ECG Monitoring

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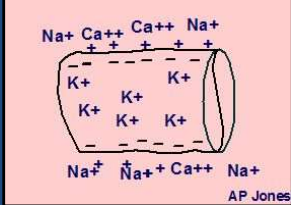**This Presentation is Approved for
1 CRCE Credit Hours**

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

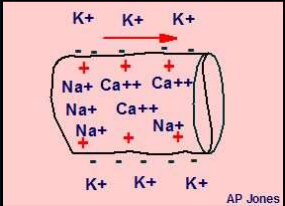## Chemical Basis for Electrical Activity

- Resting potential – cell interior negative, in relation to exterior
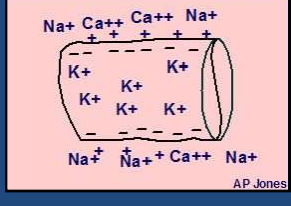

Electrochemical Basis for ECG

- Na^+, Ca^{++} channels open → influx of + → negative charge external cell → current → conduction & contraction

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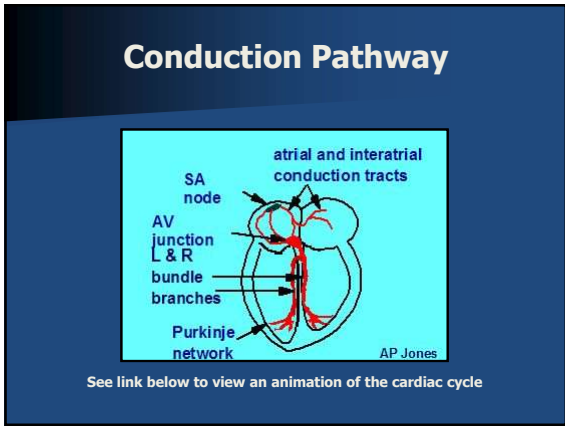
Electrochemical Basis for ECG

- Refractory period – K^+ enters cell and restores action potential

Conduction Pathway

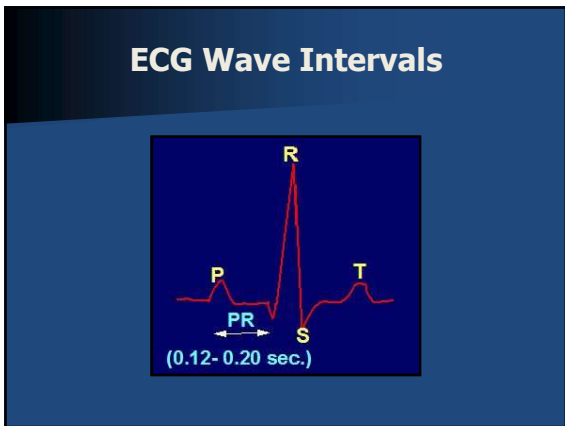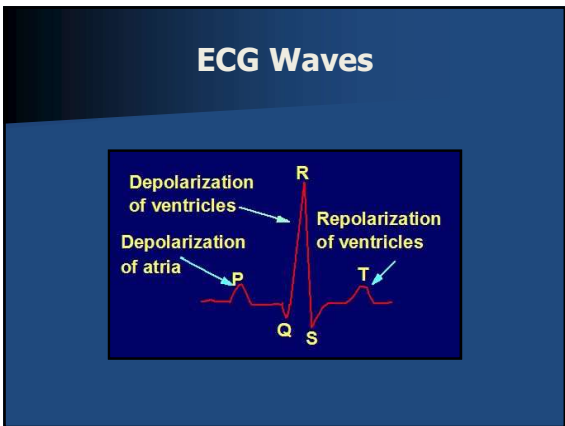## Conduction Pathway

See link below to view an animation of the cardiac cycle
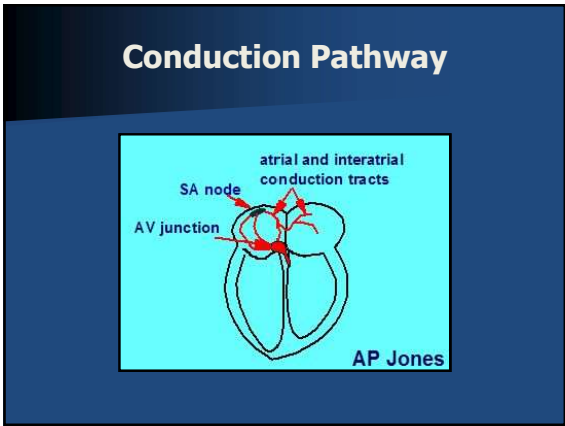
Pacemaker Cells

➢ Automatic rates for different sites

SA Node	60 - 100/min
AV Node	40 - 60/min
Bundle branches	30 - 40/min

See link below to view vintage ECG devices (scroll down)

Definitions
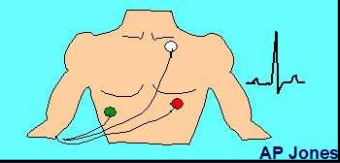
➢ Ectopic beats arise from fiber or group of fibers outside the SA node; e.g., irritable ventricular tissue.

➢ Escape beats originate from alternate sites when higher ones are depressed; e.g., junctional beats when the SA node is suppressed.

ECG Waves

ECG Wave Intervals

ECG Wave Intervals

ECG Wave Intervals

ECG Leads & Waves

ECG Leads & Waves

ECG Electrode Placement

- Lead 1
    - + under L clavicle
    - - under R clavicle

ECG Electrode Placement

- Lead 2
    - + under L pectoral
    - - under R clavicle
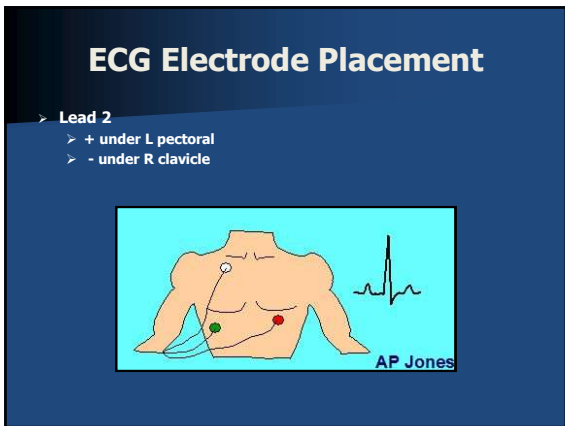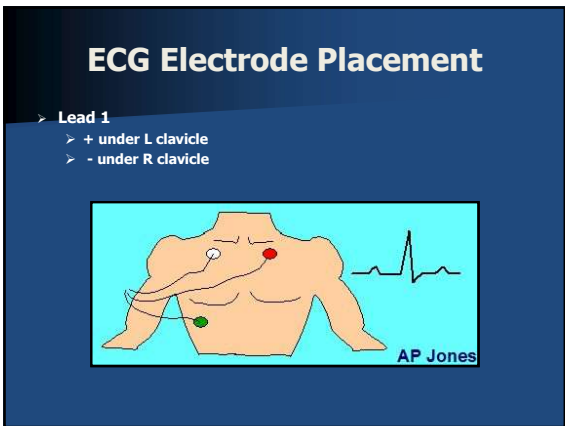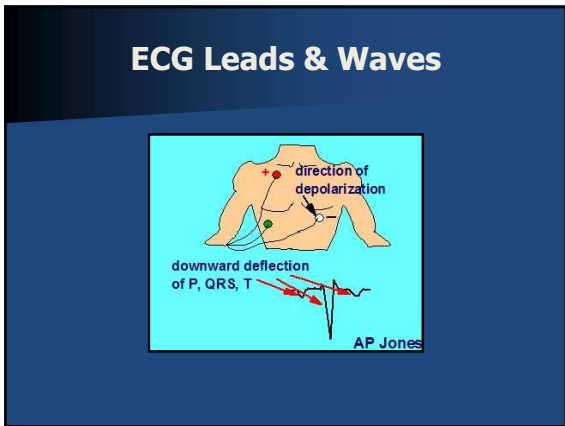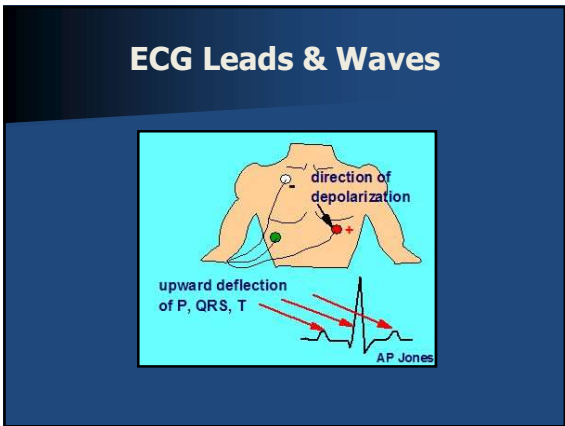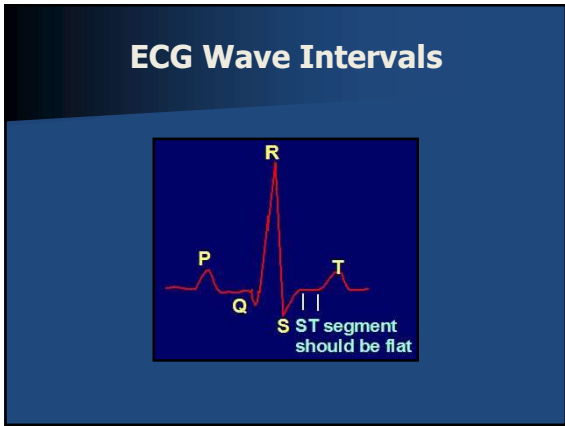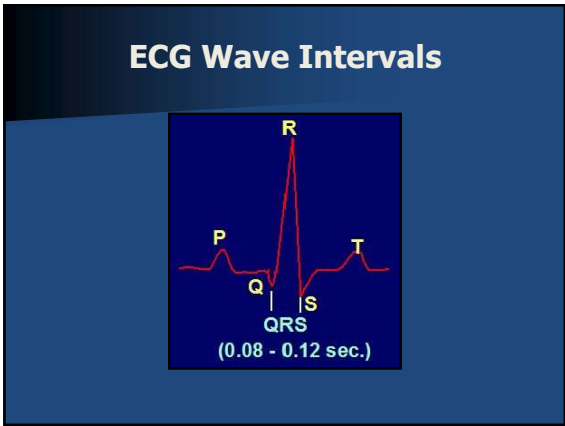
ECG Electrode Placement

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

AP Jones

ECG Electrode Placement

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

AP Jones

Rhythm Analysis
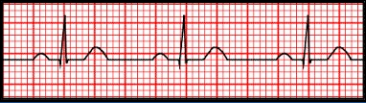
ECG Analysis Steps

- Lead – usually II or III

- Rate – 5 large boxes = 1 sec. @ paper speed of 25mm/sec

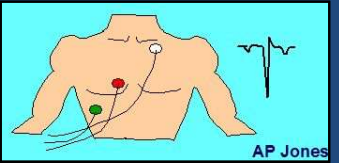Small box   5 small boxes = 1 large box

ECG Analysis Steps

- Rate – 5 large boxes = 1 sec. @ paper speed of 25mm/sec
  - Six second tracing & multiply R waves by 10
  - Count large boxes between R waves and divide into 300

HR = 300/4 or 75

ECG Analysis Steps

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

See link below to view ECG caliper application

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

ECG Analysis Steps

- PR interval
  - Prolonged (>0.2 sec) → AV block
  - Short (<0.12) → Wolff-Parkinson-White (WPW) syndrome

short P- R interval

ECG Analysis Steps

- PR relationship
  - More P than QRS →
    - AV block
    - Atrial flutter with block
  - Absent P wave →
    - Hidden by QRS complex
    - Ectopic rhythm
    - Fibrillation

ECG Analysis Steps

- QRS Complex
  - Interval > 0.12 →
    - Bundle branch block (notched QRS)
    - Hyperkalemia
    - Ventricular ectopic beat

See link below to view ECG associated with hyperkalemia

ECG Analysis Steps

- S-T segment elevation → evolving transmural infarction

S-T elevation

ECG Analysis Steps

- S-T segment depression →
  - Ischemia
  - Severe hypokalemia
  - digitoxicity

S-T depression

Up Next: Videos of S-T elevation & S-T depression

ECG Analysis Steps

- T wave – should be in the same direction as the QRS
  - Inversion → evolving infarction
  - Peaked → Hyperkalemia

See links below to view T wave inversion & peaked T waves

ECG Analysis Steps

- Interpret, with consideration to:
  - Medical history
  - General clinical status
  - Electrolyte balance
  - Medications
  - Artifacts
  - Equipment calibration, adjustment, and application to patient

Dysrhythmias

Sinus Dysrhythmias

- Sinus bradycardia
  - Beats originate in SA node
  - Normal wave configurations
  - Rate < 60/min
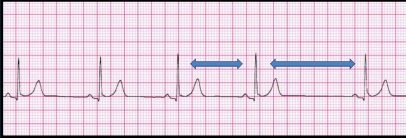

Sinus Dysrhythmias

- Sinus tachycardia
  - Beats originate in SA node
  - Normal wave configurations
  - Rate > 100/min

Sinus Dysrhythmias

- Sinus dysrhythmias
  - Beats originate in SA node
  - Normal wave configurations
  - Irregular rhythm with breathing

Up Next: Videos of sinus dysrhythmias

Atrial Dysrhythmias

- Paroxysmal atrial tachycardia – ectopic atrial focus initiates beats
  - Sudden onset, rate > 150
  - Spontaneous termination
  - Type of PSVT

See link below to view PAT

Atrial Dysrhythmias

- Atrial tachycardia

Atrial Dysrhythmias

- Atrial flutter
  - Saw tooth atrial waves
  - Associated with pulmonary disease
  - Promotes thrombus formation
  - Atrial rate 180-300/min
  - Usually 4 atrial waves per QRS

Atrial Dysrhythmias

- Atrial flutter

Saw tooth P waves

Atrial Dysrhythmias

- Atrial fibrillation
  - Non-discernible P waves
  - Promotes thrombus formation

Atrial Dysrhythmias

- Premature atrial complex (PAC)
  - Normal beat inserted between other beats
  - Normal waves and configuration

PAC

Up Next: Videos of atrial dysrhythmias

Junctional (Nodal) Dysrhythmias

- Junctional bradycardia
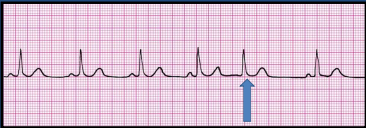 - SA node suppression
  - Absent P waves

Junctional (Nodal) Dysrhythmias

- Junctional tachycardia
  - Causes:
    - Digitalis toxicity
    - Recent cardiac surgery
    - Acute myocardial infarction
    - Medications; e.g. beta adrenergics
  - P waves absent, inverted, after QRS

Junctional (Nodal) Dysrhythmias

- Premature junctional complexes
- Most common causes:
  - Heart disease
  - Digitalis toxicity
- P waves absent, inverted, after QRS

Up Next: Videos of junctional dysrhythmias

Ventricular Dysrhythmias
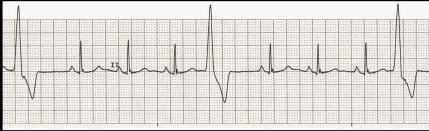
- Premature ventricular complexes (PVCs)
  - Ectoptic beats
  - P wave is absent
  - Wide QRS complex
  - Compensatory pause before next regular beat

PVCs

- Unifocal – similar configurations → one originating site

- Multifocal – variable configurations → more than one originating site

Unifocal PVCs

- Unifocal – similar configurations → one originating site

Multifocal PVCs

- Multifocal – variable configurations → more than one originating site

PVC Categories

- Frequency
  - Isolated
  - Every third – trigemini
  - Every other – bigeminy
  - Couplet = two, triplet = three
  - Every – ventricular tachycardia

Couplet PVCs

PVCs - Frequency

- Increased frequency → increased risk for R on T → V-Tach

R on T: occur on the peak of the T wave of the preceding beat
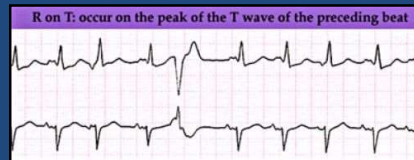
Ventricular Tachycardia

- 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^{++}

Ventricular Tachycardia
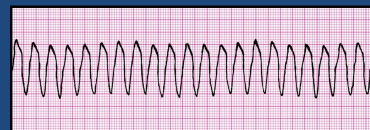
Torsades des Pointes

Wandering baseline

Ventricular Fibrillation
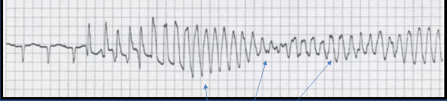
- Rapid irregular rhythm
- Course-to-fine complexes
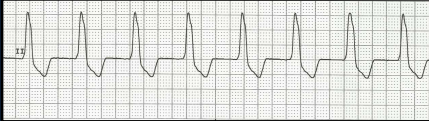
Idioventricular Rhythm

- Failure of all upper pacemakers
- Rate 20-40/min
  - Absent P waves
  - 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. M.I.
  - Reperfusion
  - Drugs, e.g. digitalis

Agonal Rhythm

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

Up Next: Videos of ventricular & agonal dysrhythmias

Heart Blocks

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

See link below to view heart blocks

Heart Blocks

- Causes:
  - Enhanced vagal tone
  - Congenital heart defects
  - Myocardia ischemia/infarction
  - Congestive heart failure
  - Cardiomyopathy
  - Cardiac surgery
  - Medications, e.g. digitalis, antidysrhythmics

First Degree Heart Block

- Benign
- P-R interval > 0.20 sec.

Second Degree Heart Block Type 1

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

Second Degree Heart Block Type 2

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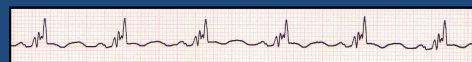- Constant PR intervals
- QRS dropped at fixed ratio

Third Degree (Complete) Heart Block

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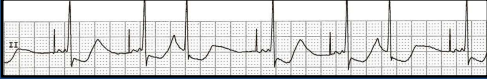- No consistent association between P wave and QRS complex

Bundle Branch Block

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

Left BBB

Artificial Pacemaker

➤ Atrial pacemaker

Artificial Pacemaker

➤ Atrial-ventricular pacemaker

Artificial Pacemaker

➤ Pacemaker capture failure

Up Next: Videos of heart blocks and failure to capture

Heterotopic Heart Transplant

➤ Two hearts → Two ECG patterns

See links below to view ECG, images, and an article on the heterotopic procedure

Dextrocardia

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

See link below to view ECG and CXR of dextrocardia

Artifacts

➤ Patient tremors
➤ Caregiver activities
➤ External devices
➤ Treacherous technician syndrome
  ➤ Reversal of leads by technician
  ➤ Most common cause of false positive diagnosis of dextrocardia

See link below to view tremor artifact

Review and Summary

- ECG is result of electrical conduction through the heart
- ECG comprised of waves and intervals
- ECG leads
- Systematic analysis of ECG
  - Rate
  - Regularity
  - Waves, intervals

Review and Summary

- Sinus Dysrhythmias
  - Bradycardia
  - Tachycardia
  - Dysrhythmias
- Atrial Dysrhythmias
  - Atrial tachycardia, PAT
  - Atrial flutter
  - Atrial fibrillation
  - Premature atrial contractions

Review and Summary

- Junctional Dysrhythmias
  - Junctional bradycardia
  - Junctional tachycardia
  - Premature junctional complex
- Ventricular Dysrhythmias
  - Premature ventricular contractions
  - Ventricular tachycardia
  - Ventricular fibrillation
  - Idioventricular rhythm

Review and 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 and Summary

- Unusual conditions
  - Heterotopic transplants
  - Dextrocardia
- Artifacts
  - Tremors, movements
  - TTS

References

- Brown KR, Jacobson S. Mastering dysrhythmias 1988: FA Davis; Phila.
- Wilkins RL, Krider SJ, Sheldon RL. Clinical assessment in respiratory care, 3rd ed. 1995 Mosby-Yearbook; St. Louis.
- 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 waveform graphics). http://www.ecgsimulator.net/