ECG for MRCP
Teaching Notes and Best of Fives with ECG Pictures

2nd Edition
Dr. Osama Amin
November 2006

http://neurology4mrcp.orgfree.com
Preface:

ECG questions are integral part of the MRCP/MRCPi examinations. Familiarity with certain ECG scenarios and clinical problems is the key to be successful in these examinations. Please read textbooks beforehand and then make a rapid review here.

This book is a collection of many questions and tips and review points; the ECG pictures with their questions and answers were taken from http://medstat.med.utah.edu/kw/ecg/, and reproduced with permission to produce this handy PDF. I am greatly thankful to: "Professor Frank G. Yanowitz, M.D, Professor of Medicine, University of Utah School of Medicine, Medical Director, ECG Department, LDS Hospital Salt Lake City, Utah" for letting me use his website's (shown above) ECG pics.

Best wishes…

Dr. Osama Amin
Neurologist and Head of Team Neurology4MRCPGroup

November 2006
Contents:
1- Chapter I; Few points to remember, page 4
2- Chapter II; Arrhythmias, page 10
3- Chapter III; Conduction Abnormalities, page 15
4- Chapter IV; Chamber Enlargement, page 21
5- Chapter V; Myocardial Infarction, page 27
6- Chapter VI; ST-T Segment, page 34
7- Chapter VII; Advanced Quiz, page 40
8- Chapter VIII; ECG Best of Five Scenarios, page 45
Chapter I / Few Points to Remember

ECG manifestations of chamber enlargement:

A-Left atrial enlargement:
   a. P wave duration equal or more than 0.12 sec.
   b. Notched, slurred P wave in lead I and II (P mitrale).
   c. Biphasic P wave in lead V1 with a wide, deep and negative terminal component.
   d. Mean P wave axis shifted to the left (between +45 to – 30 degree).

B-Right atrial enlargement:
   a. P wave duration equal or less than 0.11 sec.
   b. Tall, peaked T wave equal or more than 2.5 mm in amplitude in lead II, III, or aVF (P pulmonale).
   c. Mean P wave axis shifted to the right (more than +70 degree).

C-Left ventricular enlargement:
   a. "Voltage criteria":
      1-R or S wave in limb lead equal or more than 20mm
      2-S wave in V1, V2 or V3 equal or more than 30mm
      3-R wave in V4, V5 or V6 equal or more than 30mm.
   b. Depressed ST segment with inverted T waves in lateral leads (strain pattern; more reliable in the absence of digitalis therapy).
   c. Left axis of -30 degree or more.
   d. QRS duration equal or more than 0.09 sec.
   e. Time of onset of the intrinsicoid deflection (time from the beginning of the QRS to the peak of the R wave) equal or more than 0.05 sec in lead V5 or V6.

D-Right ventricular enlargement:
   a. Tall R waves over the right precordium and deep S waves over the left precordium (R:S ratio in lead V1 > 1.0)
   b. Normal QRS duration (if no bundle branch block)
   c. Right axis deviation.
   d. ST-T "strain" pattern over the right precordium.
   e. Late intrinsicoid deflection in lead V1 or V2.

ECG manifestations of bundle branch block (BBB):

A-Left bundle branch block:
   a. QRS duration equal or more than 0.12 sec.
   b. Broad, notched or slurred R wave in lateral leads (I, aVL, V5, V6)
   c. QS or rS pattern in the anterior precordium.
   d. Secondary ST-T wave changes (ST and T wave vectors are opposite to the terminal QRS vectors).
   e. Late intrinsicoid deflection in lead V5 and V6.

B-Right bundle branch block:
   a. QRS duration equal or more than 0.12 sec.
   b. Large R' wave in lead V1 (rsR').
d. Normal septal Q wave.
e. Inverted T wave in lead V1 (secondary T wave changes).
f. Late intinsicoid deflection in lead V1 and V2.

**ECG manifestations of fascicular blocks:**

A-Left anterior fascicular block:
- a. QRS duration equal or more than 0.10 sec.
- b. Left axis deviation (-45 degree or greater).
- c. rS pattern in lead II, III and aVF.
- d. qR pattern in lead I and aVL.

B-Left posterior fascicular block:
- a. QRS duration equal or more than 0.10 sec.
- b. Right axis deviation (+90 degree or greater).
- c. qR pattern in lead II, III and aVF.
- d. rS pattern in lead I and aVL.
- e. Exclusion of other causes of right axis deviation (COPD, RVH, lateral MI).

**Localization of myocardial infarction:**

Infarct location Leads depicting primary ECG changes Likely vessel * involved
Inferior II,III,aVF RCA
Septal V1-V2 LAD
Anterior V3-V4 LAD
Antero-septal V1-V4 LAD
Extensive anterior I,aVL,V1-V6 LAD
Lateral I,aVL,V5-V6 CIRC
High Lateral I, aVL CIRC
Posterior ** Prominent R in lead V1 RCA or CIRC
Right ventricular*** ST elevation in lead V1, and more specifically, V4R in the setting of inferior infarction RCA

*this is a simple generalization, variations occur.
** Usually in association with inferior or lateral infarctions.
*** Usually in association with inferior infarctions.

**Some observations on abnormal rhythms:**
Remember: A slow regular ventricular rhythm might be due to:
1. Sinus bradycardia.
2. Complete AV block with idioventricular rhythm.
5. Atrial flutter with high grade 4:1 AV block.
6. Sinus default with idionodal escape rhythm.
7. Sinus default with idioventricular escape rhythm.
Remember: Causes of IRREGULAR ventricular rhythm:
1- Atrial fibrillation.
2- Frequent and irregularly occurring atrial and or ventricular extrasystoles.
3- Atrial flutter with second degree AV block and varying AV conduction ratios.
4- Paroxysmal atrial tachycardia with variable second degree AV block.
5- Marked respiratory sinus arrhythmia.

Remember: "SLOW" atrial fibrillation:
Slow atrial fibrillation usually reflects treatment with digitalis; or in the absence of digitalis therapy, a structural nodal disease (sick sinus syndrome). A more correct description is "atrial fibrillation with slow or diminished ventricular response".

Remember: Common causes of bigeminal rhythm:
1- Alternate ventricular extrasystoles (the commonest cause).
2- Alternate atrial or nodal extrasystoles.
3- Any form of 3:2 AV block.
4- Atrial flutter with alternating 4:1 and 2:1 AV block.

Remember: Absent P wave might be due to:
1- SA block.
2- Atrial fibrillation.
3- Severe hyperkalemia.
4- AV nodal rhythm (the P wave might be hidden within the QRS complexes).

Remember: A long PAUSE interrupting a regular rhythm might be caused by:
1- A dropped beat as a result of 2nd degree AV block.
2- A dropped beat as a result of SA block.
3- A blocked or non-conducted atrial extrasystole.

NB: Extrasystoles occur PREMATURELY, escape beats occur LATE.
NB: When the PR interval becomes progressively shorter, AV dissociation is usually present.

Remember: Paroxysmal atrial rhythm (tachycardia, paroxysmal or flutter fibrillation) in a young person without obvious evidence of cardiac disease rises the possibility of:
1- Thyrotoxicosis.
2- WPW syndrome.
3- Lone atrial fibrillation.

Remember: TALL symmetrical T waves in the precordial leads might be due to:
1- Acute subendocardial ischemia, injury or infarction.
2- Recovering inferior wall myocardial infarction.
3- Hyperacute phase of anterior wall myocardial infarction.
4- Prinzmetal's angina.
5- True posterior wall myocardial infarctions.
6- Hyperkalemia.
Remember: Generalized LOW voltage might be due to:
1-incorrect standardization.
2-emphydema.
3-marked obesity or thick chest wall.
4-pericardial effusion.
5-myxedema.
6-hypopituitarism.
7-Cardiac Amyloid.
8-Severe cardiomyopathy
9-Global Myocardial iscehmia.

Remember: Acute rheumatic frequently associated with:
1-sinus tachycardia.
2-non paroxysmal AV nodal tachycardia( idionodal tachycardia).
3-prolonged PR interval.
4-2nd degree AV block.
5-prolonged QT interval.
NB: it is NEVER associated with 3rd degree AV block.

Some ECG finding in heart diseases:
Mitral stenosis:
1-atrial fibrillation
2-RVH ,right axis deviation
3-P mitrale, P pulmonale

Mitral reflux:
1-P mitrale
2-atrial fibrillation
3-left ventricular "diastolic" overload
4-RVH, Right axis deviation.

Tricuspid stenosis:
1-VERY TALL right atrial P wave in standard lead II.
2-1st degree AV block
3-normal QRS axis

Hypertensive heart disease:
1-left atrial P wave
2-left ventricular "systolic " overload

Arrhythmias associated with HYPERthyroidism:
1-sinus tachycardia
2-atrial extrasystoles
3-paroxysmal atrial tachycardia
4-paroxysmal atrial flutter
5-paroxysmal atrial fibrillation
6-idionodal tachycardia
7-paroxysmal nodal tachycardia
NB: Ventricular rhythms are NOT usually associated with hyperthyroidism unless there is a cardiac DECOMPENSATION.
Pulmonic stenosis:
1-P congenitale
2-right ventricular systolic overload
3-right axis deviation

Tricuspid atresia:
1-left axis deviation
2-left ventricular dominance
NB: MOST cases of cyanotic congenital heart disease are associated with RIGHT ventricular dominance and RIGHT axis deviation; tricuspid atresia is a notable exception.

Ebstein's anomaly:
1-TALL peaked P waves in standard lead II
2-RBBB with small amplitude QRS complexes
3-WPW syndrome type B, ie the QRS complex is negative in the right precordial leads
4-paroxysmal supraventricular tachycardia

Mirror image dextro-cardia:
1-Inverted P waves in standard lead I
2-all other deflections –QRS complex and T wave- are also negative in standard lead I.
3-this lead now resembles a normal lead aVR.
4-the normal appearances of standard leads II and lead III are interchanged.
5-the QRS complexes are tallest in the right precordial leads –V1 and V2- and diminished progressively towards the left.

Limb lead reversal:
This will manifest as a mirror image dextro-cardia but the precordial lead complexes are NORMAL.

Anomalous left coronary artery:
When the left coronary artery arises from the pulmonary artery, the ECG reflects the pattern of ANTERO-LATERAL myocardial infarction, viz pathological q waves, raised coved ST segments and inverted T waves in standard lead I and aVL and the left precordial leads.

Causes of SA block:
SA block is a rare ECG finding and might be caused by:
1-marked sinus bradycardia
2-marked sinus arrhythmia
3-highly trained young athletes
4-digitalis toxicity
5-ureamia
6-hypokalemia
7-sick sinus syndrome
1st degree AV block is associated with:
1-coronary artery disease
2-acute rheumatic carditis
3-Beta blockers
4-digitalis
5-cardiomyopathy

NB: Para systoles; parasystole is an uncommon arrhythmia. It may occur with myocardial diseases and following digitalis administration, however it might be seen in normal healthy people. There is no specific treatment and the treatment is of the underlying disease if present.
Q1: What type of arrhythmia is pointed out by the two arrows?

A. PACs (Premature Atrial Complexes)
B. PVCs (Premature Ventricular Complexes)
C. 1 is a PAC, and 2 is a PVC
D. PSVT (Paroxysmal Supraventricular Tachycardia)
E. Left Bundle Branch Block

Answer: A

Remember that not all sore thumbs are PVCs. In this case, 1 is a PAC with normal IV conduction and 2 is a sore thumb PAC with RBBB aberration. PACs have three fates: normal conduction into ventricles, aberrant conduction in ventricles, and non-conduction. In the example of PAC '2' the longer preceding cycle increases the refractory period in the right bundle and results in the aberration.

Q2: What type of arrhythmia is labeled by the arrows?

A. 1st degree AV block
B. PACs
C. PVCs
D. PVCs with fusion
E. PJCs

Answer: B

These PAC's, indicated by arrows, enter the ventricles and find the right bundle refractory. They therefore conduct with RBBB aberrancy. In most normal hearts the right bundle recovery time is longer than the left bundle's; most aberrancy, therefore, has a RBBB morphology.

Late PACs result in premature beats, but early PACs can initiate a paroxysmal tachycardia.

Q3: What type of arrhythmia is seen here?
A. 1st degree AV block  
B. PACs  
C. PVCs  
D. PVCs with fusion  
E. PJCs  

**Answer: B**  
These PAC's, indicated by arrows, enter the ventricles and find the right bundle refractory. They therefore conduct with RBBB aberrancy. In most normal hearts the right bundle recovery time is longer than the left bundle's; most aberrancy, therefore, has a RBBB morphology. 
Late PACs result in premature beats, but early PACs can initiate a paroxysmal tachycardia.

**Q4: Using calipers (don't poke the monitor!), what type of pause do you see after this funny looking premature beat?**

A. Complete compensatory pause  
B. incomplete compensatory pause  
C. No pause (next beat is on time)  
D. Interpolated pause  
E. None of the above  

**Answer: A**  
The distance between the P waves before and after the PVC is the same distance as two P cycles elsewhere in the rhythm strip. This implies that the sinus node was not reset, and that the funny looking beat is a PVC. 
As a side note, this PVC occurs on the peak of the T wave of the preceeding beat making it an R on T.
Q5: Using calipers, what type of pause do you see after either of these two premature beats?

A. Complete compensatory pause
B. Incomplete compensatory pause
C. No pause (next beat is on time)
D. Interpolated pause
E. None of the above

Answer: B
PAC's are identified by the arrows. Note that the PP interval surrounding the PAC is less than 2x the basic sinus cycle indicating that the sinus node has been reset by the ectopic P wave. The pause after the PAC, therefore, is incomplete. An incomplete pause suggests a PAC (although there are exceptions).

Q6: Choose from the following responses to interpret this ECG.

A. PJC (Premature junctional complex)
B. Atrial flutter
C. Atrial fibrillation
D. AV nodal reentrant tachycardia
E. Accelerated junctional rhythm

Answer: C
Atrial fibrillation is characterized by an irregularly irregular ventricular response, and the absence of discrete P waves. In the top lead in this ECG, atrial activity is poorly defined. The atrial activity seen in the lower lead resembles old saw-teeth (as opposed to the new, sharp saw-teeth of atrial flutter).
Q7: What is seen in this ECG?

A. Sinus tachycardia
B. Paroxysmal supraventricular tachycardia
C. 3rd degree AV block
D. Atrial fibrillation
E. Atrial flutter with 2:1 block

**Answer: E**

This is the most commonly mis-diagnosed SV tachycardia. Clues are a ventricular rate of around 150 bpm (atrial of ~300 bpm), and regular R-R intervals, and two atrial events for every QRS (if you can find them!). Another clue for leads II, III, and aVF is to mentally erase the QRS complexes. It is then sometimes possible to visualize the classic flutter pattern.

Q8: Choose the correct interpretation of this ECG.

A. Normal sinus rhythm
B. Atrial fibrillation
C. Sinus tachycardia
D. Junctional escape rhythm
E. Accelerated junctional rhythm

**Answer: E**

This is an active junctional pacemaker rhythm caused by events that perturb pacemaker cells such as ischemia, drugs, and electrolyte abnormalities. The normal junctional escape rate is 40-60 bpm. A rate of 60-100 bpm is accelerated (This one is about 80 bpm). The retrograde P wave is normally hidden in the QRS or found immediately after it.
Q9: What is this arrhythmia?

A. Ventricular tachycardia
B. Supraventricular tachycardia with aberration
C. Accelerated junctional rhythm
D. Accelerated ventricular rhythm
E. Ventricular bigeminy

**Answer: A**

Hints to this are the wide QRS, and the fact that regular sinus P waves can be identified which are slower than AND dissociated from the ventricular rate. Approximately 50 percent of ventricular tachycardias are associated with AV dissociation. In these cases atrial impulses can enter the ventricles and either fuse with a ventricular ectopic beat or completely capture the ventricles. This ladder diagram illustrates these events.
Chapter III / Conduction Abnormalities

Q1: Look at this ECG, what is the conduction abnormality?

A. LBBB
B. RBBB
C. LBBB+2nd degree AV block
D. RBBB+1st degree AV block
E. LAFB

Answer: A

BBB causes sequential rather than simultaneous activation of the ventricles. The second half of the QRS represents the ventricle with the blocked bundle because that ventricle is activated later. Leads I and V1 show that terminal QRS forces are oriented leftward and posterior indicating LV forces. Therefore, LBBB is recognized by:

1) QRS duration > 0.12s
2) monophasic R waves in I and V6
3) terminal QRS forces oriented leftwards (see lead I) and posterior (see V1).

Also, in BBB the ST-T waves should be oriented opposite to the terminal QRS forces, and the increased voltage in V2 is normal.

Q2: Have a rapid glance at this ECG, what is the conduction abnormality?
A. LBBB
B. RBBB
C. LBBB+1st degree AV block
D. RBBB+1st degree AV block
E. LAFB

Answer: B
The wide QRS suggests a BBB.
Looking at the latter half of the QRS in I and V1, the late forces are rightward and anterior. Thus the right ventricle has been blocked and depolarized after the left ventricle.
The rSR' complex seen in V1 is commonly seen with RBBB.

Q3: Look at this ECG, what is the conduction abnormality?

A. LBBB
B. RBBB
C. LAFB
D. RBBB+2nd degree AV block
E. LBBB+1st degree AV block

Answer: C
The mainly negative QRS in lead II should clue you in to a left axis deviation which is the main ECG abnormality produced by LAFB.
Some other findings are:
1) rS complexes in leads II, III, and aVF
2) tiny q waves in I and/or aVL
3) poor R wave progression in V1-V3 (not seen in this ECG)
4) narrow (normal) QRS
LAFB is the most common IV conduction defect.
Q4: Look at this ECG, what is the conduction abnormality?

A. LBBB
B. RBBB
C. RBBB+LPFB
D. RBBB+LAFB
E. LBBB+1st degree AV block

Answer: B
The rSR' in V1 should make you think about RBBB. In addition, there are non-specific, primary ST-T wave abnormalities in V5 and V6. Remember that the 'normal' ST-T waves in BBB are oriented opposite to the direction of the terminal QRS forces.

Q5: Look at this ECG, what is the conduction abnormality?

A. LBBB
B. RBBB
C. LAFB
D. RBBB+LAFB
E. RBBB+LPFB
Answer: D
This is the most common of the bifascicular blocks. RBBB is most easily recognized in the precordial leads by the rSR' in V1 and the wide S wave in V6 (i.e., terminal QRS forces oriented rightwards and anterior). LAFB is best seen in the frontal plane leads as evidenced by left axis deviation (-50 degrees), rS complexes in II, III, aVF, and the small q in leads I and/or aVL.

Q6: Look at this ECG, what is the conduction abnormality?

A. Sinus arrhythmia
B. Type I 2nd Degree AV
C. Type II 2nd Degree AV
D. 3rd Degree AV
E. SA Exit

Answer: E
SA exit block is characterized by an unexpected drop of the P wave. 2nd degree SA Block (types I and II) is the only degree of SA block that can be recognized on the ECG. This one is type II because of the fairly constant PP intervals, and the pause duration which is approximately twice the basic PP interval. Sinus arrhythmia (choice A) is less likely because the PP intervals are not changing gradually, but abruptly.

Q7: Look at this ECG, what is the conduction abnormality?
A. 1st Degree AV Block  
B. Type I 2nd Degree AV Block  
C. Type II 2nd Degree AV Block  
D. 3rd Degree AV Block  
E. Sinus arrhythmia

**Answer: B**

The 3 rules of classic AV Wenckebach are:
1) the PR interval lengthens until a nonconducted P wave occurs
2) the RR interval of the pause is less than the two preceding RR intervals
3) the RR interval after the pause is greater than the RR interval just prior to the pause.

Unfortunately, there are many examples of atypical forms of Wenckebach where these rules do not hold.

**Q8: Look at this ECG, what is the conduction abnormality?**

A. 1st Degree AV Block  
B. Type I 2nd Degree AV Block  
C. Type II 2nd Degree AV Block  
D. 3rd Degree AV Block  
E. SA Exit Block

**Answer: A**

The normal PR interval is 0.12 - 0.20 sec, or 120 to 200 ms. 1st degree AV block is defined by PR intervals greater than 200 ms. This may be caused by drugs (such as digoxin), excessive vagal tone, ischemia, or intrinsic disease in the AV junction or bundle branch system.

**Q9: Look at this ECG, what is the conduction abnormality?**

**Lead V₁**
A. 1st Degree AV Block
B. Type I 2nd Degree AV Block
C. Type II 2nd Degree AV Block
D. Intermittent 3rd Degree AV Block
E. WPW Preexcitation Syndrome

Answer: C
The constant PR interval distinguishes this from type I AV block. Mobitz II 2nd degree AV block is usually a sign of bilateral bundle branch disease. One of the two bundle branches is completely blocked (note the wide, negative S in V1 = LBBB). The nonconducted sinus P waves are most likely blocked in the other bundle (ie, the right bundle) which exhibits 2nd degree block. Although unlikely, it is possible that the P waves are blocked somewhere in the AV junction such as the His bundle.

Q10: Look at this ECG, what is the conduction abnormality?

A. 1st Degree AV Block
B. Type I 2nd Degree AV Block
C. Type II 2nd Degree AV Block
D. 3rd Degree AV Block
E. WPW Preexcitation Syndrome

Answer: E
Note the short PR interval and the delta wave (initial slurring) of the QRS complex.
Chapter IV / Chamber Enlargement

Q1: When using the ECG criteria for diagnosing ventricular hypertrophy (VH), which of the following is correct?

A. The patient most likely has VH if the ECG criteria are met.
B. The patient is free from VH if the ECG does not meet the criteria.
C. The Cornell Voltage Criteria should be used because of their excellent sensitivity.
D. The ECG criteria for VH have a sensitivity and specificity of at least 95%.
E. None of the above.

Answer: A
About half of all patients with ventricular hypertrophy will not meet the ECG criteria and may go unrecognized. This is because of the relatively low sensitivity (~50%).

Q2: In Left Atrial Enlargement, the P wave:

A. increases in amplitude.
B. increases in duration.
C. increases in both amplitude and duration.
D. shows terminal P negativity in lead I.
E. all of the above.

Answer: B
LAE causes a P wave duration >0.12s in the frontal plane. The P wave is also notched. Also, in LAE Lead V1 shows terminal P negativity.

Q3: When interpreting an ECG, right ventricular hypertrophy (RVH) can mimic which of the following conditions?

A. LBBB
B. AV block
C. True posterior MI
D. LAFB
E. LPFB

Answer: C
The prominent anterior forces seen in RVH are also seen in a number of other conditions including a true posterior MI. Thus, RVH is sometimes referred to as a pseudoinfarct. RBBB and WPW could also result in prominent anterior forces but they may be distinguished in other ways. (rSR' morphology in V1, delta waves, and short PR.)
Q4: What is the correct diagnosis of this ECG?

A. LVH  
B. RVH  
C. LAE  
D. RAE  
E. Bi-atrial enlargement

Answer: C  
LAE is best seen in V1 with a prominent negative (posterior) component measuring 1mm wide and 1mm deep.

Q5: What is the correct diagnosis of this ECG?

A. LAE  
B. LVH  
C. Bi-atrial enlargement  
D. LAE and LVH  
E. RAE and RVH
Answer: E

RAE is recognized by the tall (>2.5mm) P waves in leads II, III, aVF.
RVH is likely because of right axis deviation (+100 degrees) and the Qr (or rSR')
complexes in V1 and V2.

Q6: Other than 1st degree AV block, what abnormality is seen in this ECG?

A. LAE
B. RAE
C. LVH
D. RVH
E. Bi-atrial enlargement

Answer: A

The P-wave is notched, wider than 0.12s, and has a prominent negative (posterior)
component in V1. These are all criteria for left atrial enlargement (LAE).
The PR interval is >0.20s. Minor ST-T wave abnormalities are also present.

Q7: What abnormality is seen in this ECG? (Other than the PVCs)
A. RAE  
B. LAE  
C. RVH  
D. LVH  
E. Biventricular hypertrophy

Answer: D  
The combination of voltage criteria (S-V2 + R-V6 >35mm) and ST-T abnormalities in V5-V6 are definitive for LVH. There may also be LAE as evidenced by the prominent negative P terminal force in lead V1. Isolated PVCs and a PVC couplet are also present.

Q8: What is the correct diagnosis of this ECG?

A. LAD and LAE  
B. RAD and RAE  
C. LAE and LVH  
D. LAE and RAE  
E. RAD and LAE

Answer: B  
Right axis deviation is present because lead I is slightly more negative. This means the axis is slightly beyond +90 degrees (+110 degrees). RAE is best seen in the frontal plane leads; the P waves in lead II are >2.5mm in amplitude. In this case of severe pulmonary hypertension, RVH is present with the RAE but not seen in the leads shown.
Q9: What is the most likely diagnosis of this ECG?

A. LVH
B. RVH
C. LAE and LVH
D. RAE and RVH
E. None of the above

Answer: A
This question is answered by using voltage criteria. Note the R in lead II >20 mm, and the R in V5 >30 mm.
It's important to realize that voltage criteria alone are usually not sufficient for diagnosis.

Q10: What is the correct diagnosis of this ECG?
A. LAE
B. RAE
C. LVH with strain
D. Right axis deviation
E. Left axis deviation

Answer: C
The features of this ECG include increased voltage (V2,3,5,6) and ST-T oriented opposite to QRS direction (left ventricular strain pattern).
Chapter V / Myocardial Infarction

Q1: What can help to differentiate between the normal septal q wave and a pathologic Q wave?
   A. The width
   B. The height
   C. Both width and height
   D. The QRS axis
   E. The specific ECG leads involved

Answer: C
Pathologic Q waves are the most characteristic ECG finding of myocardial infarction. They can be either wide (>0.04s) or deep (>30% of QRS height).

Q2: In an acute Q-wave MI, which ECG finding is usually the first to appear?
   A. Q wave
   B. Hyperacute T wave
   C. T wave inversion
   D. ST segment elevation
   E. None of the above

Answer: B
As seen in the diagram below, hyperacute T waves usually precede ST segment elevation. However, this ECG finding may never be seen due to delays in obtaining the initial ECG. The ST segment is usually the earliest change back to normal, followed by the T wave. The Q wave may remain indefinitely.

Q3: What is the correct diagnosis of this ECG?

A. Anterolateral MI
B. High lateral MI
C. True posterior MI
D. Inferolateral MI
E. Inferior MI
The site of infarction can be localized by remembering that each lead reflects a specific area of the heart. Note the pathologic Q waves in leads II, III, and aVF. Also, there are inverted T waves in the same leads with a small amount of residual ST elevation. This is a classic inferior MI. It's not a new MI because the ST elevation has mostly returned to normal.

Q4: What is the correct diagnosis of this ECG?

A. Anteroseptal MI  
B. Anterior MI  
C. Posterior MI  
D. Posterolateral MI  
E. Right ventricular MI

Answer: A  
The QS complexes, resolving ST segment elevation and T wave inversions in V1-2 are evidence for a fully evolved anteroseptal MI. The inverted T waves in V3-5, I, aVL are also probably related to the MI. An anterior MI looks similar to this except V1 is usually spared.

Q5: What is the correct diagnosis of this ECG?
A. True posterior MI
B. Extensive Anterior/Anterolateral MI
C. Inferoposterior MI
D. Posterolateral MI
E. Posterolateral MI + LBBB

Answer: B
Posterolateral MI + LBBB

Q6: What is the correct diagnosis of this ECG?

A. Inferior MI
B. Posterior MI
C. Inferoposterior MI
D. Anterior MI
E. Non-Q wave MI

Answer: C
The inferior diagnosis is made from leads II, III, and aVF (Q waves and inverted T's). The posterior part of the infarct doesn't result in pathologic Q waves, but rather in pathologic R waves in V1-V3. The R/S ratio in V1 or V2 is >1. Another term for these tall and wide R waves in V1-V2 is prominent anterior forces. The infarcted posterior tissue allows the normal anterior forces to become more prominent on the ECG.
Q7: What is the correct diagnosis of this ECG?

A. High lateral wall MI  
B. Inferior MI  
C. Inferior MI+RBBB  
D. Anterolateral MI  
E. True posterior MI  

Answer: A
Leads I and/or aVL can reveal a high lateral wall MI. This example shows a Q wave and T inversion in lead aVL. There is also some slight ST elevation in the same lead but it's difficult to see.

Q8: What is the correct diagnosis of this ECG?

A. Inferior MI with RBBB  
B. Posterior MI with LBBB  
C. Inferoposterior MI  
D. Inferoposterior MI with RBBB  
E. None of the above
Answer: D
Leads II, III, and aVF show the inferior part of the infarct.
A wide QRS with rR' in lead V1 shows RBBB. However, this is an unusual RBBB because the initial R wave is taller than the R' wave in lead V1. This is the clue for true posterior MI. The tall initial R wave in V1 is a pathologic R wave analogous to the pathologic Q wave of an anterior MI.

Q9: What is the correct diagnosis of this ECG?

A. Non-Q wave MI
B. Acute anterior MI
C. Old inferior MI
D. Anterolateral MI
E. Posterolateral MI

Answer: B
The marked ST elevation and hyperacute T waves in leads V1-V4 suggest an acute anterior wall infarct.
Non-Q wave MI (choice A) should never be given as a diagnosis based on a single ECG reading because it could be a new Q-wave MI which hasn't yet developed Q waves.
Q10: What best describes this ECG tracing?

A. Poor R wave progression  
B. Diffuse non-specific ST-T wave changes  
C. Hyperacute anteroseptal MI  
D. Fully evolved anteroseptal MI  
E. Left ventricular hypertrophy with strain

Answer: D  
This fully evolved anteroseptal MI is diagnosed by the QS waves in V1-2, qrS in V3, and ST-T wave changes.  
As a side note, a monophasic negative QRS complex is referred to as a QS rather than just a Q.
Chapter VI / ST-T Segment

Q1: Which of the following may cause ST segment depression?
A. Ischemia
B. Hyperventilation
C. Ventricular hypertrophy
D. Hypokalemia
E. All of the above

Answer: E
ST segment abnormalities are very non-specific. The ECG changes must be correlated with clinical data to accurately diagnose any problems. Some other causes of ST segment depression are digoxin, mitral valve prolapse, CNS disease, non-Q wave MI, and poor skin-electrode contact.

Q2: The ST-T waves in this ECG are:

A. Primary ST-T wave abnormalities
B. Secondary ST-T wave changes
C. Non-specific T wave abnormalities
D. T wave inversion abnormalities (aVR and V1)
E. Normal

Answer: E
This is a normal ECG. The normal T wave is asymmetric with the first half moving more slowly (less of a slope) than the second half. The normal T wave is always upright in I, II, V3-6, and always inverted in aVR. A small amount of ST elevation in V1, V2, or V3 is normal.
Q3: Which of the following conditions is most likely to cause the changes seen in this ECG?

A. Subendocardial ischemia
B. Lesion of the circumflex artery
C. Posterior wall transmural injury
D. Acute pericarditis
E. Acute pericarditis

Answer: A

In a patient with angina pectoris ST depression usually means subendocardial ischemia and, unlike ST elevation, is not localizing to a particular coronary artery lesion.

The other answer choices would most likely result in ST elevation.

Q4: What is the correct diagnosis of this ECG?

A. Normal variant ST segment elevation
B. Acute lateral wall subendocardial ischemia
C. Acute inferior transmural ischemia
D. Non-specific ST-T wave abnormality
E. Acute pericarditis
Answer: C
ST Segment elevation with a straight or convex upwards configuration usually means transmural ischemia (or injury) and is seen in the setting of acute myocardial infarction. This ECG finding may also be seen transiently during coronary artery spasm.
Unlike ST depression, ST elevation is often localizing. In this example of inferior ST elevation, the culprit artery is often a dominant right coronary artery or dominant left circumflex artery.

Q5: Which of the following conditions is usually associated with primary ST-T wave abnormalities?

A. BBB
B. PVCs
C. WPW preexcitation
D. Electrolyte abnormalities
E. Fascicular block

Answer: D
Primary ST-T wave abnormalities may be the result of global or segmental pathologic processes that affect repolarization.
Secondary ST-T wave changes are normal changes solely due to changes in the sequence of ventricular activation. The other answer choices can all cause secondary ST-T wave changes.

Q6: This ECG shows an example of right bundle branch block. What other abnormality is present?

A. Primary ST-T wave abnormalities
B. Secondary ST-T wave changes
C. Anterolateral MI
D. LVH
E. RVH
Answer: A
In RBBB the ST-T waves should be oriented opposite to the terminal QRS forces. In this example there are primary ST-T wave abnormalities in leads V5-6 (best seen in V6). In these leads the ST-T orientation is in the same direction as the terminal QRS forces (both are negative). This is abnormal when bundle block is present. The secondary ST-T wave changes seen in V1-4 (oriented opposite to the terminal QRS forces) are normal for BBB.

Q7: What clinical condition might this ECG represent?

A. Acute pericarditis
B. Subarachnoid hemorrhage
C. Hypothyroidism
D. Aortic stenosis
E. It's a normal ECG

Answer: B
TU fusion waves (seen in lead V6) are often seen in long QT syndromes. The differential diagnosis of this ECG abnormality includes:
- Electrolyte abnormalities (hypokalemia)
- CNS disease (subarachnoid hemorrhage)
- hereditary long QT syndromes
- drugs such as quinidine.

Q8: Normal U waves are usually best seen in which leads?
A. I
B. V2,V2
C. II, III, and aVF
D. aVL or aVR
E. I and II

Answer: B
U waves are usually best seen in the right precordial leads -- especially V2 and V3. The U wave becomes prominent in clinical situations such as hypokalemia. They may also become inverted in cases of ischemia.
Q9: What is the major abnormality on this ECG?

A. RAD
B. Low voltage QRS complexes
C. Long QT interval
D. High lateral MI
E. Low amplitude T waves

Answer: C
The key word in the question is major. Right axis deviation and low voltage QRS are both present but minor abnormalities. The negative QRS in aVL may lead you to think of an MI. However, it is negative because of the rightward axis, not because of an MI.

Q10: This ECG shows LBBB with:
A. Prominent U waves
B. Primary ST-T wave abnormalities
C. Symmetrical T waves
D. Giant TU fusion waves
E. All of the above

Answer: B
Primary T wave abnormalities in LBBB refer to T waves in the same direction as the terminal half of the QRS. These are seen in leads I, II, III, aVL, aVF, and V3-6. The most likely diagnosis is myocardial infarction.
Chapter VII / Advanced Quiz

Q1:
This is an ECG taken during routine medical examination of 40 year old man. He is totally asymptomatic. What is the cause of this funny looking beat in his V1 chest lead rhythm strip?

A. It’s a PAC with LBBB aberration  
B. It’s a PAC with RBBB aberration  
C. It’s a PVC from the right ventricle  
D. It’s a PVC from the left ventricle  
E. It's an artifact

Answer: B  
Notice the rsR' complex and the preceding premature P-wave.

Q2:
Your junior house officer wants to ask you a question about this ECG V1 chest lead rhythm strip of a 61 year old man with a history of ischemic heart disease. He said" why do the RR intervals vary"?

A. This is a ventricular tachycardia with intermittent 2:1 exit block.  
B. This is paroxysmal atrial fibrillation with RBBB aberrency.  
C. This is a ventricular escape rhythm alternating with ventricular tachycardia.  
D. This is sinus rhythm with a rate-related right bundle block  
E. This is a ventricular fibrillation

Your answer is:  
A. This is a ventricular tachycardia with intermittent 2:1 exit block.  
B. This is paroxysmal atrial fibrillation with RBBB aberrency.  
C. This is a ventricular escape rhythm alternating with ventricular tachycardia.  
D. This is sinus rhythm with a rate-related right bundle block  
E. This is a ventricular fibrillation

Answer: A  
The longer RR intervals are twice the short intervals suggesting that not every impulse form the ventricular focus makes it out to the rest of the ventricles.
Q3:
You are the senior house officer of your coronary care unit and you are watching the ECG monitors of your patients. One of the V1 chest lead rhythm strips is a little bit FUNNY looking with 4 strange beats besides the normal sinus beats. What is the cause of these funny looking beats?

A. These are multifocal PVCs.
B. The first FLB is a late onset PVC, and the other three are fusion beats.
C. Intermittent right bundle branch block (RBBB)
D. Intermittent WPW type preexcitation.
E. Multiple junctional beats

Answer: B

Late PVCs often occur coincidentally with sinus activation of the ventricles. The degree of fusion may vary as seen in this example.

Q4:
This is the V1 chest lead rhythm strip of a 58-year-old man with a recent myocardial infarction. What does "F" mean in this strip?

A. ‘F’ is for “Funny-looking-beat”
B. ‘F’ is for “failure-to-capture” which implies the sinus P wave can’t get into the ventricles.
C. ‘F’ is for “fusion beat”; i.e. the fusion of a right ventricular PVC with the sinus initiated QRS complex.
D. ‘F’ is for “fusion beat”; i.e. the fusion of a left ventricular PVC with the sinus initiated QRS complex.
E. “F” is fibrillation wave

Answer: D

The subsequent ventricular ectopics are upgoing (anterior oriented) QRSs, suggestion origin from the LV.
Q5:
This is the ECG V1 cheat lead rhythm strip of a 53 year old man with dropped beats. What is the degree of AV block if present?

A. 1st degree AV block
B. 2nd degree AV block
C. 3rd degree AV block
D. No AV block; this is complete AV dissociation
E. This is a sinus pause

Answer: B
Some P waves conduct, and some do not.

Q6:
This is the V1 strip rhythm of 61-year-old woman with a history ischemic heart disease. What does "e" and "c" mean?

A. The ‘e’ represents a ventricular echo beat form the nonconducted P wave. The ‘c’ is a sinus capture.
B. The ‘e’ is for ventricular escape. The ‘c’ is a PAC.
C. The ‘e’ is a junctional escape, and ‘c’ represents a PAC.
D. The ‘e’ represents a junctional escape beat; the ‘c’ represents a sinus capture.
E. The 'e' represents a ventricular premature complex and 'c' represents a parasystole.

Answer: D
Sometimes this goes by the name of “escape-capture bigeminy”. Any pause in the rhythm may result in an escape beat if the pause is too long.
Q7: You're reading an ECG taken for 48 year old woman with idiopathic dilated cardiomyopathy. What is your conclusion of this confusing V1 strip rhythm?

A. Junctional rhythm with occasional PVC
B. Complete AV block; junctional escape rhythm; occasional PVC
C. Sinus rhythm with 1st degree AV block; occasional PVC
D. Junctional rhythm, PVC, and nonconducted PAC
E. Wandering atrial pacemaker.

Answer: C
Thanks to the PVC and resulting pause, the sinus P wave becomes separated form the preceding T wave. The 1st degree AV block is quite marked.

Q8: This is the V1 strip rhythm of a 37-year-old man with dropped beats. How do explain the pause in his ECG strip?

A. 2nd degree AV block (Type I, Wenckebach)
B. 2nd degree AV block (Type II, Mobitz)
C. Nonconducted PACs
D. Marked sinus arrhythmia
E. Pacemaker failure

Answer: C
This is the most common cause of an unexpected pause in the rhythm. The P-waves of the PACs are early relative to the sinus PP intervals.

Q9: Your junior house officer is perplexed after seeing this V1 strip rhythm with many pauses. He asked you" what event terminates these pauses?"
A. A sinus beat that has been reset by the PAC.
B. A ventricular escape beat
C. An electronic pacemaker beat originating from the right ventricle.
D. A junctional escape complex.
E. Atrial flutter with 3:1 block

Answer: D
Actually the sinus P wave is seen partially superimposed on the junctional escape beat thereby distorting the onset of the QRS.

Q10:
This is the V1 rhythm strip of a 55 year old man with ischemic heart disease. What is the cause of this BIGEMINAL looking rhythm?

A. 2nd degree AV block type II (Mobitz)
B. Nonconducted PACs following every two consecutive sinus beats.
C. 2nd degree AV block (Type I, Wenckebach)
D. Sino-atrial exit block
E. Pacemaker failure

Answer: A
The PR intervals for two consecutive beats are constant, followed by a blocked sinus P wave. The QRS is wide suggesting a bundle branch block.
Chapter VIII / ECG Best of Five Scenarios

Q1: A 27-year-old man complaining of frequent palpitations. He likes coffee too much. He stated that there is a sensation of a thumbing beat in the left side of the chest every now and then and he is anxious about it. An ECG was done. What type of arrhythmia is seen here?

A. Premature junctional beats
B. Rate-related bundle branch block.
C. Premature atrial complexes conducted with aberrancy.
D. Premature ventricular complexes (PVCs).
E. AV nodal prematures.

Answer: D
The QRS complexes are very wide, funny looking beats. So it is either PVCs or aberrantly conducted supraventricular premature beats. 3 clues help to differentiate between an aberrant PAC and a PVC:
1. Complete vs. incomplete pause
2. Abnormal preceding 'P on T' wave (suggests hidden P wave of PAC)
3. Morphology of the QRS in V1. Note the fat r wave and .08s delay from QRS onset to nadir of S wave.
There is also sinus tachycardia.

Q2: A 35-year-old nonsmoker nonalcoholic man presents with 4 weeks history of palpitations. He is reasonably well with unremarkable past medical history, and on no medications. ECG revealed an abnormal rhythm which is shown below. Apart from an anti-arrhythmic medication that you are going to prescribe, which one of the following statements is true?

A. Giving warfarine 5 mg / day
B. Giving warfarine and aspirin with frequent monitoring of his INR.
C. Giving dipyridamole 75 mg / day.
D. Giving aspirin 100 mg / day.
E. Giving infliximab infusion.
Atrial fibrillation in patients below the age of 65 years with no hypertension or cardio-respiratory diseases is called Lone Atrial Fibrillation. The risk of systemic embolization is very low, about 1.2% per year. This is reduced to 1.0% with aspirin, and to 0.5% with warfarine. So aggressive anti coagulation is not justified. Aspirin alone would suffice here. Needless to say, slowing the hear rate with for example digoxine, or a beta blocker, or a calcium channel blocker is also indicated.

Q3: A 68-year-old man with long standing hypertension presents with 2 days history of palpitations. He is a little bit dizzy with a tight sensation in the chest. ECG revealed the following abnormal rhythm, choose one only:

A- PJC (premature junctional complex).
B- Atrial flutter.
C- Atrial fibrillation.
D- AV nodal reentrant tachycardia.
E- Accelerated junctional rhythm.

Answer: C
Atrial fibrillation is characterized by an irregularly irregular ventricular response, and the absence of discrete P waves. In the top lead in this ECG, atrial activity is poorly defined. The atrial activity seen in the lower lead resembles old saw-teeth (as opposed to the new, sharp saw-teeth of atrial flutter).

Q4: A 61-year-old man with a history of ischemic heart disease since 2 years in the form of chronic stable angina; during his follow up visit, you noticed something new in his ECG. Look at this ECG, what is the abnormality?
A. Left bundle branch block.
B. Atrial flutter with 3:1 conduction.
C. Torsades de pointes ventricular tachycardia.
D. Acute inferior wall myocardial infarction.
E. Normal ECG.

Answer: A
Bundle branch block causes *sequential* rather than *simultaneous* activation of the ventricles. The second half of the QRS represents the ventricle with the blocked bundle because that ventricle is activated later. Leads I and V1 show that terminal QRS forces are oriented leftward and posterior indicating LV forces. Therefore, LBBB is recognized by:
1) QRS duration ≥ 0.12s
2) monophasic R waves in I and V6
3) terminal QRS forces oriented leftwards (see lead I) and posterior (see V1).

Also, in BBB the ST-T waves should be oriented opposite to the terminal QRS forces, and the increased voltage in V2 is normal.

Q5: A 24-year-old man is being routinely investigated prior to an employment. He is reasonably well and having no complaints. Have a rapid glance at his ECG, what is the abnormality?

Answer: B
The wide QRS suggests a BBB. Looking at the latter half of the QRS in I and V1, the late forces are rightward and anterior. Thus, the right ventricle has been blocked and depolarized after the left ventricle. The rSR' complex seen in V1 is commonly seen with RBBB.
Q6: A 56-year-old diabetic man with a history of an old anterior wall myocardial infarction presented with a few days history of cough and pleuritic chest. You diagnosed uncomplicated community acquired pneumonia and responded well to antibiotics. A routine ECG revealed something that is unrelated to his presentation; have a look at these leads, what is the abnormality?

A. Acute pericarditis.
B. Recent evidence of inferior wall myocardial infarction.
C. Left anterior fascicular block.
D. Slow atrial fibrillation.
E. Type I second degree AV block.

Answer: C

The mainly negative QRS in lead II should clue you in to a left axis deviation which is the main ECG abnormality produced by LAFB.

Some other findings are:

1) rS complexes in leads II, III, and aVF
2) tiny q waves in I and/or aVL
3) poor R wave progression in V1-V3 (not seen in this ECG)
4) narrow (normal) QRS
Q7: A 66-year-old woman with a long history of hypertension and diabetes. She is being investigated routinely prior to an open cholecystectomy. Her ECG is shown below. There are many abnormalities consisting with:

A. Established acute inferior wall myocardial infarction.
B. Severe left ventricular hypertrophy.
C. Type II second degree AV block.
D. Right bundle branch block with a left fascicular block.
E. Wandering atrial pacemaker.

Answer: D

This is the most common of the bifascicular blocks. RBBB is most easily recognized in the precordial leads by the rSR' in V1 and the wide S wave in V6 (i.e., terminal QRS forces oriented rightwards and anterior). LAFB is best seen in the frontal plane leads as evidenced by left axis deviation (-50 degrees), rS complexes in II, III, aVF, and the small q in leads I and/or aVL.

Q8: One of your colleagues from the gynecology department is consulting you about this funny looking ECG strip belonging to a 59 year old woman who is supposing to undergo total hysterectomy. You are thinking of a conduction abnormality, what is it?

A. Sinus arrhythmia
B. Type I 2nd Degree AV
C. Type II 2nd Degree AV
D. 3rd Degree AV
E. SA Exit block

Answer: E

SA exit block is characterized by an unexpected drop of the P wave.

2nd degree SA Block (types I and II) is the only degree of SA block that can be recognized on the ECG. This one is type II because of the fairly constant PP intervals, and the pause duration which is approximately twice the basic PP interval.

Sinus arrhythmia (choice A) is less likely because the PP intervals are not changing gradually, but abruptly.

Q9: An 18-year-old heavy athletic man is consulting you because of an abnormal looking ECG done as part routine investigations prior to joining a new football team. Look at his ECG, what is the conduction abnormality?

A. 1st Degree AV Block  
B. Type I 2nd Degree AV Block  
C. Type II 2nd Degree AV Block  
D. 3rd Degree AV Block  
E. Sinus arrhythmia

Answer: B

The 3 rules of classic AV Wenckebach are:
1) the PR interval lengthens until a nonconducted P wave occurs  
2) the RR interval of the pause is less than the two preceding RR intervals  
3) the RR interval after the pause is greater than the RR interval just prior to the pause.

Unfortunately, there are many examples of atypical forms of Wenckebach where these rules don't hold. This finding can be seen in heavy athletics. Other ECG findings that can be seen in heavy athletics: sinus bradycardia, sinus arrhythmia, 1st and type I second degrees AV blocks, and junctional rhythms.
Q10: A 50-year-old hypertensive man on atenolol 100 mg / day, presented with painful micturition and a supra-pubic pain, but no features of enlarged prostate upon rectal examination. General urine examination revealed a lot of pus cells per high power field. You diagnosed uncomplicated UTI. You ordered a routine ECG. Look at his ECG, what is the conduction abnormality?

A. 1st Degree AV Block  
B. Type I 2nd Degree AV Block  
C. Type II 2nd Degree AV Block  
D. 3rd Degree AV Block  
E. SA Exit Block

Answer: A

The normal PR interval is 0.12 - 0.20 sec, or 120 to 200 ms. 1st degree AV block is defined by PR intervals greater than 200 ms. This may be caused by drugs (such as digoxin), excessive vagal tone, ischemia, or intrinsic disease in the AV junction or bundle branch system.

Q11: A 68-year-old man with a history of ischemic heart disease since 5 years. Recent coronary angiogram revealed 70% narrowing in the proximal left descending coronary artery (LAD), and 50% narrowing of the mid portion of the right coronary artery (RCA). He is complaining of dropped beats which are a source of anxiety to him. Look at his ECG, what is the conduction abnormality?

A. 1st Degree AV Block  
B. Type I 2nd Degree AV Block  
C. Type II 2nd Degree AV Block  
D. Intermittent 3rd Degree AV Block  
E. WPW Preexcitation Syndrome
Answer: C

The constant PR interval distinguishes this from type I AV block.

Mobitz II 2nd degree AV block is usually a sign of bilateral bundle branch disease. One of the two bundle branches is completely blocked (note the wide, negative S in V1 = LBBB). The nonconducted sinus P waves are most likely blocked in the other bundle (ie, the right bundle) which exhibits 2nd degree block.

Although unlikely, it is possible that the P waves are blocked somewhere in the AV junction such as the His bundle.

Q12: A 64-year-old man with long standing hypertension and diabetes, presented with 20-hour history of right sided weakness. His family stated that they are unable to understand what he is saying as his speech is funny and bizarre. An emergency brain CT scan revealed a large hypodense area in the left fronto-temporo-parietal lobes consisting with an occlusion of the proximal main-stem of the left middle cerebral artery. His ECG done at the A/E department is shown below, What is the rhythm abnormality?

Answer: C

The ECG strip is consistent with atrial fibrillation. The overall clinical picture and the massive cerebral infarction involving occlusion of the proximal main stem of the middle cerebral artery are explained by this arrhythmogenic (cardiogenic) source of cerebral embolization.

End…