Identifying Patterns of Injury and on the 12 Lead ECG

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THOUGHT FOR THE DAY

“Professional nursing practice can only advance as much as individual nurses are aware that a knowledge gap exists in their practice, feel empowered to access further learning, and integrate evidence based competencies into their professional practice to provide safe, effective, efficient, patient centered, equitable care.”

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• Consider the positive pole of each lead as “the camera” (exploring electrode).

Positive pole is where the camera is located. Negative pole tells the camera which way to look.

• Note: Nothing travels toward the right leg as a positive electrode.

• The right leg is the ground used to absorb any excess electrical activity.
6 Limb Leads

<table>
<thead>
<tr>
<th>Lead 1</th>
<th>Lead 2</th>
<th>Lead 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA – Left Arm + High Lateral Wall LV</td>
<td>RA – Left leg + Inferior Wall LV</td>
<td>LA – Left leg + Inferior Wall LV</td>
</tr>
<tr>
<td>eVR</td>
<td>eVL</td>
<td>eVF</td>
</tr>
<tr>
<td>Right Arm + Footing</td>
<td>Left Arm + High Lateral Wall LV</td>
<td>Left Leg + Inferior Wall LV</td>
</tr>
</tbody>
</table>

6 Precordial (Chest) Leads

<table>
<thead>
<tr>
<th>V1</th>
<th>V4</th>
<th>V2</th>
<th>V5</th>
<th>V3</th>
<th>V6</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 4th ICS, RSB Septum</td>
<td>+ L MCL, 5th ICS Anterior Wall LV</td>
<td>+ 4th ICS, LSB Septum</td>
<td>+ L anterior axillary, same level as V4 Low Lateral Wall LV</td>
<td>+ Midway Between V2 &amp; V4 Anterior Wall LV</td>
<td>+ L midaxillary line, same level as V6 Low Lateral Wall LV</td>
</tr>
</tbody>
</table>
• Posterior wall of the left ventricle and the right ventricle are not captured on the standard 12 lead ECG.

ST Segment

• In limb leads the ST segment is normally isoelectric but may be slightly elevated or depressed by less than 1mm
• In precordial leads ST segment elevation is normally not more than 1 to 2 mm (small elevation normal in many people)

Clinical Application:
1) Do not accept any elevation in limb leads
2) Do not accept any depression in chest leads
**The “J” Point**

- Point where the QRS complex and the ST segment meet.

**Clinical Application:**
There can be ST segment elevation with no J point elevation.

**T Waves**

- Represents ventricular repolarization
- Slightly asymmetrical
- Usually upright
- Most likely abnormal if inverted in two contiguous leads
- Not normally > than 5mm (limb leads) to 10 mm (precordial) high

**Clinical Application:**
3) Never tolerate a T wave that is too big in any lead.
Never Tolerate a T Wave that is Too Big

2 hours later
ECG Assessment Priorities
When Assessing for Injury or Ischemia

1) Assess for ST segment elevation first
   – ST elevation and need for reperfusion

2) Assess for T wave inversion next
   – Non STEMI or
   – Unstable angina
     • ischemia

3) Assess for ST segment depression thirdly
   – Supply and demand ischemia (often in V5 regardless of vessel occlusion)
   – OR – reciprocal changes to ST elevation

Hyperacute T Wave

Note: Hyperacute T waves can occur within 2 minutes of a coronary occlusion
Hyperacute T Waves

Post Hyperacute T Waves
J Point Elevation

Subtle ST Elevation Forming
Larger T Wave

Note: ST elevation is often subtle in the limb leads in an acute MI.
• T wave should be positive in lead I and II
• **Normal inversion is rare in V2 – V6**
• Inversion in lead III, aVL and aVF may be normal
• Inversion in V1 is common - always compare to previous ECG

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**T Wave Inversion Associated With Ischemia/Infarction**
- Deep T wave Inversion
- Disproportionate T wave Inversion (in relation to QRS voltage)
- New or changing T wave Inversion
- QTc usually increased

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**2 Types of T Wave Inversion**

**Terminal T wave Inversion**

**Symmetrical T wave Inversion**
More on T Wave Inversion

- T wave inversion is a “warning” for ACS (either unstable angina or NonSTEMI) unless……………

- T wave inversion occurs after a STEMI
  - After a STEMI T wave inversion is expected
  - Terminal T wave inversion is a sign of reperfusion after a STEMI
  - Symmetrical T wave inversion will develop after terminal T inversion

Terminal T Wave Inversion: A Sign of Reperfusion

- “Wellen’s Warning” when seen in chest leads(V2-V3) of undiagnosed patient
  - Represents LAD occlusion that spontaneously reperfused prior to the ECG (lesion at risk for reocclusion)
  - Seen on ECG done during pain free period
  - Can be UA / NSTEMI

This pattern frequently occurs after successful reperfusion in STEMIs. It is an expected finding after reperfusion and not a warning!
Can be seen in exercise stress testing with supply and demand ischemia.

Can be seen in exercise stress testing with supply and demand ischemia.

Often seen with left ventricular hypertrophy.
Clinical Pearls

ECG

- Be suspicious of horizontal ST segment depression in patient at rest.
- Suspect left main disease (or significant 3 vessel disease) when diffuse depression and ST elevation in lead aVR (and V1 to lesser extent)

Presentation

- Assess for reasons for supply and demand ischemia at rest (i.e. low hemoglobin).
- Rule out medical reason for falls, motor vehicle crashes, and other trauma (i.e. syncope or near syncope due to cardiac cause).

Practice ECG

Admitted with fall. Fracture femur admitted to surgical floor.
Practice ECG

Developed chest pain in PACU.

ECG Evolution of a STEMI

1. R S T
2. R ST
3. R ST
4. P ST
5. P ST
6. R T
ECG Evolution: Posterior Inferior STEMI
Bedside Monitoring

18 Hours Post STEMI

36 Hours Post STEMI

ST Evolution:
Pseudo Normalization

Reocclusion
Terminal T-wave inversion
Pseudo-normalization of T-wave
Increased ST elevation
Reciprocal Changes

- Primary Change is most important – look for:
  - ST Elevation: ACS (STEMI)
  - T Wave Inversion: ACS (Non STEMI or UA)
  - ST Depression (ischemia)

- Reciprocal Changes
  - ST segment depression in leads reciprocal (opposite) those with ST elevation
  - Reciprocal changes can help confirm primary changes

**Clinical Application:**
Before calling ST segment depression ischemia – double check the reciprocal leads for missed ST segment elevation.

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Lead 1} & \text{aVR} & \text{V1} & \text{V4} \\
\text{Left Arm} & \text{Right Arm} & 4^{th} \text{ ICS, RSB} & \text{L MCL, 5^{th} ICS} \\
\text{High Lateral Wall} & \text{4^{th} ICS, RSB} & \text{5^{th} ICS} & \text{Anterior Wall} \\
\hline
\text{Posterior Wall} & \text{V1} & \text{V4} & \\
\hline
\text{Lead 2} & \text{aVL} & \text{V2} & \text{V5} \\
\text{Left Leg} & \text{Left Arm} & 4^{th} \text{ ICS, LSB} & \text{L anterior axillary, same level as V4} \\
\text{Inferior Wall} & \text{High Lateral Wall} & \text{Septal Wall} & \text{Low Lateral Wall} \\
\hline
\text{Lead 3} & \text{aVF} & \text{V3} & \text{V6} \\
\text{Left Leg} & \text{Left Leg} & \text{Midway Between} & \text{L midaxillary line, same level as V4} \\
\text{Inferior Wall} & \text{Inferior Wall} & V_2 \text{ & V}_4 & \text{Low Lateral Wall} \\
\text{Anterior Wall} & \text{Anterior Wall} & \text{Anterior Wall} & \\
\hline
\end{array}
\]
Specific Types of MIs

Nuances

Anterior MI

- Proximal LAD
  - Proximal to first diagonal
    - Anterolateral
  - Proximal to first septal perforator
    - Anteroseptal
- Mid LAD
  - Anterior MI

LAD: Anterior Wall, High Lateral Wall, Septum
Complications of Anterior MI

- Myocardium at risk
- Mortality and morbidity
- Post Infarction ejection fraction

Urgency for Reperfusion!

Complications of Anterior MI

- Tachycardia
  - Sinus tachycardia
  - Atrial tachycardia
  - Ventricular tachycardia
- Right BBB and left anterior hemiblock
- Complete heart block

- Ventricular septal defect
  - New loud systolic murmur
- Cardiogenic shock
- Long term ventricular modeling and heart failure
ECG Changes: Anterior MI

• ST Elevation
  – V₃, V₄ Anterior Wall
  – V₁, V₂ Septum

Various locations in the LAD will affect ST deviation vector with varying results on ST segment changes in the limb leads.

For Example: Occlusion proximal to diagonal branch results in ST elevation in Leads I and aVL.

For Example: Occlusion proximal to septal perforator shifts vector to right and results in additional ST elevation in Lead aVR.

Normal V1-6: R Wave Progression

• The R wave becomes taller and the S wave becomes smaller as the electrode is moved from right to left
• This pattern is called R wave progression
Practice ECG
• RCA occlusion 80% to 85% of time
  – Marginal branch: Right ventricle
  – Posterior descending artery = Posterior wall of LV
    • Concept of right versus left dominant

**Clinical application:**
Assess right sided leads in patients with inferior MI.
Inferior MI

• Variations
  • Inferior posterior
  • Inferior with RV
  • Inferior posterior and RV
  • Inferolateral (often with circumflex)

• Complications
  • Sinus Bradycardia, 1st degree and 2nd Degree HB Type I
  • Increased parasympathetic activity
  • Papillary muscle rupture with posterior wall involvement
  • RV failure with RV involvement

ST Changes in Inferior MI

• ST elevation leads II, III, aVF
  — Lead III > II (RCA occlusion)
  — Lead II > III (Circumflex occlusion)

• ST depression in aVL

• ST elevation ≥ 0.5mm in inferior leads should be considered abnormal until proven otherwise
Practice ECG 2 of 2

ECG on arrival in ED

Practice ECG 3 of 2

ECG a short time later in ED
Lateral Wall MI

- Lateral wall MIs are frequently associated with anterior, inferior, or posterior wall MIs
- However – when isolated are frequently missed
- ST elevation may be < 1 mm
- ST elevation may only be in aVL

Coronary Artery Distribution to the Lateral Wall

- Lateral Wall
  - First diagonal branch of LAD (Leads 1, aVL)
  - Obtuse marginal branches of Circumflex ($V_5$, $V_6$)
31 year old man presented with CP. The computer missed read this ECG. The physician diagnosed it as inferior ischemia.

61 yr old woman presented with 45 min of CP. Long standing history of 3 vessel CAD. Had 34 prior admissions where she ruled out for AMI. 3 mos ago cath showed severe circ and 2nd obtuse marginal disease. Previous ECG were available.
• Note: MRI studies suggest that ECG evidence of posterior injury may actually reflect more anatomical injury of the lateral wall. However, ECG interpretation guidelines recommend we continue to refer to this type of MI as posterior.

• Coronary arteries and the posterior wall
  – RCA (responsible for Inferior / Posterior STEMI)
    • Posterior descending coronary artery
  – Circumflex (responsible for isolated posterior STEMI)
    • PDA
    • Marginal Branch

• Maximal ST depression > 2 mm in V1 – V3 may be 90% specific for posterior MI
• T waves usually remain upright
• Persistent ST depression is more commonly due to posterior STEMI than LAD disease
• Anterior UA/ NonSTEMI is most likely when T wave inversion in present in V1-V4
Posterior MI

- Reperfusion is indicated if true posterior MI is confirmed
  - Even with absence of ST elevation on standard 12 lead ECG
  - 3.3% to 8.5% of MIs are isolated posterior STEMI (Smith et al., 2002)
- Non reperfused posterior MI
  - Tall R waves in V1-V3

Remember: Increased risk for papillary muscle ischemia or rupture. May hear new holosystolic murmur.

Practice ECG
Approximately 1/3 of Inferior MIs
– Occlusion proximal to marginal branch of RCA

**Recognition**
- > 0.5 mm ST elevation in V4R
  - Men < 30 years of age (> 1.0 mm ST elevation in V4R)
- Suspect when elevation in V1 but not in V2
  - However, cannot rely on if there is simultaneous RV and posterior involvement
- Combination of elevation in V4R and V1 is very specific to RV infarct
- Reciprocal changes to RV injury may be seen in low lateral leads
RV Infarct

• Implications
  – Increased short term mortality
  – RV can recover well if patient survives acute phase

• RV Failure = Decreased LV Preload = Decreased Stroke Volume = Hypotension

• Clinical presentation
  – Hypotension
  – Clear lungs
  – Signs of RV failure (increased CVP; jugular venous pressure)

Pathophysiology of RV infarct is complex
  – Ventricle can be noncompliant or distensible

Treatment of hypotension in RV infarct
  – Avoid diuretics and venous vasodilators
  – IV fluids to CVP of 15 mmHg and PAOP of 15 mmHg
    (Brenner & Tschopp, 2009)
  – Caution with too much fluid:
    • Distendability
    • Septal displacement
  – Need for inotrope when fluid loading not successful
  – Atrial fibrillation and bradyarrhythmias need treated
Right Sided ECG

Note: V1 and V2 may also be reversed with V1 on LSB and V2 on RSB.
If so, these are labeled V1R and V2R.

Right Ventricular Leads
May also record V3R, V4R, and V5R. Mirror image of normal

Posterior Leads
V7: Posterior axillary line
V8: Under tip of scapula
V9: Same level at paraspinal border
All posterior leads the same level as V6
Right Sided and Posterior Quick Look on Bedside Monitor

Right Sided Lead
- Place electrode in V4R Position
  - 5th ICS Right MCL
- Attach V monitoring lead (Brown Lead) to electrode
- Assure monitor lead selector is on V
- Run strip and clearly mark “V4 Right Chest Lead”

Posterior Lead
- Place electrode in V8 position
  - Under tip of left scapula same level as V6
- Attach V monitoring lead (Brown Lead) to electrode
- Assure monitor lead selector is on V
- Run strip and clearly mark “V8 Posterior Lead”
A Case Study

Support for Continuous ST Segment Monitoring
History of Present Illness

61 year old Caucasian male with increasing SOB and cough for 2-3 days. Treated by his PCP with ATB, Tessalon Perles and Flonase for asthmatic bronchitis. Presented to ED (via EMS) later that evening with severe DOE. Was hypoxic on arrival. + cough with yellow sputum, wheezing, SOB. Admitted and placed on IV steroids of bronchitis.

Past Medical History

• Obstructive sleep apnea (noncompliant with CPAP)
• HTN
• Psoriatic arthritis
• DM, Type II
• Obesity
• Tobaccoism
• ETOH use (daily)
Labs

- Troponin – 0.01, 0.02, 0.14
- Myoglobin – 89, 323
- WBC – 15,000; Hgb 13.9; Plt 239,000
- Glucose 419, Na 135, BUN 17, Cr 1.16, K 4.4
- Rapid flu neg
- CXR: no acute process

Initial ECG
Plan

• Symptoms did not suggest ACS, but due to risk factors another troponin was drawn. Troponin bump was felt to be due to hypoxia.

• A Lexiscan stress test was recommended once his pulmonary status improved.

Later that day....

• Troponin 0.36
• Patient more SOB
• Repeat ECG ordered
• Patient down in heart lab for echocardiogram.
• ECG done 1 hour later.
Repeat ECG

The rest of the story

• Patient emergently to the cardiac catheterization lab (called as a STEMI) and received PCI with DES to RCA (100% occluded).

  • EF 55%.

  • Was also a RV infarct
Final Thought

“Mastery is not something that strikes in an instant, like a thunderbolt, but a gathering power that moves steadily through time, like weather.”

— John Gardner, *The Art of Fiction: Notes on Craft for Young Writers*

THANK YOU!!!

BE THE BEST THAT YOU CAN BE EVERY DAY. YOUR PATIENTS ARE COUNTING ON IT!

Contact me at:
www.cardionursing.com