ECG localization of site of origin in idiopathic VT

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Disclosure

I have nothing to disclose
Contents

• Fascicular VT

• Papillary muscle VT

• Outflow tract VT
  – The relevant anatomical relationship
  – Typical ECG characteristics
  – LVOT VT, Epicardial VT

• Case study for localization of idiopathic VT
FASCICULAR VT
Fascicular VT

- Left posterior FVT
- PPM-FVT
- Left anterior FVT
- APM-FVT
- Upper Septal FVT
PAPILLARY MUSCLE VT
Papillary muscle VT

Anterolateral region LV VAs

Posteromedial region LV VAs

JCE. 2010;21:62-69
CirAE. 2010;3:324-331
# PMVT vs. FVT

Table 1. Comparison of clinical, electrocardiographic and electrophysiological characteristics between PM VT and fascicular VT

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>PM VT</th>
<th>Fascicular VT</th>
</tr>
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<tbody>
<tr>
<td>Manifestation of arrhythmia</td>
<td>Sustained VT&lt;PVC or non-sustained VT</td>
<td>PVC or non-sustained VT&lt;Sustained VT</td>
</tr>
<tr>
<td>Mechanism</td>
<td>Abnormal automaticity or triggered activity</td>
<td>Re-entrant</td>
</tr>
<tr>
<td><strong>ECG during arrhythmia</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QRS morphology</td>
<td>RBBB</td>
<td>RBBB</td>
</tr>
<tr>
<td>QRS duration</td>
<td>Longer</td>
<td>Shorter</td>
</tr>
<tr>
<td>VT</td>
<td>qR or R</td>
<td>rsR'</td>
</tr>
<tr>
<td>Q wave in limb leads</td>
<td>(-)</td>
<td>(+)</td>
</tr>
<tr>
<td>Response to verapamil</td>
<td>(-)</td>
<td>(+)</td>
</tr>
<tr>
<td>Induction mode during EPS</td>
<td>Spontaneously or during an infusion of isoproterenol or epinephrine</td>
<td>Programmed electrical stimulation</td>
</tr>
<tr>
<td>Recurrence rate after RFCA</td>
<td>Relatively high</td>
<td>Low</td>
</tr>
<tr>
<td>High frequency potential preceding the earliest local ventricular electrogram</td>
<td>(-)</td>
<td>(+)</td>
</tr>
</tbody>
</table>

ECG, electrocardiogram; EPS, electrophysiologic study; PM, papillary muscle; PVC, premature ventricular complex; RBBB, right bundle branch block; RFCA, radiofrequency catheter ablation; VT, ventricular tachycardia.
LPF vs. PPM
- lateral q wave -
OUTFLOW TRACT VT
Anatomy of Outflow tracts (I)
Anatomy of Outflow tracts (II)
Anatomical relationships for RVOT & LVOT
Anatomy and ECG correlation of Outflow tracts
ECG localization for OT VT

- Frontal axis

- Precordial transition

- Typical ECG finding for specific OT VT
  - Aortic cusp VT (LCC, RCC, LCC-RCC junction)
  - Aorto-mitral continuity (AMC) VT
  - LV summit VT
  - Idiopathic epicardial LV VT
FRONTAL AXIS
Polarity in lead I

- + in I (posterior/free wall): → right site of RVOT

- - in I (anterior) → leftward in the RVOT → qR or QS pattern (pulmonary valve)
Pulmonary artery VT

- Taller R in II, III, aVF
  1.89~1.92 mV vs 1.49~1.57 mV
  (PA VT vs RVOT VT)
- Larger R/S ratio in V2
  0.32 vs 0.17 (PA VT vs RVOT VT)
- aVL/aVR ratio of Q-wave amplitude >1
  in the PA (1.11 vs 0.88: RVOT VT)

Polarity in aVR/aVL

- Pulmonary artery VT
  - Greater negative in aVL > aVR

- Outflow tract (RVOT or LVOT)
  - superior location
  - negative in aVR, aVL

- Parahisian
  - Rightward and inferior
  - Negative aVR (QS 100%)
  - Positive aVL (monophasic R 85%)
  - Positive I: monophasic R 100%
Parahisian PVCs

1
2
3
aVR
aVL
aVF
V₁
V₂
V₃
V₄
V₅
V₆

Han S, Hwang C. AHA 2013
Amplitude of R wave

- Outflow tract VT
  - inferior axis
    (Positive in II, III, aVF)
- R wave amplitude
  - Pulmonary artery VT
  - Taller R wave in III > II
- Free wall
  - Notching in QRS in II, III, aVF
  - QRS ≥140
QRS: Free wall vs Septal

- QRS duration $\geq 140$ msec
- QRS notching in inferior leads
- Lead V$\text{3}$ R/S ratio $\leq 1$

Dixit et al. JCE 2003
Joshi et al. JCE 2005
ECG localization for OT VT

• **Frontal axis**
  – Pulmonary artery VT
  – Parahisian VT

• **Precordial transition**
  – RVOT vs. LVOT

• **Typical ECG finding for specific OT VT**
  – Aortic cusp VT (LCC, RCC, LCC-RCC junction)
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R wave in V1

(1) Anterior RVOT : a typical LBBB morphology in V1

(2), (3) Posterior RVOT and the anterior RCC : a small r wave in V1.

(4) LCC/AMC/NCC(more posteriorly) : a distinct R in V1.

(5) Posterior mitral annulus (further more posteriorly and leftward) RBBB morphology in V1
Precordial transition

- Sinus: RV & LV simultaneously activation transition V3 or 4
- LVOT: early transition ≤V2 (earlier than sinus)
- RVOT: late transition ≥V4 (later than sinus)
- Transition at V3 (both sinus and VT): need more information
V3 Transition: is there an easy way out

PVC later than Sinus, RVOT 100%

PVC at/earlier Sinus, LVOT 71%
OT VT with precordial transition in V3
- V2 transition ratio

\[
\frac{B/(B+C)}{E/(E+F)}_{VT} \quad \frac{E/(E+F)}{B/(B+C)}_{SR}
\]

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JACC 2011;57:2255
Diagnostic algorithm for OT VT with V3 transition

1. **Lead V3 PVC/VT R/S transition**
   - PVC/VT R/S transition later than SR?
     - **Yes**
       - RVOT
     - **No**
       - Measure V2 Transition Ratio
         - <0.6
           - RVOT
         - ≥0.6
           - LVOT
V2 transition ratio : Pitfalls

- Clockwise/CCW rotation or Aortic root rotation
- Excludes patients with bundle branch blocks
- Excludes patients with cardiomyopathy
ECG localization for OT VT

- Frontal axis
  - Pulmonary artery VT
  - Parahisian VT

- Precordial transition
  - RVOT vs. LVOT

- **Typical ECG finding for specific OT VT**
  - Aortic cusp VT (LCC, RCC, LCC-RCC junction)
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Myocardial Extension above the AV

- **Ventricular myocardial extension** (VME) at Aorta
  - RCC: frequent exhibits myocardial sleeves
  - LCC: not been demonstrated histologically
  - NCC: at the junction of RCC, may have VME
- VME also occurs in the Inter-leaflet triangle
From LVOT to LV epicardium
RCC vs. LCC

1. VT from RCC: transition $V_2-V_3$
   VT from LCC: transition $V_1-V_2$

2. **R-wave duration index** $\geq 50\%$ and **R/S ratio** $\geq 30\%$ in lead $V_1$ or $V_2$

A. R-wave duration index

B. R/S amplitude index

Ouyang F. J Am Coll Cardiol 2002;39:500
VT from RCC/LCC commissure
VT from RCC/LCC commissure

Notch on downstroke in V1, sensitive, not as specific
Aorto-mitral continuity (AMC) VT
Anterior mitral annulus VT

VT originating further leftward across the anterior mitral annulus: the R wave in lead I diminishes and a broad, positive R wave is seen in lead V1.
EKG Localization in LVOT VT

AMC: qR V1

NCC: A

LCC: M/W in V1, earlier Trx

RCC: rSV1, broad R in V2, V3 Trx

Lin et. al Heart Rhythm 2008
LV summit

- **LV summit**: epicardial surface bounded by LAD & LCx just below the left main bifurcation

- **GCV** bisect the LV summit into accessible area (inferior) & inaccessible area (proximity of proximal vessel & overlying epicardial fat)
LV summit VT (I)

• ECG of VT from **GCV, AIV accessible area**
  – RBBB, Transition ≤ V₁, S wave in V₅ or V₆
  – aVL/aVR amplitude ratio > 1.1

• ECG of VT from **epicardial accessible area**
  – III/II ratio > 1.25, aVL/aVR ratio > 1.75

• ECG of VT from **Inaccessible area** (**highest site** of LV)
  – R wave in inferior leads from inaccessible site >> R wave from pacing at GCV/AIV
LV summit VT (II)
– inaccessible area
Idiopathic Epicardial LV VT

- Perivascular site of origin
- Catecholamine enhanced, adenosine sensitive
- 5~10% of idiopathic VT

Daniels DV, Circulation 2006;113:1659
ECG of idiopathic Epicardial LV VT

- Precordial MDI > 0.55

- MDI: maximal deflection index
- TMD: time to maximal deflection in precordial lead

Circulation 2006;113:1659
Important considerations

• Lead placement in clinic vs. EP lab
• Lead placement during TMT
• CCW/CW rotation of heart (age, sex)
• Unfolding of the aortic root (age)
Summary (FVT & PMVT)

- PMVT - wider QRS, monophasic R (atypical RBBB) in V1 and no q wave in limb leads.
Summary (OT VT)

• Anatomic relationship
  – RVOT is anterior and to the left of the LVOT

• Frontal axis
• Precordial transition
• Specific EKG measurement
  – R-wave duration index $\geq 50\%$, R/S ratio $\geq 30\%$
  – Precordial MDI $> 0.55$
Thank you for your time.
CASE STUDY (I)
22/M, recurrent palpitation
Sinus rhythm
Holter monitoring in 2008
Activation map in 3D
74/M, DOE, palpitation, chest discomfort
Left posterior fascicle to His – Bump!!!
Thank you for your attentions