Advanced Timing Cycles

Advanced timing cycles

Objectives

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

- Identify timing cycles of single-chamber (VVI/AAI), dual-chamber (DDD), and adaptive-rate pacemakers.
- Explain the significance of TARP and calculate TARP based on given parameters.
- Describe upper rate pacing characteristics of 1:1 conduction, pacemaker Wenckebach and 2:1 block
- Describe the difference in atrial- and ventricular-based timing systems.

Timing cycles

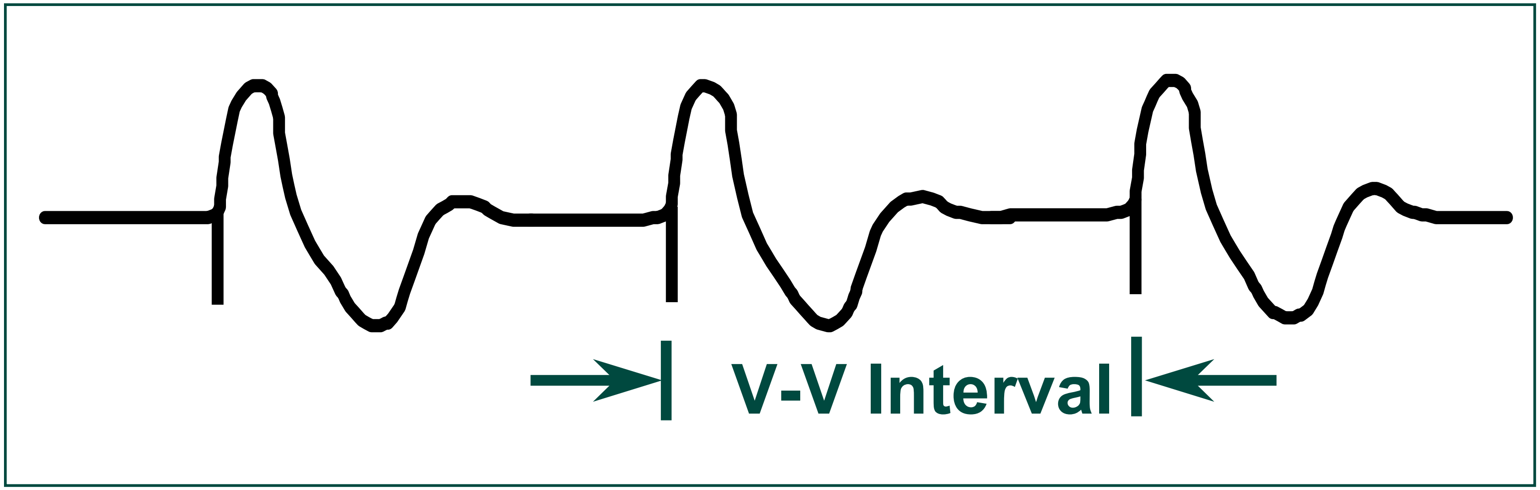
- **Single chamber**
- **Dual chamber**
- **Timing systems**

Single-chamber Timing Review

Single chamber

Timing Intervals

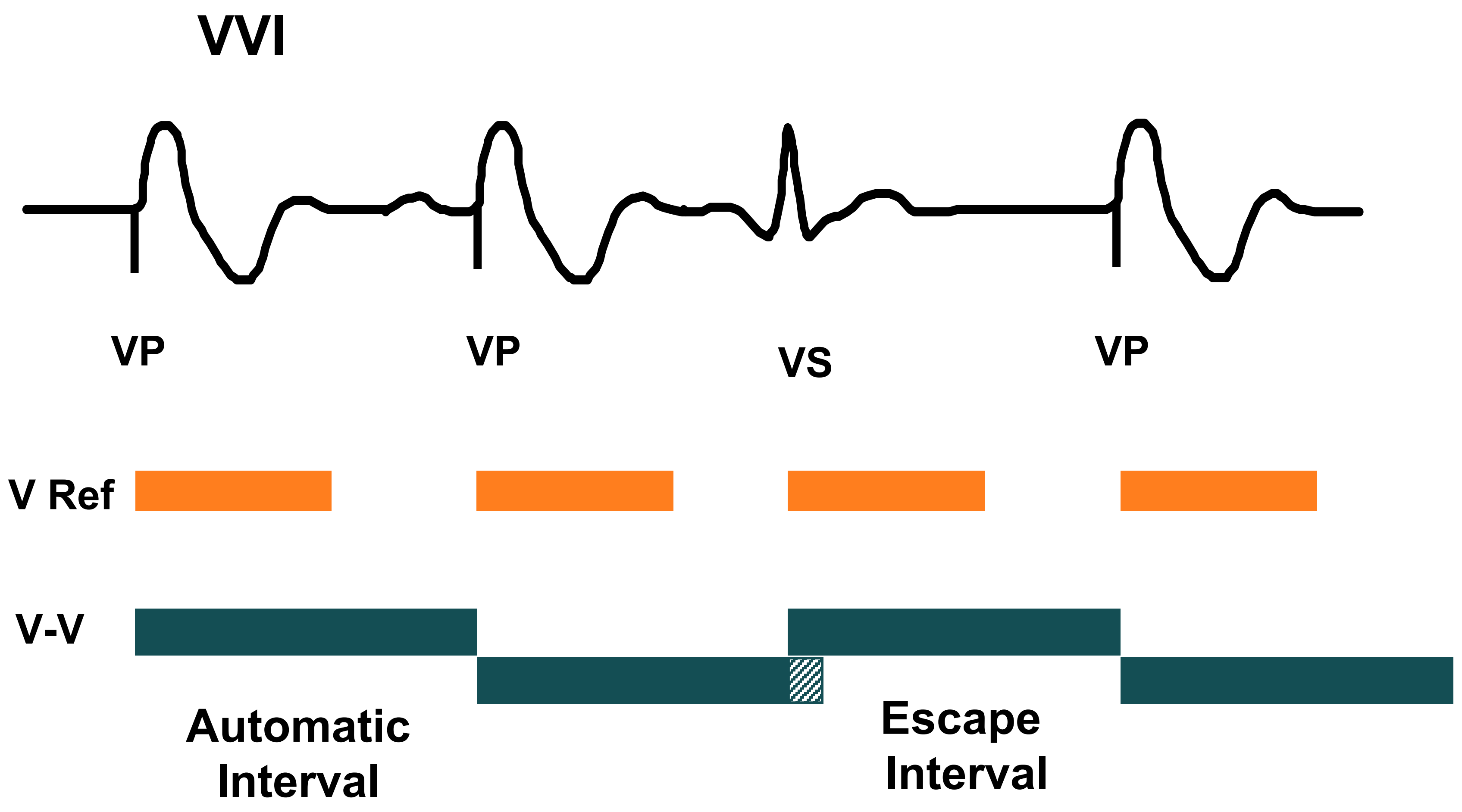
60 ppm



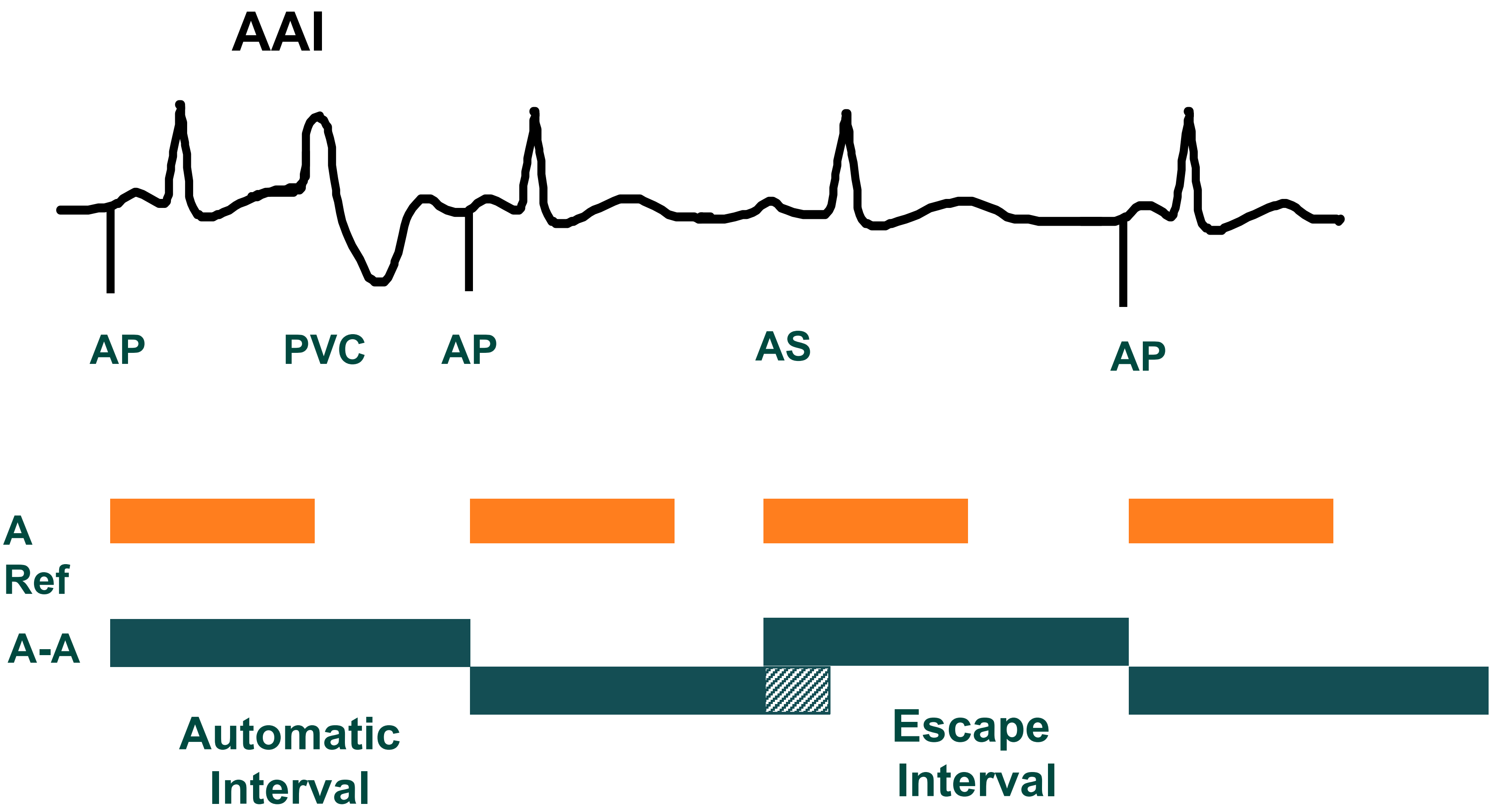
Interval (ms) = 60,000 / rate (ppm)

60,000 / 60 ppm = 1000 ms

Single chamber

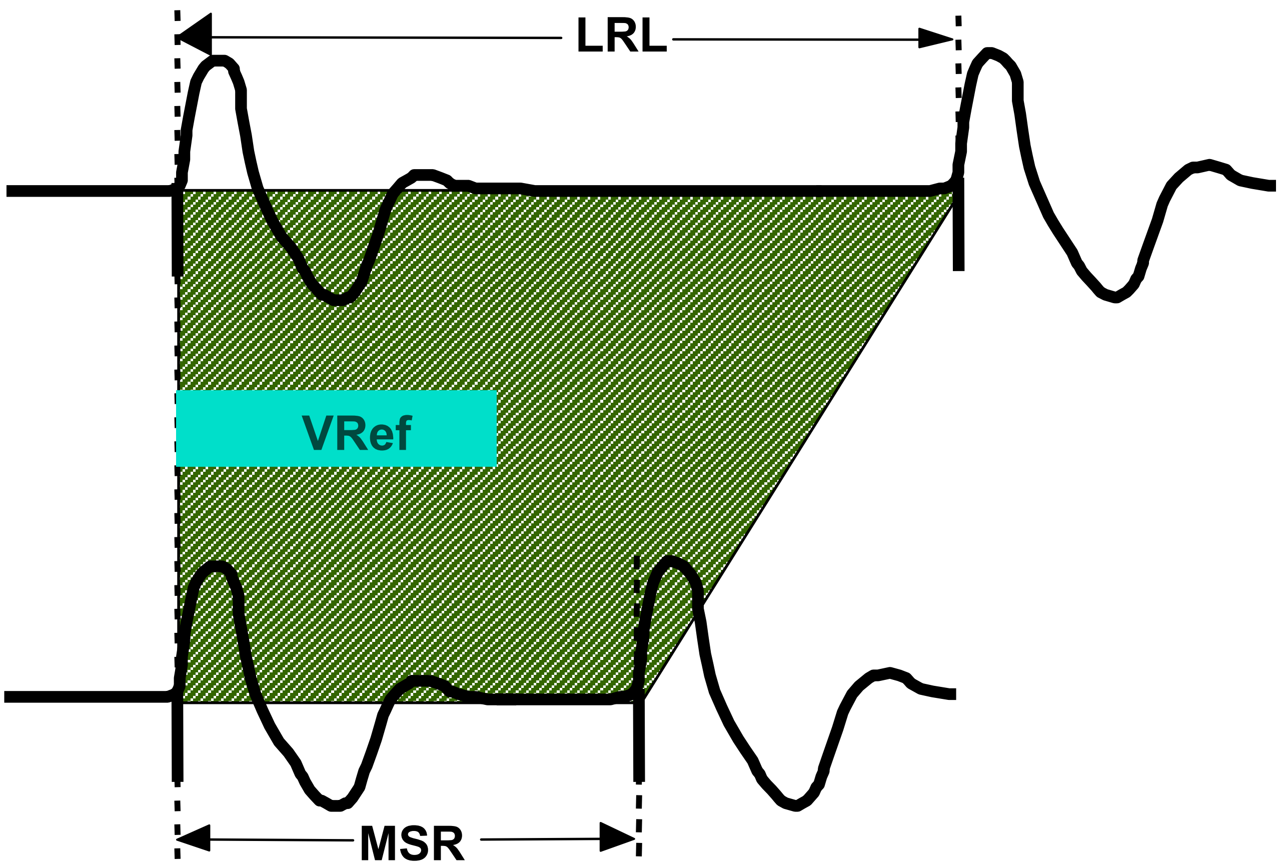


Single chamber



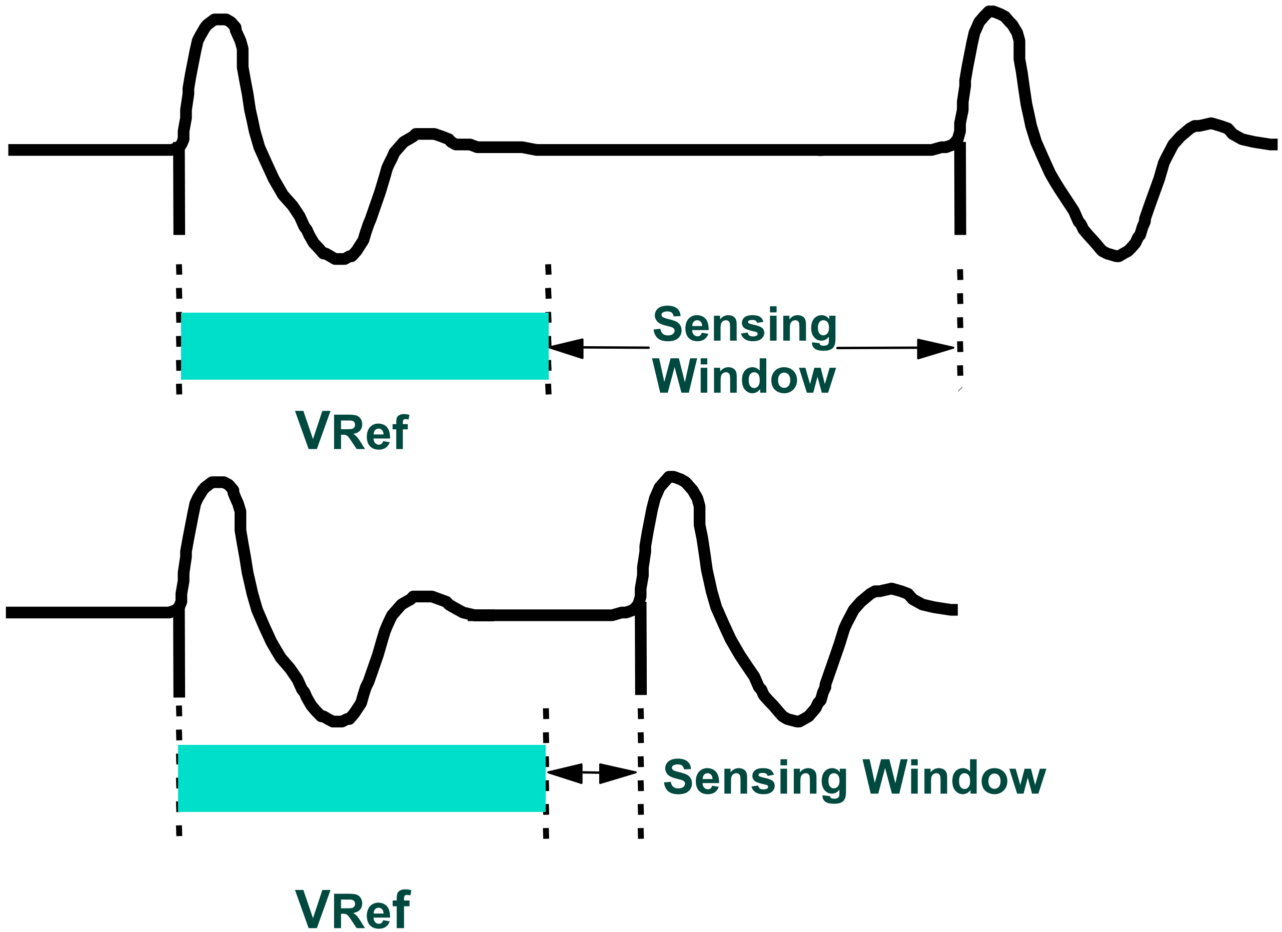
VVIR timing

Sensor-determined Rate Controls V-V Interval



VVIR timing

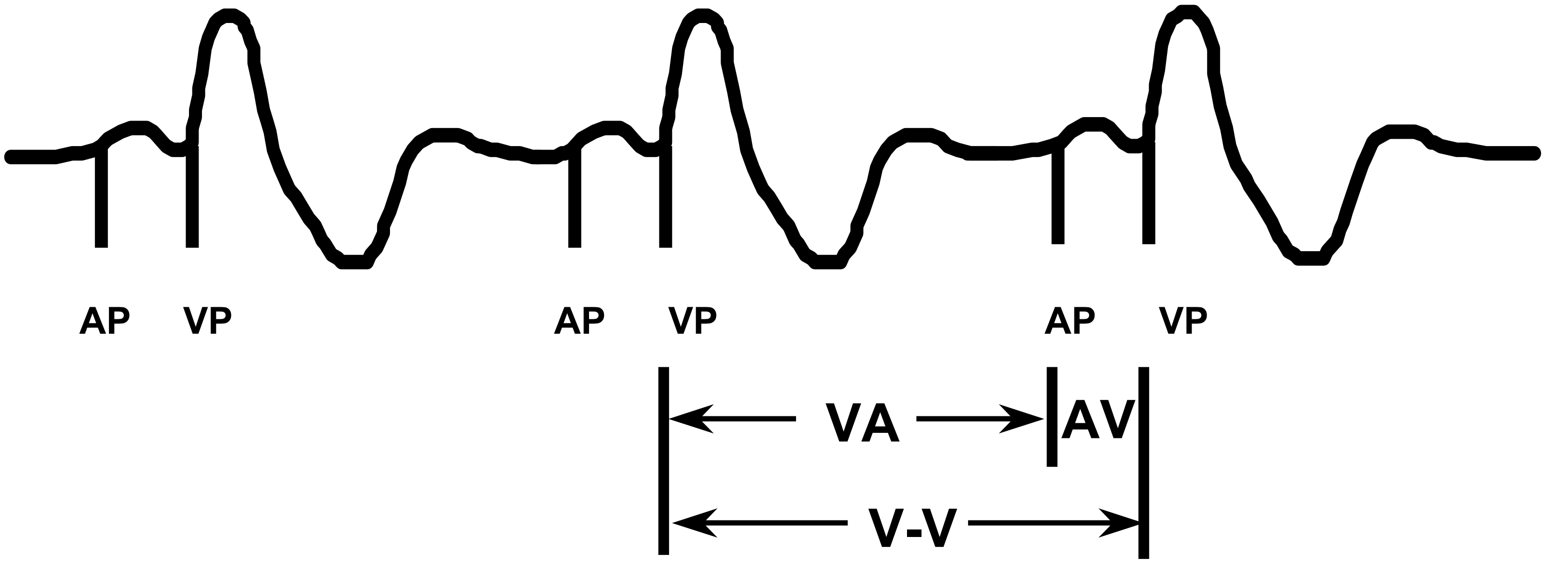
Shortened Sensing Windows at High Rates



Dual-chamber Timing Review

Timing intervals

Dual chamber (DDD)



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

V-V = VA + AV

Timing intervals

Example

V-V = VA + AV

VA = V-V - AV

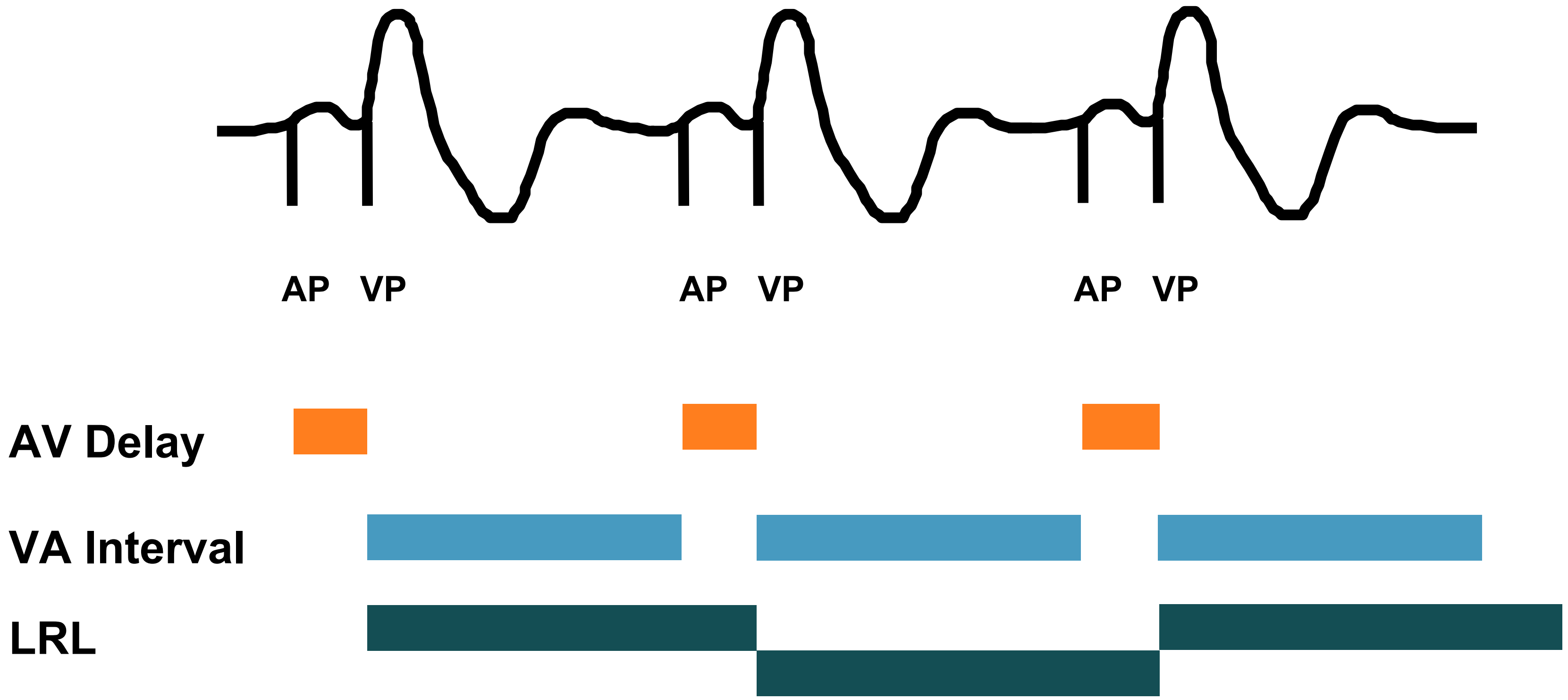
Lower Rate = 60 ppm V-V = 1000 ms

AV Delay = 200 ms

VA = 1000 ms - 200 ms = 800 ms

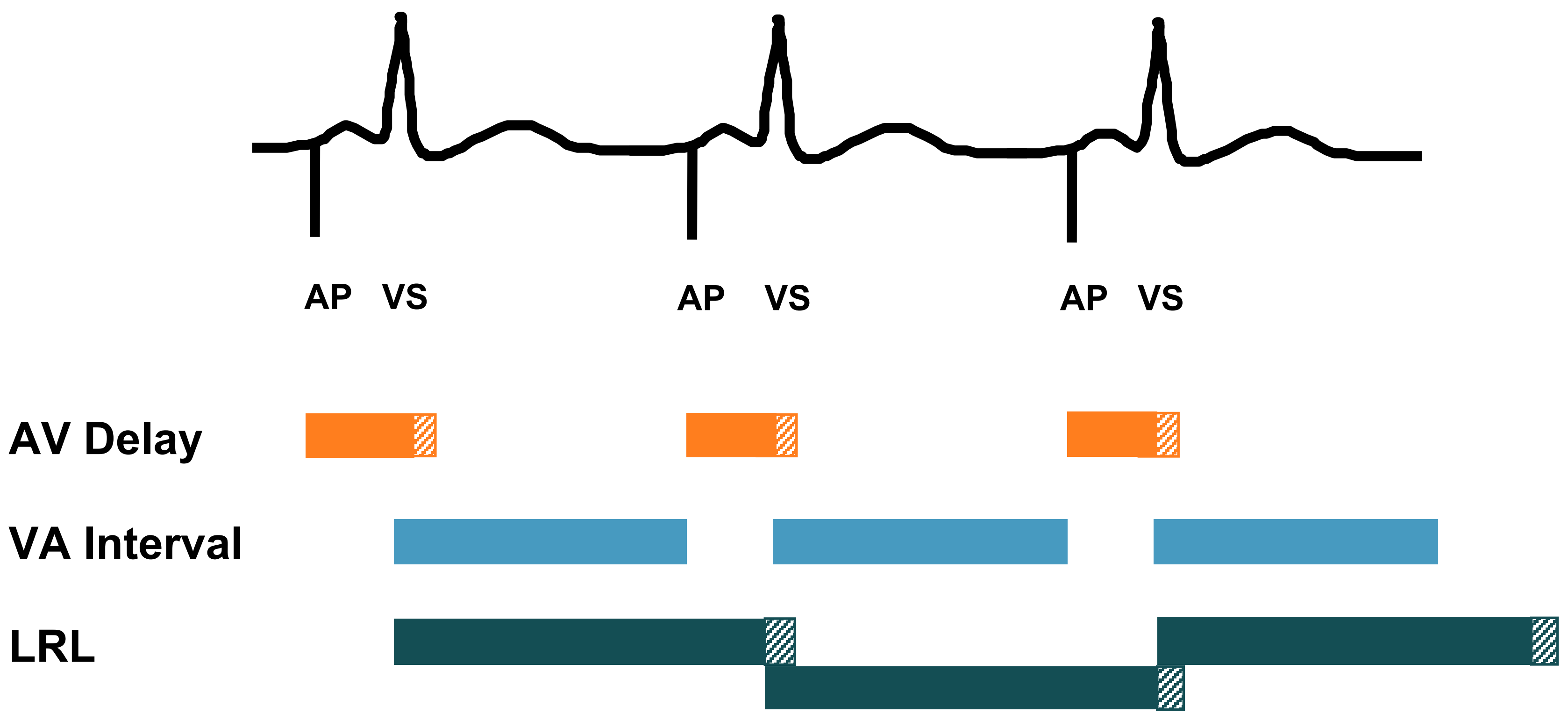
AV sequential pacing

A Pace / V Pace



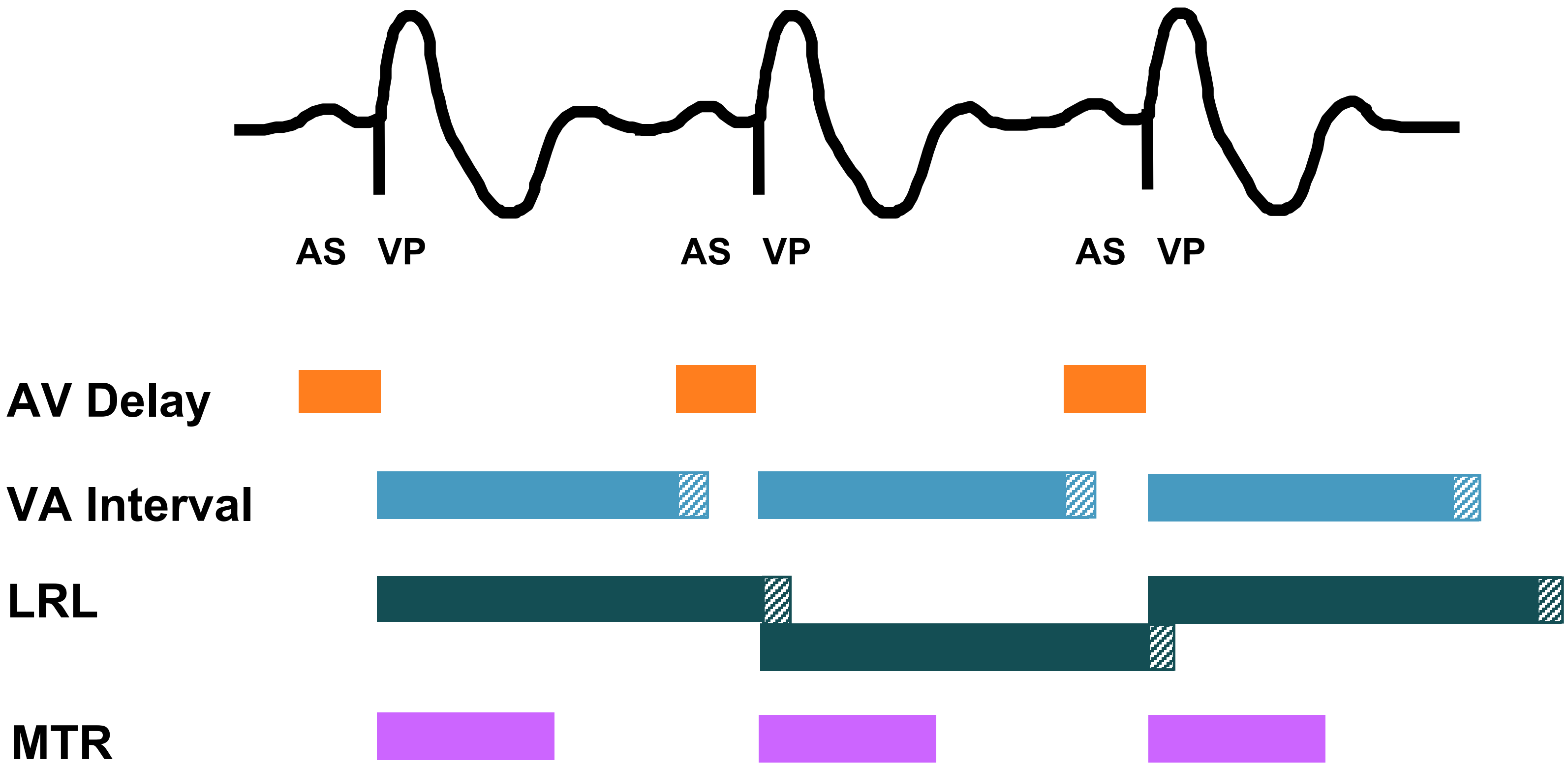
Atrial pacing with conduction

A Pace / V Sense



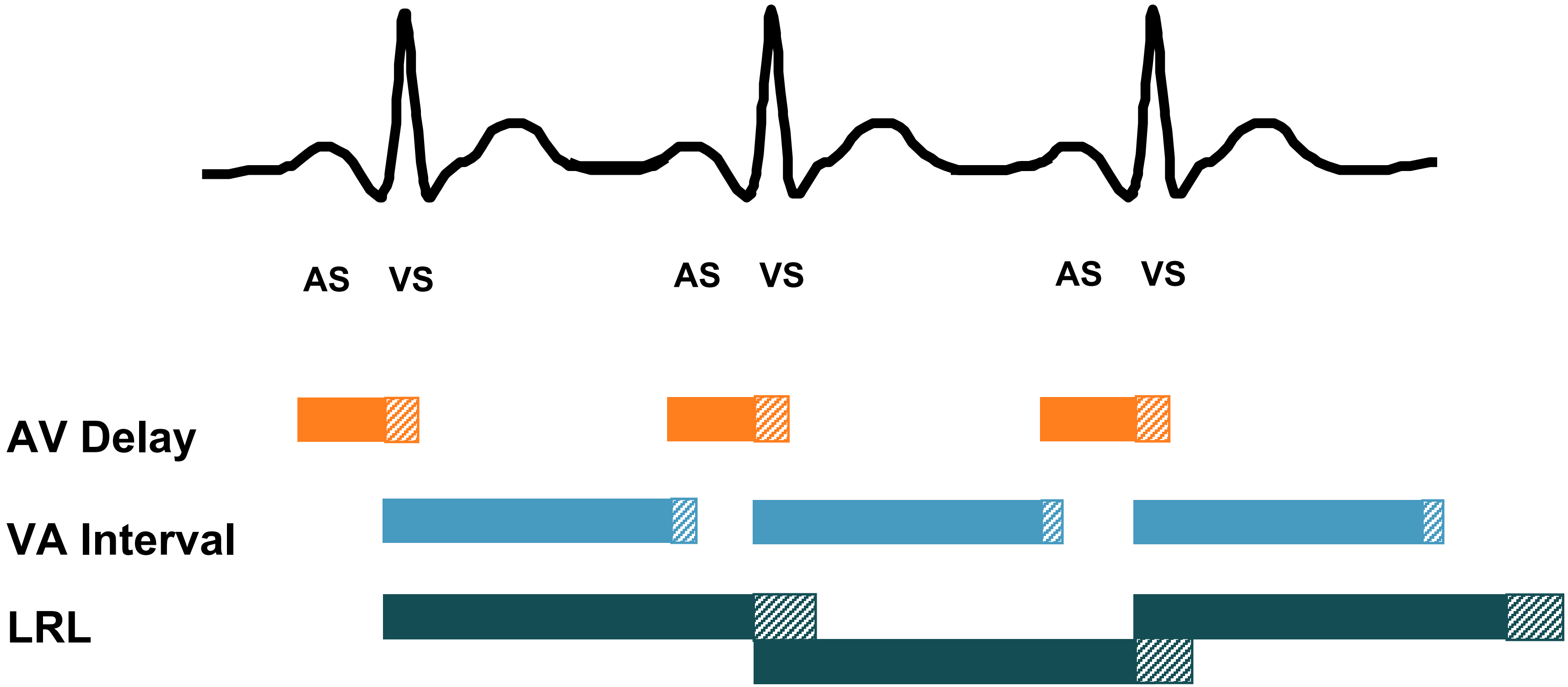
P-synchronous pacing

A Sense / V Pace



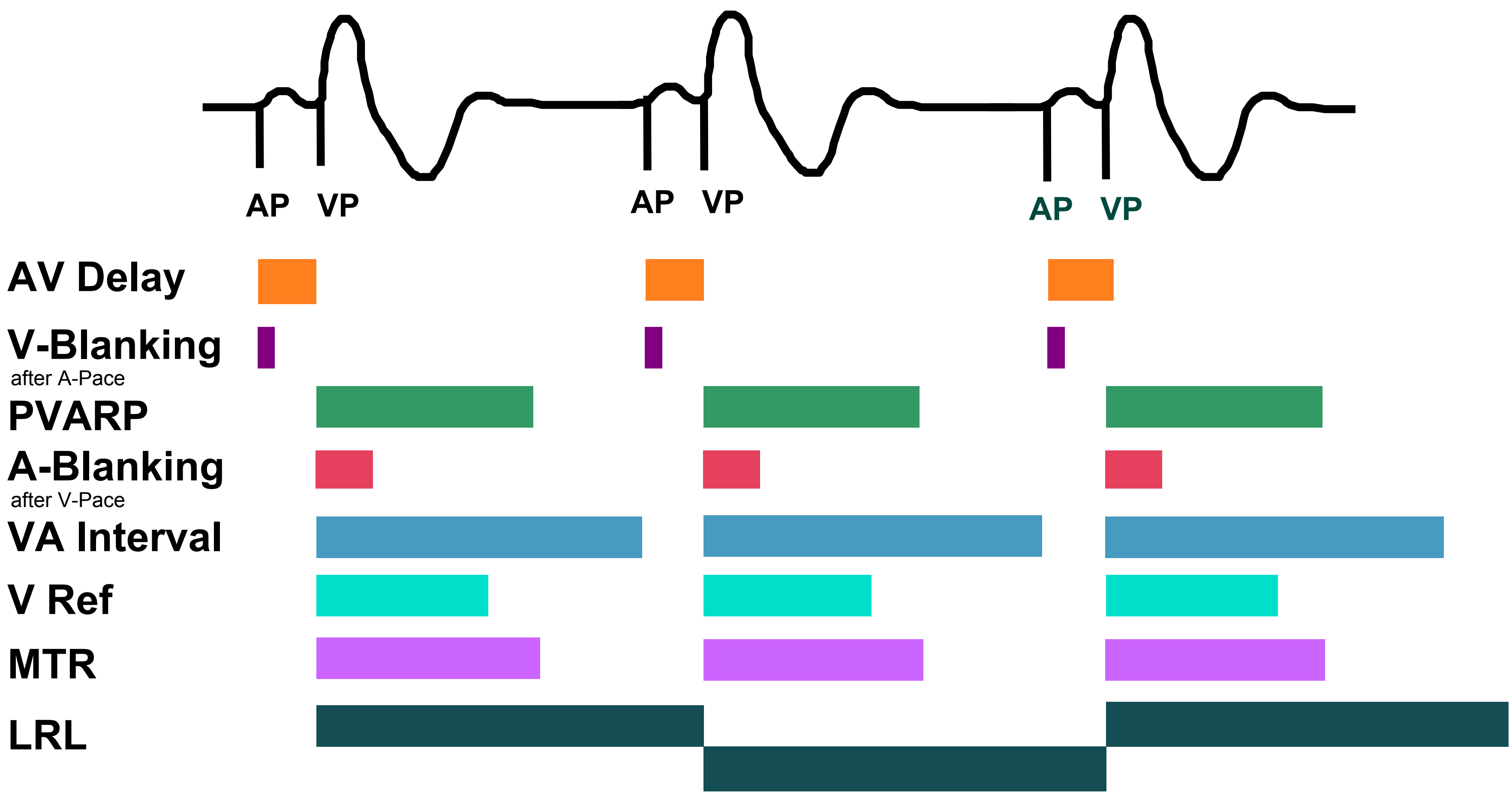
Complete inhibition

A Sense / V Sense



Timing intervals

Dual chamber (DDD)



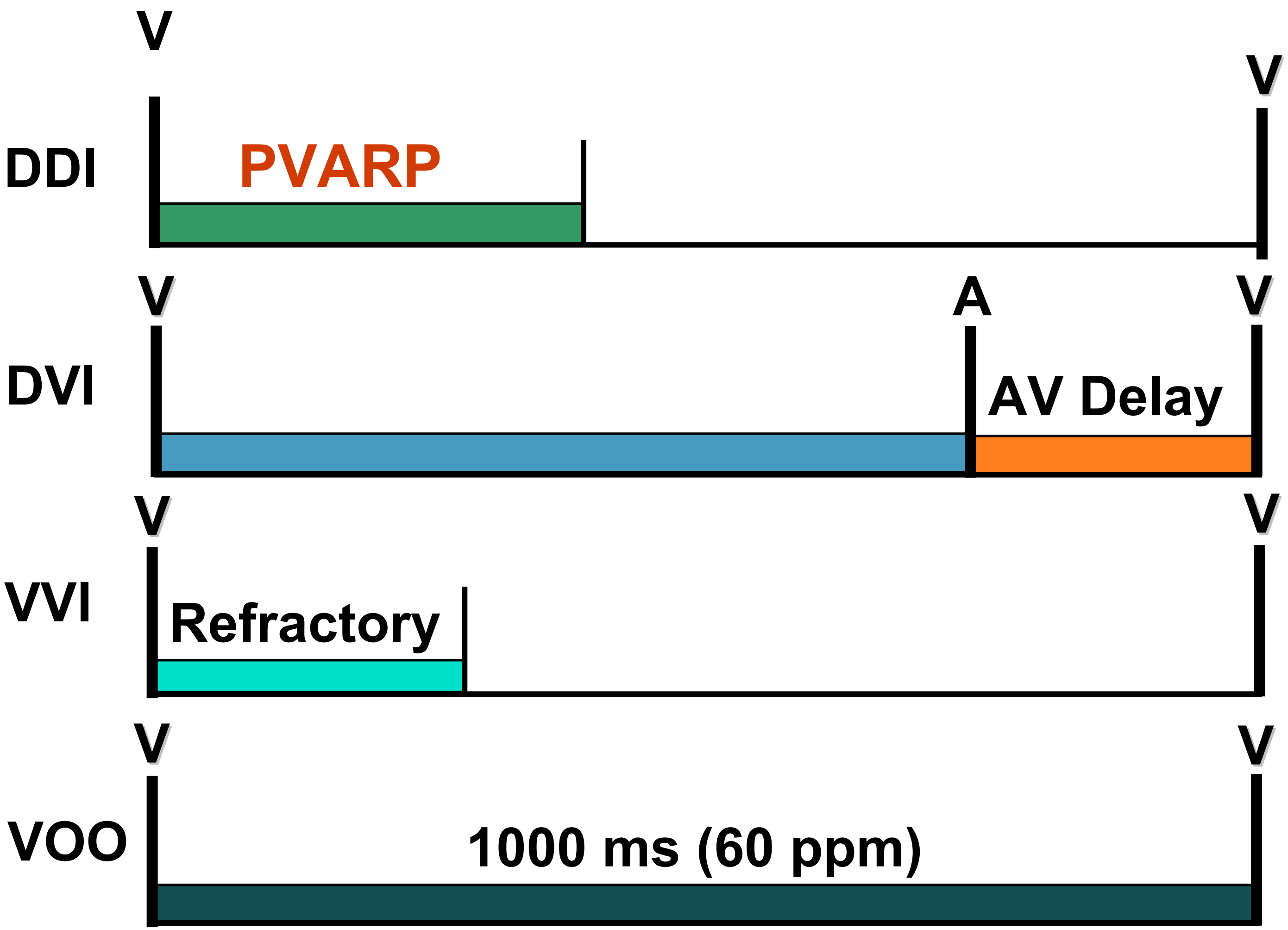
Timing intervals

DDI Mode - Review of PVARP

- Provides AV sequential pacing at the lower rate with dual-chamber sensing
- Prevents competitive atrial pacing
- Atrial refractory period is added to prevent oversensing
- PVARP is an atrial refractory period that occurs after a paced or sensed ventricular event
- Prevents the atrial channel from sensing the ventricular pacing pulse, the far-field QRS and retrograde P-waves

DDI mode

Adds PVARP



Maximum tracking rate operation

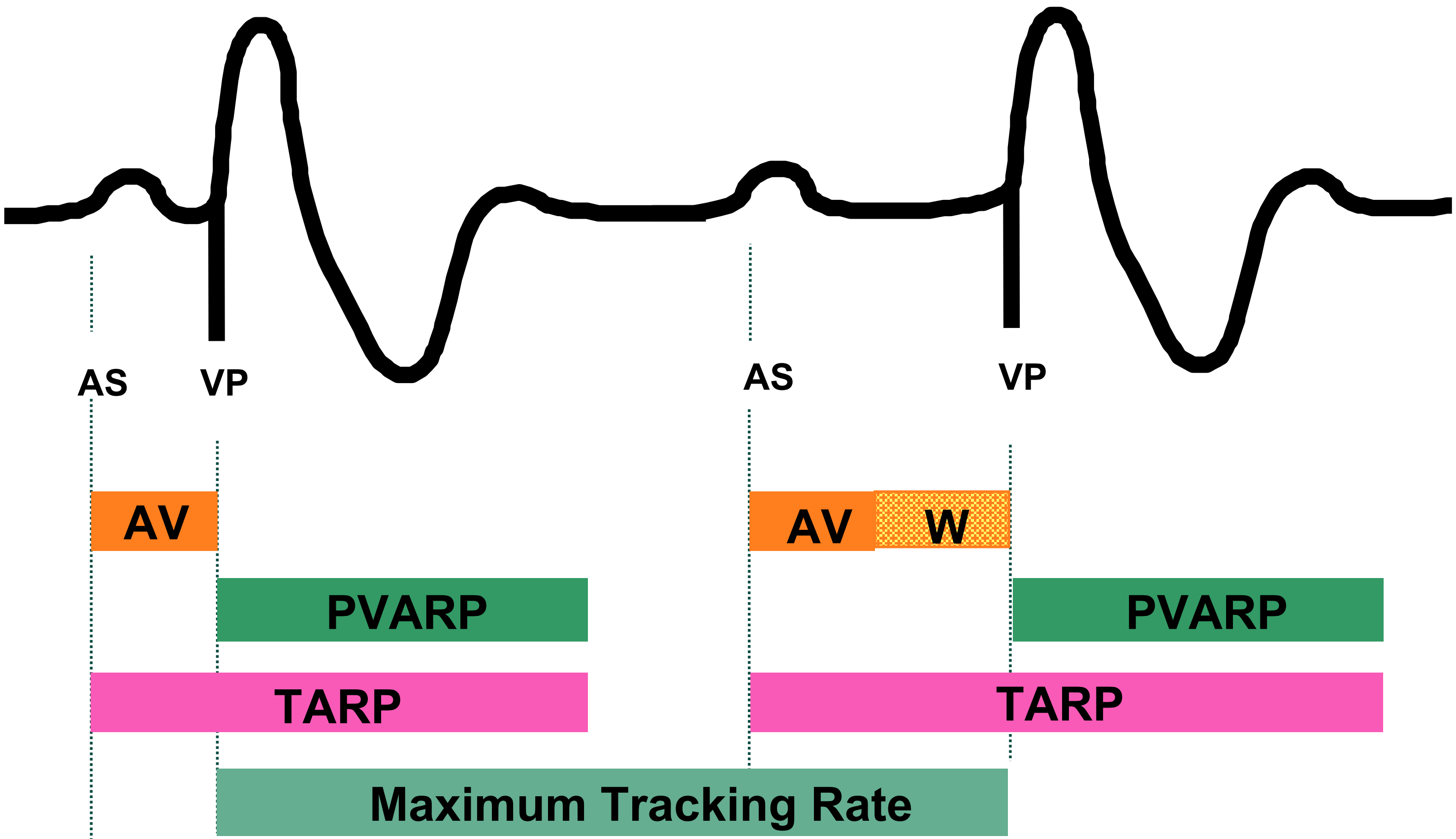
PVARP and TARP

TARP = AV + PVARP

2:1 Rate = 60,000 / TARP

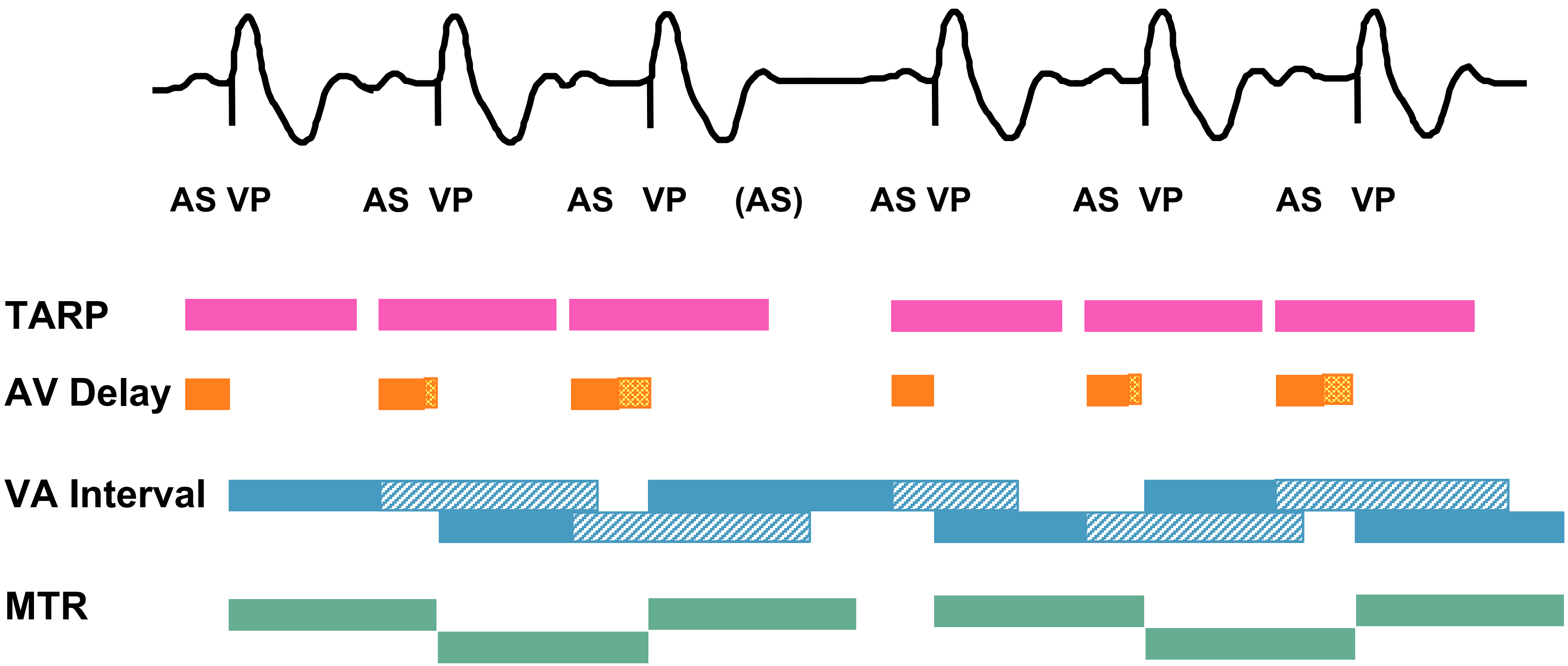
Maximum tracking rate operation

Pacemaker Wenckebach

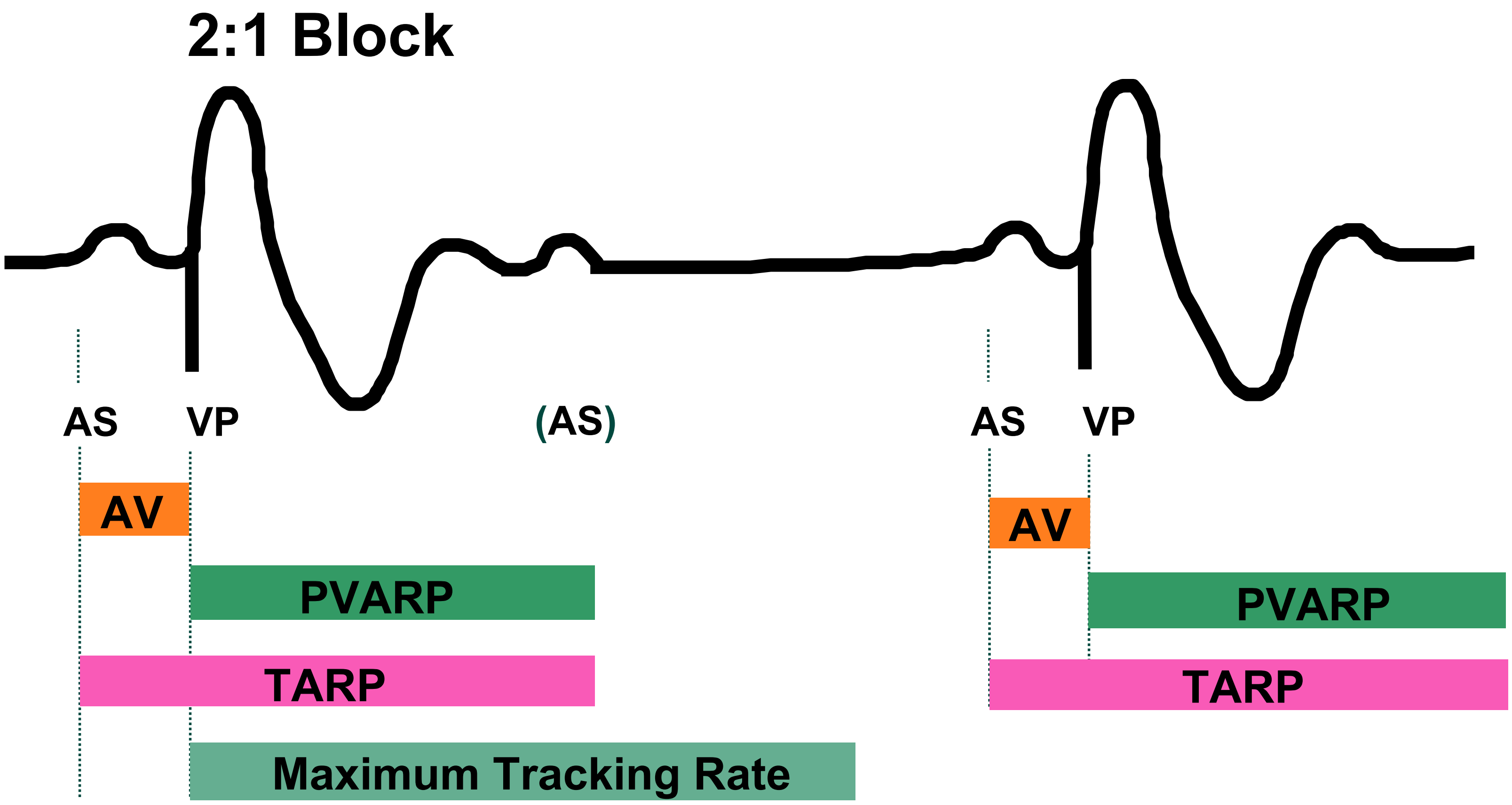


Maximum tracking rate operation

4:3 Wenckebach



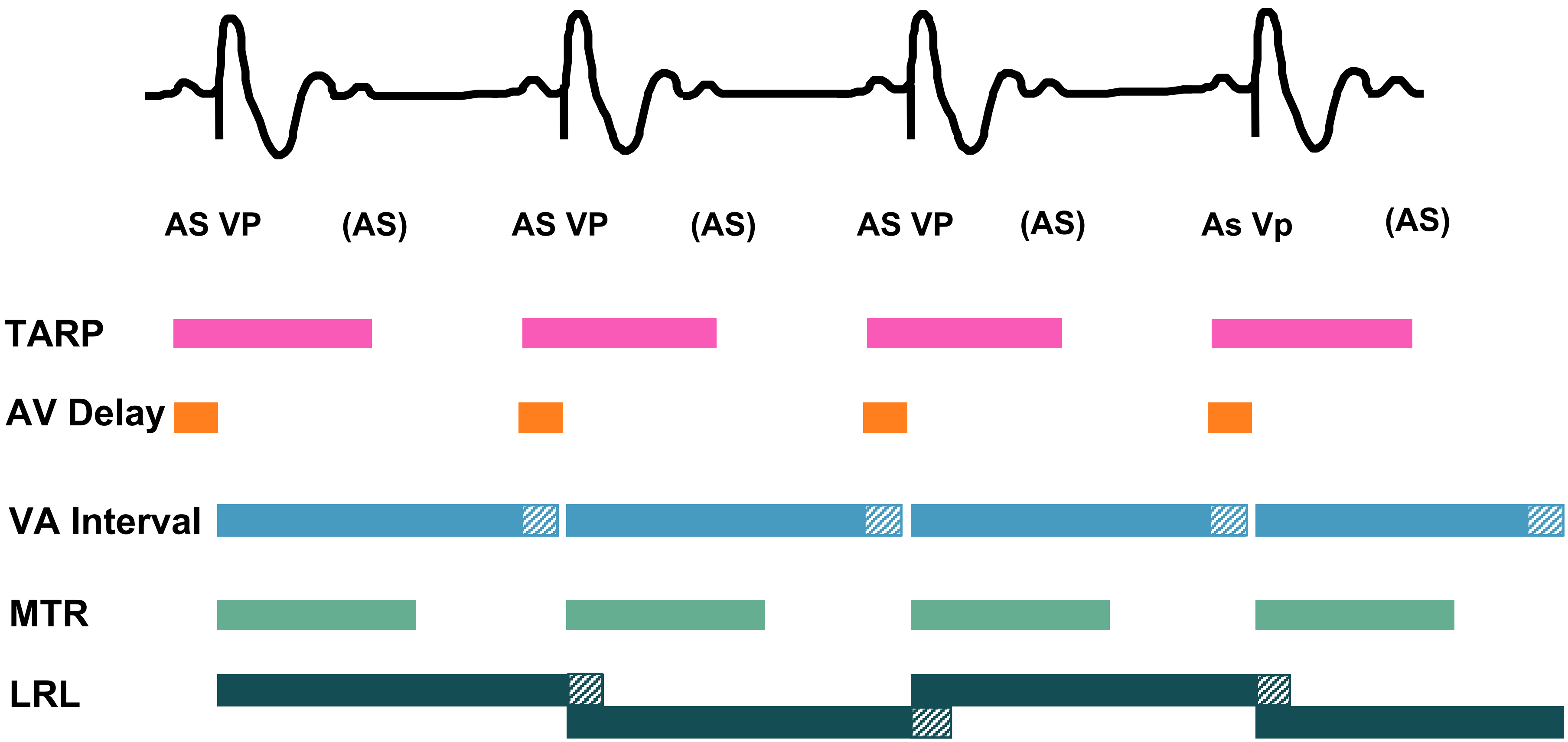
Maximum tracking rate operation



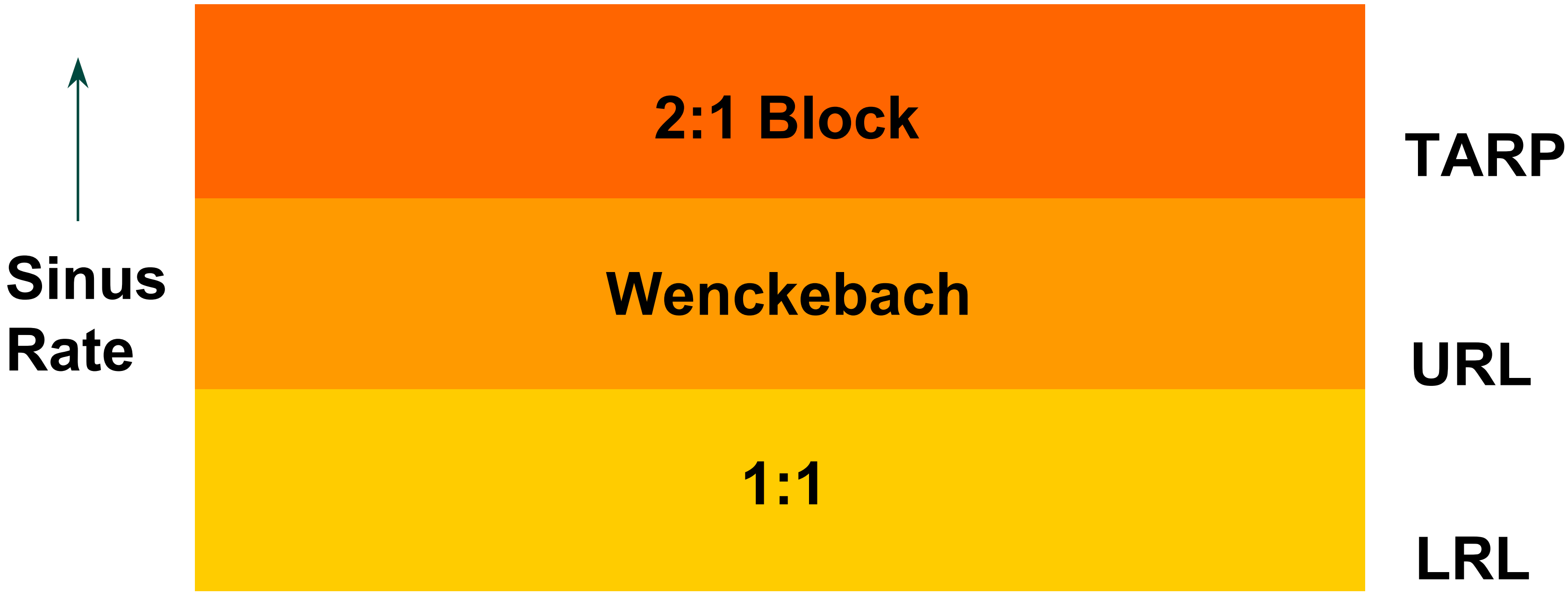
2:1 Rate = 60,000 / TARP

Maximum tracking rate operation

2:1 Block



Maximum tracking rate operation



Upper rate behavior is determined by TARP and MTR

Maximum tracking rate operation

2:1 Block > MTR

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

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

Maximum tracking rate operation

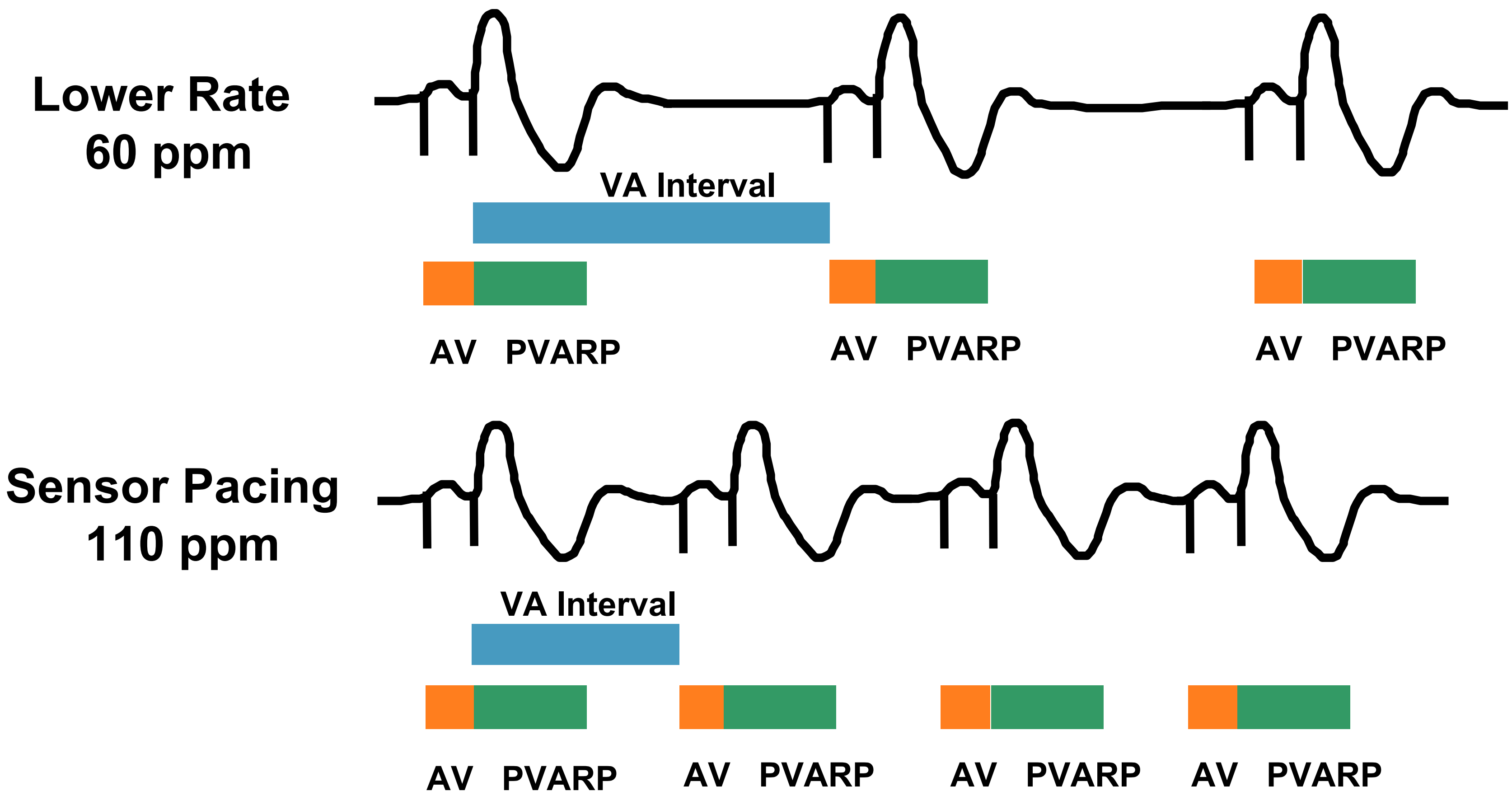
2:1 Block < MTR

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

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

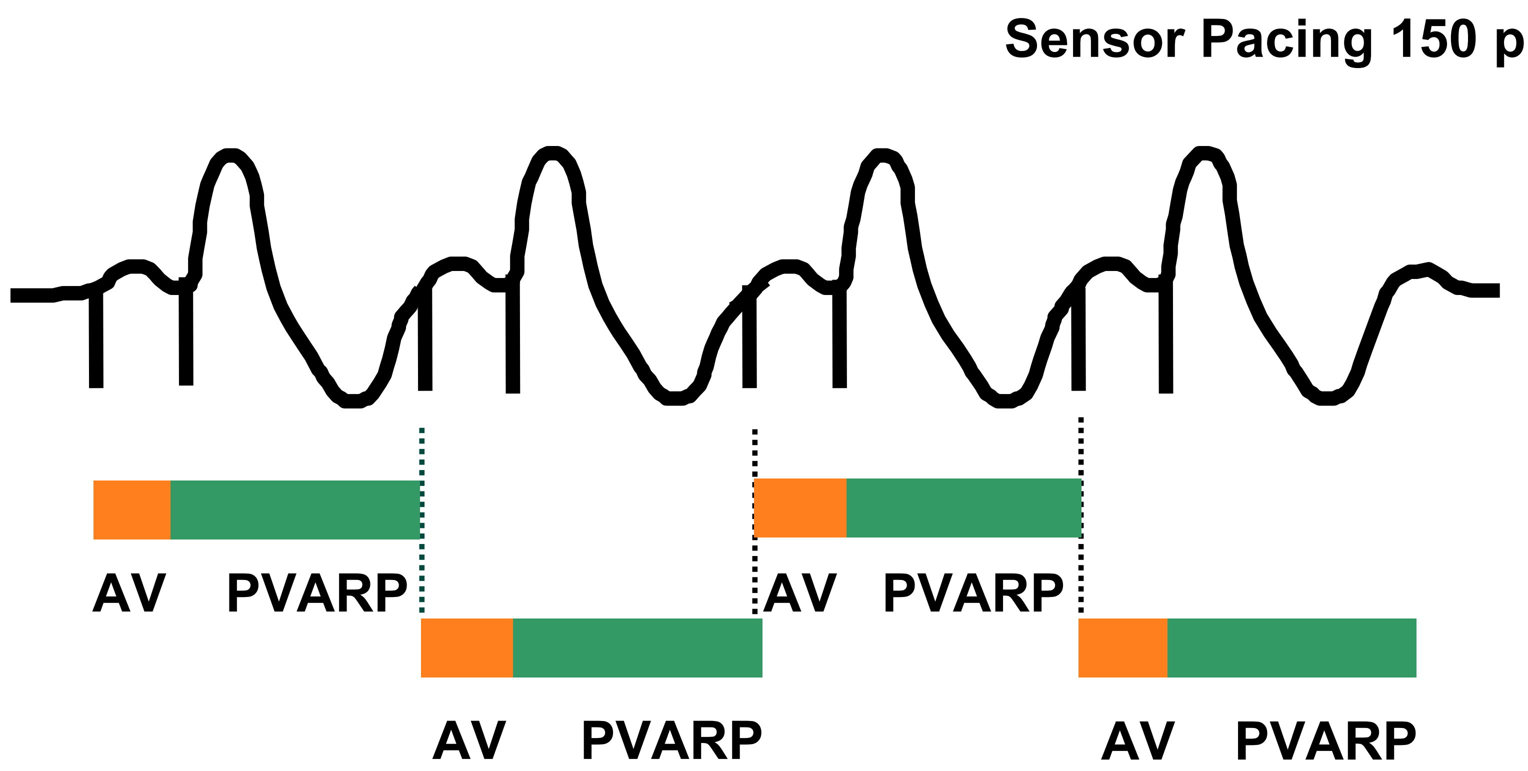
Sensor pacing

Sensor Rate Controls the VA Interval



DDDR timing

Sensor-controlled Rate Not Limited by PVARP

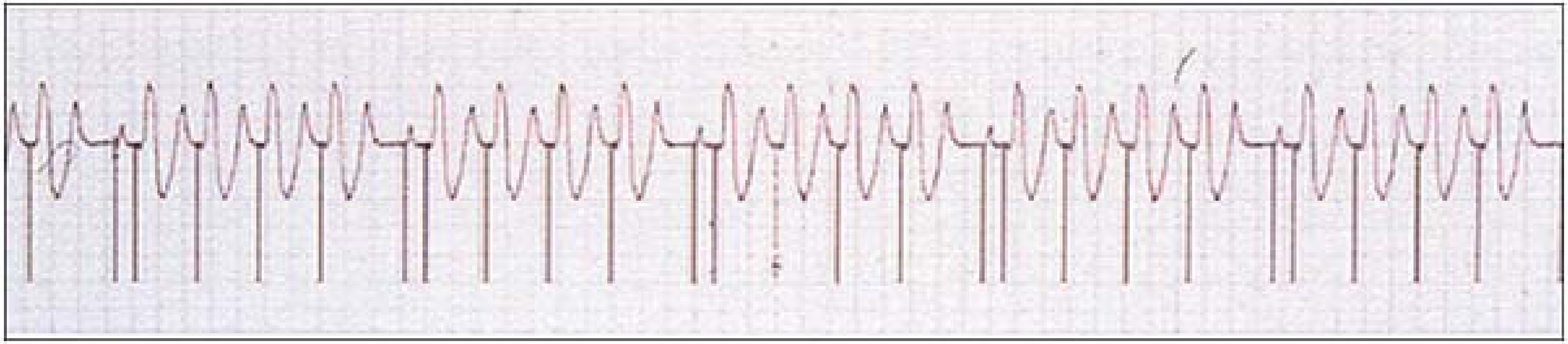


DDDR pacing

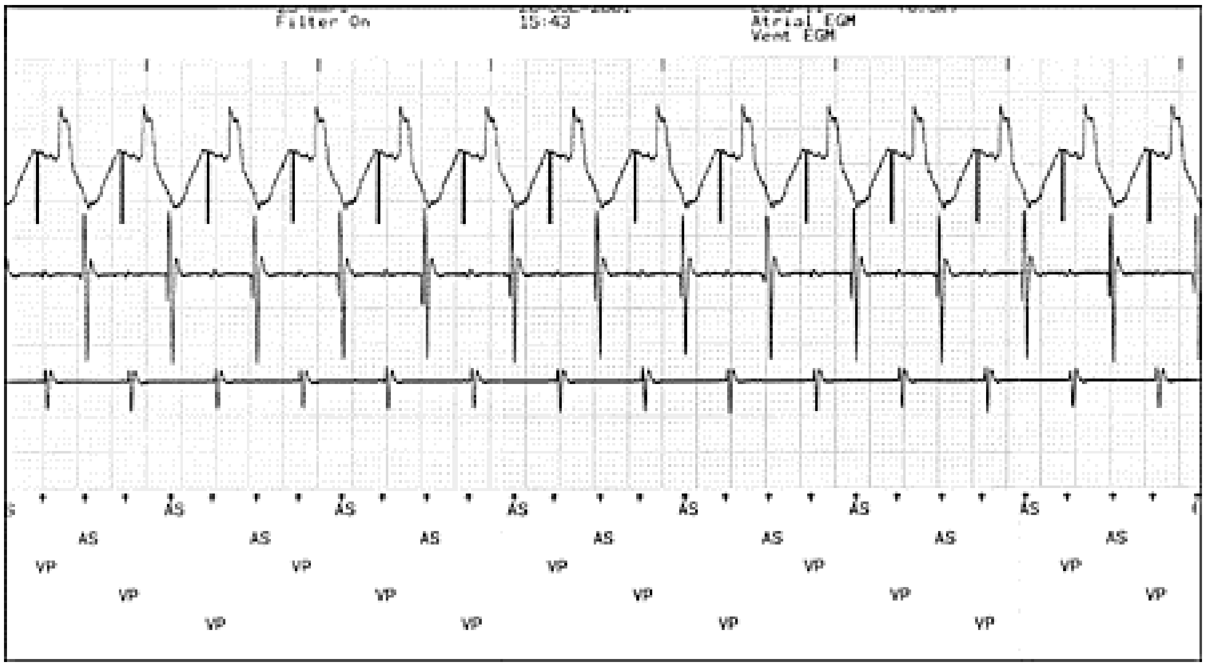
Sensor-driven (DDDR) pacing promotes a more regular rhythm if the sinus rate exceeds the MTR

DDD - Wenckebach

DDDR



Pacemaker mediated tachycardia (PMT)



PMT prevention

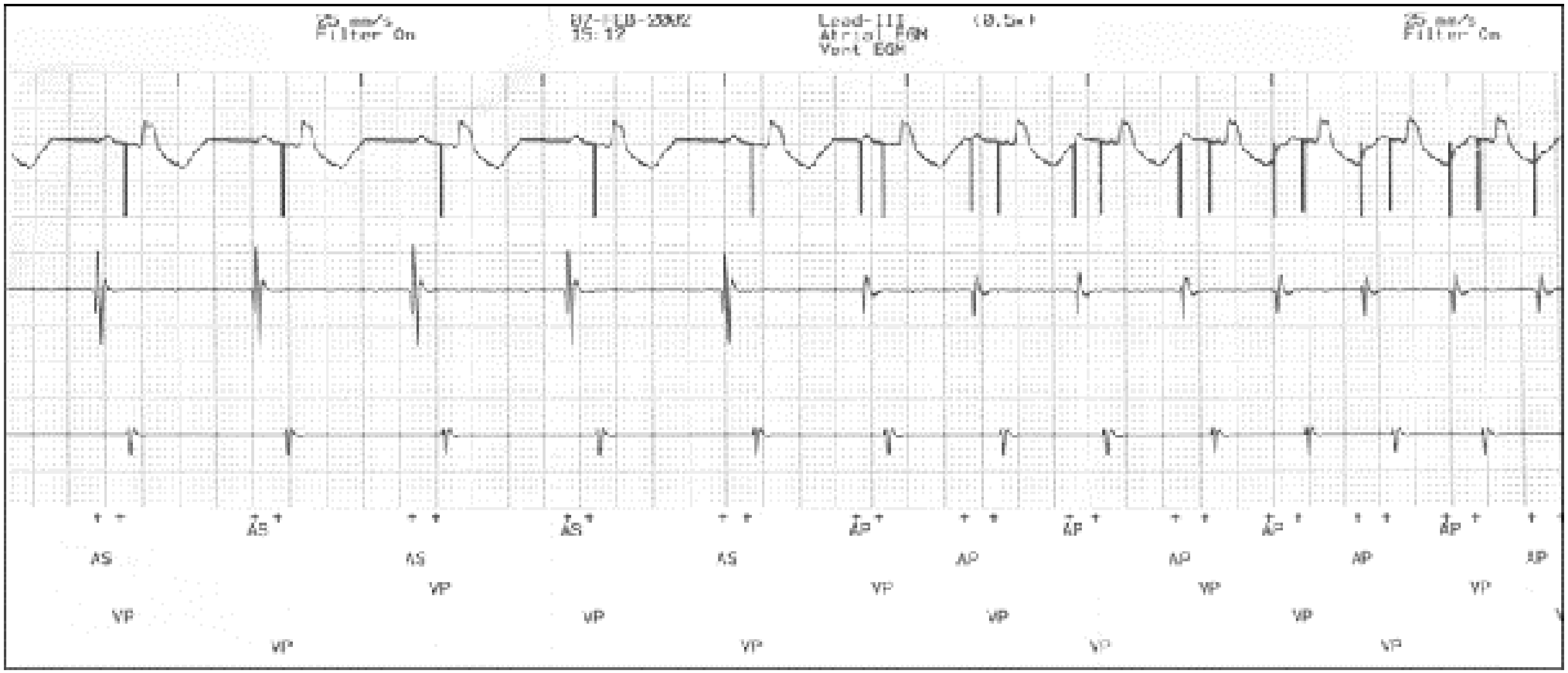
Program longer PVARP

- PVARP after PVC

Use PMT prevention scheme

DDDR: sinus or sensor?

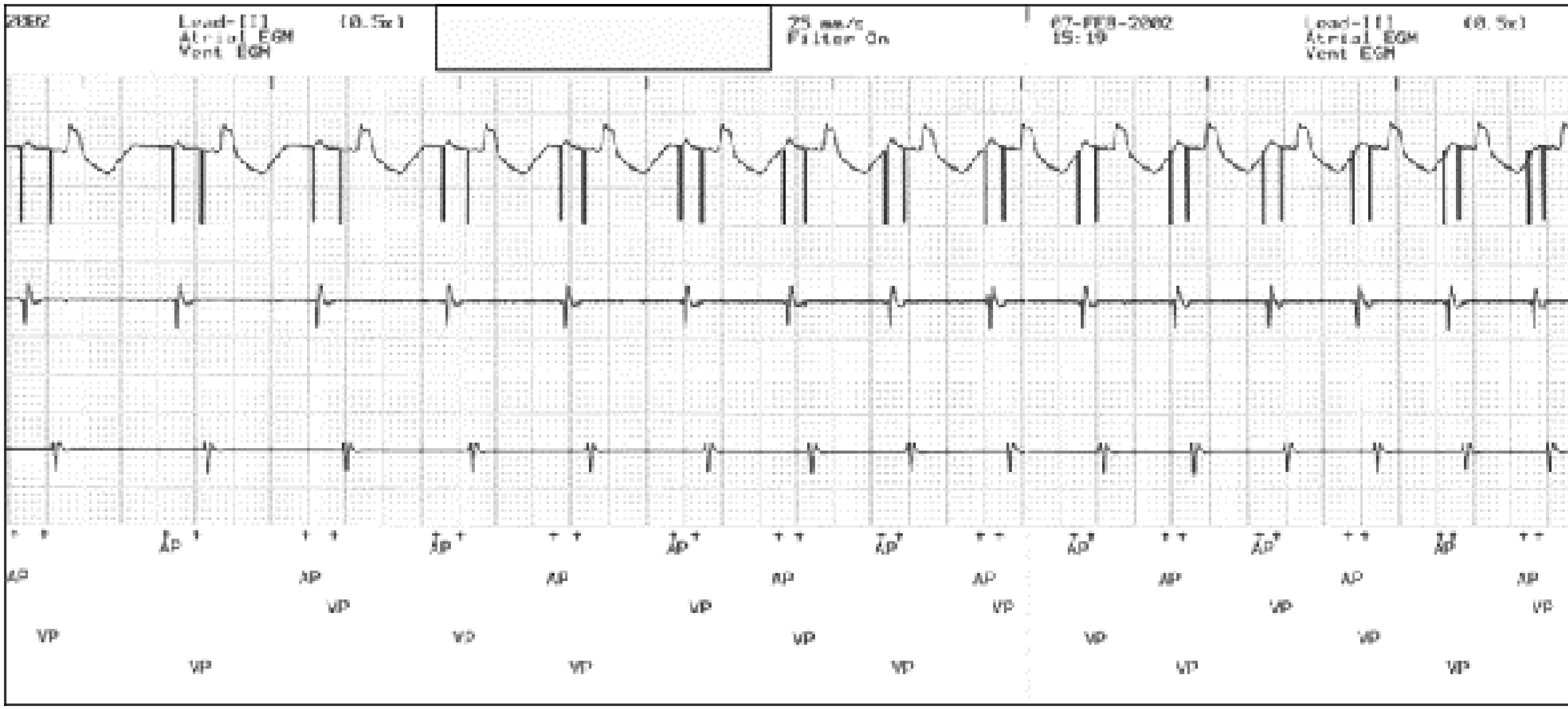
Follow the Faster Input



Dynamic AV Delay

- **Programmed AV Delay shortens with increasing rate**
- **Uses discrete steps or linear reduction**
- **Allows a higher 1:1 P-synchronous tracking rate**

Dynamic AV Delay



Rate = 65 ppm
AV Delay ~180 ms

Rate ↑ to 135 ppm
AV Delay ↓ to ~ 80 ms

Dynamic AV Delay

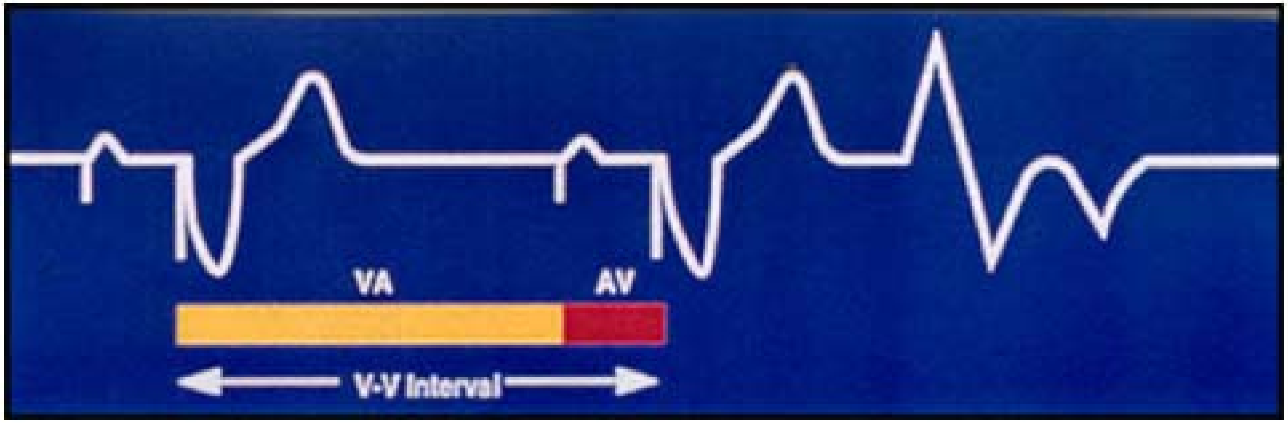
Effects of Shorter AV Delay

AV DELAY	+	PVARP	=	TARP
65 ms		300 ms		365 ms (164 ppm)
130 ms		300 ms		430 ms (139 ppm)
200 ms		300 ms		500 ms (120 ppm)

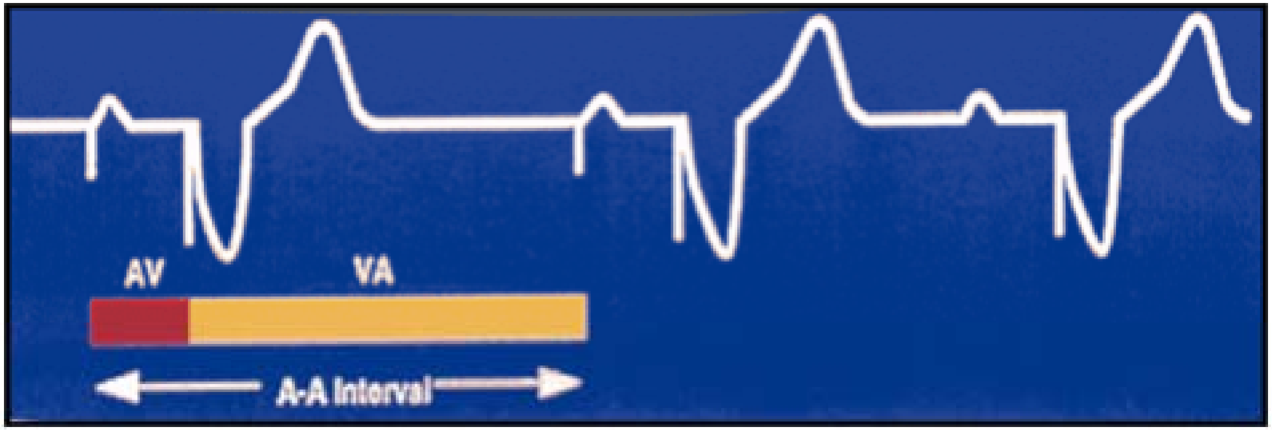
Timing Systems

Ventricular- and atrial-based timing

Ventricular-Based Timing: Ventricular events start timing cycles

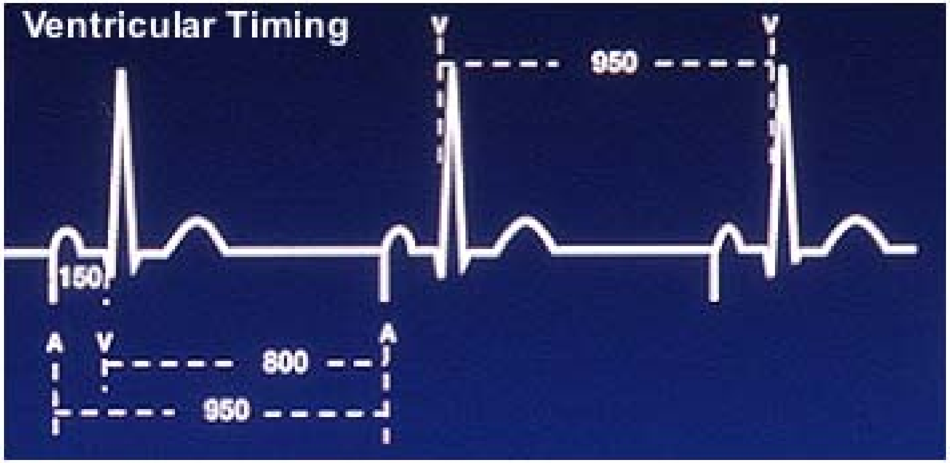


Atrial-Based Timing: Atrial events start timing cycles



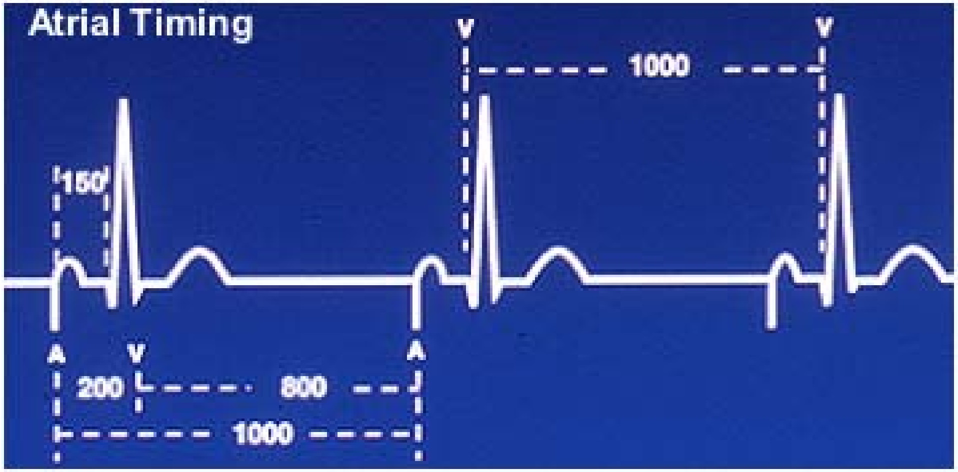
Timing systems

LRL Behavior with AV Conduction



LRL = 1000 ms (60 ppm)
AV Delay = 200 ms
VA Interval = 800 ms
PR Interval = 150 ms

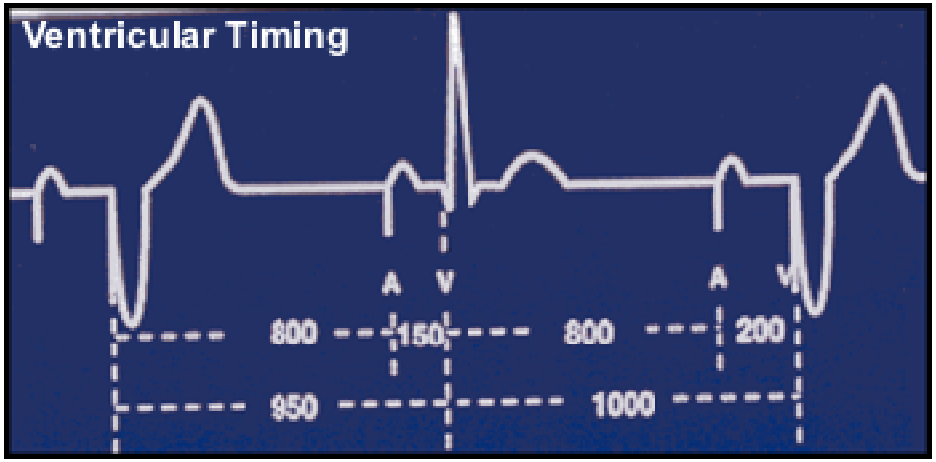
Pacing Interval = VA + PR = 950 ms
Atrial pacing = 63 ppm
Effective ventricular rate = 63 bpm



Pacing Interval = AV + VA = 1000 ms
Atrial pacing = 60 ppm
Effective ventricular rate = 60 bpm

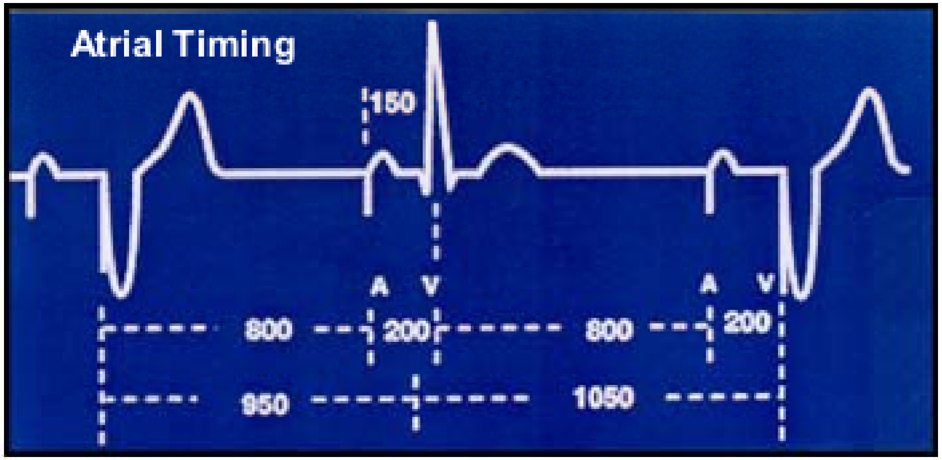
Timing systems

LRL Behavior with Intermittent AV Conduction



LRL= 1000 ms (60ppm)
AV Delay = 200 ms
VA Interval = 800 ms
PR Interval =150 ms

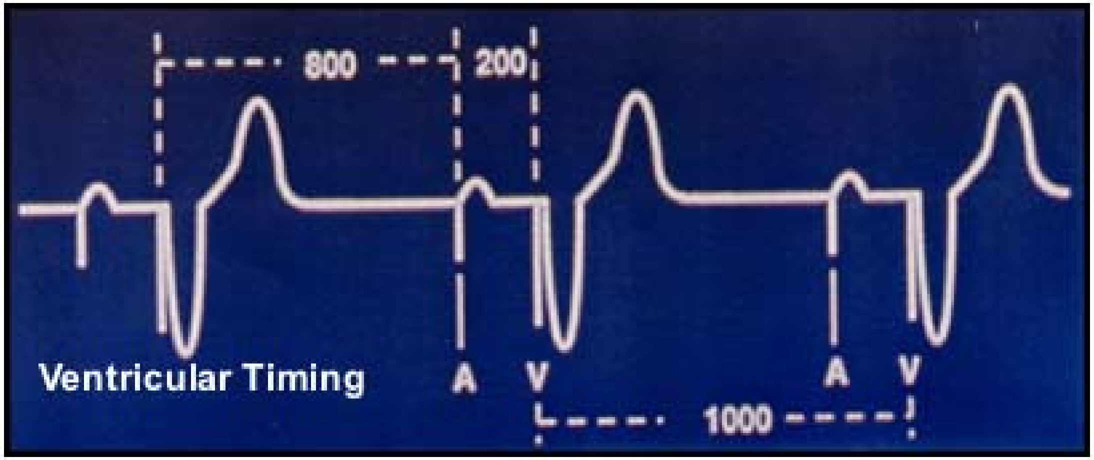
Pacing Interval = 950 or 1000 ms
Atrial pacing at 63 or 60 ppm
Effective ventricular rate= 63 or 60 ppm



Pacing Interval = A-A Interval = 1000 ms
Atrial pacing at 60 ppm
Effective ventricular rate = 63 or 57 ppm

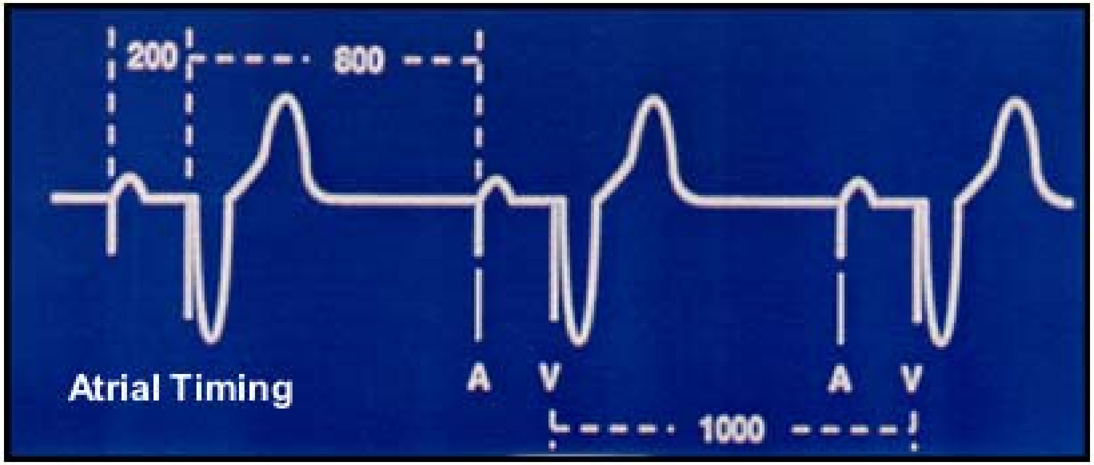
Timing systems

LRL Behavior with AV Sequential Pacing (AP + VP)



LRL= 1000 ms (60 ppm)
AV Delay = 200 ms
VA Interval = 800 ms

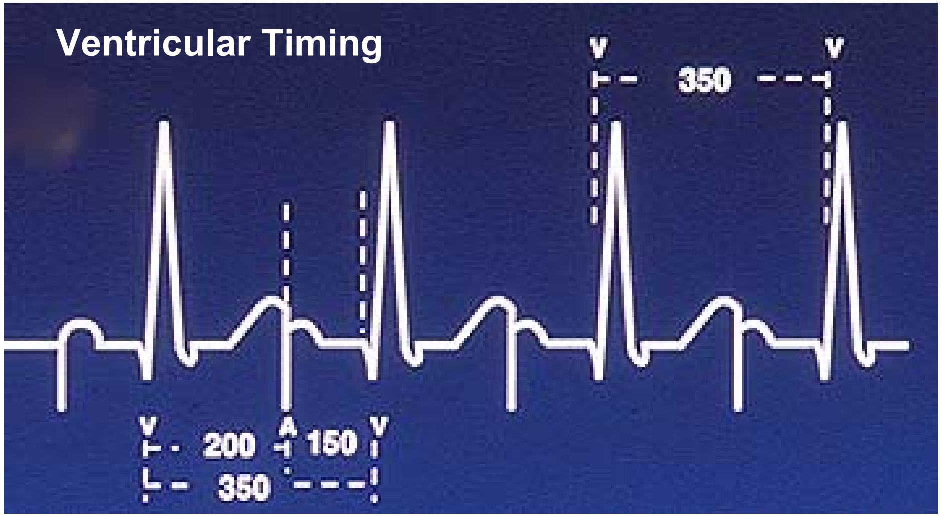
Pacing Interval = 1000 ms
Atrial pacing at 60 ppm
Effective ventricular rate = 60 ppm



Pacing Interval = 1000 ms
Atrial pacing at 60 ppm
Effective ventricular rate = 60 ppm

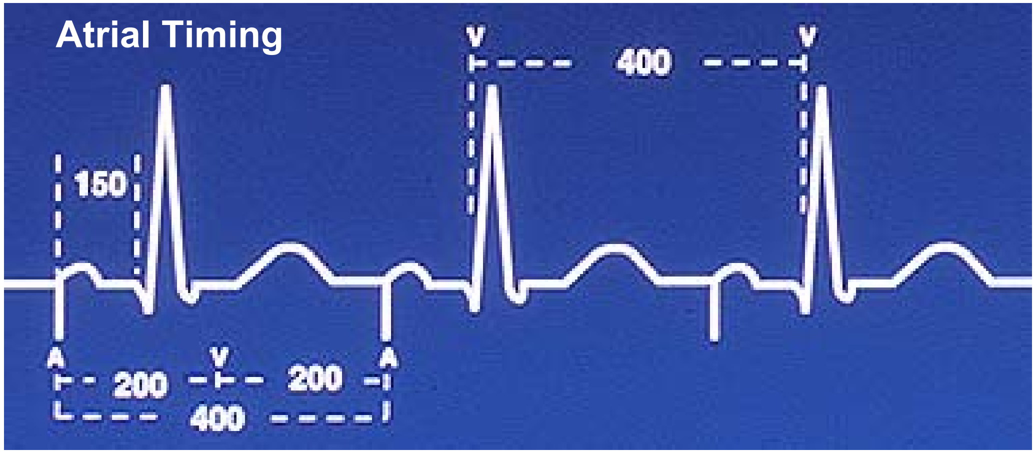
Timing systems

MSR Behavior with AV Conduction



MSR = 400 ms (150 ppm)
AV Delay = 200 ms
VA Interval = 200 ms
PR Interval = 150 ms

Pacing Interval = VA + PR = 350 ms
Atrial pacing = 171 ppm
Effective ventricular rate = 171 bpm



Pacing Interval = AV + VA = 400 ms
Atrial pacing = 150 ppm
Effective ventricular rate = 150 bpm

Summary

Single-Chamber Timing

- VVI & AAI
- VVIR

Dual-Chamber Timing

- DDD & DDI (brief review)
- Upper rate behavior
- DDDR
- Dynamic AV Delay

Timing Systems

- Ventricular- and Atrial-based timing

Questions?

Advanced Timing Cycles