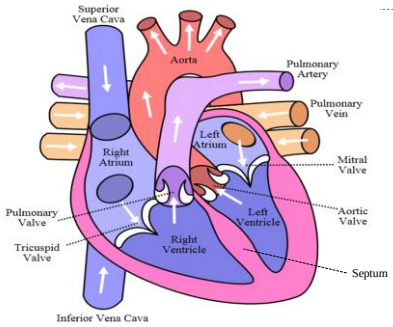
Basic Cardiac Anatomy



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http://commons.wikimedia.org/wiki/File:Diagram_of_the_human_heart_(cropped).svg

Blood Flow Through the Heart

1. Blood enters right atrium via inferior & superior vena cava
2. Right atrium contracts, sending blood through the tricuspid valve and into the right ventricle
3. Right ventricle contracts, sending blood through the pulmonic valve and to the lungs via the pulmonary artery
4. Re-oxygenated blood is returned to the left atrium via the right and left pulmonary veins
5. Left atrium contracts, sending blood through the mitral valve and into the left ventricle
6. Left ventricle contracts, sending blood through the aortic valve and to the body via the aorta

2

Fun Fact.....

- Pulmonary Artery – The ONLY artery in the body that carries de-oxygenated blood
- Pulmonary Vein – The ONLY vein in the body that carries oxygenated blood

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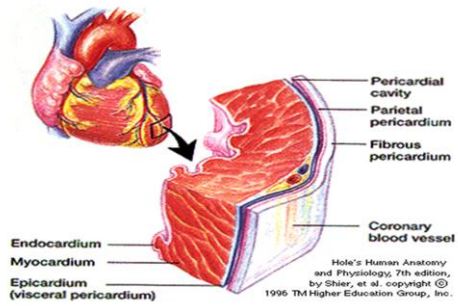
Layers of the Heart



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Layers of the Heart

- Endocardium
  - Lines inner cavities of the heart & covers heart valves
  - Continuous with the inner lining of blood vessels
  - Purkinje fibers located here; (electrical conduction system)

  Myocardium
  - Muscular layer – the pump or workhorse of the heart
  - "Time is Muscle"

  Epicardium
  - Protective outer layer of heart

  Pericardium
  - Fluid filled sac surrounding heart

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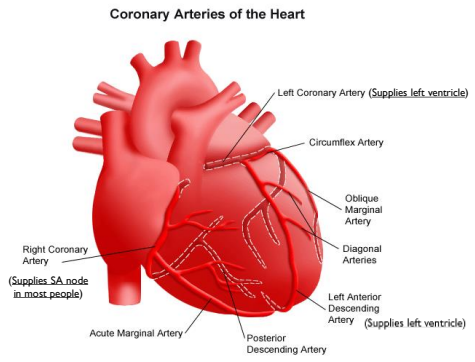

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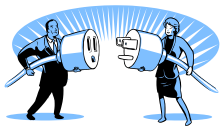
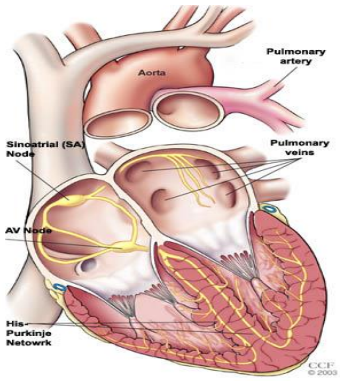
http://stanfordhospital.org/images/greystone/heartCenter/images/ei_0028.gif

What Makes the Heart Pump?

- Electrical impulses originating in the right atrium stimulate cardiac muscle contraction
- Your heart's electrical system controls all the events that occur when your heart pumps blood (that's amazing!)





Cardiac Conduction System

http://my.clevelandclinic.org/heart/heart-blood-vessels/how-does-heart-beat.aspx

Sinoatrial Node – SA Node

- Intrinsic pacemaker of the heart
- Blood supply is from the right coronary artery (RCA) in most people
- Generally fires at 60 to 100 impulses per minute (should equate to 60-100 beats per minute)
- Maximum rate 140-150 impulses per minute
- If the SA node is not firing correctly (too slow or not at all), the *next fastest* pacemaker takes over
- When the SA node fires, the atria depolarize (electrical event) then the atria contract (muscular pump event)
- **Reflected as the P wave on the EKG**

http://my.clevelandclinic.org/heart/heart-blood-vessels/how-does-heart-beat.aspx

Atrioventricular Node – AV Node

- The AV node is a cluster of cells in the center of the heart between the atria and ventricles
- Supplied by the right coronary artery (RCA)
- Acts as a gate that slows the electrical signal before it enters the ventricles, giving atria time to contract & fully empty
- This is reflected as **PR interval on the EKG**
- Surrounded by **Junctional Tissue (Junctional Node)**
  - **Inherent rate 40-60 bpm**
  - **AV node/Junctional node usually discussed interchangeably**

http://my.clevelandclinic.org/heart/heart-blood-vessels/how-does-heart-beat.aspx

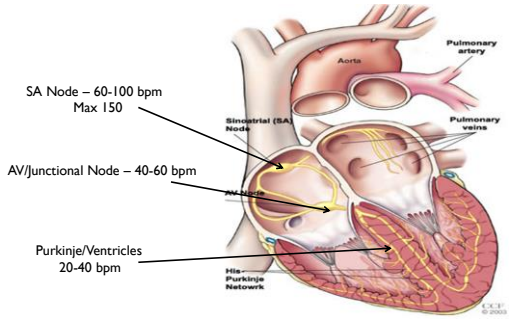
HIS – Purkinje Network

- Receives rapid conduction of impulses through the ventricles, **reflected by QRS complex on the ECG**
- Blood supply may be from either RCA, LCA or both
- Divides into the Right and Left bundle branches then the purkinjie fibers

Purkinje Fibers

- Conduct impulses rapidly through the muscle to assist in depolarization and contraction
- Can also serve as a pacemaker, discharges at an inherent rate of 20 – 40 beats per minute or even more slowly
- Are not usually activated as a pacemaker unless conduction through the bundle of His becomes blocked or a higher pacemaker such as the SA node or AV junction do not generate an impulse
- Extends form the bundle branches into the endocardium and deep into the myocardial tissue

A Second Look.....



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The Pacing Principle

- The SA node is the inherent pacemaker of the heart
- **However, the pacemaker that is firing the fastest at any given time becomes the primary pacer!**
- The further down in the conduction system, the slower the rate

SA Node	60-100 bpm
AV/Junctional Node	40-60 bpm
Purkinje fibers/ventricle	20-40 bpm

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P wave

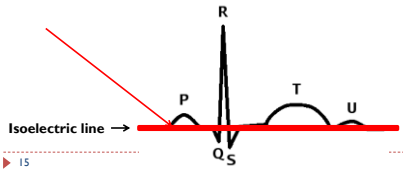
SA node fires

↓

Atria depolarize, then contract

↓

First upward deflection on the ECG



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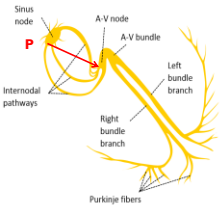
PR interval

- Beginning of P wave to beginning of QRS
- Represents the time it takes the impulse to travel through the internodal pathways in the atria & pause at the AV node



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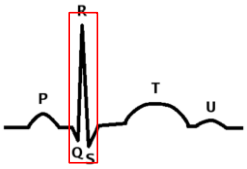
QRS complex

- Contains the Q wave, R wave & S wave
- Represents depolarization of the ventricles
- Q wave – first negative deflection after P wave
- R wave – first positive deflection after P or Q wave
- S wave – negative deflection following R wave



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So far.....

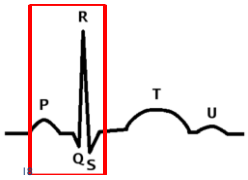
SA node fires

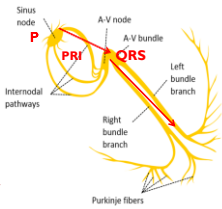
Atria depolarize, then contract

First upward deflection on the ECG (P wave)

Impulse travels through atria to AV node (PR interval)

HIS/Purkinje network releases impulse & ventricles depolarize and contract





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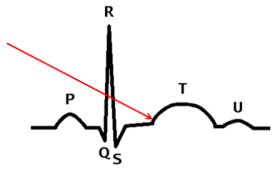
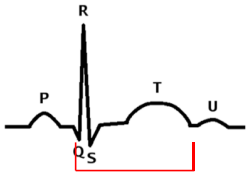
T wave

- First upward deflection after S wave
- Represents repolarization of the ventricles



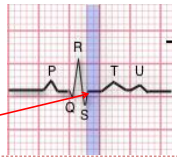
QT interval

- Beginning of Q wave to end of T wave
- Represents time it takes for impulse to travel from AV node throughout ventricles (bundle branches and purkinje fibers) and for ventricles to repolarize
- Ventricular depolarization and repolarization
- Some drugs alter QTI length and monitoring of QTI becomes very important



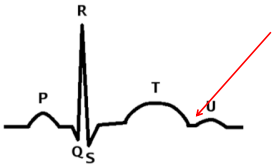
ST Segment

- Connects the QRS and the T wave
- Flat, downsloping, or depressed ST segments may indicate coronary ischemia.
- ST elevation may indicate myocardial infarction (elevation of >1mm and longer than 80 milliseconds following the J-point.)
- ST depression may be associated with hypokalemia or digitalis toxicity

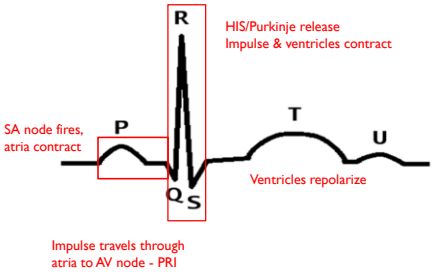


U wave

- Seen only occasionally
- Small bump after T wave
- No known clinical significance



Putting it all together....

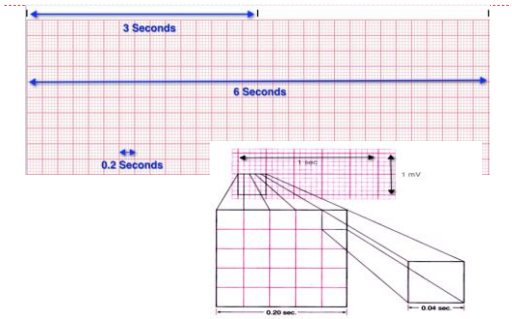


The Heart's Safety Mechanisms

- Absolute Refractory Period
  - a period in which no stimulus, no matter how strong, can cause another depolarization
  - begins with the onset of the Q wave and ends at about the peak of the T wave
- Relative Refractory Period
  - a very strong stimulus could cause a depolarization
  - a strong stimulus occurring during this period may push aside the primary pacemaker and take over pacemaker control
  - corresponds with the downslope of the T wave

http://www.andrews.edu/~schriste/Course_Notes/Anatomy__Physiology__and_Elect/anatomy__physiology__and_elect.html

Putting impulses on paper



Guiding Principles of the ECG

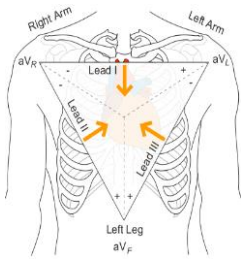
- A standard ECG is printed at 25mm per second or 25 small squares per second, making it is possible to calculate the duration of individual waves.
- The direction in which the ECG waves point indicates whether electricity is moving **towards** or **away from** a particular lead (more in a moment…..)
- Electricity always flows from negative to positive
- Electricity travels through the heart in a downward diagonal line from the right shoulder to the left lower abdomen.

ECG lead systems

- Since the heart is a 3 dimensional organ, it is helpful to look at it's electrical activity from many different angles
  - Bipolar limb leads (frontal plane):
    - •Lead I: RA (-) to LA (+) (Right Left, or lateral)
    - •Lead II: RA (-) to LL (+) (Superior Inferior)
    - •Lead III: LA (-) to LL (+) (Superior Inferior)
  - Augmented unipolar limb leads (frontal plane:
    - •Lead aVR: RA (+) to [LA & LL] (-) (Rightward)
    - •Lead aVL: LA (+) to [RA & LL] (-) (Leftward)
    - •Lead aVF: LL (+) to [RA & LA] (-) (Inferior)
  - Unipolar (+) chest leads (horizontal plane):
    - •Leads V1,V2,V3: (Posterior Anterior)
    - •Leads V4,V5,V6:(Right Left, or lateral)

Bipolar limb leads (frontal plane)

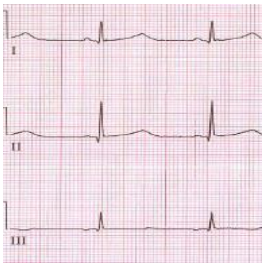
- Einthoven's Triangle

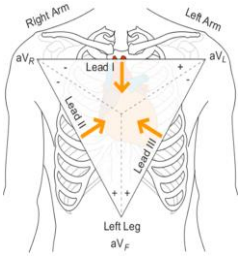


- Leads I, II and III can be represented in terms of a triangle
- Lead I + Lead III = Lead II
- In other words if you add the voltage (height) in lead I to the voltage (height) in lead III you will get the voltage of Lead II
- Lead that most closely follows the intrinsic current will be most upright (Lead II)

http://www.nottingham.ac.uk/nursing/practice/resources/cardiology/function/bipolar_leads.php

Leads I, II & III

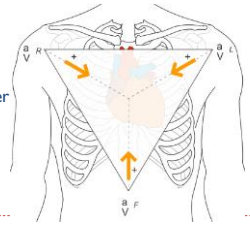




Height of I + Height of III = Height of II

Augmented Unipolar Limb Leads (frontal plane)

- The same three leads that form the standard leads also form the three unipolar leads known as the augmented leads.
- These three leads are referred to as aVR (right arm), aVL (left arm) and aVF (left leg) and also record a change in electric potential in the frontal plane.
- What's the difference?
  - Leads I, II & III use a positive & negative electrode
  - aVR, aVL & aVF use the center of the heart as the negative pole

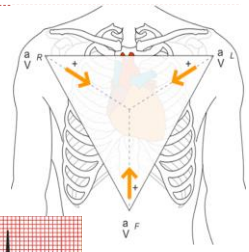


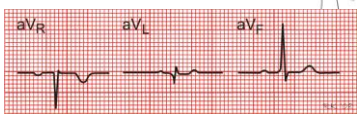
Leads aVR, aVL, aVF

aVR: looks in the exact opposite direction of current flow through the heart, therefore everything is inverted

aVL: looks perpendicular to current flow; therefore half up and half down

aVF: looks parallel to current flow; therefore most upright of unipolar leads





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Unipolar Chest Leads (V1 – V6)

- Negative pole is center of heart
- Horizontal view of heart, perpendicular to frontal leads
- V1: fourth intercostal space to the right of the sternum
- V2: fourth intercostal space to the left of the sternum
- V4: fifth intercostal space at the midclavicular line
- V3: halfway between V2 and V4
- V6: fifth intercostal space at the midaxillary line
- V5: halfway between V4 and V6
- Can only see all of these on a 12 lead ECG.

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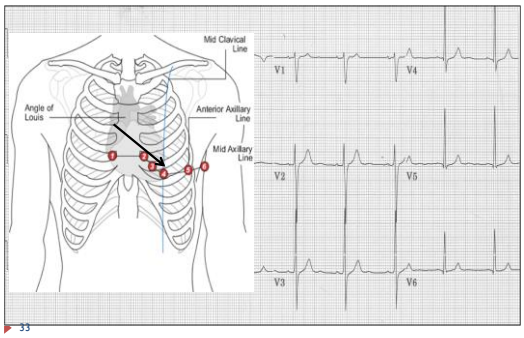
Unipolar Chest Leads (V1 – V6)



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Telemetry Monitoring Systems

- Typically 5 leads
- Skin prep matters!
  - Apply electrodes to clean skin
  - Shave if needed
  - Mild abrasion helps conductivity
  - Avoid applying electrodes directly over bone

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Identifying Cardiac Rhythms

- Systematic analysis of 5 key components
- Rate
  - Atrial: Normal 60-100 (P waves)
  - Ventricular: Normal 60-100 (QRS complexes)
- P waves
  - Morphology, consistency, frequency
- QRS complexes
  - Wide vs narrow, normal measure <0.12 (3 boxes)
- PR interval
  - Consistency; normal measure 0.12-0.20 (3-5 boxes)

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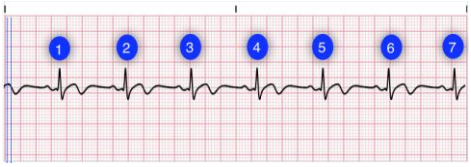
Measuring Heart Rate

- Counting method – how many QRS complexes on a 6 second strip?
  -Applies to regular & *irregular* rhythms



Rate = 70

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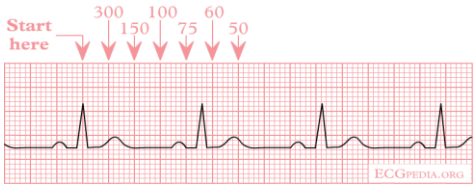
Measuring Heart Rate

- 300 rule
  - Pick a QRS complex that falls on a heavy line
  - Use 300 rule to "count" to next complex
  - 300, 150, 100, 75, 60, 50, 40, 30



http://en.ecgpedia.org/wiki/File:Ecgfreq.png

Measuring Heart Rate

- ECG ruler
- Suitable for regular rhythms

Rhythm Analysis

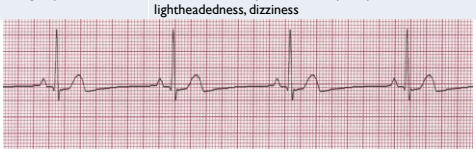
- **Atrial Rate** – is the atrial rate (P to P) regular and WNL (60-100)
- **Ventricular rate** – is the ventricular rate (R to R) regular and WNL? (60-100)
- **P waves** – is there one for each QRS and are they consistent in morphology (shape, size, direction)
- **QRS –** are they regular & consistent?

Normal Sinus Rhythm

Regularity	Regular
Atrial Rate	Regular; P to P regular with rate 60-100 bpm
Ventricular Rate	Regular; R to R regular with rate 60-100 bpm
P waves	Consistent in morphology, P wave for every QRS
QRS	Regular and consistent, measures <0.12 seconds
PR interval	Consistent, measures 0.12 to 0.20 seconds
Nursing Implications	Ensure stable hemodynamics (pulse, BP)

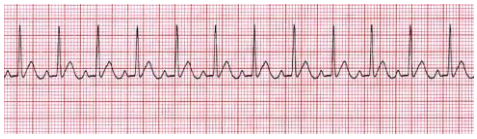
Sinus Bradycardia

Regularity	Regular
Atrial Rate	Regular; P to P regular with rate <60 bpm
Ventricular Rate	Regular; R to R regular with rate <60 bpm
P waves	Consistent in morphology, P wave for every QRS
QRS	Regular and consistent, measures <0.12 seconds
PR interval	Consistent, measures 0.12 to 0.20 seconds
Nursing Implications	Assess for hemodynamic stability; BP, pulse, lightheadedness, dizziness



Sinus Tachycardia

Regularity	Regular
Atrial Rate	Regular; P to P regular with rate 101-150 bpm
Ventricular Rate	Regular; R to R regular with rate 101-150 bpm
P waves	Consistent in morphology, P wave for every QRS
QRS	Regular and consistent, measures <0.12 seconds
PR interval	Consistent, measures 0.12 to 0.20 seconds
Nursing Implications	Monitor for s/s = dizzy, hypotensive, SOB



Sinus Arrhythmia

Regularity	Slightly irregular, rate often varies with respirations
Atrial Rate	Slightly irregular, rate often varies with respirations
Ventricular Rate	Slightly irregular, rate often varies with respirations
P waves	P wave for every QRS, morphology consistent
QRS	Regular and consistent, measures <0.12 seconds
PR interval	Consistent, measures 0.12 to 0.20 seconds
Nursing Implications	Monitor

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What is the Rhythm?

Regularity	
Atrial Rate	Regular
Ventricular Rate	Regular
P waves	Underlying – Regular, same morphology
QRS	Regular, 0.06
PR interval	Consistent, 0.18
Nursing Implications	Monitor for increased irregularity

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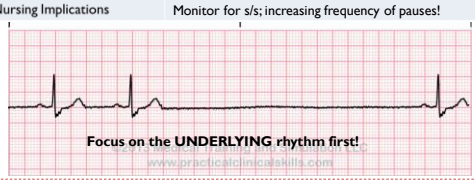
Sinus Pause/Sinus Arrest

Regularity	Underlying Regular, overall irregular
Atrial Rate	About 60 – using the 300 rule
Ventricular Rate	About 60 – using the 300 rule
P waves	Consistent, one for each QRS, same morphology
QRS	Underlying regular & consistent, 0.12
PR interval	Consistent, 0.20
Nursing Implications	Monitor for s/s; increasing frequency of pauses!



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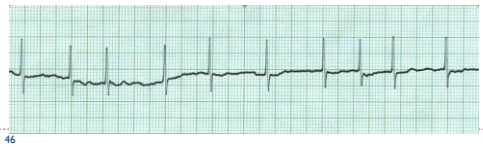
Atrial Fibrillation

Regularity	Irregular
Atrial Rate	Indeterminate; wavy baseline with no definite P waves
Ventricular Rate	Irregular; may be bradycardic, WNL, or tachycardic *Rate >100 = uncontrolled a fib*
P waves	No discernable P waves
QRS	Consistent in appearance, <0.12
PR interval	None
Nursing Implications	Prevent clots, monitor tolerance, rate



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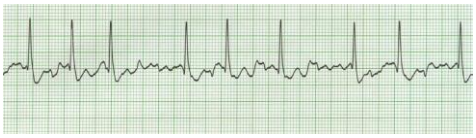
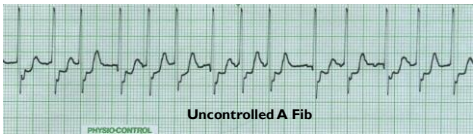
Atrial Fibrillation





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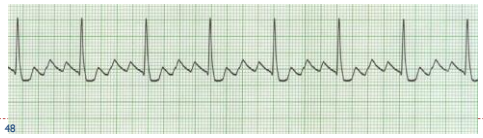
Atrial Flutter

Regularity	May be regular OR irregular
Atrial Rate	Flutter waves; often rate of 200-400
Ventricular Rate	Depends on AV conduction ratio; how many flutter waves per QRS? May be consistent or variable
P waves	Flutter waves; sawtoothed; there is ALWAYS a flutter wave burried in the QRS
QRS	Normal; <0.12
PR interval	Indeterminate
Nursing Implications	Monitor tolerance, rate



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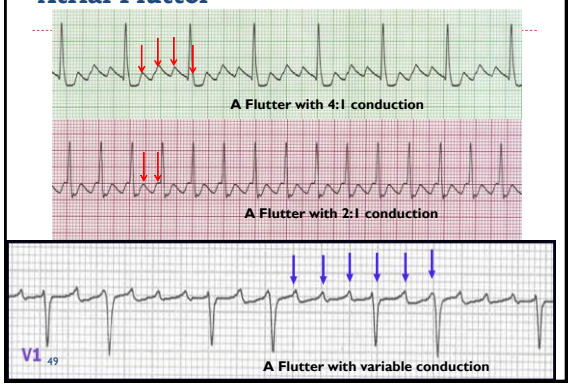
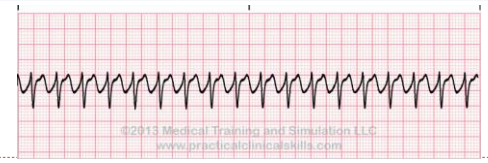
Atrial Flutter



49

Supraventricular Tachycardia (SVT)

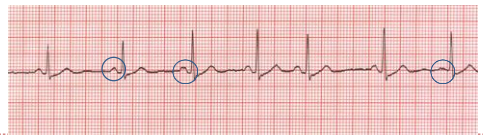
Regularity	Regular
Atrial Rate	150-250; irritable foci in atria – NOT the SA node
Ventricular Rate	150-250
P waves	Too fast to see if they are present
QRS	Normal, <0.12
PR interval	Cannot decipher
Nursing Implications	Monitor s/s – dizziness, BP, CP, SOB



50

Wandering Atrial Pacemaker (WAP)

Regularity	Slightly Irregular
Atrial Rate	Generally 60-100, irregular
Ventricular Rate	Generally 60-100
P wave	Shape/morphology varies with atrial pacemaker site
QRS	Normal, <.12
PR Interval	Varies with atrial pacemaker site but generally WNL
Nursing Implications	Monitor



51

Junctional Rhythm

Regularity	Regular
Atrial Rate	40-60 (inherent rate of junctional node)
Ventricular Rate	40-60 (inherent rate of junctional node)
P waves	May be inverted, absent, or come after the QRS
QRS	Normal, <0.12
PR interval	Short, usually less than 0.12 (decreased distance from junctional node to ventricles)
Nursing Implications	Monitor

52

Accelerated Junctional Rhythm

Regularity	Regular
Atrial Rate	60-100; accelerated rate of junctional node
Ventricular Rate	60-100; accelerated rate of junctional node
P waves	Inverted, absent or after QRS
QRS	Normal, less than 0.12
PR interval	Short, less than 0.12
Nursing Implications	Monitor

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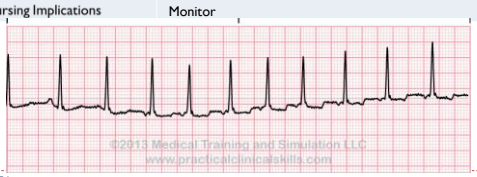
Junctional Tachycardia

Regularity	Regular
Atrial Rate	100-180
Ventricular Rate	100-180
P waves	Inverted, absent or after QRS
QRS	Less than 0.12
PR interval	Short, less than 0.12
Nursing Implications	Monitor



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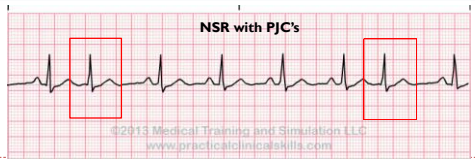
What Could it Be?

Regularity	Underlying - Regular
Atrial Rate	About 75, regular
Ventricular Rate	About 75, regular
P waves	Underlying regular, same morphology
QRS	Normal, <0.12
PR interval	Normal, 0.20
Nursing Implications	



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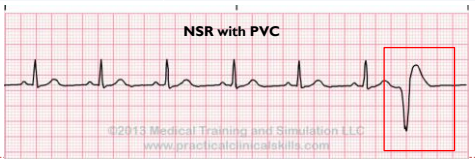
Premature Ventricular Contractions (PVC'S)

Regularity	Underlying rhythm - regular
Atrial Rate	About 70
Ventricular Rate	About 70
P waves	Regular, same morphology
QRS	Normal, <0.12
PR interval	Normal, 0.16
Nursing Implications	Monitor for increased PVC's or runs



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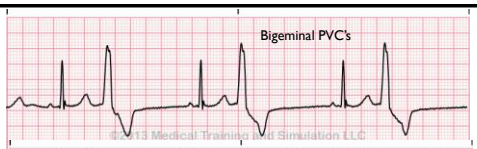

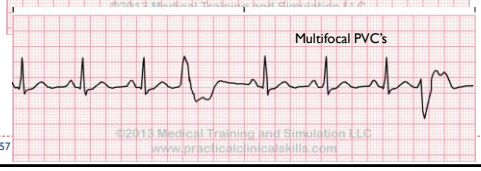

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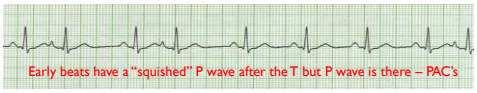
Clarifying Early Beats



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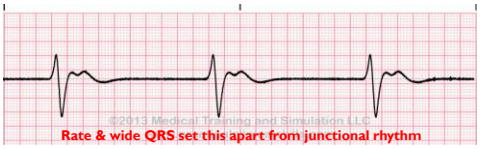
Idioventricular Rhythm (IVR)

Regularity	Regular
Atrial Rate	No P waves
Ventricular Rate	Slow – 20-40 (inherent rate of the *ventricles)*
P waves	No P waves
QRS	Wide, >0.12
PR interval	No P waves
Nursing Implications	Sometimes referred to as "dying heart"



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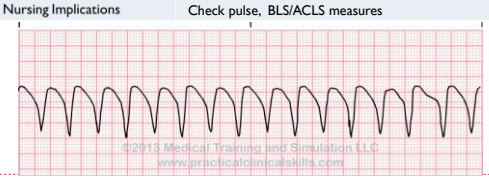
Accelerated Idioventricular (AIVR)

Regularity	Regular
Atrial Rate	No P waves
Ventricular Rate	50-110 bpm
P waves	No P waves
QRS	Wide, >0.12
PR interval	No P waves
Nursing Implications	

60

Ventricular Tachycardia

Regularity	Regular
Atrial Rate	No atrial activity
Ventricular Rate	100-300
P waves	None
QRS	Wide & bizarre
PR interval	None
Nursing Implications	Check pulse, BLS/ACLS measures



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Torsades de Pointes

Regularity	Irregular
Atrial Rate	No atrial activity
Ventricular Rate	100-300
P waves	No atrial activity
QRS	Wide & bizarre; twists upon the axis
PR interval	No atrial activity
Nursing Implications	Check pulse, BLS/ACLS measures

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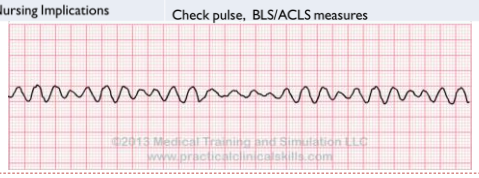
Ventricular Fibrillation

Regularity	Highly Irregular
Atrial Rate	No atrial activity
Ventricular Rate	Cannot measure; chaotic electrical activity
P waves	No atrial activity
QRS	Cannot measure; chaotic electrical activity
PR interval	No atrial activity
Nursing Implications	Check pulse, BLS/ACLS measures



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Asystole

- No discernable electrical activity
- Confirm in multiple leads!!

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	RATE	REGULARITY	PRI	QRS
NSR	60-100	Regular	.12-.20	.04-.12
Sinus Bradycardia	<60	Regular	.12-.20	.04-.12
Sinus Tachycardia	101-150	Regular	.12-.20	.04-.12
Sinus Arrhythmia	Varies	Slightly irreg	.12-.20	.04-.12
Atrial Fibrillation	Varies	Irregular	N/A	.04-.12
Atrial Flutter	Varies	Reg OR Irreg	N/A	.04-.12
SVT	>150	Regular	N/A	.04-.12
WAP	60-100	Slightly irreg	Varies slighly; P waves differ in shape	.04-.12
Junctional Accel Junctional Junctional Tach	40-60 60-100 >100	Regular	May be <.12; P waves absent/inverted/after QRS	.04-.12
IVR Accel IVR	20-40 >40	Regular	N/A	>.12
Ventricular Tach Torsades de Pointes	>100	Regular	N/A *QRS twists upon itself	>.12
Ventricular Fib	N/A	Wavy baseline	N/A	N/A
Asystole	Absence of all electrical activity			

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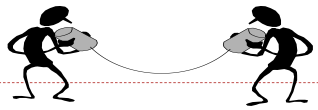
Atrioventricular Blocks (AV Block)

- First Degree Block/First Degree AV Block
- Second Degree Block/Second Degree AV Block
  - Second Degree Type 1 – Wenkebach
  - Second Degree Type 2
- Third Degree Block/Complete Heart Block

The type of AV block present indicates the error in conduction between the atria and the ventricles



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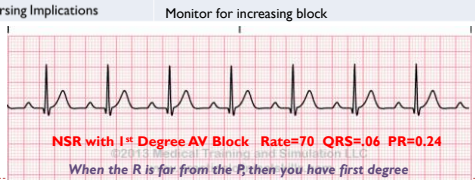
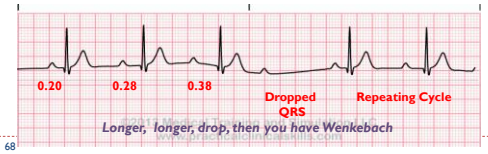
First Degree AV Block

Regularity	Regular
Atrial Rate	Dependent on underlying rhythm/rate
Ventricular Rate	Dependent on underlying rhythm/rate
P waves	Consistent in morphology, P wave for every QRS
QRS	Regular and consistent, measures <0.12 seconds
PR interval	Consistent but measures >0.20
Nursing Implications	Monitor for increasing block



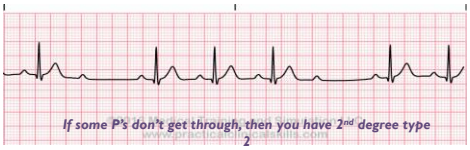
Second Degree AV Block – Type 1

Regularity	Overall irregular
Atrial Rate	Overall irregular
Ventricular Rate	Dependent on underlying rhythm/rate
P waves	Consistent shape/morphology but occasionally a P without a QRS
QRS	Consistent at <0.12 but irregular
PR interval	Progressively increases until a QRS is dropped
Nursing Implications	Monitor for increasing block



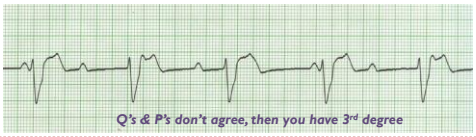
Second Degree AV Block – Type 2

Regularity	Overall irregular
Atrial Rate	Regular
Ventricular Rate	Irregular due to blocked beats
P waves	Consistent shape/morphology, some P's without a QRS
QRS	Consistent, <0.12 but some blocked beats
PR interval	Consistent when P/QRS present but some beats blocked
Nursing Implications	Monitor for increasing block



Third Degree AV Block/Complete Block

Regularity	Regular
Atrial Rate	Regular P to P but no relation to QRS
Ventricular Rate	Regular R to R but no relation to P
P waves	Consistent shape/morphology
QRS	Consistent & regular but often >0.12
PR interval	No consistent PR interval; block between atria & ventricles is complete; monitor rate and s/s
Nursing Implications	



Pacemakers

- Deliver electrical impulses to promote a regular rate and rhythm
- Relieves arrhythmia symptoms, such as fatigue and fainting & can help a person who has abnormal heart rhythms resume a more active lifestyle

http://www.nhlbi.nih.gov/health/health-topics/topics/pace

Indications for Pacing (to name a few)

- Symptomatic bradycardia
- Symptomatic heart blocks
- Sick Sinus Syndrome
- Hypertrophic Cardiomyopathy
- Cardiac support for treatment of arrhythmias requiring ablation and / or medications resulting in bradycardia
- Pacing for termination of tachyarrhythmias (part of ICD therapy)
- CHF (biventricular pacing)

Types of Pacemakers - Temporary

Transcutaneous

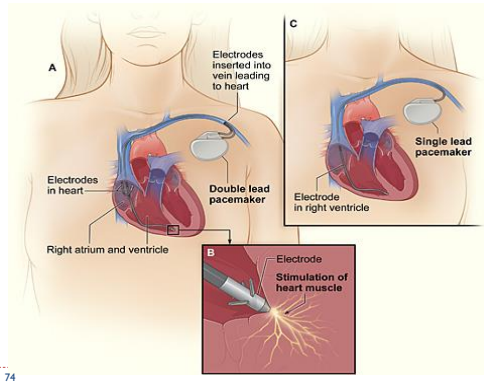
- Delivers electrical impulses through adhesive patches; usually from a defibrillator (i.e. Zoll)
- Short-term use only

Transvenous

- Often used as bridge to permanent pacing
- Inserted through jugular, subclavian or femoral

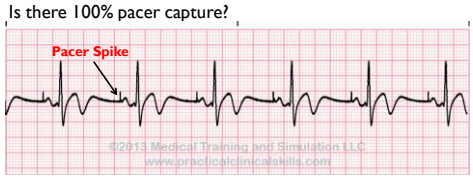
Permanent

- Device is implanted in the chest
- May be combined with a defibrillator (ICD)



Paced Rhythms

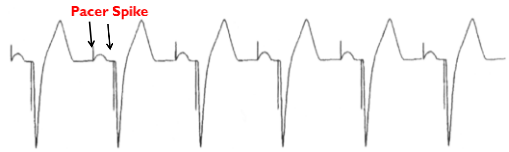
- Which chamber is paced?
- Is there 100% pacer capture?



- The pacer spike precedes the P wave, therefore we know the atria is paced
- For every pacer spike there is a P wave, therefore there is 100% pacer capture

Paced Rhythms

Which chamber is paced?
Is there 100% pacer capture?



AV sequential pacing
Spike followed by P wave, then a spike followed by a QRS
Atria and ventricle are both paced
100% pacer capture in this strip

What's Happening Here?

- Pacer spikes are regular/consistent
- Pacer spikes are followed by a QRS (ventricle paced)
- Some spikes do not prompt a QRS
- Pacer is pacing, but not capturing = **Failure to capture**

What's Happening Here?

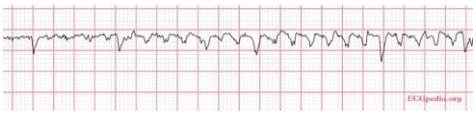
- Pacer is firing randomly at any given point in the cardiac cycle = **Failure to sense**

Other Monitoring Problems

- Artifact

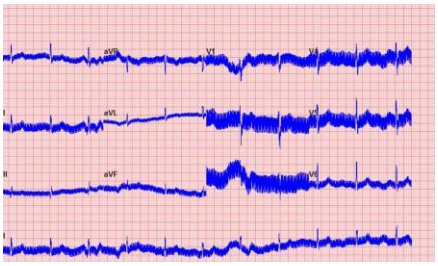
- "Nonsense" activity on the strip
- Usually caused by excess patient movement

Movement artifact



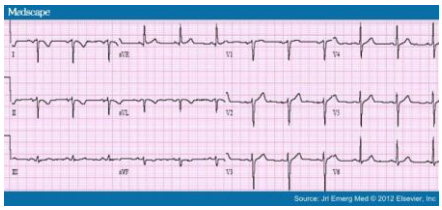
- This is actually a patient in Normal Sinus Rhythm!
- The patient has Parkinson's disease (tremor)
- Toothbrushing can look like V Tach!

60 Cycle Interference



Excess Electrical activity is interfering with the tracing. I.E. Other medical equipment in the room

Lead Reversal

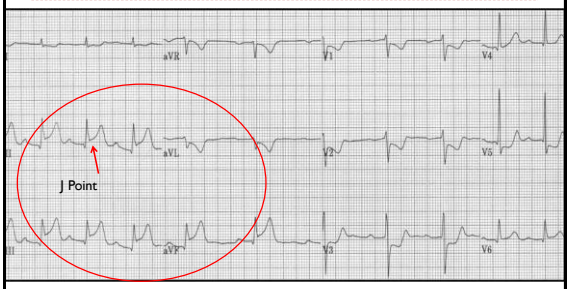


- Notice leads I and II are upside down. They are usually right side up!

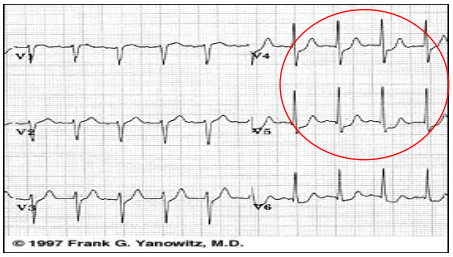
The Moral of the Story……

- Check your patient!!
- The monitor is only a tool. Your patient's clinical presentation is KEY!
- Check your electrodes when you assess the patient. Are they applied correctly??
- Don't underestimate the value of good skin prep! Is your patient sweaty, hairy, bony, agitated?
- Get help – experienced cardiac nurses can help eliminate some of these problems!

ST Elevation – That's a Problem (STEMI)



ST Depression – Also a Problem (Ischemia)



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