Mapping and Ablation Approaches for Difficult Ventricular Tachycardia

Boris Schmidt
AK St. Georg
Hamburg, Germany
Disclosures

• Research grants
  – Biosense Webster, Prorhythm, Hansen Medical
• Consultant
  – Prorhythm
Pitfalls of VT ablation

Optimal time point of VT ablation

Epicardial substrates

„Un-mappable VT“
Catheter Ablation of Difficult VT

Optimal time point of VT ablation

Epicardial substrates

„Un-mappable VT“
Optimal time point of VT ablation

- Immediately?
- After how many successful ICD therapies?
- During electrical storm?
Optimal time point of VT ablation

- Immediately?
- After how many successful ICD therapies?
- During electrical storm?
CA / unstable VT / syncope + ind. VT
VT after ICD for primary prevention
Planned ICD or ICD < 6 m

R

Catheter ablation
ICD only

1° Endpoint: Survival free of any ICD intervention

## SMASH-VT – Patient characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Ablation Group (N=64)</th>
<th>Control Group (N=64)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age — yr</td>
<td>67±9</td>
<td>66±10</td>
<td>0.65‡</td>
</tr>
<tr>
<td>Male sex — no. (%)</td>
<td>59 (92)</td>
<td>52 (81)</td>
<td>0.12‡</td>
</tr>
<tr>
<td>Interval between myocardial infarction and enrollment — yr§</td>
<td>8.8±8.5</td>
<td>7.9±7.8</td>
<td>0.66¶</td>
</tr>
<tr>
<td>Index arrhythmia — no. (%)</td>
<td>0.38±</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>13 (20)</td>
<td>10 (16)</td>
<td></td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>30 (47)</td>
<td>33 (52)</td>
<td></td>
</tr>
<tr>
<td>Syncope with inducible ventricular tachycardia</td>
<td>11 (17)</td>
<td>16 (25)</td>
<td></td>
</tr>
<tr>
<td>Recent ventricular fibrillation or tachycardia treated by a previously implanted ICD</td>
<td>10 (16)</td>
<td>5 (8)</td>
<td></td>
</tr>
<tr>
<td>Left ventricular ejection fraction — %</td>
<td>30.7±9.5</td>
<td>32.9±8.5</td>
<td>0.16¶</td>
</tr>
<tr>
<td>Left ventricular ejection fraction ≤30% — no. (%)</td>
<td>37 (58)</td>
<td>30 (47)</td>
<td>0.29‡</td>
</tr>
<tr>
<td>Left ventricular ejection fraction ≤20% — no. (%)</td>
<td>16 (25)</td>
<td>7 (11)</td>
<td>0.06‡</td>
</tr>
<tr>
<td>New York Heart Association functional class — no. (%)</td>
<td>0.37‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I or II</td>
<td>54 (84)</td>
<td>49 (77)</td>
<td></td>
</tr>
<tr>
<td>III or IV</td>
<td>10 (16)</td>
<td>15 (23)</td>
<td></td>
</tr>
<tr>
<td>Hypertension — no. (%)</td>
<td>47 (73)</td>
<td>43 (67)</td>
<td>0.35‡</td>
</tr>
<tr>
<td>Diabetes — no. (%)</td>
<td>24 (38)</td>
<td>32 (50)</td>
<td>0.21‡</td>
</tr>
<tr>
<td>Previous revascularization (PTCA or CABG) — no. (%)</td>
<td>46 (72)</td>
<td>40 (62)</td>
<td>0.35‡</td>
</tr>
<tr>
<td>Previous stroke — no. (%)</td>
<td>3 (5)</td>
<td>8 (12)</td>
<td>0.21‡</td>
</tr>
<tr>
<td>Medication — no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class I or class III drugs</td>
<td>0</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Beta-blockers</td>
<td>60 (94)</td>
<td>63 (98)</td>
<td>0.37‡</td>
</tr>
<tr>
<td>ACE inhibitors or angiotensin-receptor blockers</td>
<td>59 (92)</td>
<td>59 (92)</td>
<td>1.0‡</td>
</tr>
<tr>
<td>Statins</td>
<td>37 (58)</td>
<td>38 (59)</td>
<td>1.0‡</td>
</tr>
<tr>
<td>Aspirin</td>
<td>52 (81)</td>
<td>39 (61)</td>
<td>0.02‡</td>
</tr>
<tr>
<td>Type of ICD — no. (%)</td>
<td></td>
<td></td>
<td>0.21‡</td>
</tr>
<tr>
<td>Single-chamber</td>
<td>23 (36)</td>
<td>31 (48)</td>
<td></td>
</tr>
<tr>
<td>Dual-chamber</td>
<td>41 (64)</td>
<td>33 (52)</td>
<td></td>
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</tbody>
</table>

Results – 1° endpoint

Influence on Prognosis

SMASH-VT - Survival

Optimal time point of VT ablation

- Immediately?
- After how many successful ICD therapies?
- During electrical storm?
VT Ablation in Patients with ICD

Influence of VT ablation on ICD discharges

Marchlinski et al, Circ 2000;101:1288–1296
Optimal time point of VT ablation

• Immediately?

• After how many successful ICD therapies?

• During electrical storm?
VT ablation during electrical storm

### Targeting all VT in electrical storm (ES)

<table>
<thead>
<tr>
<th>Age (mean±SD), y</th>
<th>64±13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender, M/F</td>
<td>85/10</td>
</tr>
<tr>
<td>LV ejection fraction (mean±SD), %</td>
<td>36±11</td>
</tr>
<tr>
<td>NYHA class (mean±SD)</td>
<td>2.9±1.1</td>
</tr>
<tr>
<td>Underlying heart disease, %</td>
<td></td>
</tr>
<tr>
<td>CAD</td>
<td>72 (76)</td>
</tr>
<tr>
<td>IDCM</td>
<td>10 (11)</td>
</tr>
<tr>
<td>ARVD</td>
<td>13 (14)</td>
</tr>
<tr>
<td>Medications, %</td>
<td></td>
</tr>
<tr>
<td>Amiodarone</td>
<td>89 (94)</td>
</tr>
<tr>
<td>β-Blockers</td>
<td>92 (97)</td>
</tr>
<tr>
<td>ACE inhibitors or ARBs</td>
<td>81 (85)</td>
</tr>
<tr>
<td>Sotalol</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Class I antiarrhythmic drugs</td>
<td>6 (6)</td>
</tr>
<tr>
<td>VT episodes per patient per day (mean±SD), n</td>
<td>16±8</td>
</tr>
<tr>
<td>ICD shocks per patient per day (mean±SD), n</td>
<td>14±8</td>
</tr>
</tbody>
</table>

95 consecutive patients in ES

Non-selected group

Procedural endpoint: non-inducibility of any VT by programmed stimulation

Carbucicchio C et al, Circ 2008;117:462–69
Influence on prognosis

Targeting all VT in electrical storm

Death from any cause

Event-free survival

Log-Rank test $p = 0.0035$

Carbucicchio C et al, Circ 2008;117:462–69
Optimal time point for VT ablation

• Evaluation after each ICD therapy

• Carefully outweigh risk and benefit for the patient

• Previous antiarrhythmic drug treatment?
Catheter Ablation of Difficult VT

Pitfalls of VT ablation

Optimal time point of VT ablation

Epicardial substrates

„Un-mappable VT“
Epicardial VT ablation

**Diseases associated with epicardial substrates**

- Dilated Cardiomyopathy
- Arrhythmogenic right ventricular cardiomyopathy (ARVC)
- Sarcoidosis
- LV aneurysm
- Chagas disease (rare in Europe and Asia)
- Ischemic cardiomyopathy (10-15%)
Methods

Pericardial access

- RVA
- V PM
- A PM
- CS
- Ref
- Needle
- AP
- V PM
- CS
- Ref
- Needle
- AP
28-year-old female with VT

QRS=220 ms
CL=440 ms
Epicardial Ablation for VT

Endocardial CARTO Map during VT (CL=440ms)

No DP, earliest V preceding onset of QRS by 5 ms

Ouyang F et al. Herz2004
Epicardial Ablation for VT

Endo- and (incomplete) Epicardial CARTO Map during VT

Ouyang F et al. Herz 2004
Ablation

JC
LCX
HRA
Map
LAD
17 mm

VI
Map epicardial
QRS = 210 ms
CL = 370 ms
Epicardial Ablation for VT (near normal EF)

Endocardial CARTO Map during VT (CL=370ms)

A Left Lateral View

Endocardial Activation Map

Endocardial Voltage Map

14 ms

-07 ms

≥ 1.50 mV

≤ 0.10 mV

septal

lateral

Apex

1.36 cm

1.35 cm

AK St. Georg
Epicardial Ablation for VT (near normal EF)

Epicardial CARTO Map during VT (CL=370ms)

Epicardial Activation Map

Epicardial Voltage Map

AV groove

Apex

V1 Map

epicardial
Ablation

20020027

I

II

V1

Mp dis

Mp prx

Mp uni

RVA 1-2
Delayed potential

LV and RV endocardial voltage map
LV and RV epicardial voltage map
Isolated delayed potential at Epicardium
2 to 1 conduction of delayed potential during SR after RF applications
Experience at St. Georg

42 patients

06/2005 – 02/2008

- 8 Normal Heart
- 11 LV aneurysm
- 7 Sarcoidosis
- 1 ICM
- 8 DCM
- 7 ARVD

Legend:
- Normal Heart
- LV aneurysm
- Sarcoidosis
- ICM
- DCM
- ARVD
### Experience at St. Georg

#### Patient data (n=42)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Gender (f/m)</td>
<td>14/28</td>
</tr>
<tr>
<td>Age [years]</td>
<td>49 +/- 18</td>
</tr>
<tr>
<td>LV-EF [%]</td>
<td>45 +/-12</td>
</tr>
<tr>
<td>Patients with previous VT ablation [N]</td>
<td>20 (48%)</td>
</tr>
<tr>
<td>ICD [n]</td>
<td>23 (55%)</td>
</tr>
</tbody>
</table>
Experience at St. Georg

Mapping algorithm

Endocardial and Epicardial Map N=42

- Started endo N=27
  - No pathologic potentials N=10
  - Activation/ Stimulation criteria N=6
  - Failed endo RF N=11
- Started epi N=15
  - Previous endo RF failed N=5
  - Heart Disease N=7
  - Other N=3

Heart Disease N=7

No pathologic potentials N=10

Activation/ Stimulation criteria N=6

Failed endo RF N=11

Previous endo RF failed N=5

Heart Disease N=7

Other N=3
**Epicardial ablation for VT**

**Starting site and final success**

- **Started endo**
  - N=27
  - Success endo
    - N=7
  - Failure/other
    - N=12
- **Started epi**
  - N=15
  - Success epi
    - N=23

**Diagnosis**

Schmidt B et al.: Epicardial ablation of VT – A single center experience, DGK 2008
Experience at St. Georg

Acute procedural results – Site of success

- Failure
- only endo
- endo + epi
- only epi
- epi after failed endo
Experience at St. Georg

Complications

- Sterile pericarditis (4)
- Hepatic hemorrhage due to puncture (1)
- Non-fatal pulmonary embolism (1)
- Death after perforation of RV (1)
- Death in cardiogenic shock at d1 after RF (1)
Follow-up

FU 1-929 d (median 293d) N=35

- Successful RF N=27
  - Recurrence N=15
    - 2nd Procedure N=7
      - Recurrence N=1
      - Lost to FU N=1
  - 12/35 (34%)

- Failed RF N=8
  - Recurrence N=8
  - 2nd Procedure N=3
    - Recurrence N=2
  - 18/35 (51%)

Alive and free from VT 53% (16/29)
Epicardial Ablation for VT

Postablation management

- At end of session fluid is removed from the pericardial sac by a pigtail catheter
- After exclusion of pericardial effusion by echocardiography removal of pigtail catheter not earlier than after 24 hours
- Prophylactic antibiotics for 2-3 days
- ECG monitoring for 72 hours
Epicardial VT ablation

- Consider epicardial substrate, if....
  - Endocardial mapping not conclusive
  - Endocardial RF fails
  - Specific disease states

- Beware of potential complications
Catheter Ablation of Difficult VT

- Pitfalls of VT ablation
  - Optimal time point of VT ablation
  - Epicardial substrates
  - “un-mappable VT”
Electroanatomic based ablation of VT

Previous Problems in VT Ablation

- Non-inducibility of VT during EP study
- Mechanical block during mapping
- Tachycardia is hemodynamically not tolerated (pts with reduced LV function)
- Multiple VT morphologies
47 VT pts (post myocardial infarction)

- 4 pts incessant VT
  - CARTO VT Map

- 18 pts induced VT
  - CARTO Substrate Map and CARTO VT Map

- 25 pts:
  - 6 pts mechanical block
  - 19 pts unstable VT
  - CARTO Substrate Map

VT Group (n = 22)

Substrate Group (n = 25)

Volkmer et al, Europace 2006, 8:968-76
Fig. 4

VT-group (22 pts)

Linear ablation (19 pts) or focal ablation (3 pts)

success* (20/22 = 91%)

2 pts non arrhythmogenic death in hospital

clin. VT reinduced (2/22 = 9%)

Acute

2 pts non arrhythmogenic death in hospital

clin. VT reinduced (2/22 = 9%)

Chronic

no recurrence (12/18 = 67%)

fast VT/VF (4/18 = 22%)

slower VT (2/18 = 11%)

clin. VT reinduced (2/2 = 100%)

3/4 pts no ablation (controlled by ICD)
1/4 pts successful linear ablation

2/2 pts successful linear ablation

1/2 pt no reablation (controlled by Amio and ICD)
1/2 pt successful linear ablation

*Successful reablation during same hospitalization using irrigated catheter due to early VT- recurrence in 3 pts (2 clinical VT, 1 fast but stable VT treated by linear ablation in 1pt and focal ablation in 2pts)

Volkmer et al, Europace 2006, 8:968-76
Substrate-group (25 pts)

Linear ablation (21 pts) or focal ablation (4 pts)

**Control RV stimulation**

**Acute**
- RV stimulation performed (21/25 = 84%)
  - Clin. VT reinduced (2/21 = 10%)
  - Slow VT induced (1/21 = 5%)
  - Success* (18/21 = 86%)

**Chronic**
- 1/2 pts no VT
- 1/2 pts 1x VF
- 1/1 pt slower VT
- No recurrence (12/18 = 67%)
- Slower VT (3/18 = 17%)
- Fast VT/VF (4/24 = 17%)
- Clin. VT recurred (1/3 = 33%)
- No recurrence (1/3 = 33%)

**Linear ablation (21 pts) or focal ablation (4 pts)**

**RV stimulation not performed** (4/25 = 16%)

- 1 pt non arrhyth. death in hospital
- 1 pt refused control stimulation
- 1 pt died in hospital before control stimulation

* Successful reablation during same hospitalization using irrigated catheter due to early VT-recurrence in 1 pt (linear ablation)

** 3 pts refused control stimulation, 1 pt died in hospital before control stimulation

Volkmer et al, Europace 2006, 8:968-76
Ablation of „un-mappable VT“

- Consider substrate mapping using 3D mapping systems
- Combination with conventional EP manoeuvres