Electrical Storm: What are the options?

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Introduction

- Frequent VT/VF in patients with ICD is common and difficult to treat
- Electrical Storm (ES) is defined as three or more episodes of ventricular arrhythmias, requiring ICD therapy in a 24 hour period.
- Prognosis following ES has been assumed to be poor
Incidence

- The incidence is approximately 2 to 10 percent per year follow-up period in patients with ICDs.
- Monomorphic VT is the predominant ventricular arrhythmia in the vast majority of patients with electrical storm.
In the AVID trial, electrical storm was a significant independent risk factor for death (relative risk 2.4), which occurred most frequently within three months.

The MADIT II trial found that patients with electrical storm had a 17.8-fold increased risk of death within the first three months after storm onset.

What is not clear is whether the ventricular tachyarrhythmias or repeated implantable cardioverter-defibrillator (ICD) shocks themselves contribute to cardiac mortality or are secondary to a degenerating cardiac status.

Recurrent ventricular fibrillation (VF) results in increases in intracellular calcium concentrations which might contribute to deterioration of left ventricular systolic function.

Repeated shocks can cause myocardial injury leading to acute inflammation and fibrosis.

Myocardial injury or stunning from recurrent defibrillations may activate the neurohormonal cascade responsible for worsening heart failure.
Prognosis

• Exner reported 67% mortality related to cardiac and sudden deaths. This suggests that maximum cardiac medical therapy including antiarrhythmic therapy and complete surgical revascularization may modify this early excessive risk of death.

• The prognosis of ICD patients with ES was assessed in several previous studies (Credner, Exner, Greene, Villacastin, Levin, Grimm, Pacifico). However, these studies had relatively small sample size, short follow up, different methodology and showed conflicting results.

3-Months Window

- The risk of death after electrical storm is most pronounced in the initial 3 months after electrical storm (RR, 5.6; 95% CI, 2.8 to 11.5; \( P<0.0001 \)) - Exner.

- Most of the deaths (72.7%) were attributable to cardiac and sudden deaths.

- The 3 months window after ES was chosen as a window for intervention on the basis of prior studies (Villacastin, Exner).

- SMH also confirmed this observation and aggressive intervention for about 3-6 months is warranted.

Derek V. Exner, MD, MPH; Sergio L. Pinski, MD; D. George Wyse, MD, PhD, et al; for the AVID Derek V. Exner, MD, MPH; Sergio L. Pinski, MD; D. George Wyse, MD, PhD, et al; for the AVID Investigators. Circulation. 2001;103:2066-2071

Treatment

- Initial treatment is based on hemodynamic stability.
- Magnet
- Patients with hemodynamically unstable ventricular arrhythmias should initially undergo electrical cardioversion according to advanced cardiac life support protocol
Treatment

- If hemodynamically stable, IV Amiodarone 150 mg bolus x2 followed by 900 mg infusion over 24 hr.
- Additionally, because of the adrenergic surge associated with frequently ventricular tachyarrhythmias and defibrillator shocks, we recommend co-administration of a beta blocker (metoprolol 5 mg IV x3 to maximum 15 mg over 15 min as tolerated).
- Sedation
AA in E Storm

- Antiarrhythmic therapy may prove to be useful in preventing further deterioration of myocardial function arrhythmia recurrence and possibly sudden cardiac death in these ICD patients.
- Reducing the burden of ventricular arrhythmias and the liberal use of antiarrhythmic therapy may also play a role in delaying the time to ES compared to other studies (Exner, Villacastin,).
New AA

- The potential added benefit of aggressive antiarrhythmic antiarrhythmic therapy is still not well defined in the literature.
- Prior studies have shown that antiarrhythmic drugs mainly amiodarone (OPTIC, Sim I study, Pacifico A study, Kwowey) may play a role in preventing recurrent ventricular arrhythmias.
- Further improvement in outcomes is possible using new antiarrhythmic drugs such as azimilide (P Dorian etal), VT/VF ablation procedures (Dietmar Bänsch, Feifan Oyang et al) or biventricular pacing (Geannopoulos CJK) but data is still limited.
Revascularization

For patients with electrical storm or incessant VT in whom active myocardial ischemia is felt to be a contributing factor, urgent coronary revascularization should be pursued (O’Rourke RA ).
Treatment - Other general therapies

- Appropriate heart failure therapies, particularly beta-blockers and ACE-inhibitors, should be prescribed and titrated as tolerated.
- Appropriate anti-thrombotic and anti-ischemic therapies, Statin
- Correction of any identified inciting factors should occur. This may include removal of any offending drugs (eg, prescription or illicit drugs which prolong the QT interval) and correction of any electrolyte disturbances (ie, hypokalemia, hypomagnesemia, etc).
- Targeted therapies are indicated for specific conditions. For example, pause-dependent torsades de pointes can be effectively treated with pacing, and incessant arrhythmias associated with Brugada syndrome may be suppressed with quinidine or isuprel.
Management of refractory cases

- Rarely, patients will continue to have refractory electrical storm or incessant VT in spite of medication. A variety of salvage therapies may be considered, in conjunction with the standard therapies.
- Left ventricular aneurysmectomy
- Insertion of an intraaortic balloon pump or a left ventricular assist device
- Cardiac transplantation
- Thoracic epidural anesthesia and/or general anesthesia
- Cardiac sympathetic denervation (CSD), with one series suggesting bilateral CSD is more efficacious than isolated left CSD
- Renal artery denervation, with one small series of four patients showing marked decrease in the frequency of VT episodes following RDN
Catheter ablation

- Catheter ablation of ventricular tachyarrhythmias is an important and effective therapy if storm persists or recurs in spite of medical therapy or in patients intolerant of medical therapy due to side effects.
Ablation

- Most reports of catheter ablation in electrical storm or incessant VT have been case reports or small retrospective single-center cohort studies.

- In a meta-analysis of 471 patients with electrical storm compiled from 39 publications (case reports and cohort studies), there was a high initial success rate for ablation of all ventricular arrhythmias (72 percent) along with a low procedural mortality rate (0.6 percent) and a relatively low recurrence rate of 6 percent over 61 weeks mean follow-up.
Ablation

- In one single-center retrospective study of 52 patients with a first episode of electrical storm between 1995 and 2011 who were initially treated with pharmacologic therapy alone (29 patients) or catheter ablation (23 patients), the risk of recurrent electrical storm was significantly lower following catheter ablation, but there was no significant difference in survival over a median follow-up of 28 months.
- The lack of mortality benefit is most likely related to the severity of underlying cardiac pathology in patients who present with electrical storm or incessant VT.
- Ablation performed via an epicardial approach is another option for select patients.
- Among a cohort of 444 consecutive patients with VT and prior MI who were referred for catheter ablation, 27 patients (6 percent) had successful epicardial ablation of at least one VT.

Primary Ablation

- Catheter ablation has been evaluated as a primary preventive therapy with good results in several trials:
  - In one small multicenter randomized trial of 128 patients, there was a significant reduction in ICD therapies delivered for VT or VF
  - Observational study of 231 patients, VT episodes decreased from a median of 11.5 to zero.
Ablation

- Acute success rates for RFA of VT after MI vary from 70 to 90 percent, with procedure-related mortality of 0.5 percent.
- Long-term follow-up reveals recurrent VT in 30 to 50 percent of patients. Two-thirds of these patients have experienced at least 75 percent reduction in frequency of VT.
Ablation: Guidelines

- The role of RFA in the treatment of ventricular arrhythmias among patients with a prior MI was addressed in the 2006 ACC/AHA/ESC guidelines as well as in the more recent 2009 European Heart Rhythm Association/Heart Rhythm Society (EHRA/HRS) expert consensus statement.
- Ablation is considered first-line therapy for patients with SMVT whose overall characteristics suggest them to be at low risk for sudden death. It is also considered first-line therapy for certain specific ventricular tachycardias, such as bundle branch reentry.
Ablation - Guidelines

- The guidelines suggest that the weight of evidence supports the use of RFA as adjunctive therapy in patients with an ICD who have frequent episodes of VT. In this setting the purpose of RFA is to reduce symptoms related to VT and to reduce ICD shocks.
- The guidelines suggest that evidence was less well-established for the use of RFA in the absence of an ICD.
- Consider RFA with or without antiarrhythmic drug therapy, for patients with VT who are not candidates for or who refuse ICD implantation.
- RFA efficacy was limited in patients with rapid, hemodynamically unstable VT/VF
SMH-Methods

- Retrospective review of the clinical characteristics, therapy and outcome of patients with ES at St. Michael’s Hospital ICD database.

- Includes 653 consecutive patients who received ICDs, between December 1985 and December 2002, for secondary prevention of sudden cardiac death

  ✓ ES group (n=137)
  ✓ Only isolated ICD therapy group (n=179)
  ✓ No appropriate therapy or only inappropriate therapy (n=337)
Amiodarone use at last follow up in the storm group

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<table>
<thead>
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<tbody>
<tr>
<td>N=137</td>
<td>No</td>
</tr>
<tr>
<td>Amio (All)</td>
<td>84</td>
</tr>
<tr>
<td>Amio alone</td>
<td>24</td>
</tr>
<tr>
<td>Amio+sotalol</td>
<td>13</td>
</tr>
<tr>
<td>Amio+BB</td>
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<tr>
<td>Amio+Quinidine</td>
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<td>Amio+Dofetilide</td>
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<tr>
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<td>4</td>
</tr>
<tr>
<td>Amio+Mexilitine</td>
<td>4</td>
</tr>
</tbody>
</table>
Recurrence

- The risk of recurrence of ES is relatively low 22.6% and late compared to other studies (Dietmar Bänsch, exner, villacastin).
- ES occurred earlier in Credenr (4 months) and Exner reports (9.2 months) compared to 16.5 months in our study.
SMH Conclusion

• This study provides a unique long-term 12-year data on the clinical significance, management and the outcomes of patients with ES who had ICD for secondary prevention of sudden cardiac death.

• Patients with ES have impaired survival as opposed to patients without.

• Patients with ES should receive close follow up for 6 month with aggressive primary and secondary prevention of cardiac and sudden deaths.
References

1. Derek V. Exner, MD, MPH; Sergio L. Pinski, MD; D. George Wyse, MD, PhD, et al; for the AVID Investigators. Circulation. 2001;103:2066-2071


Ablation-Complications

- A nationwide sample of 4653 patients who underwent ablation in the United States between 2002 and 2011 for post-myocardial infarction VT, the overall in-hospital complication rate was 11 percent with in-hospital mortality of 1.6 percent.

- While utilization of VT ablation increased significantly over the decade (from 3 percent of patients in 2002 to 11 percent in 2011), the complication rate was not significantly changed over the same interval.

- Among a single-center cohort of 193 consecutive patients undergoing catheter ablation for scar-related VT, acute hemodynamic decompensation (defined as persistent hypotension in spite of vasopressors requiring mechanical support or discontinuation of the procedure) occurred in 22 patients (11 percent).
Strom: Marker vs Cause of death?

- Previous studies have suggested a relationship between Shocks/ES and gross and microscopic pathological changes and myocardial injury (Avitall B,--Allan JJ, Hurst, Joglar JA, Singer I, Epstein AE, Jones DL, Zaugg CE).

- This may explain the excessive risk of dying in this group. These changes may enhance arrhythmia initiation or SCD. Further, frequent VT/VFs may cause heart failure (Kolettis TM, Theodorakis) which is the commonest cause of death in our study.

- However it is hard to know if ES is a marker, rather than the cause, of increased mortality.
Treatment

- Medical therapy was reasonable in our cohort. Therapy with ACEI (SOLVD), BB (MERIT CIBIS 2), lipid lowering therapy (Johan De Sutter), coronary revascularization (O’Rourke RA) have also been shown effective in reducing mortality and these therapies should be assessed and reinforced in these patients particularly within 3-6 months after the development of ES when the risk of cardiac and sudden deaths is high.
Baseline Characteristics

- There were no significant differences in baseline clinical characteristics between the three groups with respect to age, sex, EF underlying coronary artery disease, amiodarone use and NYHA class.
Introduction-Back up

- Definition: Each VT/VF events need to be separated by more than 5 minutes
Limitations

- SMH study has the limitations of any retrospective study. However it provides a large sample size with the longest follow up reported so far (12 years).
- Also, univariate and multivariate analysis were used to adjust for any possible confounders.
- The safety and efficacy of antiarrhythmic drugs should be taken with caution because RCT prospective confirmation is lacking.
<table>
<thead>
<tr>
<th>Baseline Characteristics</th>
<th>All (n=653)</th>
<th>Storm (n=137)</th>
<th>Appr Tx (n=179)</th>
<th>No Tx (n=337)</th>
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<tbody>
<tr>
<td>Age</td>
<td>62.8±13</td>
<td>63.9 ±13</td>
<td>63 ±12.8</td>
<td>62.2±12.4</td>
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<tr>
<td>Male(%)</td>
<td>79.3</td>
<td>78.8</td>
<td>83.2</td>
<td>77.5</td>
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<tr>
<td>EF(%)</td>
<td>35.3±14</td>
<td>33.9±13.3</td>
<td>34.3±14.6</td>
<td>36.5±14.6</td>
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<tr>
<td>F/U(Yr)</td>
<td>3.2±2.9</td>
<td>3.9 ±3</td>
<td>4.2±3.2</td>
<td>2.4±2.4</td>
</tr>
<tr>
<td>CAD</td>
<td>72 %</td>
<td>73 %</td>
<td>73 %</td>
<td>71 %</td>
</tr>
<tr>
<td>QRS Duration</td>
<td>126±32.4</td>
<td>131.7±36.1</td>
<td>124 ±30</td>
<td>123 ±31</td>
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<td>NYHA (Class I, II)</td>
<td>89.5%</td>
<td>91.9%</td>
<td>87.7%</td>
<td>89%</td>
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## Baseline Medications

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<tr>
<td>Amiodarone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p=0.968</td>
<td>123 (18.8%)</td>
<td>27 (19.7%)</td>
<td>34 (19%)</td>
<td>63 (18.7%)</td>
</tr>
<tr>
<td>Sotalol</td>
<td></td>
<td></td>
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<tr>
<td>p&lt;0.0001</td>
<td>285 (43.6%)</td>
<td>74 (54%)</td>
<td>92 (51.4%)</td>
<td>113 (33.5%)</td>
</tr>
<tr>
<td>Beta Blocker*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p=0.0014</td>
<td>238 (36.4%)</td>
<td>36 (26.3%)</td>
<td>49 (27.4%)</td>
<td>148 (43.9%)</td>
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*Excluding sotalol
## Baseline Meds

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<tr>
<td>Quinidine</td>
<td>1 (0.7%)</td>
<td>2 (1.1%)</td>
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</tr>
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<td>Mexilitine</td>
<td>3 (2.2%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Procainamide</td>
<td>2 (1.5%)</td>
<td>2 (1.1%)</td>
<td>2 (0.6%)</td>
</tr>
<tr>
<td>ACEI/ARB</td>
<td>101 (73%)</td>
<td>127 (70%)</td>
<td>261 (80%)</td>
</tr>
<tr>
<td>Statin</td>
<td>52 (38%)</td>
<td>64 (40%)</td>
<td>159 (50%)</td>
</tr>
<tr>
<td>ASA</td>
<td>100 (73%)</td>
<td>137 (80%)</td>
<td>254 (80%)</td>
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## Index Arrhythmia

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<tbody>
<tr>
<td>VT (%)</td>
<td>75.2</td>
<td>61.5</td>
<td>48.7</td>
</tr>
<tr>
<td>p&lt;0.0001</td>
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<tr>
<td>VF (%)</td>
<td>21.9</td>
<td>33.5</td>
<td>41.8</td>
</tr>
<tr>
<td>p=0.0002</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Syncope &amp; +ve EPS (%)</td>
<td>2.9</td>
<td>5</td>
<td>9.5</td>
</tr>
<tr>
<td>p=0.0193</td>
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## EPS

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<tr>
<td>EPS (any)</td>
<td>226 (34.6%)</td>
<td>56 (40.9%)</td>
<td>71 (39.7%)</td>
<td>100 (29.7%)</td>
</tr>
<tr>
<td>VT induced</td>
<td>168 (74.3%)</td>
<td>49 (87.5%)</td>
<td>50 (70.4%)</td>
<td>66 (66%)</td>
</tr>
<tr>
<td>VF/poly. VT induced</td>
<td>23 (10.2%)</td>
<td>2 (3.6%)</td>
<td>7 (9.9%)</td>
<td>14 (14%)</td>
</tr>
<tr>
<td>-VE EPS</td>
<td>35 (15.5%)</td>
<td>5 (8.9%)</td>
<td>14 (19.7%)</td>
<td>20 (20%)</td>
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Revascularization at baseline

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<tbody>
<tr>
<td><strong>Diag.Cath (any)</strong></td>
<td>522 (79.9%)</td>
<td>101 (73.7%)</td>
<td>142 (79.3%)</td>
<td>279 (82.8%)</td>
</tr>
<tr>
<td><strong>PCI</strong></td>
<td>63 (9.7%)</td>
<td>11 (8.0%)</td>
<td>16 (8.9%)</td>
<td>18 (5.3%)</td>
</tr>
<tr>
<td><strong>CABG</strong></td>
<td>163 (24.1%)</td>
<td>3 (2.2%)</td>
<td>43 (24.0%)</td>
<td>41 (12.2%)</td>
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### Structural heart diseases at baseline

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<tbody>
<tr>
<td><strong>CAD</strong></td>
<td>467 (71.5%)</td>
<td>100 (73%)</td>
<td>131 (73.2%)</td>
<td>240 (71.2%)</td>
</tr>
<tr>
<td><strong>Idiopathic dil</strong></td>
<td>92 (14.0%)</td>
<td>20 (14.6%)</td>
<td>24 (13.4%)</td>
<td>48 (14.2%)</td>
</tr>
<tr>
<td><strong>Valvular HD</strong></td>
<td>20 (3.1%)</td>
<td>5 (3.7%)</td>
<td>4 (2.2%)</td>
<td>11 (3.3%)</td>
</tr>
<tr>
<td><strong>Congenital HD</strong></td>
<td>2 (0.3%)</td>
<td>0 (0%)</td>
<td>2 (1.1%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td><strong>HOCM</strong></td>
<td>11 (1.7%)</td>
<td>3 (2.2%)</td>
<td>4 (2.2%)</td>
<td>4 (1.2%)</td>
</tr>
<tr>
<td><strong>ARVD</strong></td>
<td>9 (1.4%)</td>
<td>4 (2.9%)</td>
<td>2 (1.1%)</td>
<td>3 (0.9%)</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>53 (8.1%)</td>
<td>5 (3.6%)</td>
<td>12 (6.7%)</td>
<td>31 (9.2%)</td>
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## A Fibrillation at baseline

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<tbody>
<tr>
<td>A Fib (any)</td>
<td>199 (30.5%)</td>
<td>41 (29.9%)</td>
<td>49 (27.4%)</td>
<td>109 (32.3%)</td>
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<tr>
<td>Persistent</td>
<td>124 (19%)</td>
<td>32 (23.4%)</td>
<td>39 (21.8%)</td>
<td>53 (15.7%)</td>
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<tr>
<td>Intermittent</td>
<td>60 (9.2%)</td>
<td>6 (4.4%)</td>
<td>8 (2.8%)</td>
<td>46 (13.7%)</td>
</tr>
<tr>
<td>Self-terminating</td>
<td>15 (2.3%)</td>
<td>3 (2.2%)</td>
<td>2 (1.1%)</td>
<td>10 (2.9%)</td>
</tr>
</tbody>
</table>
A Fib at baseline

- 41 patients (29.9%) had A fibrillation at baseline in the storm group compared to 159 patients (30.8%) in the other 2 groups
Follow up

- Patients were followed from December 1985 to August 2003
- Mean follow up was $3.2 \pm 2.9$ years
Follow up

- Follow up was complete
- 7 patients underwent heart transplant in the storm group compared to 4 patients in the other 2 groups
- ICD was explanted permanently in two patients and turned off in 3 patients by the end of follow up
Results-Storm Characteristics

- All episodes were terminated successfully (by ATP only in 30 patients and by shock with or without ATP in 107 patients)
- ES occurred 16.5 ± 20.7 months post implant
- Etiology of 1st storm: idiopathic(113), electrolyte disorders (6), active coronary ischemia (3), worsening CHF( 3) and other reasons e.g. alcohol, systemic disorders, stress (12).
- Storms occurred between 6AM – 12N in 52 patients, 12N-6PM in 38 patients, 6PM-MN in 25 patients and MN-6AM in 22 patients
Results-1\textsuperscript{st} Storm Characteristics

- The average time from implant to storm was 494 ± 622 days
- The average number of episodes 13 ± 22
- The average number of shocks 6±10 per 1\textsuperscript{st} storm per patient
- The average storm duration was 3.3 ±4.7 days
- The 1\textsuperscript{st} Storm was VT in 121 patients and VF/poly VT in 16 patients, with an average CL of 352 ±75 mseconds
Storm Characteristics

- The average number of ATP only was 13 ±22 per storm per patient in 1st Storm
- 3 patients were enrolled in the SHIELD study (Azimilide) after first storm
Results-Storm Management

- 92 patients were hospitalized during the first storm
- 132 received an additional drug therapy with and without ICD reprogramming
- 4 patients managed only with reprogramming
- Only 1 patient had no specific therapy
Results- Amiodarone use

- 98 patients received amiodarone acutely (63 received IV amiodarone, 35 received additional oral amiodarone with or without loading)
- 39 patients did not receive any amiodarone during ES, mostly because of previous amiodarone toxicity (35 patients).
Antiarrhythmics in patients who did not receive amiodarone

- 39 patients did not receive amiodarone acutely during the first storm
- These 39 patients received sotalol (n=27), beta blocker (n=9), mexilitine (n=4), procainamide (n=3) and two patients enrolled in the SHIELD study and randomized to azimilide vs. placebo.
<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>During 1&lt;sup&gt;st&lt;/sup&gt; Storm</th>
<th>Last F/U</th>
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<tbody>
<tr>
<td>Amiodarone</td>
<td>27</td>
<td>98</td>
<td>84</td>
</tr>
<tr>
<td>Sotalol</td>
<td>74</td>
<td>95</td>
<td>40</td>
</tr>
<tr>
<td>Beta blocker</td>
<td>36</td>
<td>55</td>
<td>62</td>
</tr>
<tr>
<td>Mexilitine</td>
<td>3</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Dofetilide</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Quinidine</td>
<td>1</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Procainamide</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>
Results- 1st Storm: Acute Antiarrhythmics Use

- 21 additional patients started or received additional sotalol
- 19 additional patients started or received additional beta blocker
- 4 additional patients received mexilitine
- 3 additional patients received procainamide
- 1 additional patient received quinidine and one received dofetilide
Acute antiarrhythmic therapy during the second storm

- A total of 24 out of 31 (77.4%) patients who had a second storm received amiodarone, 19 patients (61.3%) received sotalol, 16 patients (51.7%) received beta blocker, 9 patients (29.0%) received mexilitine, 7 patients (22.6%) received procainamide and 6 patients (19.4%) received quinididine.

- During the second storm: 6 additional patients started on amiodarone, 4 additional patients started on quinidine, 3 additional patients received beta blocker, 3 additional patients received procainamide and 3 additional patients received mexilitine.
Sotalol use in the storm group at last follow up

<table>
<thead>
<tr>
<th>N=137</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sotalol (All)</td>
<td>40</td>
</tr>
<tr>
<td>Sotalol alone</td>
<td>14</td>
</tr>
<tr>
<td>Sotalol+amio</td>
<td>13</td>
</tr>
<tr>
<td>Sotalol+quinidine</td>
<td>4</td>
</tr>
<tr>
<td>Sotalol+procainamide</td>
<td>4</td>
</tr>
<tr>
<td>Sotalol+Mexilitine</td>
<td>5</td>
</tr>
</tbody>
</table>
Mexilitine use at last follow up in the storm group

<table>
<thead>
<tr>
<th></th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=137</td>
<td></td>
</tr>
<tr>
<td>Mexilitine (all)</td>
<td>13</td>
</tr>
<tr>
<td>Mexilitine+amio</td>
<td>4</td>
</tr>
<tr>
<td>Mexilitine+sotalol</td>
<td>5</td>
</tr>
<tr>
<td>Mexilitine+procainamide</td>
<td>2</td>
</tr>
<tr>
<td>Mexilitine+Dofetilide</td>
<td>2</td>
</tr>
<tr>
<td>Mexilitine+BB</td>
<td>1</td>
</tr>
</tbody>
</table>
The most commonly used antiarrhythmics as a single agents at last follow up in the storm group were as follows in the order of frequency: amiodarone (17.5%) and sotalol (10.2%).

The most commonly used antiarrhythmic combinations at last follow up in the storm group were as follows in the order of frequency: amiodarone and beta blocker (31.4%), amiodarone and sotalol (9.5%), amiodarone and quinidine (3.7%) and Sotalol and mexiletine (3.7%)
Storm Recurrence

- By the end of follow up there were 187 (137+50) storms with an average of 1.4 storms per patient.
- 31 patients had $\geq 2$ recurrences
  - 22 patients had 2 Storms (terminated by shocks in 21 patients and by ATP in 10)
  - 5 patients had 3 recurrences
  - 1 patients had 4 recurrences
  - 1 patients had 5 recurrences
  - 1 patients had 6 recurrences
  - 1 patients had 7 recurrences
Results - Storm recurrence

- Time from 1S-2S was 529 ± 655 days
  - Time from 2S-3S was 180 ± 143 days
  - Time from 3S-4S was 85 ± 41 days
  - Time from 4S-5S was 14 ± 9 days
  - Time from 5S-6S was 51 ± 19 days
  - Time from 6S-7S was 147 days
Results- Appropriate therapy after 1\textsuperscript{st} Storm

- 32 patients had any isolated appropriate therapy after the first storm
- The average time from 1\textsuperscript{st} storm to any subsequent isolated appropriate therapy was 463 ± 527 days
Results- Appropriate therapy in all patients

- The average time from implant to any first appropriate therapy was 379 days in all the three groups.
- 307 patients (47%) had any appropriate therapy during follow up (153 patients had ATP only and 154 patients had appropriate shock with or without ATP)
Results-Mortality

- The estimated annual mortality (over 10 years) in the ES group was 6.2% compared to 4.8% in the isolated appropriate therapy (p=0.008) and 2.9% in the no therapy group (p=0.0003).
## Mortality

<table>
<thead>
<tr>
<th></th>
<th>All N=653</th>
<th>Storm N=137</th>
<th>App Tx N=179</th>
<th>No Tx N=337</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>120 (18.4%)</td>
<td>55 (40.2%)</td>
<td>39 (21.8%)</td>
<td>33 (9.8%)</td>
</tr>
<tr>
<td>Non-cardiac</td>
<td>27 (22.5%)</td>
<td>13 (23.6%)</td>
<td>7 (18.0%)</td>
<td>8 (24.2%)</td>
</tr>
<tr>
<td>Cardiac</td>
<td>76 (63.4%)</td>
<td>34 (61.8%)</td>
<td>26 (66.6%)</td>
<td>20 (60.6%)</td>
</tr>
<tr>
<td>SCD</td>
<td>10 (8.3%)</td>
<td>6 (10.9%)</td>
<td>3 (7.7%)</td>
<td>3 (9.1%)</td>
</tr>
<tr>
<td>Vascular</td>
<td>7 (5.8%)</td>
<td>2 (3.7%)</td>
<td>3 (7.7%)</td>
<td>2 (6.1%)</td>
</tr>
</tbody>
</table>
## Cause-Specific Mortality

<table>
<thead>
<tr>
<th></th>
<th>All the groups (N=653)</th>
<th>Storm (N=137)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Cardiac (%)</td>
<td>22.5</td>
<td>23.6</td>
</tr>
<tr>
<td>Cardiac (%)</td>
<td>63.4</td>
<td>61.8</td>
</tr>
<tr>
<td>SCD* (%)</td>
<td>8.3</td>
<td>10.9</td>
</tr>
<tr>
<td>Vascular (%)</td>
<td>5.8</td>
<td>3.7</td>
</tr>
</tbody>
</table>

*SCD: Sudden Cardiac Death*
Mortality

- Following ES:
  Mortality was 7.3% (30 day) and 12.4% (6 month).
- The average time from storm to mortality was $785 \pm 728$ days, median 600 days.
Conclusion

- Patients with ES have worse outcomes than those without
- The prognosis post-storm with aggressive therapy is relatively good
References

References

References


32- Geannopoulos CJK, Wilber DJ and Olshansky B. Control of refractory ventricular tachycardia with biventricular assist devices. PACE. 1991;14:1432–1434


Kowey PR. An overview of antiarrhythmic drug management of electrical storm. Can J Cardiol 1996; 12 Suppl B:3B.


Prognosis- Back up

- Villacastin and colleagues have demonstrated that in 80 patients who were followed for 21±19 months, the 20% of patients surviving multiple, consecutive ICD discharges (2 shocks for a single arrhythmic episode) had a greater risk of death (RR, 3.5; P=0.06). This was consistent with Exner report. Credner and colleagues, however, have shown that over 13±7 months of follow-up, 43 patients (32%) experienced ICD therapies unrelated to electrical storm, and 14 (10%) experienced electrical storm;

- Greene et al also reported that ES does not confer increased mortality; at 5 year follow up there were no significant differences in survival in patients with or without ES.

Derek V. Exner, MD, MPH; Sergio L. Pinski, MD; D. George Wyse, MD, PhD, et al; for the AVID Investigators. Circulation. 2001;103:2066-2071

Prognosis- Back up

- Compared with Exner et al report, the patients in our study and in the Credner et al’s study had higher ejection fraction values (35.3±14, 35±13 respectively) which may explain some of the findings.