Pacemaker Timing Cycles

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Timing Cycles: Single Chamber

- There is one basic interval connecting 2 consecutive events, pacing or sensing: AA or VV.
- There are two basic transitions, or pacing events that cause the basic interval to be reset (reinitiated).
- If the interval times out, a stimulus is released, and the interval starts over.
- If a spontaneous event is sensed, the interval is reset without pacing, the pending stimulus being “inhibited.”

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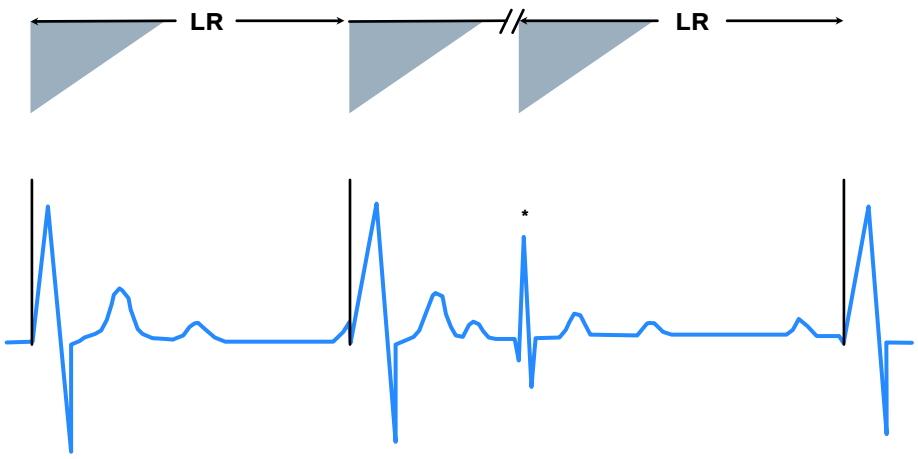
VVI



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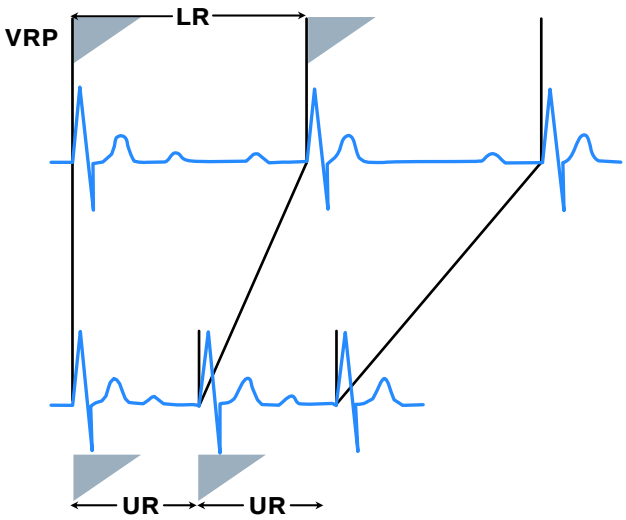
VVIR



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Timing Cycles: Dual Chamber

- Two basic intervals: AV & VA; their sum is the cycle duration or "cycle length" AA or VV.
- The DDD mode has five basic transitions, each of which resets (re-initiates) either the AV or the VA interval depending upon the event that initiates the transition.

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Five Transitions of DDD Timing

Event	Response
AV interval times out	Pace V, begin VAI

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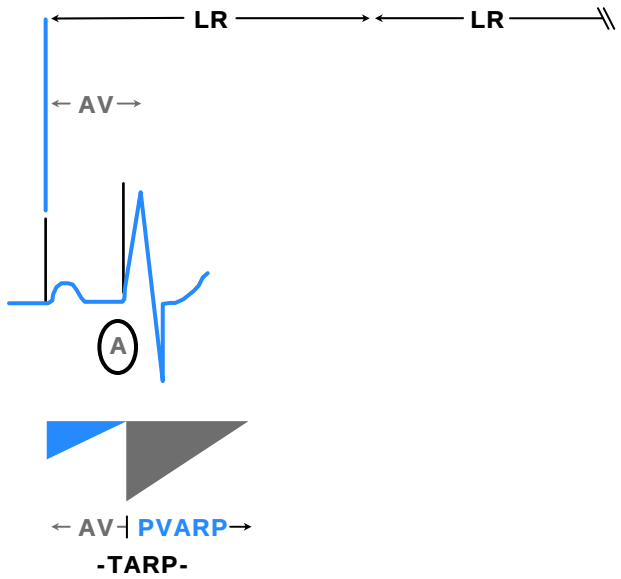

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Five Transitions of DDD Timing

Event	Response
AV interval times out	Pace V, begin VAI
VA interval times out	Pace A, begin AVI

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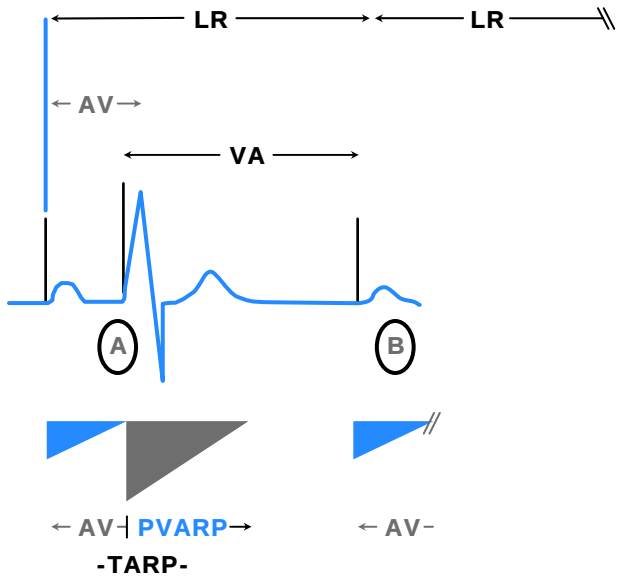

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Five Transitions of DDD Timing

Event	Response
AV interval times out	Pace V, begin VAI
VA interval times out	Pace A, begin AVI
V sense during AVI	Begin VA/no pacing
V sense during VAI	Re-start VA/no pacing

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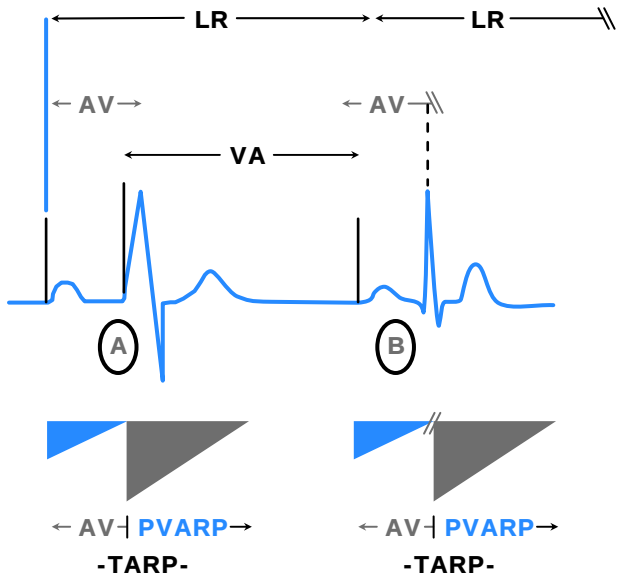

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Five Transitions of DDD Timing

Event	Response
AV interval times out	Pace V, begin VAI
VA interval times out	Pace A, begin AVI
V sense during AVI	Begin VA/no pacing
V sense during VAI	Re-start VA/no pacing
A sense during VAI	Begin AVI/no pacing

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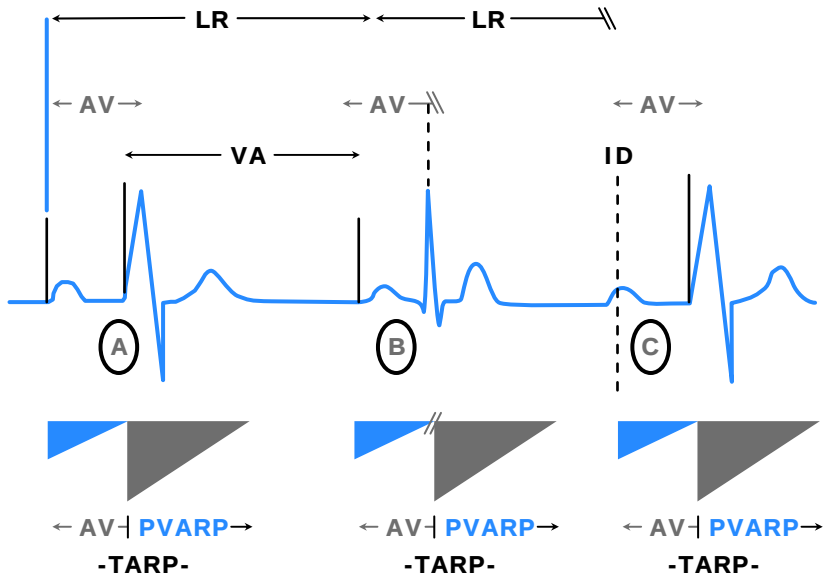

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Which of the following defines the maximum tracking rate of a DDD pacemaker?

1. PVARP
2. VRP + AVI
3. TARP
4. AVI + Blanking period
5. TARP - VRP

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TARP = AVI + PVARP

- AVI = 200 ms
- PVARP = 400 ms
- TARP = 600 ms = 100 bpm

TARP = Total Atrial Refractory Period

PVARP = Post-ventricular atrial refractory period

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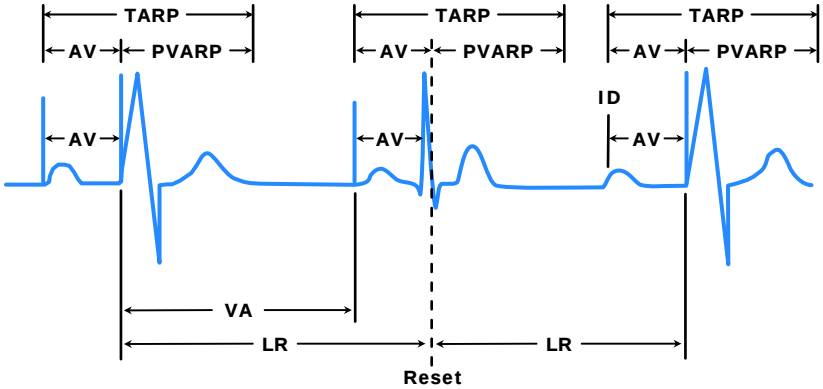

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Timing Cycles

- During a refractory period, sensed events are ignored for timing purposes – although they would usually be annotated on 'marker' channel.
- During a blanking period, the sensing amplifier is turned off and sensing cannot take place.
- The pattern of refractory and blanking periods plays a critical role in determining the beat-to-beat behavior of the pacemaker.

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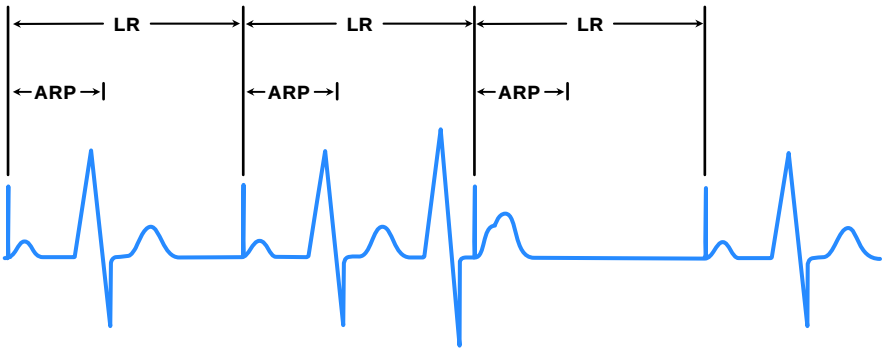
If the PM represented in this schematic is functioning normally, what is the pacing mode?

1. DDD
2. AAI
3. VVI
4. VDD
5. VAT



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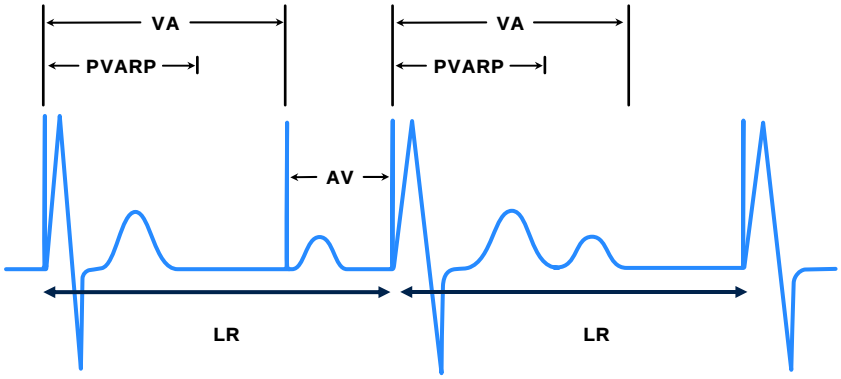
If the PM represented in this schematic is functioning normally, what is the pacing mode?

1. DDD
2. AAI
3. VVI
4. VDD
5. DDI



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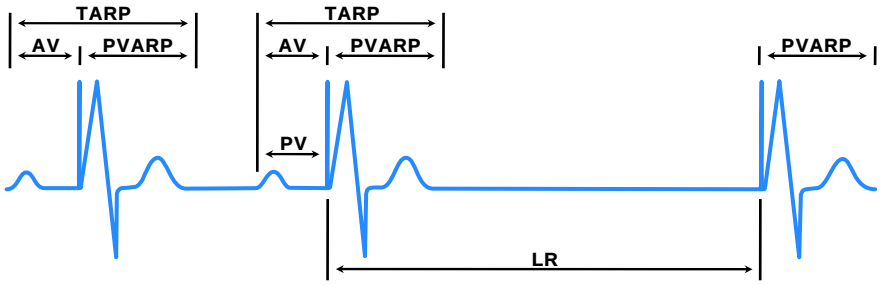
If the PM represented in this schematic is functioning normally, what is the pacing mode?

1. DDD
2. AAI
3. VVI
4. VDD
5. VAT



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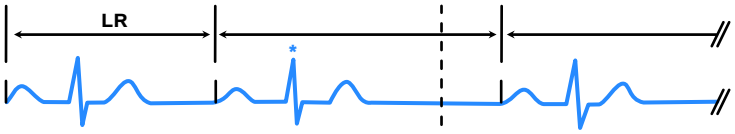
The Timing Cycle Is Compatible With:

1. AAI with farfield sensing
2. VDD pacing mode
3. Normal blanking
4. Normal VVI



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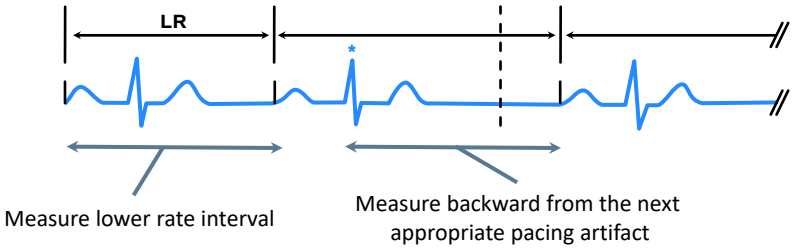
The Timing Cycle Is Compatible With:

1. **AAI with farfield sensing**
2. VDD pacing mode
3. Normal blanking
4. Normal VVI



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Specific Timing Cycles

- AAI or AAIR and appropriate lack of response to ventricular events
- VDD or VDDR and reversion to VVI timing in the absence of atrial activity
- DDI or DDIR and the lack of atrial tracking *(in DDI--lower rate = upper rate)*

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Timing Cycles: Crosstalk

- Unwanted detection in one channel of a signal from another channel
- Most common: afterpotential from atrial output sensed by V channel and resets VA interval
- AV crosstalk easier to avoid with bipolar sensing configuration, less sensitive to far-field signals

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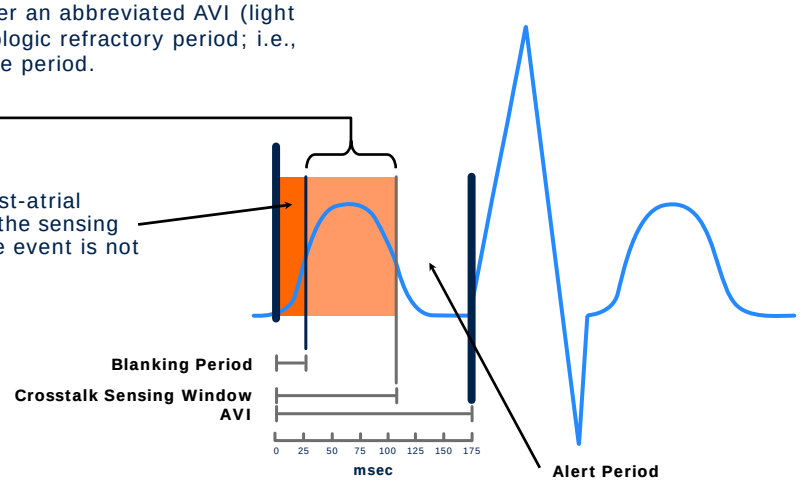
If the event that occurs in the crosstalk sensing window is sensed, the V is paced after an abbreviated AVI (light orange), falling in the physiologic refractory period; i.e., does not fall in the vulnerable period.

If the event occurs in the post-atrial ventricular blanking period, the sensing circuit is turned "off" and the event is not seen (dark orange).



If sensing occurs during the 'alert' period, ventricular output is inhibited.

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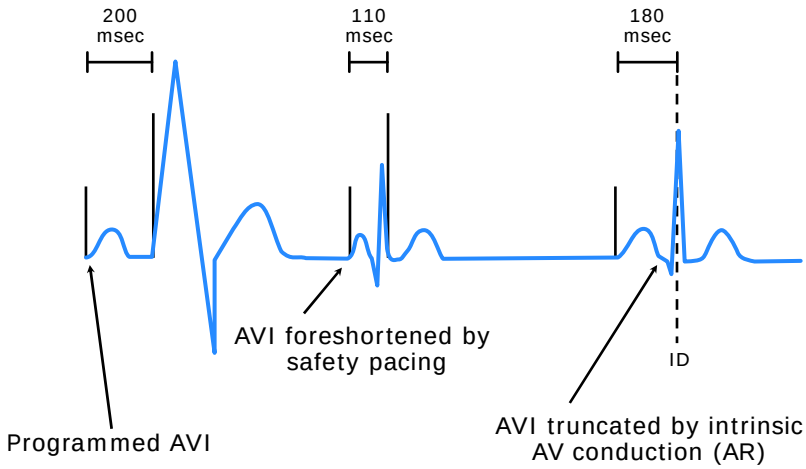

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Timing Cycles: Crosstalk

AV crosstalk may be eliminated by:

- Increasing the blanking period *(so that ventricular sensing resumes later)*
- Decreasing the atrial stimulus voltage or duration *(if adequate safety margin can be maintained)*
- Making ventricular channel less sensitive

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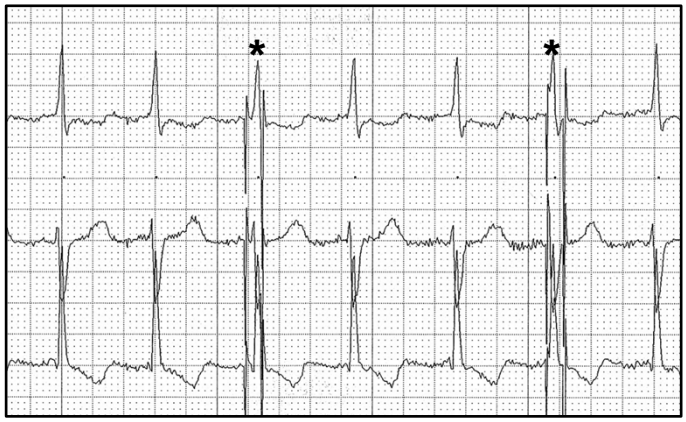
Programmed AV = 220; The labeled QRS complex (*) occurs in the:

1. Crosstalk sensing window
2. Alert portion of AVI
3. Post-atrial ventricular blanking period



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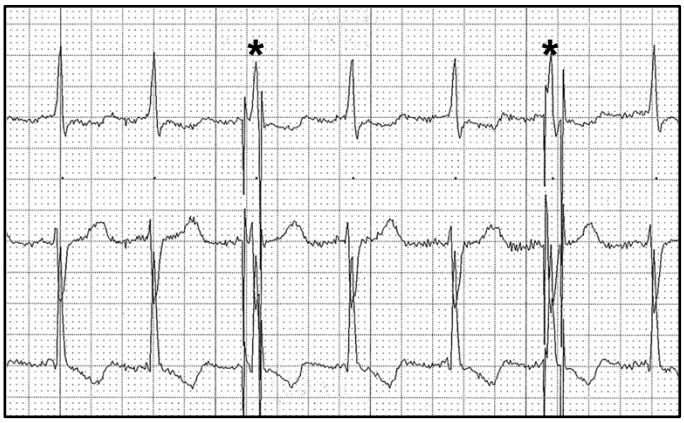
Programmed AV = 220; The labeled QRS complex (*) occurs in the:

1. Crosstalk sensing window
2. Alert portion of AVI
3. Post-atrial ventricular blanking period



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Upper Rate Behavior

Components of basic timing

- TARP (AVI + PVARP)
- Dynamic AVI
- Rate-adaptive parameters
- Timing system

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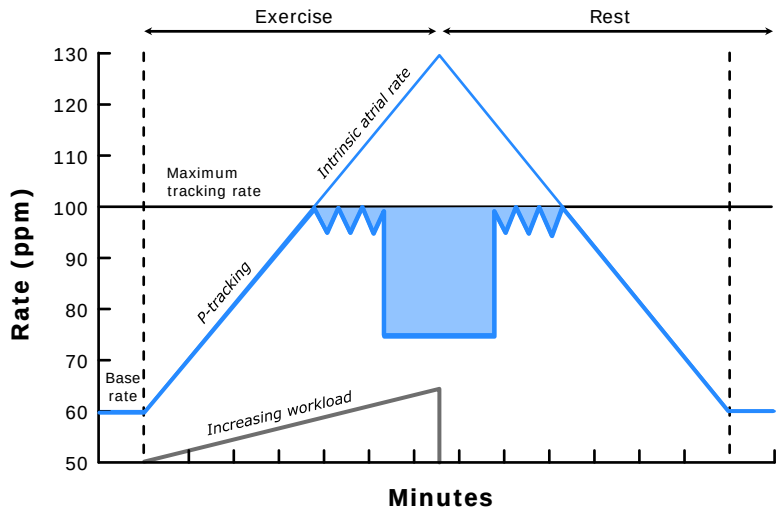
Schematic of DDD Timing



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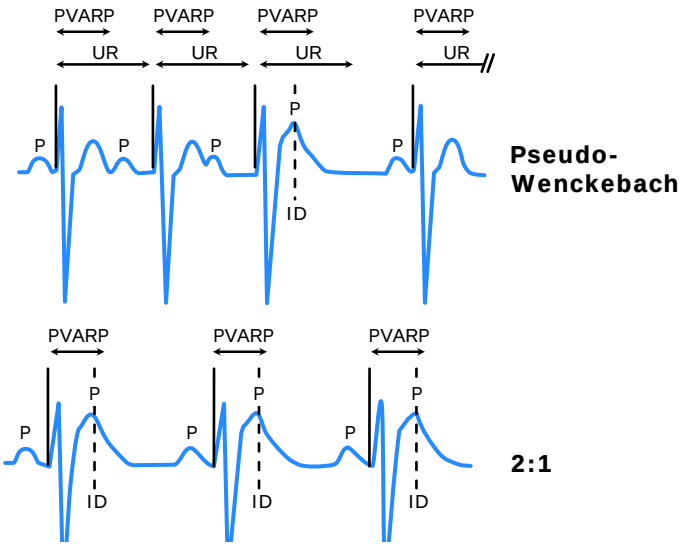
DDD Upper Rate Behavior



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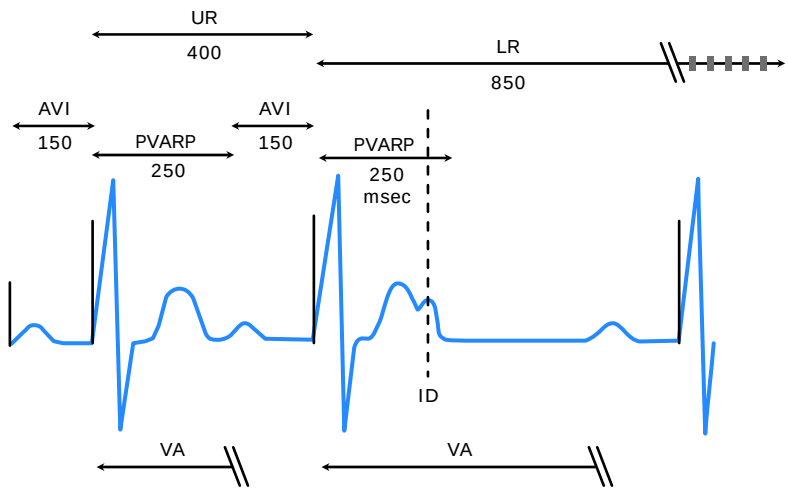
Schematic of DDD Upper Rate Behavior



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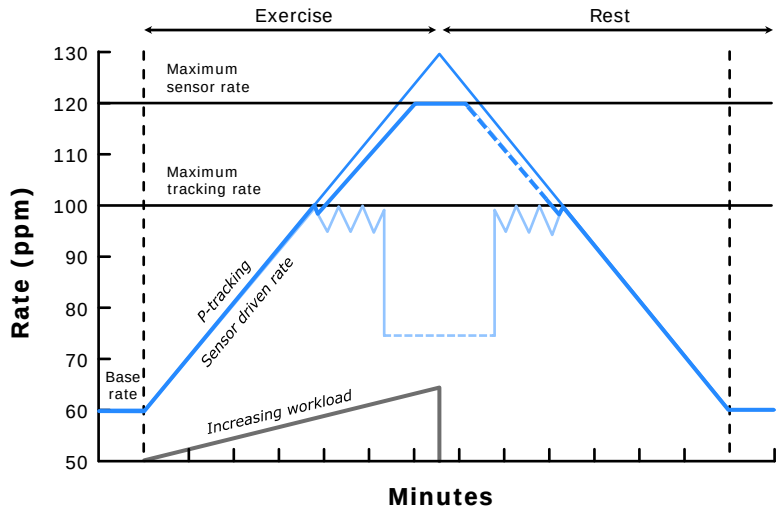
Schematic of DDD Timing



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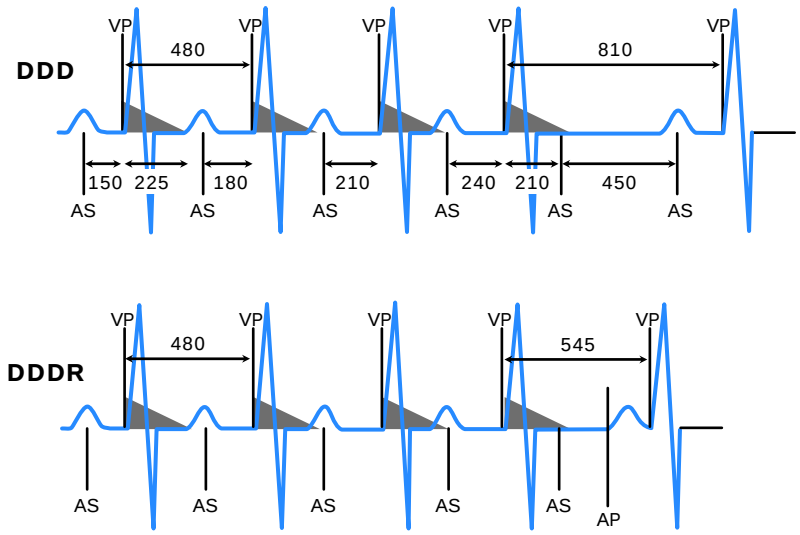
Schematic of Sensor-Driven Rate Smoothing



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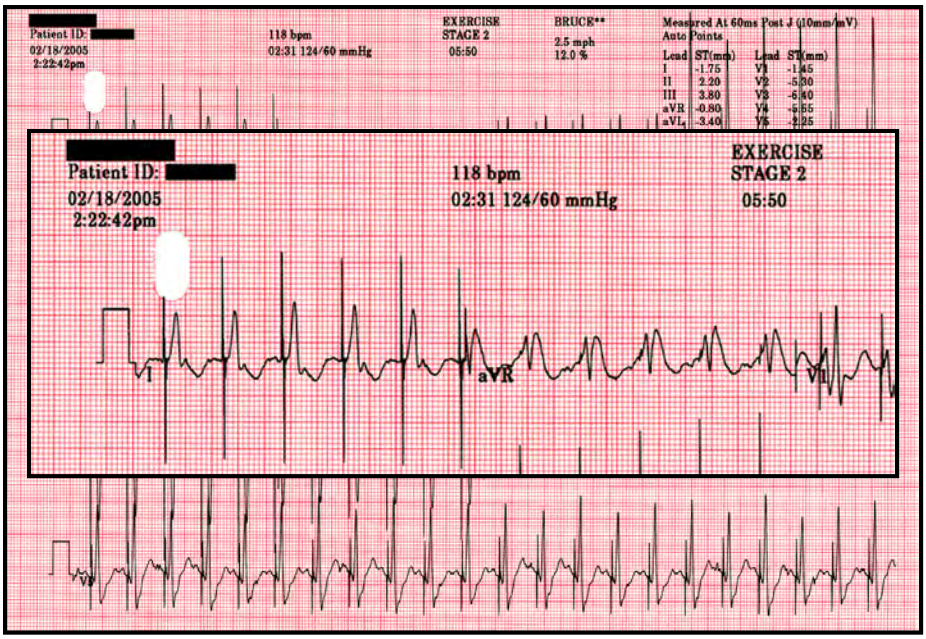

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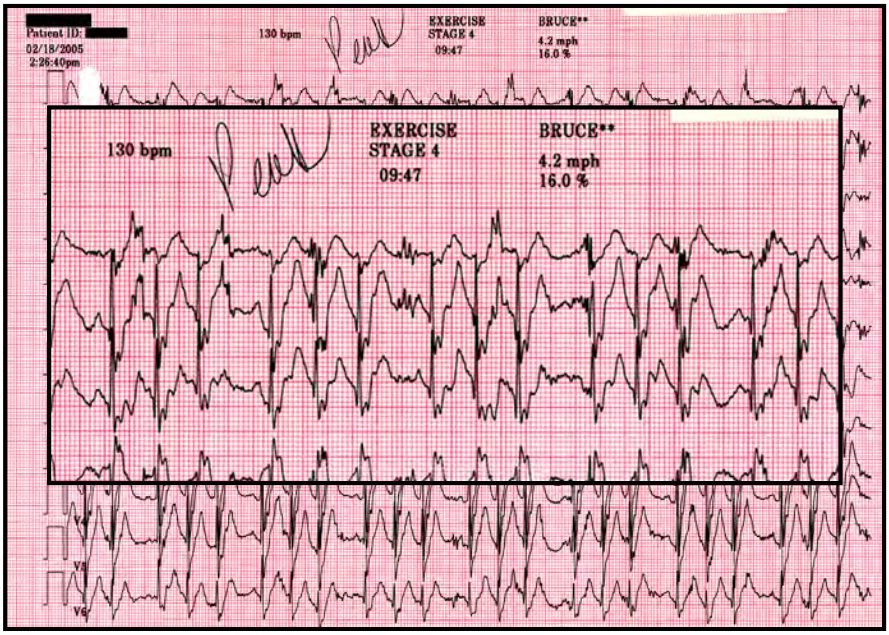

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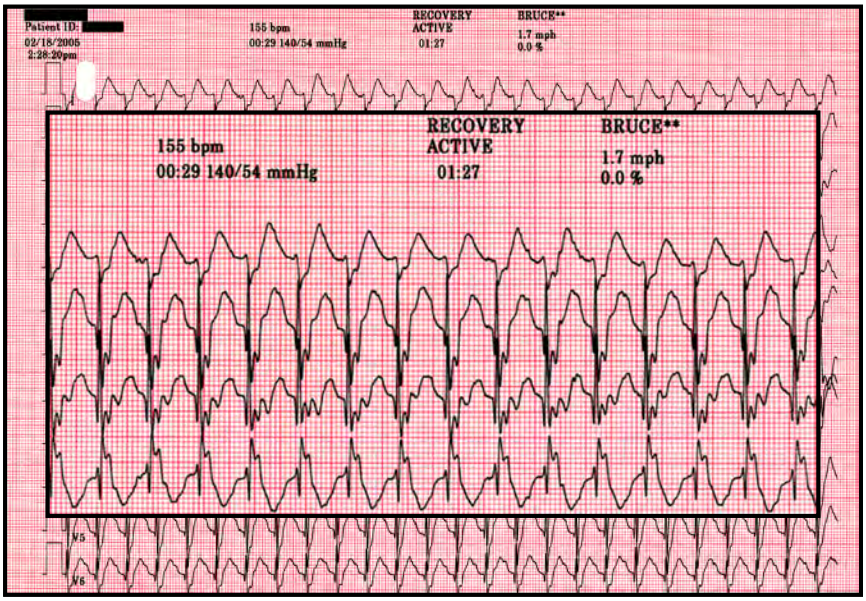

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Timing Cycles

- Understanding basic timing cycles is critical for ECG interpretation of all CIEDs.
- Exceptions and nuances exist for every manufacturer.
- If interpretation doesn't fit basic timing cycle principles, contact technical services for assistance.

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