Pathophysiology and outcome of incessant VT, electrical storm and acute cardiac failure
Outline

- VT/VF: background
- VT/VF in ICD patients
- Incessant VT
- Electrical storm
- Acute heart failure
Disclosure

Research grants: Medtronic, Biotronik
Consultant: Medtronic, Biotronik, Boston Scientific
Speakers Bureau: Medtronic, St-Jude Medical, Sorin
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Sudden cardiac death

Most common cause of death

~ 50% of all cardiovascular death

In ~ 25% the first symptom of CV disease

- 88% Arrhythmic Cause
- 12% Other
- VT 62%
- Primary VF 8%
- Bradycardia 17%
- Torsades de Pointes 13%
Incidence of SCD in specific populations

GROUP

General population
High coronary-risk profile
Previous coronary event
Ejection fraction <35%, congestive heart failure
Previous out-of-hospital cardiac arrest
Previous myocardial infarction, low ejection fraction, and ventricular tachycardia

Incidence of Sudden Death (% per year)

No. of Sudden Deaths per year

Ventricular arrhythmia

**With** structural heart disease
- Acute ischemia (MI)
- Chronic IHD
- DCM
- HCM
- ARVC
- Cardiomyopathies
- Valvular heart disease
- Congenital heart disease
- Neurological disorders

**Without** structural heart disease
- LQTS
- Brugada
- Catecholaminergic polymorphic VT
- Idiopathic
  - Outflow tract VT
  - Fascicular VT
- (Early repolarization)
- (Short QT)
Mechanisms of arrhythmogenesis

- Re-entry
- Triggered activity
- Enhanced automaticity
- Heterogeneity of repolarization
Cardiac arrest

Circadian variation

Seasonal variation

n = 10,868, Swedish National Registry

Herlitz et al, Resuscitation 54 (2002) 133/138
Cardiac arrest: survival

Swedish Cardiac Arrest Register
n=38,646 Out of Hospital Cardiac Arrest with CPR (1992-2005)

Cardiac arrest

Swedish Cardiac Arrest Register
n=38 646 Out of Hospital Cardiac Arrest with CPR (1992-2005)

Survival in relation to rhythm

Outcome after VT/VF

Meta-analysis of secondary SCD prevention trials: AVID, CIDS, CASH

n = 1866: VT, VF, syncope (low proportion with beta-blocker and ACE-I)

ICD shocks, a complex clinical issue

- Caused by implanted device
- Occurs with or w/o arrhythmia
- Symptoms with a broad range of severity
- Other medical conditions may be involved
- Causes patient distress and anxiety
- Causes physician anxiety
- Barrier to ICD implantation
Types of shock

1) Appropriate shocks
   - VF, VT

2) Unnecessary shocks
   - Haemodynamically tolerated NSVT
   - Haemodynamically tolerated VT sensitive for ATP

3) Inappropriate shocks
   - Supraventricular tachycardia (AF!)
   - Signal misinterpretation
     T-wave oversensing
     Atrial far-field sensing
     Double or triple sensing of ventricular signals
     Myopotentials
     Lead- and connector-block failure
     Electromagnetic interference

4) Phantom shocks
How common are ICD shocks?

Annual shock rate appr 10% (appr), 7.5% (inappr)
Shock: type of arrhythmia

MADIT II

Patients receiving 1 or more device therapies

First Therapy: VT

First Therapy: VF

54% of repeat episodes occurring within 24 h, 67% within 1 w, 93% within 6 M

Further predictors of electrical therapy:

• Higher NYHA-class
• Interim MI was no predictor

Impact of ICD shocks on prognosis

SCD-HeFT (ICD group analysis)

n=811 (269 pts received shocks: 128 only appr, 87 only inappr, 54 both)

Adjusted for baseline prognostic factors
Death due to progressive HF: 42.9%

Possible explanations

- VT / VF = harbinger of end stage heart failure
- VT / VF = marker of progressive IHD
- AT / AF (inappr) = marker of heart failure
- Post traumatic stress
- Independent adverse impact of VT/VF and/or shocks?
  - cellular damage
  - negative inotropic effects
  - activation of signaling pathways
Vicious circle of stress and arrhythmia

Psychological reactions *should be* assessed already in the acute setting!
Management of patients receiving implantable cardiac defibrillator shocks

Recommendations for acute and long-term patient management

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Incessant VT

Definition:
Repeatedly recurring, persisting for more than half of a 24-h period despite repeated attempts to termination

Typical forms:
1) sustained, terminated by external CV, but recurrent (e.g. ischemic VT)
2) repeated bursts, spontaneously terminating for a few sinus beats, followed by next tachycardia burst (e.g. ideopathic VT)

Symptoms:
Asymptomatic → palpitations → hypotension → death

Incessant idiopathic VT can cause tachycardia-induced cardiomyopathy if not recognized and treated.
Electrical storm

Definition:
3 or more distinct VT/VF episodes within 24 h

Definition for ICD patients:
≥3 VTs in 24 h (appropriate therapies by ATP or shock, sustained VT in VT-monitoring zone).

- 10% to 20% of ICD recipients
- More common in secondary (10-40%) vs primary prevention
- Typically sustained monomorphic VT (90%)
- Polymorphic VT or VF uncommon
- Occurs 6-36 months after ICD implantation
Electrical storm

• No apparent cause in majority of cases
• Potential triggering factors:
  - Drugs (pro-arrhythmia, non-compliance)
  - Worsening HF
  - Myocardial ischaemia
  - Emotional stress and anger
  - Alcohol excess
  - Electrolyte abnormalities
  - Early postoperative period
### Electrical storm: outcome

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>N = 208</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>66 ± 12</td>
</tr>
<tr>
<td>Mean left ventricular ejection fraction (%)</td>
<td>25 ± 12%</td>
</tr>
<tr>
<td>Male</td>
<td>180 (86%)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>157 (75%)</td>
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<tr>
<td>Idiopathic cardiomyopathy</td>
<td>41 (20%)</td>
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<tr>
<td>Other heart disease</td>
<td>10 (5%)</td>
</tr>
<tr>
<td>Congenital</td>
<td>6</td>
</tr>
<tr>
<td>Valvular</td>
<td>4</td>
</tr>
<tr>
<td>Amiodarone</td>
<td>83 (40%)</td>
</tr>
<tr>
<td>Angiotensin-converting enzyme inhibitor</td>
<td>170 (82%)</td>
</tr>
<tr>
<td>Sotalol</td>
<td>14 (7%)</td>
</tr>
<tr>
<td>Beta-blocker</td>
<td>113 (54%)</td>
</tr>
<tr>
<td>ICD for primary prevention</td>
<td>50 (24%)</td>
</tr>
<tr>
<td>ICD for ventricular fibrillation</td>
<td>60 (29%)</td>
</tr>
<tr>
<td>ICD for ventricular tachycardia</td>
<td>98 (47%)</td>
</tr>
<tr>
<td>Follow-up (days)</td>
<td>588 ± 380</td>
</tr>
<tr>
<td>Mean number of ICD therapy per patient</td>
<td>5 ± 5</td>
</tr>
<tr>
<td>Death</td>
<td>57 (27%)</td>
</tr>
</tbody>
</table>

Verma et al. JCE 2004 (15) 1265
Electrical storm: outcome

Verma et al. JCE 2004 (15) 1265
Electrical storm: outcome

MADIT II substudy

Sesselberg et al, Heart Rhythm 2007;4:1395–1402
## Electrical storm: outcome

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Hazard ratio</th>
<th>95% Confidence interval</th>
<th>P value</th>
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<tbody>
<tr>
<td><strong>Effect of ES and isolated VT/VF on death</strong></td>
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<td></td>
<td></td>
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<tr>
<td>No episodes</td>
<td>550</td>
<td>1.0</td>
<td></td>
<td></td>
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<tr>
<td>Isolated VT/VF</td>
<td>142</td>
<td>2.5</td>
<td>1.5–4.0</td>
<td>&lt;.01</td>
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<tr>
<td>ES</td>
<td>27</td>
<td>7.4</td>
<td>3.8–14.4</td>
<td>&lt;.01</td>
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<tr>
<td>&lt;3 months post ES</td>
<td>9</td>
<td>17.8</td>
<td>8.0–39.5</td>
<td>&lt;.01</td>
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<tr>
<td>&gt;3 months post ES</td>
<td>18</td>
<td>3.5</td>
<td>1.2–9.8</td>
<td>.02</td>
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<td><strong>Effect of ES and isolated VT/VF on CHF hospitalizations†</strong></td>
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<tr>
<td>No episodes</td>
<td>1.0</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Isolated VT/VF</td>
<td>1.5</td>
<td>0.9–2.3</td>
<td>.12</td>
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<tr>
<td>ES</td>
<td>2.3</td>
<td>0.8–6.3</td>
<td>.11</td>
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<tr>
<td><strong>Effect of ES and isolated VT/VF on MI/angina‡</strong></td>
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</tr>
<tr>
<td>No episodes</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated VT/VF</td>
<td>1.2</td>
<td>0.6–2.2</td>
<td>.58</td>
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<tr>
<td>ES</td>
<td>4.5</td>
<td>1.8–11.4</td>
<td>&lt;.01</td>
<td></td>
</tr>
</tbody>
</table>

*Sesselberg et al, Heart Rhythm 2007;4:1395–1402*
Patient case
Male, 78 y, SCA 1993 → ICD
Ischemic CMP, CABG 1998
LVEF 45%
ICD check (external) shows high impedance of shock electrode
Scheduled for lead exchange

Repeated ICD shock (n=12) while sitting in a car
Repeated ICD shocks in ambulance (n=8)
Repeated ICD shocks in emergency dept (n=8)

Cardiologist on call applies magnet
ICD check shows 28 inadequate discharges
Patient traumatized
Patient case

- *Repeated shocks without VT*
- *Repeated shocks with hemodynamically tolerated VT*

→ Magnet !!
Acute heart failure

Decompensated HF

- Malignant condition
- Impact on costs
- No effective treatment
- Prevention only valid strategy
Acute heart failure
Acute heart failure
Acute heart failure

Decompensated HF does not come over night…

RV Systolic pressure

Hospitalization for decompensated HF

(days)

(mmHg)
Acute heart failure

OPTIMIZE-HF (n = 48 612)

Precipitating factors and in-hospital mortality
