EKG Review

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Systematic Approach

- *First three questions to ask with every EKG:*
  - Is it fast or slow?
  - Is it regular or irregular?
  - Are there P-waves – yes or no?
- Then look at QRS complex, ST segments and T-wave
- Look in ALL leads for
  - P-waves
  - Pacer spikes
- Verify findings in consecutive leads

*Whenever possible, compare to old tracings*

Artifact vs VTach
Normal Conduction

Coronary Blood Flow

Waves and Intervals

= Electrical Information

Electricity moving towards electrode creates upward deflection.
Electricity moving away from electrode creates downward deflection.

- **P-wave**: atrial depolarization
- **PR Interval**: time from onset of atrial depolarization to onset of ventricular depolarization
- **QRS Complex**: ventricular depolarization
- **RR Interval**: time from one QRS complex to the next
- **ST Segment**: all parts of ventricular muscle are in activated state
- **T-wave**: ventricular repolarization and relative refractory period
- **QT Interval**: total duration of ventricular systole
- **U-wave**: origin not clear, “after-depolarization”
Leads = Spacial Information

- Frontal view --- Limb leads: I, II, III, avL, avF, (avR)
- Horizontal view --- Chest/precordial leads: V1-V6
- Lead Grouping --- leads look at heart from same viewpoint (‘camera’)

Leads

Frontal or Limb leads

Chest or Precordial Leads

- For telemetry monitoring, use lead II
- Problem due to chest incisions/tubes/burns/large breasts, etc
- Wrong lead placement may lead to false positive findings

12 lead Composite
Improper Lead Placement

Used with permission

Lead Reversal …
(RA – LA and RL – LL)

…leads to false Q-waves and ST/T-wave changes

Measurements

- **Standardization** (or calibration)
  - normal: 10mm or 2 large boxes
  - ½ standard: 5mm or 1 large box
  - double standard: 20mm or 4 large boxes

- Vertical lines = voltage or amplitude
- Horizontal lines = time or duration
- Small square = 0.04 sec time or 1mm amplitude
- Large square = 0.20 time or 5 mm amplitude
Normal Ranges

- Normal HR 60 – 100 bpm with 10% variation
- PR interval 0.12 – 0.20 sec (3-5 small boxes)
- QRS duration 0.04 – 0.12 sec (3 small boxes)
- QT interval < 0.45 sec
- QT must be corrected for rate (QTc formula)
- Easy way to ‘ballpark’ QT interval
  - If QT longer than ½ RR interval, need to physically measure it

Rate Calculation

1. 1 strip = 6 sec
   count number of QRS complexes and multiply by 10
   ➔ ballpark figure
2. Heart rate series
   300 – 150 – 100 – 75 – 60 – 50 – 43 – 37 – 33
   [counts number of large boxes between QRS complexes and divides into 300]
3. Count number of small boxes and divide into 1500
   most accurate, best to make up a chart
   (e.g. 19 squares = 78 bpm, 32 squares = 46 bpm)

Heart Rate Measurements
**P-Wave**
- Smooth, rounded
- 3 small boxes
- < 0.12 sec
- II and V1 best for looking for P-wave
- Upright in lead II = NSR
- Inverted in avR

**QRS Complex**
- <0.12 sec, amplitude variable
- Q = 1st downward deflection
- R = 1st upward deflection
- S = 2nd downward deflection
- <0.12 sec, amplitude variable

**ST Segment**
- Often difficult to define
- Pulled imperceptibly into ascending limb of T wave
- Mildly concave appearance

**T-Wave**
- Usually upright I, II, V4-6
- Inverted avR
- Variable in III, often inverted in V1

**Q-Waves**
- Pathologic Q-Wave
  - >0.04 sec duration or 1 small box wide
  - >1/4 height/width of R-Wave
- Frequently seen in III and V1
  - Must be present in consecutive leads to be pathologic
- Always present in avR
- Typically result from STEMI due to scarring
- Can lead the computer to interpret a prior MI
- Frequently due to lead placement, body habitus, rotation of the heart
Atrial Rhythms

- P-wave
- Small boxes, < 0.12 sec
- Represents atrial de- and repolarization
- Upright in lead II = sinus rhythm
- Should be followed by a QRS in one-to-one relationship
- II and V1 best for looking for P-wave
- Inverted in avR

Standard EKG

NSR with PACs/PVC

(Computer: Atrial Fibrillation)
Atrial Arrhythmia

- **Premature Atrial Contractions (PACs)**
  - Single or repetitive, regularly irregular (e.g. bigeminy, trigeminy, couplets)

- **Atrial Fibrillation (AFib or AF)**
  - Irregularly irregular – “Kindergarten class out of control” – NO distinct P-waves

- **Multifocal Atrial Tachycardia (MAT)**
  - Irregularly irregular but **WITH** distinct P-waves of varying morphology

- **Atrial Flutter (AFl)**
  - “Sawtooth pattern” (flutter waves)
  - Regular or irregular, watch out for 2:1 conduction with HR at 150
  - distinct P-waves – MORE P’s than QRS’s

- **Supraventricular Tachycardia (SVT)**
  - Regular and very rapid, generally >150
  - Various pattern such as WPW vs AVNRT

**NSR**

**Atrial Fibrillation**
Sinus Tachycardia with PACs

NSR with PACs – NOT AFib

Atrial Flutter
Atrial Flutter (4:1 conduction)

2:1 Atrial Flutter

Atrial Flutter

If regular narrow complex QRS with a heart rate of 150, think

2:1 Atrial Flutter
Atrial Flutter with Conversion to NSR

Supraventricular Tachycardia

- Paroxysmal – sudden onset, abrupt cessation
- Narrow QRS unless in presence of LBBB
- 3 main Types
  - AV nodal reentrant tachycardia (AVNRT)
  - AV reciprocating tachycardia (AVRT → WPW)
  - Afib/Aflutter technically also SVT

AVNRT versus AVRT

- AVNRT
  - Fast and slow pathways within the AV node or close by in the atrial tissue

- AVRT (WPW)
  - Accessory pathways generally located in the AV valvular rings
    - Provide direct connection (‘bridge’) between the atria and ventricles
    - Bypasses AV node
    - Characterized by short PR interval and Delta Wave
AVNRT versus AVRT (WPW)

SVT - AVNRT
Ventricular Rhythms

- PVC’s
  - Single, grouped, unifocal, multifocal
- Junctional rhythm
  - Inverted Pwave before/after QRS or buried in it
- Ventricular tachycardia (VTach or VT)
  - ‘Salvo’, non-sustained, sustained
- Torsades de Pointe
  - ‘Twisting of the points’, form of polymorphic VT
- Ventricular fibrillation (VFib or VF)
Junctional Rhythm

Ventricular Tachycardia
- Wide complex tachycardia, VT until proven otherwise
- Could also be SVT with BBB or WPW
- If prior MI, VT 98% likely
- Treat like VT and you will be right 4 out of 5 times
- Rate 100 – 250 bpm
- Very wide QRS (>140ms)
- Usually regular
- Sustained vs. non-sustained (<30 sec)
- Monomorphic vs polymorphic vs Torsades
  - Torsades: variations of QRS polarity around baseline
  - HR >200 with V-Fib as consequence
  - Associated with long QT

VTach
VTach

Torsades de Pointes

Prolonged QT

QT = 482ms; QTc = 621ms
Bundle Branch Blocks

- Wide (>0.12) QRS can be due to
  - PVCs
  - BBBs
  - Ventricular rhythms
  - Pacing
- Transient, intermittent, rate-related
- Associated with ST changes
- Like turn signals (in V1):
  - Up for R turn → QRS mostly positive (RBBB)
  - Down for L turn → QRS mostly negative (LBBB)

LBBB
- Broad monophasic R (‘big ugly bizarre’)
- V1-2: rS or qS with ST elevation, T wave upright → QRS negative V1
- V5-6: Slurred notched monophasic broad R or rsR
**LBBB**

- rsR pattern V1 – V3
  - ‘M’, Rabbit ears'
- wide slurred S-wave lead I and V6
- QRS V1 positive

**RBBB**

- rsR pattern V1 – V3
  - ‘M’, Rabbit ears'
- wide slurred S-wave lead I and V6
- QRS V1 positive
AV Blocks
“A Marriage gone bad”

- NSR: 1:1 P:QRS → ‘happily married’
- 1st degree: 1:1 P:QRS but long fixed PR → ‘married, but sleeping in separate rooms’
- 2nd degree Type I: progressive rhythmic lengthening of PR till drop of QRS → ‘drifting apart, going away but still coming back home on regular basis’
- 2nd degree Type II: fixed PR interval, but random QRS drops → ‘keeping outward appearance of stable relationship but going separate ways randomly’
- 3rd degree: complete dissociation of P’s and QRS’s → ‘divorced, leading separate lives’

1st degree AV Block

2nd degree AV Block Mobitz Type I
Is ST Elevation Always a Sign of an MI?

ST Elevations Patterns

- **Acute MI**
  - Focal ST elevation with reciprocal depression
  - Upwardly convex shape → 'tombstone'

- **Pericarditis**
  - Diffuse ST elevation without reciprocal depression
  - PR depression (not always present!)
  - Upward concave shape → 'smiling face'
Pericarditis

- Early Repolarization
  - ST elevation without reciprocal depression
  - Upwardly concave shape → "fish-hook"
  - Peaked T-wave in the mid-precordial leads

ST Segment Morphology For Acute ST elevation MI

- Upward concave → "smiley face"
- Upward convex → "sad face"
**Terminology**
- ST Depression = ischemia
- ST Elevation = injury
  - Always confirm in two or more consecutive lead
- Qwaves develop in presence of permanent tissue damage
  - No longer used to diagnose MI
- STEMI = “Qwave MI”
- NSTEMI = “Non-Qwave MI”
  - Seen with ST depression and/or Twave abnormalities, but also with normal EKG!

**Localization of STEMI**
- Inferior MI
  - Leads II, III, avF
  - Right coronary artery (RCA) territory
- Anterior MI
  - V2 – 4
  - Left anterior descending artery (LAD) territory
- Lateral MI
  - V4 – 6, I, avL
  - Left circumflex artery (LCx) territory
- Posterior MI
  - V1 – 3 BUT as significant ST Depression
  - RCA/LCx territory – usually seen with inferior MI

**Early evolving MI (1)**

![ECG Image]
Diagnosis by cardiac enzymes
- Levels of enzymes usually lower than with STEMI
- Good history taking important to raise suspicion for NSTEMI

Localization by STT-wave changes in specific leads not valid

Evolving STT-wave changes may include:
- Downward ST depression (common)
- T-wave inversion (common)
- NO Q-wave development (submural vs transmural)
NSTEMI (Troponin 0.09 → 13.2)

Pacing
- Atrial, ventricular, or both
  - Pacer spikes may be very small
  - Can easily be overlooked
  - Pacer spike should be followed by either a Pwave or QRS
- Pacer lead in R ventricle creates LBBB pattern
- Biventricular pacing generally creates RBBB pattern
- Fusion beats
  - Pacer doesn’t recognize normal beats and fires anyways creating unnecessary spikes
- Non-Capture
  - Look for oddly placed spikes
  - Pacemaker spike but no response from the heart

Atrial Pacing
Resources

- healio.com/cardiology/learn-the-heart
- lifeinthefastlane.com/ecg-library/
- ecguru.com/
- ecgcourse.com
- hqmeded-ecg.blogspot.com
- ecg.uth.edu
- ecglibrary.com/ecghome/
- ems12lead.com/
- unp.edu/~lkravitz/EKG/ekg