“ADDITIVES” IN DEVICE THERAPY
Adaptive–Rate Pacing

- Rate Responsiveness
- Sensors detect changes in physiologic needs
- Increase pacer rate in response to needs
- Sensors detect changes in metabolic demand
  - Sense motion
  - Physiologic indicators
    - Minute ventilation – depth of breath

Adaptive–Rate Pacing Examples
Rate Adaptive AV Delay (Interval)

Special Features:

Safety Pacing

- Delivery of ventricular pacing impulse at a very short AV interval when the ventricular channel senses something early in the AV interval
- Used to prevent inappropriate inhibition of V pacing due to crosstalk
Safety Pacing

Upper Rate Response

- Wenckebach
Upper Rate Response

- 2:1 Block

Mode Switching

- Paroxysmal Atrial Fibrillation
- Provides rate control in atrial fibrillation
- Supports atrium upon return to NSR
Minimizing RV Pacing with Dual Chamber Pacers

- Increased hospitalizations for HF (DAVID Trial)
- Increased mortality (DAVID Trial)
- No improvement in mortality, HF hospitalizations or stroke free survival when compared to VVI (MOST Trial, CTOPP Trial)
- AAI pacing demonstrates improved outcomes
- Reducing RV pacing to less than 10% in patients with dual chamber pacemakers reduced the relative risk of developing persistent atrial fibrillation by 40% compared to conventional dual chamber pacing (SAVE PACe Trial)
Minimizing Right Ventricular Pacing

- RV pacing results in mechanical dysynchrony (mechanical LBBB)
- Similar changes occur as do with LBBB normally:
  - LV remodeling
  - Systolic dysfunction
  - Decreased perfusion
  - Wall motion abnormalities
  - Mitral valve regurgitation
  - Increased risk of AF and HF

Pacer Lead Placement Options

- His Bundle
- RV outflow tract
- RV septal sites
- Dual pacers in RV
- LV pacing
- Biventricular pacing
## Minimizing Right Ventricular Pacing

- Programming Options
  - DDIR mode
  - AAIR mode with mode switching
  - VVI mode with low rate for those being paced as defibrillation back up only
  - Long AV delays

## DDI Pacing

- **DDI**
  - Paces both Atrium and Ventricle
  - Senses both Atrium and Ventricle

1. Atrial sensing inhibits atrial pacing and **DOES NOT** trigger ventricular pacing
2. Ventricular sensing inhibits ventricular and atrial pacing
DDI Pacing

BASIC DUAL-CHAMBER
THE DDI MODE

Managed Ventricular Pacing

- Promotes Intrinsic Conduction
- Reduces unnecessary RV pacing
- Risk of atrial fibrillation increases as the percentage of ventricular pacing increases
- AAI(R) pacing
- Back up dual chamber system available
- Medtronic Program
- VIP (Ventricular Intrinsic Preference) — St. Jude
Managed Ventricular Pacing

**AAI(R) Mode**
Atrial Based pacing allowing intrinsic AV conduction

**Ventricular Backup**
Ventricular pacing only as needed in the presence of transient loss of conduction

**Single Backup Pace**

**Managed Ventricular Pacing**

**DDD(R) Switch**
Ventricular support if loss of AV conduction is persistent

**Switching from DDD(R) to AAI(R)**
If AV conduction check passes (1 beat)
AV Search Hysteresis

- Guidant Program
- Functions in DDD/R mode and automatically searches for intrinsic AV conduction by extending the AV delay by 10% - 100% (programmable value) to look for intrinsic conduction
- If intrinsic conduction is present, AV delay remains long until conduction fails, then pacer returns to DDD/R mode

Search AV Operation

- Search AV periodically measures AV intervals
- Determine the effect of Search AV delay in reducing unnecessary ventricular pacing, especially in patients with 1:1 conduction
- Encourage intrinsic conduction
Pacemaker Mediated Tachycardia

- Re-entrant tachycardia
- Can result from anything that causes loss of AV synchrony
- Only with dual chamber pacer
- Requires retrograde conduction through the AV node
  - PVC with retrograde conduction
  - PAC prolonging the AV interval
  - Loss of atrial capture
  - Removal of magnet after pacemaker test
  - Myopotential tracking
Pacemaker Mediated Tachycardia

Cardiac Resynchronization Therapy
## Cardiac Resynchronization Therapy

- Treatment modality for heart failure not just pacing
- Treatment modality in conjunction with drug therapy
- **Goals:**
  - Improve hemodynamics by restoring synchrony of ventricular contraction
  - Improve quality of life
  - Decrease mortality and morbidity

### Cardiac Resynchronization Therapy

- Improves ventricular systolic function with reduced metabolic costs
- Decreases functional mitral regurgitation
- Induces favorable remodeling with reduction of cardiac chamber dimensions
- Mortality reduction – 24-36%
- Reduction in hospitalizations - 30%
- Improved 6 minute walk tests
- Improvement by at least one NYHA class
- Clinical improvement in quality of life
- Improved ejection fraction
- Improved peak oxygen consumption
Cardiac Resynchronization Therapy

- Septum contracts with LV
- Increased LA filling time – improved “atrial kick”
- Improves papillary muscle contraction - ↓ MR
- Reverse remodeling

Understanding Dyssynchrony

- **Normal function:**
  - Septum moves towards left ventricle during ventricular contraction
  - Mitral valve papillary muscles contract slightly before LV free wall
Understanding Dyssynchrony

- **Electrical Abnormalities with LBBB**
  - RV depolarizes normally
  - Septum depolarizes after activated by the right bundle branch and before the left ventricle
  - Left ventricle depolarizes late

- **Mechanical abnormalities with LBBB**
  - LV activation delayed
  - Septum completes contraction before LV contracts
  - Septum bulges into RV when LV contracts
  - Mitral valve papillary muscle contract late allowing leaflets to open into LA resulting in mitral regurgitation
Indications for CRT

- For patients who have LVEF less than or equal to 35%
- QRS duration greater than or equal to 0.12 seconds
- Sinus rhythm
- NYHA functional Class III or ambulatory Class IV heart failure symptoms with optimal recommend medical therapy

Lead Location
HOW DO YOU KNOW YOUR PATIENT IS RECEIVING RESYNCHRONIZATION THERAPY BY LOOKING AT THE RHYTHM STRIP?
Internal Monitoring with CRT

- Heart Rate Variability
- Patient Activity
- Night Heart Rate
- Impedance

CRT

- Goal: Force biventricular pacing
- Goal: Ventricular Pacing 90% of time or greater
- Causes of Loss of Bi V pacing:
  - Long AV Delays
  - Prolonged PVARP
  - ST with 1 degree AV Block
  - Lead dislodgement
Dealing with Non Responders

- 30% are “nonresponders”
- Hemodynamics
- Clinical Assessment
- Echocardiogram
- Location of lead
- Programming

AUTOMATIC IMPLANTABLE CARDIOVERTER DEFIBRILLATORS
Sudden Cardiac Death

- Cardiac arrest with cessation of cardiac function
- Ventricular fibrillation or pulseless VT
- Pulseless electrical activity
- Asystole
- Occurs most often in patients with:
  - CAD
  - Cardiomyopathy

Indications for ICD

- Survivors of cardiac arrest due to VF or hemodynamically unstable sustained VT after evaluation to define the cause of the event and to exclude any completely reversible causes.
- Structural heart disease and spontaneous sustained VT, whether hemodynamically stable or unstable.
- Syncope of undetermined origin with clinically relevant, hemodynamically significant sustained VT or VF induced at electrophysiological study.
Indications for ICD

- LVEF ≤35% due to prior MI ≥ 40 days old and NYHA functional Class II or III.
- Nonischemic DCM, LVEF ≤35% and NYHA functional Class II or III.
- LV dysfunction due to prior MI ≥ 40 days old, LVEF ≤30%, and are in NYHA functional Class I.
- Nonsustained VT due to prior MI, LVEF ≤40%, and inducible VF or sustained VT at electrophysiological

Other Indications

- Patients with long QT syndrome and prior cardiac arrest, syncope, and strong family history of sudden death, or intolerance to beta blockers.
- Patients with HCM with family history of sudden death, syncope, nonsustained VT, abnormal blood pressure response to exercise, left ventricular wall thickness > 30 mm.
- Secondary prevention in patients with arrhythmogenic right ventricular dysplasia, but primary prevention in patients with syncope or inducible VT.
ICD Device

- Pulse Generator
  - Single chamber, dual chamber, or biventricular pacing
  - Back up pacing
  - Antitachycardia pacing
  - Implanted subcutaneously – same as pacemaker

- Defibrillator lead
  - Detects arrhythmias
  - Delivers therapy
  - Defibrillator lead capable of pacing and defibrillating
  - Placed in right ventricle

ICD Function – Rhythm Detection

- Heart Rate
  - Monitors ventricular rate and delivers therapy when rate exceeds programmed tachycardia detection rate
  - Defined rate boundaries
    - Tachycardia zones

- Sudden Onset
  - Detects sudden shortening of cycle length
ICD Function – Rhythm Detection

- **Interval stability**
  - Looks for variability in cycle lengths
  - Differentiates regular from irregular rhythms
- **Morphology**
  - Measures width of electogram
  - Only treats if width is greater than programmed value

ICD Termination Therapies

- **ATP-Antitachycardia Pacing**
  - Painless
  - “Slow” VT’s
  - Burst
  - Ramp
  - Decremental Scanning
- **Cardioversion Shock**
- **Defibrillating Shock**
ICD Function
ATP-Anti tachycardia Pacing

- Tiered Antiarrhythmia Therapies

**BURST**
- Delivers shocks from 0.1 to 30 joules synchronized on the R wave

**RAMP**

ICD Functions

- Cardioversion Shock
  - Delivers shocks from 0.1 to 30 joules synchronized on the R wave
ICD Function

- **Defibrillating Shock**
  - Delivers high energy (20-34 joules) unsynchronized shock for VF

Other Device Features

- Brady Pacing
- Atrial Diagnostics
  - Differentiates between SVT and VT
- Stored Electrograms
  - Store arrhythmia event
- Noninvasive EPS
  - EP study through implantable leads
Care of Patient With ICD

- **Implantation**
  - Cath Lab, EP Lab, OR
  - Similar to permanent pacer
  - General anesthesia or conscious sedation

- **Note Status of Device**
  - Is device on or off
  - Know what therapies will be delivered for detection of ventricular arrhythmias: pacing, cardioversion, defibrillation

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Care of Patient With ICD

- **Emergency Care for VT/VF**
  - Device will deliver therapy within 10-15 seconds and will continue to deliver therapy as programmed
  - DO NOT WAIT for device to deliver all its therapies if patient is hemodynamically unstable or in VF
  - Defibrillate if necessary – avoid placing paddles directly over device
  - Assure patient
  - Document rhythm
Care of the Patient with ICD

- **Inappropriate firing of ICD**
  - Device may fire with SVT’s
  - Notify physician to have device deactivated
  - All ICDs can be turned off using a programmer
  - A round magnet over the generator will deactivate arrhythmia detection
  - Removal of magnet will reactivate arrhythmia detection
  - Considerations when the patient requires surgery

NOTE: Magnet works differently for ICD’s than pacemakers!

Care of the Patient with ICD

- **Patient / Family Education**
  - Reason for ICD, how it works, what to expect
  - Carry ID card always
  - Continue to take antiarrhythmic medications if on them
  - Importance of follow up visits
    - Every 4-6 months
  - Family should learn CPR
  - Activities
    - Contact sports restricted
    - Driving may be restricted
    - Swimming and boating OK but not alone
  - Support groups
What To Do When ICD Fires

- If patient is aware of rhythm sit or lie down
- If receive only one shock – notify MD
- If receive multiple shocks or feels terrible after one shock– call 911
- If device fires and patient does not wake up immediately call 911.

PATIENT CARE ISSUES WITH IMPLANTABLE DEVICES
Patient Education with Pacemakers

- **What to avoid**
  - Strong Magnets
  - Security wands
  - Store security devices
  - Large stereo speakers
  - Industrial magnets
  - Arc and resistance welders
  - Large generators or power plants
  - Large TV or radio transmitting towers – 25 feet away
  - Electrocautery
  - MRI

**Remember:** Patients with implantable defibrillators all have a back up pacemaker

Patient with ICD or Pacemaker

- **Cell Phones**
  - May be potential interaction
  - Keep phone at least 6 inches away from device
  - Carry phone in opposite pocket and at least 6 inches away from device
Complications Related to Pacemaker / ICD

- Complication of Subclavian Vein Stick
  - Pneumothorax
  - Hemothorax
  - Subclavian artery puncture
  - Air embolism
  - Bleeding
  - Brachial plexus injury
    - Pain or paresthesias in arm, hand, finger

- Complications related to pulse generator
  - Pocket erosion
  - Pocket hematoma
  - Infection
  - Generator migration
  - Generator malfunction
  - Premature battery depletion
Complications Related to Pacemaker / ICD

- Complications Related to Leads
  - Perforation of RV, subclavian veins
  - Lead dislodgement
    - Twiddlers Syndrome
  - Insulation breaks, lead fracture
  - Diaphragmatic stimulation
  - Venous thrombus
  - Pulmonary embolus

Twiddler’s Syndrome
Complications Related to Pacemaker / ICD

- Other Problems
  - Shocks for non VT rhythms
  - Failure to deliver therapy when needed
  - Ineffective therapy
  - High defibrillation thresholds
  - Device deactivation

Postoperative Care ICD / Pacemaker

- Monitored unit
- Monitor for infection
- Monitor for bleeding / hematoma
- Monitor for signs of tamponade
- Monitor for pneumothorax
- Limit arm mobility
- Discharge within 24 hours
  - Battery replacement home same day
Discharge Instructions

- Follow up appointments
- Wound care
- Signs of infection
- Use of arm on pacer / ICD side
- Lifting
- Driving
- Emergency Care
- Physician notification
- Things to avoid

Thank You!

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