Current Status and the Challenge in Pediatric RFCA

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National Taiwan University Children’s Hospital, Taipei, Taiwan
Wu MH, unpublished data
Pediatric Arrhythmias Diagnosis and Treatment in NTUH, Taiwan

Radiofrequency catheter ablation of tachycardia in children with and without congenital heart disease: indications and limitations

Supraventricular Tachycardia in Patients With Right Atrial Isom

Special electrophysiological characteristics of pediatric idiopathic ventricular tachycardia
Pediatric Arrhythmias Diagnosis and Treatment in Taiwan

Current status

Challenges

Landscape
Mechanisms for Pediatric Tachycardia without structural heart disease

NTUCH 1993-2009

AVRT: atrioventricular reentrant tachycardia
AVNRT: atrioventricular nodal reentrant tachycardia
AT: atrial tachycardia, EAT
AF: atrial flutter
JET: junctional ectopic tachycardia
VT: ventricular tachycardia
WPW CMP

US registry data

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Pediatric tachyarrhythmia: Dynamic strategic approach in 2019

- Resolution in children < 5 yrs
- Risk of SD (0.1-0.2%/1000) in WPW
- Tachycardia cardiomyopathy, dyssynchrony: reversible after ablation
- Medical control: still an option
Special circumstances: Tachycardia Cardiomyopathy: CHF, Cardiomegaly, LVEF <50% (median 34%), 9 patients

- Acute success in all
- Recurrence in one, success at the repeated RFCA
- LV function returned to normal after RFCA and remained normal at follow-up
Special circumstances: Dyssynchrony from Ventricular Pre-excitation

- Right septal or posteroseptal accessory pathways → an abnormal interventricular septal motion
- Left-sided accessory pathways → abnormal LV posterior wall motion.
- Regional dyssynchrony, particularly the abnormal IVS movement, may provoke LV dyssynchrony and dysfunction
- In those with pre-excitation (but no tachycardia) and impaired LV function, RFCA of the accessory pathway restored the LV function.

Special circumstances: Dyssynchrony from Ventricular Pre-excitation

Onset: 1.5 yrs, ablation at the age of 6.5 years (two accessory pathways, right anterior and right anteroseptal)

Late restored cardiac function 2 years after successful ablation of right posterior accessory pathway ablation

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Tachycardia, QoL
- Acute success: 87-98%
- Serious complication: 1%
- Late complications?
- No change on AF in late adulthood

Child health

Outcomes

Treatment options

Medical control: still an option

WPW Syndrome in Adults

- **Nonablated WPW** patients had a higher *long-term death risk* compared with **ablated WPW patients** (hazard ratio, 2.10)
- **Incident atrial fibrillation** risk was higher in the WPW group compared with the control population (hazard ratio, 1.55). But, nonablated WPW patients had lower risk than ablated patients (hazard ratio, 0.39).

T. Jared Bunch et al. Circ Arrhythm Electrophysiol. 2015;8:1465-1471
Pediatric tachyarrhythmia: Dynamic strategic approach in 2019

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- **Child health**

- **Outcomes**
  - Acute success: 87-98%
  - Serious complication: 1%
  - Late complications?
  - No change on AF in late adulthood

- **Treatment options**
  - Intervention: EP system with 3-D electroanatomical guide (Non- or Zero-fluro), Energy: RF energy, cryo, --

**Pediatric tachycardia, QoL**
## AV Block in RFCA of SVT in Children

<table>
<thead>
<tr>
<th>Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVNRT</td>
<td>1.6%</td>
</tr>
<tr>
<td>AVRT</td>
<td></td>
</tr>
<tr>
<td>Midseptal pathway</td>
<td>10.4%</td>
</tr>
<tr>
<td>Anteroseptal</td>
<td>2.7%</td>
</tr>
<tr>
<td>R’t posteroseptal</td>
<td>1.0%</td>
</tr>
<tr>
<td>R’t posterior</td>
<td>0.9%</td>
</tr>
</tbody>
</table>
CRYO-ABLATION FOR AVNRT: NTU CHILDREN’S HOSPITAL

- 52 patients: age \(15.8 \pm 5.3\) years
- There were typical AVNRT in 44, atypical AVNRT in 5 and both type in 3.
- Acute success rate was 98.1 %. \((52/53)\)
- There was no permanent atrioventricular (AV) block.
- During the mean follow-up of \(1.93 \pm 0.83\) years, two patients had recurrences \(3.9\%\) with one received cryoablation again
Fluoroscopic mapping

- ALARA radiation goal: “As Low As Reasonably Achievable”

  Maximize diagnostic and therapeutic benefit by using the lowest possible radiation dose.

- There is NO “safe dose” radiation, especially for children.
## Non-fluoroscopic imaging tools

<table>
<thead>
<tr>
<th>Commercial name</th>
<th><strong>Ensite NavX</strong></th>
<th><strong>Mediguide technology</strong></th>
<th><strong>Carto 3 system</strong></th>
<th><strong>Localisa</strong></th>
<th><strong>Rhythmia</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Localization-based system</td>
<td>Voltage-guided field</td>
<td>Low-powered electromagnetic field</td>
<td>Magnetic and impedance field</td>
<td>Electrical field</td>
<td>Magnetic and impedance field</td>
</tr>
<tr>
<td>Movement sensibility (mm)</td>
<td>1.4</td>
<td>0.5</td>
<td>1.0</td>
<td>1.4</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Multipoint activation mapping available</td>
<td>Yes (max 128 point)</td>
<td>No</td>
<td>Yes (max 20 point)</td>
<td>No</td>
<td>Yes (max 64 points)</td>
</tr>
<tr>
<td>Open architecture system</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Possibility to merge with pre-acquired images</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

NTUCH: (ZF) technique utilizing EnSite PrecisionTM Cardiac Mapping System in pediatric ablation of cardiac arrhythmias since 2016
## Non-fluoroscopic imaging in NTUCH

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Study Group</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient numbers (M:F)</td>
<td>75 (43:32)</td>
<td>50 (30:20)</td>
<td>-</td>
</tr>
<tr>
<td>Procedures (times)</td>
<td>82</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Age at ablation (yr)</td>
<td>14.2 ± 3.07</td>
<td>12.2 ± 3.19</td>
<td>.583</td>
</tr>
<tr>
<td>Body Weight (kg)</td>
<td>158.5 ± 14.6</td>
<td>151.1 ± 15.7</td>
<td>.432</td>
</tr>
<tr>
<td>Body Height (cm)</td>
<td>52.2 ± 13.9</td>
<td>47 ± 16.4</td>
<td>.117</td>
</tr>
<tr>
<td>Procedure Time (min.)</td>
<td>100.52 ± 65.24</td>
<td>91.82 ± 55.08</td>
<td>.414</td>
</tr>
<tr>
<td>Fluoroscopic Time (min.)</td>
<td>28.64 ± 23.47</td>
<td>0.38 ± 2.01</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Acute Success Rate (%)</td>
<td>98.78 (81/82)</td>
<td>98 (49/50)</td>
<td>1.00</td>
</tr>
<tr>
<td>Zero-fluoroscopy</td>
<td>-</td>
<td>84% (42/50)</td>
<td>-</td>
</tr>
</tbody>
</table>

- No ZF technique related, catheter-induced complications.
The cumulative incidence of SVT was 1.39/1000 (WPW syndrome, 16%) by the age of 15 years, (i.e., 1 in 722).

Disease Burden estimated from Birth Cohort 2000-2008 with 2000-14 medical data: disease burden

Wu MH et al. Heart Rhythm 2016
## Epidemiology update, congenital heart disease

<table>
<thead>
<tr>
<th>Study types</th>
<th>Incidence (/1000 LB)</th>
<th>Study population</th>
<th>Severe CHD</th>
<th>Incidence (/1000LB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China: Yang, Chin Med J, 2009</td>
<td>6.7</td>
<td>registry data, BCMR</td>
<td>83,292</td>
<td>12.8</td>
</tr>
<tr>
<td>China: Zhoa, Acta Pedita, 2013</td>
<td>9.6</td>
<td>Hospital bases</td>
<td>5190</td>
<td>14.6</td>
</tr>
<tr>
<td>Japan: Ooshima, Cardiology, 1995</td>
<td>10.6</td>
<td>13 hosp. nursery echo</td>
<td>502</td>
<td>13.5</td>
</tr>
<tr>
<td>Korea: Jung, J Hum Genet, 1999</td>
<td>14.77</td>
<td>KFMI</td>
<td>1,202,835</td>
<td>14.8</td>
</tr>
<tr>
<td>Taiwan: Wu J Pediatr, 2010</td>
<td>13.08</td>
<td>NHI database</td>
<td>1,667,001</td>
<td>10.8</td>
</tr>
<tr>
<td>US: Reller J Pediatr, 2008</td>
<td>8.14</td>
<td>Registry data, MACDP</td>
<td>398,140</td>
<td>17.4</td>
</tr>
</tbody>
</table>

- The cumulative incidence of SVT is similar to that of severe CHD.

- Severe CHD: TOF, TGA, AVSD, tricuspid atresia, truncus arteriosus, univentricular heart, HLHS, TAPVR
1/5 of SVT patients have already received ablation in the pediatric ages.

1/3 -1/2 received ablation in the pediatric ages after the introduction of non-fluoroscopic EP and various energy ablation?
Pediatric tachyarrhythmia: Dynamic strategic approach in 2019

Specialty centers with adequate volume: probably one/100,000-200,000 newborn

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Tachycardia, QoL

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Treatment options
- Intervention: EP system with 3-D electroanatomical guide (Non- or Zero-fluro), Energy: RF energy, cryo, --
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NTUCH PCV genetic panel 2018: a case with VPC and decreased LV function

catecholaminergic polymorphic ventricular tachycardia (CPVT)

14 yr
Dizziness
headache

16 yr
An episode of palpitation with near syncope, not related to exercise
Atenolol

18 y/o Frequent dizziness
pro-BNP 720pg/mL

RYR2 gene mutation
Atenolol + flecainide
NT-pro BNP 17 pg/mL

<table>
<thead>
<tr>
<th>Ventricular Ectopy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total VE Beats</td>
<td>43236 (40.7%)</td>
</tr>
<tr>
<td>Vent Runs</td>
<td>0</td>
</tr>
<tr>
<td>Beats</td>
<td>0</td>
</tr>
<tr>
<td>Longest</td>
<td>0</td>
</tr>
<tr>
<td>Fastest</td>
<td>0 BPM</td>
</tr>
<tr>
<td>Triplets</td>
<td>1 Event</td>
</tr>
<tr>
<td>Couplets</td>
<td>173 Events</td>
</tr>
<tr>
<td>Single/Interp PVC</td>
<td>1938/416</td>
</tr>
<tr>
<td>R on T</td>
<td>0</td>
</tr>
<tr>
<td>Single/Late VE's</td>
<td>1/0</td>
</tr>
<tr>
<td>Bi/Trigeminy</td>
<td>39639/893 Beats</td>
</tr>
</tbody>
</table>
NTUCH PCV panel 2018: initial experience

**Aborted Sudden death**

Yield rate: 88%

Mutations (64%) and likely pathogens (36%)

Diseases:

- Long QT syndrome
- Catecholaminergic polymorphic ventricular tachycardia (CPVT)
- Brugada syndrome
- Arrhythmogenic right ventricular dysplasia
- LV noncompaction
## Adult CHD, prevalence

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Prevalence (/1000)</th>
<th>Severe CHD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Administrative data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taiwan $^1$</td>
<td>2014</td>
<td>2.17</td>
<td>11.7</td>
</tr>
<tr>
<td>Canada (Quebec) $^2$</td>
<td>2000</td>
<td>4.09</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>6.12</td>
<td>10.13</td>
</tr>
<tr>
<td><strong>Estimates from CHD incidence at birth and the survival</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other high-income countries, estimates</td>
<td>2000s</td>
<td>1.77-4.91</td>
<td></td>
</tr>
<tr>
<td>Japan $^3$</td>
<td>2011</td>
<td>3.93</td>
<td></td>
</tr>
</tbody>
</table>

1: Wu MH et al. JAHA 2018  
2: Marelli et al, Circulation 2014  
3: Shiina Y et al. Int J Cardiol 2011

Tachyarrhythmia burden in various CHD

Wu MH et al. JAHA 2018
Catheter Ablation for Atrial Fibrillation in ACHD:
84 patients from 7 centers in US

- mean age 51.5±12.1 years, 65.5% male, 45.2% with paroxysmal AF

Ablation sites:
- PVI 80 (95.2%): 30 (35.7%) patients undergoing PVI alone.
- non-PV triggers, cavotricuspid isthmus, creation of a roof line, mitral annular linear ablation, CFAE ablation
- At 1 yr: complete freedom 53.1% : complete/partial 71.6%
- no significant differences between those with simple, moderate, or severe complexity.

1. > Half would receive ablation in the pediatric ages, WPW syndrome, a pediatric disease?

2. Genomic diagnosis, functional changes by AI, Genomics era regulation/guideline!!

3. Non-fluoroscopic guide EPS/ablation is the trend for pediatric 8?/1000 adults, the older, the higher risk for arrhythmias.

4. Grown up pediatric illness, a new field!!
Thank you!
고맙습니다

Mei-Hwan Wu, MD, PhD
National Taiwan University Children’s Hospital,
Taipei, Taiwan
Channelopathy and Sudden Cardiac Death: a model link the genotype and phenotype

Tailored therapy

13 y/o: SCD, ICD, negative genetic screening

18, 21, 25, 32 y/o, replace battery

28 y/o: CS delivery of a normal female baby

31 y/o: RYR2 mutation

Control of idiopathic ventricular fibrillation by implantable cardioverter-defibrillator in a child who survived sudden death.

Lin YC, Chang WT, Chen WJ, Lai LP, Lin JL, Wu MH.
NTUCH PCV panel 2018: initial experience

Aborted Sudden death

> 300 genes

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</tr>
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</table>

下午 05:13:21  77 BPM  Size x1,x1,x1  Couplet

Ch1

Ch2

I

P