ECG Course:
Pearls and Pitfalls

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Approach to The Critical EKG

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OUTLINE

• Background
• Algorithm for diagnosis of Arrhythmia
  • Rate and Rhythm
• Algorithm for diagnosis of ACS – MI and Ischemia
  • 6 Causes of Wide QRS
  • 6 Causes of ST elevation
  • 6 Causes of ST depression
  • T waves and Q waves
  • Other EKG Abnormalities
• Summary

Goals

• Emphasize a methodical approach to assessment
• Focus on findings associated with life-threatening conditions
• Improve identification of significant abnormalities
• Emphasize the differential diagnoses associated with a given EKG finding

Initial EKG in AMI

• Diagnostic
  30-50% sensitive for acute MI
• Non Diagnostic
  Not predictive of ACI
• Normal ECG’s
  1-10% with acute MI will have normal ECG

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Initial EKG in AMI

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Diagnostic value of initial EKG

<table>
<thead>
<tr>
<th>Feature</th>
<th>MI</th>
<th>30 day death/reinfarct</th>
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<tbody>
<tr>
<td>ST elevation/depression</td>
<td>89%</td>
<td>12.4%</td>
</tr>
<tr>
<td>ST elevation</td>
<td>81%</td>
<td>9.4%</td>
</tr>
<tr>
<td>ST depression</td>
<td>48%</td>
<td>10.5%</td>
</tr>
<tr>
<td>T wave inversion</td>
<td>32%</td>
<td>5.5%</td>
</tr>
</tbody>
</table>

Savonitto et al. JAMA. 1999

Prognostic value of EKG in AMI

Rate of death or life-threatening events
- Normal EKG = 19%
- Non Diagnostic EKG = 27.5%
- Diagnostic EKG = 35%

Welch et al. JAMA. 2001

Lesson

An ischemic EKG significantly increases the likelihood of ACS and the risk of adverse outcomes
**Normal Ventricular Depolarization**

**EKG Wall Anatomy**
- Diffuse ST elevation
- ST elevation in non-contiguous leads
- ST elevation in 2 myocardial walls
- Inferior ST elevation
- Anterior ST elevation

**LIFE THREATENING ARRHYTHMIA**

**THE TABAS ALGORITHM**
- Rate
- Rhythm
Sinus Rhythm

- P waves originate from the sinus node
- P is upright in 2, flipped in aVR

Normal AV Conduction
- Each P followed by a QRS
- Constant PR interval

Main Diagnostic Entities for “Not Sinus Rhythm”
- Is the P wave axis normal?
  - Abnormal => Limb lead misplacement
- Is the rhythm regular?
  - Irregular => Atrial Fibrillation
- Is the QRS wide?
  - Wide Reg => V tach
  - Narrow Reg => Sinus Tach vs. SVT or Flutter
- Is the rhythm slow?
  - Junctional, Dig Toxicity, Hyperkalemia

Narrow & Regular Sinus Tach
- P wave upright in 2
- P wave inverted in aVR
- P followed by QRS
- Rate should slow with fluids or fever reduction
- Adenosine will block AV node
Narrow and Regular Atrial Flutter

- Flutter waves best seen in 2 and V1
- May have some irregularity due to varying AV node block
- Rate may or may not change with fluids or fever reduction
- Adenosine will reveal underlying flutter waves

Narrow and Regular SVT

- Rate will not vary or change
- When Adenosine given, will convert to sinus
1. 65 y.o. male doesn't feel well. HR-150, BP-80/P

2. 44 y.o. female complains of chest pain.
4. 25 y.o. M complains of chest pain.
Assessment for Acute Ischemia

Is there ST elevation signifying acute injury?

ST ELEVATION

Show me the money

AMI with ST elevation has worse prognosis than without

AMI with ST elevation is an indication for thrombolytics
- Ongoing CP (Sx's) < 12 hours
- 1 mm elevation in 2 contiguous leads
- or LBBB

Non STEMI / USA

- NO BENEFIT from THROMBOLYSIS in absence of ST elevation!
- Benefit from aspirin, beta blockers (maybe nitrates, heparin, clopidogrel, GP 2b3a’s)
- Probable benefit from revascularization (stents, angioplasty, etc)
Assessment for Acute Ischemia

THE TABAS ALGORITHM
- Widened QRS - 6 causes
- ST Elevation - 6 causes
- ST Depression - 6 causes
- Other Findings of Ischemia

6 CAUSES - WIDE QRS
- Bundle branch block
- Ventricular rhythm
- Hyperkalemia
- Medications
- Paced rhythm
- WPW

THE J POINT
- Measure at the end of the QRS
- Compare to height of T-P segment
THE J POINT

6 CAUSES – ST Elevation

- Benign Early Repolarization (BER)
- Acute MI
- Pericarditis
- LV Aneurysm
- Printzmetal's Angina (Vasospasm)
- Bundle Branch Block

CONTOUR
Benign Early Repolarization  
(J Point Elevation)

- Smiley Face Contour
- Anterior Leads (V1-V4)
- Does not evolve / Present on old EKG
- Often associated with LVH
- “Fishhook” Contour in V4

Clues to Early Repolarization

ACUTE MI

- Frowny Face Contour
- Reciprocal Changes
- Contiguous leads
- Evolution / Change from old ECG
- Other Findings of Ischemia
Pericarditis

- Diffuse ST elevation
- Benign morphology
- PR depression is diagnostic
- Clinical presentation:
  Stabbing / burning; worse lying flat / relieved sitting up; persistent and prolonged

LV aneurysm

- ST segment elevation in V1 - V2 (benign or concerning morphology)
- Evidence of previous anterior MI
  Q waves in V1 – V4
- Lack of:
  New Changes
  Evolution
  Reciprocal Depression
**Prinzmetal’s angina (Vasospasm)**

- Occurs Rarely
- Resolution of ST segment elevation without revascularization
- Occurs in setting of baseline coronary artery disease

**Bundle Branch Block**

- QRS is greater than .12 msecs
- ST segments are in opposite direction of terminal QRS
9. 75 y.o. female with SOB

10. 65-year-old male complaining of 5 days of right-sided chest pain, sense with movement. MI in the past.

11. 65-year-old male with AIDS in new with severe chest pain. Improved with sitting up.
ST SEGMENT DEPRESSION

6 CAUSES
- Reciprocal Changes
- Subendocardial Infarct
- Posterior MI
- Ischemia
- LVH with repol abnmty = STRAIN
- Digoxin

ST Depression - Contours

Reciprocal Changes

SUBENDOCARDIAL INFARCTION OR ISCHEMIA

Flat or “PLANAR” ST Depression
Acute Posterior MI

- ST Depression in V1-V3
- Upright T wave in same leads
- May have Tall R wave in V2
- Obtain posterior leads for diagnosis

Posterior Leads

Look for ST elevation in V8 to diagnose Posterior MI

<table>
<thead>
<tr>
<th>Normal V8</th>
<th>V8 in Posterior MI</th>
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</thead>
</table>

Posterior lead ECG

Right sided lead ECG
“Strain” Pattern of LVH

Left Chest Leads

Asymmetric Inverted T Wave

LVH

1. High Voltage
   - S (in V1 or V2) + R (in V5 or V6) is >35 mm
   - AVL > 11 (or 13) is diagnostic
   - Any R wave > 20 mm in limb or 25mm in precordial

2. Strain Pattern
   - ST Depression with asymmetric T waves

3. Left Atrial Enlargement
   - Terminal P is 1x1 box in V1

EKG diagnosis is 95% specific but only 15-30% sensitive

DIGOXIN EFFECT

Swooping ST segments

Dr. Jeffrey Tabas, SFGH

12. 58 y.o. M with episode of near syncope
13a. Patient with unconscious, substernal chest pain and cough, Dr. Jeffrey Tabas, SFGH

13b. Same patient, EKG from 4 months earlier, Dr. Jeffrey Tabas, SFGH

14. Patient discharged home in study of missed MI's
   ED interpretation: NSR, LVH with strain

15. 68 y.o F with palpitations earlier. Now resolved. Visit 2 months ago with same complaint and identical EKG
Insignificant Q Waves

Less than 1 box wide (0.04 msec) and ¼ the height of QRS

2, 3, F

1, L, V5, V6

Other Findings of Ischemia

- Q Waves
- T Wave abnormalities

T Waves

Enlargement, Symmetry, and Inversion suggest pathology
T Wave Inversion

Inversion is normal in Lead V1
Inversion is acceptable in Lead 3 and V2 as well

17. 55 y.o. F with pleuritic chest pain for 10 hours

18. Another patient with same diagnosis
BUNDLE BRANCH BLOCKS

- The QRS is wide, usually > 0.14
- Look at TERMINAL portions of the QRS in leads V1 and V6
  - Terminal R wave in V1 = Right BBB
  - Terminal R wave in V6 = Left BBB
  - The opposite lead shows a widened S wave
- The ST segments are opposite to the terminal portion of the QRS
19a. 55 y.o M with new onset CHF and chest discomfort relieved by Ntg

19b. Prior EKG from 5 years ago
21. 67 y.o male with indigestion

22. 51 y.o female referred by primary MD for evaluation of chest pain. History of nausea, vomiting.

23. 80 year old man feeling very weak, nauseous, hypotensive.

Hyperkalemia

- QRS Widens
- Loss of P
- Enlarged T
- QT Shortens
24. Dr. Jeffrey Tabas, SFGH

ACUTE MI in LBBB

- 1 mm ST segment change in same direction as terminal QRS
- More than 5 mm ST elevation in direction opposite direction to terminal QRS

25. 58 y.o. F with CP and IDDM
26. Patient discharged home: ED interpretation = NSR, RBBB

27. 20 y.o male with Syncope

- RBBB Pattern in leads V1-V3
- ST elevation in leads V1-V3
- AICD’s decrease Sudden Cardiac Death rate to 0!

28. What’s the Rhythm?
Atrial Fibrillation with accessory pathway - NARROW BEAT

Conducted beat through AV Node

Atrial Fibrillation with accessory pathway - WIDE BEAT

Conducted beat down accessory pathway

Atrial Fibrillation with accessory pathway - FUSION BEAT

Conducted beat through AV Node AND accessory pathway

28. What’s the Rhythm?
Another Young Patient with Palpitations

LOW VOLTAGE

< 5mm in all limb leads or
<10mm average of V1-V6

Clinical signs of tamponade!
- tachycardia,
- hypotension,
- elevated neck veins

Hypokalemia

EKG ALGORITHM

Arrhythmia
- Rate
- Rhythm

Acute Coronary Syndrome
- QRS width
- ST Elevation
  Distribution, Contour, Comparison, Evolution
- Other findings of ACS
  ST depression, T waves, Q waves
Take Home Points

- Use a methodical approach
- An EKG in isolation is not diagnostic
- Consider the entire range of diagnoses when an abnormality is found
- Identify normal and abnormal ST segments in patients with Bundle Branch Block

Your Head Might Be Spinning – Review at Home!
1. 65 y.o. male doesn’t feel well. HR-150, BP-80/P
2. A 44 year old female complains of chest pain.
A 56 year old man with a history of CHF complains of shortness of breath.
3B. After Adenosine
4. 25 y.o. M complains of chest pain
5. A 64 year old male with alcohol intoxication and complaints of chest pain.
7. 73 year old female complains of feeling weak. Heavy smoker in the past. High cholesterol.
8. 65 year old man with known angina complains of chest pain for 30 minutes. Awoke him from sleep.
8b. Repeat EKG after pain free with 3 sublingual Nitroglycerin.
9. 75 y.o. female with SOB
10. 60 year old male complains of 3 days of right sided chest pain, worse with movement. MI in the past.
11. 31 year old male with AIDS awoke from sleep with severe chest pain. Improved with sitting up.
50 y.o. M with episode of near syncope
13a. 5 year old male with intermittent substernal chest pain and cough
13b. Same patient. EKG from 4 months earlier.
14. Patient discharged home in study of missed MI’s
ED interpretation: NSR, LVH with strain
15. 68 y.o F with palpitations earlier. Now resolved. Visit 2 months ago with same complaint and identical EKG
15b. 68 y.o F post treatment with beta blockers
16. 40 year old male with pneumonia. Missed hemodialysis.
17. 55 y.o. F with pleuritic chest pain for 10 hours

- Sinus tachycardia, rate 122
- Normal P axis, rate >= 100
- Vertical axis, unusual for age
- ORS axis & in 90 & age > 40
- Consider Anterior infarct
- Q wave in V3
- Nonspecific Inferior T abnormalities
- T neg or T/QRS ratio < .05
- ABNORMAL ECG

PRELIMINARY-MD MUST REVIEW
18. Another patient with same diagnosis

**Dx:**
- NORMAL SINUS RHYTHM, RATE 66
- BORDERLINE RIGHT AXIS DEVIATION
- ABNORMAL T, PROBABLE ISCHEMIA, ANTEROLAT LDS
- MINIMAL ST ELEVATION, INFERIOR LEADS

**Oper:** GRL

**PV/RV/DX**

**SOB**

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**--AXIS--**
- P 61
- ORS 89
- T -14

--- ABNORMAL ECG ---

PRELIMINARY - MD MUST REVIEW
19a. 55 y.o M with new onset CHF and chest discomfort relieved by Ntg
19b. Prior EKG from 5 years ago
21. 67 y.o male with indigestion
22. 51 year old female referred by primary MD for evaluation of shortness of breath. History of heavy smoking.
59 year old man feeling very weak, nauseous, hypotensive.
24. 67 year old male with chest pressure, history of hypercholesterolemia.
25. 58 y.o. F with CP and IDDM
26. Patient discharged home: ED interpretation = NSR, RBBB
27. 20 y.o male with Syncope
1. Sinus Tach – Upright P waves in 2 and inverted in aVR. Pt had urosepsis
2. Limb lead reversal – Upright P waves in 2 and upright in aVR.
3. Atrial Flutter
4. Sinus rhythm
5. Sinus rhythm with artifact
6. Junctional rhythm with retrograde P waves
7. Sinus Tach, Lateral MI with ST elevations in 1, aVL and reciprocal ST depression in 2,3,F. Also very poor R waves in anterior leads
8. ST elevation laterally in 1,L, V5, V6 and also in 2. ST depression in V1 and V2 that could be due to reciprocal changes or posterior wall MI. A misleading PVC.
8b. Immediate resolution of ST elevation consistent with Prinzmetal’s Angina
9. Subtle ST elevation in 2,3,aVF and subtle reciprocal ST depression in aVL
10. ST elevation in V1-V4 consistent with Anterior STEMI or LV aneurysm
11. Pericarditis with PR depression and diffuse ST elevation
12. ST depression in V2,V3 with tall R waves consistent with posterior MI or anterior NTSE-ACS
13a. Marked strain pattern in the lateral leads, probably accentuate by hypertension and tachycardia. Atypical extension in V3 and V4 should raise suspicion of ischemia, which was not the case
13b. Prior EKG showing baseline strain pattern.
15a. Probably ischemic ST depressions in V1-V4
15b. Resolution of ST depression post Rx
16. Hyperkalemia = 7.2
17. Anterior flipped T waves c/w ischemia or PE. This was a PE
18. Another PE
19a. LBBB without ischemic findings. Pt ruled out for ACS
19b. Progression over 5 years.
20. RBBB without ischemia
21. LBBB without ischemia
22. Paced
23. Hyperkalemia = 7.4
24 LBBB with Anterior STEMI. Discordant ST elevation > 5mm in V2 and V3
25. LBBB with ischemic ST depression in V5 and V6 consistent with AMI
26. RBBB with concordant ST elevation in V3 consistent with STEMI. Also ST elevation in V4-V6 consistent with STEMI
27. Brugada syndrome. RBBB pattern with STE in V1-V3
28. Afib with WPW. Irregular, markedly fast, wide complex tachycardia.