Learning Objectives

- Explain the generation and conduction of the electrical impulse in cardiac tissue.
- Analyze the components of a normal ECG.
- Identify common dysrhythmias on an ECG monitor.

Introduction to Electrocardiography

Chemical Basis for Electrical Activity

Resting potential - cell interior negative, in relation to exterior

Electrochemical Basis For ECG

Na+, Ca++ channels open ==> influx of + ==> negative charge external cell ==> current ==> conduction & contraction

Electrochemical Basis For ECG

Refractory period - K+ enters cell & restores action potential
Conduction Pathway

Click for animation of cardiac cycle

Pacemaker Cells
- Automatic rates for different sites

<table>
<thead>
<tr>
<th>Pacemaker Site</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA Node</td>
<td>60 - 100/min</td>
</tr>
<tr>
<td>AV Node</td>
<td>40 - 60/min</td>
</tr>
<tr>
<td>Bundle branches</td>
<td>30 - 40/min</td>
</tr>
</tbody>
</table>

Definitions
- Ectopic beats arise from fiber or group of fibers outside the SA node; e.g., irritable ventricular tissue.
- Escape beats originate from alternate sites when higher ones are depressed; e.g., junctional beats when the SA node is suppressed.

ECG Waves
- Depolarization of atria
- Repolarization of ventricles
- Depolarization of ventricles

FYI - Click to see another wave
http://www.thoughtequity.com/video/clip/1B02864_0008.do

ECG Wave Intervals
- PR interval: 0.12 - 0.20 sec.
ECG Wave Intervals

R

P

QRS

(0.08 - 0.12 sec.)

ST segment should be flat

ECG Leads and Waves

direction of depolarization

upward deflection of P, QRS, T

downward deflection of P, QRS, T

ECG Electrode Placement

Lead 1

+ under L clavicle

- under R clavicle

Lead 2

+ under L pectoral

- under R clavicle
**ECG Electrode Placement**

- **Lead 3**
  - + under L pectoral
  - - under L clavicle

- **MCL**
  - + R sternum 4th intercostal
  - - under L clavicle

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**Rhythm Analysis**

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**ECG Analysis Steps**

- **Rate** - five large boxes = 1.0 sec. @ paper speed = 25 mm/sec.
  - six second tracing & multiply R waves by ten
  - count large squares between R waves and divide into 300

- **Regularity** - compare distances between QRS complexes with calipers or marked scrap paper

Click to see ECG caliper application

http://1.bp.blogspot.com/_7JDOLPHMD2FDGgT9wP_5lUAAAAAAAAXYIcOVoLgypedEmD6e4g8/Pictures3.png
**ECG Analysis Steps**

**P wave**
- absent ==> 
  - beats are ectopic
  - rate is excessive
  - atrial fibrillation
  - tall or wide ==> atrial enlargement
  - inverted ==> 
    - junctional rhythm
    - dextrocardia
    - lead reversal

**PR interval**
- prolonged (>0.2 sec) ==> AV block
- short (<0.12 sec) ==> Wolff-Parkinson-White (WPW) syndrome

**PR relationship**
- more P than QRS ==> 
  - AV block
  - atrial flutter with block
- absent P wave ==> 
  - hidden by QRS complex
  - ectopic rhythm
  - fibrillation

**QRS complex**
- interval > 0.12 ==> 
  - bundle branch block (notched QRS)
  - hyperkalemia
  - ventricular ectopic beat

**ST segment- elevation ==>**
- evolving transmural infarction

**ST segment depression ==>**
- ischemia
- severe hypokalemia
- digitoxicity
**ECG Analysis Steps**

- T wave - should be same direction as QRS
  - inversion ==› evolving infarction
  - peaked ==› hyperkalemia

Click to see T wave inversion
http://www.bmj.com/highwire/filestream/412208/field_highwire_fragment_image_l/0.jpg

Click to see peaked T waves
http://ecg.bidmc.harvard.edu/mavendata/images/case36900x400.gif

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**Dysrhythmias**

- **Sinus Dysrhythmias**
  - **Sinus bradycardia**
    - beats originate in SA node
    - normal wave configurations
    - rate < 60/min

Click for video of sinus bradycardia
http://www.youtube.com/watch?v=mVGikydo0GM&feature=fvsr

- **Sinus tachycardia**
  - beats originate in SA node
  - normal wave configurations
  - rate > 100/min

Click for video of sinus tachycardia
http://www.youtube.com/watch?v=vcKXrzLrQOCc

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**Sinus Dysrhythmias**

- **Sinus dysrhythmia**
  - beats originate in SA node
  - normal wave configurations
  - irregular rhythm with breathing

Click for video of sinus dysrhythmia
http://www.youtube.com/watch?v=kJEeKHTakI

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Interpret, with consideration to:
- medical history
- general clinical status
- electrolyte balance
- medications
- artifacts
- equipment calibration, adjustment and application to patient
**Atrial Dysrhythmias**

**Paroxysmal atrial tachycardia** - ectopic atrial focus initiates beats
- sudden onset, rate >150/min
- spontaneous termination
- type of PSVT

Click to see PAT
http://www.mceu.com/ekg/pat.gif

**Atrial Dysrhythmias**

**Atrial tachycardia**

Click for video of atrial tachycardia
http://www.youtube.com/watch?v=9RNhr36KIW0

**Atrial Dysrhythmias**

**Atrial flutter**
- sawtooth atrial waves
- associated with pulmonary disease
- promotes thrombus formation
- atrial rate 180-300/min
- usually four atrial waves per QRS

Click for video of atrial flutter
http://www.youtube.com/watch?v=ZlAcYRThLJ8&feature=related

**Atrial Dysrhythmias**

**Atrial flutter**

sawtooth p waves

**Atrial Dysrhythmias**

**Atrial fibrillation**
- non-discernible P waves
- promotes thrombus formation

Click for video of atrial fibrillation
http://www.youtube.com/watch?v=R-Z_SSsVBJA&feature=related

**Atrial Dysrhythmias**

**Premature atrial complex (PAC)**
- normal beat inserted between other beats
- normal waves and configurations

PAC
Junctional (Nodal) Dysrhythmias

- Junctional bradycardia
  - SA node suppression
  - absent P wave

Click for video of junctional bradycardia
http://www.youtube.com/watch?v=uv4lrSNGsdo&feature=related

- Junctional tachycardia
  - causes:
    - digitalis toxicity
    - recent cardiac surgery
    - acute myocardial infarction,
    - medications; e.g., beta adrenergics
  - P waves absent, inverted, after QRS

Click for video of junctional tachycardia
http://www.youtube.com/watch?v=iPqn02sQPOQ

Junctional (Nodal) Dysrhythmias

- Premature junctional complexes
  - most common causes:
    - heart disease
    - digitalis toxicity
  - P wave - inverted, absent, after QRS

Click for video of PJCs
http://www.youtube.com/watch?v=nDC3puqOjMA

Ventricular dysrhythmias

- Premature ventricular complexes (PVCs)
  - ectopic beats originate in ventricle
  - P wave is absent
  - wide QRS complex
  - compensatory pause before next regular beat

PVCs

- unifocal- similar configurations ==> one originating site
- multifocal- variable configurations ==> more than one originating site

Unifocal PVCs

Click for video of unifocal PVCs
http://www.youtube.com/watch?v=PWebMp4Qg38
Multifocal PVCs

PVC categories

- Frequency
  - isolated
  - every third- trigeminy
  - every other- bigeminy
  - couplet = two, triplet = three
  - every- ventricular tachycardia

Click for video of bigeminy
http://www.youtube.com/watch?v=7n80ejhnt2g&feature=fvw
Click for video of bijiminy
http://www.youtube.com/watch?v=IJCKb044mu4&feature=related

Couplet PVCs

PVCs - frequency

- increased frequency ==> increased risk for R on T ==> VT

Click for strip of R on T
Click for video of R on T
http://www.youtube.com/watch?v=dyb30hJnpTM

Ventricular tachycardia

- All beats originate in ventricle
- Wide QRS complexes
- P waves are absent
- Torsades des pointes- type of VT
  - caused by hypomagnesia
  - common in alcoholics
  - no response to defibrillation - must restore Mg++

Click for video of VT
http://www.youtube.com/watch?v=rHCD2iXNfMw&feature=related
Torsades des pointes
- VT with wandering baseline

Ventricular fibrillation (VF)
- Rapid, irregular rhythm
- Coarse-to-fine complexes

Idioventricular rhythm
- Failure of all upper pacemakers
- Rate 20-40/min
  - Absent P wave
  - Widened QRS
- Causes:
  - Myocardial ischemia/infarction
  - Pacemaker failure

Accelerated idioventricular rhythm
- Looks like VT; but, slower and non-lethal
- Causes
  - Spinal anesthesia
  - Heart disease; e.g., MI
  - Reperfusion
  - Drugs; e.g., digitalis

Agonal rhythm
- Slow, irregular rhythm
- Wide ventricular complexes
- Varying morphology
- Unsuccessful resuscitation

Heart Block
- Blockage of conduction between atria and ventricles at:
  - Lower atrial tissue
  - AV junction
  - Bundle of His
  - Bundle branches
Heart Block

- Causes
  - enhanced vagal tone
  - congenital heart defects
  - myocardial ischemia/infarction
  - congestive heart failure
  - cardiomyopathy
  - cardiac surgery
  - medications; e.g., digitalis, antidysrhythmics

First degree heart block

- benign
- PR interval > 0.20 sec.

Second degree block type I

- AKA - Wenckebach, Mobitz I
- Progressive lengthening of PR, then dropped beat

Second degree block type II

- AKA - Mobitz type II
- Constant PR intervals
- QRS dropped at fixed ratio

Third degree (complete) block

- Very slow ventricular rate
- No consistent association between P wave and QRS complex

Bundle branch block

- Conduction blocked at one of the bundle branches, left or right
- Bradycardia with wide, notched (sometimes) QRS complex

Click for video of Mobitz I
http://www.youtube.com/watch?v=muLRPg41EwI

Click for video of Mobitz II, with 3:1 block
http://www.youtube.com/watch?v=AB_yAP-WJ5o&feature=fvw

Click to see LBBB strip
http://library.med.utah.edu/kw/ecg/mml/ecg_lbbb.gif

Click for video of third degree heart block
http://www.youtube.com/watch?v=NEGnCKC0Mrk&NR=1

Click for video of sinus tachycardia with RBBB
http://www.youtube.com/watch?v=DF7c7epplJs&feature=related
Artificial Pacemakers

- Atrial pacemaker

![Pacemaker spike](image)

Artificial Pacemakers

- Atrial-ventricular pacemaker

![Pacemaker spikes](image)

Artificial Pacemakers

- Pacemaker capture failure

![QRS??](image)

Click for video of capture failure
http://www.youtube.com/watch?v=JbUFncA9NSw

Heterotopic heart transplant

- Two hearts ==> two ECG patterns

Click to see ECG and images of heterotopic heart

FYI - click to download article on heterotopic procedure
http://ats.ctsnetjournals.org/cgi/reprint/78/4/1345

Dextrocardia

- Heart located on right
- Leads should be reversed for patients with dextrocardia

Click to see ECG and chest x-ray of dextrocardia
http://www.medicmadness.com/tag/dextrocardia-ecg/

Artifacts

- Patient tremors
- Caregiver activities
- External devices
- Treacherous technician syndrome
  - reversal of leads by technician
  - most common cause of false positive diagnosis of dextrocardia

Click to see tremor artifact
http://library.med.utah.edu/kw/ecg/mml/ecg_tremor.gif
Review & Summary
- ECG trace is result of electrical conduction through heart.
- ECG comprised of waves and intervals.
- ECG leads
- Systematic analysis of ECG
  - rate
  - regularity
  - waves, intervals
FYI - ECG blog web site to bookmark
http://ecgblog.wordpress.com/

Review & Summary
- Sinus dysrhythmias
  - bradycardia
  - tachycardia
  - dysrhythmia
- Atrial dysrhythmias
  - atrial tachycardia, PAT
  - atrial flutter
  - atrial fibrillation
  - premature atrial contractions

Review & Summary
- Junctional dysrhythmias
  - junctional bradycardia
  - junctional tachycardia
  - premature junctional complex
- Ventricular dysrhythmias
  - premature ventricular contractions
  - ventricular tachycardia
  - ventricular fibrillation
  - idioventricular rhythm

Review & Summary
- Heart block - conduction defects
  - first degree
  - second degree, Mobitz I
  - second degree, Mobitz II
  - third degree (complete)
  - bundle branch
- Pacemaker beats
  - atrial
  - atrioventricular
  - failure to capture

Review & Summary
- Unusual conditions
  - heterotopic transplants
  - dextrocardia
- Artifacts
  - tremors, movements
  - TTS

Review & Summary
- Heart block - conduction defects
  - first degree
  - second degree, Mobitz I
  - second degree, Mobitz II
  - third degree (complete)
  - bundle branch
- Pacemaker beats
  - atrial
  - atrioventricular
  - failure to capture

References
- Elstun LR. Electrocardiography and cardiac monitoring, Chap 7 in Chang DW, Elstun LR, Jones AP. The multiskilled respiratory therapist: A competency-based approach 2000: FA Davis; Phila.
- Pace Symposia. ECG Simulator 2009. (source of ECG wave form graphics).