Cardiac Implanted Electronic Devices
Pacemakers, Defibrillators, Cardiac Resynchronization Devices, Loop Recorders, etc.

The Miracle of Living
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Reasons for Implanted Device

- Treatment of slow heart rates (bradycardia): Pacemaker
- Treatment of congestive heart failure / cardiomyopathy: Cardiac Resynchronization Device (CRT) or defibrillator (ICD).
- Treatment/Prevention of Sudden Cardiac Arrest: ICD
- Monitoring for dangerous heart rhythms after syncope (passing out), stroke, or other serious cardiac condition: Implantable loop recorder (ILR)
Symptoms of Bradycardia (Slow Heart Rate)

- Usually occurs when heart is not pumping enough blood to meet body's needs. This often happens when the heart rate is very slow or remains slow for a long period of time.

- Related to organ hypo-perfusion and include:
  - Dizziness or lightheadedness
  - Fainting (syncope) or near-fainting
  - Tiredness (fatigue)
  - Shortness of breath
  - Palpitations
  - Chest pain (angina)
  - Increased difficulty exercising
  - Confusion or difficulty concentrating
  - Some people with bradycardia do not have symptoms

Classifications of Bradyarrhythmias

- There are two types of bradyarrhythmias
  - Those related to problems with impulse formation
  - Those related to problems with impulse conduction

Sinus node

AV node
Classification of Bradyarrhythmias

Problems with Impulse Formation

- Sinus Arrest
- Sinus Bradycardia
- Chronotropic Incompetence
- Brady/Tachy syndrome
Sinus Arrest

- Failure of sinus node discharge
- Absence of atrial depolarization
- Periods of ventricular asystole
- May be episodic as in vaso-vagal syncope, or carotid sinus hypersensitivity
  - May require a pacemaker
Sinus Bradycardia

- Sinus Node depolarizes very slowly
- If the patient is symptomatic and the rhythm is persistent and irreversible, may require a pacemaker
Chronotropic Incompetence

The heart rate is unable to change in response to the body’s metabolic demand.

Brady/Tachy Syndrome

- Intermittent episodes of slow and fast rates from the SA node or atria
- Brady < 60 bpm
- Tachy > 100 bpm
- AKA: Sinus Node Disease/ Sinus Node Dysfunction
  - Patient may also have periods of AF (Atrial Fibrillation) and chronotropic incompetence
  - Most common pacing indication

Bradycardia Classifications

Problems with Impulse Conduction

- Exit Block
- First Degree AV block
- Second Degree AV block
  - Mobitz Type 1 – Wenckebach
  - Mobitz Type 2
- Third Degree AV block – Complete heart block
- Bifasicular/Trifasicular block
Second-Degree AV Block – Mobitz II

- Regularly dropped ventricular beats
  - 2:1 block (2 P-waves for every 1 QRS complex)
  - Atrial rate = 75 bpm, Ventricular rate = 42 bpm
- A “high grade” block, usually an indication for pacing
  - May progress to third-degree, or Complete Heart block (CHB)
Third-Degree AV Block

COMPLETE HEART BLOCK

No impulse conduction from the atria to the ventricles

- Atrial rate = 130 bpm, Ventricular rate = 37 bpm
- Complete A – V disassociation
- Usually a wide QRS as ventricular rate is idioventricular
Fascicular Block

Right bundle branch block and left posterior hemiblock

Right bundle branch block and left anterior hemiblock

Complete left bundle branch block
Trifascicular Block

- Complete block in the right bundle branch, and
- Complete or incomplete block in both divisions of the left bundle branch
- Identified by EP Study
Treatment: Pacemakers

- Artificial pacemakers: devices that are implanted into the body, just below the collarbone, to take over the job of the heart’s own electrical system and prevent slow heart rates.
- Size of a large wristwatch face, contains a computer with memory and electrical circuits, a powerful battery (generator), and special wires called “leads.”
- The generator creates electrical impulses that are carried by the leads to the heart muscle, signaling it to pump.
Treatment: Pacemakers

- Getting a pacemaker does not require open-heart surgery
- The pacemaker generator is implanted in a small pocket made under the skin. The leads are usually placed in a vein near the collarbone, and then moved to the heart with the help of an X-ray machine.
- The leads touch the heart muscle on one end, and are connected to the pacemaker generator on the other end, programmed to send signals to the heart, and settings can be changed at any time.
Pacemaker Implantation
Pacing Circuit

A pacing circuit consists of a:
- power source
- lead
- cathode
- anode
- body tissue

These form a conduction pathway along which electricity flows.
Pacemaker Types

Pacing systems are generally described by the number of chambers paced by the device.
A single chamber system paces either the right atrium or right ventricle.

- Single chamber systems do not provide AV synchrony
- Atrial only systems do not provide back up ventricular pacing support

May be used for patients in chronic AF (VVI pacemaker) or patients with sinus node dysfunction and no history of AV block (AAI pacemaker)
Dual chamber systems consist of 2 leads, one in the atrium the other in the ventricle.

- Provides AV synchrony and pacing support in both atrium and ventricle if needed
- May be used in cases of sinus node disease even without AV block.
Triple chamber pacemaker systems are most commonly called a Bi-Ventricular Pacemaker or Cardiac Resynchronization Therapy (CRT-P).

- Three leads: right atrium, right ventricle, left ventricle (via the Coronary Sinus vein)
- Paces both ventricles together to “resynchronize” the ventricles
CRT (Cardiac Resynchronization Therapy)
• Torrance Memorial Medical Center participation in Active Quad IDE trial.
• Study completed Jan 2018
Conduction System

- S-A node
- His bundle
- A-V node
- Right bundle branch
- Left bundle branch
- Purkinje fibers
- Sinoatrial node
- Atrioventricular node
- Left posterior bundle
- Right bundle
- Bachmann's bundle
- His bundle
- Purkinje fibers
A BETTER WAY TO PACE HEART

Pacemakers restore normal heartbeats in millions of people, but the widely used technique of connecting the pacemaker wire to a spot in the lower right ventricle triggers heart failure in a surprising number of patients, recent studies show. A small-but-growing number of doctors are using a new implant technique called His bundle pacing to avoid pacing-induced problems. In His bundle pacing, the doctor puts the right-ventricular lead in the right atrium, millimeters from the heart’s natural conduction system. This creates a natural heartbeat, avoiding the dyssynchrony in heart chambers that leads to pacing-induced heart failure.

The pacemaker is implanted under skin close to the clavicle

Approaching the His bundle

Named for discoverer Wilhelm His Jr. (1863–1934), the His bundle is a collection of highly conductive muscle cells that transmit electric impulses to make the heart’s lower ventricles beat. The His bundle can be stimulated directly, recreating a natural heart rhythm instead of the “elongated” heartbeat that causes problems in some patients over time.
Leadless Pacemakers
Sudden Cardiac Arrest

IMPLANTABLE CARDIAC DEFIBRILLATORS

- Implantable cardiac defibrillators (ICDs) treat abnormal heart rhythms (ventricular arrhythmias) such as ventricular tachycardia and ventricular fibrillation.

- These life-threatening rhythms can cause sudden cardiac arrest (SCA), which results in death if not treated.

- 98% of people survive a lethal arrhythmia when treated with defibrillation.¹ Only 5% of people survive SCA without defibrillation.²

Indications for ICD Implantation

- Survivor of sudden cardiac arrest (Secondary Prevention of SCA)
- Conditions with high risk for SCA (Primary Prevention of SCA)
  - Congestive Heart Failure, Cardiomyopathy, Previous Heart Attack, Primary Arrhythmia Disorder, Significant Structural Cardiac Abnormality, etc.
The ICD System

VENTRICULAR LEAD
- Bradycardia sensing/pacing
- Antitachycardia pacing (ATP)
- Cardioversion
- Defibrillation

ATRIAL LEAD
- Bradycardia sensing/pacing
- Antitachycardia pacing (ATP)
- Atrial Arrhythmia prevention therapies

IMPLANTED ICD
ICD components Overview

- Battery
- Circuitry
- Capacitor
- Header
- Circuitry
How high voltage is generated

**BATTERY**
- Provides low voltage energy
- 3.2 volts

**Transformer**
Multiplies Voltage

**Capacitor**
Stores high energy for use

**HIGH VOLTAGE SHOCK**
- Delivered on demand
- Up to 800 volts

**FOR PACING**
Major Functions of an ICD

- Sense appropriate cardiac signals
- Detect dangerous rhythms reliably
- Provide pacing and defibrillation therapy
- Store diagnostics
ICD Defibrillation
Subcutaneous ICD
ILR (Implantable Loop Recorder)

Cardiac Monitoring

Indications for use

The Insertable Cardiac Monitor (ICM) is an implantable patient-activated and automatically-activated monitoring system that records subcutaneous ECG and is indicated in the following cases:

- Patients with clinical syndromes or situations at increased risk of cardiac arrhythmias.
- Patients who experience transient symptoms such as dizziness, palpitation, syncope, and chest pain, that may suggest a cardiac arrhythmia.
AN ADVANCED MONITORING SOLUTION

Reveal LINQ™ ICM

MyCareLink™ Patient Monitor

CareLink™ Network and Reports

SOLUTION ENABLERS

Insertion Tools
Minimally invasive procedure

Patient Assistant
One-button symptom marking

Reveal LINQ™ Insertable Cardiac Monitoring System
THE REVEAL LINQ ADVANTAGE
SIMPLE INSERTION PROCEDURE
Conclusions

• Multiple Indications for Cardiac Implantable Electronic Devices
  • Therapeutic and Diagnostic Purposes
• Pacemakers (for slow heart rates/bradycardia)
  • Single, dual, leadless, His Bundle, CRT devices
• Defibrillators (for treatment/prevention of SCA)
  • With or without pacing, CRT capacity.
• Loop Recorders (for arrhythmia monitoring)
Thank you

Questions?