S306- Pediatric Electrocardiography: A Potpourri

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Disclosure of Relevant Relationship

• Dr. Kanter (or spouse/partner) has not had (in the past 12 months) any conflicts of interest to resolve or relevant financial relationship with the manufacturers of products or services that will be discussed in this CME activity or in his presentation.

• Dr. Kanter will support this presentation and clinical recommendations with the “best available evidence” from medical literature.

• Dr. Kanter does not intend to discuss an unapproved/investigative use of a commercial product/device in this presentation.
The Standard ECG Grid
Remember, 2 of 3: right & left arm; left leg

Remember: each site above grounded to remaining pair

Remember: each V lead is unipolar, and grounded to central Wilson terminus
Objectives of Presentation

• Understand the changes in the normal 12L ECG from neonate to adult, esp. in the V leads
• Establish a sequential method to ECG interpretation
• Be able to describe 10 abnormal ECG or rhythm strip findings which always require referral
• Be able to describe 5 ECG or rhythm strip findings which are “gray zone” in terms of clinical significance and must be interpreted in clinical context
• Be able to describe 5 ECG or rhythm strip findings which are normal variants
The ECG from Cradle to the Prom

Vectors have both velocity & direction

The vectorcardiogram integrates electrical vectors in a given plane over the course of a heart beat. A single lead provides a one-dimensional view.
The ECG from Cradle to Prom, cont.

1 day old  

3 months  

8 months  

6 years
The ECG, from Cradle to Prom, cont.
(Who can remember all those numbers?)

Table 9. R wave expressed as percentage of RS deflection (values in parentheses are upper and lower extremes of normal)\(^a\)

<table>
<thead>
<tr>
<th>Age</th>
<th>(V_1)</th>
<th>(V_4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth–1 day</td>
<td>62 (26–96)</td>
<td>50 (0–100)</td>
</tr>
<tr>
<td>1 day–1 week</td>
<td>58 (35–81)</td>
<td>65 (25–100)</td>
</tr>
<tr>
<td>1 week–1 month</td>
<td>66 (34–94)</td>
<td>76 (30–100)</td>
</tr>
<tr>
<td>1–3 months</td>
<td>63 (27–100)</td>
<td>78 (60–100)</td>
</tr>
<tr>
<td>3–6 months</td>
<td>60 (33–86)</td>
<td>86 (60–100)</td>
</tr>
<tr>
<td>6 months–1 year</td>
<td>56 (28–84)</td>
<td>83 (70–100)</td>
</tr>
<tr>
<td>1–3 years</td>
<td>45 (32–67)</td>
<td>94 (75–100)</td>
</tr>
<tr>
<td>3–5 years</td>
<td>42 (21–67)</td>
<td>95 (68–100)</td>
</tr>
<tr>
<td>5–8 years</td>
<td>35 (10–55)</td>
<td>94 (69–100)</td>
</tr>
<tr>
<td>8–12 years</td>
<td>34 (16–50)</td>
<td>95 (80–100)</td>
</tr>
<tr>
<td>12–16 years</td>
<td>27 (10–55)</td>
<td>90 (70–100)</td>
</tr>
</tbody>
</table>

Sequential Approach to ECG Interpretation

• Establish rhythm: Every P followed by QRS? Every QRS preceded by P? Who controls whom?
• Measure QRS duration; PR, RR, and QT intervals
• Milk the P wave: Sinus node origin (axis)? If so, atrial enlargement?
• Milk the QRS: Axis? Normal septal Q wave? Bundle branch block? Chamber hypertrophy?
• Is REPolarization (ST segment/Twaves) appropriate for DEpolarization (QRS)?
• Any “gestalt” abnormalities? (WPW syndrome, biventricular hypertrophy, etc.)

USE YOUR REFERENCES FOR AGE-APPROPRIATE RATE, INTERVALS, AXIS’, CRITERIA FOR CHAMBER ENLARGEMENT
Short PR interval and the delta wave of Wolff-Parkinson-White syndrome
Deep Q waves of a myocardial infarction in an infant having anomalous coronary artery. Note the ST segment abn.
The Knee-Jerk Referral: Sinus Rhythm, but Wassup with the QRS’s?

R wave in V1 > 20 mm, must consider right ventricular hypertrophy. Use your age-corrected charts!!
A qR in V1 is always abnormal: Either RVH or congenitally corrected transposition.
The Knee-Jerk Referral: Sinus Rhythm, but Wassup with the QRS’s?

Katz-Wachtel criterion for biventricular hypertrophy: $R+S$ in any V lead $>60$ mm (6.0 mV). Use half-standard!!
Very dominant S (rS pattern) in V1 in a neonate suggests bad problem: tricuspid atresia, single ventricle, pulmonary atresia
The Knee-Jerk Referral: Sinus Rhythm, but Wassup with the QRS’s?

2 year old (QRS=0.11 s)

Left bundle branch block pattern (rS or QS in V1 and QRS duration >> normal for age): Always a problem
The Knee-Jerk Referral: When ST and T waves Cannot be Ignored

Upright T wave in V1 after 3 days of age is usually RVH
The Knee-Jerk Referral: When ST and T waves Cannot be Ignored

12 year old male with syncope

The long QT syndrome: Use the Bazett formula to correct for rate:

\[ QTc = \frac{QT \text{ interval (sec.)}}{\sqrt{R-R \text{ interval (sec.)}}} \]

In this case, \( QTc = 0.54 \text{ sec.} \) (ULN = 0.44 sec. for male, 0.45 sec. for female)
The Knee-Jerk Referral:
Why Long QT Syndrome is Dangerous

Torsades de pointes ventricular tachycardia
The Knee-Jerk Referral: When Rhythm Gives Us the Blues

Supraventricular tachycardia: Regular narrow-complex tachycardia, with monotonous inter-R wave pattern
Atrial flutter with 2:1 atrioventricular relationship:
Rare in children, and easily missed
The Knee-Jerk Referral: When Rhythm Gives Us the Blues

Adenosine blocks the AV node during atrial flutter without altering the flutter circuit.
The Knee-Jerk Referral: When Rhythm Gives Us the Blues

The many faces of pathologic atrial tachycardia
Wide QRS complex (for age) tachycardia should be considered ventricular tachycardia until proven otherwise.
Ventricular couplets may be benign, but should be investigated.

Sinus capture or fusion beats (*) prove that the wide complex rhythm is ventricular tachycardia.
3rd degree AV block: No relationship between the P’s and QRS’s and there are more P’s than QRS’s
The Knee-Jerk Referral: When Rhythm Gives Us the Blues

“Tachy-brady” or “sick sinus syndrome”: Can be a very bad actor after congenital heart surgery
2nd degree AV block, type II: Very rare in children and overdiagnosed

Note the constant PR interval prior to the non-conducting P wave.
Right ventricular hypertrophy appears in 15% of conditioned young athletes
Mind the Milieu and Minimize Mistakes: Shades of Gray

16 year old female

PR=0.35 sec

1st degree AV block rarely important
(if post-operative, with syncope, with certain infections)
Criteria for left ventricular hypertrophy in children are in need of revision. There may be ethnic differences causing many false positives.
Mind the Milieu and Minimize Mistakes: Shades of Gray

J point elevation ("early repolarization") is common in the mid-precordial leads in teens.

The Brugada pattern is more ominous at any age.
Common Exercise-Related ECG Changes

ESC Group 1 Training Related Changes (2005)

- Sinus bradycardia
- First-degree AV block
- Incomplete RBBB
- Early repolarisation
- Isolated QRS voltage criteria for LVH
Mind the Milieu and Minimize Mistakes: Darker Shades of Gray?

16 yr old soccer player

Common findings from the “athlete’s ECG”: Borderline QTc, inverted T waves, and PVCs
Mind the Milieu and Minimize Mistakes: Darker Shades of Gray?

Right bundle branch block usually post-operative; when *isolated* abnormality, generally, benign
Mind the Milieu and Minimize Mistakes: Darker Shades of Gray?

Persistently junctional rhythm may deserve follow-up, but does not require treatment, if asymptomatic.
The spectrum of sinus arrhythmia to marked sinus arrhythmia to sinus pauses to sinus arrest parallels the spectrum of normal vagotonia to hypervagotonia to true sick sinus syndrome.
2nd degree AV block (type II) seen in 15% of normal children and teens during sleep. It is not normal when awake or after heart surgery.
Premature ventricular beats are normal in a normal heart, and they are abnormal in an abnormal heart.
Neonates are very “vagally charged”, especially during oropharyngeal manipulation. There is nothing wrong with their hearts.
When the V leads look the same, consider fusion of conductor: Too much gel or overlapping ECG electrode patches.
Low atrial rhythm (at normal rate) is almost always a normal variant. The rhythm originates near the coronary sinus ostium.
“Idioventricular rhythm” takes over sinus rhythm at a rate within 10% of prevailing sinus rate
Second only to sinus arrhythmia, junctional takeover during sinus slowing is a very common and normal vagal phenomenon in children.