Practical Cardiology Review

Practical Cardiology Review:

A Self-assessment Tool

Edited by
Majid Maleki, Azin Alizadehasl
and Majid Haghjoo

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PREFACE

Practical Cardiology Review contains more than 400 multi-choice questions and detailed answers regarding various cardiology cases.

This book should appeal to a wide range of colleagues, from practicing professionals to residents and fellows preparing for higher qualifications, thanks to its informative chapters on such mainstays of cardiology as physical examinations, electrocardiography, echocardiography, electrophysiology, intervention, and pharmacological treatment, as well as such commonly confronted issues as cardiomyopathy, heart failure, and cardiac surgery.

Practical Cardiology Review is a learning tool to complement the previously printed books on practical cardiology. The authors each have contributed original questions and meticulous answers in their particular field of expertise.

As cardiologists, we feel a responsibility to be at the cutting edge of the ever-advancing cardiology so as to be able to manage the vast array of cardiac diseases, many of which are life-threatening.

We have had the immense pleasure of collaborating with Cambridge Scholars Publishing in the preparation of this book and wish to express our heartfelt thanks to its editorial and printing departments.

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CHAPTER 1

EVALUATION OF PATIENTS WITH CARDIOVASCULAR PROBLEMS

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1. What is your diagnosis?

A. Hyperkinetic pulse in a high output state
B. Bisferiens pulse in hypertrophic obstructive cardiomyopathy
C. Dicrotic pulse
D. Pulsus alternans in heart failure

Answer: D

The pulse pressure waveform shows the variation in pressure between the beats in pulsus alternans. Pulsus alternans is a physical finding, with the arterial pulse waveform presenting alternating strong and weak beats. It is almost always indicative of left ventricular systolic impairment, and carries a very poor prognosis.

2. Which phrase is incorrect about V waves?

   A. They start at the end of the systole.
   B. TR produces a prominent V wave that is premature (CV wave) and makes the X descent disappear.
   C. High cardiac output states such as exercise, anemia, and hyperthyroidism may cause increased V wave amplitude.
   D. ASD decreases V wave amplitude.

Answer: D

V wave starts at the end of systole. TR produces a prominent V wave that is premature (CV wave) and makes the X descent disappear. High cardiac output states such as exercise, anemia, and hyperthyroidism may cause increased V wave amplitude. ASD can increase V wave amplitude.

3. The paradoxical bulging of LV impulse is seen in:

   A. Severe MR
   B. IHD
   C. Severe AI
   D. LVH

Answer: B

The paradoxical bulging of LV impulse is seen in myocardial infarction with LV apical aneurysm.

4. The following picture shows a 34-year-old man after coronary artery bypass surgery. What is your diagnosis?

A. Progeria syndrome
B. Turner syndrome
C. Holt-Oram syndrome
D. Friedreich's ataxia

Answer: A

Progeria is an extremely rare autosomal dominant genetic disorder in which symptoms resembling aspects of aging are manifested at a very early age. Progeria is one of several progeroid syndromes.

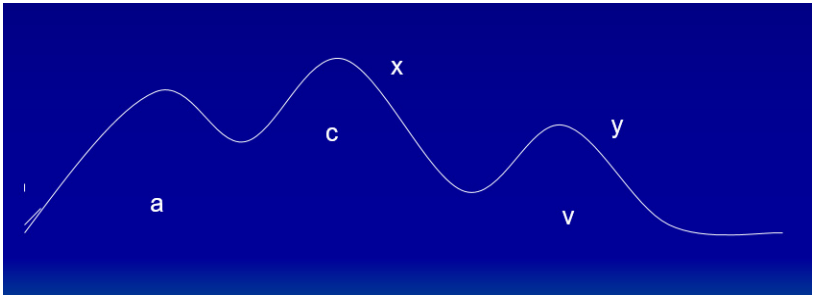
5. Soft S1 is heard in:

A. Pregnancy
B. Arteriovenous fistula
C. Severe MR
D. Atrial myxoma

Answer: C

Soft S1 is heard in calcified mitral valve, first-degree AV block, severe MR, dilated cardiomyopathy and myocarditis.

6. Which of the following processes is not depicted in the diagram (jugular venous pulse)?



A. Atrial contraction (a)
B. Closure of tricuspid valve (c)
C. Ventricle begins to fill (x)
D. Tricuspid valve opening and ventricular filling (y)

Answer: C

Jugular venous pulse waves indicate the following:

a: Atrial contraction
c: Closure of tricuspid valve
x: Atria begins to fill
v: Volume of atria increases
y: Tricuspid valve opening and ventricular filling

7. Which phrase is incorrect about S3?

A. It occurs in early diastole (soon after S2).
B. Blood rushes in just after the mitral valve opens, striking the LV wall (PALPABLE).
C. It is heard only at the left sternal border.
D. It can also be heard in healthy young people.

Answer: C

S3 is heard at apex only.

8. Which phrase is incorrect about aortic valve stenosis murmur?

A. It has a harsh quality.
B. It is best heard in LSB.
C. It is accompanied by a soft S2.
D. It has a diamond-shaped pattern.

Answer: B

Aortic Stenosis features: Harsh murmur at right sternal border, soft S2, diamond-shaped pattern, late peak, delay in carotid pulse, radiates to carotid artery and failure to radiate makes aortic stenosis less likely.

References

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CHAPTER 2

ELECTROCARDIOGRAPHY

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1. In which situation could the right QRS axis deviation not be seen?
   A. Right ventricular hypertrophy
   B. Left posterior fascicular block
   C. Dextrocardia
   D. Primum atrial septal defect

Answer: D

QRS complex: The initial wave (low amplitude and brief duration, less than 30 ms) is positive in leads aVR and V1, and is negative in leads I, aVL, V5, and V6 (representing septal q waves). The QRS pattern in inferior leads may be predominantly upright (qR, rS or RS pattern complexes), and in lead I may present as an isoelectric RS pattern or a predominantly upright qR pattern. The normal mean QRS axis in adults is between −30º and +90º (Table 2.1). Causes of QRS axis deviation are shown in Table 2. In pericardial leads, the transition zone (in this zone, the QRS complex is present as an isoelectric RS pattern) typically occurs in lead V3 or V4. It should be mentioned that men have greater QRS amplitudes and longer QRS durations than women. In contrast to PR interval, the duration of the QRS complex is not influenced by heart rate.

Table 2.1 Axis of QRS complex.

	Range of QRS axis (º degrees)
Normal	−30 to +90
Right axis deviation	> +90
Moderate	+90 to +120
Marked	+120 to +180
Left axis deviation	< −30
Moderate	−30 to −45
Marked	−45 to −90
Superior axis deviation	−80 to −90
Extreme axis deviations (right superior axis deviations)	−90 to −180 (+180 to +270)

Table 2.2 Causes of QRS axis deviation

Right axis deviation	**Left axis deviation**
Normal variation (vertical heart with an axis of 90º)	Normal variation (physiological, often with age)
Mechanical shifts, such as inspiration and emphysema	Mechanical shifts, such as expiration, high diaphragm (pregnancy, ascites, abdominal tumor)
Right ventricular hypertrophy	Left ventricular hypertrophy
Right bundle branch block	Left bundle branch block
Left posterior fascicular block	Left anterior fascicular block
Dextrocardia	Congenital heart disease (primum atrial septal defect, endocardial cushion defect)
Ventricular ectopic rhythms	Emphysema
Pre-excitation syndrome (Wolff-Parkinson-White)	Pre-excitation syndromes (Wolff-Parkinson-White)
Lateral wall myocardial infarction	Inferior wall myocardial infarction
Secundum atrial septal defect	Ventricular ectopic rhythms
	Hyperkalemia

2. In which situation, is the J point elevation abnormal and needs more evaluation?

   A. J point elevation equals 0.2 in lead V4 in a 30-year-old man.
   B. J point elevation equals 0.2 in lead V2 in a 50-year-old man.
   C. J point elevation equals 0.25 in lead V2 in a 30-year-old man.
   D. J point elevation equals 0.15 in lead V2 in a 50-year-old women.

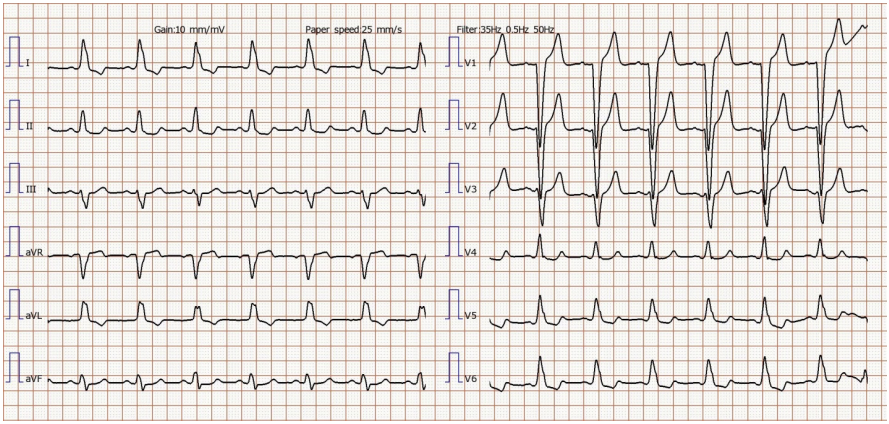
Answer: A

J point: The intersection of the end of the QRS complex and the beginning of the ST segment is termed the J point, and it is normally at or near the isoelectric baseline of the ECG. The greatest amplitude of J point is seen in lead V2 (Table 2.3) (1).

Table 2.3 Upper limits of normal J point elevation based on various conditions.

Leads V2 and V3	
Men ≥ 40 years	0.2 mV
Men < 40 years	0.25 mV
Women	0.15 mV
Leads (except V2 and V3)	0.1 mV

3. Regarding ventricular repolarization interval calculation in this ECG, which method is correct?



A. Corrected QT interval based on Bazett's Formula
B. Corrected QT interval based on Fridericia's formula
C. Corrected QT interval based on a linear model
D. JT interval

Answer: D

QT and JT intervals: JT interval is a more accurate measure of ventricular repolarization, especially in patients with bundle branch block (BBB). The QT interval is rate-dependent, decreasing as heart rate increases.

Formula for measurement of corrected QT interval:

1. Bazett's Formula (QT and RR intervals are measured in seconds): $QTc = QT/\sqrt[2]{RR}$
2. Fridericia's formula (QT and RR intervals are measured in seconds): $QTc = QT/\sqrt[3]{RR}$
3. Formula based on linear model (intervals are measured in milliseconds): QTc = QT +1.75(HR − 60)

Formula for measurement of corrected QT interval in patients with atrial fibrillation:

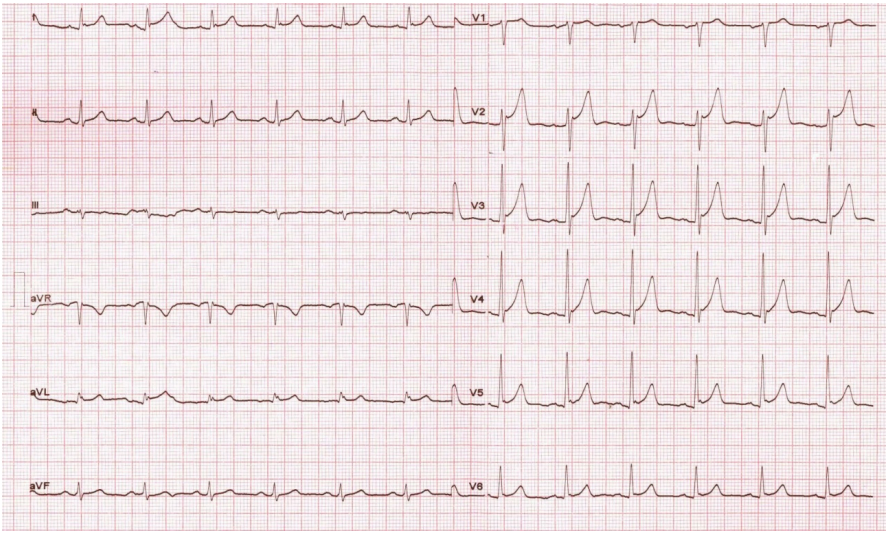
1. $(QTc_{short} + QTc_{long})/2$
2. Onset of R wave to peak of the T wave. (If this was more than half the R-R interval, then the QTc interval is likely to be above the critical threshold of 500 ms)
3. Average of multiple QTc intervals (up to 10)
4. Measure the QT interval in a beat that the R-R interval that is of exactly 1-second duration (because the square root of 1 is 1, so, in this beat, the QTc interval = non-corrected QT interval)

Formula for measurement of corrected JT interval (in the setting of a BBB):

1. Formula based on QT interval: JTc = QTc – QRS
2. JT interval = JT (HR + 100)/518

A JT interval equal to or greater than 112 ms can be identified as a repolarization prolongation.

4. A 47-year-old man presents with atypical chest pain in your emergency department. The CT angiogram shows normal coronary arteries. Which diagnosis is correct?



A. Benign early repolarization
B. Malignant early repolarization
C. Prinzmetal angina
D. Acute pericarditis

Answer: A

Benign early repolarization

The ECG pattern of benign early repolarization (BER) is most commonly seen in young, healthy patients under 50 years of age (Table 4). It produces widespread ST segment elevation that may mimic pericarditis or acute MI. BER can be difficult to differentiate from pericarditis because both conditions are associated with concave ST elevation. These two conditions can be distinguished using the ST segment elevation (from the end of the PR segment to the J point) compared to the amplitude of the T wave in V6. An ST segment / T-wave ratio of more than 0.25 suggests pericarditis, but if this ratio is less than 0.25, it is consistent with BER (Table 2.5, Figure 2.1).

Table 2.4 Criteria for benign early repolarization

Widespread concave ST elevation, most prominent in the mid- to left precordial leads (V2-5).
Concavity of initial upsloping portion of ST segment.
Notching or slurring at the J point.
Prominent, slightly asymmetrical T waves which are concordant with the QRS complexes (pointing in the same direction).
The degree of ST elevation is modest in comparison to the T wave amplitude (less than 25% of the T wave height in V6; against pericarditis).
ST elevation is compatible with the criteria in Table 3.
No reciprocal ST depression to suggest STEMI (except in aVR).
ST changes are relatively stable over time (no progression on serial ECG tracings).
Reduction in ST segment elevation with sympathomimetic factors.

Table 2.5 Criteria for distinguishing BER from pericarditis.

In favor of BER	In favor of pericarditis
ST elevation limited to the precordial leads Absence of PR depression Prominent T waves ST segment / T-wave ratio < 0.25 Characteristic “fish-hook” appearance in V4 ECG changes relatively stable over time	Generalized ST elevation Presence of PR depression Normal T-wave amplitude ST segment / T-wave ratio > 0.25 Absence of “fish hook” appearance in V4 ECG changes evolve over time

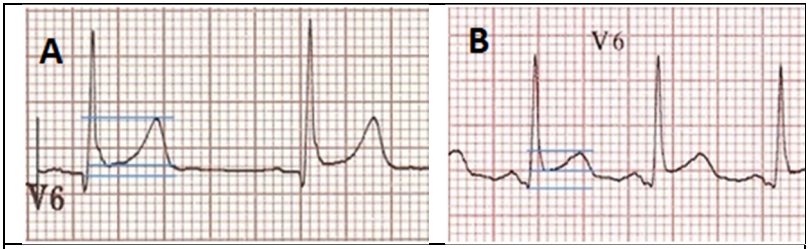


Figure 2.1: A) BER: The ST-segment height (1 mm) / T-wave height (6 mm) ratio is equal 0.16. B) Pericarditis: The ST-segment height (2 mm) / T-wave height (4 mm), ratio is equal (0.5).

5. Which of the following is not compatible with right atrial abnormalities?

A. Rightward shift of mean P wave axis to more than +75 degrees.
B. Increased duration and depth of terminal-negative portion of P wave in lead V1 (P terminal force) such that area subtended by it is >0.04 mm-sec.
C. qR pattern in the right precordial leads without evidence of myocardial infarction (especially with other signs of RV overload)
D. Low-amplitude (<600 μV = 6 mm at usual gain) QRS complexes in lead V1 with a ≥ 3 increase in lead V2

Answer: B

Atrial abnormality

The three general categories of P wave that can alter atrial activation to produce abnormal P wave patterns are: abnormal patterns of activation and conduction, left atrial abnormalities, and right atrial abnormalities. The common diagnostic criteria for left and right atrial abnormalities are listed in Table 6.

Left atrial abnormality: Anatomical abnormalities of the left atrium that alter the P waves include atrial dilation, atrial muscular hypertrophy, and elevated intra-atrial pressures. The most common conditions that lead to left atrial enlargement include hypertension, valvular heart diseases, heart failure and atrial fibrillation.

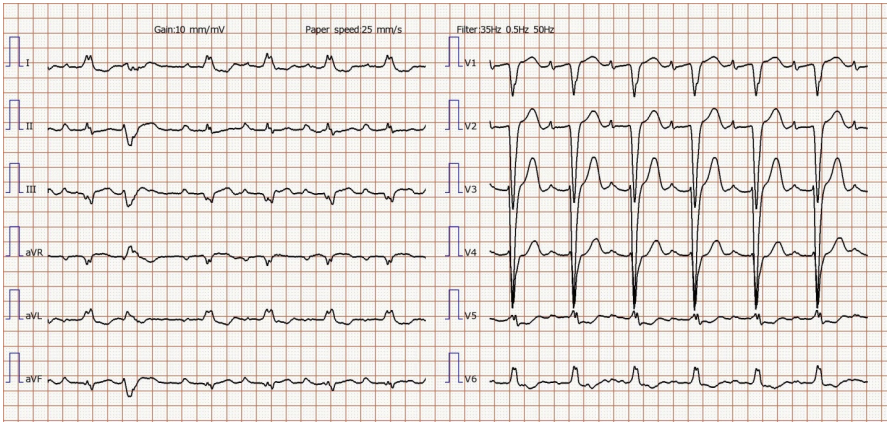
Right atrial abnormality: Right atrial abnormality is a marker of the severity of disease, and also predicts outcome in some disorders including tricuspid regurgitation, pulmonary hypertension, congenital heart disease, and right heart failure. Enlargement of the right atrium may result from right atrial volume or pressure load.

Biatrial abnormality: ECG pattern findings include large biphasic P waves in lead V1 and tall and broad P waves in leads II, III, and aVF.[11]

Table 2.6 Common diagnostic criteria for left and right atrial abnormalities

Left atrial abnormalities	Right atrial abnormalities
• Prolonged P wave duration to >120 ms in lead II • Prominent notching of P wave, usually most obvious in lead II, with an interval between notches of >0.40 ms ("P mitrale") • Ratio between the duration of P wave in lead II and duration of PR segment >1.6 • Increased duration and depth of terminal-negative portion of P wave in lead V1 (P terminal force) so that area subtended by it is >0.04 mm-sec • Leftward shift of mean P wave axis to between −30 and −45 degrees	• Peaked P waves with amplitudes in lead II to >0.25 mV ("P pulmonale") • Prominent initial positivity in lead V1 or V2 >0.15 mV (1.5 mm at usual gain) • Increased area under initial positive portion of P wave in lead V1 to >0.06 mm-sec • Rightward shift of mean P wave axis to more than +75 degrees • qR pattern in the right precordial leads without evidence of myocardial infarction (especially with other signs of RV overload) • low-amplitude (<600 μV = 6 mm at usual gain) QRS complexes in lead V1 with a ≥ 3 increase in lead V2

6. Select the correct option based on this ECG.



A. Left ventricular hypertrophy
B. Hypertrophic cardiomyopathy
C. Dilated cardiomyopathies
D. Biventricular hypertrophy

Answer: C

Dilated cardiomyopathies (DCM): The presence of a relatively low limb voltage (QRS voltage <0.8 mV in each of the limb leads) accomplished with a relatively prominent QRS voltage in the pericordial leads (SV1 or SV2 + RV5 or RV6 >3.5 mV) and poor R wave progression in the pericardial leads suggests DCM. These changes are relatively specific but not a sensitive sign for DCM.[14]

7. In a patient with right ventricular hypertrophy (RVH), which of these options correlates more closely to right ventricular volume overload compared with severe concentric RVH?

A. Tall R waves in anteriorly and rightward-directed leads (leads aVR, V1, and V2)
B. rSr′ pattern in V1
C. Deep S waves and small r waves in leftward-directed leads (I, aVL, and lateral precordial leads)
D. Shift in the frontal plane QRS axis to the right
E. Presence of S waves in leads I, II, and III (the S1S2S3 pattern)

Answer: B

Right ventricular hypertrophy: The common diagnostic criteria for RVH and the ECG criteria for RVH based on its severity are listed in Tables 2.7 and 2.8. Evidence of true RVH in patients with chronic obstructive pulmonary disease includes a positive right axis deviation of more than 110 degrees, deep S waves in the lateral precordial leads, and an S1Q3T3 pattern. Hyperinflation of the lungs in these patients could cause a decrease the amplitude of the QRS complex, right axis deviation, and delayed transition in the precordial leads even in the absence of RVH.

Table 2.7 Common diagnostic criteria for RVH

• R in V1 ≥0.7 mV • QR in V1 • R/S in V1 >1 with R >0.5 mV • R/S in V5 or V6 <1 • S in V5 or V6 >0.7 mV • R in V5 or V6 ≥0.4 mV with S in V1 ≤0.2 mV • Right axis deviation (>90 degrees) • S1Q3 pattern • S1S2S3 pattern • P pulmonale

Table 2.8 ECG criteria for RVH based on severity

Moderate to severe concentric RVH	Less severe hypertrophy (limited to the outflow tract of the right ventricle*)
• Tall R waves in anterior and rightward-directed leads (leads aVR, V1, and V2) • Deep S waves and small r waves in leftward-directed leads (I, aVL, and lateral precordial leads) • A reversal of normal R wave progression in precordial leads • Shift in the frontal plane QRS axis to the right • Presence of S waves in leads I, II, and III (the S1S2S3 pattern).	• rSr′ pattern in V1 • Persistence of s (or S) waves in the left precordial leads
* This pattern is typical of right ventricular volume overload such as that produced by an atrial septal defect.	

8. Which of the following is more often associated with a massive pulmonary embolism?

A. QR or qR pattern in the right ventricular leads
B. S1Q3T3 pattern
C. ST-segment deviation and T-wave inversions in leads V1 to V3
D. Incomplete or complete right bundle branch block (RBBB).
E. Atrial fibrillation
F. ST-segment elevations in the right mid-precordial leads

Answer: F

Pulmonary embolism: ECG changes in patient**s** with pulmonary embolism include:

1. Sinus tachycardia (the most common abnormality)
2. QR or qR pattern in right ventricular leads
3. S1Q3T3 pattern
4. ST-segment deviation and T-wave inversions in leads V1 to V3
5. Incomplete or complete right bundle branch block (RBBB)
6. Right axis deviation
7. Right atrial enlargement (P pulmonale)
8. Atrial tachyarrhythmias (atrial fibrillation, flutter, and tachycardia)
9. ST-segment elevations in the right mid-precordial leads (in massive pulmonary arterial obstruction)

9. Which of the following is not correct in a patient with left bundle branch block?

A. Broad, notched, or slurred R waves in leads I, aVL, V5, and V6
B. Late intrinsicoid (prolonged time to peak R wave) in V1 >50 ms
C. Small or absent initial r waves in right precordial leads (V1 and V2) followed by deep S waves
D. Absent septal q waves in leads I, V5, and V6

Answer: B

Left bundle branch block: The common diagnostic criteria for LBBB are listed in Table 2.9. The mean QRS axis can be normal, deviated to the left, or deviated to the right. In most cases, the ST-T segments are discordant with the QRS complex. LBBB has significant prognostic implications. In patients with or without overt heart disease, LBBB is associated with a higher risk of mortality and morbidity from myocardial infarction, heart failure, and arrhythmias such as high-grade atrioventricular block.

Table 2.9 Common diagnostic criteria for bundle branch blocks

Complete Left Bundle Branch Block	Complete Right Bundle Branch Block
• QRS duration ≥120 ms • Broad, notched, or slurred R waves in leads I, aVL, V5, and V6 • Small or absent initial r waves in right precordial leads (V1 and V2) followed by deep S waves • Absent septal q waves in leads I, V5, and V6 • Late intrinsicoid (prolonged time to peak R wave) in V5 and V6 >60 ms	• QRS duration ≥120 ms • rsr′, rsR′, or rSR′, patterns in leads V1 and V2 • S waves in leads I and V6 ≥40 ms wide • Early intrinsicoid (normal time to peak R wave) in leads V5 and V6 • Late intrinsicoid (Prolonged time to peak R wave) in V1 >50 ms

10. In patients with unstable angina, which of these ECG findings is less correlated with short-term risk for death or nonfatal myocardial ischemia?

A. Angina at rest with transient ST-segment depression of 0.1 mV in leads V1-4
B. New left bundle branch block
C. Sustained ventricular tachycardia
D. T-wave inversion of 0.2 mV in leads V1-4
E. Pathologic Q waves in inferior leads
F. ST-segment depression of 0.05 mV in leads V1-3

Answer: F

Myocardial Infarction: An ECG should be taken within 10 minutes of arrival at the emergency department for patients suspected of acute coronary syndrome. During a symptomatic episode at rest, new persistent or transient ST-segment abnormalities (≥0.05 mV) are strongly suggestive of acute ischemia and severe coronary disease. A normal ECG has a negative predictive value of 80% to 90%; however, a normal ECG does not exclude the possibility of acute coronary syndrome. The risk for acute MI in a patient with a history of CAD and normal ECGs is approximately 4%, and if they do not have a history of CAD, the risk will be 2%. Nonspecific ST-T-wave changes (ST-segment deviation <0.05 mV or T-wave inversion ≤0.2 mV) with or without abnormal Q waves are the most common abnormalities on the ECG in patients with chronic CAD. The presence of a hyperacute T wave or an upright T wave in lead V1 more than lead V6 in a patient with angina pectoralis is highly suggestive of the presence of subendocardial ischemia secondary to coronary artery involvement. However, a symmetrically and deeply inverted T wave suggests transmural ischemia. The likelihood and short-term risks for acute coronary syndrome based on ECG findings are shown in Table 2.10.

Table 2.10 The likelihood and short-term risk for acute coronary syndrome (ACS)

A) Likelihood for ACS based on ECG findings		
High	Intermediate	Low
• New or presumably new transient ST-segment deviation (≥0.1 mV) or T-wave inversion (≥0.2 mV) in multiple precordial leads	• Fixed Q waves • ST-segment depression of 0.05-0.1 mV or T-wave inversion >0.1 mV	• T-wave flattening or inversion <0.1 mV in leads with dominant R waves • Normal ECG
B) Short-term risk of death or nonfatal myocardial ischemia in patients with unstable angina based on ECG findings		
High	Intermediate	Low
• Angina at rest with transient ST-segment changes >0.05 mV • Bundle branch block, new or presumed new • Sustained ventricular tachycardia	• T-wave changes • Pathologic Q waves or resting ST-segment depression <0.1 mV in multiple lead groups (anterior, inferior, lateral)	• Normal or unchanged ECG

11. In which situation, would ST-segment elevation not be seen?

A. Acute pulmonary embolism
B. Brugada pattern
C. Class IB antiarrhythmic drugs
D. Hypercalcemia
E. Hyperkalemia
F. Hypothermia

Answer: C

Electrocardiographic differential diagnosis of ischemia and infarction is shown in Table 2.11.

Table 2.11 Electrocardiographic differential diagnosis of ischemia and infarction

Q wave	ST elevation	Tall R Waves in Leads V1 and V2
Physiologic or Positional Factors Normal variant septal Q waves Normal variant Q waves in V1-V2, III, and aVF Left pneumothorax or dextrocardia—loss of lateral R-wave progression **Myocardial Injury or Infiltration** Acute processes—myocardial ischemia with or without infarction, myocarditis, hyperkalemia (rare cause of transient Q waves)	Myocardial ischemia or infarction Non-infarction, transmural ischemia (e.g. Prinzmetal angina pattern, takotsubo syndrome) Acute myocardial infarction (due to obstructive coronary occlusion or other causes) Post-myocardial infarction (ventricular aneurysm pattern) Acute pericarditis Normal variants (including the classic early	**Physiologic and Positional Factors** Misplacement of chest leads Normal variants Displacement of heart toward right side of chest (dextroversion), congenital or acquired **Myocardial Injury** Lateral or true posterior myocardial infarction Duchenne muscular dystrophy