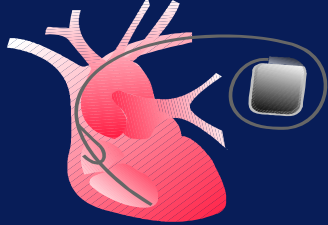


Pacemakers and Defibrillators

Everything you wanted to know but were afraid to ask



Naomi J. Kertesz, M.D.
Associate Professor of Pediatrics
Associate Director Pacing and Electrophysiology

NBG Code

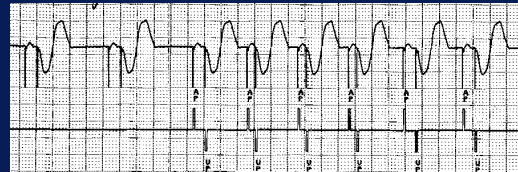
I Chamber Paced	II Chamber Sensed	III Response to Sensing	IV Programmable Functions/Rate Modulation	V Antitachy Function(s)
V: Ventricle	V: Ventricle	T: Triggered	P: Simple programmable	P: Pace
A: Atrium	A: Atrium	I: Inhibited	M: Multi-programmable	S: Shock
D: Dual (A+V)	D: Dual (A+V)	D: Dual (T+I)	C: Communicating	D: Dual (P+S)
O: None	O: None	O: None	R: Rate modulating	O: None
S: Single (A or V)	S: Single (A or V)		O: None	

Magnet Operation in Pacemakers

- ⌘ Either AOO, VOO, or DOO
- ⌘ No intrinsic cardiac activity is sensed
- ⌘ Magnet rate many times is not lower rate limit of device and varies between pacemaker companies
 - Not appropriate for long cases
 - Can vary from 46 bpm to 98 bpm
 - Will change if the pacemaker is near end of service life
 - Magnet placement on device at end of service life can cause cessation of pacing altogether

Magnet Operation

- ⌘ Magnet application causes asynchronous pacing at a designated “magnet” rate

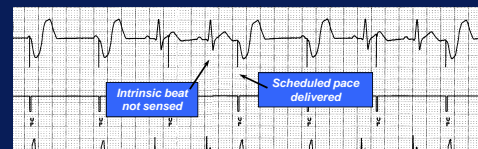


Sensing

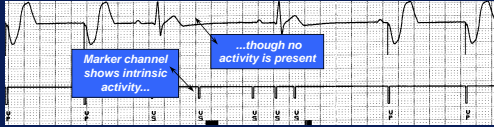
- ⌘ Sensing is the ability of the pacemaker to “see” when a natural (intrinsic) depolarization is occurring
 - Pacemakers sense cardiac depolarization by measuring changes in electrical potential of myocardial cells between the anode and cathode

Undersensing . . .

- ⌘ Pacemaker does not “see” the intrinsic beat, and therefore does not respond appropriately



Oversensing



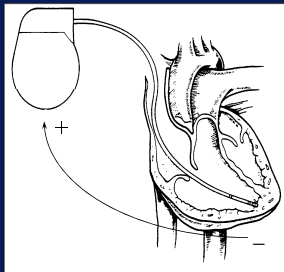
VVI / 60

- ⌘ An electrical signal other than the intended P or R wave is detected
- ⌘ Seen more commonly with unipolar devices



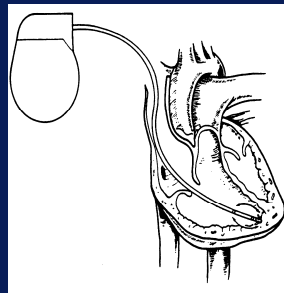
Unipolar Sensing

- ⌘ Produces a large potential difference due to:
 - A cathode and anode that are farther apart than in a bipolar system



Bipolar Sensing

- ⌘ Produces a smaller potential difference due to the short interelectrode distance
 - Electrical signals from outside the heart such as myopotentials are less likely to be sensed



Electromagnetic Interference (EMI)

- ⌘ Interference is caused by electromagnetic energy with a source that is outside the body
- ⌘ Electromagnetic fields that may affect pacemakers are radio-frequency waves
 - 50-60 Hz are most frequently associated with pacemaker interference
- ⌘ Few sources of EMI are found in the home or office but several exist in hospitals

Sources of EMI Are Found Most Commonly in Hospital Environments

⌘ Sources of EMI that interfere with pacemaker operation include surgical/therapeutic equipment such as:

- Electrocautery
- Transthoracic defibrillation
- Extracorporeal shock-wave lithotripsy
- Therapeutic radiation
- RF ablation
- TENS units
- MRI

Electrocautery is the Most Common Hospital Source of Pacemaker EMI

⌘ Outcomes

- Oversensing-inhibition
- Undersensing (noise reversion)
- Power on Reset
- Permanent loss of pacemaker output (if battery voltage is low)

⌘ Precautions

- Reprogram mode to VOO/DOO, or place a magnet over device
- Strategically place the grounding plate
- Limit electrocautery bursts to 1-second burst every 10 seconds
- Use bipolar electrocautery forceps

Transthoracic Defibrillation

⌘ Outcome

- Inappropriate reprogramming of the pulse generator (POR)
- Damage to pacemaker circuitry

⌘ Precautions

- Position defibrillation paddles apex-posterior (AP) and as far from the pacemaker and leads as possible

Defibrillators

⌘ All defibrillators are pacemakers

⌘ Additional ability to overdrive pace and/or defibrillation

⌘ Oversensing due to electrocautery may cause inappropriate therapies i.e. defibrillation – therefore therapies should be turned off at the beginning of the case and turned on at the end

⌘ Application of magnet in most devices will turn therapies off while magnet is in place

Know the Patient's Indication for Pacing

⌘ Sinus node dysfunction

⌘ Complete AV Block

⌘ Underlying escape rate

- Pacemaker dependant or no underlying rate

⌘ Remember to reprogram patient's device back to original settings after the case is finished

Temporary Pacing

⌘ Used for bradycardia support

- Sinus node dysfunction – AAI or VVI
- Complete AV block – DDD

⌘ Promote AV synchrony

- Accelerated junctional rhythm – AAI or DDD

Emergency Temporary Pacing

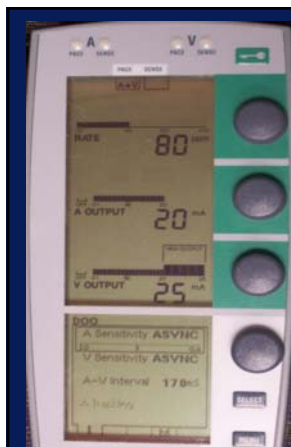


- ⌘ Push the red button on the pacemaker
- ⌘ Pacemaker comes on DOO at full output pacing at 80 beats per minute

Emergency Pacing



- ⌘ Change the rate by turning the dial
- ⌘ You must push the key at the top right of the pacemaker to unlock it
- ⌘ Turn down atrial output to change into VOO or may run risk of atrial flutter or fibrillation



- ⌘ Note ASYNC under sensitivity

Default Settings



- ⌘ When you turn device on it comes on DDD with 10mA on the A and V leads
- ⌘ Upper rate is 110 beats per minutes which is not appropriate for most children
- ⌘ PVARP is 300
- ⌘ AV delay 170
- ⌘ Note this is menu 2

Select the Mode

- ⌘ Menu M
- ⌘ AAI pacing
 - Sinus bradycardia
 - Accelerated junctional rhythm
 - Promotes AV synchrony
- ⌘ DDD pacing
 - AV Block

Programming the Pacemaker

- ⌘ Program the device before you hook it up to the patient
- ⌘ At the beginning of the case have the device set
 - VOO at 100bpm
 - 20mAmp
 - To program VOO select DOO in the mode and then turn the atrial output to zero
 - When the bovie stops being used you can switch the mode to VVI by changing the sensitivity to 2.0mA on Menu 1

Single Chamber Pacing

- ⌘ Lower rate limit
 - Dependant on age and hemodynamic status
- ⌘ Atrial and Ventricular output
 - Normal pacing threshold for new leads is about 2 mA
- ⌘ Thresholds
 - Turn down output until lose capture. Set output at 2x lowest capture threshold. If capture at .5 and lose at .4 set at 1.0

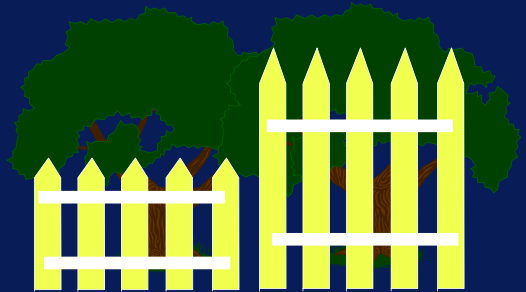
The Medtronic Temporary Pacemaker

- ⌘ How to change mode
 - No AAI or AOO or VOO mode on device
 - For AAI turn ventricular output to zero after selecting DDD
 - For either VOO or AOO turn output to zero after selecting DOO
- ⌘ How to change battery

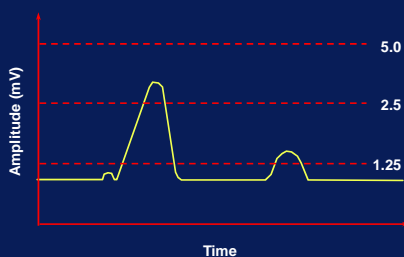
Sensing

- ⌘ The lower the number the more sensitive the device
- ⌘ Atrial lead can be turned lower than ventricular lead because P waves smaller than QRS
- ⌘ Bipolar leads (two leads on the heart) less likely to have problems with oversensing

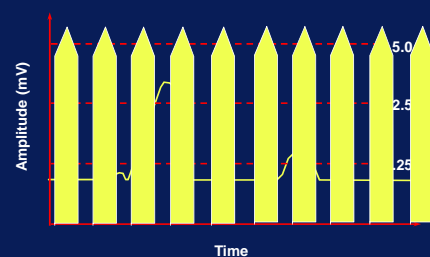
Sensitivity – The Greater the Number, the Less Sensitive the Device to Intracardiac Events

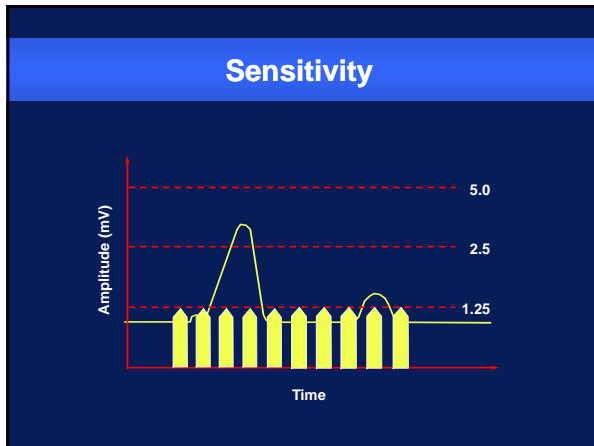


Sensitivity



Sensitivity





- ⌘ This message will come up when you are pacing in DOO mode.
- ⌘ Push on and it will come on with some sensing but it will need to be adjusted

AAI Pacing

- ⌘ Usually AAI is not an option in mode selection
- ⌘ Select DDD
- ⌘ Turn ventricular output to zero and the mode will switch to AAI

Dual Chamber Pacing

- ⌘ Get another device and program it before hooking up to patient
- ⌘ Lower rate limit
- ⌘ Upper tracking limit – default is 110bpm
- ⌘ AV delay
- ⌘ PVARP

Upper Tracking Rate

⌘ The maximum rate the ventricle can be paced in response to sensed atrial events

DDDR 60 / 100 (upper tracking rate)
Sinus rate: 100 bpm

Upper Rate Programming

- ⌘ Make sure A Tracking is on – which is default
- ⌘ If it is off you will pace DDI which means you will effectively be VVI

Dual Chamber Pacing

- ⌘ Post Ventricular Atrial Refractory Period
 - PVARP
 - The time after the ventricular paced event that the atrial lead sensing is off
- ⌘ AV delay
 - The time from the atrial spike that the pacemaker looks for a native QRS before pacing the ventricle

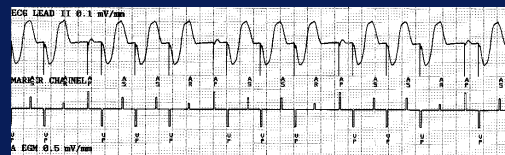
Dual Chamber Programming

- ⌘ PVARP
 - Usually around 220 – 250 msec
 - May need to shorten to achieve higher tracking rates
- ⌘ AV Delay (PR interval)
 - Around 150 msec
 - Do not make too short or will not allow time for atria to empty

Total Atrial Refractory Period

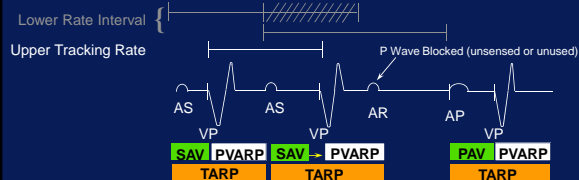
- ⌘ $PVARP + AV Delay = TARP$
- ⌘ Above this rate the device will track every other P wave
- ⌘ Default is $300 + 170 = 470$ or 127 bpm
- ⌘ $220 + 150 = 370$ or 2:1 block rate of 160 bpm
- ⌘ In infants may shorten AV delay to 120 and PVARP to 200 to achieve tracking up to 185 bpm

Is This Normal Device Operation?



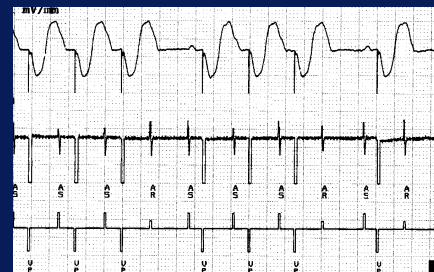
Wenckebach Operation

- ⌘ Prolongs the SAV until upper rate limit expires
 - Produces gradual change in tracking rate ratio



DDD Sinus rate = 109 bpm (550 ms) LR = 60 bpm (1000 ms) UTR = 100 ppm (600 ms)
 SAV = 200 ms PAV = 230 ms PVARP = 300 ms

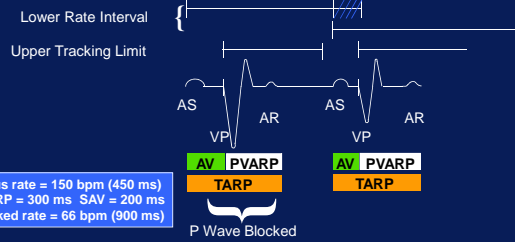
Wenckebach Operation



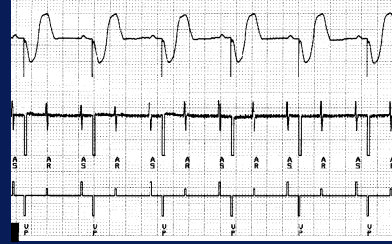
DDD / 60 / 120 / 310

2:1 Block

⌘ Every other P wave falls into refractory and does not restart the timing interval



2:1 Block



DDD / 60 / 120 / 310

Wenckebach vs. 2:1 Block

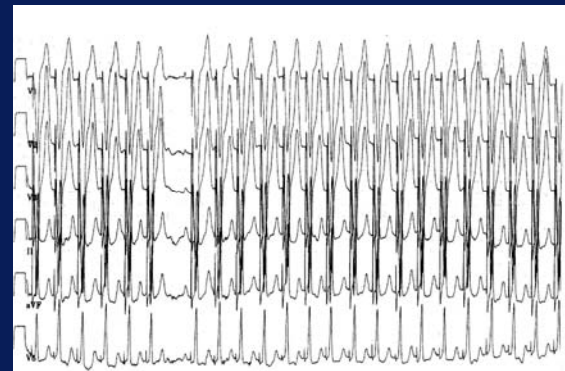
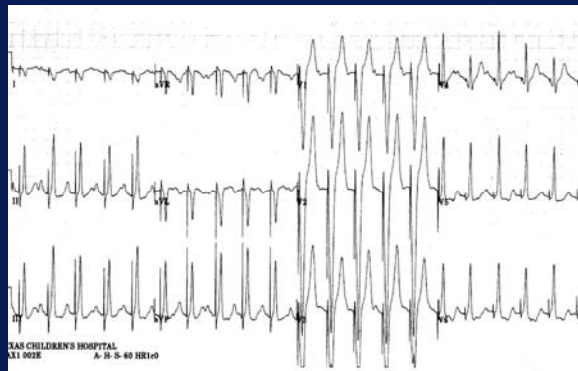
⌘ If the upper tracking rate interval is longer than the TARP, the pacemaker will exhibit Wenckebach behavior first...

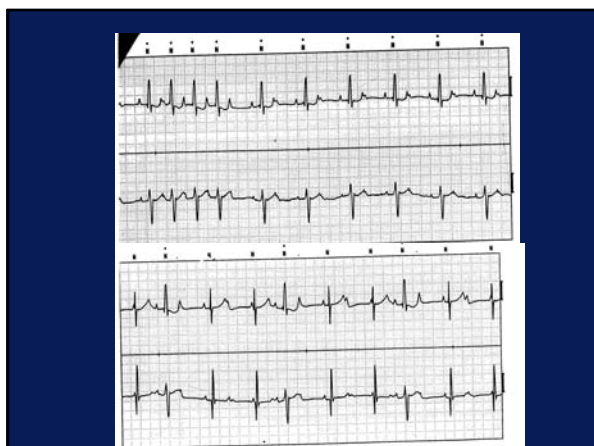
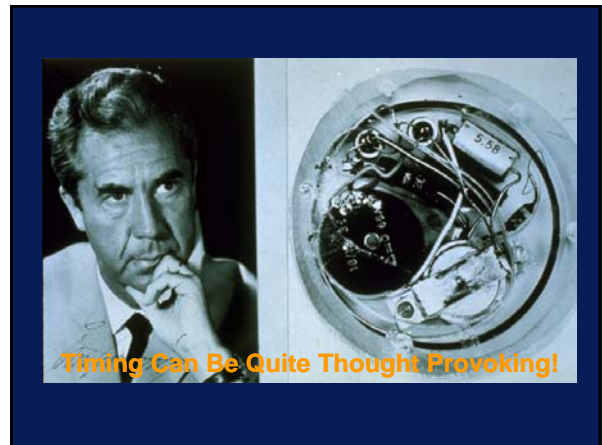
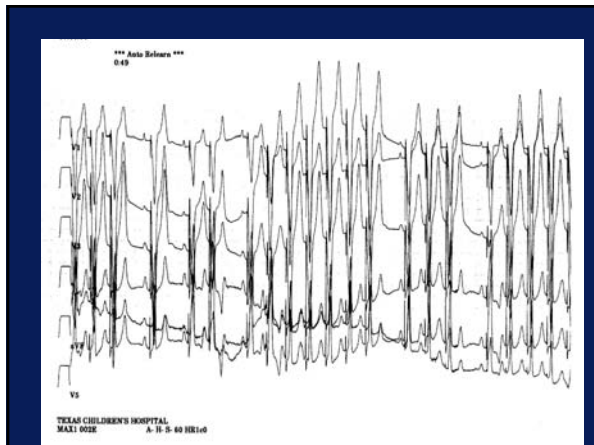
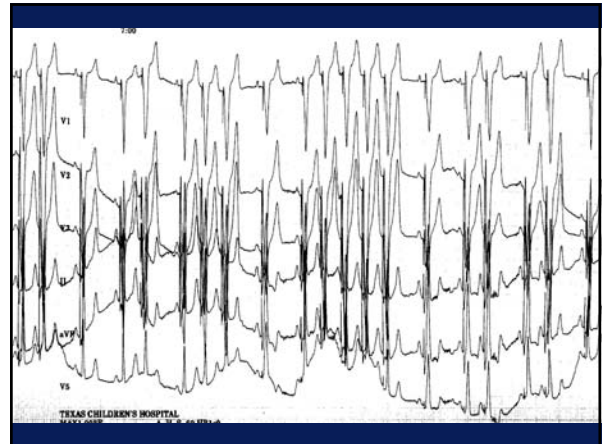
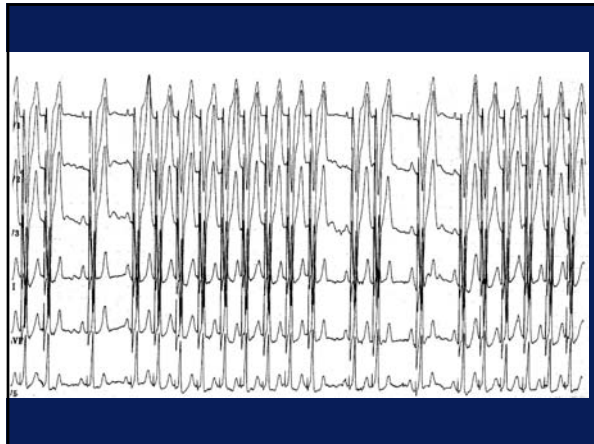
⌘ If the TARP is longer than the upper tracking rate interval, then 2:1 block will occur

Upper Rate Behavior



⌘ When you program your upper rate without adjusting the AV delay and PVARP the pacemaker gives you this message





Pacing Wires

- ☞ In perfect world
 - Two atrial wires
 - Two ventricular wires
- ☞ In emergency if only one ventricular wire placed by surgeons
 - Place skin electrode and plug wire on the heart into negative port
 - If one ventricular and one atrial wire then place ventricular wire in negative port and atrial wire in positive port

Temporary Pacing

- ⌘ Pacing spikes do not mean the heart is beating
 - Make sure pulse or pulse ox or arterial line is registering a pulse
- ⌘ Pacing spikes on monitor do not mean the pacemaker is pacing
 - Look at lights on the box
- ⌘ Know how to change the battery

Laminate for Your Pocket

- ⌘ Front of Device
 - Rate 80 to 100
 - A Output 5 mA
 - V Output 5 mA
- ⌘ Menu 1
 - A sensing 0.5 mV
 - V sensing 2.0 mV
- ⌘ Menu 2
 - Upper rate 150
 - PVARP 220-240 mS
 - AV interval 150 mS
- ⌘ Menu M
 - Select DDD

Diagnostic Utility of Pacing Wires

- ⌘ Atrial electrograms
- ⌘ Hook RA and LA ECG leads to the atrial wires if there are two – atrial activity on lead I
- ⌘ Hook V1 to the atrial wire if only one – atrial activity on V1
- ⌘ Also use lights on pacing box

