Advances in Pediatric Electrophysiology

No disclosures to report

KidsHeart Medical Center &
New York Presbyterian Hospital / Columbia University Medical Center
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Pediatric Arrhythmia Diagnosis and Treatment

- **Diagnosis**
  - “Patch” monitors
  - Smartphone event monitors
  - Implantable loop monitors

- **Ablations**
  - 3-D mapping systems

- **Pacing and ICD’s**
  - Leadless pacemakers
  - Subcutaneous ICD’s
Diagnosis

- Holter monitor

Norman Holter
1947
Holter monitors
Event monitors
Patch monitor
Patch monitor
Comparison of Holter with Patch Ambulatory Electrocardiographic Monitoring in Children: A Prospective Clinical Trial

Meena Bolourchi, MD, Eric S. Silver, MD, David Morewana, BS, Esteban Mendez, and Leonardo Liberman, MD

Background

- Holter is the standard for ambulatory arrhythmia monitoring.
- Newer single-lead Zio XT (Zio) patch monitor is FDA-approved for adults, however its utility in children is less clear.

Objectives

- To determine if the Zio patch is as good as the Holter monitor for arrhythmia detection in children.
- To determine if patients prefer the Zio or the Holter.

Methods

- 200 patients < 22 years-old referred for ambulatory ECG monitoring at Columbia from October 2017 – February 2019 were enrolled to wear the Holter and the Zio simultaneously for 48 hours.
- A patient satisfaction survey was completed afterwards.
- The detection of clinically significant arrhythmias was compared between each device using McNemar’s test.

Clinically Significant Arrhythmias

- SVT ≥ 4 beats
- VT ≥ 4 beats
- Atrial or ventricular ectopy ≥ 5%
- Advanced heart block
- Atrial fibrillation/flutter
- Pause ≥ 3 seconds

Patients

<table>
<thead>
<tr>
<th>N (%)</th>
<th>Median (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>94 (2870)</td>
</tr>
<tr>
<td>Age (y)</td>
<td>11.6 (21.76)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>158 (151-170)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>31 (15.3-72)</td>
</tr>
<tr>
<td>Chest circumference (cm)</td>
<td>64 (60-150)</td>
</tr>
<tr>
<td>Congestive heart disease</td>
<td>30 (24%)</td>
</tr>
<tr>
<td>Prior cardiac intervention</td>
<td>30 (27%)</td>
</tr>
<tr>
<td>Cardiac surgery</td>
<td>7 (5%)</td>
</tr>
</tbody>
</table>

Results: Patient Satisfaction

73% preferred the Zio over the Holter (p < 0.0001) due to:

Overall Preference

<table>
<thead>
<tr>
<th>Overall Preference</th>
<th>Zio</th>
<th>Holter</th>
<th>Neither</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easier for shower</td>
<td>79%</td>
<td>8%</td>
<td>13%</td>
</tr>
<tr>
<td>Number of stickers</td>
<td>97%</td>
<td>0%</td>
<td>3%</td>
</tr>
<tr>
<td>More comfortable</td>
<td>88%</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>Number of wires</td>
<td>94%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>Easier under clothes</td>
<td>85%</td>
<td>0%</td>
<td>9%</td>
</tr>
<tr>
<td>Less skin irritation</td>
<td>72%</td>
<td>14%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Results: Arrhythmia Detection

There was no difference in the detection of clinically significant arrhythmias with the Zio as compared to the Holter, p = 0.29.

Conclusions

- The Zio was as good as the Holter in detection of clinically significant arrhythmias in children, and with less artifact.
- Patients/parents more often preferred the Zio over the Holter.

Disclosure: Funded through Matthew’s Hearty of Hope and Colman’s Kids Grants.
Comparison of Holter with Patch Ambulatory Electrocardiographic Monitoring in Children: A Prospective Clinical Trial

Meena Bolourchi, MD, Eric S. Silver, MD, David Nwanga, BS, Esteban Mendez, and Leonardo Liberman, MD
Division of Pediatric Cardiology, Columbia University Irving Medical Center, Vagelos College of Physicians and Surgeons

Background

- Holter is the standard for ambulatory arrhythmia monitoring.
- Newer single lead Zio XT (Zio) patch monitor is FDA-approved for adults, however its utility in children is less clear.

Objectives

- To determine if the Zio monitor is equally effective for arrhythmia monitoring in children
- To determine if patient satisfaction with the Zio monitor is equivalent to Holter

Methods

- IRB-approved prospective study
- www.clinicaltrials.gov (NCT03554417)
- 200 patients < 22 years-old undergoing 12-lead ECG monitoring at Columbia University Irving Medical Center between 2017 and 2019 were enrolled to receive both devices simultaneously for 48 hours
- A patient satisfaction survey was completed afterwards
- The detection of clinically significant arrhythmias was compared between each device using McNemar’s test

Clinically Significant Arrhythmias

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<tr>
<td>89%</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>97%</td>
<td>0%</td>
<td>3%</td>
</tr>
<tr>
<td>88%</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>94%</td>
<td>2%</td>
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<td>6%</td>
<td>9%</td>
</tr>
<tr>
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<td>14%</td>
<td>14%</td>
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Conclusions

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Results: Patient Satisfaction

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<td>13%</td>
<td>14%</td>
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- **Competition**
  - Comfort: Zio 2.7, Holter 1.8
  - Skin irritation: Zio 2, Holter 2.1
  - Lack of interference with activities: Zio 3.4, Holter 2.4

  *p < 0.001 for Zio vs Holter*
**Pediatric Arrhythmia Diagnosis and Treatment:**

*There’s an App for That*

- **Diagnosis**
  - “Patch” monitors
  - Smartphone event monitors
  - Implantable loop monitors

- **Ablations**
  - 3-D mapping systems

- **Pacing and ICD’s**
  - Leadless pacemakers
  - Subcutaneous ICD’s
Traditional event monitors
Smartphone event monitors
A Smartphone Application to Diagnose the Mechanism of Pediatric Supraventricular Tachycardia

Dina J. Ferdman¹ · Leonardo Liberman¹ · Eric S. Silver¹

Fig. 2 Lead placement

Fig. 3 SVT tracings. a AVRT with visible retrograde P waves (arrow), b AVNRT with no visible retrograde P waves
Pediatric Arrhythmia Diagnosis and Treatment: 
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Implantable looping event monitors
2. Pinch the skin and make incision

Push blade in approximately 90 degrees to the pinched tissue.
Case #1

• 7-year-old with Long QT syndrome
  – Episodes of syncope, ?vasovagal
  – Placed an implantable loop monitor
Case #1
Case #2

• 21-year-old with a mild cardiomyopathy
  – Episode of syncope
  – PVC’s noted on monitoring
  – Placed an implantable loop monitor
  • Recurrent episode of syncope
Case #2
Case #3

• 11 year old with hypertrophic cardiomyopathy
  – Palpitations
  – Near syncope
  – Placed an implantable loop
# Case #3

![Graph showing heart rate over time with symptom at -60 seconds.](image.png)

**Assessment Legend:**
- ☑ Appropriate
- ☞ Indeterminate
- ✗ Inappropriate

<table>
<thead>
<tr>
<th>ID#</th>
<th>Assessment Type</th>
<th>Date</th>
<th>Detected hh:mm</th>
<th>Duration hh:mm:ss</th>
<th>Max V. Rate</th>
<th>Median V. Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>Symptom</td>
<td>26-Aug</td>
<td>21:23</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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Case #3
Implantable loop monitor

• Indications:
  – Infrequent but worrisome symptoms
  • Mostly syncope
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Sore knee, huh? Have you tried icing it?
Ablations

Angled AP

Angled lateral
Ablations

10 years ago, that was it . . .
Fluoroscopic exposure over time for ablations

Comparing before with after 3-D mapping introduced $P < 0.001$
Since June of 2018 > 50% of ablations with zero fluoroscopy
Pediatric Arrhythmia Diagnosis and Treatment: There’s an App for That

• Diagnosis
  – “Patch” monitors ✓
  – Smartphone event monitors ✓
  – Implantable loop monitors ✓

• Ablations
  – 3-D mapping systems ✓

• Pacing and ICD’s
  – Leadless pacemakers
  – Subcutaneous ICD’s
Pacemaker
A transvenous pacemaker
Epicardial pacemaker for post-op AV block
At 11 she presents with syncope
Pacemaker limitations
Pacemaker limitations

- Relying on leads
  - Tendency to fracture, especially in children
    - Epicardial
    - Growth
    - Stress from active lifestyle
  - Risk of dislodgement
Coronary artery compression from epicardial leads: More common than we think

Douglas Y. Mah, MD,* Ashwin Prakash, MD,* Diego Porras, MD,* Francis Fynn-Thompson, MD,† Elizabeth S. DeWitt, MD,* Puja Banka, MD*

From the *Department of Cardiology, Boston Children’s Hospital and Harvard Medical School, Boston, Massachusetts, and †Department Cardiovascular Surgery, Boston Children’s Hospital and Harvard Medical School, Boston, Massachusetts. (Heart Rhythm 2018;14:1–9)
Pacemaker limitations

• Relying on leads
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    • Stress from active lifestyle
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  – Risk of coronary compression
Pacemaker limitations
Pacemaker limitations

• Relying on leads
  – Tendency to fracture, especially in children
    • Epicardial
    • Growth
    • Stress from active lifestyle
  – Risk of dislodgement
  – Risk of coronary compression
  – Vascular occlusion
  – Pocket issues
Pacemakers Through the Years: Process of Technological Evolution

- **First External Pacemaker**
  - 1958
- **5800**
- **5858**
- **Activitrax**
  - Rate response
- **MicroMinix**
  - Radically smaller size
- **Thera**
  - First microprocessor-based, mode switching
- **EnPulse**
  - Full automaticity

- **First Implantable Pacemaker**
  - 1960
- **Chardack-Greatbatch**
- **1979**
- **Byrel**
- **1989**
- **Synergist**
- **1990**
- **Elite**
- **1991**
- **Kappa**
- **1995**
- **MVP, Full Automaticity**
- **2004**
- **Adapta**
Leadless pacemakers
Leadless pacemakers
Pediatric Arrhythmia Diagnosis and Treatment: 
There’s an App for That

• Diagnosis
  – “Patch” monitors
  – Smartphone event monitors
  – Implantable loop monitors

• Ablations
  – 3-D mapping systems

• Pacing and ICD’s
  – Leadless pacemakers
  – Subcutaneous ICD’s
Traditional ICD
What is an ICD?

• Basically a pacemaker plus . . .
ICD’s
Patient

• 12 year old male (38 kg), playing in gym class in school, collapsed, received CPR and a shock from an AED
Patient

- 12 year old male (38 kg), in gym class, collapsed, received CPR and a shock from an AED
- Diagnosed with hypertrophic cardiomyopathy
Patient

• A few months later missed a dose of his beta blocker, playing in gym class in school

• Syncope
ICD’s

• Incredible, lifesaving devices
  – Very reliable
  – Current Batteries last 10-15 years

– However, they also rely on leads . . .
T wave oversensing
Lead failure
Subcutaneous ICD
Subcutaneous versus transvenous ICD

• Subcutaneous ICD
  – Advantages
    • No leads within the veins (easier/safer to extract)
  – Disadvantages
    • Size (about twice as big)
    • Not as much data on effectiveness of shocks and sensing
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