Risk stratification of sudden death in ACHD: Do current adult guidelines apply?

Paul Khairy, MD, PhD
Canada Research Chair, Electrophysiology and ACHD
Director, Montreal Heart Institute Adult Congenital Center

The California Heart Rhythm Symposium

AUDIENCE RESPONSE

With regards to the relative prevalence of pediatric and ACHD in North America, which is true?

1. 10x more children than adults with CHD
2. Twice as many children than adults with CHD
3. Equal # of children and adults with CHD
4. # of adults surpasses # of children with CHD

CHANGING MORTALITY IN CHD

Mortality reduction
- Overall: 31%
- Children with severe CHD: 67%

Khairy P et al. JACC 2010;56(14):1149-57
MODE OF DEATH IN ACHD

Oechslin E et al. Am J Cardiol 2000;86:1111-6

“GENERAL ADULT CRITERIA”
Primary Prevention

Primary Prevention ICD Trials

APPRAOCHES TO RISK STRATIFICATION

"Gut-feeling" approach

Probabilistic approach

Koyak Z et al. Circ EP 2012;5;101-10

Yap SC et al. Eur Heart J 2007;28;1854-61


AARCC. Circulation 2010;31;122:868-875

9.2%
LVEF ≤35%

Class I(B): "ICD therapy is indicated in patients with nonischemic DCM who have an LVEF≤35% and who are in NYHA Class II or III"

PRIMARY PREVENTION ICD TRIALS

Study | N | Age (yrs) | LVEF (%) | FU (mo) | Annual mortality (controls) | Annualized SCD (controls) | RR with ICD
--- | --- | --- | --- | --- | --- | --- | ---
MADIT | 198 | 63 | 26 | 27 | 17 | 8.0 | 54%
CAEBG-Patch | 900 | 64 | 27 | 32 | 6 | NEG
MUSTT | 704 | 66 | 29 | 39 | 14 | 6.6 | 51%
MADIT-II | 1232 | 64 | 23 | 20 | 10 | 5.2 | 31%
CAT | 104 | 52 | 24 | 23 | 4 | NEG
AMIOVIRT | 103 | 52 | 23 | 24 | 4 | NEG
COMPANION | 1520 | 67 | 22 | 15 | 19 | 9.5 | 36%
DEFINITE | 458 | 58 | 21 | 29 | 7 | 3.5 | 35%
SCD-HeFT | 2521 | 60 | 25 | 46 | 7 | 3.5 | 23%
DINAMIT | 674 | 62 | 28 | 30 | 8 | NEG

APPROACHES TO RISK STRATIFICATION

"Gut-feeling" approach

Probabilistic approach

"Gut-feeling" approach

Probabilistic approach

PRINCIPLES TO RISK STRATIFICATION

APPROACHES TO RISK STRATIFICATION

"Gut-feeling" approach

Probabilistic approach

PRINCIPLES TO RISK STRATIFICATION

APPROACHES TO RISK STRATIFICATION

"Gut-feeling" approach

Probabilistic approach

APPROACHES TO RISK STRATIFICATION

"Gut-feeling" approach

Probabilistic approach

PRINCIPLES TO RISK STRATIFICATION

APPROACHES TO RISK STRATIFICATION

"Gut-feeling" approach
CASE: 27 year-old woman with TOF

- Surgical history
  - RBTS: 10 months
  - Corrective surgery at 6 years
    - Ventriculotomy incision; subannular RVOT patch
    - Age 16: surgery for RVOTO
- Med: none
- NYHA I/IV
- Palpitations with dizziness during non-strenuous walk
- Mild to moderate PR; mild RV dilation
- QRS 160 ms; Holter 5-beats NSVT (180 bpm)

AUDIENCE RESPONSE: RECOMMENDATION?

1. Reassure patient PVCs are common; no sustained arrhythmia; no hemodynamic issues
2. Initiate β-blockers; annual follow-up
3. Further risk stratify with EP study
4. Implant ICD

NON-INVASIVE RISK FACTORS IN TOF

<table>
<thead>
<tr>
<th>N=793</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at repair, years</td>
<td>1.08</td>
<td>1.02-1.15</td>
</tr>
<tr>
<td>QRS ≥180 msec</td>
<td>2.29</td>
<td>1.05-5.02</td>
</tr>
<tr>
<td>Transannular patch</td>
<td>11.7</td>
<td>1.33-103.1</td>
</tr>
<tr>
<td>QRS annual change, ms</td>
<td>1.05</td>
<td>1.02-1.09</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N=556</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior cardiac surgeries, N</td>
<td>1.3</td>
<td>1.1-1.6</td>
</tr>
<tr>
<td>QRS duration, ms</td>
<td>1.02</td>
<td>1.01-1.03</td>
</tr>
<tr>
<td>LV diastolic dysfunction</td>
<td>3.3</td>
<td>1.5-7.1</td>
</tr>
</tbody>
</table>

SCD BY CHD SUBTYPE

Silka MJ et al. JACC 1998;32:245-51

Gatzoulis MA et al. Lancet 2000;356:975-81
**PROGRAMMED VSTIM IN TOF**

- Logrank P<0.0001
- Hazard ratio (multivariate) 4.7, 95% CI (1.3-18.5)

**VSTIM TOF: TEST CHARACTERISTICS**

<table>
<thead>
<tr>
<th></th>
<th>Inducible VT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>77.4%</td>
</tr>
<tr>
<td>Specificity</td>
<td>79.5%</td>
</tr>
<tr>
<td>Diagnostic accuracy</td>
<td>79.0%</td>
</tr>
<tr>
<td>(+) Predictive value</td>
<td>55.2%</td>
</tr>
<tr>
<td>(-) Predictive value</td>
<td>91.5%</td>
</tr>
<tr>
<td>(+) Likelihood ratio</td>
<td>3.77</td>
</tr>
<tr>
<td>(-) Likelihood ratio</td>
<td>0.28</td>
</tr>
</tbody>
</table>

**RISK STRATIFICATION IN TOF**

- Non-invasive markers:
  - CPET?
  - Degree fibrosis?
  - Neurohormones?
  - QRS duration?
  - Age?
  - Transannular patch?
  - Prior palliative shunt?
  - Number surgeries?
  - NSVT?
  - CTR?
  - Ventriculotomy incision?
  - LVDD (LVEDP)?

- Low risk (<1%)
- Intermediate risk (1%-11.5%)
- High risk (>11.5%)
- EP study
- Conservative therapy (<3.5%)
- SCD prevention (≥3.5%)

**PRIMARY PREVENTION ICD IN CHD**

- Variable | Point |
- Prior palliative shunt | 2 |
- Inducible sustained VT | 2 |
- QRS ≥180 ms | 1 |
- Ventriculotomy incision | 2 |
- Non-sustained VT | 2 |
- LVEDP ≥12 mmHg | 3 |

**TOTAL POINTS** 0-12

- Risk score
  - Low: 0-2
  - Intermediate: 3-5
  - High: 6-12
- Risk category
  - Low: 18
  - Intermediate: 24
  - High: 26
- Annualized rate of appropriate shocks
  - Low: 0%
  - Intermediate: 3.0%
  - High: 17.9%
CASE: 27 year-old woman with TOF

- Surgical history
  - RBTS: 10 months
  - Corrective surgery at 6 years
    - Ventriculotomy incision; subannular RVOT patch
    - Age 16: surgery for RVOTO
- Med: none
- NYHA I/IV
- Palpitations with dizziness during non-strenuous walk
- Mild to moderate PR; mild RV dilation
- QRS 160 ms; Holter 5-beats NSVT (180 bpm)

ICDs IN D-TGA/ATRIAL SWITCH

- Syncope: 35%
- NSVT: 48%
- RVEF<35%: 35%
- QRS ≥180 ms: 30%
- Inducible VT: 30%

ICD INDICATIONS: D-TGA/ATRIAL BAFFLE

- Primary Prevention
  - Syncope: 35%
  - NSVT: 48%
  - RVEF<35%: 35%
  - QRS ≥180 ms: 30%
  - Inducible VT: 30%
- Secondary Prevention
  - Cardiac arrest: 71%
  - Sustained VT: 29%
VSTIM IN D-TGA/atrial baffles

VSTIM and ICDs
N=17

Inducible VT/VF
N=9 (53%)

Non-inducible
N=8 (47%)

Appropriate shock
N=0/9 (0%)

Appropriate shock
N=3/8 (38%)
P=0.043


VT, SCD, appropriate ICD shocks

OR or HR (95% CI)

Janousek J et al. Z Cardiol 1994;83:933-8
Supraventricular tachyarrhythmia N/A
Systemic RV dysfunction or severe TR N/A

Kammeraad et al. JACC 2004;5:1095-102
Documented AF/Flutter OR 4.9 (1.9, 12.5)
Arrhythmia symptoms OR 21.6 (2.8, 166.8)

Prior VT/VF, cardiac arrest HR 18.0 (1.2, 261.0)
Lack of beta-blockers HR 16.7 (1.3, 185.2)

D-TGA, SVT, and SCD

Longer tachycardia cycle length favors 1:1 conduction


Why does SVT induce VT/VF in D-TGA?

HEART RATE AND STROKE VOLUME


D-TGA AND PERFUSION DEFECTS

Lubiszewska B et al. JACC 2000;36:1365-70

RISK REDUCTION: β-BLOCKERS?


CATHETER ABLATION

Khairy P, Van Hare GF. Heart Rhythm 2009;6:283-9
SELECTIVE WITH PRIMARY PREVENTION ICDs

• 33 year-old man: Mustard; RVEF 12%; LVEF 52%; moderate TR; QRS 220 ms; palpitations


KEY POINTS

• Risk stratification for SCD in ACHD is complex and evolving
  • Probabilistic approach offers best opportunity for progress
  • VSTIM of value when mechanism is macroreentry (e.g., TOF), particularly in patients at intermediate risk
  • The systemic RVEF cut-off value for primary prevention ICDs remains TBD
  • SVTs may be an important contributor to risk of SCD (e.g., D-TGA/atrial switch)

BONUS QUESTION

• Risk stratification of sudden death in ACHD is...
  A) An esoteric topic unlikely to ever be encountered in the real world
  A) A nuisance to a few patients with a limited number of anatomical subtypes
  A) Hopeless issue not worthy of discussion
  A) An important area of interest with effective treatment options and great potential to reduce mortality in a young, dynamic, and growing patient population

THANK YOU!

International Society for Adult Congenital Heart Disease

www.isachd.org
## INCIDENCE OF SCD IN CHD

<table>
<thead>
<tr>
<th>Lesion</th>
<th>N</th>
<th>FU (pt-yrs)</th>
<th>Annual incidence SCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASD</td>
<td>622</td>
<td>7904</td>
<td>0</td>
</tr>
<tr>
<td>VSD</td>
<td>527</td>
<td>6354</td>
<td>0.02</td>
</tr>
<tr>
<td>AVSD</td>
<td>254</td>
<td>2217</td>
<td>0.09</td>
</tr>
<tr>
<td>PDA</td>
<td>623</td>
<td>8753</td>
<td>0</td>
</tr>
<tr>
<td>PS</td>
<td>241</td>
<td>3568</td>
<td>0.03</td>
</tr>
<tr>
<td>AS</td>
<td>169</td>
<td>1860</td>
<td>0.54</td>
</tr>
<tr>
<td>CoA</td>
<td>536</td>
<td>6706</td>
<td>0.13</td>
</tr>
<tr>
<td>TOF</td>
<td>445</td>
<td>7082</td>
<td>0.15</td>
</tr>
<tr>
<td>D-TGA</td>
<td>172</td>
<td>1413</td>
<td>0.49</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3589</strong></td>
<td><strong>45857</strong></td>
<td><strong>0.09</strong></td>
</tr>
</tbody>
</table>

Silka MJ et al. JACC 1998;32:245-51