

Welcome to the second edition of Knowledge Notes!

The Franciscan Northwest Physicians Health Network (FNPHN) is bringing Knowledge Notes to you as a quarterly educational resource. Each edition will provide a variety of short articles on a particular clinical topic. This Spring Edition, we are looking at Cardiac topics, with a focus on Heart Failure clinical terminology, Ejection Fraction,, Implantable Cardiac Defibrillators, and Pacers with a small amount of basic cardiac arrhythmias. The Summer Edition will focus on aspects of Palliative Care. The Fall Edition will be devoted to Diabetes.

Knowledge Notes is produced by the Franciscan Health System Education Services Department, with guidance from the CCN Clinical Education Ad Hoc Subcommittee, and is intended to support our partner organizations in the delivery of excellent patient care in the post-acute care setting.

While learning is fun, we want to make Knowledge Notes more fun. Every edition will contain a question that is based on that quarter's content. We will offer a \$5 Starbucks card to two people who email in the correct answer. This month, cards will go to the **third** and **seventh** person with the right answer. So look for that question, and send your answer to www.knowledgenotes@outlook.com

Over time, the FNPHN website (www.fnphn.com) will become a convenient repository of information and learning that you and your fellow employees can freely access 24/7/365. We are always looking for feedback about how we are doing, so please give us feedback at zenafuhrmann@fhshealth.org

Once again, welcome to the second edition of Knowledge Notes.

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Knowledge Notes

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New HF Terminology & Ejection Fraction

It has recently been noticed that there is new terminology being used to describe Heart Failure (HF). Heart Failure is a bit difficult to understand when reviewing the specific types of HF that exist, however this new terminology may be helpful as it better describes the condition. To facilitate understanding the difference in the two major types of HF the term **Ejection Fraction** will be defined.

Ejection Fraction – the percentage of blood that is pumped with each heart beat.

- Each cardiac cycle has a relaxation phase and a contraction phase. When the ventricle contracts it ejects a *percentage* of the blood that filled it during its relaxation phase. This is called systole. The relaxation phase is called diastole. The ventricle can never completely empty itself, regardless of the force of each contraction.
- Normal Ejection Fraction = 55-70%
- Reasons for a decrease in Ejection Fraction:
 - A heart attack that resulted in loss of cardiac muscle
 - Heart valve problems
 - Weakened muscle from a viral infection
 - As a result of untreated or long-standing hypertension
- Diagnostic tests used:
 - Echocardiogram – ultrasound test used via trans-thoracic or trans-esophageal approach to measure cardiac function. One of the measurements obtained in this test is Ejection Fraction
 - Cardiac catheterization – during a heart cath the ejection fraction can be determined in a more sophisticated manor than by echo and is reported as one of many findings.

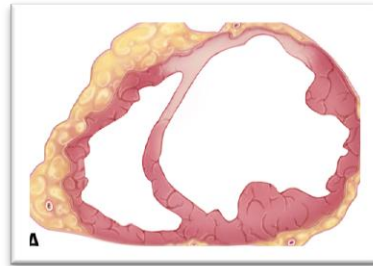
New Heart Failure Terminology

Heart Failure is defined as a very complex clinical syndrome that can develop from any cardiac disorder that impairs the ability of the ventricle to fill properly or eject blood optimally and thereby does not meet the metabolic demands of the body for delivery of oxygen and nutrients. Currently 5.7 million Americans have heart failure.

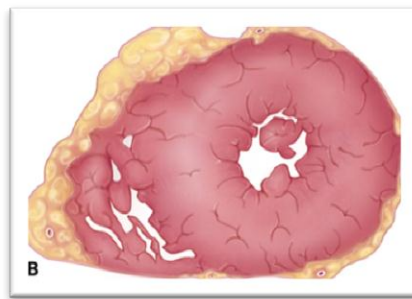
Common terminology:

- **Systolic Heart Failure** – by definition a patient with systolic heart failure has an ejection fraction less than 40%. The amount of blood pumped with each heart beat is less – the stroke volume (volume in mL of blood pumped with each heart beat) is decreased.
 - Approximately 60% of the patients that have “heart failure” have systolic dysfunction
 - Involves the ventricles inability to contract well

- Most commonly the patient with a diagnosis of Heart Failure has systolic dysfunction
- The ventricular size is enlarged and dilated



- **Diastolic Heart Failure** - appears to have a more normal ejection fraction.
 - The ventricle is unable to relax
 - The ventricular wall is thick
 - A smaller amount of blood is able to fill the ventricle; therefore a smaller amount of blood is pumped with each heart beat. (This is called the stroke volume)



New Terminology:

- **Heart Failure with reduced Ejection Fraction** (Systolic Dysfunction) – abbreviated as HFrEF and pronounced like hefref. This definition clearly defines that one can expect the Ejection Fraction to be reduced from the normal value of 55-70%.
- **Heart Failure with preserved Ejection Fraction** (Diastolic Dysfunction)– abbreviated as HFpEF and pronounced hefpef. This leads one to believe that the Ejection Fraction is normal, which technically it is. However, the volume of blood ejected is less than normal.

Cardiac Output = Heart Rate x Stroke Volume

NORMAL CO (5L/min) = Heart Rate (70 beats per min) x Stroke Volume (70 ml)

HFrEF CO (5L/min), Heart Rate (must be 100 beats per min) x Stroke Volume (50 ml)

HFpEF CO (5L/min), Heart Rate (must be 111 beats per min) x Stroke Volume (45 ml)

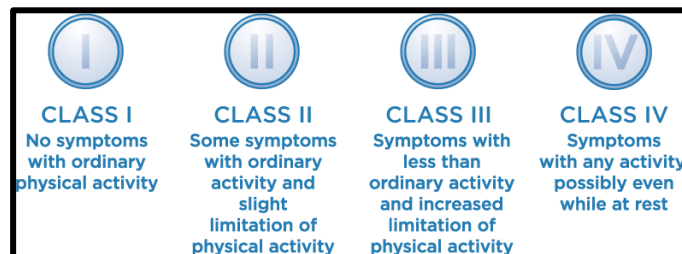
Clinical Consideration - Notice that as the Stroke Volume (or blood ejected with each beat) decreases, the heart rate has to increase to keep up with the maintaining the Cardiac Output. Is this a good compensatory measure for the long-term?

Implanted Cardiac Defibrillator – ICD

ICDs are used for patients that have abnormal cardiac rhythms that may lead to death if untreated. The American Heart Association, American College of Cardiology Foundation, and the Heart Rhythm Society have identified certain conditions in which they highly recommend the insertion of an ICD. The rhythms that are typically “lethal” are ventricular fibrillation and ventricular tachycardia. It is well known that patients that have Heart Failure or Left Ventricular Dysfunction are at higher than normal risk for developing these lethal rhythms. The ICD is programmed to detect these rhythms and send out low-energy electrical pulses in an attempt to encourage the heart to return to its normal rhythm. If the low-energy pulses do not convert the abnormal rhythm, a high-energy electrical pulse is delivered. Most patients find this high-energy electrical pulse painful and have described it as feeling like a “horse kicked in the chest”.

Recommended Conditions for Implantation of ICD:

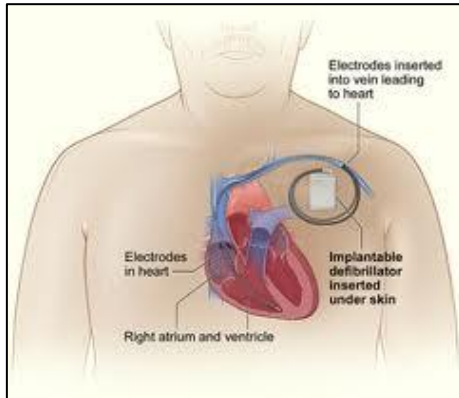
- Heart Failure and an Ejection Fraction (EF) less than or equal to 35% due to prior myocardial infarction (MI or heart attack) and are 40 days post-MI with New York Heart Association** (NYHA) Functional Class II or III
- Left Ventricular dysfunction due to prior MI who are at least 40 days post MI, have an EF less than or equal to 30% and are a NYHA Functional Class I
- Survivors of cardiac arrest due to Ventricular Fibrillation (VF) or hemodynamically unstable sustained Ventricular Tachycardia (VT) after evaluation to define the cause of the event and to exclude any completely reversible causes



**New York Heart
Association
Functional Classes**

Types of ICDs:

The ICD resembles a pacemaker in that it is a small metal device that is placed under the skin of the chest or abdomen. The device has a pulse generator, battery, and small computer that coordinate the detection and action required if an arrhythmia is identified.



- Single-chamber ICDs – a wire that senses the electrical activity of the heart and then responds if necessary with the electrical pulse is placed in either the right atrium or the right ventricle.
- Dual-chambered ICDs – has two wires, placed in the atrium and the ventricle. These ICDs can respond with the low-energy or high-energy electrical pulse to either or both chambers.
- Dual-chambered ICDs with three wires – these ICDs are used in the atrium and both ventricles to resynchronize the ventricular contractions.

ICD Tones:

It is surprising to patients and spouses/significant others, as well as, healthcare personnel when it is discovered that there is a tone coming from the ICD. Perhaps you have heard one of these tones in your practice; the first time it takes a bit of investigation to determine exactly where the noise is originating from. The tones have a meaning that may vary from one manufacture to another – the information presented within this “Knowledge Notes” is from Medtronic.

- “Alternating High/Low Tones” - signifies that there may be a low battery, abnormal impedance (resistance), or electrical reset condition (preprogrammed settings change to the factory nominal settings). The tone will sound for anywhere from 10 to 30 seconds depending on the age of the device. It will be audible more than once and will likely occur daily at the same time each day. When this tone is heard the **Physician should be contacted**, in most cases it is not life threatening, but the device needs to be interrogated to determine the reason for the tone. The tone will continue at its preprogrammed alert time until it is interrogated.

- “No Condition” - This tone alerts you that the ICD has encountered a magnetic field and the device is DISABLED and will not respond to a ventricular arrhythmia if the patient should have one. The tone will re-sound whenever it identifies a magnetic field. Again, the tone will last for anywhere from 10-30 seconds depending on the age of the device. When a magnet is placed over the ICD this tone will sound, verifying that the device has been disabled (as may be necessary if the patient is undergoing surgery where electrocautery may be used). Additionally, it is a means of confirming that the ICD is functioning correctly.

ADDITIONAL Things:

- If you are interested in hearing the tones go to the following web site and click on the **BLUE** links <http://icdusergroup.blogspot.com/2009/08/that-little-beep-could-be-telling-you.html>.
- This YouTube video explains how the ICD can be disabled by the use of the Reed Switch works http://www.youtube.com/watch?v=gje8LhZXwO0&feature=player_detailpage, it makes more sense how it works when you actually see it.

Respond to this question via email and win a coffee card if you are the 3rd or 7th person to correctly answer the question.

You are traveling to Cabo San Lucas for the very first time and are at Sea-Tac airport in the security line. The lady three people in front of you appears to be causing a concern for the security people. You are in a hurry because you over-slept your alarm, so you start paying more attention. They are telling the lady to sit down and wait there while they get a supervisor to help figure out why she had a steady tone emitting from her chest briefly as she approached the scanner. She is elderly and does not seem to mind sitting down for a bit, but they have closed that area down and you are not pleased.

What is happening and what is the concern for this elderly lady?

Permanent Pacemaker

(& a small very basic rhythm review)

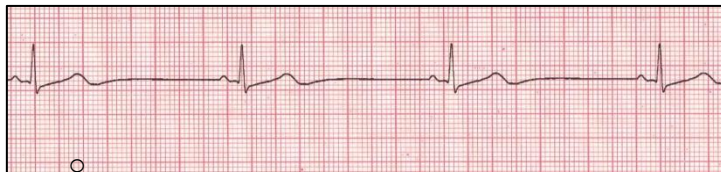
Pacemakers are generally inserted when the patient has had a problem with their heart rhythm. Typically the heart rate has been too slow, although pacemakers are very complex and may have been inserted for a variety of reasons. The underlying reason for the rhythm problem is usually related to a problem in the electrical conduction system. Normal function within the electrical conduction system is necessary for the patient to adequately meet the metabolic demands of the body (through cardiovascular circulation of nutrients and oxygen), when the conduction system is damaged or injured this function is at risk and the patient is said to be having arrhythmias.

Impulses may travel; too slowly, are stopped, or are too fast

Arrhythmias That May Necessitate Pacemaker Insertion:

Bradyarrhythmias:

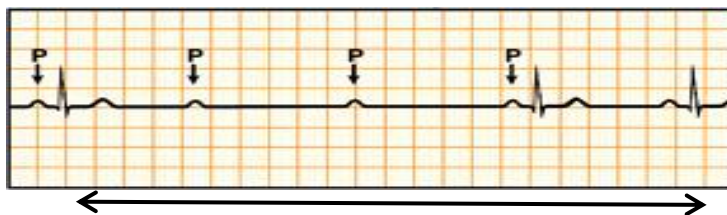
- Sinus bradycardia – heart rate is slowed. Sino atrial (SA) node rate is slow and unable to respond to the need for an increase in heart rate.



Sinus Brady

Heart rate (HR) = <40
One P wave for every QRS

- Heart Blocks – second and third degree heart blocks. In this arrhythmia the sinus impulse is not conducted to the ventricle with every impulse, thus effectively lowering the heart rate such that it does not support normal cardiac function.



Second Degree Type II

HR = 23 (looking at only these 2 intervals)
There are more P waves than QRSs, but the conducted P wave has a consistent PR interval

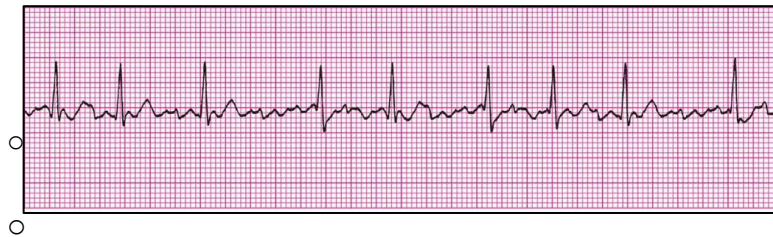


Third Degree Heart Block

HR = ~30
Note: the P waves do not correlate with the QRS at all; the atria & ventricles are functioning independently

Tachyarrhythmias:

- Atrial Fibrillation – the upper portions of the heart (atria) have chaotic electrical discharges. There is no organized electrical and therefore functional atria activity and the cardiac output suffers because of this lack of “atrial kick”. Atrial kick typically supplies 15-35% of the volume in the ventricle just before it contracts. The elderly are particularly affected by this decrease in volume if they develop atrial fibrillation.

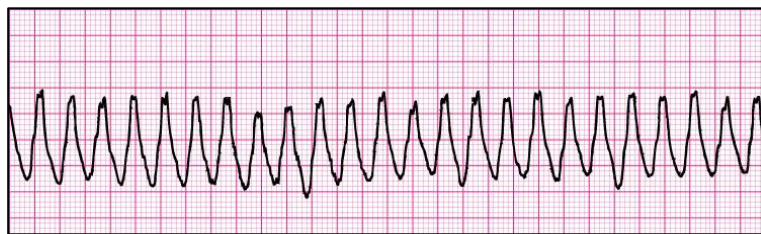


Atrial Fibrillation

HR = ~100

Note: there are no P waves, the baseline is chaotic & the QRSs occur

- Ventricular Tachycardia – the lower portion of the heart, the ventricle, can start firing independently of the normal conduction system that originates in the atria. Because these ventricular beats are not using the conduction system and speeding through the heart, the impulse must go from cell to cell, which makes the QRS wide. Blood generally will not be pumped effectively and the patient will be symptomatic, if not in cardiac arrest.



Ventricular Tachycardia

HR = ~250 (very fast)

QRS complex wide

Underlying Conditions That May Necessitate Insertion:

- Coronary artery disease – such that an adequate supply of blood does not reach the arteries that supply the various areas of the conduction system
- Congenital heart defects
- Inherited genetic abnormalities, such as long QT syndrome, which generally occurs in the younger patient
- Nervous system abnormalities that affect the control and regulation of the heart beat

- Medication induced rhythm problems, where the patient needs the medication despite the side effects (like in rate control issues, where the medication influences the heart to beat too slowly)
- Cardiomyopathies
- Normal aging process



Components of a pacemaker:

- 1.) Pacing lead or leads – insulated wire(s) that carry a tiny electrical impulse from the generator to the cardiac muscle. Additionally, the lead carries information back to the generator from the heart. The most common place for the lead wire(s) to be placed is in the right atria or right ventricle.
- 2.) Electrodes – sits at the tip of the wire and transmits the electrical impulse to the cardiac muscle when the patient's heart rate is outside of the set parameters. It senses the heart's intrinsic electrical activity and sends the information back to the generator.
- 3.) Pulse generator – a small (1-2 ounce) metal box that contains the power source that produces the electrical impulses of the pacemaker. Contains a small computer processor that is programmed to respond to the particular conduction problem that the patient is exhibiting. Programmable parameters are: rate, pattern of pacing, and energy output. Changes to the pacemaker settings are done with a programmer that is typically kept in the facility or can be accessed from the pacemaker representative.

Types of pacemakers:

Pacing electrodes may be placed in one, two, or three locations within the heart:

- Single chamber pacemaker – has one electrode/lead wire in either the right atrium or ventricle
- Dual chamber pacemaker – two electrodes/lead wires typically placed in the right atrium and ventricle. This pacemaker permits a more normal cardiac rhythm with an atrial contraction followed by ventricular contraction, thus maintaining atrial kick and therefore increased cardiac output.

- Triple chambered pacemaker – as the name implies has three electrodes/lead wires. Typically one is placed in the right atrium, one in the right ventricle, and one in the left ventricle. This pacemaker is used with heart failure patients that have lost the closer relationship that in the normal heart exists between contraction of the right and the left ventricle. The triple chamber pacer, described as a pacemaker that facilitates “cardiac resynchronization”, allows for the ventricles to contract in closer time proximity to each other. This tends to improve the functioning of the heart and therefore improve cardiac output.

Functional description of the pacemaker (mode):

- Demand pacemaker – provides electrical stimulus only if the intrinsic rate of the heart drops below a programmed rate or if the heart has pauses or missed beats that effectively lower the heart rate below the pre-programmed rate.
- Fixed-rate or asynchronous pacemakers – less frequently used in clinical practice than in the past. This pacemaker fires at a preprogrammed rate regardless of the patient’s underlying electrical activity.
- Rate-responsive pacing – is one of the most complex pacemakers used today. Electrical impulses are discharged from the pacemaker in response to the body’s need for increased or decreased heart rate based on the perceived metabolic demands being placed on the body because of physical exercise or rest. This is a more complex “demand” mode pacemaker.

Follow-up Care:

After the initial implantation of the pacemaker and a brief hospital stay one can expect that periodic follow-up will occur. The pacemaker will likely be interrogated at a somewhat regular interval. Newer pacemakers can be interrogated remotely for information regarding the patient’s heart rhythm, the functionality of the leads, the frequency of pacemaker use, the battery life, and the ability to review arrhythmias and frequency of arrhythmias.

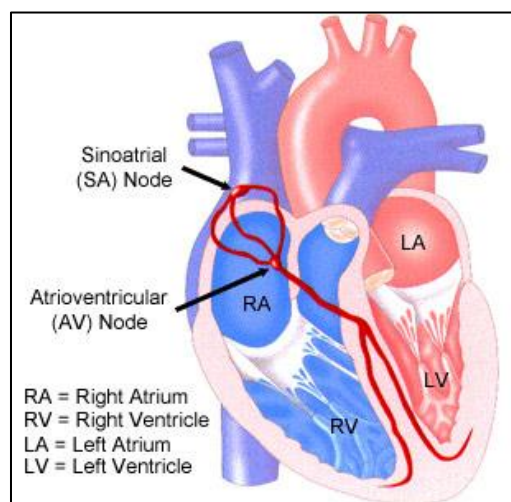
Lithium batteries, which are used to power the pacemaker generally, have a life span of 5-8 years. Batteries have a slow decline over time and typically have plenty of pre-warning of their decline. The generator replacement requires a relatively simple surgery as the leads are expected to last the life time of the pacemaker, although this is not always the case they have no planned decline. If a lead requires replacing it is common to disconnect it from the generator

and leave it in place. The new lead is inserted into the same location and it is connected to the generator. (Over time the leads become incorporated through scarring into the tissue and are difficult to remove.)

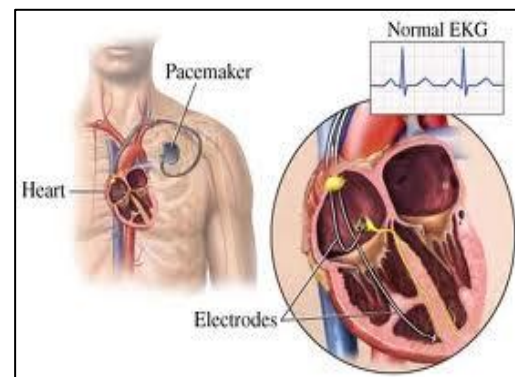
Electromagnetic Interference:

Older pacemakers were much more susceptible to electromagnetic interference – you may remember all the warnings about not being around microwave ovens and cell phones. There are still some precautions for the person with a pacemaker but they are much less alarming. Common household items such as: microwaves, televisions, radios, and electric blankets do not require any special precautions. Likewise cellular phones, modern wireless communication devices, and portable media players do not reportedly interfere with the function of the newer pacemakers and/or ICD's. However, there are some precautions that do need consideration. Anti-theft systems and metal detectors in airports are two of the electromagnetic fields that may cause problems if the pacemaker patient were to linger in that area for extended periods of time, they should move through such an area at an ordinary pace. It would be unusual if the patient experienced any significant clinical adversity.

As mentioned in the ICD section, if the patient is going to have surgery where there will be electrocautery used the pacemaker will likely need to be reprogrammed before and after the surgery to prevent problems. (Electrocautery may cause the pacemaker to be inhibited). A magnet placed over the device may be all that is required for some procedures: MRI, TENS units, diathermy, lithotripsy done with extracorporeal shock waves, therapeutic radiation, and again electrocautery. If transferring a patient to another facility, assure that the presence of a pacemaker is communicated to the receiving facility.



**Chambers of the Heart with
Conduction System Overlaid**



Pacemaker

Description of the NASPE/BPEG Pacer Code:

The code used to describe pacemakers has 5 positions that outline how the pacemaker will function. Pacemaker can be very complex; the following will demonstrate the ability of today's technology.

- Position I – indicates which chamber(s) is paced. If the atrium is paced the letter “A” is used, if the ventricle is paced the “V”, and if both are paced the “D” represents both.
- Position II – indicates which chamber has sensing for intrinsic signal function. The same letter designations are used as in position I
- Position III – indicates the mode to sensing.
 - Inhibited – if the pacemaker senses an event it will withhold a pacemaker output
 - Triggered – if the atrial lead senses an output it will *inhibit* an output, but start a timer that will cause a *triggered* ventricular output within a preset time if no impulse is sensed
 - Dual – the pacemaker will respond to a sensed signal by either inhibiting the pacemaker response, tracking the sensed signal, or inhibiting the output on the sensed channel and triggering an output to facilitate the atria and ventricles functioning synchronously
- Position IV – offers information on the programmable parameters of the pacemaker. Does the pacemaker have a sensor to regulate the rate during exercise, can it be programmed, and/or does it have the ability to communicate?
- Position V - indicates whether the pacemaker has any Antitachycardia features. If the pacemaker can respond by shocking (S) the patient or pacing and shocking (D) it acts as an ICD.

North American Society of Pacing Electrophysiology				
I	II	III	IV	V
Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing	Programmability, rate modulation	Antitachycardia Function(s)
V=Ventricular A=Atrium D=Dual (A+V) O=None	V=Ventricular A=Atrium D=Dual (A+V) O=None	T=Triggered I=Inhibited D=Dual (Triggered/Inhibited) O=None	R=Rate Modulation C=Communicating M=Multi- Programmable P=Simple Programmable O=None	O=None P=Paced S=Shocks D=Dual (P+S)