# Chapter 2
# Practical Approach

There are beginners in electrocardiogram (ECG) analysis who are fascinated by a special pattern (e.g., a bundle-branch block or a striking Q wave) and thereby overlook other abnormalities. The best way to avoid similar errors is to analyze an ECG systematically, step by step. However, for experienced ECG interpreters, loss of concentration can also occur for a variety of reasons (see Short Story).

**Short Story**

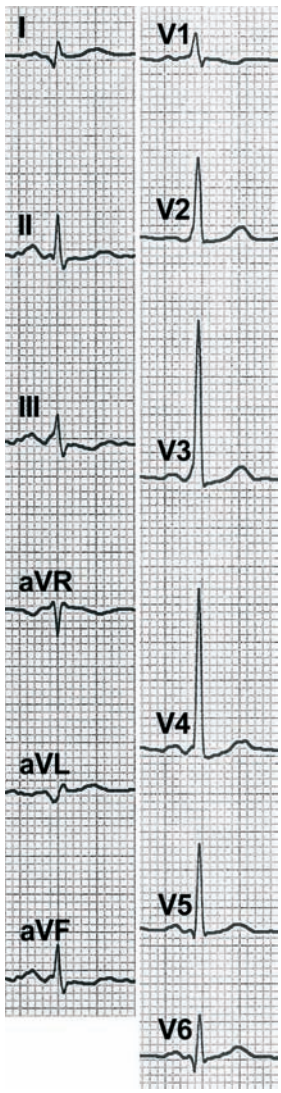
About 10 years ago, an ECG with obvious preexcitation (ECG 2.1), diagnosable by any dentist, was shown to the author by a very good-looking young colleague. The author's concentration was focused on the "wrong" subject and he interpreted the ECG as being normal.

## Practical Approach

The practical approach includes:

- Analysis of rhythm
- Morphologic analysis of p, QRS, ST, and T (U) waves. The measurements of the PQ interval and of the QT (QTc) interval are included
- Definitive ECG diagnosis

M. Gertsch, *The ECG Manual: An Evidence-Based Approach*,




**ECG 2.1** Preexcitation with short PQ interval (0.10 s). Obvious positive delta waves in III and aVF. Striking Q waves (negative delta waves) in I and aVL and abnormal R waves in $V_1$ and $V_2$

1. Analysis of rhythm

Step 1: Rhythm regular or irregular?
- a. Regular: in most cases, normal SR
  Pathologic regular rhythms: *escape rhythms; some forms of supraventricular tachycardias; VT*
- b. Irregular: the most frequent cause of irregularity is regular SR *with supraventricular and ventricular premature beats. Complete irregularity of the R-R intervals: atrial fibrillation*

Step 2: Normal (sinusal p) wave present? → SR. If not:
- a. Abnormal (nonsinusal) p waves present: *atrial rhythm*
- b. No p waves: *AV junctional rhythm*
- c. Replacement of p waves by *other atrial waves: atrial flutter or atrial fibrillation*

1. Analysis of rhythm (continued)

Step 3: Rate (of the ventricles)? Eventually rate of the abnormal (nonsinusal) p waves or flutter waves?

Step 4: PQ interval? If we measure the PQ interval, we will not only recognize a prolongation or shortening of the PQ time, but also the following:
- a. every p is conducted, or *not every p wave is conducted: in the 3 forms of AV block 2°*
- b. no p wave is conducted. *This means that atria and ventricles are working independently from each other, in the presence of AV block 3° = complete AV block*
- c. p waves are twisting around the QRS complexes: *in the special forms of AV dissociation*

Step 5: QRS duration normal (≤90 ms) or *prolonged*?
QRS ≥120 ms: *pattern of BBB*
- a. Supraventricular rhythm/tachycardia *with aberration*.
- b. *Ventricular origin of the rhythm (with AV dissociation):*
  - *Low rate: ventricular escape rhythm*
  - *Medium rate: accelerated idioventricular rhythm*
  - *High rate: VT*

*Note*: Typical pathologic findings are italicized.
AV, atrioventricular; BBB, bundle-branch block; SR, sinus rhythm; VT, ventricular tachycardia.

2. Detailed analysis of morphology

Step 1: P
1. Normal (sinusal)? (p duration 90–110 ms)
   *Note*: A negative p in lead I and (often) a positive p in lead aVR means "false poling" of the upper limb leads in 99% of the cases
2. Pathologic p waves

2a. p duration ≥110 ms, accentuated terminal negativity in lead $V_1$: *Left atrial enlargement*
2b. p voltage ≥2.5 mm in leads III and aVF:*Right atrial enlargement*
2c. Summation of 2a and 2b:*Biatrial enlargement*

Step 2: QRS
1. Frontal QRS axis = ÅQRS$_F$? (DD of different ÅQRS$_F$ values, see Chapter 3)
2. *Broad QRS?*

2a. *Typical configuration for aberration: RBBB (QRS ≥120 ms) or LBBB (≥140 ms). More or less typical BBB (≥160 ms): suspicious for severe hyperkalemia.*
2b. *Typical pattern of bilateral BBB (RBBB + LAFB or RBBB + LPFB)*
2c. *Atypical BBB-like configuration (QRS ≥140 ms): suspicious for ventricular origin of rhythm, generally with AV dissociation*
3. (Formally) pathologic Q or QS waves?

3a. Typical for *old MI? (combined with symmetric negative T waves; typical history; risk factors for CHD)*
3b. Atypical for old MI? (combined with asymmetric discordant T waves; atypical history; no risk factors for CHD)

DD:
- Artifact: Q/QS in lead I; R/qR in lead aVR—false poling of limb leads (DD: *situs inversus*)
- Normal variant: QS in lead III ($Q_{III}$)—attributable to projection
- *LVH*
- *Preexcitation (QS in III, aVF)*
- *Hypertrophic (obstructive) cardiomyopathy*
- *LBBB (QS in III, aVF, $V_1$ to $V_4$, with duration ≥140 ms)*

(continued)

2. Detailed analysis of morphology (continued)

4. Signs of *LVH or RVH?* (Chapters 5 and 6)
5. Signs of *LAFB or LPFB?* (Chapter 9)
6. *Presence of delta wave?* (with shortened PQ: preexcitation)
7. Presence of notching/slurring? DD: intraventricular conduction disturbance versus *normal variant*

7a. Normal variant (Chapter 3)
7b. *Pathologic, e.g., in old MI or left fascicular block* (Chapters 13 and 9, respectively)

Step 3: ST

1. ST elevation?

1a. Normal variants: ST (in $V_2/V_3$), early repolarization (Chapter 3)
1b. Pathologic:
- Typical for *acute MI: consider other findings*; symptoms, history, risk factors for CHD (Chapter 13).
- Typical for *acute pericarditis: frontal ST vector about +70°—ST elevations in leads aVF, II, and I* (Chapter 15).
- Typical for *mirror image of ST depression: e.g., in LVH/systolic LV overload*.

2. ST depression?

2a. *Ischemic*
2b. *LVH/LV overload*
2c. *Related to BBB or other conditions* (Chapter 17)

Step 4: T (and U)

1. Asymmetric T negativity?

1a. Normal in lead $V_1$; normal in vertical $ÅQRS_F$: in aVF, III(II); normal in left $ÅQRS_F$: in aVL.
1b. Pathologic in *LVH/LV overload; preexcitation; BBB*

2. Symmetric T negativity?

2a. *Often ischemic*, but extensive DD
2b. *Later stage of pericarditis; LVH/LV overload; acute pancreatitis; drugs; others*

3. High and symmetric T?

3a. *Ischemia* (rare, because short-lasting)
3b. *Hyperkalemia*

4. U negativity?

4b. *Ischemic*; other conditions

Step 5: QT

1. QT prolonged

1a. *Long QT syndromes*
1b. *Hypocalcemia*

2. QT shortened: *hypercalcemia*
3. Fusion of T and U: *hypokalemia, long QT syndromes*

Step 6: Definitive diagnosis

*Note*: Typical pathologic findings are italicized.
DD, differential diagnosis; $ÅQRS_F$, frontal QRS axis; AV, atrioventricular; BBB, bundle-branch block; CHD, coronary heart disease; LAFB, left anterior fascicular block; LPFB, left posterior fascicular block; LBBB, left bundle-branch block; RBBB, right bundle-branch block; LV, left ventricle; LVH, left ventricular hypertrophy; MI, myocardial infarction.

## *Definitive Electrocardiogram Diagnosis*

Take the important normal and pathologic findings from the analysis above and put them into the following scheme:
Note: As mentioned above, an ECG must be interpreted in context with the clinical findings of a patient. Therefore, in this book, age and gender and the clinical diagnosis of the patient are provided for many ECG examples in the text.

| | Example 1 | *Example 2* |
|---|---|---|
| Rhythm/rate | SR, 72 beats/min | *Atrial fibrillation*, medium rate 90 beats/min (maximum 140 beats/min, minimum 40 beats/min) |
| p | Normal | – |
| PQ | Normal (0.16 s) | – |
| $\text{ÅQRS}_F$ | (+80°) | LAD (−60°): *LAFB* |
| QRS | Normal | 0.12 s, *LVH* |
| ST | Normal (elevation in $V_2/V_3$) | *Minor changes attributable to LAFB* |
| T | Normal(negative in III) | *Idem* |
| QT | Normal | Prolonged? |
| Special remarks | – | *Fusion of T and U* |
| Diagnosis | Normal ECG | *Atrial fibrillation, LAFB, LVH, Hypokalemia?* |

*Note*: Typical pathologic findings are italicized.
LAD, left axis deviation; LAFB, left anterior fascicular block; LVH, left ventricular hypertrophy; SR, sinus rhythm.

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