CARDIAC SURGERY IN ASIA

20 – 22 February 2009, Hong Kong
Walking The Wall
ការារ ដែលកើតឡើង ត្រូវបាន ដឹកនាំ ដោយ សាច់ប្រយ័ត្ន និង មាន ប្រជាជន ដ៏ អប្សរ ដ៏ មាន សមត្ថភាព និង ប្រជាជន ដ៏ ប្រុង ប្រយោជន៍ ដ៏ ល្អិត
Pacemaker Mediated Tachycardia

- Any undesired rapid pacing rate resulting from ventricular stimulation as a result of triggering via the atrial channel or by interaction between the pulse generator with the patient.
Pacemaker Mediate Tachycardia: Different Causes

- Endless Loop Tachycardia
- Sensor Mediated Tachycardia
- Atrial Arrhythmia
- Myopotential Tracking
- Magnetic Resonance Imaging
- Runaway Pacemaker
Pacemaker Mediate Tachycardia: Different Causes

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Endless Loop Tachycardia

- The likelihood of retrograde conduction is directly correlated with the status of AV nodal conduction.
- In patients with sinus node dysfunction and intact AV nodal conduction; the majority will also have intact retrograde conduction.
- The incidence of retrograde conduction in the presence of complete AV block is very low
  - (10-20% of individuals)
Endless Loop Tachycardia

- Endless-loop tachycardia sustained, in part, by the presence of the pacemaker
- PMT requires the presence of retrograde VA conduction and a triggering event
  - Enabled by loss of AV synchrony
- Not all patients are able to have PMTs but it is often hard to know who is susceptible until it happens
- PMTs can be avoided by programming a sufficiently long PVARP
Endless Loop Tachycardia

The pacemaker is one limb of the reentry circuit

A loss of AV synchrony triggers retrograde conduction (yellow)

Typical triggers
- PVC
- Loss of atrial capture
- Atrial undersensing
- Premature atrial contraction
- Magnet removal
Endless Loop Tachycardia

A triggering event; such as a PVC occurs but instead of traveling forward, it conducts backward

This causes a ventricular contraction to occur dissociated from forward conduction

The retrograde (dissociated) P-wave falls in the atrial alert period ... and is sensed, which causes the pacemaker to pace the ventricle in response (atrial tracking)

This creates an endless loop: forward from atrium and ventricle then backward from ventricle to atrium

- Each retrograde P-wave triggers a ventricular paced event
Patient Assessment

- History
- Symptoms
- Physical examination
- Device examination
- Review of daily activities...active or sedentary
Symptoms

- Palpitations
- Light-headedness
- Chest discomfort
- Syncope
Physical Examination

- Confirmation of tachycardia

- Findings on ECG:
  - Intermittent or continues ventricular paced at the upper rate limit.
Pacemaker-Mediated Tachycardia (PMT)

PMT requires the presence of retrograde VA conduction and a triggering event such as

- PVC - loss of AV synchrony
- loss of atrial capture leading to potential for
Progression to PMT

Loss of Atrial Capture

PMT
Retrograde VA Conduction

Occurs when an electrical impulse in the heart can conduct backward (from ventricle to atrium) as well as forward.

Not all patients have the ability to conduct an impulse retrograde.

Retrograde (VA) Conduction is Necessary for PMT to occur.
Measuring VA Conduction

Temporarily program the pacemaker to a rate that is above the patient’s intrinsic atrial rate in order to force ventricular pacing

- Temporarily program the mode to VVI
- Or, DDD with sub threshold atrial output

Monitor the atrial rhythm with a surface ECG or an atrial EGM

Look for atrial sensed events derived from ventricular paced events

Measure the RVAC interval
Measuring RVAC with ECG/Atrial EGM
Preventing Endless Loop Tachycardia

When possible, treat the cause

- for instance, atrial loss of capture

Measure the RVAC and program a PVARP value that is equal to the VA conduction time

- + 50 ms (safety margin)

Use PMT detection and termination algorithms

- PVC Options and PMT Options
Preventing Endless Loop Tachycardia

PMTs can be avoided by programming a sufficiently long PVARP
Post Ventricular Atrial Refractory Period (PVARP)

The period after a sensed or paced ventricular event during which the atrial sensing circuit is refractory. Any atrial event occurring during the PVARP will not be sensed by the atrial sensing circuit.
**Total Atrial Refractory Period (TARP)**

TARP is the timing cycle on the atrial channel during which the pacemaker will not respond to incoming signals.

TARP consists of the AV delay plus the PVARP

\[ TARP = AV\text{ delay} + PVARP \]
How Pacemakers See PVCs

A PVC is an intrinsic ventricular event not preceded by a paced or sensed atrial event.

If an intrinsic atrial event is sensed during the relative refractory portion of the PVARP, it counts as a valid atrial event if it is followed by an intrinsic ventricular event within the next 280 ms.
Preventing Endless Loop Tachycardia

PMTs can be avoided by programming a sufficiently long PVARP.
Algorithms to Prevent Endless Loop Tachycardia

PMT Options

- PVARP on PVC
- A Pace on PVC
- 10 beats > PMT
- Auto-Detect
+PVARP on PVC

- This automatic algorithm extends the PVARP value to 480 ms whenever the pacemaker determines a PVC has occurred
- After the extended PVARP, there is an automatic 330 ms alert period
- The atrial escape interval is now 480 + 330 (810 ms) or 72 ppm
A Pace on PVC
new feature (similar to +PVARP)

- When a PVC occurs, the atrial channel launches a 480 ms PVARP

- An atrial event sensed in the relative refractory period is considered a retrograde P-wave

- If a retrograde P-wave is sensed, an atrial output is automatically delivered 330 ms after that retrograde P-wave
10 beats > PMT

10 beats > PMT automatically extends the PVARP when a PMT is detected

How the pacemaker detects a PMT

- A PMT detection rate must be programmed (90 to 180 ppm)
- PMT is confirmed when there are 10 consecutive AS-VP events at a rate higher than the PMT detection rate
- On the 10\textsuperscript{th} such event, PVARP is extended to 480 ms and a 330 ms alert period is imposed
- This is repeated after 256 cycles if the PMT continues
10 beats > PMT (PMT Option)
Auto-Detect

- Detects PMT and responds on the 10th cycle
- When the patient’s intrinsic atrial rate exceeds the programmable PMT detection rate, the pacemaker measures the VP-AS interval for eight cycles
  - Averages the values
  - Compares the average to each of the individual values
  - If all VP-AS intervals are within 16 ms of the average. Diagnosis: PMT
  - On the ninth cycle, the AS-VP is either shortened or lengthened
Auto-Detect Response

• If PMT is confirmed (VP-AS intervals are all within 16 ms of the average VP-AS interval), Auto-Detect responds on the 10th cycle

• It inhibits the next ventricular output pulse

• The pacemaker paces the atrium 330 ms after the sensed atrial event (next P-wave)

• This is followed by a ventricular output pulse when the AV delay times out
Auto-Detect in Action

The figure illustrates a typical auto-detect process with intervals:

- AS-VP: 325 ms
- 250 ms
- 250 ms
- 250 ms
- 250 ms
- 200 ms
- 170 ms

The red sections represent Paced/Sensed AV Delay.

325 ms = VP-AS Interval

250 ms = AP Pace Interval
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Sensor Mediated Tachycardia

- Rapid pacing rate for non-physiologic event
- Vibration sensor - Piezocrystal
  - Oversensitive setting result in excessive pacing with slight motion
- Impedance – Based sensor - Minute Ventilation
  - Hyperventilation, electro-cautery, electrical interference
  - Recommendation to disable sensor for pre-op surgery
Atrial Arrhythmia

- Atrial fibrillation and Atrial Flutter
- Tracking rapid atrial rates
- Programmable Options
  - Non-tracking modes: DDI, VVI
  - Enable Mode Switch
- Medications
- Cardioversions
Myopotential Tracking

- Oversensing of muscle potentials in the atrial channel resulting in P-wave tracking to the upper rate limit.
- Common in unipolar dual-chamber system
- Program the atrial sensitivity to a less sensitive setting.
MRI Pacemaker Interactions

- The MRI environment can lead to rapid ventricular pacing due to the lead acting as an antennae for radiofrequency energy pulses given during scanning.
Runaway Pacemaker

- Component failure in the pulse generator
- Management
  - Removal pacemaker and leads.
- Some device have a runaway protection circuit with a preset rate limit
- Find the clinically appropriate settings for each patient based on their individual needs
- Optimize for exercise tolerance and hemodynamic status
- Observe the patients’ “real life” activities of daily living, and
- Most importantly, diagnose the specific type of PMT and reprogram accordingly
Thank you