Timing Cycles

Timing cycles

Objectives

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

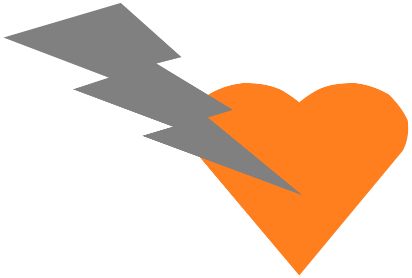
- Identify the basic timing cycles of a single and dual chamber pacemaker.
- Describe the characteristics of upper rate pacing in the DDD pacing mode.
- Describe how timing cycles are affected by rate adaptive pacing.
- Explain PMT and name one treatment option.

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**

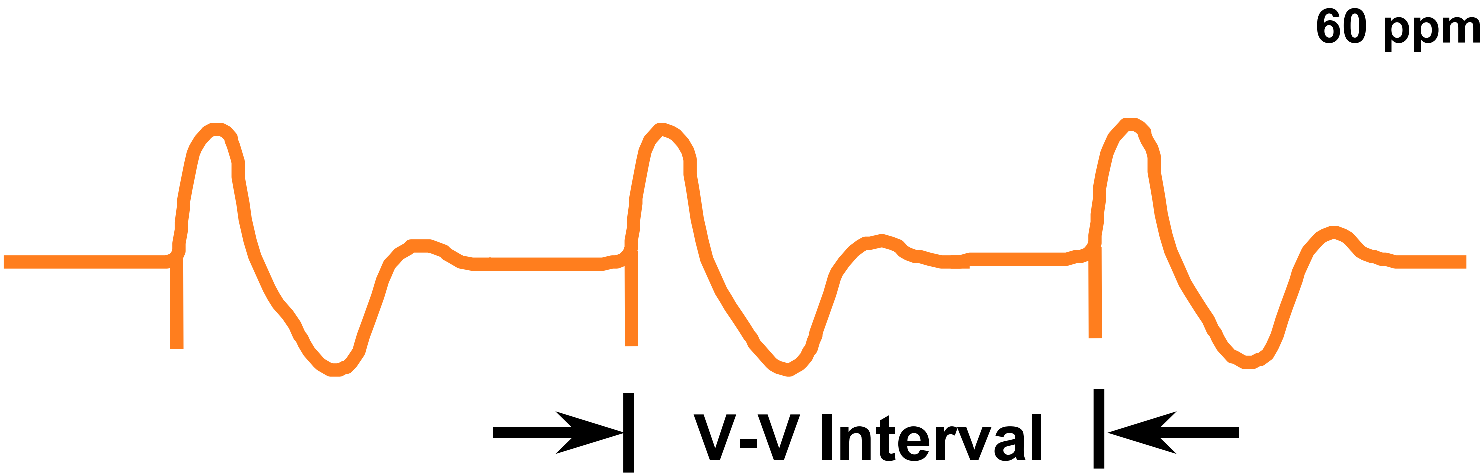
Timing cycles

- **Single Chamber**
- **Dual Chamber**
- **Adaptive Rate**

Single Chamber Timing

Single chamber

Timing Intervals

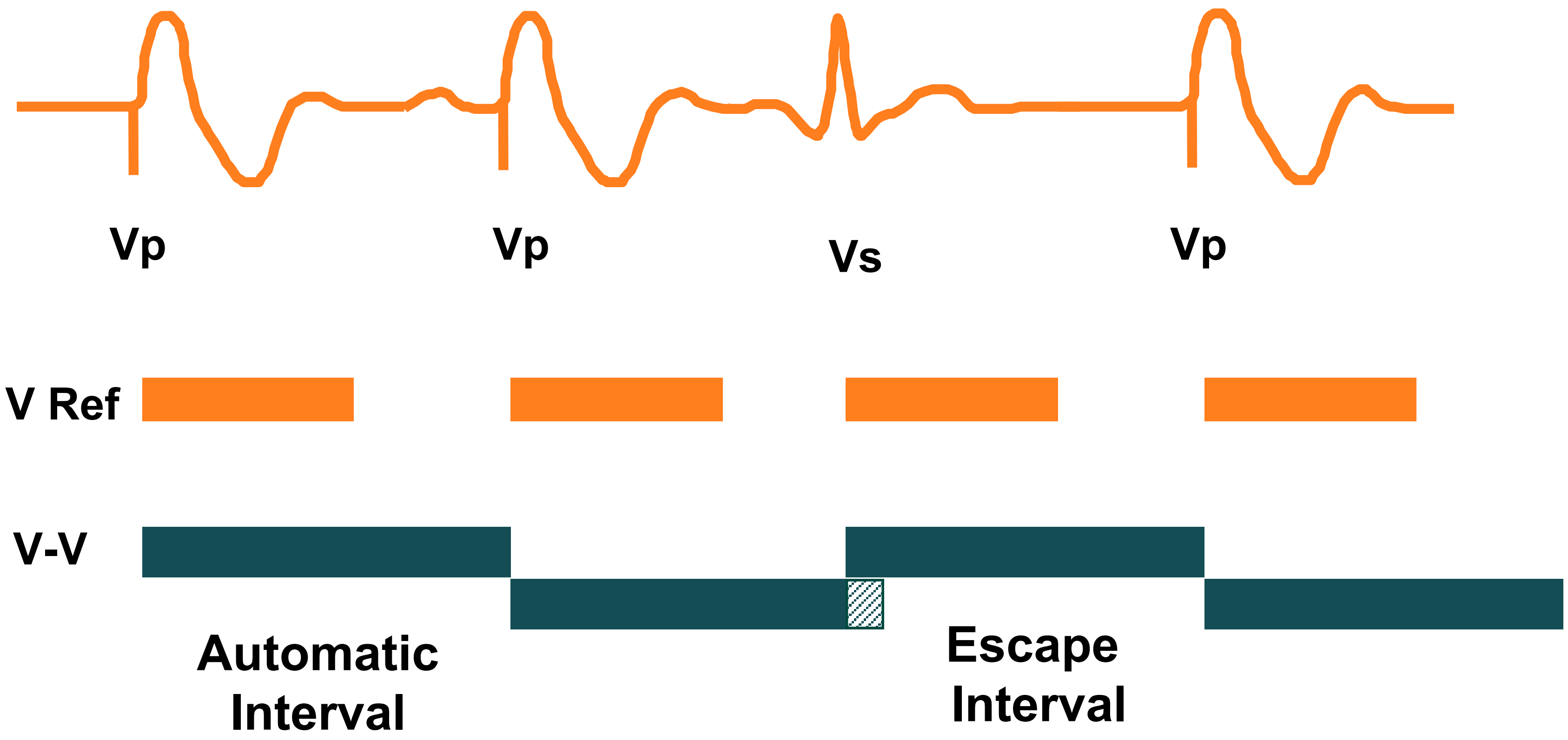


Interval (ms) = 60,000 / rate (ppm)

60,000 / 60 ppm = 1000 ms

Single chamber

VVI



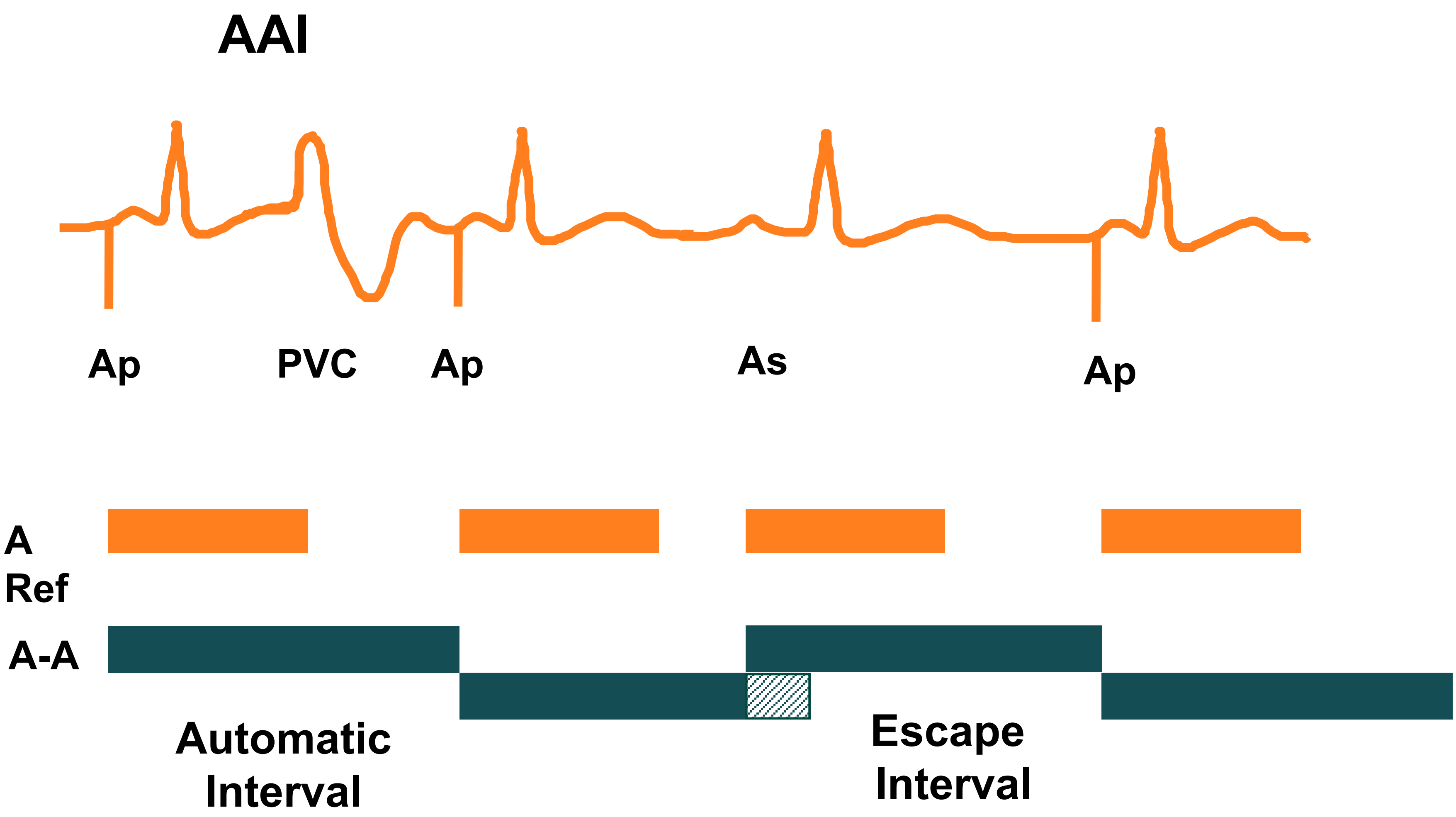
Terminology

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

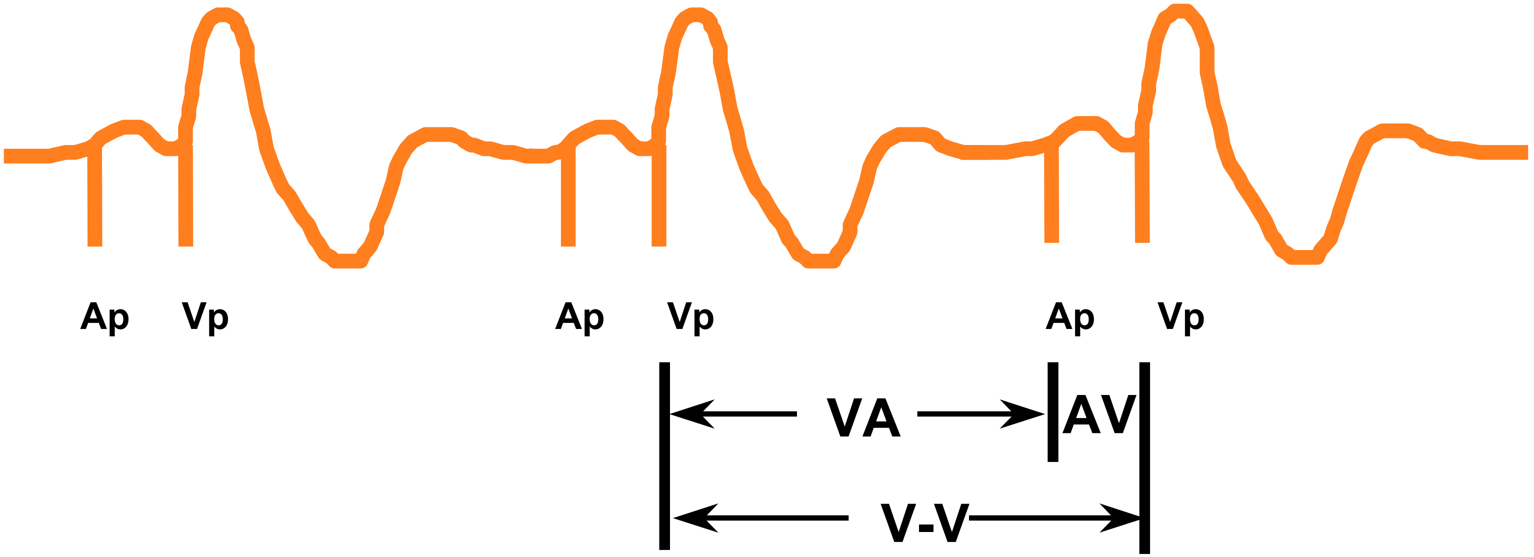
Single chamber



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

$$VA = V\text{-}V - AV$$

$$V\text{-}V = VA + AV$$

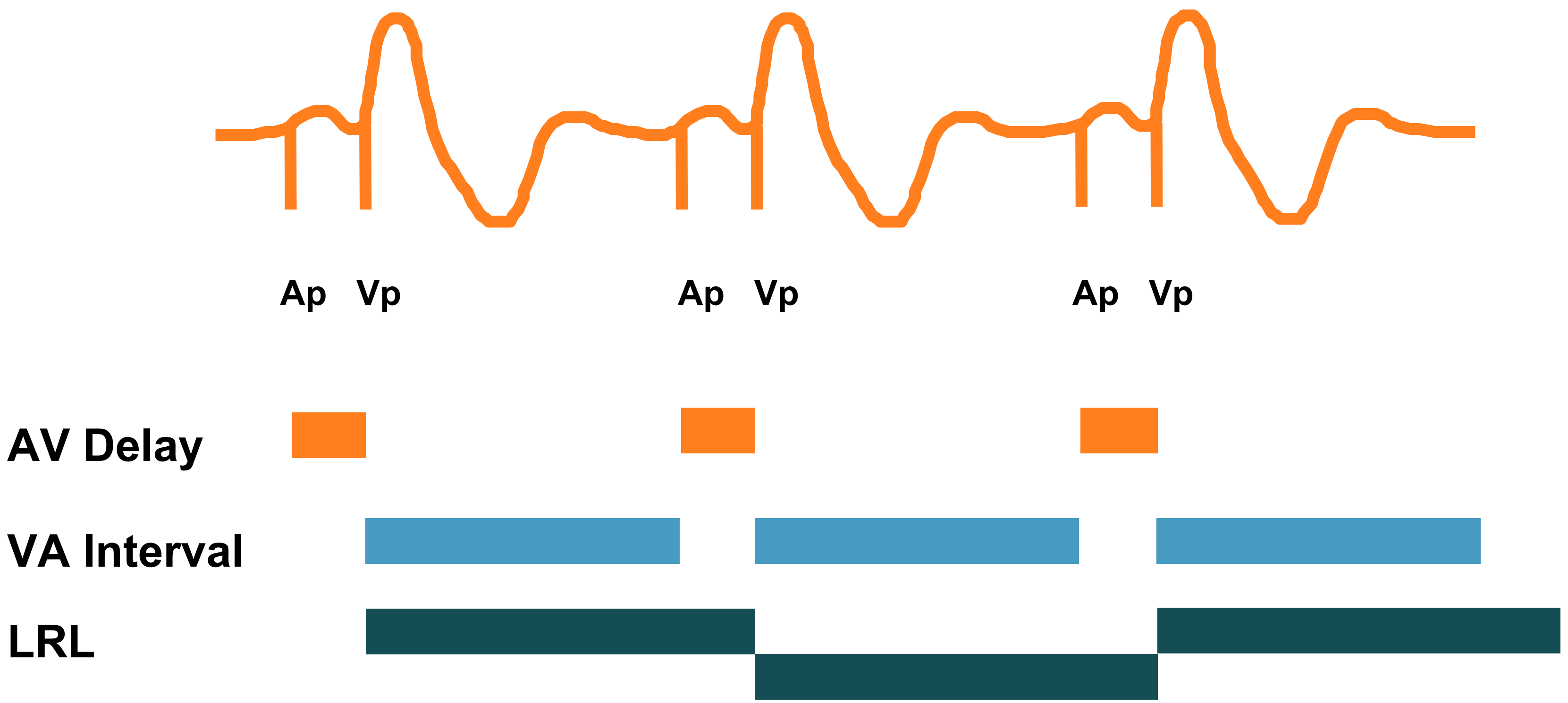
Lower Rate = 60 ppm V-V = 1000 ms

AV Delay = 200 ms

VA = 1000 ms - 200 ms = 800 ms

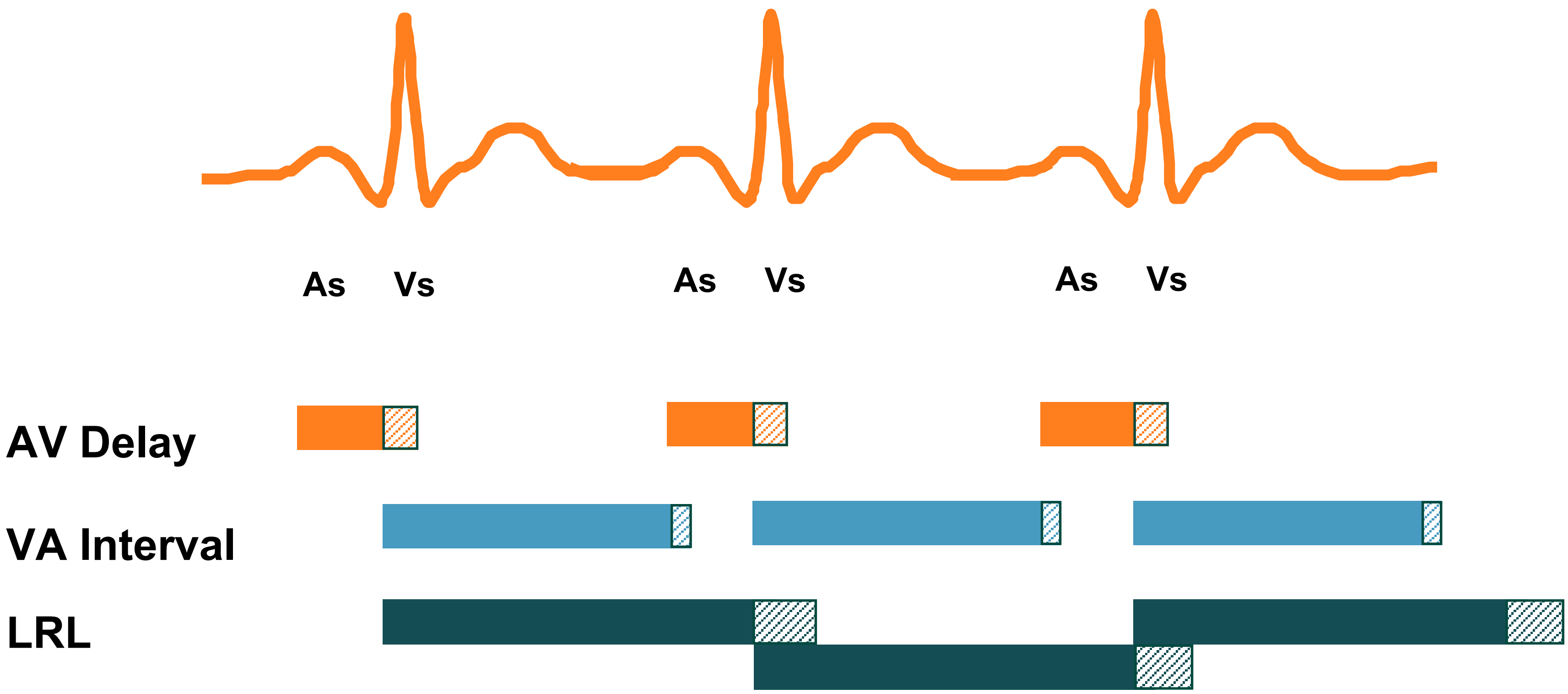
AV sequential pacing

A-Pace / V-Pace



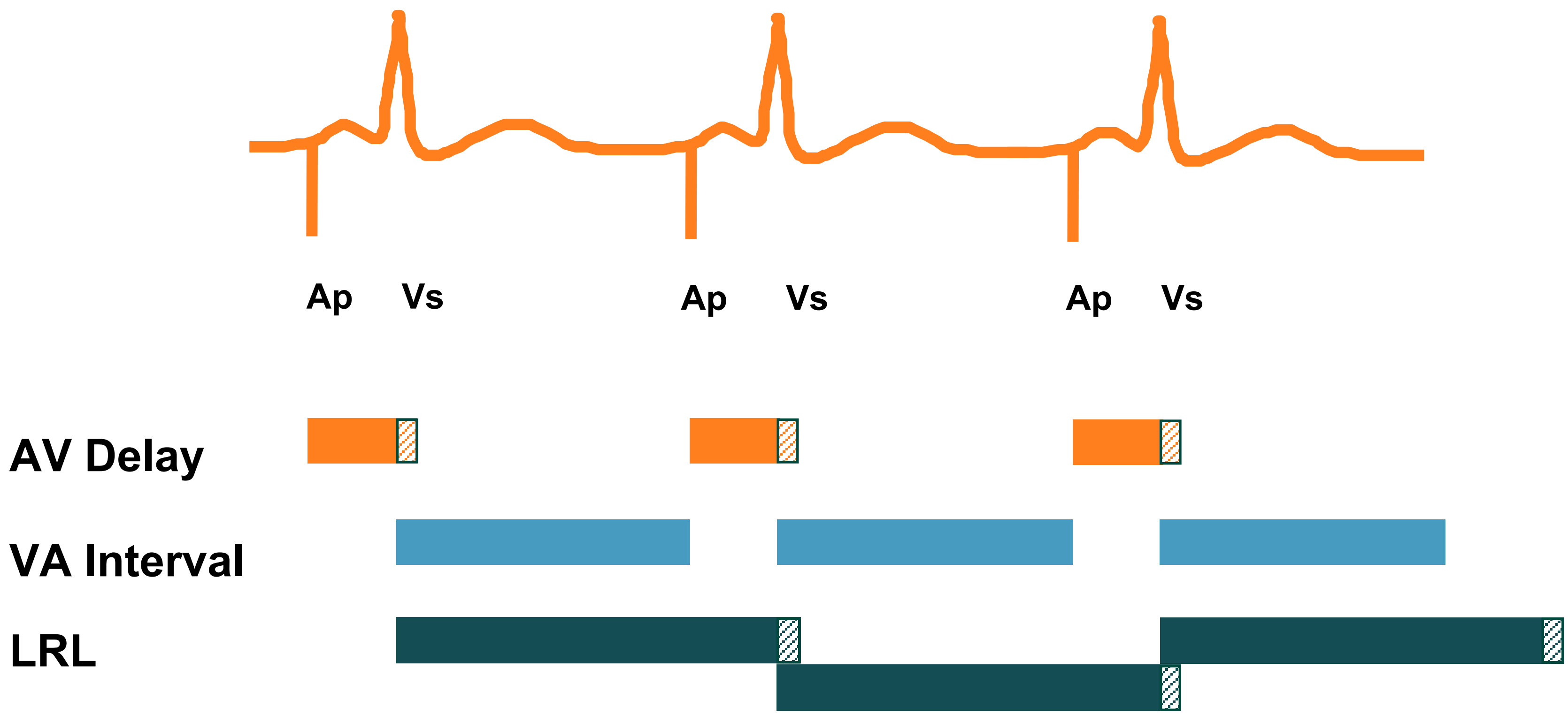
Complete inhibition

A-Sense / V-Sense



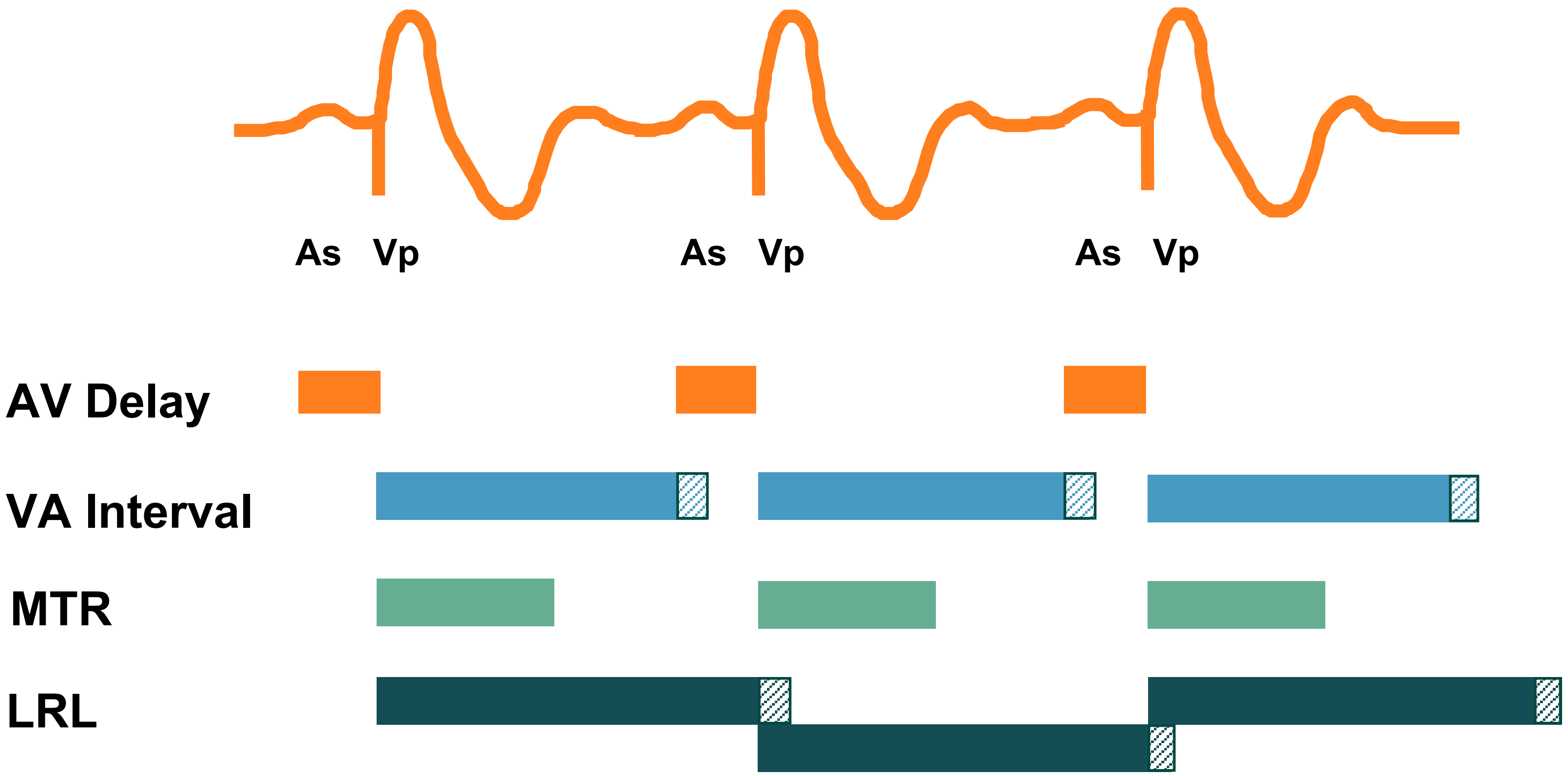
Atrial pacing with conduction

A-Pace / V-Sense



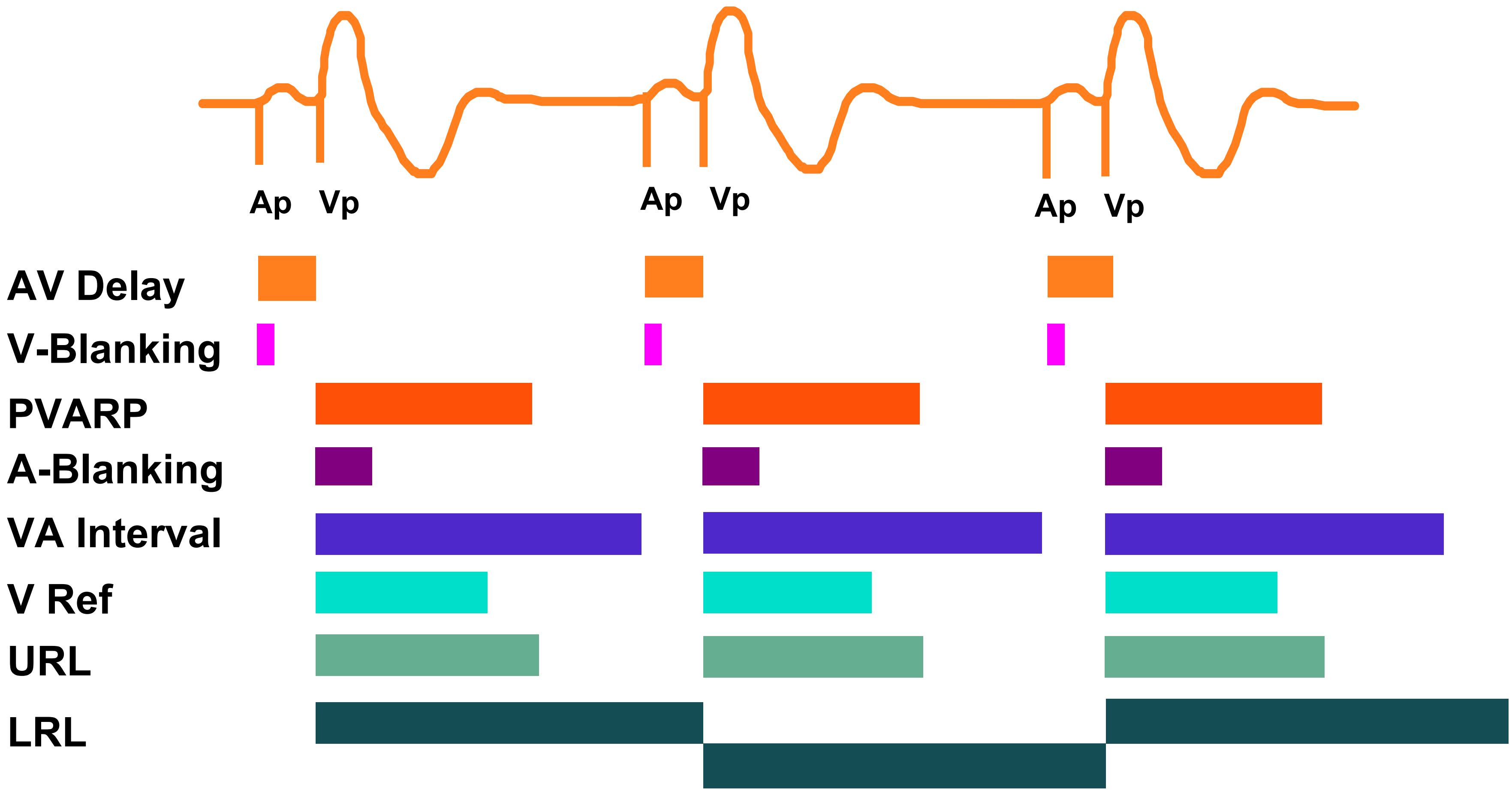
P-synchronous pacing

A-Sense / V-Pace



Timing intervals

Dual Chamber (DDD)



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

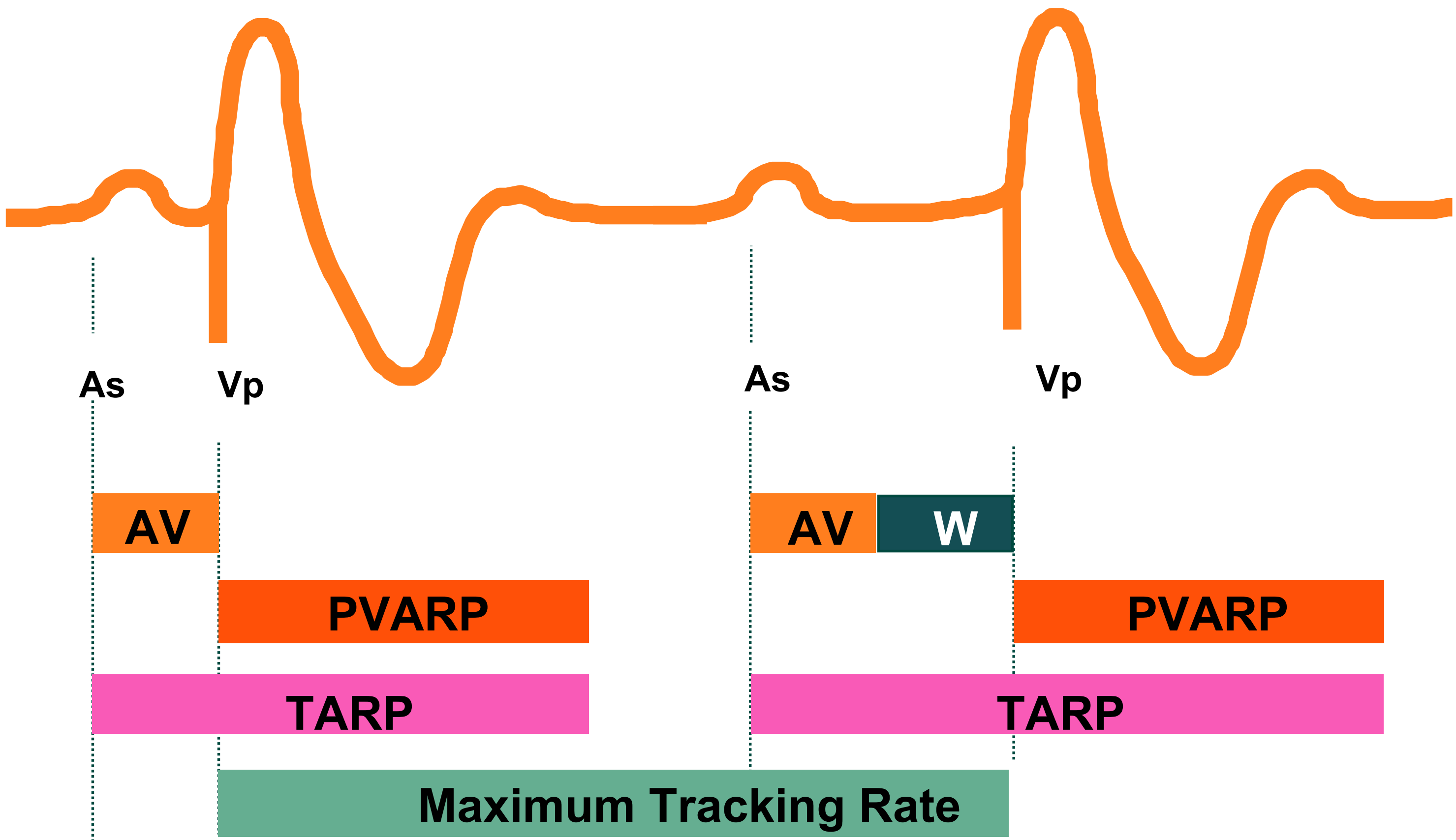
Upper rate operation

PVARP AND TARP

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

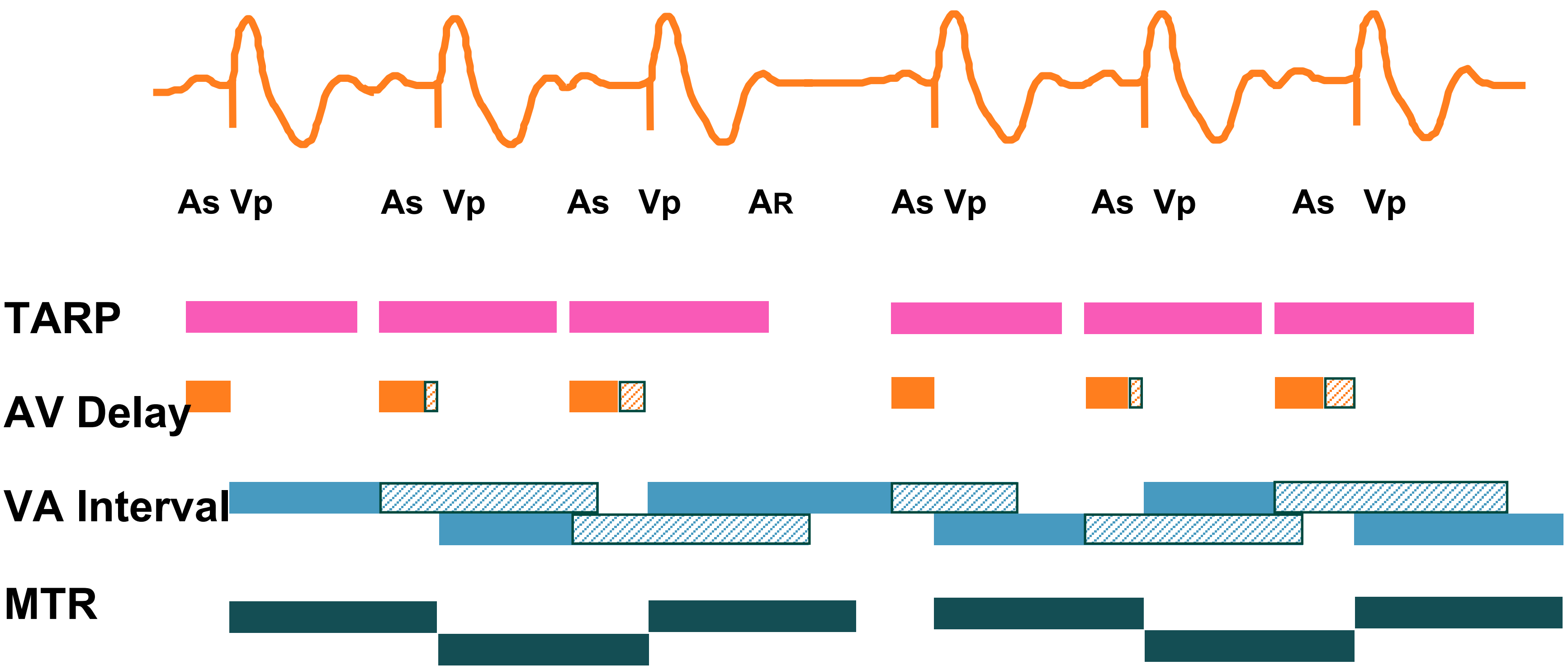
Upper rate operation

Pacemaker Wenckebach

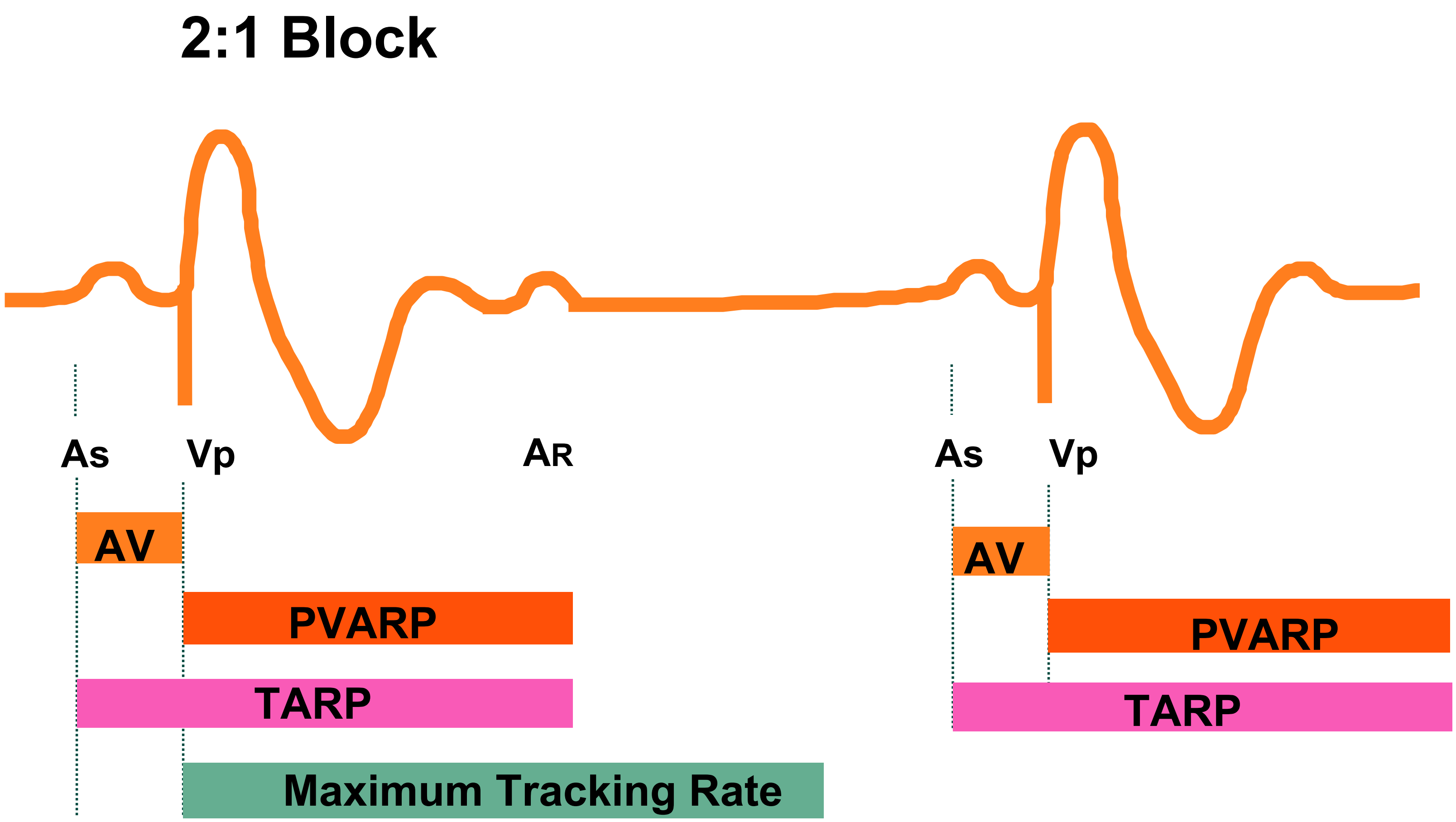


Upper rate operation

Wenckebach (4:3 Block)

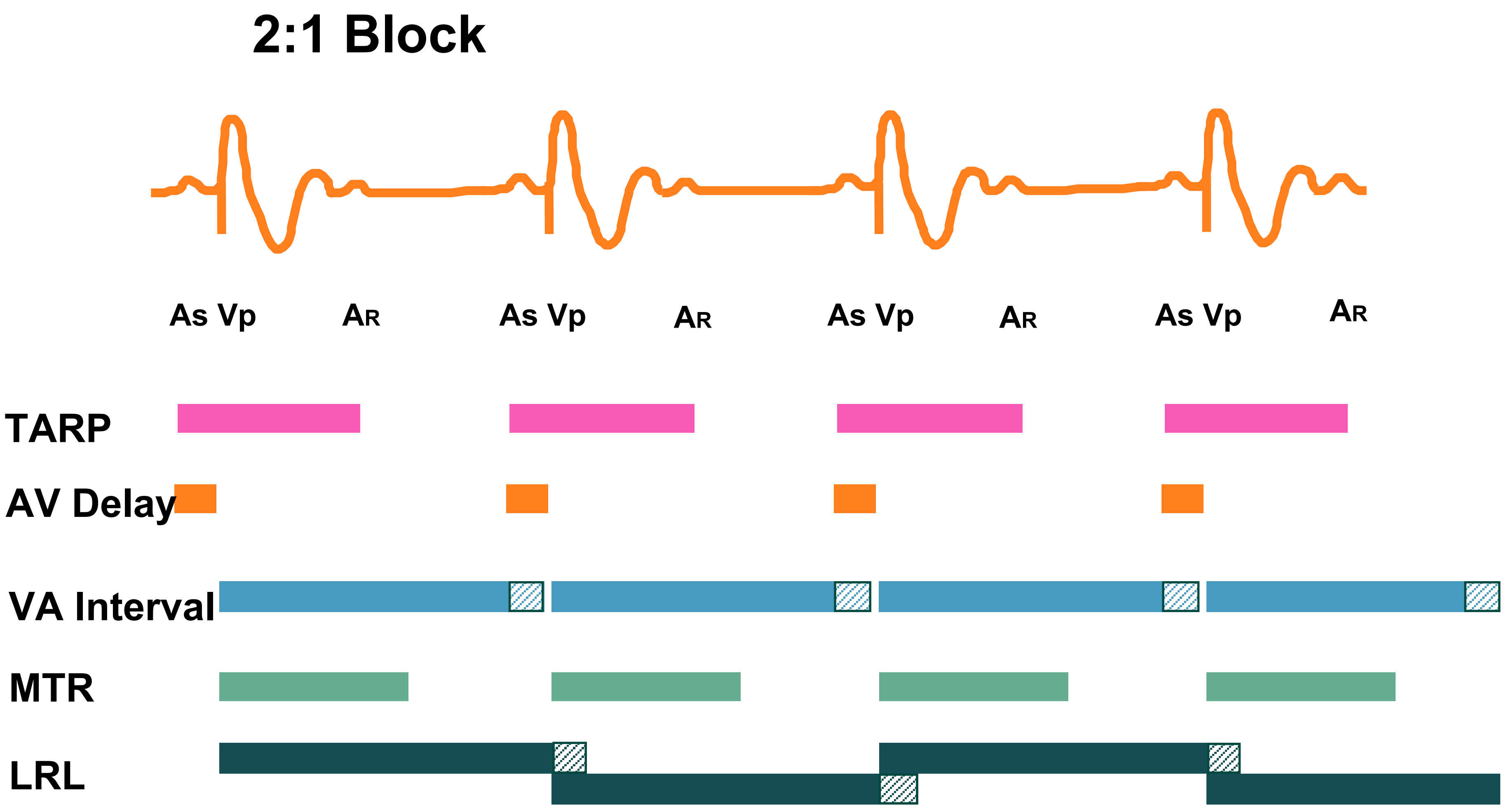


Upper rate operation



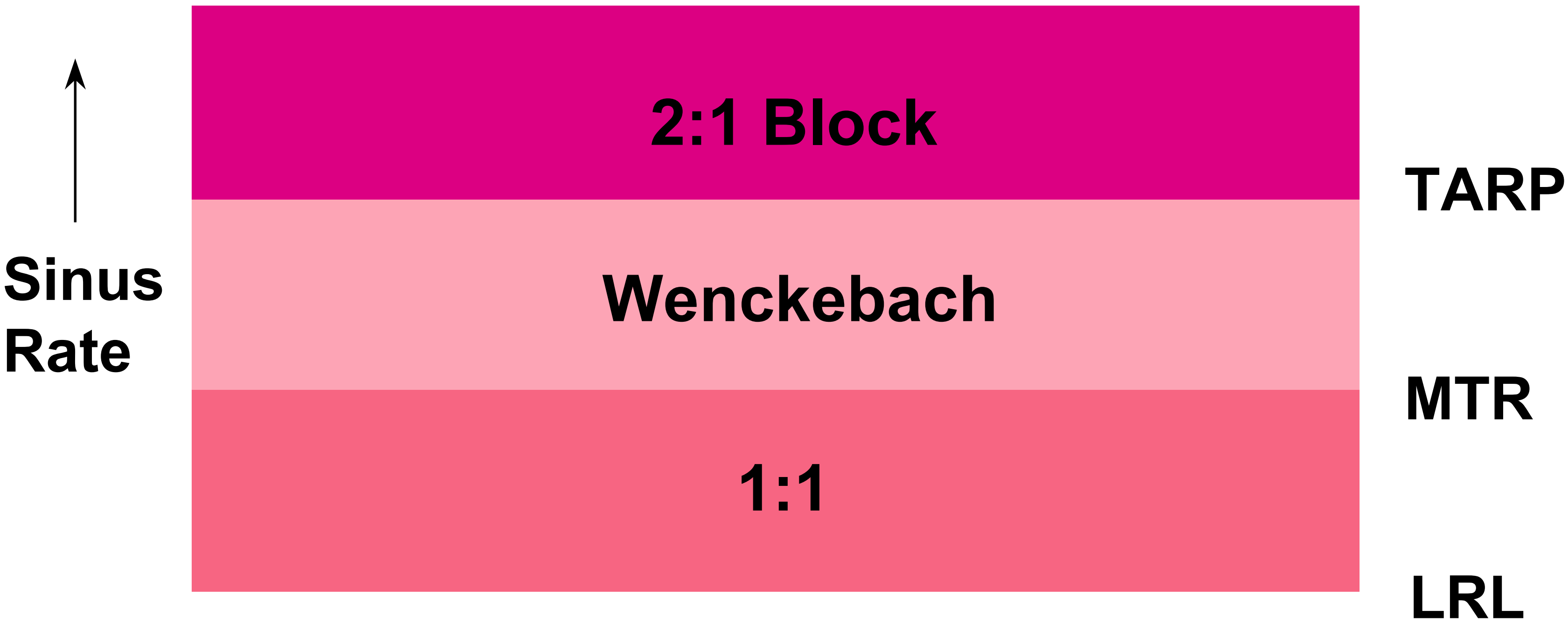
2:1 Rate = 60,000 / TARP

Upper rate operation



Upper rate operation

Upper rate behavior is determined by TARP and MTR



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

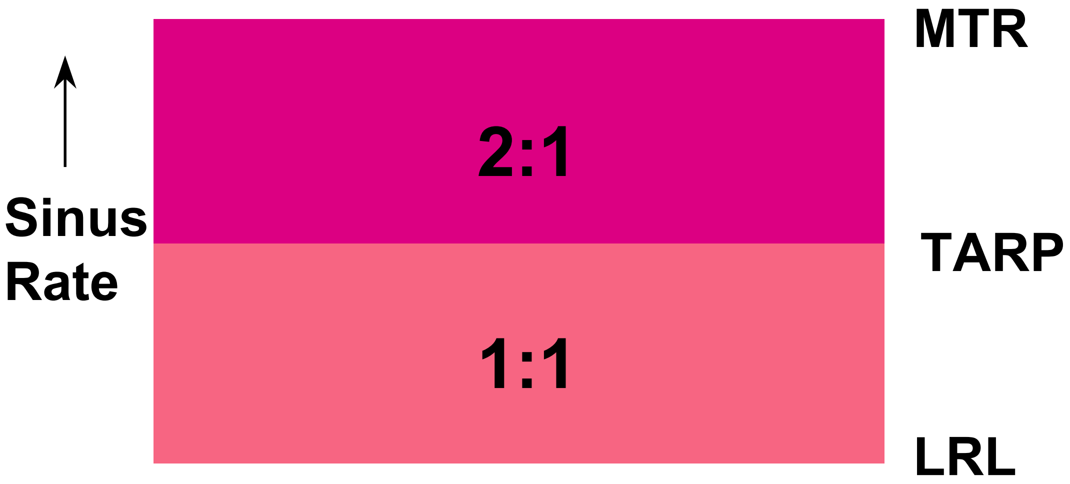
= 60,000/400

=150 bpm

Upper rate operation

2:1 Block < URL

MTR = 140 ppm
AV = 200 ms
PVARP = 300 ms
TARP = 500 ms



2:1 Block Point
= 60,000/TARP
= 60,000/500
= 120 bpm

Adaptive Rate

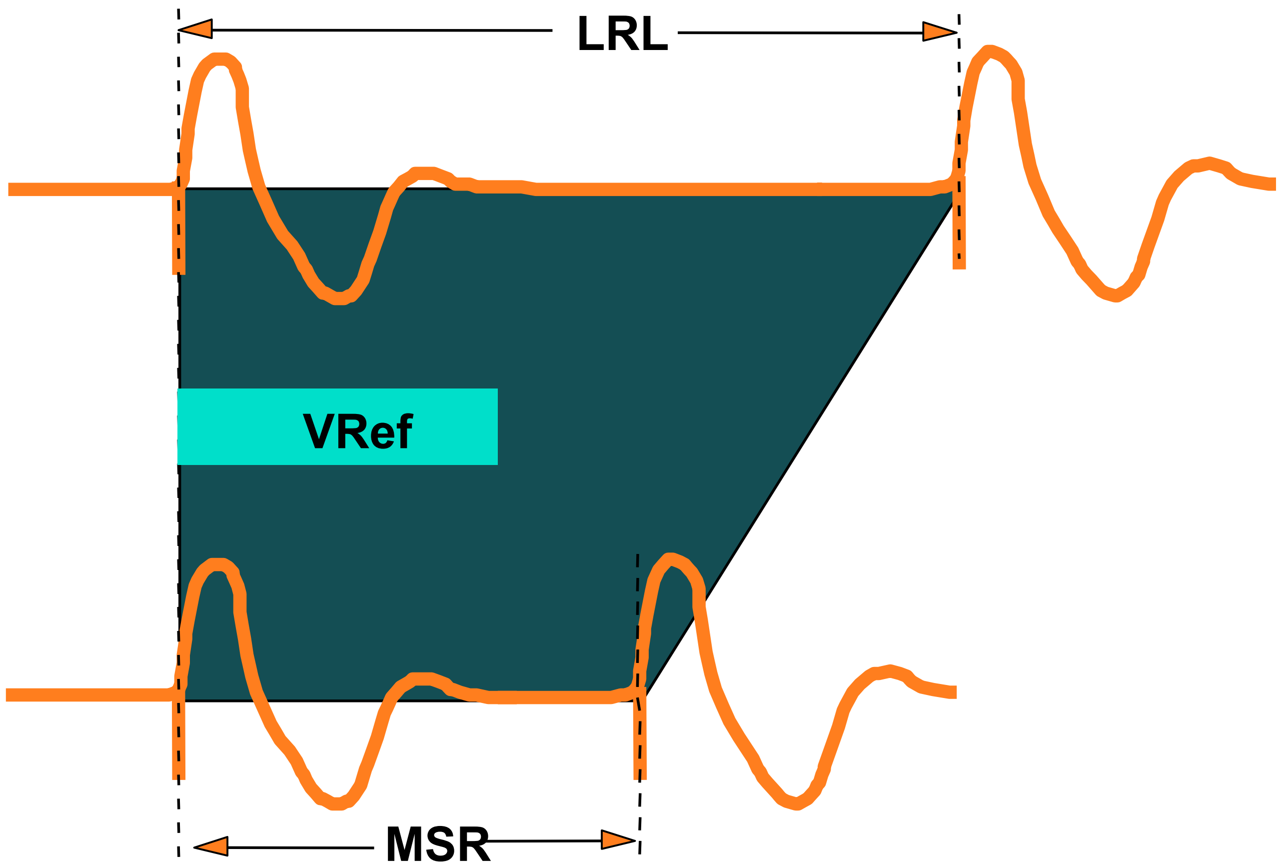
Rate responsiveness/adaptive-rate pacing

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.

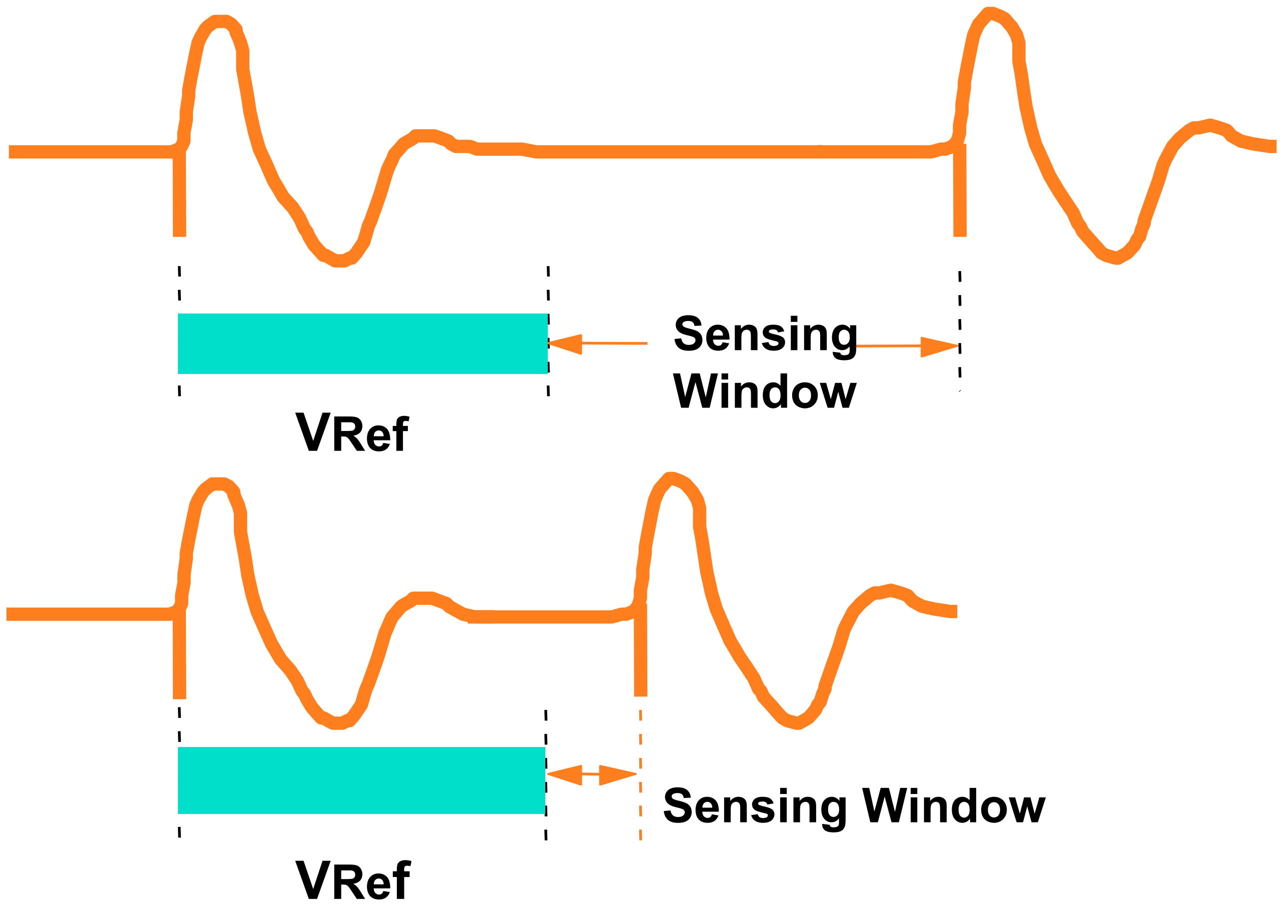
VVIR timing

Sensor-Determined Rate Controls V-V Interval



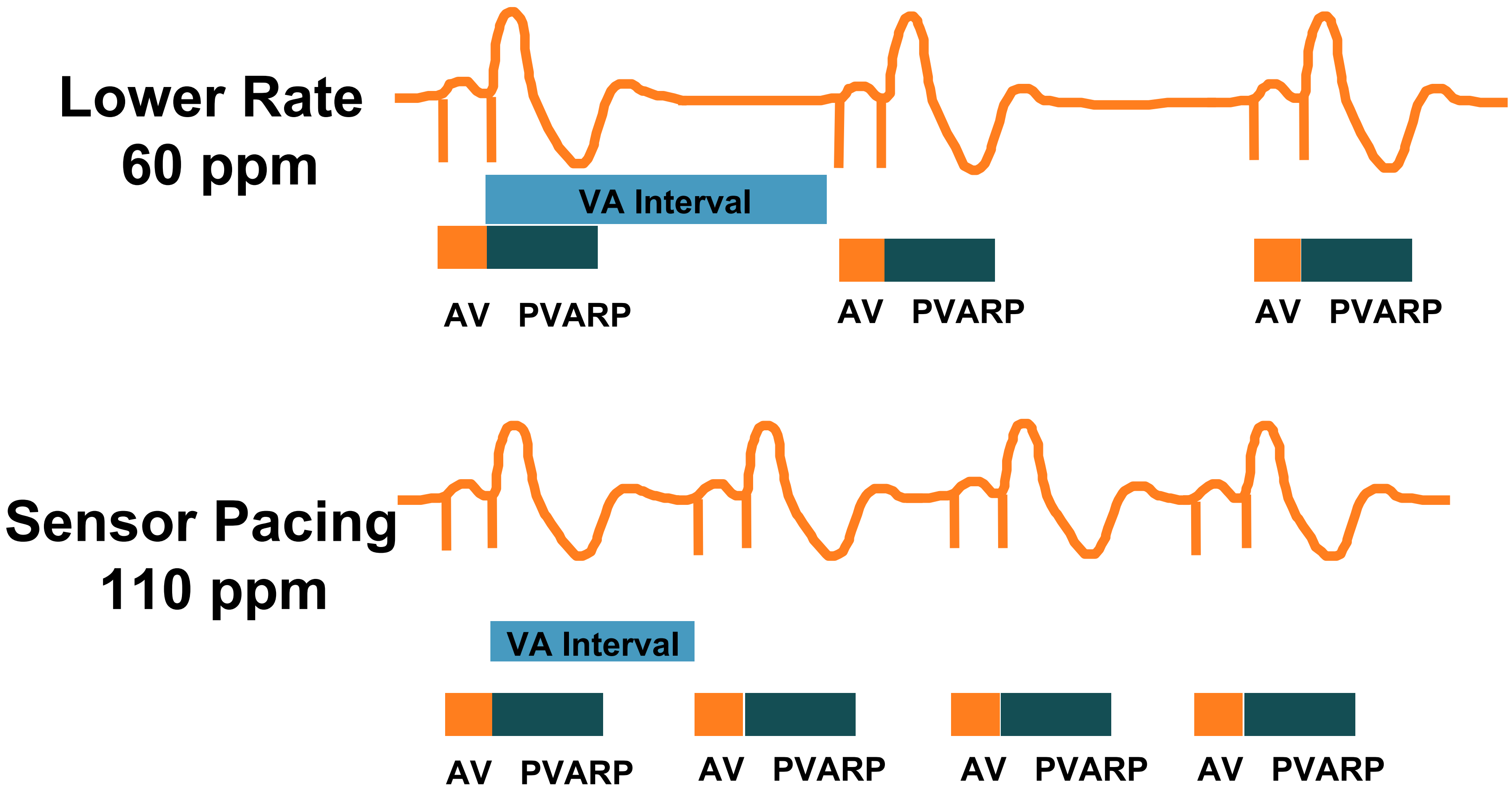
VVIR timing

Shortened Sensing Windows at High Rates



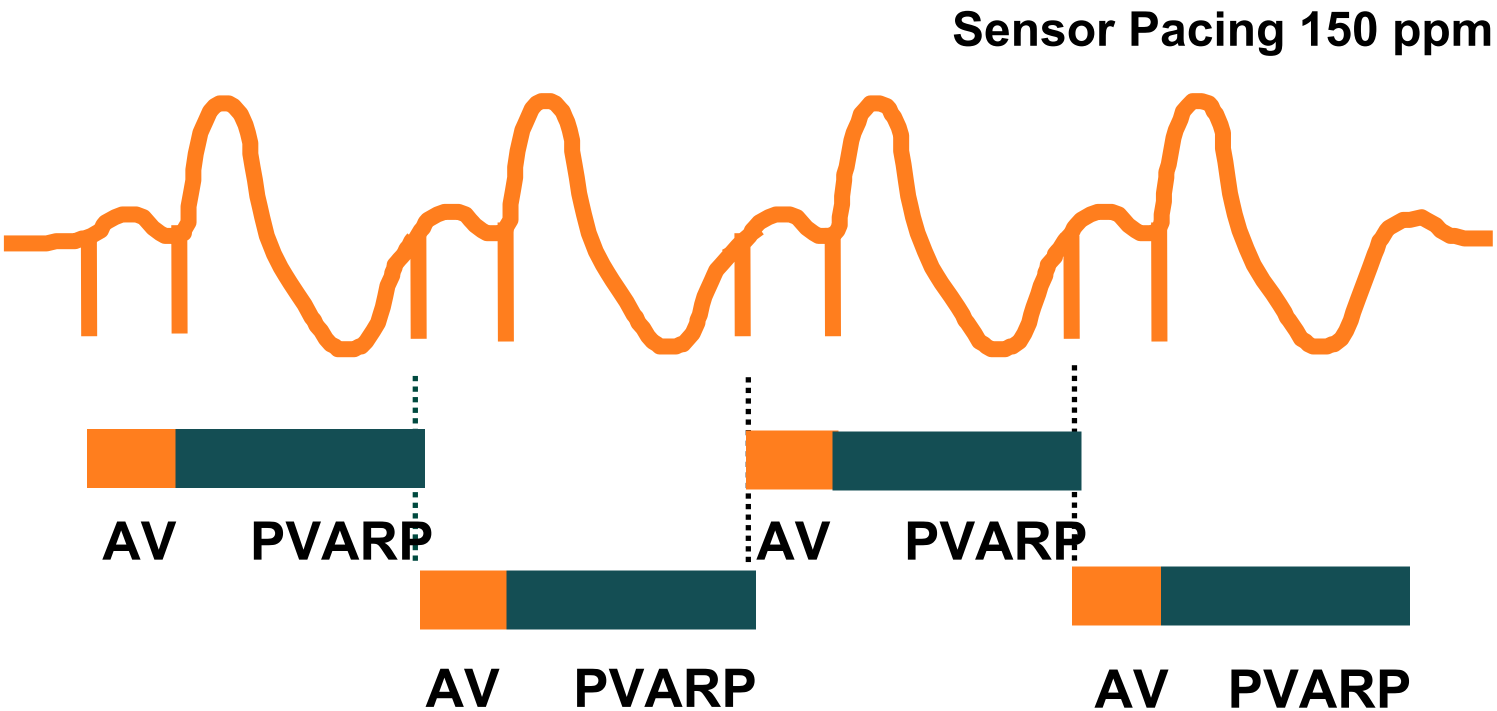
DDDR timing

Sensor Rate Controls VA Interval



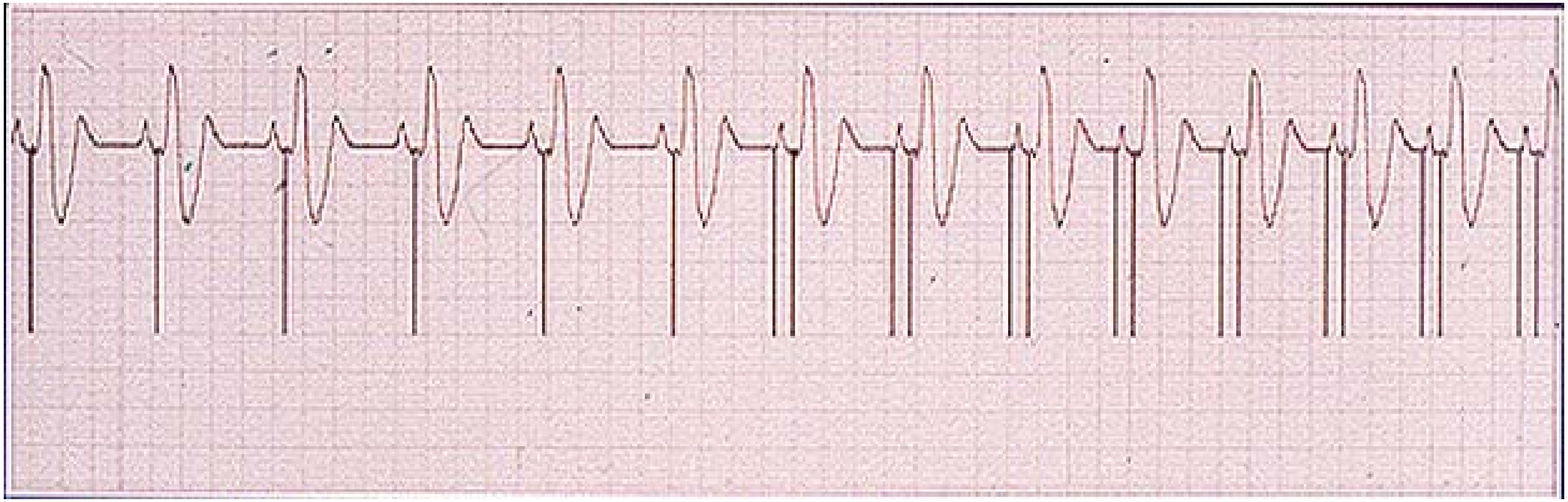
DDDR timing

Sensor-Controlled Pacing Not Limited By PVARP



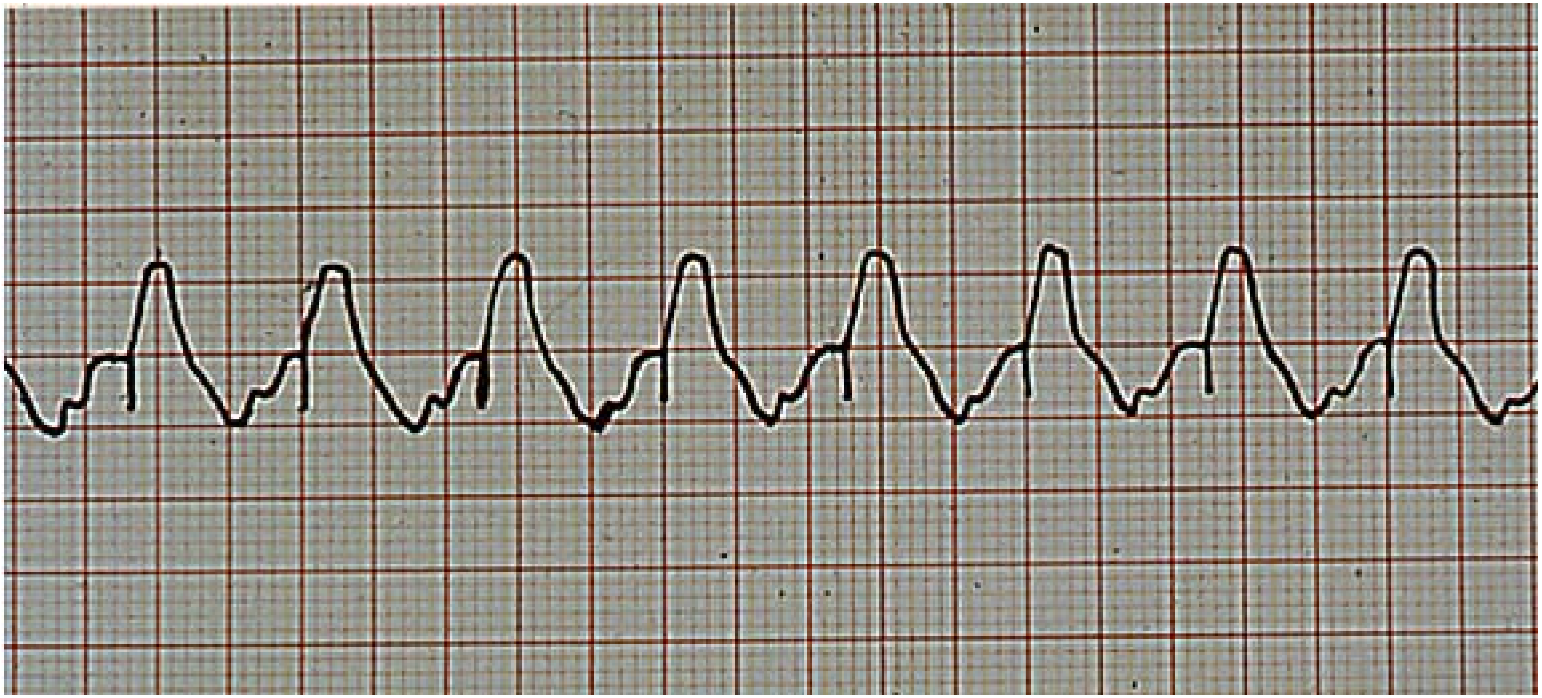
DDDR: Sinus or sensor?

Follow the Faster Input

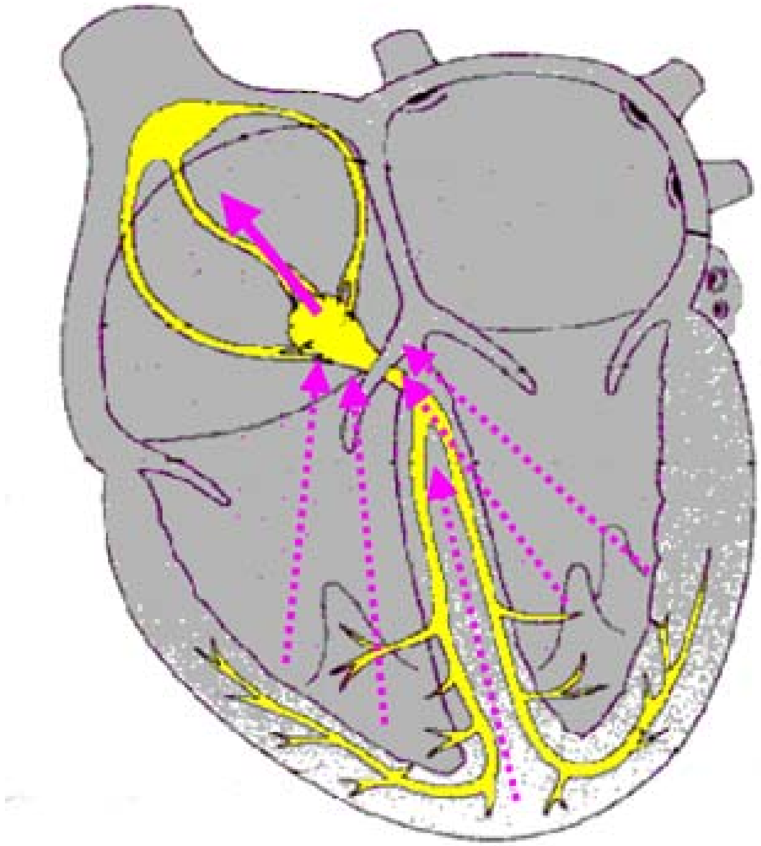


Pacemaker mediated tachycardia

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**

Initiators of retrograde conduction

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