1. First thing’s first
   a) Check the name on the top of the ECG – is this your patient?
   b) Check the date – is this the one you ordered?
   c) Check for old ECGs – just like a chest xray, it’s always a good idea to compare with an old one
   d) Check for the age of the patient – the heart physiology and the normal values differ in different age groups in the pediatric population

   Note: You may want to cover the top part of the ECG sheet now. Do not rely on the computer calculated numbers; it may be wrong. Trust yourself!

2. Technical Aspects
   a) Is the ECG full standard?
      ❑ Full standard means that the ECG was not reduced in size so that it can fit on the paper
      ❑ Look at the left hand side of each line
      ❑ If it is full standard, the rectangle’s height should be 2 big squares

      ❑ If it is half standard, the rectangle’s height is only 1 big square. You will need to double all the waves to normalize them

   b) What is the paper speed?
      ❑ The standard speed is 25mm/sec
That means each little box is **0.04 seconds**, each big box is **0.2 seconds**, the whole strip is **6 seconds**

Now look at the top of the ECG, there should be a print out of what speed the ECG was ran at

For tachyarrhythmias, the speed of the ECG may have been increased to 50 mm/sec in order to visualize the p waves; in this case, the speed and duration of the ECG components will need to be doubled

### 3. Rate

a) Normal, Fast or Regular Rates
- Find 2 adjacent R waves, count the number of big squares between the R’s
- Divide **300** by the number of big squares → this is your rate
  
  Or . . . .

- Find a QRS complex that starts on a thick line, then count the thick lines using these numbers **“300-150-100-75-60-50”** to the next QRS

b) Slow or Irregular Rates
- The easiest way to calculate the rate is to count the total number of QRS complex along the length of the entire strip and multiply it by 10 → this is your rate (bpm)

Note: The normal value for heart rate ranges dramatically depending on your patient’s age. Please compare your patient’s age and heart rate with Table 1.

### 4. Rhythm

a) Analysis
- Is the rhythm sinus?
  
  **Sinus** rhythm:
  
  ▪ Is there a P wave before each QRS complex?
  ▪ Is there a QRS complex after every P wave?
  ▪ Are the P waves upright in leads I, II, III?
  ▪ Do all P waves should look the same?
  ▪ Are all P wave axis normal (0° to +90°)?
  ▪ Are the PR intervals constant?

- Is the rhythm fast or slow? (refer to Table 1 values)
- Is the rhythm regular or irregular? Do the P waves and QRS follow a regular pattern?
- If it is irregular, is it consistently irregular or consistently irregular?
  
  **Consistently irregular** = some form to the pattern of irregular complex i.e. predictable
  
  **Inconsistently irregular** = no pattern at all i.e. unpredictable

b) Abnormal Rhythms

| Premature Atrial Contraction (PAC) | ➢ Length of two cycles (R-R) usually shorter  
|                                   | ➢ Preceded by P wave, followed by normal QRS  
|                                   | ➢ No hemodynamic significance |
| Premature Ventricular Contraction (PVC) | ➢ Premature, wide QRS, no P waves, T wave opposite to |
QRS
- I.e. multifocal, bigeminy, trigeminy, couplets
- Maybe normal if uniform and decrease with exercise

Atrial Flutter
- Rapid atrial rate (~300 bpm) with varying ventricular rate
- Sawtooth pattern
- Suggests significant pathology

Atrial Fibrillation
- Very fast atrial rate (350-600 bpm)
- Irregularly irregular
- No P waves, normal QRS
- Suggests significant pathology

Ventricular Tachycardia
- Wide, unusually shaped QRS
- T waves opposite direction of QRS
- HR 120-200 bpm
- Suggests significant pathology

Ventricular Fibrillation
- Very irregular QRS
- Rate is rapid and irregular
- “terminal arrhythmia”

5. Axis
- Axis is the “conduction flow” of the heart
- Normal axis varies with age – i.e. newborns have a right axis deviation because the left and right ventricles are the same size due to fetal circulation
- Look at the QRS complex of Lead I and Lead aVF
- Is the QRS complex of Lead I more negative (downgoing or conduction away from the lead) or positive (upgoing or conduction towards the lead)?
- Is the QRS complex of Lead aVF more negative or positive?

<table>
<thead>
<tr>
<th>Lead I</th>
<th>Lead aVF</th>
<th>Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>Normal</td>
</tr>
<tr>
<td>+</td>
<td>-</td>
<td>Left Axis Deviation</td>
</tr>
<tr>
<td>-</td>
<td>+</td>
<td>Right Axis Deviation</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Extreme Right Axis Deviation</td>
</tr>
</tbody>
</table>

6. P Wave and PR Interval
- PR = beginning of P to beginning of QRS
- P wave normal is 2-3 little squares (0.08-0.12); if wide P wave = left atrial enlargement
If P wave is taller than 2-3 little squares = **right atrial enlargement**
PR interval is dependent on age (Table 1); if PR is wide = **first degree AV block**

7. **QRS Complex**
- If beginning of Q to end of S is longer than 2-3 small squares → **bundle branch block**
- Look for the “M” sign in either V1 or V6
- If the “M” is on V1 → **Right bundle branch block (RBBB)**
- ![V1 V6 Diagram]
- If the “M” is on V6 → **Left bundle branch block (LBBB)**
- ![V1 V6 Diagram]

8. **QTc Interval**
- Beginning of Q to end of T
- QT corrected interval for heart rate because as HR decrease, QT lengthens and vice versa
- Normal: <0.45 (<6 months), <0.44 (>6 months)
- QTc = QT / square root of RR interval
- DDx prolonged QT: long QT syndrome, hypokalemia, hypomagnesemia, hypocalcemia, neurologic injury
- Prolonged QT predisposes to ventricular tachycardia and associated with sudden death

9. **T wave**
- DDx of peaked, pointed T = hyperkalemia, LVH
- DDx of flattened T waves = hypokalemia, hypothyroidism

10. **Ventricular Hypertrophy**
   a) **Right ventricular hypertrophy**
   - if any of the following:
     - R wave >98% in V1 or S wave >98% in I or V6
     - Increased R/S ratio in V1 or decreased R/S in V6
     - RSR' in V1 or V3R in the absence of complete RBBB
     - Upright T wave in V1 (>3 days)
     - Presence of Q wave in V1, V3R, V4R
     - DDx of RVH: ASD, TAPVR, pulmonary stenosis, TOF, large VSD with pulmonary HTN
   b) **Left ventricular hypertrophy**
   - if any of the following:
     - R >98% in V6, S >98% in V1
     - Increased R/S ratio in V6 or decreased R/S in V1
     - Q >5mm in V6 with peaked T
     - DDx: VSD, PDA, anemia, complete AV block, aortic stenosis, systemic HTN
## Appendix

### a) Table 1: Normal Values

<table>
<thead>
<tr>
<th>Age</th>
<th>HR bpm</th>
<th>QRS axis degrees</th>
<th>PR interval seconds</th>
<th>QRS interval seconds</th>
<th>R in V1 mm</th>
<th>S in V1 mm</th>
<th>R in V6 mm</th>
<th>S in V6 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st week</td>
<td>90-160</td>
<td>60-180</td>
<td>0.08-0.15</td>
<td>0.03-0.08</td>
<td>5-26</td>
<td>0-23</td>
<td>0-12</td>
<td>0-10</td>
</tr>
<tr>
<td>1-3wks</td>
<td>100-180</td>
<td>45-160</td>
<td>0.08-0.15</td>
<td>0.03-0.08</td>
<td>3-21</td>
<td>0-16</td>
<td>2-16</td>
<td>0-10</td>
</tr>
<tr>
<td>1-2 mo</td>
<td>120-180</td>
<td>30-135</td>
<td>0.08-0.15</td>
<td>0.03-0.08</td>
<td>3-18</td>
<td>0-15</td>
<td>5-21</td>
<td>0-10</td>
</tr>
<tr>
<td>3-5 mo</td>
<td>105-185</td>
<td>0-135</td>
<td>0.08-0.15</td>
<td>0.03-0.08</td>
<td>3-20</td>
<td>0-15</td>
<td>6-22</td>
<td>0-10</td>
</tr>
<tr>
<td>6-11 mo</td>
<td>110-170</td>
<td>0-135</td>
<td>0.07-0.16</td>
<td>0.03-0.08</td>
<td>2-20</td>
<td>0.5-20</td>
<td>6-23</td>
<td>0-7</td>
</tr>
<tr>
<td>1-2 yr</td>
<td>90-165</td>
<td>0-110</td>
<td>0.08-0.16</td>
<td>0.03-0.08</td>
<td>2-18</td>
<td>0.5-21</td>
<td>6-23</td>
<td>0-7</td>
</tr>
<tr>
<td>3-4 yr</td>
<td>70-140</td>
<td>0-110</td>
<td>0.09-0.17</td>
<td>0.04-0.08</td>
<td>1-18</td>
<td>0.5-21</td>
<td>4-24</td>
<td>0-5</td>
</tr>
<tr>
<td>5-7 yr</td>
<td>65-140</td>
<td>0-110</td>
<td>0.09-0.17</td>
<td>0.04-0.08</td>
<td>0.5-14</td>
<td>0.5-24</td>
<td>4-26</td>
<td>0-4</td>
</tr>
<tr>
<td>8-11 yr</td>
<td>60-130</td>
<td>-15-110</td>
<td>0.09-0.17</td>
<td>0.04-0.09</td>
<td>0-14</td>
<td>0.5-25</td>
<td>4-25</td>
<td>0-4</td>
</tr>
<tr>
<td>12-15 yr</td>
<td>65-130</td>
<td>-15-110</td>
<td>0.09-0.18</td>
<td>0.04-0.09</td>
<td>0-14</td>
<td>0.5-21</td>
<td>4-25</td>
<td>0-4</td>
</tr>
<tr>
<td>&gt; 16 yr</td>
<td>50-120</td>
<td>-15-110</td>
<td>0.12-0.20</td>
<td>0.05-0.10</td>
<td>0-14</td>
<td>0.5-23</td>
<td>4-21</td>
<td>0-4</td>
</tr>
</tbody>
</table>

### References


2. Interpreting Pediatric ECG. Pediatric Cardiology at the University of Chicago. [http://pediatriccardiology.uchicago.edu/MP/ECG/ECG-submenue.htm](http://pediatriccardiology.uchicago.edu/MP/ECG/ECG-submenue.htm)

### Acknowledgements

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