The Essential of Ventricular Tachycardia Diagnosis and Treatment
11:20 AM – 11:45 AM

David M. Donaldson, MD, FACC FHRS
2020 Cath Lab and EP Essentials CME Conference
February 1st 2020
2020 Cath Lab and EP Essentials CME Conference
Saturday, Feb. 1, 2020
UCI School of Medicine
Disclosure

- **No** grant/research support, no consultant fees, nor stock holder in pharmaceutical or medical device company.
- This talk will be strictly **free** of commercial bias.
- This talk will be **balanced** view of therapeutic options, only generic names will be utilized.
- This lecture will **not** include discussion on unlabeled / investigational use of commercial products.
- Talk will be in compliance of ACGME, UCI policies to provide a balanced, independent, objective and scientifically rigorous educational talk.
A 78 year old male with a history of CAD and CABG in 2010 at UCI with HFrEF (TTE LVEF 40-45% January 2020) and a Thallium Stress Test showed LVEF 41% with fixed Anterior-apical and Anterior Lateral dense scar and no ischemia, holter with rare PVC’s and no NSVT on GDMT had sudden onset of palpitations while watching t.v. on his couch. He felt faint, flushed in face and fullness in his neck, followed by feeling cold and clammy, dizzy, lightheaded lasting 20-25 minutes, the palpitations stopped and then had full recovery without intervention. Prior to the episode he had felt well with no prodrome or other complaints other than mild worsening edema with weight gain. What was the most likely etiology of the event?

1. Seizure
2. Vasovagal Syncope
3. Ventricular Fibrillation
4. SVT
5. Ventricular Tachycardia
In patient with ischemic cardiomyopathy with palpitations and hemodynamic changes without fully reversible trigger, ventricular tachycardia is the more common etiology. Seizure and vasovagal syncope are less clinically suspected in this clinical scenario. SVT is more commonly seen in younger population with structurally normal hearts. Ventricular Fibrillation is more commonly seen in the setting of ischemia and usually does not spontaneously terminate without intervention.

1. Seizure
2. Vasovagal Syncope
3. Ventricular Fibrillation
4. Orthostatic Hypotension
5. Ventricular Tachycardia

Reference: Cardiac Electrophysiology: From Cell to Bedside: Zipes and Jalife; edition 4; chapters 61, 62, 78, 101, 106, 118
Outline: Ventricular Tachycardia: Clinical manifestations, diagnosis, and therapy

- Epidemiology
- Clinical
- EKG Diagnosis
- Supporting Diagnosis
- Therapy
Ventricular Tachycardia: Epidemiology

- Cardiovascular disease (CVD) is common in US.
- Sudden Cardiac Death (SCD) seen in CVD and even “low risk” patients.
- VT / VF leading cause of SCD.
- VT breakdown includes:
  - CAD and prior MI (70% of all cases of SCD)
  - Hypertrophic Cardiomyopathy (HCM)
  - NICM / DCM
  - Complex Congenital Heart Disease
  - Left Ventricular Non compaction
  - Infiltrative Cardiomyopathy (sarcoid, amyloid, etc)
  - ARVD (Arrhythmogenic right ventricular cardiomyopathy)
  - Cardiac Channelopathy
Ventricular Tachycardia: Clinical manifestations

• 12-lead EKG during VT is essential
• Detailed CV history and medications pro-arrhythmic (AAR, QTc prolonging medications)
• Signs and Symptoms: Variable and rate related and underlying cardiac status.
  • **Severe CV Status (low CO)**
    • Hemodynamic deterioration / Hypoperfusion / CHF
    • LOC
    • Cardiac Arrest
  • **Preserved CV Status (Normal CO)**
    • Better tolerated
    • Palpitations
    • SOB
    • Unwell feelings.
Ventricular Tachycardia: ECG FINDINGS

MMVT

Pleo.VT

PMVT

Figure 1  Monomorphic (A), pleomorphic (B), and polymorphic (C) VT. Reproduced with permission of the Heart Rhythm Society from Aliot et al. EHRA/HRS expert consensus on catheter ablation of ventricular arrhythmias. Heart Rhythm 2009;6:886-933. VT = ventricular tachycardia.
Ventricular Tachycardia: EKG FINDINGS

• EKG Findings (Most Important feature once stable):
  • 12 leads essential to compare to EKG when in NSR

• Differential Diagnosis:
  • supraventricular tachycardia with aberrant conduction (BBB)
  • supraventricular tachycardia with pre-excitation
  • V’ Paced
  • Artifact
Ventricular Tachycardia: EKG FINDINGS

- CRITERIA:
  - Wide Complex (QRS width >120 msec.) (Wider QRS favors VT) (QRS > 160 msec very strongly favors VT)
  - Regular
  - Minor change in QRS morphology suggestive of VT (SVT usually has more fixed conduction to ventricular and subsequently more uniform QRS and T morphology).
  - Tachycardia Rates > 100 bpm.
  - AV dissociation.
  - Fusion complexes (Supraventricular beat mixed with Ventricular beat)
  - Captured Beat “Dressler beat” (Supraventricular beat capturing the Ventricle before the VT generated beat)
  - Retrograde VA block (Pathognomonic of VT)
  - Extreme right axis deviation (Right superior axis) [“NW” axis -90 to ±180 degrees] or > 40 degree change from baseline; R wave in aVR (diagnostic of VT)
  - Concordance (Monophasic QRS in Lead V1 - V6) (biphasic QRS, qR, or RS complexes, concordance is not present).
    - (+) concordance seen also in Antidromic reciprocating SVT.
    - (-) concordance seen in VT.
Ventricular Tachycardia: EKG FINDINGS : Brugada Criteria
Ventricular Tachycardia: EKG FINDINGS: Vereckei Algorithm
Ventricular Tachycardia: Diagnostic Testing

- Once restoration of NSR: (ACLS protocol)
- Assess for triggers / reversible causes: drugs, electrolytes, anemia, CHF, SVT (Tachycardia induced tachycardia)
- Evaluation for ischemia
- Structural Heart disease (undiagnosed cardiomyopathy (NICM / HCM / ARVD), anomalous origin of a coronary artery.
  
  **NON INVASIVE**
  - TTE (LVEF, Congenital HD and Valvular HD)
  - continuous ECG monitoring
  - CMR (cardiac magnetic resonance) (ARVD, Sarcoid, Infiltrative CM, LGE)
  - Exercise testing — Exercise stress testing for LQTS or trigger CPVT
  - PET - CT
  - Signal-averaged ECG (SAECG) rarely used (low amplitude electrograms post QRS complex).

  **INVASIVE**
  - Left heart catheterization
  - EPS +/- ablation
Ventricular Tachycardia: Treatment

- **Treatment of associated conditions**
  - Myocardial ischemia (revascularization, GDMT and AAR)
  - Electrolyte disturbances (hypokalemia or hypomagnesemia)
  - Drug proarrhythmia (TdP and PMVT with QTc ≥ 500 milliseconds)
  - CHF

- **AAR Medications**
  - Lidocaine bolus 1-1.5 mg/kg then 1-4 mg/min (limited SE and usually 24 hours max.).
  - Procainamide infusion 20-40 mg/min. or blouses 0.5 mg/kg every 5 minutes (use to terminate not maintenance and monitor QRS widening)
  - Amiodarone 150 mg over 10 minutes then start gtt 1 mg/minutes x 6 hours then 0.5 mg / minute over next 18 hours (max 2 grams in 24 hours) (SE hypotension, through filtered line and preferably central line); Oral loading 400 mg PO Q8H overlapping IV for 24 hours to 10 grams over 7-10 days
  - Sotalol 80 mg PO Q12H and up titrate to 120 mg PO BID and possible 160 mg PO BID with 12 lead EKG 2 hours post doing to 5 doses in hospital.
Ventricular Tachycardia: Treatment

• AAR
  • Amiodarone
    • Most effective (take with meals to minimize GI distress)
    • Check LFT’s, TFT’s, DFT’s with DLCO, eye and skin exams
  • Sotalol and Dofetilide
    • Similar efficacy yet Dofetilide better long term tolerance.
  • Mexiletine
    • Lidocaine responsive and adjunct to Amiodarone.
• Beta blockers and GDMT
• ICD
  • Large, prospective randomized clinical trials (AVID, CASH, and CIDS) and Meta-analyses
  • ICD therapy superior to AAR
• Ablation
Sudden Cardiac Death Primary Prevention Protocols

Ejection Fraction ≤
35% for Non-Ischemic Cardiomyopathy
40% for Ischemic Cardiomyopathy

Any Cardiomyopathy
Not on Optimal Medical Therapy

Post-MI or Ischemic Cardiomyopathy
With Revascularization (PCI or CAB)
ICD Waiting Period > 3 Months

Post-MI
Without Revascularization
ICD Waiting Period > 40 Days

Any Cardiomyopathy
Beyond ICD Waiting Period on Optimal Medical Therapy

Initiate or Titrate Medical Therapy
Beta Blocker — ACE/ARB — Aldosterone Antagonist

Discharge Home; Continue Optimization of Medical Therapy
Consider Consultation with Heart Rhythm Specialist/Consider Wearable Cardioverter Defibrillator

Reassess EF @ 3 Months

Non-ischemic Cardiomyopathy
EF ≤ 35%

Ischemic Cardiomyopathy
EF = 36–40%
Consider Further Risk Stratification/Consultation with Heart Rhythm Specialist*

EF ≤ 35%

Refer for Consultation with Heart Rhythm Specialist

*EF = EF estimate
LVEF is the most important initial parameter.

• LVEF > 40 %, no further risk stratification.
• LVEF of 35 - 40 %, periodic Holter monitoring and consider EP study.
• LVEF < 35% device therapy an option

• Limited data for utilizing additional studies to guide decisions regarding ICD or antiarrhythmic drug therapy)
Ventricular Tachycardia: Ablation Therapy

2019 HRS/EHRA/APHRS/LAHRS Expert Consensus Statement on Catheter Ablation of Ventricular Arrhythmias
May 10, 2019—The consensus statement, accompanied by a systematic review and meta-analysis and an Executive Summary, serves as a resource guide and comprehensive review of the field for clinicians working to improve the care of patients undergoing ablation for ventricular arrhythmias. It offers guidance on how to select patients for catheter ablation, perform procedures in a safe and efficacious manner, and provide follow-up and adjunctive care to obtain the best possible outcomes for patients with ventricular arrhythmias.
Ventricular Tachycardia: Ablation Therapy
### Ventricular Tachycardia: Ablation Therapy

#### 4.4. Ventricular Arrhythmia in Ischemic Heart Disease

<table>
<thead>
<tr>
<th>COR</th>
<th>LOE</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>B-R</td>
<td>1. In patients with IHD who experience recurrent monomorphic VT despite chronic amiodarone therapy, catheter ablation is recommended in preference to escalating AAD therapy.</td>
</tr>
<tr>
<td>I</td>
<td>B-NR</td>
<td>2. In patients with IHD and recurrent symptomatic monomorphic VT despite AAD therapy, or when AAD therapy is contraindicated or not tolerated, catheter ablation is recommended to reduce recurrent VT.</td>
</tr>
<tr>
<td>I</td>
<td>B-NR</td>
<td>3. In patients with IHD and VT storm refractory to AAD therapy, catheter ablation is recommended.</td>
</tr>
<tr>
<td>IIa</td>
<td>C-EO</td>
<td>4. In patients with IHD and recurrent monomorphic VT, in whom AADs are not desired, catheter ablation can be useful.</td>
</tr>
<tr>
<td>IIb</td>
<td>A</td>
<td>5. In patients with IHD and an ICD who experience a first episode of monomorphic VT, catheter ablation may be considered to reduce the risk of recurrent VT or ICD therapies.</td>
</tr>
<tr>
<td>IIb</td>
<td>C-LD</td>
<td>6. In patients with prior myocardial infarction and recurrent episodes of symptomatic sustained VT for whom prior endocardial catheter ablation has not been successful and who have ECG, endocardial mapping, or imaging evidence of a subepicardial VT substrate, epicardial ablation may be considered.</td>
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### 4.5. Nonischemic Cardiomyopathy

**Recommendations for catheter ablation of VT in nonischemic cardiomyopathy (NICM)**

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<tr>
<td>I</td>
<td>B-NR</td>
<td>1. In patients with NICM and recurrent sustained monomorphic VT for whom antiarhythmic medications are ineffective, contraindicated, or not tolerated, catheter ablation is useful for reducing recurrent VT and ICD shocks.</td>
</tr>
<tr>
<td>I</td>
<td>B-NR</td>
<td>2. In patients with NICM and electrical storm refractory to AAD therapy, catheter ablation is useful for reducing recurrent VT and ICD shocks.</td>
</tr>
<tr>
<td>IIa</td>
<td>B-NR</td>
<td>3. In patients with NICM, epicardial catheter ablation of VT can be useful after failure of endocardial ablation or as the initial ablation approach when there is a suspicion of an epicardial substrate or circuit.</td>
</tr>
<tr>
<td>IIa</td>
<td>B-NR</td>
<td>4. In patients with cardiac sarcoidosis and recurrent VT despite medical therapy, catheter ablation can be useful to reduce the risk of VT recurrence and ICD shocks.</td>
</tr>
<tr>
<td>IIa</td>
<td>C-E0</td>
<td>5. In patients with NICM and recurrent sustained monomorphic VT for whom antiarhythmic medications are not desired, catheter ablation can be useful for reducing recurrent VT and ICD shocks.</td>
</tr>
<tr>
<td>IIb</td>
<td>B-NR</td>
<td>6. In patients with NICM related to lamin A/C (LMNA) mutations and recurrent VT, catheter ablation may be considered as a palliative strategy for short-term arrhythmia control.</td>
</tr>
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### Recommendations for catheter ablation of VA in inherited primary arrhythmia disorders

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<tr>
<td>I</td>
<td>B-NR</td>
<td>1. In patients with arrhythmogenic right ventricular cardiomyopathy (ARVC) who experience recurrent sustained VT or frequent appropriate ICD interventions for VT in whom AAD therapy is ineffective or not tolerated, catheter ablation, at a center with specific expertise, is recommended.</td>
</tr>
<tr>
<td>I</td>
<td>B-NR</td>
<td>2. In patients with ARVC who have failed one or more attempts of endocardial VT catheter ablation, an epicardial approach for VT ablation is recommended.</td>
</tr>
<tr>
<td>IIa</td>
<td>B-NR</td>
<td>3. In patients with ARVC who experience recurrent sustained VT or frequent appropriate ICD interventions for VT in whom AAD therapy is not desired or preferred, catheter ablation, at a center with specific expertise, is reasonable.</td>
</tr>
<tr>
<td>IIa</td>
<td>B-NR</td>
<td>4. In patients with Brugada syndrome who experience recurrent sustained VAs or frequent appropriate ICD interventions, catheter ablation can be useful.</td>
</tr>
<tr>
<td>IIa</td>
<td>C-LD</td>
<td>5. In patients with ARVC, a first-line combined endocardial/epicardial approach for VT ablation is reasonable.</td>
</tr>
</tbody>
</table>
Ventricular Tachycardia: Ablation Therapy

Ablation Indications:
• Structural HD with symptomatic VT (ICD shocks DCCV or symptoms) despite AAR.
• Incessant VT / VT storm.
• VT / VF triggered by PVC.
• Alternative to long term use of one or more antiarrhythmic drugs, most commonly Amiodarone (SE profile concern).
• Well tolerated VT with prior MI even if they have not failed AAR.
Ventricular Tachycardia: Ablation Therapy

Catheter ablation techniques:
• VT Focus ablation
  • Activation mapping and Entrainment endocardial mapping
  • Substrate ablation (map of scar and ablate border zones of myocardium with abnormal electrograms)
  • Similar efficacy, safety and interestingly areas to ablate
  • More ablation less recurrence
• Epicardial may improve outcomes, yet possible higher complication rates
Ventricular Tachycardia: Reentrant Circuits
Ventricular Tachycardia: Entrainment

1. Time (msec) is Distance

2. Measure Tachycardia Cycle Length (TCL)

3. Entrainment = overtake circuit

4. Measure Post Pacing Interval (PPI) Return Cycle Length

5. PPI-TCL > 30 msec “Outside Circuit”

5. PPI-TCL < 30 msec “Inside Circuit”
Ventricular Tachycardia: Entrainment

Outer Loop #1

Outer Loop #2

Entrance

Exit

Bystander

Outer Loop #1 = Different QRS Morphology

Outer Loop #2 = Different QRS Morphology

Entrance = Same QRS Morphology, stim to QRS Later

Exit = Same QRS Morphology, stim to QRS Earlier

Bystander = Same QRS Morphology, yet long
Ventricular Tachycardia: Ablation Efficacy

Prophylactic Catheter Ablation for the Prevention of Defibrillator Therapy SMASH VT
V.Y. Reddy et al. NEJM 2007; 357:2657-2665

GOAL
Examine whether prophylactic radiofrequency catheter ablation of VT scar would reduce the incidence of ICD therapy.

INCLUSION
• CAD with prior MI
• ICD indication for spontaneous VT or VF arrest
• No AAR
• Randomly ICD insertion alone (CONTROL) or ICD insertion with adjunctive catheter ablation (ABLATION) (64 patients in each group).
• Ablation was substrate-based approach in sinus rhythm.
• The primary end point was survival free from any appropriate ICD therapy.

RESULTS
• 21 out of 64 patients ICD alone (33%) vs. 8 out of 64 patients ICD plus ablation (12%) received appropriate ICD therapy (Shock or ATP).
• Mortality was similar in both groups (9% control vs. 17% ablation).
• LVEF and CHF status was unchanged.

CONCLUSIONS
Prophylactic substrate-based catheter ablation reduced the incidence of ICD therapy.
Ventricular Tachycardia: Ablation Efficacy

- VANISH trial
  - Multicenter, non-blinded trial of 259 patients
  - CAD and prior MI and ICD.
  - VT within the six month on AAR
  - Ablation (132 patients) vs. Increasing AAR (dose or added AAR)
  - 28 months
  - Ablation SIGNIFICANTLY lower rates of death, VT storm, ICD shocks than AAR arm.
  - Total mortality the same

- How dangerous are ICD shocks (regardless of appropriate vs inappropriate); inconclusive
  very data suggest may not be benign.
- Efficacy if non – Inducible post ablation highly variable but 80%
- Mortality around 1% (age, low LVEF, CRI, CHF status, COPD, hemodynamic tolerance, experience operator, VT storm, volume of lab.)
- Surgical therapy (aneurysmectomy bilateral sympathectomy, encircling endocardial ventriculotomy) rarely performed
Ventricular Tachycardia: Ablation Therapy

Procedural Factors
- Procedure success
- Complications
- Lesion healing

Patient Factors
- Heart disease severity
- Comorbidities
- Disease progression

Post-Procedural Management
- Antiarrhythmic drug
- ICD programming
- Eligibility / availability for LVAD or Transplantation

Outcome
- Mortality
- Recurrent VT
- VT burden
- Prevention of VT storm
- Hospitalizations
- Patient-reported outcomes / Quality of life

Outline: Ventricular Tachycardia: Clinical manifestations, diagnosis, and therapy

- Epidemiology
- Clinical
- EKG Diagnosis
- Supporting Diagnosis
- Therapy
Thank you and enjoy the day!
Defibrillator in Acute Myocardial Infarction Trial.

- Prophylactic ICD vs. standard medical therapy
- Post MI 6 to 40 days (mean of 18 days)
- LVEF ≤ 35 %
- Reduced HRV or baseline HR > 80 bpm
- 674 patients
- Mean 30 months

- HIGHER annual all-cause mortality with ICD (7.5%) vs. GDMT alone (6.9 %).
  - Arrhythmic deaths were more frequent in the GDMT group.
  - Non-arrhythmic deaths were more frequent in the ICD arm.

This negative trial, Guideline recommendation that ICD implantation should be deferred until at least 40 days after an MI.