REDUCTION IN ICD SHOCKS
THE ROLE OF DRUGS AND DEVICE PROGRAMMING

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DEFINITIONS

- Inappropriate
- Appropriate
- Unnecessary
ICD shocks:
- Reduces Quality of Life
- Worsen HF
- Increases anxiety and depression
- Increases mortality (SCD-HeFT, MADID II)
SCD despite ICD 5%

20% of all ICD shocks are inappropriate

Only 3-35% of shocked episodes are sustained VT/VF that absolutely require a shock for termination (depending on the trial)
OPTIONS

- DRUGS
- RFC
- DEVICE PROGRAMMING
HF Patient with ICD Shock

- Device Interrogation

1 shock, no symptoms
1 shock with symptoms or >1 shock

1 week

Urgent visit within 24 hours or emergency room

Time Frame of Initial Evaluation

Etiology of shock

Appropriate shock
- Sustained VT or VF
- Treat reversible causes,
  Check electrolytes,
  Consider antiarrhythmia therapy,
  Optimize beta-blocker therapy,
  Optimize antitachycardia pacing,
  Catheter ablation for refractory VT

Electrical storm (> 3 shocks in 24 hours)
- Persistent cardiac ischemia,
  Severe electrolyte disturbance,
  End-stage HF
- Treat reversible causes,
  Check electrolytes,
  IV antiarrhythmic therapy,
  Intubation and sedation

Inappropriate shock
- AF, SVT, Sinus tachycardia,
  T-wave oversensing,
  Lead fracture,
  Double counting of QRS complex
- Treat supraventricular tachycardia,
  Optimize ICD programming,
  Assess lead oversensing,
  Catheter ablation for refractory SVT

Acute Management Strategies

Chronic Management Strategies

Refractory HF or Hemodynamic Instability
- Consider
  Left Ventricular Assist Device,
  Heart transplant evaluation
Pros
Decrease in appropriate ICD shocks due to suppression of recurrent VT/VF
Decrease in inappropriate ICD shocks due to reduced frequency and better rate control of SVT
Slowing of tachycardia leading to improved hemodynamic tolerance
Slowing of rate of tachycardia facilitating successful termination by ATP
Prolongation of ICD battery life
Decrease in frequency of symptomatic non-sustained ventricular arrhythmias
Prevention and better treatment of electrical storm
Improved quality of life and sense of well-being
Reduced defibrillation threshold facilitating easier defibrillation
Improved control of maximal sinus rate
Reduced rate of recurrent ICD related hospitalizations

Cons
Interference in ICD function due to
  Increase in defibrillation threshold
  Increase in pacing threshold
Interference in accurate arrhythmia detection due to
  Slowing of rate of ventricular tachycardia
  Decrease in amplitude of electrocardiogram interfering with sensing
  Limiting effectiveness of rate stability criterion
Adverse effects
  Cardiac
    Bradyarrhythmia
    Torsades de pointes
    Impairment of myocardial function
  Extracardiac toxicity
Figure 1. Kaplan-Meier time-to-event curves for combined end point of all-cause death or all-cause shock in control and sotalol groups.
Effect of azimilide (AZ) on all-cause shocks plus symptomatic tachyarrhythmias terminated by antitachycardia pacing.

Cumulative risk of shock in all 3 treatment groups.
Unresolved issues

- Which drug should be started after b-blocker
- When an AAD should be started
- Limited benefits in incessant slow VT and in pts with electrical storm
DEVICES PROGRAMMING
Unresolved issues:

- Which drug should be started after β-blockers?
- When should an AAD be started?
- Limited benefits in patients with electrical storm and slow incessant VT.
Reducing Unnecessary Shocks

1. ATP therapies to a cycle length of 240 ms.
2. Longer detection time to allow more episodes to terminate spontaneously.
3. New synchronization intervals to reduce shocks for nonsustained events.
4. Tachycardia detection rate cutoff.
To compare empiric ATP versus shocks for spontaneous fast VT in ICD patients

Primary objective:
To assess safety: FVT episode duration treated with ATP was not > 6 seconds

Secondary objectives:
Self-reported quality of life, ATP efficacy, acceleration, syncope
634 patients
42 US centers
Single-blinded
Enrollment: January 2001 to March 2002
Follow-up ended April 2003
Only Medtronic devices used
49% primary prevention
Distribution of ventricular arrhythmias by detection zone and median CL. In conventional ICD programming, all episodes <320 ms (VF and FVT in pie chart) would be detected as VF and shocked without ever attempting ATP. Note that FVT episodes represent 76% of these rhythms.

Figure 2. Terminating therapy for FVT episodes in each arm.

Distribution of ATP success by detected CL. Raw percentages are reported.

EMPIRIC TRIAL
Preventing Shocks After ICD Implantation: Can a Strategy of Standardized ICD Programming Match Physician Tailored
A strategic empiric set of VT/VF programmable settings is at least as effective as physician-tailored choices as measured by the shock related morbidity of ICD therapy.

Primary Endpoint

- Proportion of true VT/VF episodes shocked

and

- Proportion of true SVT episodes shocked

- Non-inferior if both proportions \( \leq 10\% \) greater
  - \( \geq 80\% \) powered for each proportion
  - Alpha = 0.05 for each proportion

Key Secondary Endpoint

Time to first all-cause shock

- Empiric programming non-inferior if upper confidence limit for hazard ratio is < 1.5

## Empiric Arm Programming

<table>
<thead>
<tr>
<th>Zone</th>
<th>Detection</th>
<th>Interval/Rate</th>
<th>Beats to Detect</th>
<th>Therapies</th>
</tr>
</thead>
<tbody>
<tr>
<td>VF</td>
<td>On</td>
<td>300 ms (&gt; 200 bpm)</td>
<td>18 of 24</td>
<td>30 J x 6</td>
</tr>
<tr>
<td>VT</td>
<td>Via VF</td>
<td>240 ms (201 – 250 bpm)</td>
<td>NA</td>
<td>Burst (1), 30 J x 5</td>
</tr>
<tr>
<td>VT</td>
<td>On</td>
<td>≥ 400ms (≤ 150 – 200 bpm)</td>
<td>16</td>
<td>Burst (2), Ramp (1), 20J, 30 J x 3</td>
</tr>
</tbody>
</table>

PR Logic® Detection On: AF/Afl, Sinus Tach (1:1 VT-ST = 66%), SVT Limit = 300 ms

Burst ATP: 8 intervals, R-S1 = 88%, 20 ms decrement
Ramp ATP: 8 intervals, R-S1 = 81%, 10 ms decrement

## Physician Tailored Arm Programming

- Physician discretion
  - Changes during follow-up ok if medically justified.
VT Therapy “ON” by Heart Rate

<table>
<thead>
<tr>
<th>Median Rate Threshold</th>
<th>Empiric</th>
<th>Tailored</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Patients</td>
<td>150 bpm</td>
<td>171 bpm</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Only Spont. Sust. MVT*</td>
<td>150</td>
<td>162</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>All Others</td>
<td>150</td>
<td>176</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

*Monomorphic VT (MVT)

ATP Therapy “ON” by Heart Rate

RESULTS

A. Time to First All-Cause Shock

HR (90% CI): 0.95 (0.74 - 1.23)
Non-inferiority p = 0.0016

B. Time to First True VT/VF Shock

HR (90% CI): 0.80 (0.56 - 1.14),
Superiority p = 0.297

C. Time to First True SVT Shock

HR (90% CI): 1.19 (0.84 - 1.69)
Superiority p = 0.401
## RESULTS

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>Empiric</th>
<th>Tailored</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT/VF</td>
<td>22.3%</td>
<td>28.7%</td>
</tr>
<tr>
<td>SVT</td>
<td>11.9%</td>
<td>26.1%</td>
</tr>
</tbody>
</table>

### % Episodes Shocked

### Difference of % Shocked

Non-inferiority margin

- Favoring EMPIRIC
- Favoring TAILORED
PREPARE Programming Strategy

Extended VF detection time:
NID = 30/40

Fast detection rate:
FDI = 182 bpm (330 ms)

ATP for fast VTs

- VT zone MONITOR:
  Arrhythmias slower than 182 bpm are monitored only
  (no therapy)

- Eliminates 3 out of 4 shocks for fast VTs

**Graphical Representation:**

- PREPARE
  - VF zone NID = 30/40
  - FVT via VF zone with ATP

- Medtronic PainFREE™ Rx II
  - VF zone NID = 18/24
  - FVT via VF zone with ATP

- EMPIRIC
  - VF zone NID = 18/24
  - FVT via VF zone with ATP

**BPMs:**
- 182 bpm
- 150 bpm
PREPARE Methods

- Prospective, historic cohort controlled study
- Primary prevention ICD indications
- 700 patients
  - 38 Centers: United States and Europe
  - October 2003 – May 2005
- One-year follow-up
- Medtronic Marquis®-based ICDs and leads
- Single, dual, and BiV patients
PREPARE Study Programming Considerations

Devices used in PREPARE cohort: Medtronic Marquis® single and dual chamber ICDs, InSync Marquis™ CRT

Programming considerations in this document do not replace a physician’s expert judgment. The physician’s knowledge of the patient’s medical condition should be considered, and parameter values in the above considerations may be tailored to fit the patient.
PREPARE Hypothesis

Strategically chosen ICD VT/VF detection and therapy parameters can reduce the combined incidence of device-delivered shocks, arrhythmic syncope, and untreated sustained symptomatic VT/VF in primary prevention patients.
PREPARE Primary End Point

- Morbidity Index
  - Spontaneous episodes treated with shocks
  - Arrhythmic syncope
  - Untreated, sustained symptomatic VT/VF episodes
PREPARE: Shocked Episodes Were Reduced by 63%
PREPARE Patients Were Less Likely to Receive a Shock in the First Year

* Results remain significant after adjusting for differences in baseline characteristics.

** Not significant after adjusting for differences in baseline characteristics.

Overall safety was excellent as measured by arrhythmic syncope, untreated VT, and mortality.

- Arrhythmic syncope was rare (1.6%).
- All-cause mortality was low (Kaplan-Meier estimated 12-month mortality: 4.9%).
Objective:
- To determine whether using 30 of 40 intervals to detect ventricular arrhythmias (VT) (long detection CL ≤ 320ms) during spontaneous fast VT episodes reduces antitachycardia pacing (ATP) and shock delivery more than 18 of 24 intervals (standard detection).

Methods:
- 94 centers, 1902 patients including primary and secondary prevention pts implanted with SC, DC and CRTD.
- Measured total number of ATPs and shocks delivered for all episodes and inappropriate shocks, mortality, and syncopal rate.

Results:
For primary and secondary prevention patients, programming NID 30/40 combined with ATP During Charging…
- **45% Reduction of inappropriate shocks**
- **19% Reduction of all-cause hospitalizations**

1Gasparini, MD et al. JAMA. 2013;309(18):1903-1911.
Patients programmed to 30/40 showed a 37% reduction of shock and ATP therapies as compared to patients programmed to 18/24.

<table>
<thead>
<tr>
<th>Exposure, per Patient-Year&lt;sup&gt;a&lt;/sup&gt;</th>
<th>No. of Detected Arrhythmias</th>
<th>No. of Therapies Delivered</th>
<th>No. of Patients</th>
<th>Therapy Rate per 100 Patient-Year (95% CI)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>IRR (95% CI)&lt;sup&gt;c&lt;/sup&gt;</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard-interval detection</td>
<td>830</td>
<td>321</td>
<td>557</td>
<td>67 (62-73)</td>
<td>1 [Reference]</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Long detection</td>
<td>826</td>
<td>209</td>
<td>346 Therapies</td>
<td>42 (38-47)</td>
<td>0.63 (0.51-0.78)</td>
<td></td>
</tr>
</tbody>
</table>

- Median Follow up: 12 months

<sup>1</sup> Gasparini, MD et al. JAMA. 2013;309(18):1903-1911.
Primary Endpoint Results

Time to first therapy is significantly different between 18/24 and 30/40 detection intervals

1 Gasparini, MD et al. JAMA. 2013;309(18):1903-1911.
### Secondary Endpoints Results

#### 45% Reduction of inappropriate shocks

<table>
<thead>
<tr>
<th>Exposure, per Patient-Year</th>
<th>No. of Ventricular Arrhythmias</th>
<th>No. of Therapies Delivered</th>
<th>No. of Patients</th>
<th>Shock Rate per 100 Patient-Year (95% CI)</th>
<th>IRR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard-interval detection</td>
<td>830</td>
<td>230</td>
<td>58</td>
<td>18 (15-20)</td>
<td>1</td>
<td>.80</td>
</tr>
<tr>
<td>Long detection</td>
<td>826</td>
<td>163</td>
<td>55</td>
<td>13 (11-16)</td>
<td>0.95 (0.67-1.37)</td>
<td>.003</td>
</tr>
<tr>
<td>Standard-interval detection</td>
<td>830</td>
<td>85 Inappropriate detections</td>
<td>93</td>
<td>11 (9-14)</td>
<td>1</td>
<td>.003</td>
</tr>
<tr>
<td>Long detection</td>
<td>826</td>
<td>40 Inappropriate detections</td>
<td>42</td>
<td>5 (4-7)</td>
<td>0.55 (0.36-0.85)</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Gasparini, MD et al. JAMA. 2013;309(18):1903-1911.
Conclusion

Reducing shocks by NID extension for both primary and secondary patients is important

In Primary Prevention Patients
PREPARE showed a 63% reduction in shocks for patients programmed with strategically chosen programming, including a NID of 30/40, as compared to historical trials

In Secondary Prevention Patients
ADVANCE III showed a 37% reduction of shock and ATP therapies for patients programmed to 30/40 as compared to 18/24 with no difference in syncopal events

ATP During Charging with ATP success

Capacitor Charging

Detection ATP

Shock Avoided

CE Normal sinus rhythm detected
<table>
<thead>
<tr>
<th>Condition</th>
<th>Arrhythmia Features</th>
<th>Programming</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary prevention (low EF)</td>
<td>FVT often is monomorphic and heart rate is &gt;200 beats/min</td>
<td>Use 2 detection zones with VT cutoff of 180–190 beats/min. Use 1–2 sequences of ATP for tachycardias &lt;250 beats/min. Long duration or 30 of 40 NID.</td>
<td>Detection algorithms are not exposed to lower rates, thus minimizing inappropriate detections. Two zones permit increased ATP use in the lower heart rate zone.</td>
</tr>
<tr>
<td>Secondary prevention</td>
<td>Monomorphic VT with heart rates 120–200 beats/min</td>
<td>Use 3 detection zones. Program detection enhancements on; use DC enhancements if available.</td>
<td>Permits increased detection enhancements and ATP for slow VTs. Permits tiered therapies.</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>Bradycardia VT/VF</td>
<td>Avoid RV pacing and use RV pacing avoidance algorithms if available. Program as for primary and secondary prevention.</td>
<td>Chronic RV pacing may exacerbate heart failure.</td>
</tr>
<tr>
<td>History or risk of rapidly conducting AF</td>
<td>AF Sinus bradycardia</td>
<td>Promote atrial pacing and minimize ventricular pacing. SVT discriminators such as interval stability and morphology.</td>
<td>Atrial termination algorithms may be particularly useful in patients with atrial flutter and other atrial tachycardias. Avoid use in first month because of potential for lead dislodgement. Avoid shocks for atrial arrhythmias.</td>
</tr>
<tr>
<td>Channelopathies</td>
<td>Rapid polymorphic VT/VF, Frequent nonsustained episodes Brugada and long QT during sinus rhythm</td>
<td>Single detection zone for heart rates &gt;200 beats/min. Detection enhancements off. Avoid ATP Prolong detection Screen for TWOS and program as necessary</td>
<td>Clinical arrhythmia is rapid, thus underdetection of slower rhythms is not a concern; young patients can achieve physiologically rapid heart rates with exercise. Enhancements generally are ineffective in VF zone at rapid rates. Role of ATP in polymorphic VT/VF is not established; ATP could be proarrhythmic. Prevents unnecessary charging and shocks. Prevents inappropriate shocks.</td>
</tr>
</tbody>
</table>
THANK YOU FOR YOUR ATTENTION