ECG Conference

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P wave

• Duration
  • 0.08 to 0.12 seconds

• Amplitude
  • <0.25 mV in lead II, <0.1 mV in V₁

• Axis
  • 0° to +75°
QRS

- **Duration**
  - 0.06 to 0.11 seconds

- **Initial forces**
  - Rightward and anterior

- **Main forces**
  - Leftward and inferior

- **Terminal forces**
  - Posterior
QRS

• **Intrinsicoid deflection**
  - <0.035 seconds in $V_1$ or $V_2$
  - <0.045 seconds in $V_5$ or $V_6$

• **Axis**
  - -30° to 105°
  - ≤40 years: 0° to 50°
  - > 40 years: -30° to 90°

Marriot. 10th ed.
Atrial ‘enlargement’

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>VI</th>
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</thead>
<tbody>
<tr>
<td><strong>Normal</strong></td>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
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<tr>
<td><strong>RAE</strong></td>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
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<tr>
<td><strong>LAE</strong></td>
<td><img src="image5.png" alt="Diagram" /></td>
<td><img src="image6.png" alt="Diagram" /></td>
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<tr>
<td><strong>RAE + LAE</strong></td>
<td><img src="image7.png" alt="Diagram" /></td>
<td><img src="image8.png" alt="Diagram" /></td>
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</tbody>
</table>

Marriot. 10th ed.
Left atrial ‘enlargement’
Left atrial ‘enlargement’

• Basics
  • Notched, ‘M like’ appearance in lead II (P mitrale).
  • Terminal deflection in V₁ >0.04 seconds and >0.10 mV.
  • LAE *increases* P wave duration and *shortens* the PR segment.
  • LAE does not typically affect the axis of the P wave, although it may cause a leftward shift that remains within the normal limit of 0° to +75°.

Marriot. 10th ed.
Right atrial ‘enlargement’

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Right atrial ‘enlargement’

• Basics
  • Peaked, ‘A like’ appearance in lead II (p pulmonale), most often in patients with CHD and pHTN not due to COPD.
  • Amplitude >0.25 mV in lead II.
  • Amplitude >0.15 mV in V₁.
  • RAE does not affect the duration of the P wave.
  • RAE does not typically affect the axis of the P wave, although it may cause a slight rightward shift that remains within the normal limit of 0° to +75°.

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Biatrial ‘enlargement’

Marriot. 10th ed.
Biatrial ‘enlargement’

• Basics
  • Large, biphasic P wave in lead $V_1$.
  • $V_1 > 1.5 \text{ mV}$ and lead II $> 0.12$ seconds (wide, notched).
  • Limb leads $\geq 0.25 \text{ mV}$ and $> 0.12$ seconds (wide, notched).
Sinus rhythm
Left atrial abnormality
Left axis deviation
Left ventricular hypertrophy
General Considerations

• No specific criteria distinguish ‘hypertrophy’ and ‘enlargement’.
• Hypertrophy can lead to myocardial conduction delays, but not to the same extent as bundle branch block.
• Lead V₁ provides the optimal view of competition between the two ventricles.
• Don’t forget to look for atrial hypertrophy to ‘support your case’ for the existence of ventricular hypertrophy.
LVH

• **Romhilt-Estes Criteria**
  
  • Limb lead voltage criteria
  • Left ventricular strain
  • Left atrial enlargement
  • Left axis deviation
  • QRS duration
  • Intrinsicsoid deflection
LVH

• Romhilt-Estes Criteria
  • Limb lead voltage criteria
    • R or S in any limb lead ≥ 2.0 mV
    • or S in $V_1$ or $V_2$ ≥ 3.0 mV
    • or R in $V_5$ or $V_6$ ≥ 3.0 mV
  • Left ventricular strain
  • Left atrial enlargement
  • Left axis deviation
  • QRS duration
  • Intrinsicoid deflection
LVH

• **Romhilt-Estes Criteria**
  - Limb lead voltage criteria
  - **Left ventricular strain**
    - ST-T wave opposite direction to QRS
      - *without digitalis* 3 points
      - *with digitalis* 1 point
  - Left atrial enlargement
  - Left axis deviation
  - QRS duration
  - Intrinsicoid deflection
LVH

- Romhilt-Estes Criteria
  - Limb lead voltage criteria
  - Left ventricular strain
  - Left atrial enlargement
    - Terminal negativity $V_1 \geq 0.10 \text{ mV and } 0.04 \text{ s.}$ 3 points
  - Left axis deviation
  - QRS duration
  - Intrinsicoid deflection
LVH

• **Romhilt-Estes Criteria**
  - Limb lead voltage criteria
  - Left ventricular strain
  - Left atrial enlargement
  - *Left axis deviation* $\geq -30^\circ$  
    2 points
  - QRS duration
  - Intrinsicoid deflection
LVH

• **Romhilt-Estes Criteria**
  - Limb lead voltage criteria
  - Left ventricular strain
  - Left atrial enlargement
  - Left axis deviation
  - **QRS duration** ≥ 0.09 s
  - Intrinsicoid deflection
• **Romhilt-Estes Criteria**
  - Limb lead voltage criteria
  - Left ventricular strain
  - Left atrial enlargement
  - Left axis deviation
  - QRS duration
  - *Intrinsicoid deflection* in V5 or V6 $\geq 0.05$ s  
    1 point
LVH

- Romhilt-Estes Criteria
  - LVH 5 points
  - Probable LVH 4 points
LVH

• Sokolow-Lyon
  • $S_{V1} + R_{V5} + > 3.5 \text{ mV}$. 
LVH

• Cornell Criteria
  • Males
    • $R_{aVL} + S_{V3} > 2.8 \text{ mV}$.
  • Females
    • $R_{aVL} + S_{V3} > 2.0 \text{ mV}$.
LVH

- **Perugia Score** *(at least 1 of the following)*
  - \( R_{aVL} + S_{V3} > 2.4 \text{ mV} \) in men.
  - \( R_{aVL} + S_{V3} > 2.0 \text{ mV} \) in women.
  - LV strain.
  - Romhilt-Estes score \( \geq 5 \) points.

LVH

- **Miscellaneous**
  - $R_{aVL} > 1.1 \text{ mV}$
  - If LAD present, $R_{aVL} > 1.1 \text{ mV and } S_{III} > 1.5 \text{ mV}$
Ectopic atrial rhythm
Right axis deviation
Right ventricular hypertrophy
• Sokolow-Lyon Criteria
  • $R_{V1} + S_{V5 \text{ or } V6} \geq 1.0 \text{ mV}$
  • IRBBB, RBBB pattern, or ‘qR’ pattern in $V_1$
  • Right axis deviation, usually $\geq 110^\circ$
  • T wave inversion in right precordial leads
  • RAE

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Biventricular Hypertrophy

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Biventricular Hypertrophy

- High voltage, biphasic RS complexes in the mid-precordial leads
- Voltage criteria for LVH in the precordial leads with right axis deviation
- Low amplitude S wave in $V_1$ combined with a very deep S wave in $V_2$
- Criteria for LVH in the left precordial leads combined with prominent R waves in the right precordial leads.
- LAE, combined with any other criterion suggestive of RVH

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Sinus rhythm
LBBB, complete
LBBB

• Basics
  • QRS ≥ 0.12 seconds.
  • ‘QS’ or ‘rS’ in $V_1$.
  • Broad monophasic R wave in I, $V_5$, and $V_6$.
  • No q wave in I, $V_5$, and $V_6$.
  • Delayed intrinsicoid (~0.1 second) in $V_5$, and $V_6$.
  • *Secondary* ST-T wave changes.
LBBB

• Associated findings
  • Poor R wave progression.
  • Left axis deviation in 70%. *LBBB with leftward axis has a worse prognosis than LBBB with a normal axis*.
  • ‘Rs’ pattern in $V_5$ and $V_6$.
  • ‘qs’ pattern in inferior leads, mimicking IMI.
  • There should not be a q wave in $V_6$; if noted, consider complicated LBBB, e.g. prior ASMI.
Sinus rhythm
RBBB, complete
RBBB

• **Basics**
  
  • QRS ≥ 0.12 seconds.
  
  • rsR’ or rSR’ in $V_1$ and $V_2$.
  
  • Intrinsicoid deflection in $V_1$ >0.05 seconds; sometimes wide R or qR.
  
  • S wave in leads I, $V_5$, and $V_6$.
  
  • *Secondary* ST-T wave changes.

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Sinus rhythm
Left anterior fascicular block
• Basics
  • Left axis deviation (-30° to -90°, usually ≥-45°).
  • Terminal forces are superior and leftward.
  • ‘qR’ pattern in leads I, aVL.
  • ‘rS’ pattern in leads II, III, aVF with ‘S’ in lead III > II.
  • QRS duration normal or slightly prolonged (≤0.120 s).

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LAFTB

• Associated findings
  • *Increased* voltage in limb leads.
  • *Decreased* voltage in precordial leads.
  • Small q waves may be seen in $V_1$ to $V_3$; the initial vector moves *inferiorly*, away from these leads which are positioned on a higher plane.
  • Deep S wave in $V_5$ and $V_6$; the terminal vector moves *away* from the LV apex.
LAFB

• Miscellaneous
  • LAF and RBBB are both supplied by the first septal perforator, hence LAFB + RBBB are often associated with each other.
  • LAFB complicates 7-15% of pLAD infarcts.
  • LAFB can *obscure or mimic* IMI.
  • LAFB can *mimic* ASMI by generating small ‘q’ waves in V₂ and V₃ and poor R wave progression.
Sinus rhythm
Left posterior fascicular block
• Basics
  • Right axis deviation (+90° to +180°, usually ≥120°).
  • Terminal forces are *inferior* and rightward.
  • ‘rS’ pattern in lead I.
  • ‘qR’ pattern in lead III.
  • QRS duration normal or slightly prolonged (≤0.120 s).
  • RVH should *not* be present.

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LPFB

• Miscellaneous
• The posterior division of the LBB is short, thick, and supplied by a dual blood supply, so it relatively protected from injury.
• LPFB + RBBB in AMI is associated with a high risk of complete AV block (>40%) and mortality (>80%) during the first weeks after the event.
Sinus rhythm
Left anterior fascicular block
Left ventricular hypertrophy
ST-T abnormalities secondary to hypertrophy
LVH with LAFB

- Low specificity.
- $S_{III} > 1.5$ mV.
- LAE.
- ST-T wave changes consistent with ‘strain’ pattern.
- QRS may be widened.
Sinus rhythm
LBBB, complete
Left ventricular hypertrophy
LVH with LBBB

- Low specificity.
- $S_{V2} + R_{V6} > 4.5$ mV.
- LAE.
- QRS > 0.16 s.
Sinus rhythm
Right axis deviation
RBBB, complete
Right ventricular hypertrophy
RVH with RBBB

- Low specificity.
- R’ > 1.5 mV (>1.0 mV with IRBBB).
- RAE.
- RVH does not typically cause RBBB.