HYPERTROPHY PATTERNS

Right atrial abnormality (P-pulmonale)
Left atrial abnormality (P-mitrale)
Biatrial hypertrophy
Right ventricular hypertrophy (RVH)
Left ventricular hypertrophy (LVH) – limb lead criteria
Left ventricular hypertrophy (LVH) – chest lead criteria
Biventricular hypertrophy
A 54-year-old lady with bronchiectasis
Right atrial abnormality (P-pulmonale)

- Peaked (A-shaped) P waves more than 3 mm in height in leads II, III, or aVF.
- Other features:
  - tall P waves in the right chest leads (> 1.5 mm)
  - prominent atrial repolarisation (Ta) wave.

FEATURES OF THIS ECG

- Sinus tachycardia, 120 b.p.m., rightward QRS axis
- Diagnostic features of P-pulmonale:
  - abnormally tall P waves in II, III, and aVF (Fig. 68.1)
  - tall P wave in lead V3 (Fig. 68.2)
  - prominent Ta wave (Fig. 68.2)
- Features of chronic obstructive airways disease:
  - clockwise electrical rotation (late transition)
  - posterior displacement of the QRS axis (deep S waves in the right chest leads)

CLINICAL NOTE

Her chest x-ray (Fig. 68.3) shows right atrial enlargement and features of chronic lung disease (hyperexpanded lungs with flattened diaphragms).

Causes of right atrial abnormality

- Raised right ventricular pressure:
  - pulmonary hypertension from any cause
  - cor pulmonale
- Tricuspid valve stenosis:
  - acquired (endocarditis from i.v. drug use)
  - congenital (Ebstein’s anomaly)
- Right atrial ischaemia or infarction (uncommon)
CASE 69

A 43-year-old Maori man with a diastolic murmur
**Left atrial abnormality (P-mitrale)**

- Notched (M-shaped) P wave which exceeds 120 ms (3 small squares) in duration in leads I, II, aVF or aVL.
- Other features:
  - prolonged duration (> 40 ms/1 small square) and increased amplitude (0.1 mV) of the terminal negative component to the P wave in V1.
  - duration between the two peaks of the ‘M’ > 40 ms (1 small square).

**FEATURES OF THIS ECG**

- Sinus rhythm, 72 b.p.m., vertical QRS axis
- Features of P-mitrale:
  - broad, notched P waves seen in the inferior leads (Fig. 69.1)
  - marked negative component to P wave in lead V1 (Fig. 69.2)
- Features of right ventricular hypertrophy:
  - dominant R wave in lead V1, with ST depression and T wave inversion (Fig. 69.2)
  - deep S waves in the lateral leads (Fig. 69.3)

**CLINICAL NOTE**

The combination of left atrial hypertrophy and right ventricular hypertrophy suggests mitral stenosis. This patient had mitral stenosis on the basis of rheumatic heart disease. His chest x-ray (Fig. 69.4) shows cardiomegaly, enlargement of the pulmonary outflow tract (A) and left atrial enlargement (B).

**Causes of left atrial abnormality**

- Left atrial hypertrophy
- Left atrial distension
- Interatrial conduction block
- Left atrial scarring
A 24-year-old lady with a history of rheumatic fever
Biatrial hypertrophy

- P waves in the limb leads more than 3 mm in height and also greater than 120 ms (3 small squares) in duration.
- Large biphasic P waves in V1 with an initial positive deflection of more than 2 mm and a terminal negative portion at least 1 mm deep and 40 ms (1 small square) in duration.
- P wave greater than 2 mm in height in V1 in combination with notched P waves, greater than 120 ms in duration in the limb leads or left precordial leads.

Any of these three criteria suggests the diagnosis of biatrial hypertrophy.

FEATURES OF THIS ECG

- Sinus rhythm, 92 b.p.m., vertical QRS axis
- Features of biatrial hypertrophy:
  - P waves in the limb leads which are broad, notched, and tall (Fig. 70.1)
  - large biphasic P wave in V1 (Fig. 70.2)
  - notched P waves with a duration of greater than 120 ms in the left precordial leads (Fig. 70.3)
- Long PR interval, greater than 200 ms (Fig. 70.4)

CLINICAL NOTE

This lady had rheumatic triple valve disease. Her cardiac catheter study documented critical tricuspid stenosis, severe mitral stenosis, and severe aortic stenosis.
A 25-year-old lady with Down syndrome
Right ventricular hypertrophy (RVH)

- Right axis deviation (QRS axis > +90°)
- Dominant R wave in V1.
- No evidence of anterolateral myocardial infarction or bundle branch block.
- Other features:
  - ST segment depression and T wave inversion in the right chest leads (V1–4)
  - deep S waves in the lateral leads (V4–6, I and aVL).

FEATURES OF THIS ECG

- Sinus rhythm, 84 b.p.m.
- Features of RVH:
  - right axis deviation, +125° (Fig. 71.1)
  - dominant R wave in V1 (Fig. 71.2)
  - deep S waves in the lateral leads (Fig. 71.3)
- Features of right atrial hypertrophy:
  - abnormally tall P waves in the inferior leads and V1 (Figs 71.2 and 71.4)

CLINICAL NOTE

This lady had a congenital ventricular septal defect with a large right-to-left shunt (Eisenmenger syndrome). She was deeply cyanosed and died several days after this ECG was taken.

Causes of a dominant R wave in V1

➔ Normal finding in children
➔ Right ventricular hypertrophy
➔ Right bundle branch block
➔ True posterior myocardial infarction
➔ Ventricular pre-excitation (WPW syndrome)
➔ Duchenne muscular dystrophy
A 25-year-old male soccer player with an ejection systolic murmur
### Left ventricular hypertrophy (LVH) – limb lead criteria

- There are a number of criteria for LVH based on the voltages of the QRS deflections (see criteria listed below). These criteria have good specificity but poor sensitivity.
- Other features:
  - ST depression and T wave inversion (LV strain pattern) in leads with prominent R waves
  - counterclockwise electrical rotation (early transition)
  - increased ventricular activation time
  - inverted U waves in the left chest leads
  - leftward QRS axis.

### Voltage criteria for LVH

<table>
<thead>
<tr>
<th>Source</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sokolow &amp; Lyon: 1</td>
<td>$SV_1 + R(V5$ or V6) $&gt; 35$ mm</td>
</tr>
<tr>
<td>Cornell: 2</td>
<td>$SV_3 + RaVL &gt; 28$ mm in men</td>
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<tr>
<td>Framingham: 3</td>
<td>$RaVL &gt; 11$ mm</td>
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<tr>
<td></td>
<td>$RV4-6 &gt; 25$ mm</td>
</tr>
<tr>
<td></td>
<td>$SV1-3 &gt; 25$ mm</td>
</tr>
<tr>
<td></td>
<td>$S(V1$ or V2$) + R(V5$ or V6$) $&gt; 35$ mm</td>
</tr>
<tr>
<td></td>
<td>$RI + SIII &gt; 25$ mm</td>
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<tr>
<td>Romhilt &amp; Estes: 4</td>
<td>Point score system</td>
</tr>
</tbody>
</table>

### FEATURES OF THIS ECG

- Sinus bradycardia, 54 b.p.m.
- Features of LVH (Fig. 72.1):
  - leftward axis
  - early electrical transition (dominant R in V2)
  - tall R waves in aVL and lead I
  - tall R waves in the left chest leads and deep S wave in V1
  - widespread ST depression and T wave inversion

### CLINICAL NOTE

Hypertrophic obstructive cardiomyopathy (HOCM) was diagnosed at echocardiography.
A 70-year-old man with longstanding hypertension
Left ventricular hypertrophy (LVH) – chest lead criteria

- There are a number of criteria for LVH based on the voltages of the QRS deflections (see p. 157).
- Other features:
  - ST depression and T wave inversion (LV strain pattern) in leads with prominent R waves
  - counterclockwise electrical rotation (early transition)
  - increased ventricular activation time
  - inverted U waves in the left chest leads
  - leftward QRS axis
  - associated left atrial abnormality.

FEATURES OF THIS ECG

- Sinus rhythm, 54 b.p.m.
- Frequent ventricular premature beats (VPBs)
- Features of LVH:
  - leftward axis (−30°)
  - voltage criteria for LVH in the chest leads, SV1 + RV6 > 35 mm (Fig. 73.1)
  - RaVL > 11 mm
  - associated left atrial abnormality (Fig. 73.2)
  - widespread ST depression and T wave inversion (Fig. 73.1)

Causes of left ventricular hypertrophy

- Systolic overload:
  - systemic hypertension
  - aortic stenosis
  - coarctation of the aorta
  - hypertrophic cardiomyopathy
- Diastolic overload:
  - mitral incompetence
  - aortic incompetence

Fig. 73.1 Voltage criteria for LVH.

Fig. 73.2 Left atrial abnormality.
A 17-year-old woman with a loud pansystolic murmur
Biventricular hypertrophy

- Voltage criteria for LVH in the chest leads combined with right axis deviation and prominent R waves in the right precordial leads.
- High voltage biphasic RS complexes in the mid-precordial leads (most common in VSD).
- Evidence of associated left atrial enlargement.

FEATURES OF THIS ECG

- Sinus tachycardia, 130 b.p.m.
- Features of RVH:
  - right axis deviation (+100°)
  - dominant R wave in V1 (rSR’)
  - ST segment depression and T wave inversion in the right chest leads (Fig. 74.1)
- Features of LVH:
  - tall R waves in the left chest leads (RV5 35 mm)
  - prominent negative component to P wave in V1 suggesting associated left atrial abnormality (Fig. 74.2)
- High voltage biphasic RS complexes in the mid-precordial leads (Fig. 74.1)

CLINICAL NOTE

This young woman had a small to moderate sized VSD.