

# EKG Notes

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# Methods for Reading

## *The Only EKG Book You'll Ever Need*

### **Data gathering**

1. Standardization: check the standardization mark (10 mm high = 1 mV), paper speed
2. Heart rate
3. Intervals: duration of PR interval, QT interval, QRS complex
4. Axis: P waves, QRS complexes, T waves

### **Diagnoses**

5. Rhythm
  - Normal P waves
  - QRS complexes wide or narrow
  - Relationship between P waves and QRS complexes
  - Regular or irregular
6. AV block
7. Bundle branch block or hemiblock
8. Preexcitation
9. Enlargement and hypertrophy
10. Coronary artery disease: Q waves and ST segment and T wave changes
11. Utter confusion: Is there anything you don't understand?

## Dr. Wyatt

### 1. Rate

- Atrial (P waves)
- Ventricular (QRS)

### 2. Rhythm

- Fast vs. slow
- Regular vs. irregular
- P waves present: atrial vs. junctional vs. idioventricular
- P upright in lead II (sinus)?
- All P waves with same morphology?
- All Ps followed by QRS and all QRS preceded by P?
- QRS narrow vs. wide
- Dropped beats/extra beats/escape beats?

	Narrow	Wide
	SVT	
	Paroxysmal atrial tachycardia	
	Paroxysmal junctional tachycardia	VTach
–	AFlutter with fixed block	SVT with aberrancy
	AVRT/AVNRT	
	AFib	
	Wandering pacemaker/MAT	AFib with aberrancy
	AFlutter with variable block	

### 3. Intervals

- PR: beginning of P to beginning of QRS
  - Normal: 3–5 small boxes (0.12–0.2 sec)
  - Assess for AV blocks
    - ▷ 1°: > 0.2 sec
    - ▷ 2°: Mobitz I, II
    - ▷ 3°: Complete
- QRS
  - Normal: < 3 small boxes (0.12 sec)
  - Assess for BBBs
    - ▷ RBBB: RSR' in V1/V2
    - ▷ LBBB: R-R' in V5/V6
    - ▷ TCA overdose
- QT: beginning of Q to end of T
  - Normal: <  $\frac{1}{2}$  R-R
  - Normal QTc: < 0.42 sec
  - Long: hypo-Mg, hypo-Ca, congenital, medications, TCA overdose

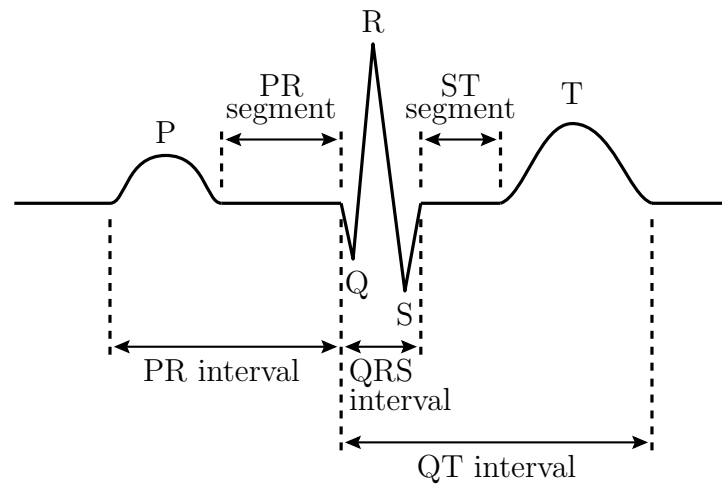
- Prolongation  $\rightarrow$  torsades de pointes
- 4. Axis
  - Normal:  $(-30^\circ)$ – $(90^\circ)$
  - Thumb method
    - L thumb is lead I
    - R thumb is aVF
    - Up, up  $\rightarrow$  normal axis
    - Up, down  $\rightarrow$  LAD (if lead II is down)
    - Down, up  $\rightarrow$  RAD
    - Down, down  $\rightarrow$  extreme AD
- 5. Hypertrophy
- 6. Ischemia
  - Q pathologic if:
    - $> 1$  small box (0.04 sec) wide
    - $> \frac{1}{3}$  of R wave deep
  - ST elevation/depression  $\rightarrow$  injury
  - T inversion  $\rightarrow$  ischemia
    - II, III, aVF  $\rightarrow$  inferior
    - V1–V4  $\rightarrow$  anterior/septal
      - $\triangleright$  ST depression in V1–V2  $\rightarrow$  posterior
    - I, aVL, V5–V6  $\rightarrow$  lateral

**Dr. Ortiz**

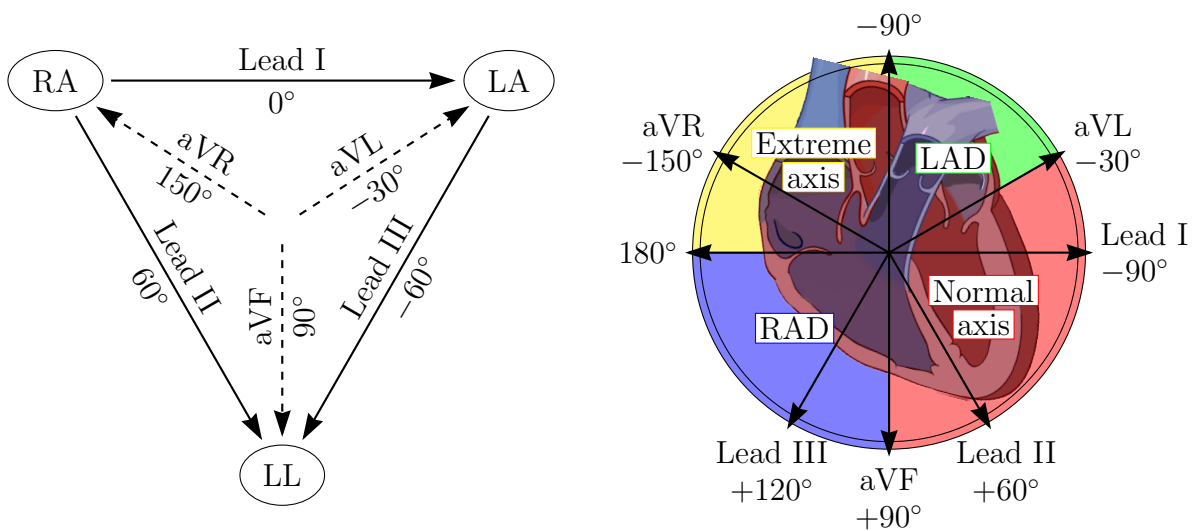
1.
  - Demographics: name, number, date
  - Calibration (looks like Roman numeral **I**)
    - Vertically: 10 mm = 1 mV
    - Horizontally: 1 small box = 0.04 sec, 1 large box = 0.2 sec
    - Paper speed: 25 mm/sec
2. Rhythm strip (lead **II**,  $\pm$  V1 and V5)
  - Regularity?
  - Funny beats?
  - P wave: completely positive (sinus) vs. “m”-shaped (LAE) vs. peak (RAE), negative component (not sinus) vs. multiple or irregular (AFib) vs. regular and saw-tooth (AFlutter)
  - Regular groups of P-QRS-T?
  - PR interval (including P)
    - < 3 small boxes (< 120 msec)  $\rightarrow$  accessory pathway or low atrial rhythm
    - 3–5 small boxes (120–200 msec)  $\rightarrow$  normal
    - > 5 small boxes (> 200 msec)  $\rightarrow$  1° AV block
  - QRS: pathologic Q?
  - QT: QTc
3. QRS (step **3**, **3** letters, **3** foci with **3** sub-foci)
  - Axis: normal ((+90°)–(–30°)), left axis, right axis
    - Leads I and II ( $I + II = \mathbf{3}$ )
  - Width: normal (< **3** small boxes), RBBB, LBBB
    - Wide  $\rightarrow$  look at V1 (V5 will be opposite)
      - ▷ Up with R'  $\rightarrow$  RBBB
      - ▷ Down with large S  $\rightarrow$  LBBB
  - Height: low voltage, normal, L/RVH
4. Last **4** things
  - Rate
  - ST
  - T: upright in all leads but aVR
  - Infarcts (old)
    - Anterior and septal (V1–V4): poor R wave progression and/or pathologic Q  $\rightarrow$  infarct
    - Lateral (aVL, I, V5, V6): pathologic Q  $\rightarrow$  infarct
    - Inferior: pathologic Q in one of the following combinations:
      - ▷ II and III
      - ▷ II and aVF
      - ▷ III and aVF
      - ▷ II, III, and aVF

## Basics

- Anterior: V1, V2, V3, V4
- Inferior: II, III, aVF
- Left lateral: I, aVL, V5, V6
- Right: aVR, V1
- P: atrial depolarization
- QRS: ventricular depolarization
- T: ventricular repolarization



## Axes



## Normal Values

- PR: 3–5 small boxes (0.12–0.20 sec)
- QRS < 3 small boxes (0.12 sec)
- QT  $\leq \frac{1}{2}$  R-R
- QTc  $\leq 0.42$  sec
  - $QTc = \frac{QT}{\sqrt{R-R}}$  where R-R = length of cardiac cycle (time between R waves)
- Axis: (-30°)–(+90°)

## Inherent Pacing Rates

- Sinus: 60–100
- Atrial ectopic: 60–80
- AV/junctional: 40–60
- Ventricular: 20–40

## Enlargement and Hypertrophy

- Right atrial enlargement (first part of P wave)
  - P waves with an amplitude exceeding 2.5 mm in the inferior leads
  - No change in the duration of the P wave
  - Possible right axis deviation of the P wave
- Left atrial enlargement (last part of P wave)
  - The amplitude of the terminal (negative) component of the P wave may be increased and must descend at least 1 mm below the isoelectric line in lead V1
  - The duration of the P wave is increased, and the terminal (negative) portion of the P wave must be at least 1 small block (0.04 second) in width
  - No significant axis deviation is seen because the left atrium is normally electrically dominant
- Right ventricular hypertrophy
  - Right axis deviation is present, with the QRS axis exceeding +100°
  - The R wave is larger than the S wave in V1, whereas the S wave is larger than the R wave in V6
- Left ventricular hypertrophy
  - The R wave in V5 or V6 plus the S wave in V1 or V2 exceeds 35 mm
  - The R wave in aVL is 11 mm
  - The R wave in aVL plus the S wave in V3 exceeds 20 in women and 28 in men
  - Left axis deviation exceeding  $-15^\circ$  is also often present

## Arrhythmias

1. Sinus arrhythmias
2. Ectopic rhythms
3. Reentrant arrhythmias
4. Conduction blocks
5. Preexcitation syndromes

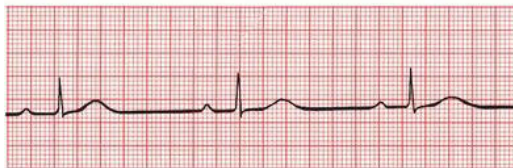
### Sinus Arrhythmias



Normal sinus rhythm



Sinus tachycardia



Sinus bradycardia




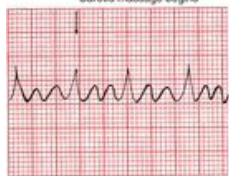
Sinus arrest or exit block






Sinus arrest or exit block with junctional escape

### Supraventricular Arrhythmias

Narrow QRS, except in the case of aberrancy

Paroxysmal Supraventricular Tachycardia (PSVT)	Regular	
	P waves are retrograde if visible	
Atrial Flutter	Rate: 150–250 bpm	
	Carotid massage: slows or terminates	
	Regular, saw-toothed	
	2:1, 3:1, 4:1, etc., block	
	Atrial rate: 250–350 bpm	
	Ventricular rate: one-half, one-third, one-quarter, etc., of atrial rate	
	Carotid massage: increases block	

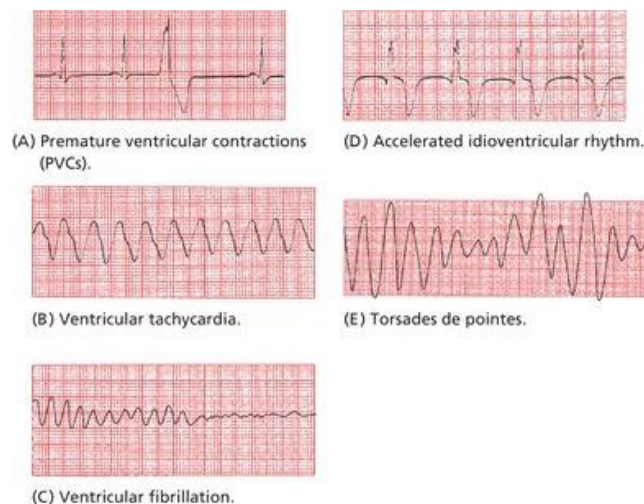


Atrial Fibrillation	Irregular Undulating baseline Atrial rate: 350–500 bpm Ventricular rate: variable Carotid massage: may slow ventricular rate	
Multifocal Atrial Tachycardia (MAT), Wandering Atrial Pacemakers	Irregular At least three different P-wave morphologies Rate: 100–200 bpm; sometimes < 100 bpm Carotid massage: no effect	
Paroxysmal Atrial Tachycardia (PAT)	Regular Rate: 100–200 bpm Characteristic warm-up period in the automatic form Carotid massage: no effect, or only mild slowing	

Aberrancy: atrial premature beat occurs before Purkinje fibers fully repolarize, so only part of the signal conducts quickly, and the rest travels slowly

## Ventricular Arrhythmias

Wide QRS



## PVCs

Red flags (increased chance of life-threatening arrhythmia)

- Frequent PVCs
- Consecutive PVCs (esp., three or more in a row)
- Multiform PVCs
- “R-on-T” phenomenon: PVCs falling on the previous T wave
- PVC in the setting of an acute myocardial infarction

**Ventricular Tachycardia:** three or more PVCs in a row

**Ventricular Fibrillation:** almost exclusively in dying hearts

## Conduction Blocks

- Sinus node block: within the sinus node
- AV block: between the sinus node and the terminal Purkinje fibers
  - 1°: PR interval  $> 0.2$  seconds
  - 2°, Mobitz type I (Wenckebach): Progressive lengthening of the PR interval until a P wave is not followed by a QRS complex (a “dropped beat”), documented as the ratio of P waves to QRS complexes (e.g., 4:3)
  - 2°, Mobitz type II: Constant PR interval with a P wave that is not followed by a QRS complex (a “dropped beat”) every  $x$  cycles
  - 3°(complete): Complete AV dissociation with ventricular rate slower than atrial rate
- Bundle branch block
  - Right bundle branch block
    - ▷ Wide QRS ( $> 0.12$  seconds)
    - ▷ RSR' (rabbit ears) in V1, V2 with ST depression and T wave inversion
    - ▷ Reciprocal deep S waves in I, aVL, V5, V6
  - Left bundle branch block
    - ▷ Wide QRS ( $> 0.12$  seconds)
    - ▷ I, aVL, V5, V6 show prolongation of rise of R waves (broad or notched) with ST depression and T wave inversion
    - ▷ Reciprocal deep, broad S waves in V1, V2
  - Hemiblock: block of one of the three fascicles of the left bundle branch
    - ▷ Axis deviation
    - ▷ Normal QRS
  - Bifascicular block: RBBB + hemiblock
  - Incomplete bundle branch block: RBBB or LBBB appearance of tracing, but QRS 0.10–0.12 seconds

## Preexcitation Syndromes (AVRTs)

Accessory pathways bypass the AV node, causing the ventricles to contract too early

- Wolff–Parkinson–White: bundle of Kent connects an atrium to a ventricle
  - $PR < 0.12$  seconds
  - Wide QRS ( $> 0.1$  second)
  - Delta wave: slurred initial upstroke of the QRS
- Lown–Ganong–Levine: *intranodal* James fiber bypasses delay of AV node
  - $PR < 0.12$  seconds
  - Narrow QRS
  - No delta wave

## Myocardial Ischemia and Infarction

Evolution of EKG during acute MI:

1. T wave peaking followed by symmetric T wave inversion (indicative of ischemia, nonspecific for MI)
  2. ST segment elevation, merged with the T wave (indicative of myocardial injury)
  3. The appearance of new Q waves ( $> \frac{1}{3}$  height of R wave,  $> 0.04$  seconds)
- Reciprocal changes

## Homeostatic Disturbances

### Electrolyte Disturbances

- Hyperkalemia (in order of increasing  $[K^+]$ )
  1. Diffuse peaked T waves
  2. PR prolongation
  3. P wave flattens and disappears
  4. QRS widens and merges with T wave
  5. Sine wave
- Hypokalemia
  - ST segment depression
  - Flattening of the T wave with prolongation of the QT interval
  - Appearance of a U wave
- Hypercalcemia
  - QT shortening
- Hypocalcemia
  - QT prolongation

## Hypothermia

- Slowing: sinus bradycardia, prolongation of all segments and intervals
- Distinctive ST segment elevation: abrupt ascent right at the J point, followed by equally sudden plunge back to baseline (“J/Osborn wave”)
- Arrhythmias, esp., slow atrial fibrillation
- Muscle tremor artifact due to shivering

## Drug Effects

- Digitalis
  - Therapeutic levels (expected changes)
    - ▷ ST segment depression (asymmetric) with gradual downslope, merged with R wave
    - ▷ T wave flattening or inversion
  - Toxic levels
    - ▷ Sinus node suppression: exit block or complete suppression
    - ▷ AV block (any)
    - ▷ Tachyarrhythmia (any)
- Medications that prolong the QT interval
  - Antiarrhythmics: sotalol, quinidine, procainamide, disopyramide, amiodarone, dofetilide, dronedarone
  - Antibiotics: macrolides (e.g., erythromycin, clarithromycin, azithromycin) and fluoroquinolones (e.g., levofloxacin and ciprofloxacin)
  - Antifungals (e.g., ketoconazole)
  - Nonsedating antihistamines (e.g., astemizole, terfenadine)
  - Psychotropic drugs: antipsychotics (e.g., haloperidol, phenothiazines), TCAs (e.g., amitriptyline), SSRIs (e.g., citalopram, fluoxetine), and methadone

## Other Cardiac Disorders

- Pericarditis
  - Diffuse ST segment elevation
  - Diffuse T wave flattening or inversion (after ST returns to baseline)
- Pericardial effusion
  - Low voltage in all leads
  - If large: electrical alternans (axis varies beat-to-beat due to rotation of floating heart)
- Hypertrophic obstructive cardiomyopathy
  - Left ventricular hypertrophy

- Left axis deviation
- Q waves laterally or inferiorly
- Myocarditis
  - Conduction blocks (esp., BBB or hemiblock)

## Pulmonary Disorders

- COPD
  - Low voltage (precordial leads)
  - Right axis deviation (precordial leads) due to expanded lungs
  - Poor R wave progression (precordial leads)
- Cor pulmonale
  - Right atrial enlargement
  - Right ventricular hypertrophy
  - Repolarization abnormalities
- Acute massive PE
  - Right ventricular hypertrophy
  - Repolarization abnormalities
  - RBBB
  - S1Q3 pattern: large S wave in lead I and a deep Q wave in lead III
  - Arrhythmia

## Other Disorders

- CNS (e.g., subarachnoid bleed or cerebral infarction)
  - Diffuse T wave inversion (symmetrical, very deep and wide)
  - U waves
  - Sinus bradycardia