An early Electrocardiograph
Einthoven's first published EKG, 1902
“I do not however imagine that the string galvanometer...is likely to find any very extensive use in the hospital”

August D. Waller, 1909
The Electrocardiogram
(ECG/EKG)

- Most Commonly Utilized Cardiovascular Lab Test
  - 100 Million Performed per Year
  - $5 Billion Cost per Year
  - Reimbursements have dropped
  - Key to Therapy for ACS/MI
  - Diagnosis of Arrhythmias
Indications For An ECG

- Chest or Epigastric Pain or Sensation
- CHF Signs or Symptoms
- Abnormal Pulse
- Hypotension
- Unexplained Weakness
- Altered Mental State (Coma, CVA)
- Drug Overdose
- Chest Trauma
- Syncope or Near Syncope
- Systemic Illness
- Metabolic Disease

Screening??
P’s and Q’s of Electrocardiography

Atrial Depolarization

Ventricular Depolarization

Ventricular Repolarization

QRS Complex

P Wave

ST Segment

U Wave

PR Interval

QRS

QT

http://medstat.med.utah.edu
RL/LL- side does not matter, place anywhere below umbilicus
The Electrocardiogram (ECG/EKG)

- Rhythms
- ST Segments
LAD 95%
LAD 0%
Post PCI
Basic Principles of ECG Interpretation

- Place electrodes correctly (??)
- Be Careful to Get Correct Data
- Consider Clinical Context/Setting
  - Chest pain? … consider ST segments
- Compare to Previous ECG
- Be Systematic
  - Rate, Rhythm, ?Pacemaker Spikes
  - QRS duration, Other intervals
  - Axis
  - Q waves
  - Pattern read
QRS Prolongation (=>120msec, 3 40 msec boxes)

- Ventricular Origin
  - PVCs
  - Ventricular Tachycardia
  - Ventricular Electronic Pacemaker
- SVT with Aberrant Conduction
- Bundle Branch Block
  - Right (rabbit ears on the right)
  - Left (rabbit ears on the left)
- WPW
- IntraVentricular Conduction Delay
Why is QRS Prolongation so important except for RBBB???

- Q waves not diagnostic
- ST Depression not diagnostic
- Possibly Ventricular Origin
- Usually High Risk
Survival Plot

Follow-up (yrs)

Survival

QRSs core

1 (<110ms): N=38,943 (1.1%)
2 (110-120ms): N=4,787 (2.6%)
3 (120-130ms): N=481 (4.6%)
4 (>130ms): N=61 (6.6%)
Rabbit Ears

Inverted T wave
RBBB
LBBB
Rabbit Ears

Inverted Twave
WPW
LAD
Criteria For Infarction Q Waves

- Equal or Greater than .04 seconds (one millimeter box horizontal width, 40 milliseconds)

- Q Wave Amplitude must be 25% or greater of following R Wave

- Pathophysiology: no muscle to generate R wave
Localization of Posterior Infarcts

Postero-inferior infarct

Occlusion of posterior inter-ventricular branch of r. coronary artery

ECG tracings from different leads:
- I
- II
- III
- aVF
- V1
- V2
- V3
- V4
- V5
- V6
Basic Principles of ECG Interpretation

- Place electrodes correctly (??)
- Be Careful to Get Correct Data
- Consider Clinical Context/Setting
  - Chest pain? … consider ST segments
- Compare to Previous ECG
- Be Systematic
  - Rate, Rhythm, ?Pacemaker Spikes
  - QRS duration, Other intervals
  - Axis
  - Q waves
  - Pattern read
Right ventricular involvement: RVH, RBBB

Left ventricular involvement: LVH, LBBB
Pattern Reading of the ECG

- **Diagonal Line Rule**
  - Box around aVR (everything inverted)
  - Line thru III, aVL, V1
  - Everything else upright

- **Parallel Line Rule**
  - R waves increase then drop off in V6
  - S waves decrease from greatest in V1
  - Rabbit ears on right side (V1-2) for RBBB, on left side for LBBB
The 5 Commandments of ECG Interpretation

• Be systematic
• Put into the clinical context
• Find an old ECG

  Watch out for bad data

• Do NOT be afraid to get help
Watch for bad data!!

“Wait! Wait! … Cancel that, I guess it says ‘helf.’”
RA/LA reversed

V1/V3 reversed
What happened?
Basic Principles of ECG Interpretation

❤ Be Systematic
❤ Rate: Fast-Normal-Slow
❤ Rhythm: Sinus, Blocks, Atrial, Ventricular
❤ Axis: Normal, Right, Left
❤ Intervals and Durations

**Intervals and Durations:**
Short ? Long ?
Intervals, segments, and durations
Intervals

- PR Interval
- QRS Duration
- QT Interval

Normal PR Interval: 0.12 - 0.20 sec

Normal QRS Duration: 0.07 - 0.10 sec

Normal QT Interval (corrected for rate or QTc): 0.440 - 0.470 sec
Intervals: Conduction System Abnormalities

- Congenital Syndromes
- Electrolyte/Metabolic Abnormalities
- Intrinsic Cardiac Disease
- Medications
- CNS Disorders
- Systemic Illnesses
Electrolyte Abnormalities and the ECG

HeartPotassium
- Hyper: tall, peaked T waves (also ischemia), atrial arrest
- Hypo: prominent U waves, low T wave

HeartCalcium
- Hyper: short QT
- Hypo: long QT (also Quinidine, ischemia)

HeartMagnesium
- Hyper: short QT interval
- Hypo: long QT interval
Long QT intervals
(>50% of the RR interval)

- Congenital
- HypoMg/CA
- anti-arrhythmics
- Myocarditis
- Hypokalemia
- Ischemia
- Phenothiazines
- Tricyclics
- CNS--Subarachnoid Hemorrhage
- Torsades des Pointes
The QT interval

❤️ Long QT
(>50% of the RR interval)
❤️ Congenital
❤️ Hypomagnesium
❤️ Hypocalcemia
❤️ IA anti-arrhythmics
❤️ Ischemia
❤️ Torsades de Pointes
❤️ Phenothiazines
❤️ Tricyclics
❤️ Myocarditis
❤️ Hypokalemic

❤️ Short QT
❤️ Hypercalcemia
❤️ Hypermagnesium
❤️ Hyperkalemia
❤️ Digoxin
❤️ Thyrotoxicosis
“Mr. Osborne, may I be excused? My brain is full.”
Other Patterns

• Atrial Abnormalities
• R>S V1

http://medstat.med.utah.edu
Normal

Left atrial abnormality (LAA)

Right atrial abnormality (RAA)
Atrial Abnormalities

❤️ Right (P-pulmonale)
  ❤️ Right atrium right heart border, first hump
  ❤️ tall, peaked in inferior leads (>2.5mm)

❤️ Left (P-mitrale)
  ❤️ Left atrium posterior, second hump
  ❤️ broad P wave (>120msec) with negative component in V1-2 (> 1mm x 1mm)

Normal=2.5x2.5 boxes (100msec x .25Mv)
P pulmonale or RAA
P mitrale or LAA
a. LAA (-), P duration <120ms  n=33,827 (1.3%)
b. LAA (-), P duration >120ms  n=4,476 (2.0%)
c. LAA (+), P duration <120ms  n=1,273 (3.5%)
d. LAA (+), P duration >120ms  n=407 (4.7%)