>
<tr>
<td>Tachycardia cycle length (msec)</td>
<td>315 ± 67</td>
<td>277 ± 94</td>
<td>0.109</td>
</tr>
<tr>
<td><strong>3D mapping</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scar in the RVOT (voltage &lt;0.5 mV)</td>
<td>37%</td>
<td>57%</td>
<td>0.416</td>
</tr>
<tr>
<td>Scar in the RV body</td>
<td>47%</td>
<td>57%</td>
<td>0.697</td>
</tr>
<tr>
<td>Total RV conduction time (msec)</td>
<td>129 ± 46</td>
<td>222 ± 77</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Chen SA et al. 2010 HRS abstract**
Arrhythmogenic RV Dysplasia

- **Histology:** RV muscle becomes replaced by adipose and fibrous tissue.
- **Arrhythmia:** Re-entrant Type (scarring & late Potentials) with LBBB type ECG;
- **ECG:** Diffuse T wave inversion over precordial leads, and Epsilon Wave.
- **Ablation:** The effect of catheter ablation is temporizing, implanted cardioverter defibrillator (ICD) is the only reliable therapy for sudden cardiac death.
- **Clinical diagnosis was based on 1994 Task Force Criteria, and modified 2010 Task Force Criteria.**
All patients were diagnosed with ARVC on the basis of the modified criteria for diagnosis of arrhythmogenic right ventricular cardiomyopathy/dysplasia proposed by an international working group.

All patients (100%) received 12-lead resting ECG, 24-h Holter, 2D echocardiography, left ventricle and right ventricle angiography, coronary arteriography, and electrophysiological (EP) study, and a subset of patients (83%) received magnetic resonance imaging (MRI).
Methods- Follow-Up

- Endpoint of follow-up was rapid VT/VF and cardiovascular mortality.
- All patients received national based mortality survey of Taiwan health bureau. No patients lost follow-up.
Surface ECG, Averaged ECG, and PCA
Illustration of VectoCardioGraphy

Chang et al. HRS 2012 Abstract
Angle between each consecutive precordial leads is wider in 3 dimensional plain in ARVC/D patient
Example of RVOT-VT

Angle between each consecutive precordial leads is narrower in 3 dimensional plain in RVOT-VT patient
Example of ARVC and RVOT-T

- ARVC
- RVOT-VT

Angle between V4V5
Angle between V1V2

ARVC
RVOT

Example of ARVC and RVOT-VT
Reasons For Failure of Catheter Ablation of ARVC/D

- ARVD substrate is progressive
- Disease is predominantly epicardial
- Diffuse involvement of the right ventricle
- Multiple VT morphologies that are hemodynamically unstable.
Epicardial Mapping and Ablation was required in previous failed endocardial procedure (N=13)

**Arrhythmia/Electrophysiology**

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

*Background*—Efficacy of endocardial ventricular tachycardia (VT) ablation in arrhythmogenic right ventricular cardiomyopathy/dysplasia may be limited by epicardial VT, right ventricular thickening, or both. We sought to characterize the endocardial versus epicardial substrate, measure right ventricular free wall thickness, and determine epicardial ablation efficacy in patients with right ventricular cardiomyopathy/dysplasia.

*Methods and Results*—Thirteen consecutive patients (3 female; aged 43±15 years; range, 17 to 70 years) undergoing endocardial and epicardial sinus rhythm voltage mapping and epicardial VT ablation after failed endocardial VT ablation were included. In each patient, the low bipolar voltage area (<1.0 mV for epicardium and <1.5 mV for
Importance of Abnormal Late Potentials in ARVC in prediction of future ICD therapy

Only the Abnormal Signals Correlate with Future Malignant Events

A. Natale Group, Heart Rhythm, 2012, in press
Ablation results in reduction of VT burden, and epicardial ablation procedure and 3D mapping are required for ARVC patients.
Case ARVC in Taipei VGH

- 63 year-old man, presenting with near syncope episodes since 2007
- ARVD diagnosed. ICD was implanted for VT/VF
- Experienced frequent ICD therapy and electrical storm, after two times of failed catheter ablation of endocardial substrate.
Documented VPCs and VT s/p Cardioversion
Endocardial substrate

Some area of unipolar voltage of less than 5 mV

2012, Taipei VG Hospital
Endo- and Epi- substrate

Diffuse LVZ in the RV epicardium and extend to LV epicardium

2012, Taipei VG Hospital
RV epicardial substrates, local electrograms

Local Eg and potential Exits

2012, Taipei VG Hospital
After Catheter Ablation
Outcome of Definite ARVC patients (N=30)
Median follow-up period = 2 years, to 56 months

30 Definite ARVC Pts

13 with ICD (43%)

6 with rapid VT/VF

4 with electric storm

1 with ablation, no further event

2 with rapid VT/VF and medication

3 with medication

2 with inappropriate shocks

2 without ICD therapy

7 without rapid VT/VF

No rapid VT/VF

9 with ablation (30%)

8 with medication (27%)

No rapid VT/VF

10 pt (33%) received ablation, none had rapid VT/VF or mortality
Outcome of Probable/Possible patients (N=62)
Median follow-up period = 2 years, to 56 months

62 with probable ARVC patients

2 with ICD (3%)
- 1 ablation
  - 1 recurrent VT
  - 0 mortality

60 without ICD (97%)
- 54 ablation
  - 23 recurrent VT
  - 0 mortality
- 6 medication
  - 1 recurrence and mortality (16%)

1 with ICD
- 1 medication
  - 0 recurrence
  - 0 mortality (0%)

24 pt (39%) received ablation, none had rapid VT/VF or mortality
Kaplan-Meier analysis of survival free of rapid VT/VF event in ARVC patients

Most of rapid VT/VF occurred within 2 years
Conclusions

- The electrophysiologic characteristics of ARVD are variable, and deserve further investigation.

- Catheter ablation with the endocardial and epicardial approach can be effective in ARVD VT.
## Predictor of VT Recurrence After Ablation in TF (-) Patients

<table>
<thead>
<tr>
<th>Factors</th>
<th>VT recurrence (+)</th>
<th>VT recurrence (-)</th>
<th>Odds ratio CI (95%)</th>
<th>Multivariate analysis P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TF criteria (1 major one minor, or 3 minors)</td>
<td>35%</td>
<td>13%</td>
<td>7.5 0.95-59</td>
<td>0.055</td>
</tr>
<tr>
<td>Substrate Mapping RV body &amp; free wall scar</td>
<td>46%</td>
<td>17%</td>
<td>5.9 1.02-34</td>
<td>0.047</td>
</tr>
<tr>
<td>Distance to the pulmonary valve</td>
<td>29±19</td>
<td>19±10</td>
<td>1.1 1.01-1.17</td>
<td>0.047</td>
</tr>
</tbody>
</table>

The presence of Scar / Foci near the body indicated future recurrence in TF (-) patients.
Survival curve of all VT patients
(N=239, National Mortality Survey)

Cumulative survival (%)

Follow-Up Duration (Month)
Advantage of 3D mapping in RVOT-T/ARVC

- **RVOT-VT (focal in origin):** Identification of the arrhythmogenic foci by Eg analysis, activation map and spectral analysis.

- **ARVC (reentrant type):** Substrate analysis, identification of the low voltage area for the maintenance of VT.

- Detection of atypical and early form of ARVC from idiopathic RVOT-T by substrate mapping.
In Taipei Veteran General Hospital Laboratory experience, a total 239 patients received mapping/ablation for VT from 2000 to 2010;

The common types of VT were idiopathic right ventricular outflow tract tachycardia (RVOT-T, 33%), probable arrhythmogenic right ventricular cardiomyopathy (ARVC, 26%), and definite ARVC 12%.

In between, 3D substrate mapping/catheter ablation were performed in 72 patients (50%) with optimal successful result (70%).
RV-VT, morphology Could be initiated by extrastimulation and entrained r/o reentry in mechanism