Shock Reduction Strategies
Michael Geist
E. Wolfson MC
Shock Therapy

Thanks, I needed that!
Why Do We Need To Reduce Shocks

Shocks burden and increased mortality in implantable cardioverter-defibrillator patients

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BACKGROUND Implantable cardioverter-defibrillator (ICD) shocks are associated with an increased risk of death. It is unclear whether ICD shocks are detrimental per se or a marker of higher risk patients.

OBJECTIVE We aimed to assess the association between ICD shocks and time to death after correction for baseline mortality based on the Seattle Heart Failure Model (SHFM).

METHODS The primary analysis compared time-to-death between patients receiving no shocks and patients receiving shocks of any type adjusted for SHFM score at time of implantation and other comorbidities. Subgroup analyses were performed to further describe the relationship between shocks and mortality risk.

RESULTS Over a median follow-up of 41 months (interquartile range 23–64), one or more shock episodes occurred in 59% of 425 patients and 40% of the patients died. Patients receiving shocks of any type had increased risk of death (hazard ratio 1.55; 95% confidence interval 1.07–2.23; P = .02) versus patients receiving no shocks. While patients with 1–5 days with shock (shock days) did not show evidence of increased risk of death (1.30 [0.88–1.94]; P = .19), those with 6–10 shock days (2.22 [1.21–4.08]; P < .01) and >10 shock days (3.66 [1.86–7.19]; P < .01) had increasingly higher risk. There was no increased hazard for death (0.73 [0.34–1.57]; P = .41) in patients treated only with antitachycardia pacing (ATP).

CONCLUSION ICD shocks were associated with increased mortality risk after adjustment for SHFM-predicted mortality, and the burden of shocks played a role in this association. ATP did not increase mortality risk, suggesting that shocks may themselves be detrimental.

KEYWORDS Implantable cardioverter-defibrillator: Shocks; Antitachycardia pacing; Ventricular arrhythmia; Death

ABBREVIATIONS ATP = antitachycardia pacing; AF = atrial fibrillation; CAD = coronary artery disease; CHF = congestive heart failure; CI = confidence interval; CKD = chronic kidney disease; DM = diabetes mellitus; EF = ejection fraction; HR = hazard ratio; HTN = hypertension; ICD = Implantable cardioverter defibrillator; IQR = interquartile range; SHFM = Seattle Heart Failure Model; VA = ventricular arrhythmia; VF = ventricular fibrillation; VT = ventricular tachycardia

(Heart Rhythm 2011;8:1881–1886) Published by Elsevier Inc. on behalf of the Heart Rhythm Society.)
Survival status in patients implanted with ICD and CRT devices across the United States from a single manufacturer was assessed. Outcomes were compared between patients followed in device clinic settings and those who regularly transmit remote data collected from the device an average of 4 times monthly. Shock delivery and electrogram analysis could be ascertained from patients followed on the network, enabling survival after ICD shock to be evaluated. **One- and 5-year survival rates in 185,778** patients after ICD implantation were 92% and 68% and were 88% and 54% for CRT-D device recipients. In 8228 patients implanted with CRT-only devices, survival was 82% and 48% at 1 and 5 years, respectively. For the 69,556 ICD and CRT-D patients receiving remote follow-up on the network, 1- and 5-year survival rates were higher compared with those in the 116,222 patients who received device follow-up in device clinics only (50% reduction; P<0.0001). There were no differences between patients followed on or off the remote network for the characteristics of age, gender, implanted device year or type, and economic or educational status. **Shock therapy was associated with subsequent mortality risk for both ICD and CRT-D recipients.**

**CONCLUSIONS:**

- Survival after ICD and CRT-D implantation in patients treated in naturalistic practice compares favorably with survival rates observed in clinical trials.
- Remote follow-up of device data is associated with excellent survival, but arrhythmias that result in device therapy in this population are associated with a higher mortality risk compared with patients who do not require shock therapy.
Shock Reduction Strategies

Arrhythmia Reduction Methods

- **Treat precipitating factors:**
  - Electrolyte abnormality.
  - CHF -including CRT implant.
  - Avoid proarrhythmic medications.
  - Consider arrhythmic inducing pacing sites.
  - Use Guidelines recommended anti arrhythmics – ACE inhibitors, Statins, Beta-blockers.
  - Correct Ischemia.
  - Correct bradycardia
  - Treat Endocrine abnormalities (thyrotoxicosis..).

*Geist M, Rozenman Y. Patients with recurrent malignant ventricular arrhythmias–therapeutic challenge. Harefuah. 2006 May;145(5):348-9, 398*
Shock Reduction Strategies
Arrhythmia Reduction Methods

Specific treatment.

- Anti arrhythmic therapy.
- Avoid inappropriate treatment
- Avoid hasty appropriate treatment -
- ATP
- VT Ablation & Scar excision.

Geist M, Rozenman Y. Patients with recurrent malignant ventricular arrhythmias—therapeutic challenge. Harefuah. 2006 May;145(5):348-9, 398

302 Patients RCT 160-320 mg Sotalol /day ,f/u 12 month.

- 41 European, 3 USA centers.
- Mean age 61 Placebo 63 Sotalol
- LVEF% 39 Placebo 37 Sotalol
- Mean/median dose 207±55/242 mg Sotalol
- Discontinue: Sotalol -34%
  - Placebo 35%

OUTCOME:
- Death 7 Placebo 4 Sotalol
- DC 73(48%) 45(30%)
Comparison of β-Blockers, Amiodarone Plus β-Blockers, or Sotalol for Prevention of Shocks From Implantable Cardioverter Defibrillators

The OPTIC Study: A Randomized Trial

JAMA, January 11, 2006—Vol 295, No. 2
OPTIC STUDY

**Design, Setting, and Patients**  A randomized controlled trial with blinded adjudication of events of 412 patients from 39 outpatient ICD clinical centers located in Canada, Germany, United States, England, Sweden, and Austria, conducted from January 13, 2001, to September 28, 2004. Patients were eligible if they had received an ICD within 21 days for inducible or spontaneously occurring ventricular tachycardia or fibrillation.

**Intervention**  Patients were randomized to treatment for 1 year with amlodarone plus β-blocker, sotalol alone, or β-blocker alone.

**Main Outcome Measure**  Primary outcome was ICD shock for any reason.

**Results**  Shocks occurred in 41 patients (38.5%) assigned to β-blocker alone, 26 (24.3%) assigned to sotalol, and 12 (10.3%) assigned to amlodarone plus β-blocker. A reduction in the risk of shock was observed with use of either amlodarone plus β-blocker or sotalol vs β-blocker alone (hazard ratio [HR], 0.44; 95% confidence interval [CI], 0.28-0.68; \( P < .001 \)). Amlodarone plus β-blocker significantly reduced the risk of shock compared with β-blocker alone (HR, 0.27; 95% CI, 0.14-0.52; \( P < .001 \)) and sotalol (HR, 0.43; 95% CI, 0.22-0.85; \( P = .02 \)). There was a trend for sotalol to reduce shocks compared with β-blocker alone (HR, 0.61; 95% CI, 0.37-1.01; \( P = .055 \)). The rates of study drug discontinuation at 1 year were 18.2% for amlodarone, 23.5% for sotalol, and 5.3% for β-blocker alone. Adverse pulmonary and thyroid events and symptomatic bradycardia were more common among patients randomized to amlodarone.

**Conclusions**  Despite use of advanced ICD technology and treatment with a β-blocker, shocks occur commonly in the first year after ICD implant. Amlodarone plus β-blocker is effective for preventing these shocks and is more effective than sotalol but has an increased risk of drug-related adverse effects.
Table 4. Adverse Events of the 3 Treatment Assignments

<table>
<thead>
<tr>
<th>Adverse Event</th>
<th>β-Blocker (n = 138)</th>
<th>Amiodarone + β-Blocker (n = 140)</th>
<th>Sotalol (n = 134)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>2 (1.4)</td>
<td>6 (4.3)</td>
<td>4 (3.0)</td>
<td>.36</td>
</tr>
<tr>
<td>Arrhythmic death</td>
<td>1 (0.7)</td>
<td>2 (1.4)</td>
<td>1 (0.8)</td>
<td>.60</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>1 (0.7)</td>
<td>1 (0.7)</td>
<td>0</td>
<td>.62</td>
</tr>
<tr>
<td>Heart failure</td>
<td>9 (6.5)</td>
<td>12 (8.6)</td>
<td>14 (13.4)</td>
<td>.14</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>6 (4.4)</td>
<td>1 (0.7)</td>
<td>6 (4.5)</td>
<td>.13</td>
</tr>
<tr>
<td>Pulmonary adverse event</td>
<td>0</td>
<td>7 (5.0)</td>
<td>4 (3.0)</td>
<td>.03</td>
</tr>
<tr>
<td>Hypothyroidism</td>
<td>0</td>
<td>6 (4.3)</td>
<td>1 (0.8)</td>
<td>.01</td>
</tr>
<tr>
<td>Hyperthyroidism</td>
<td>0</td>
<td>2 (1.4)</td>
<td>0</td>
<td>.14</td>
</tr>
<tr>
<td>Symptomatic bradycardia</td>
<td>1 (0.7)</td>
<td>8 (6.4)</td>
<td>2 (1.5)</td>
<td>.009</td>
</tr>
<tr>
<td>Torsades de pointes</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Skin adverse event</td>
<td>2 (1.5)</td>
<td>4 (2.9)</td>
<td>3 (2.2)</td>
<td>.72</td>
</tr>
<tr>
<td>Device infection</td>
<td>1 (0.7)</td>
<td>2 (1.4)</td>
<td>4 (3.0)</td>
<td>.34</td>
</tr>
<tr>
<td>Hospitalized during follow-up</td>
<td>60 (43.3)</td>
<td>49 (34.9)</td>
<td>40 (30.1)</td>
<td>.32</td>
</tr>
</tbody>
</table>
**Figure 1. Flow of Patients in the OPTIC Trial**

- 412 Patients Randomized
  - 136 Assigned to Receive β-Blocker
  - 136 Received Intervention as Assigned
  - 8 Lost to Follow-up
  - 7 Discontinued Therapy
  - 138 Included in Analysis

- 140 Assigned to Receive Amiodarone + β-Blocker
  - 140 Received Intervention as Assigned
  - 5 Lost to Follow-up
  - 25 Discontinued Therapy
  - 140 Included in Analysis

- 134 Assigned to Receive Sotalol
  - 134 Received Intervention as Assigned
  - 2 Lost to Follow-up
  - 31 Discontinued Therapy
  - 134 Included in Analysis

OPTIC indicates Optimal Pharmacological Therapy in Cardioverter Defibrillator Patients.

**Figure 2. Cumulative Rate of Shock for the 3 Treatment Groups by Time Since Randomization**

![Cumulative Rate of Shock Graph]

- Log-rank P < .001 for amiodarone plus β-blocker vs β-blocker alone, log-rank P = .02 for amiodarone plus β-blocker vs sotalol alone, and log-rank P = .055 for sotalol vs β-blocker.
Methods To Avoid Or Reduce Inappropriate Shocks Therapies.

- High cut off – Detect only at faster rhythms.
- Sudden onset.
- Stability.
- Detect during charge.
- Reconfirmation post charge.
- Dual chamber sensing. (DATAS trial)
- QRS template Identification.
- Remote monitoring.

DATAS Europace. 2008 May;10(5):528-35.
Methods To Avoid or Reduce Appropriate Shocks Therapies.

- Programming ATP prior to DC in all zones.
- Avoidance of “Shock box”, Programming multiple zones-PainFREE Rx II.
- Prolonged detection – ADVANCE, “MADIT RIT”
Single Vs. Multiple Zones

Real world evaluation of dual-zone ICD and CRT-D programming compared to single-zone programming: the ALTITUDE REDUCES study.

- frequency of appropriate and inappropriate shocks and survival in patients were followed for 1.6 ± 1.1 years.
- The 12-month incidence of any shock was lower for dual-versus single-zone programmed detection at rates ≤170 bpm and between 170-200 bpm (P < 0.001).
- Appropriate shock rates at 1 year were also lower with dual-zone programming in these rate intervals (single zone 9.1%, 5.4%, P < 0.001, dual zone 6.7%, 4.7%, P < 0.02).
- There were no detectable differences between single- and dual-zone shock incidence at detection rates ≥ 200 bpm (P = 0.14).
- Inappropriate shock incidence was less with dual- versus single-zone detection at all detect rates <200 bpm, but not at rates ≥200 bpm (P < 0.001, P = 0.37).
- The lowest risk of appropriate and inappropriate shock was associated with dual-zone programming and detection rates ≥200 bpm (2.1%).
- Dual-zone detection was associated with more nonsustained and diverted therapy episodes but these patients did not have an increased risk of death compared to patients with single-zone programming.
- Patients programmed to low detection rate, single-zone detection and shock-only therapy also had the highest preshock mortality risk (P = 0.05).

CONCLUSIONS:

- Shock incidence is lowest with either single- or dual-zone detection ≥200 bpm.
- For detection rates <200 bpm, dual-zone programming is associated with a reduction in the incidence of total shocks, appropriate shocks, and inappropriate shocks.

Meta analysis of Studies to Prevent DC.

ICD Trials With Algorithms To Prevent Shocks (pre MADIT RIT)

Specific Trials
PREPARE Strategic Programming of Detection and Therapy Parameters in Implantable Cardioverter-Defibrillators Reduces Shocks in Primary Prevention Patients:

- Prospective, historic cohort controlled study Vs. -Primary prevention ICD indications
- 700 pts - October 2003 – May 2005
- 1 year follow-up
- Medtronic Marquis-based ICD’s and leads, Single, dual and Bi-V patients.
- MIRACLE ICD -978 patients Bi-V devices 415 primary prevention patients.
  - EMPIRIC trial – 900 dual chamber ICD 276 primary prevention patients Total Control Cohort
  - 691 primary prevention, Bi-V and Non Bi-V

Bruce L. Wilkoff et al. Results from the PREPARE (Primary Prevention Parameters Evaluation) Study1. J Am Coll Cardiol 2008; 52:541-50
## 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
Patients Shocked at One year

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

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

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

Patient Mortality

% Patients

0% 2% 4% 6% 8% 10% 12%

0 3 6 9 12

Pts at Risk
PREPARE: 700 674 633 615 434
Control: 689 612 531 445 345

p < 0.01

Control: 8.7%
PREPARE: 4.9%
PainFREE Rx II
Prospective, Randomized Multicenter Trial of Empirical ATP versus Shocks for Fast VT in ICD Patients:

- 634 patients-Single-Blinded (248 PRIMARY 334 secondary 52 non standard)
- Enrollment: January 2001 - April 2003
- Demographics:
  - Age -67, 32% LVEF, 80% Male, 85% CAD, 48 % 1 prevention.
- Required Detection Programming:
  - Fast VT via VF
  - # intervals to detect = 18/24
  - PR Logic “ON” in all dual chamber ICD, SVT limit of 320ms.
  - Zones: VF 240 (250 ms), FVT via VF 188 (320 ms), VT 167 (360 ms).

## PainFREE $R_x$ II
Required FVT Therapy

<table>
<thead>
<tr>
<th>ATP Arm</th>
<th>Shock Arm</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_x1$ Burst ATP</td>
<td>Shock DFT+10 J</td>
</tr>
<tr>
<td>- 1 sequence</td>
<td></td>
</tr>
<tr>
<td>- 8 pulses</td>
<td></td>
</tr>
<tr>
<td>- 88% of VTCL</td>
<td></td>
</tr>
<tr>
<td>$R_x2$ Shock DFT+10 J</td>
<td>Shock max output</td>
</tr>
<tr>
<td>$R_x3$-6 Shock max output</td>
<td>Shock max output</td>
</tr>
</tbody>
</table>
True Ventricular Episodes* (n=1342)

- "Slow" VT 167-188/min: 777, 58%
-VF> 240 min: 134, 10%
- FVT 188-240 min: 431, 32% (98 pts)

*Rhythms adjudicated by a physician panel
Distribution of ventricular arrhythmias by detection zone and median CL

- VT: 58%
- FVT: 32%
- VF: 10%

Median Cycle Length (ms)

# of episodes

- <200
- 200-220
- 220-240
- 240-260
- 260-280
- 280-300
- 300-320
- 320-340
- 340-360
- 360-380
- 380-400
- 400-420
- 420-440
- >460
FVT Outcome: Shock Arm

- Shocked: 99/147 (64%)
- Spontaneous Termination: 44/147 (34%)
- ATP**: 4/147 (2%)

- Percentages adjusted for patients with multiple episodes (generalized estimating equation used)
- **crossover patients
FVT Outcome: ATP Arm

ATP Success
229/284
72%

ATP Failed
49/284
28%

* Percentages adjusted for patients with multiple episodes (generalized estimating equation used)
## Other FVT Endpoints

<table>
<thead>
<tr>
<th></th>
<th>ATP Arm</th>
<th>Shock Arm</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acceleration</strong></td>
<td>n=4</td>
<td>n=2</td>
<td></td>
</tr>
<tr>
<td>(&gt;10% ↓ in CL)</td>
<td>2%</td>
<td>1%</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Syncope FVT</strong></td>
<td>n=2</td>
<td>n=1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.7%</td>
<td>0.7%</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Mortality</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32 (10%)</td>
<td>24 (7%)</td>
<td>NS</td>
</tr>
<tr>
<td>Sudden Cardiac</td>
<td>1 (0.3%)</td>
<td>2 (0.6%)</td>
<td>NS</td>
</tr>
</tbody>
</table>
Conclusions- PainFREE Rx II

1. A single empiric ATP attempt terminated 72% (adjusted) of Fast VTs.

2. ATP did not increase negative outcomes in terms of acceleration, syncope and mortality.

3. Patients treated by ATP have improved QoL score as compared to patients treated with shock.

4. Investigators of the PainFREE Rx II trial recommend ATP as the preferred therapy for FVT in most ICD patients.

Reduction in Inappropriate Therapy and Mortality through ICD Programming

BACKGROUND
The implantable cardioverter–defibrillator (ICD) is highly effective in reducing mortality among patients at risk for fatal arrhythmias, but inappropriate ICD activations are frequent, with potential adverse effects.

METHODS
We randomly assigned 1500 patients with a primary-prevention indication to receive an ICD with one of three programming configurations. The primary objective was to determine whether programmed high-rate therapy (with a 2.5-second delay before the initiation of therapy at a heart rate of ≥200 beats per minute) or delayed therapy (with a 60-second delay at 170 to 199 beats per minute, a 12-second delay at 200 to 249 beats per minute, and a 2.5-second delay at ≥250 beats per minute) was associated with a decrease in the number of patients with a first occurrence of inappropriate antitachycardia pacing or shocks, as compared with conventional programming (with a 2.5-second delay at 170 to 199 beats per minute and a 1.0-second delay at ≥200 beats per minute).

RESULTS
During an average follow-up of 1.4 years, high-rate therapy and delayed ICD therapy, as compared with conventional device programming, were associated with reductions in a first occurrence of inappropriate therapy (hazard ratio with high-rate therapy vs. conventional therapy, 0.21; 95% confidence interval [CI], 0.13 to 0.34; P=0.001; hazard ratio with delayed therapy vs. conventional therapy, 0.24; 95% CI, 0.15 to 0.40; P=0.001) and reductions in all-cause mortality (hazard ratio with high-rate therapy vs. conventional therapy, 0.45; 95% CI, 0.24 to 0.85; P=0.01; hazard ratio with delayed therapy vs. conventional therapy, 0.56; 95% CI, 0.30 to 1.02; P=0.06). There were no significant differences in procedure-related adverse events among the three treatment groups.

CONCLUSIONS
Programming of ICD therapies for tachyarrhythmias of 200 beats per minute or higher or with a prolonged delay in therapy at 170 beats per minute or higher, as compared with conventional programming, was associated with reductions in inappropriate therapy and all-cause mortality during long-term follow-up. (Funded by Boston Scientific; MADIT-RIT ClinicalTrials.gov number, NCT00947310.)
1500 patients with a primary-prevention ICD with one of three programming with Average follow-up of 1.4 years configurations:

- **High-rate** therapy (2.5-second delay before the initiation of therapy at a heart rate of ≥200 beats/minute.
- **Delayed** therapy -60-second delay at 170 to 199 beats per minute, a 12-second delay at 200 to 249 beats per minute, and a 2.5-second delay at ≥250 beats.
- Conventional programming (with a 2.5-second delay at 170 to 199 beats per minute and a 1.0-second delay at ≥200 beats.

Results: high-rate therapy and delayed ICD therapy, as compared with conventional device programming, were associated with reductions in a first occurrence of inappropriate therapy

- HR high-rate therapy vs. conventional therapy, 0.21; CI, 0.13 to 0.34; P<0.001;
- HR with delayed therapy vs. conventional therapy, 0.24; CI, 0.15 to 0.40; P<0.001).

Reductions in all-cause mortality:

HR high-rate therapy vs. conventional therapy, 0.45; CI, 0.24 to 0.85; P=0.01;
HR delayed therapy vs. conventional therapy, 0.56; CI, 0.30 to 1.02; P=0.06

There were no significant differences in procedure-related adverse events among the three treatment groups.

**CONCLUSIONS:** Programming of ICD therapies for tachyarrhythmias of > 200 beats or prolonged delay in therapy at 170 beats per minute or higher, compared with conventional programming, was associated with reductions in inappropriate therapy and all-cause mortality during long-term follow-up

1st And Total Occurrence Of Therapy – Main Difference In ATP In Conventional Arm

<table>
<thead>
<tr>
<th>Variable</th>
<th>Conventional Therapy (N=514)</th>
<th>High-Rate Therapy (N=500)</th>
<th>Delayed Therapy (N=466)</th>
<th>P Value for High-Rate Therapy vs. Conventional Therapy</th>
<th>P Value for Delayed Therapy vs. Conventional Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>First occurrence of therapy — no. of patients (%)</td>
<td>Appropriate therapy</td>
<td>114 (22) 45 (9) 27 (6)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shock</td>
<td>20 (4) 22 (4) 17 (3)</td>
<td>0.64</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antitachycardia pacing</td>
<td>94 (18) 23 (5) 10 (2)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Inappropriate therapy</td>
<td>Appropriate therapy</td>
<td>105 (20) 21 (4) 26 (5)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shock</td>
<td>20 (4) 11 (2) 13 (3)</td>
<td>0.12</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antitachycardia pacing</td>
<td>85 (17) 10 (2) 13 (3)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Any occurrence of therapy — no. of patients (%)</td>
<td>Appropriate therapy</td>
<td>28 (5) 26 (5) 19 (4)</td>
<td>0.86</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shock</td>
<td>111 (22) 38 (8) 20 (4)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antitachycardia pacing</td>
<td>31 (6) 14 (3) 15 (3)</td>
<td>0.01</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Inappropriate therapy</td>
<td>Shock</td>
<td>104 (20) 20 (4) 25 (5)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antitachycardia pacing</td>
<td>105 (20) 25 (5) 40 (16)</td>
<td>0.001</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Total occurrences of therapy — no. of occurrences</td>
<td>Appropriate therapy</td>
<td>517 185 196</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shock</td>
<td>71 72 53</td>
<td>0.35</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antitachycardia pacing</td>
<td>446 113 143</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Inappropriate therapy</td>
<td>Shock</td>
<td>998 75 264</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antitachycardia pacing</td>
<td>105 25 40</td>
<td>0.001</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>893 50 215</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

* Crude rates of the first occurrence of therapy and any occurrence of therapy were compared with the use of chi-square tests, and mean counts of total occurrences of therapy were compared with the use of negative binomial regression models.
Cumulative Probability Of 1st Inappropriate Therapy.

Cumulative Probability Of Death

Figure 1. Cumulative Probability of First Occurrence of Inappropriate Therapy According to Treatment Group.
The values in parentheses are Kaplan–Meier estimates of the cumulative probability of a first occurrence of inappropriate device-delivered therapy in patients randomly assigned to therapy programmed for delivery at a heart rate of 170 beats per minute or higher (conventional therapy), at a heart rate of 200 beats per minute or higher (high-rate therapy), or at a heart rate of 170 beats per minute or higher with longer tachycardia hemia monitoring (delayed therapy).

Figure 2. Cumulative Probability of Death According to Treatment Group.
The values in parentheses are Kaplan–Meier estimates of the cumulative probability of death.
Table 3. Hazard Ratios for a First Occurrence of Inappropriate Therapy, Death, and a First Episode of Syncope According to Treatment Group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Conventional Therapy (N = 514)</th>
<th>High-Rate Therapy (N = 500)</th>
<th>Delayed Therapy (N = 486)</th>
<th>High-Rate Therapy vs. Conventional Therapy</th>
<th>Delayed Therapy vs. Conventional Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hazard Ratio (95% CI)</td>
<td>P Value</td>
<td>Hazard Ratio (95% CI)</td>
<td>P Value</td>
<td>Hazard Ratio (95% CI)</td>
</tr>
<tr>
<td>First occurrence of inappropriate therapy</td>
<td>105</td>
<td>21</td>
<td>26</td>
<td>0.21 (0.13–0.34)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Death</td>
<td>34</td>
<td>16</td>
<td>21</td>
<td>0.45 (0.24–0.85)</td>
<td>0.01</td>
</tr>
<tr>
<td>First episode of syncope</td>
<td>23</td>
<td>22</td>
<td>22</td>
<td>1.32 (0.71–2.47)</td>
<td>0.39</td>
</tr>
</tbody>
</table>
Implantable cardioverter-defibrillator shock prevention does not reduce mortality: A systemic review.
Does Shock Reduction Improve Survival
CONTEMPORARY REVIEW

Implantable cardioverter-defibrillator shock prevention does not reduce mortality: A systemic review

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BACKGROUND Mortality is increased among implantable cardioverter-defibrillator (ICD) recipients who receive shocks; however, whether shocks cause this increase or are simply a marker of risk is unknown. Antiarrhythmic medications, catheter ablation, and enhanced ICD programming all may reduce ICD shocks, but whether shock reduction decreases mortality is unknown.

OBJECTIVE The purpose of this study was to conduct a meta-analysis to estimate the impact of ICD shock reduction on survival.

METHODS Two independent reviewers searched MEDLINE, EMBASE, and clinicaltrials.gov and extracted data from randomized controlled trials assessing the efficacy of interventions to prevent ICD shocks.

RESULTS Seventeen randomized trials were included in this analysis, including 5875 patients. Mean ejection fraction of all trial participants was 32%, and 25% of the patients received ICD therapy for primary prophylaxis. Antiarrhythmic medications (odds ratio [OR] 0.59, 95% confidence interval [CI] 0.36–0.96, P = .03) and catheter ablation of ventricular tachycardia (OR 0.35, 95% CI 0.19–0.62, P = .0004) significantly reduced the proportion of patients receiving shocks. However, there was no significant reduction in mortality among trials of antiarrhythmic medications (OR 1.07, 95% CI 0.72–1.59, P = .73) or catheter ablation (OR 0.72, 95% CI 0.32–1.64, P = .44). The 5 ICD programming trials had sufficiently heterogeneous interventions that pooling of their results was not performed. However, only the PAINFREE-II (Pacing Fast Ventricular Tachycardia Reduces Shock Therapies) trial demonstrated a significant reduction in shocks (OR 0.38, 95% CI 0.22–0.65), but this was not associated with any significant reduction in mortality (OR 1.41, 95% CI 0.81–2.45).

CONCLUSION There is no compelling evidence that existing interventions that reduce ICD shocks significantly improve survival.

KEYWORDS Implantable cardioverter defibrillator; Mortality; Prevention; Shock

ABBREVIATIONS ATP = antitachycardia pacing; CI = confidence interval; ICD = implantable cardioverter-defibrillator; OR = odds ratio; VT = ventricular tachycardia

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Implantable cardioverter-defibrillator shock prevention does not reduce mortality: A systemic review.
Summary

- A significant number of clinical arrhythmias self terminate.
- Patients who receive ICD shocks have a worse prognosis.
- Intelligent programming reduces Inappropriate and appropriate DC.
- Shock prevention has morbidity & QOL implications but not necessarily mortality effect.
- Use of programmable technology facilitates better programming, and reduces device shocks, Specifically:
  - Faster minimal detection rates. (> 200)
  - Longer waiting time before device activated treatment.
  - Use of ATP in all zones prior to shock down to 250-270 ms cl.
  - Remote monitoring to detect hardware failure earlier and avoid inappropriate therapy?
- **MADIT RIT** – “Think before you act” is valid also for defibrillators.