Single vs. Tiered Therapy: When and For Whom?

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Akron, OH
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Evolution of ICD Technology

Therapeutic modality of last resort

Preferred Treatment
Therapies for VA

ICDs: Results from Primary and Secondary Prevention Trials

<table>
<thead>
<tr>
<th>Trial Name, Pub Year</th>
<th>Hazard ratio</th>
<th>LVEF, other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>MADIT-I 1996</td>
<td>0.46</td>
<td>0.35 or less, NSVT, EP positive</td>
</tr>
<tr>
<td>AVID 1997</td>
<td>0.62</td>
<td>Aborted cardiac arrest</td>
</tr>
<tr>
<td>CABG-Patch 1997</td>
<td>0.83</td>
<td>0.35 or less, abnormal SAECG and scheduled for CABG</td>
</tr>
<tr>
<td>CASH 2000</td>
<td>0.82</td>
<td>Aborted cardiac arrest</td>
</tr>
<tr>
<td>CIDS 2000</td>
<td>0.82</td>
<td>Aborted cardiac arrest or syncope</td>
</tr>
<tr>
<td>MADIT-II 2002</td>
<td>0.69</td>
<td>0.30 or less, prior MI</td>
</tr>
<tr>
<td>DEFINITE 2004</td>
<td>0.65</td>
<td>0.35 or less, NICM and PVCs or NSVT</td>
</tr>
<tr>
<td>DINAMIT 2004</td>
<td>0.77</td>
<td>0.35 or less, MI within 6 to 40 days and impaired cardiac autonomic function</td>
</tr>
<tr>
<td>SCD-HeFT 2005</td>
<td>0.77</td>
<td>0.35 or less, LVD due to prior MI and NICM</td>
</tr>
</tbody>
</table>

N = sample size
ICD better: lower hazard ratio indicates better outcomes with ICD treatment.
Mortality Benefit Obscured by Morbidity

- Painful Shocks
  - Both appropriate and inappropriate

- 15-25% patients who receive multiple shocks experience
  - Anxiety
  - Depression
  - Difficulty adjusting to life with an ICD
Proarrhythmia of Shock Therapy

Scope of the Problem:

Impact of Appropriate Therapy

- Prognostic significance of ICD Shocks
  - Death from all causes increased by a factor of 6 among patients who receive appropriate shock
    - 30% of death occurring within 24 hrs

- After exclusion of these patients in which an appropriate shock was imminent of death, appropriate shocks were still associated with a risk of death that was increased by a factor of 3

Inappropriate Shocks

- 15-40% occur within first 6 months of F.U
- associated with an increased risk of death, although to a lesser extent.

Patients who receive both types of shocks and survived >24 hrs had a risk of death that was increased by a factor of nearly 5, as to those who received no ICD shocks

Causes of Inappropriate shock

- SVT
- AF
- Oversensing
  - P Wave
  - T Wave
  - Double counting R waves
- EMI
- Lead Fx artifact

Primary vs. Secondary Prevention

- Substantial difference
  - Frequency
  - Rate
  - Mechanism of tachycardia

- Primary Prevention Indications
  - Lower incidence of VTA
  - Higher proportion have inappropriate therapy

PainFREE Trial

- ATP not routinely applied for VT > 188 bpm
  - Efficacy
  - Risk of acceleration
  - Delay of definitive shock therapy

- 220 Patients with CAD & Standard ICD indications
  - ICD programmed to 3 zones
    - VT < 188 bpm
    - FVT 188-250 bpm
    - VF > 250 bpm
  - Randomized to ATP or Shock as initial therapy for FVT

FVT (CL 320 ms) is common in ICD Patients
- ATP can terminate 3 of 4 of these episodes with a low incidence of acceleration and syncope
- ATP for FVT may safely reduce morbidity of painful shocks.

Programming Strategy for Primary Prevention Patients

- Programming strategies tested in previous trials
  - SCD-HeFT – Rx only for fast rhythms
  - PainFREE Rx II – ATP before shock
  - EMPIRIC – Prescribed programming for all ICD recipients utilizing PF II programming and SVT discriminators
Strategy for VT/VF Detection and Therapy Parameters

- Strategically chosen ICD VT/VF detection and therapy parameters can reduce:
  - The combined incidence of device-delivered shocks
  - Arrhythmic syncope
  - Untreated sustained symptomatic VT/VF in primary prevention patients

Methods

- Prospective, historic cohort controlled study
- Primary prevention ICD indications
- 700 pts
  - 38 Centers, US & Europe
  - October 2003 – May 2005
- 1 year follow-up
- Medtronic Marquis-based ICDs and leads
- Single, dual and Bi-V patients

PREPARE Strategies to Reduce Shocks

- Avoid detecting slower tachycardia
- Avoid detecting non-sustained tachycardia
- Avoid detecting SVT as VT/VF
- ATP therapy for fast VT
- High output 1st shock

# VT/VF Detection

<table>
<thead>
<tr>
<th>Detection</th>
<th>Heart Rate</th>
<th>Beats to Detect</th>
<th>Therapies</th>
</tr>
</thead>
<tbody>
<tr>
<td>VF ON</td>
<td>&gt; 250 bpm</td>
<td>30 of 40</td>
<td>30-35 J</td>
</tr>
<tr>
<td>FVT Via VF</td>
<td>182-250 bpm</td>
<td>(30 of 40)</td>
<td>1 seq ATP, 30-35J</td>
</tr>
<tr>
<td>VT Monitor</td>
<td>167-181 bpm</td>
<td>32</td>
<td>None</td>
</tr>
</tbody>
</table>

**PR Logic ON:** AF/Afl, Sinus Tach \(1:1\) VT-ST = 66% or

**Wavelet ON:** SVT Limit = 200 bpm
Endpoints

Primary

● Morbidity Index
  ◆ Spontaneous episodes treated with shocks
  ◆ Arrhythmic syncope
  ◆ Untreated sustained symptomatic VT/VF episodes

Secondary

● Morbidity-Tachycardia Index
  ◆ Morbidity Index plus ATP episodes

● Time to first shock
  ◆ All-cause
  ◆ Appropriate
  ◆ Inappropriate
**Implant and Device Type**

<table>
<thead>
<tr>
<th>Device Type</th>
<th>PREPARE (n=700)</th>
<th>Control (n=691)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Bi-Ventricular</td>
<td>452 (65%)</td>
<td>276 (40%)</td>
</tr>
<tr>
<td>Single chamber</td>
<td>110 (16%)</td>
<td>0</td>
</tr>
<tr>
<td>Dual Chamber</td>
<td>342 (49%)</td>
<td>276 (40%)</td>
</tr>
<tr>
<td>Bi-Ventricular</td>
<td>247 (35%)</td>
<td>415 (60%)</td>
</tr>
<tr>
<td>Unsuccessful implant</td>
<td>1 (&lt;1%)</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Time to First Shock: All-Cause

Time to First Shock (All-Cause)

\[ p < 0.01 \]

Control: 16.9%

PREPARE: 8.5%

% Patients

Pts at Risk
PREPARE 700
Control 689

Months
0 3 6 9 12

656 604 567 541
548 452 373 246
Time to First Shock

**Time to First Shock (True VT/VF)**

- **Control:** 9.4%
- **PREPARE:** 5.4%

<table>
<thead>
<tr>
<th>Pts at Risk</th>
<th>Months</th>
<th>% Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREPARE 700</td>
<td>663</td>
<td>0%</td>
</tr>
<tr>
<td>Control 689</td>
<td>560</td>
<td>5%</td>
</tr>
<tr>
<td>PREPARE 581</td>
<td>624</td>
<td>10%</td>
</tr>
<tr>
<td>Control 497</td>
<td>479</td>
<td>15%</td>
</tr>
<tr>
<td>PREPARE 559</td>
<td>601</td>
<td>20%</td>
</tr>
<tr>
<td>Control 531</td>
<td>571</td>
<td>25%</td>
</tr>
</tbody>
</table>

*P<0.01*

**Time to First Shock (True SVT/Other)**

- **Control:** 7.5%
- **PREPARE:** 3.6%

<table>
<thead>
<tr>
<th>Pts at Risk</th>
<th>Months</th>
<th>% Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREPARE 700</td>
<td>670</td>
<td>0%</td>
</tr>
<tr>
<td>Control 689</td>
<td>571</td>
<td>5%</td>
</tr>
<tr>
<td>PREPARE 619</td>
<td>619</td>
<td>10%</td>
</tr>
<tr>
<td>Control 573</td>
<td>479</td>
<td>15%</td>
</tr>
<tr>
<td>PREPARE 590</td>
<td>590</td>
<td>20%</td>
</tr>
<tr>
<td>Control 537</td>
<td>397</td>
<td>25%</td>
</tr>
</tbody>
</table>

*P<0.01*

**Appropriate**

**Inappropriate**
### Syncope

<table>
<thead>
<tr>
<th>Adverse Event</th>
<th>Pts (%)</th>
<th>Events (n=700)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syncope and near-syncope</td>
<td>131 (18.7%)</td>
<td>290</td>
</tr>
<tr>
<td>Arrhythmia-related</td>
<td>27 (3.9%)</td>
<td>31</td>
</tr>
<tr>
<td>True syncope</td>
<td>31 (4.4%)</td>
<td>40</td>
</tr>
<tr>
<td>Arrhythmia-related</td>
<td>11 (1.6%)</td>
<td>12</td>
</tr>
<tr>
<td>Related to PREPARE programming</td>
<td>9 (1.3%)</td>
<td>10</td>
</tr>
</tbody>
</table>

- 10 events identified as possibly or probably related to PREPARE programming in 9 patients.
  - None associated with injuries or death
  - 7 patients completed study
  - 2 patients withdrew for other reasons
Mortality

Patient Mortality

\[ p < 0.01 \]

- Control: 8.7%
- PREPARE: 4.9%

<table>
<thead>
<tr>
<th>Months</th>
<th>Pts at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>700</td>
</tr>
<tr>
<td>3</td>
<td>674</td>
</tr>
<tr>
<td>6</td>
<td>633</td>
</tr>
<tr>
<td>9</td>
<td>615</td>
</tr>
<tr>
<td>12</td>
<td>434</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Months</th>
<th>Pts at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>689</td>
</tr>
<tr>
<td>3</td>
<td>612</td>
</tr>
<tr>
<td>6</td>
<td>531</td>
</tr>
<tr>
<td>9</td>
<td>445</td>
</tr>
<tr>
<td>12</td>
<td>345</td>
</tr>
</tbody>
</table>
Conclusion

- Strategically chosen VT/VF detection and therapy options targeting primary prevention patients can safely reduce the morbidity related to ICD therapy
  - 62% reduction in Morbidity Index
  - 63% reduction in shocked episodes
  - 64% reduction in Morbidity Tachycardia Index
  - 8.5% vs. 16.9% pts shocked at 1 year
  - 3.6% vs. 7.5% pts inappropriately shocked at 1 year
Strategically chosen VT/VF detection and therapy options targeting primary prevention patients can safely reduce the morbidity related to ICD therapy

- 74% reduction Morbidity index
- 68% reduction Morbidity Tachycardia index
Implications

- Large majority of ICD implants are for primary prevention
- Most ICD patients receive too many shocks
- Using strategic PREPARE programming to treat sustained and fast tachycardias with ATP before shocks should safely reduce ICD morbidity
MVT often treated with ATP Therapy
Many “VF” detected episodes are fast MVT
ATP during Charge could terminate VT painlessly with out delay in shock therapy if unsuccessful

- Programmable
- Applied during charge
- ATP delivered if all last 8 RR intervals ≥ 240 ms (nominal)
- Successful ATP = aborted shock
- Shock occurs within 5 beats after completion of capacitor charging
ATP During Charge

Appropriate
The 2nd ventricular episode in Figure 2. also displays the painless delivery of ATP During Charging. In this case, the ATP does not terminate the arrhythmia and a shock was delivered without delay to definitive therapy. A 3rd and final episode on July 15th was successfully terminated painlessly by ATP During Charging.
Case Study 357
Clinic History

- 67 year-old male
- Ischemia cardiomyopathy
- EF 35%
- Hx of PAF
- Hyperlipidemia
- Spinal Stenosis
Medications

- Cozaar 50 mg qd
- Lopressor 12.5 mg bid
- Lasix 20 mg qd
- Lopid 600 mg bid
- Pravachol 20 mg qd
- Micro-K 10 meq 2 bid
- ASA 325 mg qd
- Coumadin as directed
- Vitamins
Device History

- First ICD 3-27-00
- GDT AVT A155 (4-23-04)
  - A: MDT 6960
  - V: MST 6945 Sprint
Clinical History

- Called for reports of ICD discharges x 2 over the weekend

- Denies palpitations, dizziness

- Was using upper arms without symptoms.
ICD Programming

2 Zones

- VF
  - 200 bpm

- VT
  - 150 bpm

- Shock therapy

- Detection enhancements
  - On
# VT Zone: Programming

<table>
<thead>
<tr>
<th>Detection Enhancements</th>
<th>Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrial Tachyarrhythmia Discrimination</td>
<td>✓</td>
</tr>
<tr>
<td>Sinus Tachycardia Discrimination</td>
<td>✓</td>
</tr>
<tr>
<td>Polymorphic VT Discrimination</td>
<td></td>
</tr>
</tbody>
</table>

## Initial Detection

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Initial Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate Interval</td>
<td>400 ms</td>
</tr>
<tr>
<td>Duration</td>
<td>2.5 sec</td>
</tr>
<tr>
<td>V Rate &gt; A Rate</td>
<td>On</td>
</tr>
<tr>
<td>A Fib Rate Threshold</td>
<td>200 bpm</td>
</tr>
<tr>
<td>Stability</td>
<td>20 ms</td>
</tr>
<tr>
<td>And/Or</td>
<td>And</td>
</tr>
<tr>
<td>Onset</td>
<td>9 %</td>
</tr>
<tr>
<td>Sustained Rate Duration</td>
<td>3:00 m:s</td>
</tr>
<tr>
<td>Shock if Unstable</td>
<td>-- ms</td>
</tr>
</tbody>
</table>

## Redetection

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Initial Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redetection Duration</td>
<td>1.0 sec</td>
</tr>
<tr>
<td>Post-shock Duration</td>
<td>1.0 sec</td>
</tr>
<tr>
<td>V Rate &gt; A Rate</td>
<td>On</td>
</tr>
<tr>
<td>A Fib Rate Threshold</td>
<td>200 bpm</td>
</tr>
<tr>
<td>Stability</td>
<td>20 ms</td>
</tr>
<tr>
<td>Sustained Rate Duration</td>
<td>0:15 m:s</td>
</tr>
</tbody>
</table>
Ventricular Conversion Summary

Since Last Reset: 02-Nov-2004 to 01-Nov-2004

- 2 Episodes
  - 0 Patient Triggered
  - 0 STAT & Commanded
    - 0 Non-sustained
    - 0 VF
    - 2 VT
    - 0 VT-1

Multiple Therapies:
- Accelerated
- Shock only
- ATP(s) and Shock(s)
- ATP only
- Single Therapy
  - 1st Shock
  - 1st ATP
  - Divert/Reconfirm
  - No Therapy Programmed

Melanie’s Case Study 357 CW
# Episode Detail Report

<table>
<thead>
<tr>
<th>Episode</th>
<th>Date</th>
<th>Time</th>
<th>Type</th>
<th>A&amp;V</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>19-NOV-2004</td>
<td>21:51</td>
<td>Spontaneous</td>
<td></td>
</tr>
</tbody>
</table>

## Programmed Initial Detection Parameters

- **VF:**
  - >200
  - >150 VT: Onset 9% And A Fib 200 bpm, Stability 20 ms
- **VT:**
  - V>A, SRD 3:00 m:s

## Elapsed Time

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Detection</td>
<td></td>
<td>VT Zone 296 bpm</td>
</tr>
<tr>
<td>Pre-attempt Avg A Rate</td>
<td></td>
<td>151 bpm</td>
</tr>
<tr>
<td>Pre-attempt Avg V Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured V Rate &gt; A Rate</td>
<td></td>
<td>False</td>
</tr>
<tr>
<td>Measured Stability</td>
<td></td>
<td>9 ms</td>
</tr>
<tr>
<td>Measured Onset A Fib</td>
<td></td>
<td>16%, 83 ms</td>
</tr>
<tr>
<td>A Fib</td>
<td></td>
<td>True</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Event</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempt 1 VT Shock 1</td>
<td>00:02</td>
<td></td>
</tr>
<tr>
<td>Therapy Delivered</td>
<td></td>
<td>5J, Biphasic</td>
</tr>
<tr>
<td>Charge Time</td>
<td></td>
<td>1.0 sec</td>
</tr>
<tr>
<td>Shocking Impedance</td>
<td></td>
<td>43 Ω</td>
</tr>
<tr>
<td>Post-attempt Avg A Rate</td>
<td></td>
<td>112 bpm</td>
</tr>
<tr>
<td>Post-attempt Avg V Rate</td>
<td></td>
<td>79 bpm</td>
</tr>
</tbody>
</table>

- **00:35** End of Episode

- Intervals Stored: Yes

- End of Report
EGMs Onset of Episode

AEGM

VEGM

SHOCK

Melanie’s Case Study 357 CW
## Episode Detail Report #2 Event

### Melanie’s Case Study

### CW

### Episode Detail Report

<table>
<thead>
<tr>
<th>Episode</th>
<th>Date</th>
<th>Time</th>
<th>Type</th>
<th>A&amp;V</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>19-Nov-2004</td>
<td>18:29</td>
<td>Spontaneous</td>
<td></td>
</tr>
</tbody>
</table>

### Programmed Initial Detection Parameters

- **VF**: >200
- **VT**: >150
- Onset 9%
- A Fib 200 bpm, Stability 20 ms
- V>A, SRD 3:00 ms

### Elapsed Time

- **Initial Detection**
  - Pre-attempt Avg A Rate: 194 bpm
  - Pre-attempt Avg V Rate: 98 bpm
  - Measured V Rate > A Rate: True
  - Measured Stability: 8 ms
  - Measured Onset: 37%, 245 ms
  - A Fib: False

- **Attempt 1**
  - VT Shock 1
  - Therapy Delivered: 00:03
  - Charge Time: 1.0 sec
  - Shocking Impedance: 41 Ω
  - Post-attempt Avg A Rate: 78 bpm
  - Post-attempt Avg V Rate: 80 bpm

- **End of Episode**
  - 00:35

### Intervals Stored: Yes
EGM
Onset

- AEGM
- VEGM
- Shock

Melanie’s Case Study 357 CW
Melanie's Case Study 357 CW
Melanie's Case Study 357 CW
What is the most appropriate next step?

- A: Program on ATP therapy VT zone
- B. Increase lopressor to 25 mg bid
- C. Reprogram to VF zone only
- D. Program detection enhancements off
- E. A & B
Clinical History

- 43 y.o. female
- Obesity
- Sleep Apnea
- HTN
- Presents in the ED after being resuscitated by SCA event
12 Lead ECG
How would you program this patient?

- **A:** VF zone only

- **B:** 2 zones
  - VT at 150 bpm with ATP therapy
  - VF 180 bpm HV Shock

- **C:** 3 zones
  - VT at 150 bpm with ATP therapy
  - FVT at 188-250 bpm
  - VF at 188 bpm
Patient-Specific Optimized Programming
**Arrhythmia Characteristics**

- Rapid polymorphic VT/VF
- Frequent, NSVT
- Long QT During Sinus Rhythm

**Programming Considerations**

- Single detection zone for HR > 200bpm
- Detection Enhancements OFF
- Avoid ATP
- Prolong Detection (30-40)
- Screen for T wave OS
Primary Prevention (CAD or DCM)

- Fast VT/VF is often MVT, HR > 200 bpm
- Use 2 zones
- VT cutoff at 180-190 bpm
- ATP: use 1-2 sequences for HR < 250 bpm
Secondary Prevention (CAD, DCM)

- MVT 120-200 bpm
- 3 detection zones
- Detection enhancements ON
- Use dual chamber enhancements if available
- Fast VT/VF is often Monophorpic, HR >200 bpm
- Multiple sequence ATP in slower zones
- 1-2 sequences for 200<HR<250 bpm

Hayes D et al Programming 2008 in Cardiac Pacing, Defibrillation, and Resynchronization 2008;300-379
Heart Failure

- Bradycardia
- VT/VF

- Avoid RV pacing in non CRT systems
- Program for primary or secondary prevention

Hayes D et al Programming 2008 in Cardiac Pacing, Defibrillation, and Resynchronization 2008;300-379
Patient Independent & General Programming Optimization
Sensing

- **FFRWOS**
  - Program to eliminate
  - Ensures appropriate detection enhancement operation

- **T-Wave OS**
  - Program to eliminate
  - Avoids double counting and inappropriate detection

Hayes D et al Programming 2008 in Cardiac Pacing, Defibrillation, and Resynchronization 2008;300-379
Detection

- Use Detection enhancements in all pt with AV nodal conduction and a VT zone with HR cut-off of <200 bpm
  - Minimize the risk of inappropriate detection

- Prolong NID or detection time in patients w freq self-terminating arrhythmias
  - Prevents unnecessary capacitor charging and shocks

Hayes D et al. Programming 2008 in Cardiac Pacing, Defibrillation, and Resynchronization 2008;300-379
**Tachycardia Therapy**

- Program liberal ATP in VT zones <200 bpm and 1-2 ATP sequences in faster zones
  - Minimize the risk of inappropriate or appropriate shocks

- Program 1st shock strength for VT or VF based on DFT or ULV testing or to maximum output
  - DFT or ULV testing not likely to transform VT to VF

- Program all subsequent shocks at maximum output
  - Maximum output shocks more likely to be effective and lower risk of repetitive shocks
  - Longer charge time may allow spontaneous termination

Hayes D et al Programming 2008 in Cardiac Pacing, Defibrillation, and Resynchronization 2008;300-379
La France Croisee (The Cross of France)
Romaine Brooks (1914)
Other Programming Considerations

- Minimize RV pacing in non CRT devices
- Enable patient alerts
- Enable remote monitoring