Common ECG and Telemetry Missteps:

Don’t Miss a beat!

Siva Soma, MD
Outline

• ECG Basics

• Common ECG Missteps
  • Old infarct
  • Heart blocks
  • Wide complex tachycardia
  • ST elevation on ECG

• Common Telemetry Missteps
  • Artifact
  • Inaccurate HR
Heart Beat Anatomy

Sinus Node (SA Node)

The Heart’s ‘Natural Pacemaker’

60 - 100 BPM at rest
Heart Beat Anatomy

Sinus Node (SA Node)

Atrioventricular Node (AV Node)
Normal Sinus Rhythm
Normal Sinus Rhythm
Normal Sinus Rhythm
Normal Sinus Rhythm
Normal Sinus Rhythm
Normal Sinus Rhythm
Normal Sinus Rhythm
Normal Sinus Rhythm
Normal Sinus Rhythm
Normal features of the electrocardiogram

- P-R: P-R interval
- QRS: QRS interval
- S-T: S-T segment
- T: T wave
- U: U wave

Recording Conventions, Waveform Nomenclature, and Normal Values for the Electrocardiogram.
What is the approximate heart rate?

1. 40
2. 50
3. 60
4. 70
What is the approximate heart rate?

1. 40
2. 50
3. 60
4. 70
Calculation of Heart Rate

• **Rule of 300**
  - Divide 300 by the number of boxes between each QRS = rate

• Although fast, this method only works for regular rhythms.

<table>
<thead>
<tr>
<th>Number of big boxes</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
</tr>
</tbody>
</table>
Standardized Methods & Devices

• **ECG Graph Paper**
  • Vertical axis - voltage
    • 1 small box = 1 mm = 0.1 mV
  • Horizontal axis - time
    • 1 small box = 1 mm = 0.04 sec.
  • Every 5 lines (boxes) are bolded
  • Horizontal axis - 1 and 3 sec marks
What is the heart rate?

(300 / ~ 4) = ~ 75 bpm
What is the heart rate?

\[(300 / 1.5) = 200 \text{ bpm}\]
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  • Artifact
  • Inaccurate HR
48 year old for Pre-Op ECG

Sinus Bradycardia
-Old anterior infarct

ABNORMAL

Rate: 55 BPM
PR: 124 msec
QT: 418 msec
QTc: 411 msec
QRS: 84 msec
P Axis: 49
QRS Axis: 19
T Axis: 43
In order to “clear” patient for surgery

1. Repeat ECG
2. Exercise treadmill test (without imaging)
3. Stress echocardiography
4. Cardiac catheterization
In order to “clear” patient for surgery

1. Repeat ECG
2. Exercise treadmill test (without imaging)
3. Stress echocardiography
4. Cardiac catheterization
With Proper Placement

Sinus Bradycardia
WITHIN NORMAL LIMITS
Normal R Wave Progression

Transition Zone?
R Wave Progression

Transition Zone?
Transition Zone
Early & Delayed Transition

V1    V2    V3    V4    V5    V6

Transition zone

Transition zone
Precordial Leads

Adapted from: www.numed.co.uk/electrodepl.html
Chest Lead Placement

**V1 Fourth Intercostal space right sternal border.**

**V2 Fourth Intercostal space left sternal border**

Mid-Cavicular line (Body drawing is turned to the right.)

**CHEST LEAD POSITIONING**
Chest Lead Placement

V1: Fourth intercostal space, right sternal border.

V2: Fourth intercostal space, left sternal border.

V4: On the imaginary midcavicular followed down to the fifth intercostal space.

V3: Located midway between V2 & V4.
Chest Lead Placement

V1 Fourth Intercoastal space right sternal border.

V2 Fourth Intercoastal space left sternal border

V3 is locate midway between V2 & V1.

V6 is placed on left midaxillary line at the same level as V4.

V4 is placed on the imaginary mid clavicular line (find the middle of the collar bone visualize an intersecting line) which will cross the 5th Intercoastal space. Place electrode where they cross.

V5 is placed midway between V4 & V6

V6 is placed on left midaxillary line at the same level as V4.

V4 is placed on the imaginary mid clavicular line (find the middle of the collar bone visualize an intersecting line) which will cross the 5th Intercoastal space. Place electrode where they cross.
Precordial leads

The location of these leads is as follows:

V₁: on the fourth intercostal space at the right sternal margin
V₂: on the fourth intercostal space at the left sternal margin
V₃: midway between leads V₂ and V₄
V₄: on the fifth intercostal space at the midclavicular line
V₅: on the anterior axillary line at the horizontal level of lead V₄
V₆: on the midaxillary line at the horizontal level of lead V₄
Chest Lead Placement
Precordial Leads
Normal QRS

• Two phases

  • Brief phase; depolarization of ventricular septum

  • Longer phase; depolarization of both ventricles but the left is larger
First Phase

- Depolarization of ventricular septum
Second Phase

• Depolarization of both ventricles but the left is larger
Septal Q waves vs Septal infarct

• QS pattern in lead V1 and V2 can suggest septal MI
• However it can be seen in multiple other conditions ( emphysema, obesity, chest deformity etc) and is unreliable indicator of MI
• Look for other ECG abnormalities suggestive of Infarction
• Infarction limited to the interventricular septum is very rare
• When QS deflections in V1 and V2 are accompanied by other ECG abnormalities, especially ischemic-type precordial T wave inversions, the probability of underlying MI is greatly increased.
• Septal Q waves are seen commonly due to improper lead position
ECG of a 74-year-old woman with no evidence of cardiovascular disease.

Lead V2 from multiple ECGs over a 10-year period showed varying morphologies from QS to rS, suggesting changes due to varying right precordial lead placement.
Lead V2 from multiple ECGs over a period of 7 years showed QRS morphology varying from QS to qrS to rS. Interpretations of ECGs ranged from “septal infarction” to “within normal limits.”
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  • Wide complex tachycardia
  • ST elevation on ECG

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  • Artifact
  • Inaccurate HR
AV Heart Block
What is the type of heart block?
What is the type of heart block?

1. Second degree. Mobitz type 1 (Wenckebach)
2. Second degree. Mobitz Type 2
3. Blocked PAC
4. Cannot say which type of second degree heart block
What is the type of heart block?

1. Second degree . Mobitz type 1 (Wenckebach)
2. Second degree . Mobitz Type 2
3. Blocked PAC
4. Cannot say which type of second degree heart block
Classification of AV Heart Blocks

<table>
<thead>
<tr>
<th>Degree</th>
<th>AV Conduction Pattern</th>
</tr>
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<tbody>
<tr>
<td>1st Degree Block</td>
<td>Uniformly prolonged PR interval</td>
</tr>
</tbody>
</table>
First Degree Block

Note the prolonged PR interval
### Classification of AV Heart Blocks

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<tr>
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<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Degree Block</td>
<td>Uniformly prolonged PR interval</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Degree, Mobitz Type I</td>
<td>Progressive PR interval prolongation</td>
</tr>
</tbody>
</table>
Second Degree AV Block Type I or Wenckebach

<table>
<thead>
<tr>
<th>P Wave</th>
<th>PR Interval (in seconds)</th>
<th>QRS (in seconds)</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduction intermitant</td>
<td>Increasingly Prolonged</td>
<td>&lt;.12</td>
<td>QRS dropped in a repeating pattern</td>
</tr>
</tbody>
</table>
Second Degree AV Block - Type I
Wenckebach

1. Progressive lengthening of the PR interval from beat to beat until a beat is dropped.

2. The PR interval after the nonconducted P wave is shorter than the PR interval before the nonconducted P wave.

3. May be grouping of QRS complexes
What is this?
# Classification of AV Heart Blocks

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<td>2nd Degree, Mobitz Type I</td>
<td>Progressive PR interval prolongation</td>
</tr>
<tr>
<td>2nd Degree, Mobitz Type II</td>
<td>Sudden conduction failure</td>
</tr>
</tbody>
</table>
Second Degree AV Block
Type II

1. Sudden appearance of a single, non-conducted sinus P wave.

2. Without
   1. Progressive prolongation of the PR intervals
   2. And shortening of the PR interval in the beat after the non-conducted P wave.
Second Degree AV Block
Type II
2:1 AV Blocks

• Often are type II blocks
  • look for slightly prolonged QRS

• They can be type I blocks
  • look at long rhythm strip

• Sometimes they are labelled a “second degree block” only
Third-Degree (Complete) AV Block

<table>
<thead>
<tr>
<th>P Wave</th>
<th>PR Interval (in seconds)</th>
<th>QRS (in seconds)</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal but not related to QRS</td>
<td>None</td>
<td>N/A</td>
<td>No relationship between P &amp; RS</td>
</tr>
</tbody>
</table>
Third-Degree (Complete) AV Block

1. P waves are present, with a regular atrial rate faster than the ventricular rate
2. QRS complexes are present, with a slow (usually fixed) ventricular rate
3. The P wave bears no relation to the QRS complexes, and the PR intervals are completely variable
4. (Some properly timed P waves may be conducted)
What is this?
What is this?
What is this?
What is this?
ECG from 2014
Male

Systolic Blood Pressure: 120 mmHg
Diastolic Blood Pressure: 80 mmHg
Heart Rate: 60 BPM

Sinus Bradycardia with Prolonged PR Interval and Frequent Supraventricular Premature Complexes
Marked Left Axis Deviation
Right Bundle Branch Block
Abnormal ECG

Unconfirmed Report
Blocked PAC
SINUS RHYTHM WITH 2ND DEGREE AV BLOCK, MOOTTZ TYPE II
NONSPECIFIC ST ELEVATION
ABNORMAL ECG
• Blocked PACs
61 year old female with light headedness
Blocked PACs
Under sensing of P waves by ECG machine leading to inaccurate AF diagnosis
Abnormal QRS waveforms with a competing ventricular pacemaker.

Abnormal QRS waveforms with a competing ventricular pacemaker.

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Abnormal QRS waveforms with a competing ventricular pacemaker.

Abnormal QRS waveforms with a competing ventricular pacemaker.

Abnormal QRS waveforms with a competing ventricular pacemaker.
Limb lead gain was increased. Can see P waves
Look for P waves
Sinus arrhythmia

Figure by MIT OCW.
Outline

• ECG Basics

• Common ECG Missteps
  • Old infarct
  • Heart blocks
  • Wide complex tachycardia
  • ST elevation

• Common Telemetry Missteps
  • Artifact
  • Inaccurate HR
What is the rhythm?
What is the rhythm?

1. Ventricular Tachycardia
2. Atrial fibrillation with aberrant conduction
3. Ventricular Fibrillation
4. Don’t know. Call STAT EP consult
What is this?

1. Ventricular Tachycardia
2. Atrial fibrillation with aberrant conduction
3. Ventricular Fibrillation
4. Don’t know. Call STAT EP consult
Wide complex tachycardia

Common scenarios

• Ventricular tachycardia

• Supra ventricular tachycardia or Atrial fibrillation with aberrant conduction

• SVT with conduction over accessory pathway
# Differential Diagnosis of Tachycardia

<table>
<thead>
<tr>
<th>Tachycardia</th>
<th>Narrow Complex</th>
<th>Wide Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td>ST</td>
<td>ST w/ aberrancy</td>
</tr>
<tr>
<td></td>
<td>SVT</td>
<td>SVT w/ aberrancy</td>
</tr>
<tr>
<td></td>
<td>Atrial flutter</td>
<td>VT</td>
</tr>
<tr>
<td>Irregular</td>
<td>A-fib</td>
<td>A-fib w/ aberrancy</td>
</tr>
<tr>
<td></td>
<td>A-flutter w/ variable</td>
<td>A-fib w/ WPW</td>
</tr>
<tr>
<td></td>
<td>conduction</td>
<td>VT</td>
</tr>
<tr>
<td></td>
<td>MAT</td>
<td></td>
</tr>
</tbody>
</table>
AF with aberrant conduction
Right Bundle Branch Block
Right Bundle Branch Block
Afib with RBBB and LAFB
Baseline
Wolff-Parkinson-White Syndrome

Delta Wave
WPW Arrhythmia Mechanisms

Orthodromic

Antidromic

Atrial Fibrillation
Ventricular Tachycardia
Monomorphic VT

AV dissociation, fusion beats and capture beats.
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  • ST elevation on ECG

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  • Artifact
  • Inaccurate HR
ST elevation

Think

• Acute MI

• Pericarditis

• Early repolarization
Not all ST elevations are Acute MI/STEMI
Acute MI-LAD Occlusion
Lateral MI

Reciprocal changes

A 45-year-old man reports eight hours of left chest and arm pain.
Inferolateral MI

ST elevation II, III, aVF

ST depression in aVL, V1-V3 are reciprocal changes
Pericarditis

• Diffuse ST elevation

• No reciprocal changes

• PR depression

• Clinical scenario
Acute pericarditis
Acute pericarditis
Early repolarization
There is generalized concave ST elevation in the precordial (V2-6) and limb leads (I, II, III, aVF).

J-point notching is evident in the inferior leads (II, III and aVF).

There are prominent, slightly asymmetrical T waves that are concordant with the main vector of the QRS complexes.
upward concavity or ST coving

J-point notching
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New consult for “Atrial Fibrillation”
What is the Rhythm?

1. Atrial fibrillation with RVR
2. Atrial Flutter with RVR
3. Polymorphic VT
4. None of the above
Baseline wander/artifact
Non physiologic RR intervals
Concordance in other ECG leads
What was the patient doing at this time?
Wat je niet kent, herken je niet”.

• “What you do not know, you do not recognize.”

Reminder to students of electrocardiography, inscribed in the lecture hall of Professor Hein J.J. Wellens, MD.
Muscle tremor artifact
Rhythm Strip of Electrocardiographic Artifact That Mimicked Monomorphic Ventricular Tachycardia and Led to the Patient's Being Treated with Lidocaine.
Electrocardiographic artifact mimicking ventricular tachycardia.

QRS complexes are hidden by pseudo-QRS complexes in most of the leads except in lead II (asterisks).
Rhythm Strip of Electrocardiographic Artifact That Mimicked Polymorphic Ventricular Tachycardia and Led to the Patient's Being Treated with Lidocaine.
<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Characteristics of the Patient</th>
<th>Features of the Artifact</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age (yr)/Sex</td>
<td>Monomorphic/Poly/Polymorphic</td>
<td>Associated Symptoms</td>
</tr>
<tr>
<td>1</td>
<td>74/F</td>
<td>Polymorphic</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>54/M</td>
<td>Monomorphic</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>41/F</td>
<td>Polymorphic</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>40/M</td>
<td>Monomorphic</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>38/F</td>
<td>Polymorphic</td>
<td>Arm paresthesias</td>
</tr>
<tr>
<td>6</td>
<td>53/M</td>
<td>Monomorphic</td>
<td>None</td>
</tr>
<tr>
<td>7</td>
<td>59/F</td>
<td>Polymorphic</td>
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<tr>
<td>8</td>
<td>71/F</td>
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<tr>
<td>9</td>
<td>65/M</td>
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</tr>
<tr>
<td>10</td>
<td>54/F</td>
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<tr>
<td>11</td>
<td>84/M</td>
<td>Monomorphic</td>
<td>None</td>
</tr>
<tr>
<td>12</td>
<td>50/M</td>
<td>Polymorphic</td>
<td>None</td>
</tr>
</tbody>
</table>

*LVEF denotes left ventricular ejection fraction, bpm beats per minute, CAD coronary artery disease, ICD implantable cardioverter-defibrillator, ICU intensive care unit, DCM dilated cardiomyopathy, CABG coronary-artery bypass grafting, and COPD chronic obstructive pulmonary disease.*
Clinical Studies

Physician Interpretation of Electrocardiographic Artifact That Mimics Ventricular Tachycardia

Bradley P. Knight, MD, Frank Pelosi, MD, Gregory F. Michaud, MD, S. Adam Strickberger, MD, Fred Morady, MD
Figure 1. Two-lead surface electrogram included in the physician questionnaire that depicts electrocardiographic artifact simulating monomorphic ventricular tachycardia. Four QRS complexes (arrows) and corresponding T waves (arrowheads) were visible within the artifact at intervals that equal the cycle length of the sinus rhythm preceding the artifact. The arrows and arrowheads were not included in the questionnaire.
Figure 2. Diagnoses made by 55 internists, 221 cardiologists, and 490 electrophysiologists to a questionnaire that depicted an electrocardiogram of artifact.
An example of electrocardiographic artifact that is difficult to differentiate from ventricular tachycardia. QRS complexes cannot be identified at every expected interval within the artifact. However, discrete components of the QRS complexes are visible at intervals that correspond to multiples of the baseline rhythm RR interval. X denotes the baseline RR interval.
Called for abrupt onset of “Rapid Tachycardia”
True VT - Not artifact
Subsequent Electrocardiogram (ECG) and Telemetry Strip A, The ECG was recorded 4 hours after patient presentation; the arrowheads represent giant TU waves.

B, Telemetry strip documenting initiation of torsades de pointes.

From: Electrocardiographic Harbingers of Ventricular Tachycardia Arrest—A Moment of Pause
She doesn’t have a pacemaker!
Telemetry under sensing
Pulse 36

PisNBP ?  RESP 18  ST-MCL ?

11:42:35 (4/17/2013)

11:42:41

4/17/2013 11:42:46 ***BRADY 36 < 40

11:42:47
If ECG or telemetry says pacemaker malfunction: Check if they have a pacemaker first 😊
• Thank you