Timing Cycles
Objectives

Upon completion of this program the participant will be able to:

- Identify the basic timing cycles of a single and dual chamber pacemaker.
- Describe the characteristics of upper rate pacing in the DDD pacing mode.
- Describe how timing cycles are affected by rate adaptive pacing.
- Explain PMT and name one treatment option.
Outline

- Single- and Dual-Chamber Timing
  - Describe the 4 scenarios of dual chamber pacing
- Upper Rate Pacing Characteristics
- Timing & Rate-Adaptive Pacing
- Pacemaker Mediated Tachycardia (PMT)
Pacemakers have two basic functions

- Pace
- Sense intrinsic rhythm and Inhibit
Timing cycles

- Single Chamber
- Dual Chamber
- Adaptive Rate
Single Chamber Timing
Interval (ms) = $\frac{60,000}{\text{rate (ppm)}}$

$60,000 / 60 \text{ ppm} = 1000 \text{ ms}$
Single chamber

VVI

Vp Vp Vs Vp

V Ref

V-V

Automatic Interval

Escape Interval
Refractory Period:
In pacing, a programmable parameter that controls the length of time following a paced or sensed beat, during which the pacemaker’s sensing circuit does not respond to sensed events.

- PVARP = Post Ventricular Atrial Refractory Period = atrial refractory period
- VRP = Ventricular Refractory Period
Single chamber

AAI

Ap  PVC  Ap  As  Ap

A  Ref  A-A

Automatic Interval  Escape Interval
Dual-Chamber Timing
Timing intervals

Dual-Chamber (DDD)

V-V = Lower Rate Limit
VA = Atrial Escape Interval
AV = AV Delay

V-V = VA + AV
Timing intervals

Example

\[
\text{VA} = \text{V-V} - \text{AV} \\
\text{V-V} = \text{VA} + \text{AV}
\]

Lower Rate = 60 ppm \hspace{1cm} \text{V-V} = 1000 \text{ ms} \\
AV Delay = 200 \text{ ms}

\[
\text{VA} = 1000 \text{ ms} - 200 \text{ ms} = 800 \text{ ms}
\]
AV sequential pacing

A-Pace / V-Pace

AV Delay

VA Interval

LRL
A-Sense / V-Sense

AV Delay
VA Interval
LRL
Atrial pacing with conduction

A-Pace / V-Sense

AV Delay

VA Interval

LRL
P-synchronous pacing

A-Sense / V-Pace

AV Delay

VA Interval

MTR

LRL
Timing intervals

Dual Chamber (DDD)

AV Delay  V-Blanking  PVARP  A-Blanking  VA Interval  V Ref  URL  LRL
Terminology

Blanking Period

- The interval of time following a paced output during which the pacemaker’s sense amplifiers are disabled
- This timing parameter prevents cross chamber sensing
Upper rate operation

PVARP AND TARP

- TARP = AV + PVARP
- 2:1 Rate = 60,000 / TARP
Upper rate operation

Pacemaker Wenckebach

Maximum Tracking Rate
Upper rate operation

Wenckebach (4:3 Block)

TARP
AV Delay
VA Interval
MTR
Upper rate operation

2:1 Block

As       Vp       AR       As       Vp
AV
PVARP
TARP

Maximum Tracking Rate

2:1 Rate = 60,000 / TARP
Upper rate operation

2:1 Block

As Vp  AR  As Vp  AR  As Vp  AR  As Vp  AR

TARP
AV Delay
VA Interval
MTR
LRL
Upper rate behavior is determined by TARP and MTR.

- 2:1 Block
- Wenckebach
- 1:1

Sinus Rate

TARP
MTR
LRL
Upper rate operation

2:1 Block > URL

MTR = 140 ppm
AV = 100 ms
PVARP = 300 ms
TARP = 400 ms

2:1 Block Point
= 60,000/TARP
= 60,000/400
= 150 bpm

Sinus Rate

Wenckebach

1:1

TARP
MTR
LRL
### Upper rate operation

#### 2:1 Block < URL

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTR</td>
<td>140 ppm</td>
</tr>
<tr>
<td>AV</td>
<td>200 ms</td>
</tr>
<tr>
<td>PVARP</td>
<td>300 ms</td>
</tr>
<tr>
<td>TARP</td>
<td>500 ms</td>
</tr>
</tbody>
</table>

2:1 Block Point
- \( \frac{60,000}{TARP} \)
- \( \frac{60,000}{500} \)
- 120 bpm

2:1 Block Point

### Diagram

- **MTR**
- **TARP**
- **LRL**

**Sinus Rate**

- **2:1**
- **1:1**
In Rate Responsive pacing (modes ending with “R”), sensor(s) in pacemaker are used to detect changes in physiologic needs and increase the pacing rate accordingly.

- **The sensor**
  - Sensors are used to detect changes in metabolic demand
  - “Sensors” sense motion (piezoelectrode crystal or accelerometer) or use a physiologic indicator, i.e., minute ventilation

- **The algorithm**
  - With-in the software of the pacemaker
  - Uses the input from the sensor to determine the appropriate paced heart rate for the activity.
Sensor-Determined Rate Controls V-V Interval
Shortened Sensing Windows at High Rates

![Diagram showing shortened sensing windows at high rates](image)
Sensor Rate Controls VA Interval

**Lower Rate 60 ppm**

**Sensor Pacing 110 ppm**
Sensor-Controlled Pacing Not Limited By PVARP

Sensor Pacing 150 ppm
DDDR: Sinus or sensor?

Follow the Faster Input
Pacemaker mediated tachycardia

Rapid ventricular pacing secondary to retrograde conduction
Retrograde conduction

Conduction of an electrical impulse from the ventricles to the atria through the heart’s conduction system.
Conditions required for PMT

- Loss of A-V Synchrony
- Intact V-A Conduction
- V-A Conduction Time > programmed PVARP
Retrograde conduction is caused by any loss of AV synchrony, such as the following:

- PVC (Retrograde conduction)
- Oversensed P wave
- Undersensed P wave
- Loss of Atrial Capture
- EMI
- Magnet Application or Removal
PMT prevention

- Program longer PVARP
  - PVARP after PVC
- Use PMT prevention scheme
- Need to make a programming change, or PMT will recur
Summary

- List and explain the four different scenarios that may be observed with dual-chamber pacing.
- Explain upper rate pacing characteristics of Wenckebach and 2:1 Block.
- Describe the mechanism and corrective actions for Pacemaker Mediated Tachycardia (PMT).
Timing Cycles