Useful Tips for Successful RF Ablation Originated from Papillary Muscle, Purkinje System, and Cardiac Crux
Idiopathic Ventricular Arrhythmia Originating From the Cardiac Crux or Inferior Septum 
Epicardial Idiopathic Ventricular Arrhythmia

Mitsuharu Kawamura, MD; Edward P. Gerstenfeld, MD; Vasanth Vedantham, MD, PhD; 
Derek M. Rodrigues, MD; J. David Burkhardt, MD; Youichi Kobayashi, MD; 
Henry H. Hsia, MD; Gregory M. Marcus, MD, MAS; Francis E. Marchlinski, MD; 
Melvin M. Scheinman, MD; Nitish Badhwar, MD

LBBB pattern

R < S in lead V6

YES

NO

Crux-VA: QS in lead II and/or III, R > S in lead V2 and MDI ≥ 0.55

RBBB pattern

R < S in lead V6

Apical crux-VA

Basal crux-VA

1) Proximal-CS mapping
2) Proximal-MCV mapping

Apical crux-VA

1) LV posteroseptal mapping
2) Distal-MCV mapping

Apical crux-VA

Middle MCV mapping

Epicardial surface mapping using subxiphoid approach

Epicardial surface mapping using subxiphoid approach

(LAO)
## Baseline clinical characteristics of 2 groups
(Crux VA vs other form of idiopathic VA)

<table>
<thead>
<tr>
<th></th>
<th>Crux VA (n=18)</th>
<th>Idiopathic VA (n=251)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>53 ± 12</td>
<td>48 ± 21</td>
<td>0.07</td>
</tr>
<tr>
<td>Male</td>
<td>8 (44 %)</td>
<td>115 (46 %)</td>
<td>0.81</td>
</tr>
<tr>
<td>Symptoms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymptomatic/Palpitation</td>
<td>10 (56 %)</td>
<td>201 (80 %)</td>
<td>0.01</td>
</tr>
<tr>
<td>Syncope/Cardiac arrest</td>
<td>8 (44 %)</td>
<td>50 (20 %)</td>
<td>0.01</td>
</tr>
<tr>
<td>Arrhythmias</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VT/NSVT</td>
<td>15 (83 %)</td>
<td>83 (33 %)</td>
<td>0.001</td>
</tr>
<tr>
<td>PVC</td>
<td>3 (17 %)</td>
<td>168 (67 %)</td>
<td>0.001</td>
</tr>
<tr>
<td>QRS duration (msec)</td>
<td>150 ± 27</td>
<td>138 ± 19</td>
<td>0.04</td>
</tr>
<tr>
<td>LV ejection fraction (%)</td>
<td>60 ± 5</td>
<td>58 ± 8</td>
<td>0.26</td>
</tr>
<tr>
<td>ICD implantation</td>
<td>3 (17 %)</td>
<td>7 (3 %)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Basal crux VA
Comparison of QRS morphology
(Basal Crux-VT vs TA VA vs MA-VA)

Successful ablation site (Basal crux)

(A) ECG tracings
- I, II, III, aVR, aVL, aVF, V1-V6, ABL-d, ABL-p, RVp, RVd
- V-QRS = -30 msec

(B) Images showing RAO and LAO views with annotations:
- Top arrow: His
- Bottom arrow: ABL

(C) Voltage mapping and Activation mapping images:
- Images showing LV, MCV, RV, CS

Case 1
Fascicular VT

35 years old, male.
He had palpitation and had VT.
He had no structural heart disease.

RBBB+superior axis, HR 248 /bpm,
QRS 120 msec
VT termination

VT

SR

P1: diastolic potential
P2: presystolic purkinje potential

(100mm/sec)
Catheter position

VT Activation Map

liner ablation to transect the involved middle to distal left fascicular tract.

point ablation at the earliest ventricular activation with a fused P2.
Mapping and ablation of Fascicular VT

Mapping

LV septal mapping using a multipolar electrode catheter is useful. Activation mapping is not typically required, however the ability to tag catheter positions of interest is often helpful. The diastolic potential (P1) and Purkinje potential (P2) can be recorded during VT from the mid-septum. Because P1 has been proved a critical potential in the VT circuit, this potential can be targeted to cure the tachycardia.

Ablation

P1 is the antegrade limb of the VT circuit. The earliest P1 is not need. The distal third of P1 potential is usually targeted to avoid LBBB or AV block. If FVT isn’t induced, we perform an anatomic liner ablation to transect the involved middle to distal left fascicular tract.
Case 2
Papillary PVC

56 years old, male.
He had palpitation and had PVC.
He had no structural heart disease.
How to extract a papillary muscles?
First, we position a sound-star at a His area. We advance a sound-star toward apex in a posterior deflection.
We can easily see LV long axis view and papillary muscle in a clockwise.
Successful ablation site

Intracardiac ECG

Fluoroscopic view

V-QRS = -48 msec
Mapping and ablation method of Papillary VT/PVC

**Mapping**
Intracardiac echocardiography (ICE) is essential to ensure adequate catheter-tissue contact and correct orientation of the catheter tip. We use a Carto system and the CartoSound module allows integration of the anatomic shell based on the echo images with real-time integration of the ICE views.

**Ablation**
Ablation is challenging as compared to those with other VAs probably because of the deep location of the origin and the difficulty in maintaining stable contact of the catheter tip at the papillary muscles. Targets for ablation include sites with earliest ventricular activation and a QS in the local unipolar recording. These sites usually exhibit an excellent pace map.
How to differentiate VT Originating from
• Posterior Papillary Muscles
• Posterior Fascicular
• Apical Crux. ? ?
Comparison of clinical and ECG characteristics (Apical Crux VT vs PPM VT vs LPF VT)

Clinical and electrocardiographic characteristics of idiopathic ventricular arrhythmias with right bundle branch block and superior axis: Comparison of apical crux area and posterior septal left ventricle

Mitsuharu Kawamura, MD, Jonathan C. Hsu, MD, MAS, Vasanth Vedantham, MD, PhD, Gregory M. Marcus, MD, MAS, Henry H. Hsia, MD, Edward P. Gerstenfeld, MD, Melvin M. Scheinman, MD, Nitish Badhwar, MD

From the Division of Cardiology, University of California, San Francisco, California, and Section of Cardiac Electrophysiology, Division of Cardiology, University of California, San Diego, San Diego, California.

BACKGROUND Right bundle branch block (RBBB) with superior axis electrocardiographic (ECG) morphology is common in patients with idiopathic ventricular arrhythmia (VA) originating from the left posterior fascicle (LPF), from the left ventricular (LV) posterior papillary muscles (PPM), and rarely from the cardiac apical crux.

OBJECTIVE The purpose of this study was to describe the ECG and clinical characteristics of idiopathic VA presenting with RBBB and superior axis.

METHODS We studied 40 patients who underwent successful catheter ablation of idiopathic VAs originating from the LPF (n = 18), LV PPM (n = 15), and apical crux (n = 7). We investigated clinical and ECG characteristics, including maximum deflection index and QRS morphology in leads aVR and V6.

RESULTS Syncope was more frequently seen in apical crux VA compared with other VAs (57% vs 6%, P < .001). Patients with apical crux VA more frequently had an maximum deflection index ≥0.55 compared with LPF VA and PPM VA (P = .02). A monophasic R wave in aVR and QS or r/S ratio <0.15 in V6 (P < .001) could distinguish apical crux VA from other VAs with high accuracy. All patients with VA underwent attempted ablation in the endocardium (success rate: LPF 89%, PPM 80%, crux 14%). Only 1 of 7 patients with apical crux VA had acute success with ablation in the middle cardiac vein. In 2 of apical crux patients, epicardial ablation using subxiphoid approach was performed successfully.

CONCLUSION We could distinguish LPF VA, PPM VA, and! apical crux VA using a combination of clinical and ECG characteristics. These findings might be useful for counseling patients and planning an ablation strategy.

KEYWORDS Ventricular tachycardia; Catheter ablation; Epicardial approach; Cardiac crux; Right bundle branch block

ABBREVIATIONS CS = coronary sinus; ECG = electrocardiography; LBBB = left bundle branch block; LPF = left posterior fascicle; LV = left ventricle; MCV = middle cardiac vein; MDI = maximum deflection index; NPV = negative predictive value; PPM = posterior papillary muscle; PPV = positive predictive value; RBBB = right bundle branch block; RV = right ventricle; VA = ventricular arrhythmia; VT = ventricular tachycardia

(Heart Rhythm 2015;12:1137–1144) © 2015 Published by Elsevier Inc. on behalf of Heart Rhythm Society.
Panel A shows the R/S ratio in V₆ was significantly lower in patients with apical crux VA as compared to those with other VAs. The R/S ratio also tended to be lower in patients with PPM VA compared to those with LPF VA ($P = .06$).

Panel B shows MDI was significantly higher in patients with apical crux VA as compared to those with other VAs.

Panel C shows QRS durations in patients with LPF VA were significantly narrower as compared with other VAs.

VA with RBBB and superior axis (n=40)

$$\text{MDI} \geq 0.55$$

YES (7)

Crux (5), PPM (2)

1) QS or r/S ratio < 0.15 in V6
2) Monophasic R in a VR

YES (5)

Crux (5)

NO (2)

PPM (2)

NO (33)

Crux (2), LPF (18), PPM (13)

1) QS or r/S ratio < 0.15 in V6
and
2) Monophasic R in a VR or
3) QS in II

YES (2)

Crux (2)

NO (31)

LPF (18), PPM (13)

1) QRS duration > 150 msec
2) qR in V1

YES (11)

PPM (11)

NO (20)

LPF (18), PPM (2)

<Summary>

1) Clinical and electrophysiological characteristics are important for fascicular VA. Patients with FVT are younger as compared to those with other VAs. FVT is narrower with QRS duration as compared to those with other VAs. Purkinje potentials (P2) and diastolic potentials (P1) are preceding ventricular activation during VT.

2) Anatomic landmark by intracardiac echocardiography is important for papillary muscle-VAs. QRS duration with PPM-VAs are wider as compared to those with fascicular VT. In PPM-VA, PVC is more frequently than VT.

3) It is challenging to distinguish from PPM-VA and LPF-VA due to overlap of successful ablation point. Therefore, we need to judge these VAs comprehensively.
Thank you for your attention