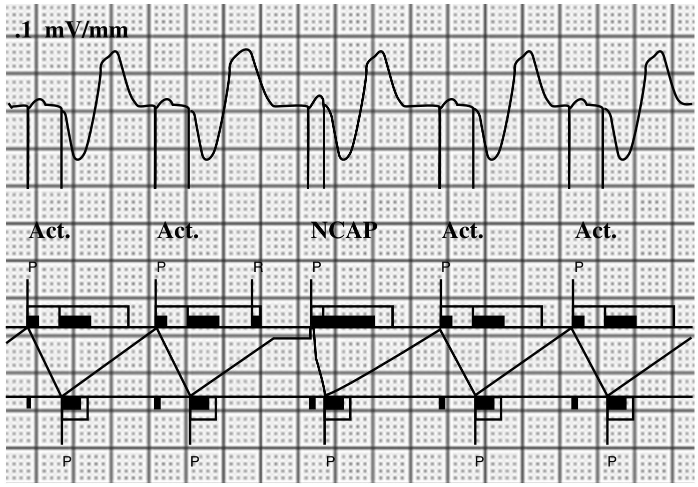
Timing Cycles



A pacemaker operates in repetitive cycles called timing cycles, which are similar to the normal cardiac cycle.

The timing circuit of a pulse generator is controlled by a crystal oscillator, a component that generates accurate signals with frequencies in the KHz range. Its output is set to a digital timer and logic control circuits that operate internal clocks. It receives input from the sensing amplifier and triggers pacing output, based on programmed parameters and pacing modes.

A pacemaker timing cycle operates predictably: Either the timer starts and completes its cycle, or it starts over (resets) based on input from sensing circuits.

Note: See Marker Channel diagram in Medtronic Pacing Glossary.

Notes

Timing cycles are similar to the normal cardiac cycle, but more predictable.

Question:

The repetitive cycle of pacing is called a ______________________.

Answer: timing cycle

NBG Pacemaker Code

I	II	III	IV
Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing	Programmability / Rate Modulation
O = none A = atrium V = ventricle D = dual (A+V)	O = none A = atrium V = ventricle D = dual (A+V)	O = none T = triggered I = inhibited D = dual (T+I)	O = none P = simple programmability M = multiparameter programmability C = communication with programmer R = rate modulation

The ***NBG code*** describes the pacing mode - the manner in which the pacemaker paces and senses. The NBG code was developed and is updated by the North American Society of Pacing and Electrophysiology (NASPE) and the British Pacing and Electrophysiology Group (BPEG).

The ***first letter*** in the NBG code indicates which chambers are paced, and the ***second letter*** identifies the chambers sensed. The ***third letter*** identifies the pacemaker response to sensing (see figure above):

- An inhibited (I) response means the scheduled output pulse is withheld when intrinsic sensed activity is faster than the programmed pacing rate (called demand pacing).
- A triggered (T) response in a single chamber mode means the scheduled output pulse is delivered when intrinsic activity is sensed. This response may be used for troubleshooting or EP studies.
- A dual chamber (D) response indicates the pacemaker has two modes of response to sensed activity. For example, a sensed atrial event inhibits atrial output and triggers ventricular output following a scheduled interval (also called tracking).

The ***fourth letter*** describes programmability and rate response. P means the pacing system provides one or two programmable variables, and M means there are three or more changeable parameters. C indicates the pacemaker has bidirectional telemetry for communication with a programmer and is also multiprogrammable. R means the system provides rate modulation, has telemetry, and is multiprogrammable. R is used most often.

The NBG code includes a fifth letter, which relates to antitachycardia functions.

Notes

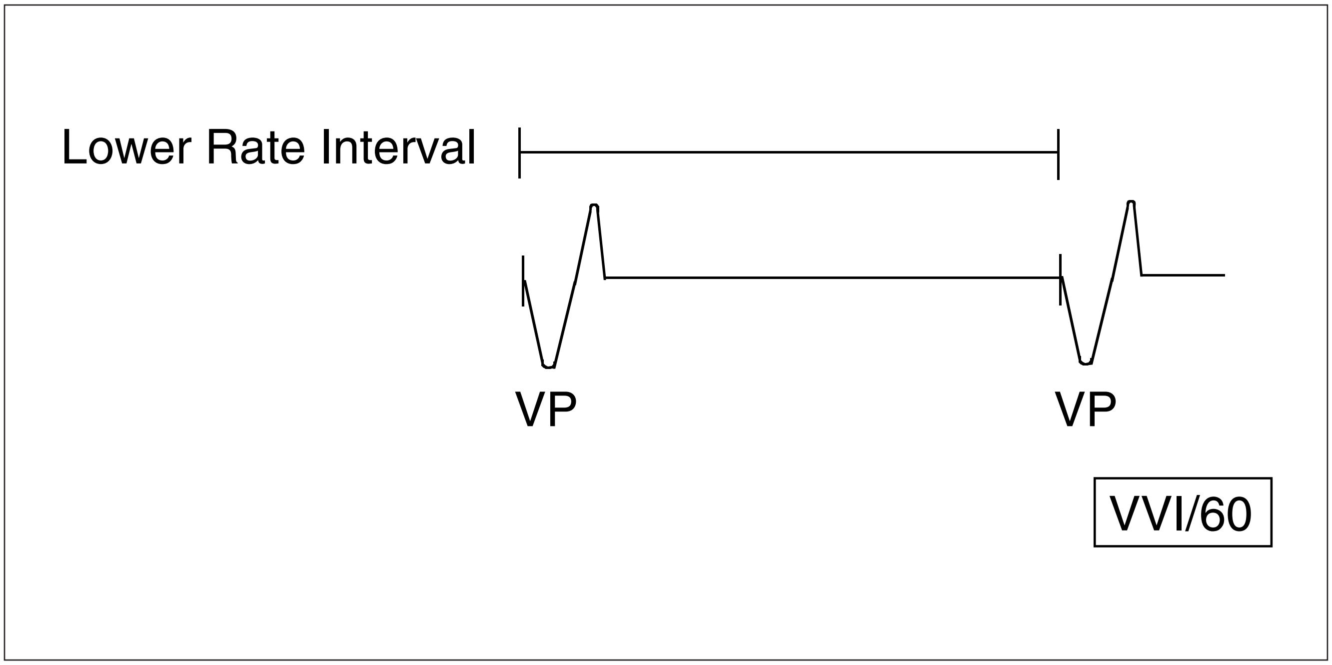
See Energy for Life CD, (UC199702939b EN)

Question:

The __________ describes the pacing mode of a pacemaker.

Answer: NBG code

VVI Pacing



In VVI mode, the pacemaker paces the ventricles at the end of the lower rate interval in the absence of a sensed ventricular event. A new lower rate interval starts at the moment of pacing.

The ***lower rate interval*** - also called the pacing interval - is the longest period of time allowed before delivery of a pacing pulse in the absence of sensed activity. Its duration is determined by the programmed ***lower rate***.

Example:

$$\frac{60{,}000 \text{ (ms in 1 minute)}}{60 \text{ ppm (lower rate)}} = 1000 \text{ ms (lower rate interval)}$$

At a programmed lower rate of 60 ppm, a pacemaker programmed to VVI mode, paces the ventricles every 1000 ms in the absence of sensed ventricular activity. If the sensed ventricular rate is faster, the pacing pulse is inhibited.

Notes

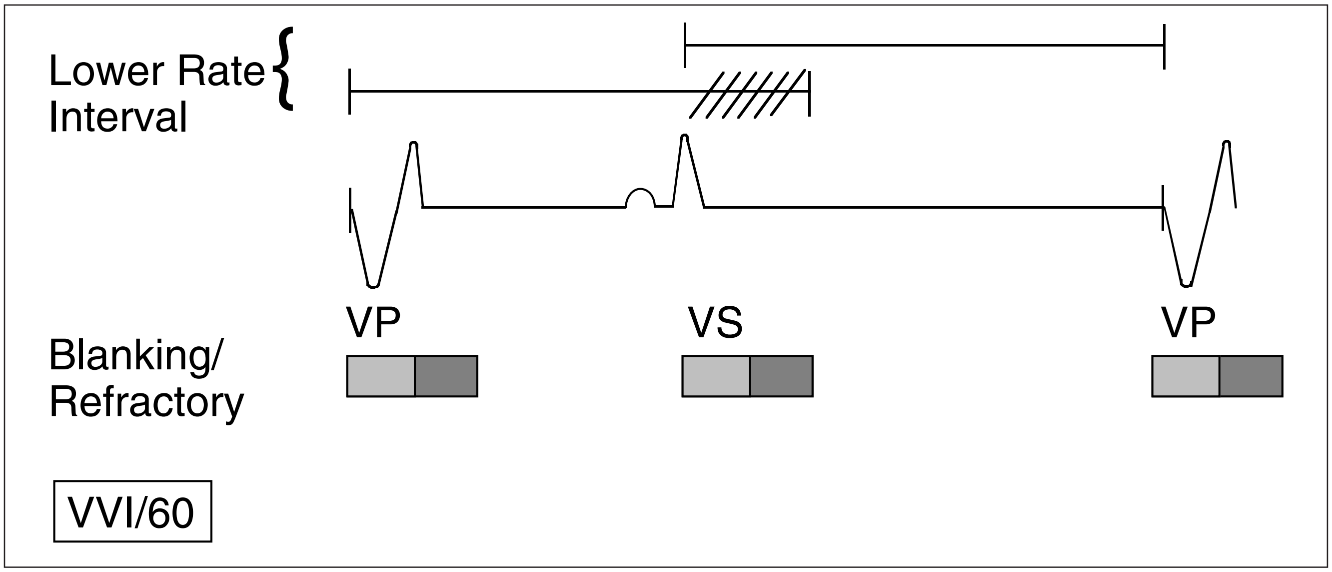
In VVI mode, the lower rate interval is the longest allowable interval between ventricular events.

Question:

If the lower rate is set to 70 ppm, the lower rate interval is ________ ms.

Answer: 857

VVI Sensing



In VVI mode, the pacemaker inhibits the scheduled pacing pulse when ventricular activity is sensed outside the refractory period*. A new lower rate interval starts at the moment of sensing.

*The ***refractory period*** is an interval that starts immediately after a paced or sensed event. It is programmed to prevent detection of unwanted signals, which may inappropriately inhibit or delay the scheduled pacing pulse.

In VVI mode, the ***ventricular refractory period (VRP)*** prevents oversensing of the T-wave, which may inappropriately start a new lower rate interval and inhibit the next ventricular pace. The first portion of a refractory period is a ***blanking period***, a brief time during which the pacemaker is insensitive to electrical signals. Ventricular blanking prevents another detection of the same R-wave or detection of the ventricular output pulse.

The nonblanking portion of the refractory period is a ***noise sampling period***, a time during which the pacemaker looks for repetitions of the same signal type to determine if the pacemaker is continuously oversensing.

Notes

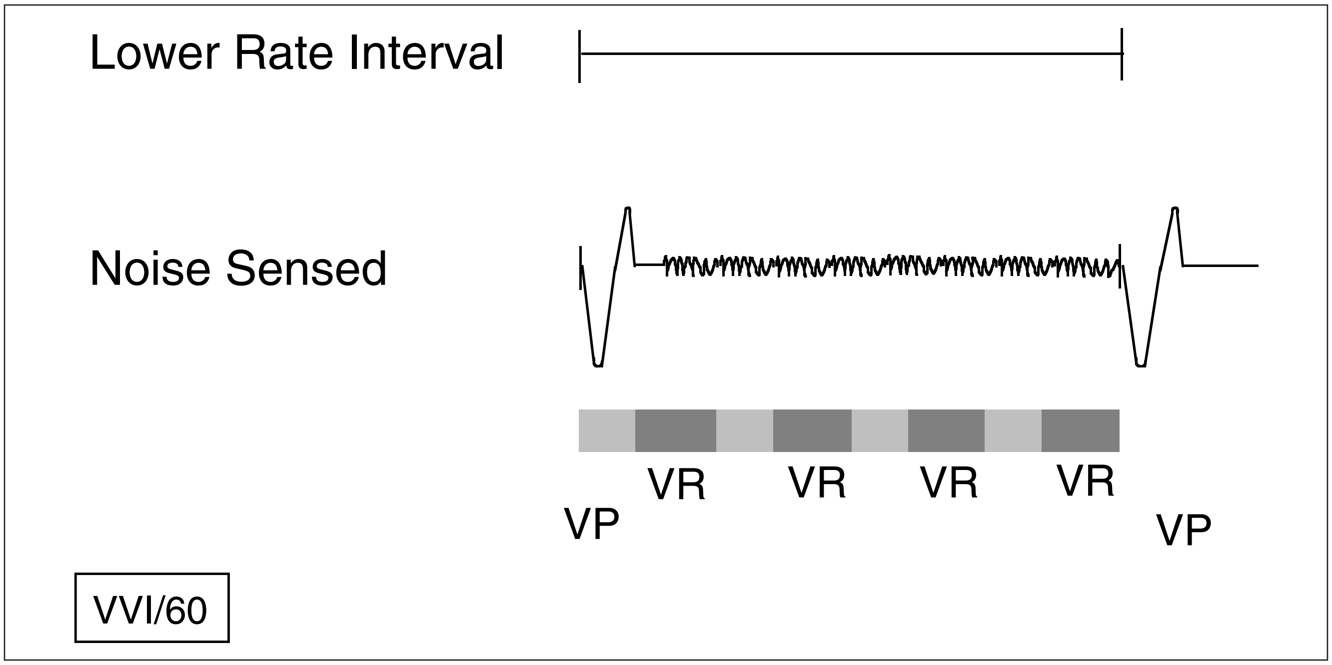
Questions:

Refractory sensed events (do, do not) start a new lower rate interval.

The pacemaker is insensitive to electrical signals during the ______________ period.

Answers: do not / blanking

Noise Reversion



Events sensed during the noise sampling period start another refractory period.

The pacemaker marks sensed events that occur during a noise sampling period (VR). A sensed event in the noise sampling period initiates a new refractory period and blanking period. If sensed events continue to occur, the pacemaker reverts to ***asynchronous pacing*** — pacing without sensing to protect the patient from inappropriate inhibition. The term for this phenomenon is ***Noise Reversion.***

In a single chamber mode, asynchronous pacing occurs at the programmed lower rate.

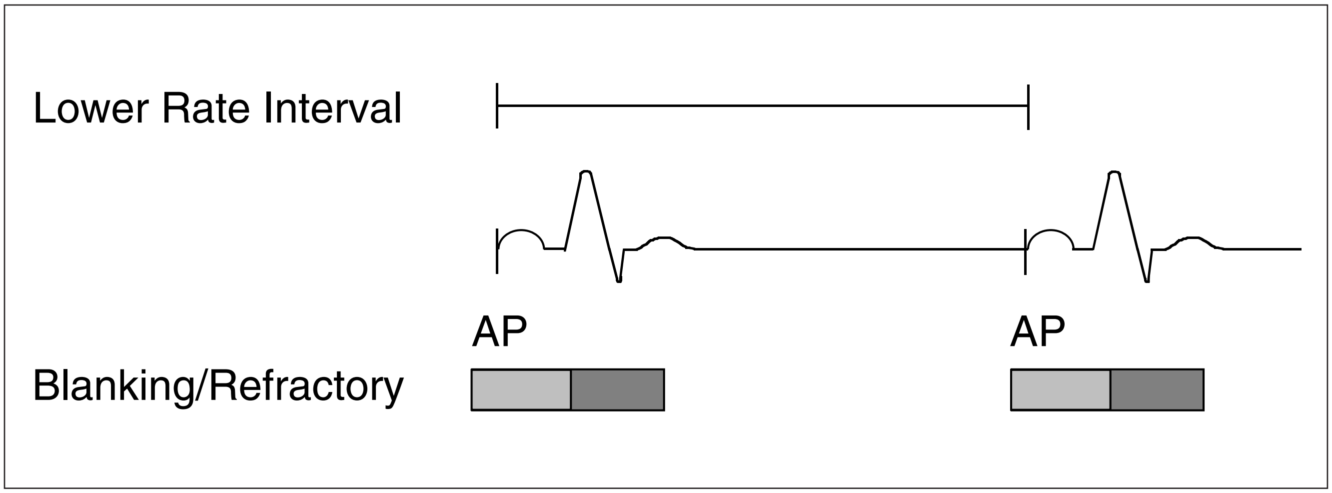
Notes

Question:

Asynchronous pacing at the low rate in the presence of continuous noise is ______________.

Answer: Noise Reversion

AAI Mode



In AAI mode, the pacemaker paces the atrium in the absence of a sensed atrial event and inhibits the scheduled pacing pulse when an atrial event is sensed outside the refractory period.

In AAI mode, the ***atrial refractory period (ARP)*** prevents oversensing of the far-field T-wave or R-wave. The refractory period in AAI mode is longer than that in VVI mode, because far-field ventricular signals are more easily detected and the refractory period must also include the PR interval. The ***atrial blanking period*** prevents another detection of the same P wave or detection of the atrial output pulse.

Note: AAI mode allows normal AV conduction in the absence of AV block, and should be used only in patients with intact AV conduction.

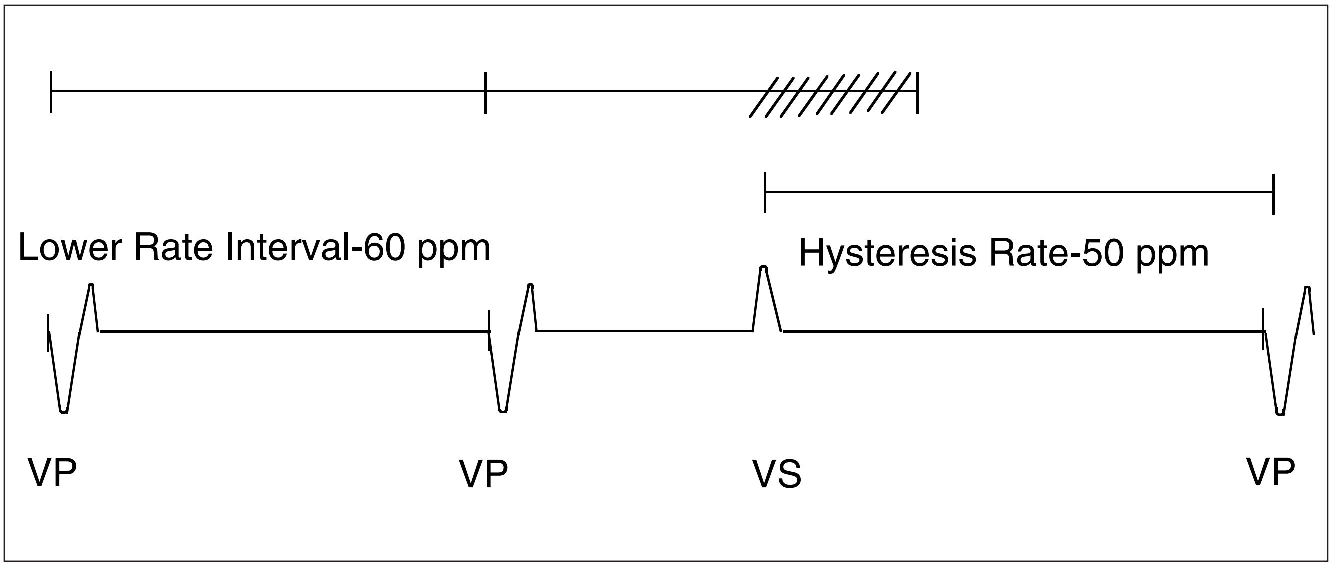
Notes

True or False:

The atrial refractory period in AAI mode is longer than the ventricular refractory period in VVI mode. ______

Answer: True

Hysteresis



Single chamber hysteresis is a programming option that temporarily suspends the lower rate and allows a slower pacing rate after a sensed event.

The purpose of a ***hysteresis rate*** is to allow as much intrinsic activation as possible, which is hemodynamically preferred. Hysteresis may be beneficial to prevent pacing during periods of rest or sleep, when the heart rate is lower.

Example:

$$\frac{60{,}000 \text{ (ms in 1 minute)}}{50 \text{ ppm (hysteresis rate)}} = 1200 \text{ ms (hysteresis rate interval)}$$

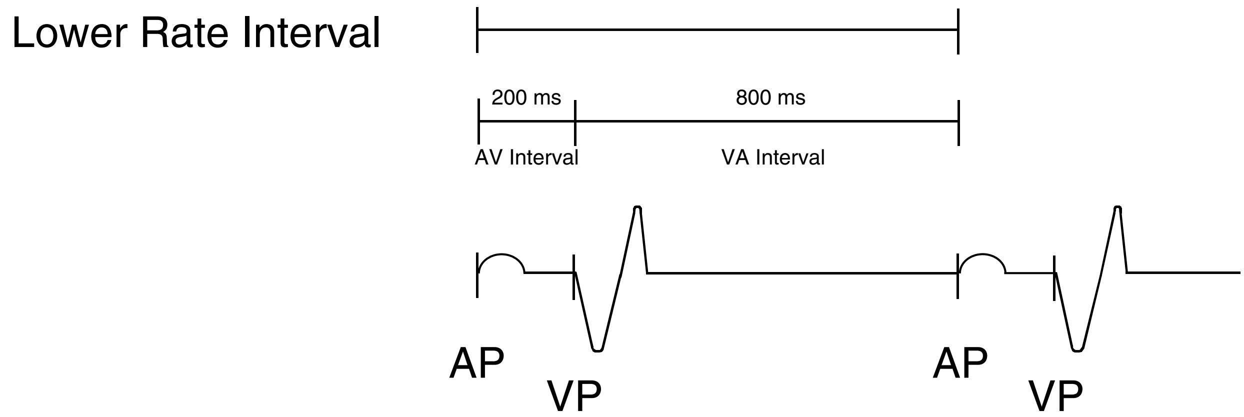
Notes

Question:

__________ maintains the patient's intrinsic rate during periods of rest when the heart rate slows normally.

Answer: Hysteresis

DDD - Lower Rate Interval



In DDD mode, the lower rate interval has two portions - an AV interval, which starts with an atrial event, and a VA interval, which starts with a ventricular event.

The ***AV interval*** is the longest period of time allowed before delivery of a ventricular pace in the absence of a sensed ventricular event. It mimics the PR interval - the time between atrial and ventricular depolarization in a healthy heart. An appropriately programmed AV interval provides sufficient time for a complete atrial contraction and adequate left ventricular filling - that is, it provides AV synchrony.

The ***VA interval*** - also called the atrial ***escape interval (AEI)*** - is the longest period of time allowed before delivery of an atrial pace in the absence of sensed atrial activity. Its duration is determined by the difference between the programmed lower rate and AV intervals.

Example:

1000 ms (lower rate interval) - 200 ms (AV interval) = 800 ms (VA interval)

Notes

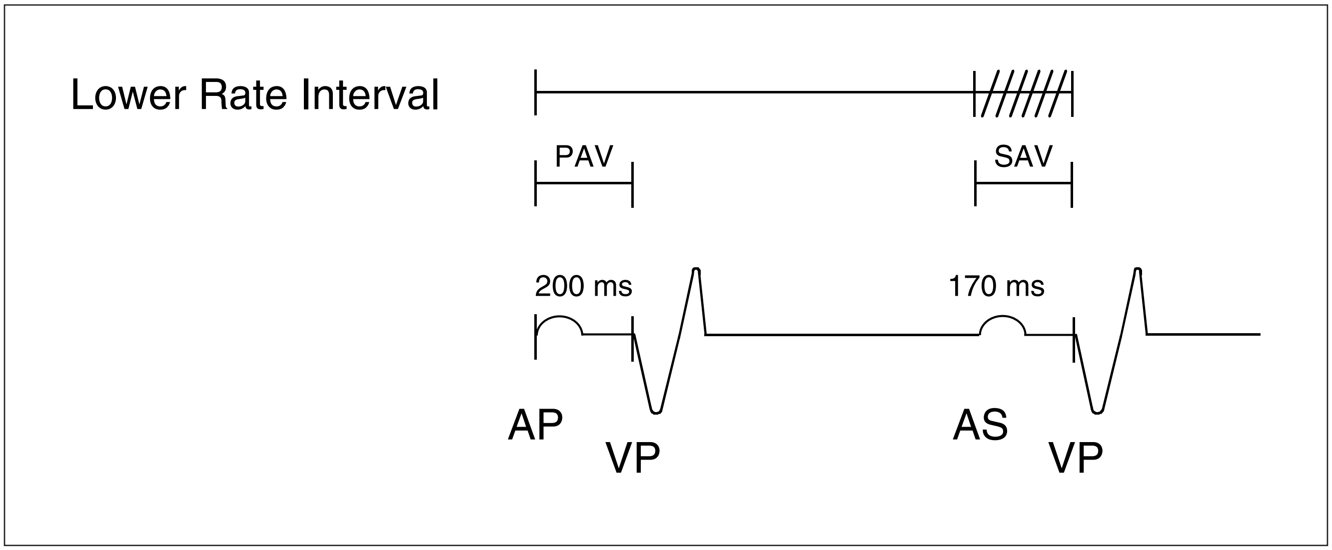
The AV interval is the longest allowable interval between an atrial and ventricular event. The VA interval is the longest allowable interval between a ventricular and atrial event.

Questions:

The ______ mimics normal PR interval and provides the delay needed for adequate left ventricular filling.

The ______ is the difference between the lower rate and AV intervals.

Answers: AV interval / VA interval



In DDD mode, two separate AV intervals may be programmed - one starts with a sensed atrial beat and the other with a paced atrial beat.

Separate programming of a ***sensed AV interval (SAV)*** and a ***paced AV interval (PAV)*** accommodates differences in the ***interatrial conduction time (IACT)*** - the time needed for a depolarization wave to travel from the right to the left atrium. The IACT is usually longer after a paced beat than an intrinsic beat, because paced beats travel through muscle tissue rather than along the normal conduction pathway. Because the IACT determines when left atrial depolarization begins, it directly affects left heart hemodynamics.

Programming an SAV about 30 to 70 ms shorter than the PAV provides atrioventricular times of equal duration thereby optimizing hemodynamics whether the atrial contraction is sensed or paced. IACTs vary from patient to patient therefore SAV and PAV intervals are independently programmable.

Notes

The SAV interval is the longest allowable interval between a sensed atrial event and a paced ventricular event (AS to VP). The PAV interval is the longest allowable interval between a paced atrial event and a paced ventricular event (AP to VP).

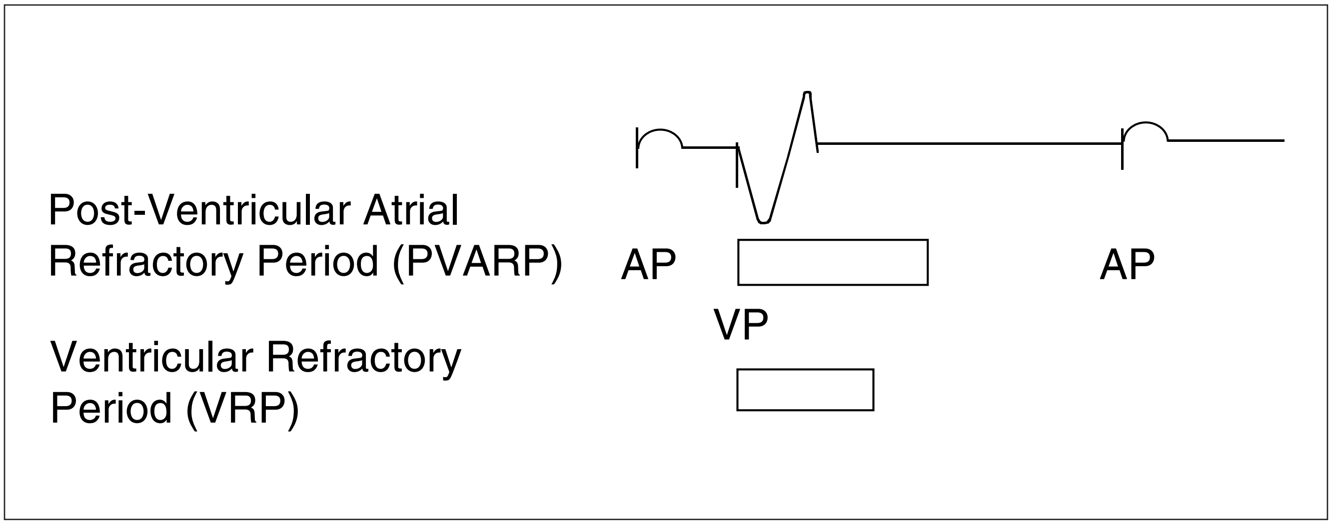
Questions:

The AV interval after a (paced, intrinsic) beat is longer.

Separate programming of the SAV and PAV intervals accounts for differences in ____________.

Answers: paced / interatrial conduction time (IACT)

DDD Mode - Refractory Periods



The DDD timing cycle has atrial and ventricular refractory periods.

The ***ventricular refractory period (VRP)*** is the programmable interval after a ventricular event during which the ventricular channel is refractory to sensed events. It prevents detection of the T-wave.

The ***post-ventricular atrial refractory period (PVARP)*** is the programmable interval following a ventricular event when the atrial channel is refractory to sensed events. It prevents atrial sensing of far-field signals and retrograde P-waves. Pacemaker mediated tachycardias (PMTs) result from inappropriate sensing of retrograde P-waves causing closely coupled ventricular paces.

In DDD mode, the atrial channel is refractory during the entire AV interval and the PVARP. Thus the ***total atrial refractory period (TARP)*** is the AV interval plus the PVARP. ***Example***: 200 ms (SAV) + 300 ms (PVARP) = 500 ms (TARP). Events that fall within the TARP will be registered on the marker channel but do not start another SAV interval.

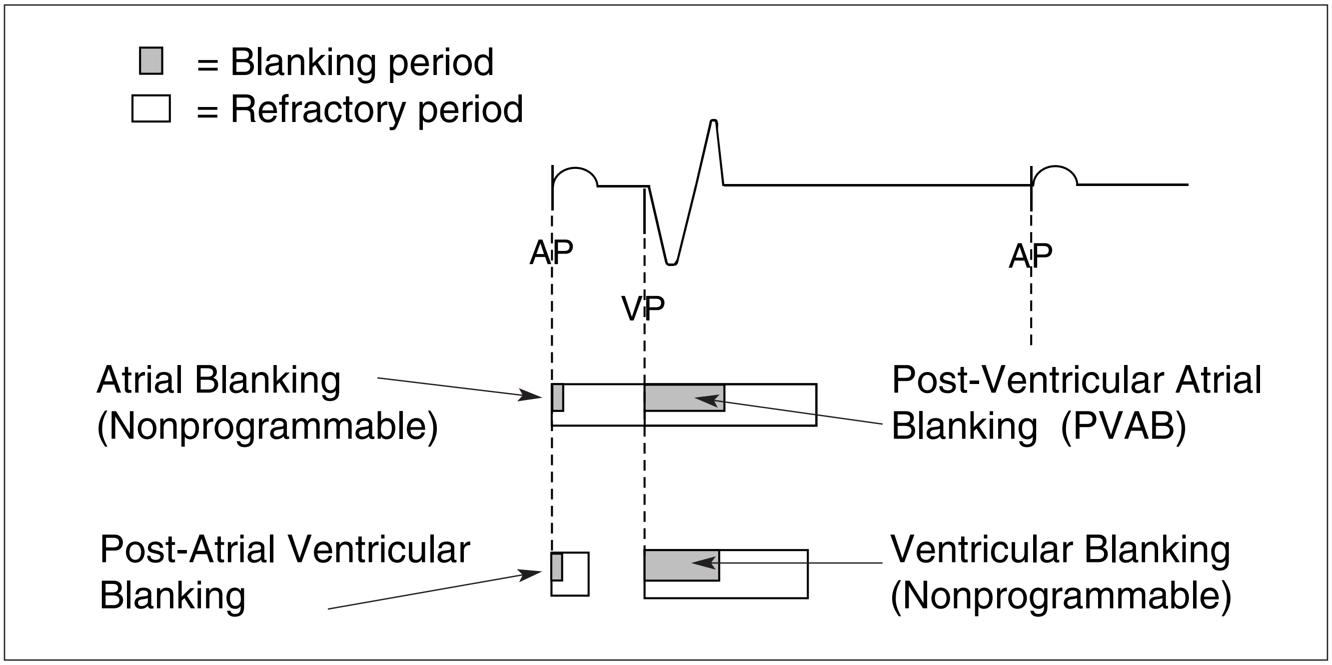
Notes

Question:

In DDD mode, the (atrial, ventricular) channel is refractory during the AV interval and the PVARP.

Answer: atrial

DDD Mode - Blanking Periods



The DDD timing cycle has four blanking periods.

Atrial blanking occurs in the first portion of the PAV or SAV interval. It prevents self inhibition due to sensing of the atrial output pulse or another detection of the same P-wave. ***Ventricular blanking*** occurs in the first portion of the VA interval. It prevents self-inhibition due to sensing of the ventricular output pulse or another detection of the same R-wave.

The ***post-ventricular atrial blanking (PVAB)*** is the first portion of the PVARP. It prevents atrial sensing of far-field ventricular signals. ***Post-atrial ventricular blanking (PAVB)*** occurs after an atrial pace and prevents ventricular sensing of far-field atrial pacemaker outputs (crosstalk). It is usually programmed to a short duration (20 to 44 ms), so the next R-wave does not go unsensed if it occurs early. Failure to sense an R-wave could trigger a competitive ventricular pace.

Notes

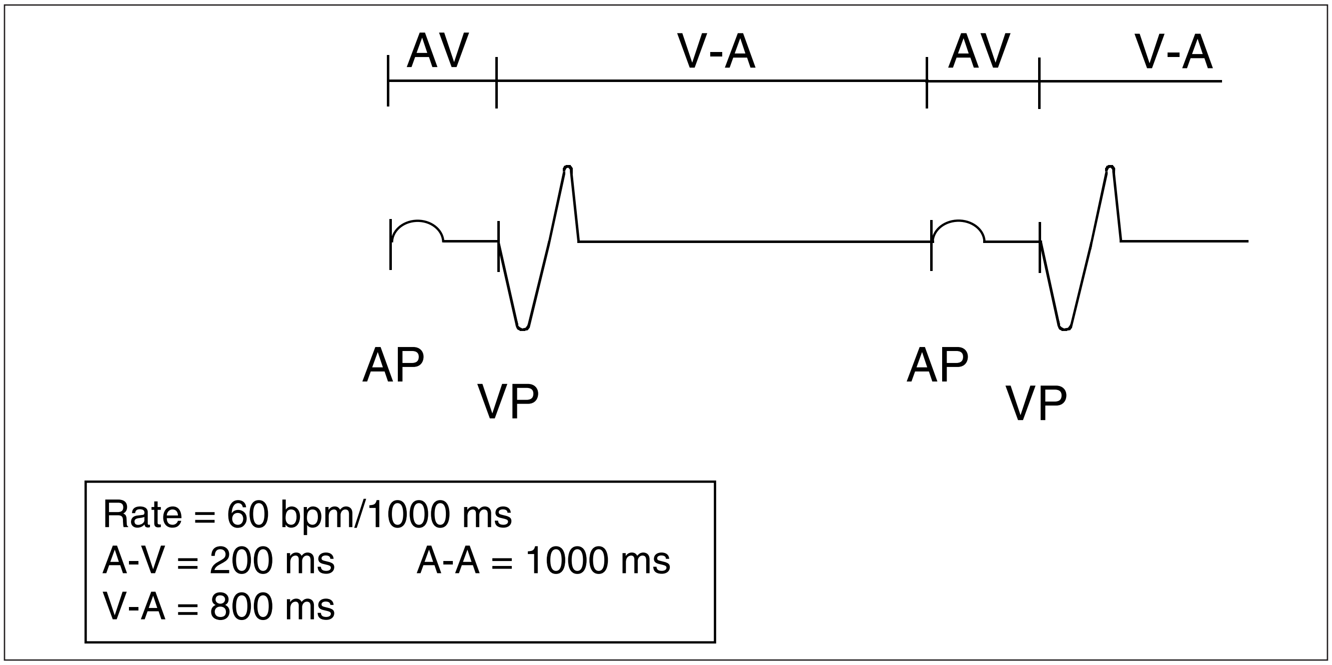
Questions:

The PAVB is designed to prevent ____________________.

The (PVAB, PAVB) is short to prevent undersensing of an early intrinsic ventricular beat.

Answers: crosstalk / PAVB

DDD Timing - AP-VP Sequence



The DDD timing cycle has four possible sequences (faces).

In the AP to VP sequence, AV sequential pacing occurs at the programmed lower rate.

In this sequence, a P-wave is not sensed before the end of the VA interval, so the pacemaker delivers the scheduled atrial pace and starts a PAV interval. An R-wave is not sensed before the end of the PAV interval, so the pacemaker delivers the scheduled ventricular pace and starts the next VA interval.

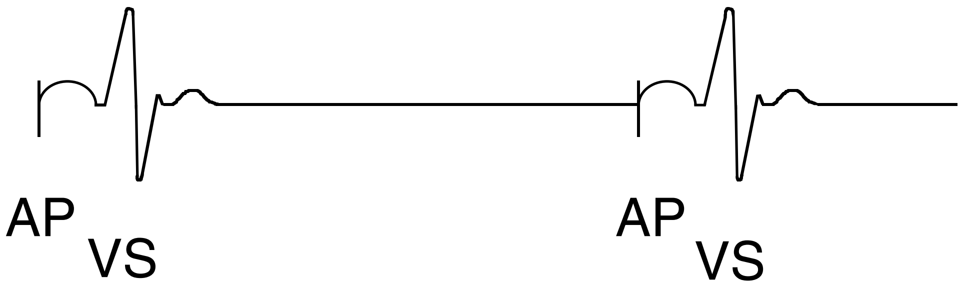
Notes

True or False:

In the AP to VP sequence, atrial and ventricular output pulses are delivered as scheduled, because no events are sensed outside the refractory periods. ____________

Answer: True

DDD Timing - AP -VS Sequence



In the AP to VS sequence, the atrium is paced and the pulse is conducted to the ventricles.

In this sequence, a P-wave is not sensed before the end of the VA interval, so the pacemaker delivers the scheduled atrial pace and starts a PAV interval. An R-wave is sensed before the end of the PAV interval, so the pacemaker inhibits the scheduled ventricular pace.

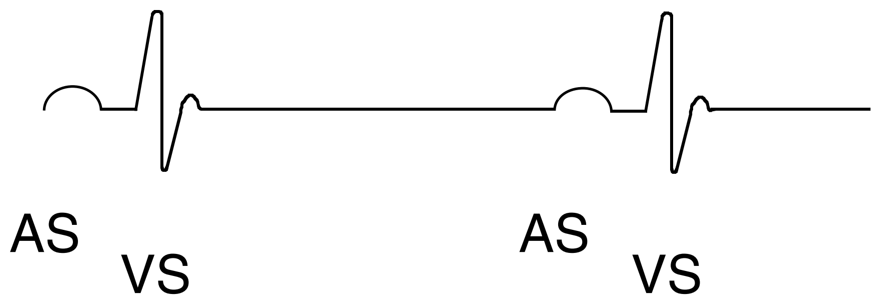
Notes

True or False:

In the AP to VS sequence, the atrial output pulse is delivered as scheduled and the ventricular output pulse is inhibited by a nonrefractory sensed event. ______

Answer: True

DDD Timing - AS-VS Sequence



In the AS to VS sequence, pacing is completely inhibited by nonrefractory sensed events.

In this sequence, a P-wave is sensed before the end of the VA interval, so the pacemaker inhibits the scheduled atrial pace and starts an SAV interval. An R-wave is sensed before the end of the SAV interval, so the pacemaker inhibits the scheduled ventricular pace.

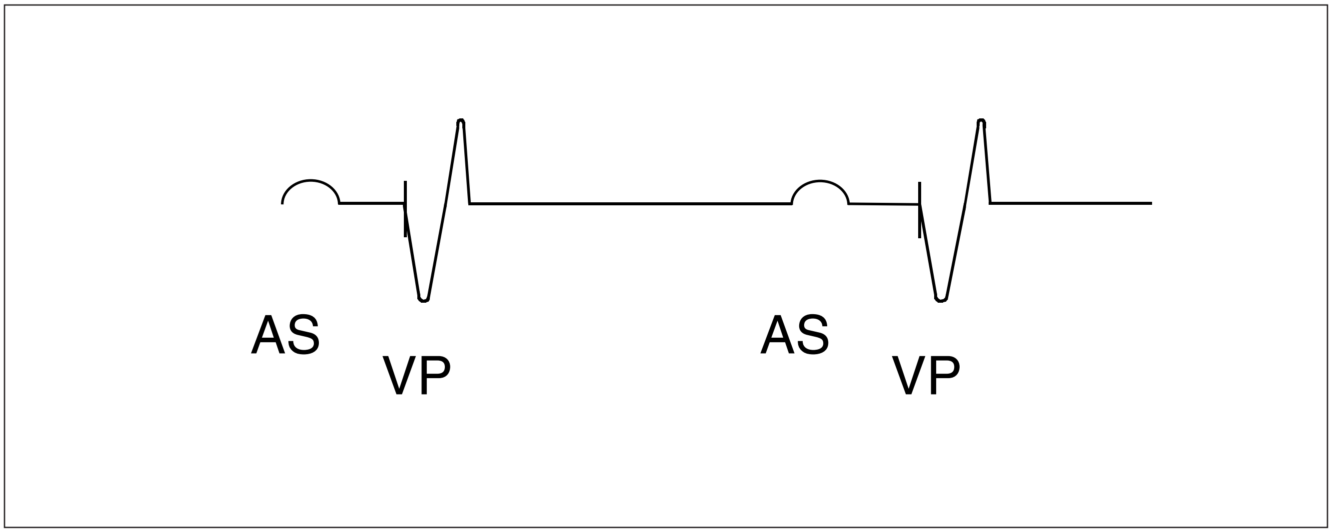
Notes

True or False:

In the AS to VS sequence, both the atrial and ventricular output pulses are inhibited by sensed events outside the refractory period.

Answer: True

DDD Timing - AS-VP Sequence



In the AS to VP sequence, the ventricular rate is synchronized to the sensed atrial rate - called P-wave tracking.

In this sequence, a P-wave is sensed before the end of the VA interval, so the pacemaker inhibits the scheduled atrial pace and starts an SAV interval. An R-wave is not sensed before the end of the SAV interval, so the pacemaker delivers the scheduled ventricular pace.

Notes

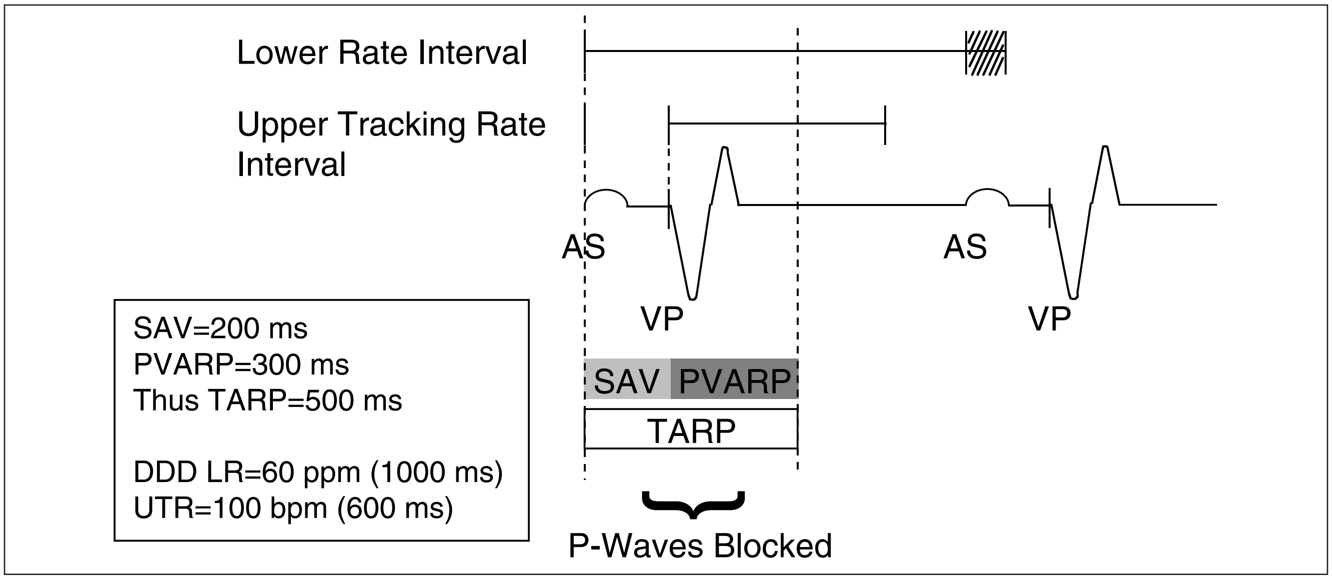
True or False:

In the AS to VP, the ventricular pacing rate matches the sensed atrial rate. __________

There are four possible pacing sequences in normal DDD timing. __________

Answer: True, True

DDD Mode - Upper Rate Behavior (P-wave Tracking)



In DDD mode, P-wave tracking occurs within the confines of the **total atrial refractory period (TARP)**, programmed lower rate and **upper tracking rate (UTR)**.

The ***total atrial refractory period (TARP)*** determines the fastest rate the pacemaker tracks atrial events. P-waves that are faster than the rate defined by the TARP are blocked, disrupting AV synchrony (2:1 block point). Recall that the TARP = SAV + PVARP.

Example: $\frac{\text{60,000 (ms in one minute)}}{\text{500 ms (TARP)}}$ = 120 ppm (2:1 block rate)

The programmable ***upper tracking rate (UTR)*** is the fastest rate the ventricles may be paced in response to the sensed atrial rate. The upper tracking rate determines the duration of the ***upper tracking rate interval***.

Example: $\frac{\text{60,000 (ms in one minute)}}{\text{100 ppm (upper tracking rate)}}$ = 600 ms (UTR interval)

P-wave tracking is governed by the TARP (2:1 block rate) and the UTR (UTR interval). When atrial events fall outside the TARP (slower than 2:1 block rate), one ventricular pace is synchronized to each atrial event by the SAV, provided the atrial rate is slower than the UTR.

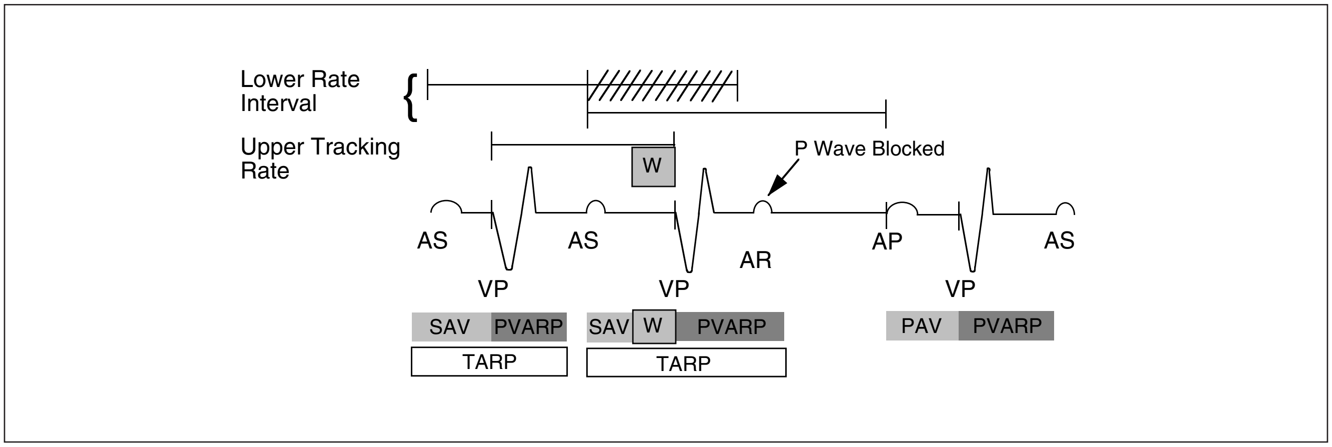
Notes

Question:

1:1 AV synchrony occurs only if the interval between atrial beats is longer than the ______ and the ______.

Answers: TARP and UTR interval

DDD Mode - Upper Rate Behavior (Wenckebach Block)



In pacemaker **Wenckebach block**, the SAV is progressively lengthened producing a gradual change in the tracking ratio.

The ***Wenckebach block*** pattern develops as follows:

- In the first complex, a P-wave falls outside the PVARP and starts an SAV interval. The pacemaker delivers the scheduled ventricular pace (1:1 AV synchrony). At this point, both the SAV and UTR interval have timed out.
- In the second complex, the pacemaker senses another P-wave outside the PVARP and again starts an SAV interval. However, this time the scheduled ventricular pace must be delayed until the end of the UTR interval. The delay prolongs the SAV interval and places the ventricular pace closer to the next P-wave.
- In the third complex, a P-wave falls into the PVARP and does not start an SAV. An atrial pace is delivered when the lower rate interval times out, resulting in a substantial drop in the paced rate. The Wenckebach pattern then repeats itself.

Pacemaker Wenckebach is characterized by progressive lengthening of the AS-VP intervals with ventricular pacing at the upper tracking rate interrupted by drops in the paced rate in ratios of 3:2 or 4:3, etc. (sensed P-waves to ventricular paced beats).

Notes

The prerequisite for Pacemaker Wenckebach is that the TARP be shorter than the UTR interval. The difference between the TARP and UTR interval is called the Wenckebach window or interval:

Example:

UTR interval (600 ms) - TARP (500 ms) = Wenckebach interval (100 ms)

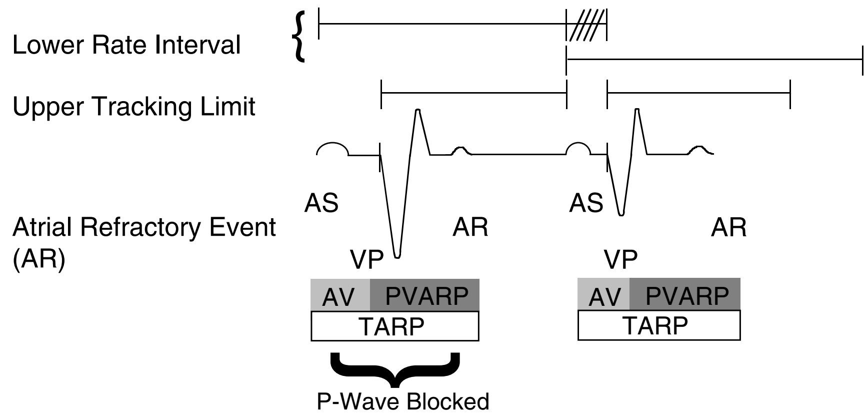
DDD LR=60 bpm (100 ms)
UTR=100 ppm (600 ms)
SAV=200 ms
PVARP=300 ms

Question:

The Wenckebach pattern shows a progressive lengthening of the ______ interval and a ratio of 3:2 or 4:3 between the sensed P-wave and ventricular pace.

Answer: AS-VP

DDD Mode - Upper Rate Behavior (2:1 Block)



Pacemaker 2:1 block develops when every other P-wave falls into the PVARP.

2:1 block occurs when the time between intrinsic atrial events is shorter that the TARP (intrinsic atrial rate exceeds the TARP rate). 2:1 may occur abruptly or after a period of Wenckebach block, depending on the TARP and the UTR interval. Patients can more easily tolerate Wenckebach as the ventricular rate drop is less frequent.

Recall that the 2:1 block point or rate is determined by the TARP.

- If the TARP is shorter than the UTR interval, the pacemaker may exhibit a period of Wenckebach block first depending on the atrial rate.
- If the TARP is equal to or longer than the UTR interval, the pacemaker falls abruptly into 2:1 block when the atrial rate exceeds the rate that corresponds to the TARP.

Example:

500 ms (UTR interval) - 500 ms (TARP) = 0 ms (Abrupt 2:1 block)

$$\frac{\text{60,000 (ms in one minute)}}{\text{500 ms (TARP)}} = \text{120 bpm (2:1 block rate)}$$

2:1 block is one ratio of atrial events to ventricular paced beats. With increasing atrial rates, block may occur as 3:1, 4:1 etc. The way to minimize the effects of block is to shorten TARP and ensure that a Wenckebach interval exists.

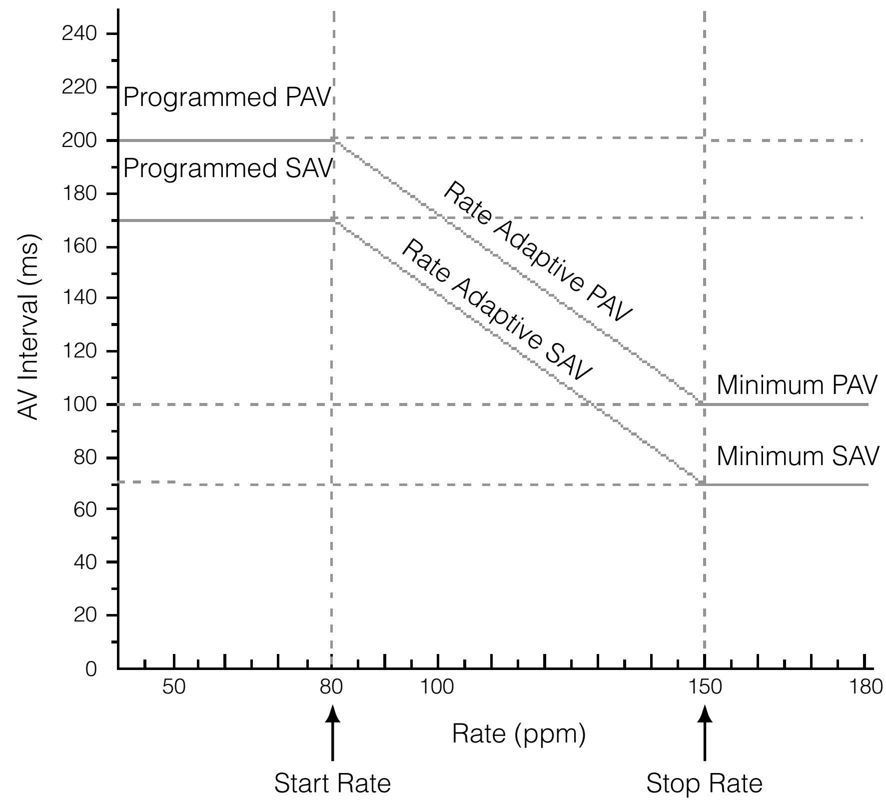
Notes

Question:

What would the ventricular rate be for 2:1 block with an atrial rate of 120 bpm?

Answer: 60 bpm

DDD Mode - Rate-Adaptive AV Intervals



A rate-adaptive AV is a programming option that mimics normal PR conduction.

A rate-adaptive AV interval automatically shortens as the rate increases and lengthens as it decreases, just as the normal PR interval shortens and lengthens with heart rate changes. Both the PAV and SAV shorten with increasing rates. For the PAV, the adaptation is based on input from an artificial sensor, while SAV adaptation is based on the intrinsic atrial rate.

As the rate-adaptive SAV interval shortens, so does the TARP. This allows 1:1 tracking of the P-wave at higher rates, thereby maintaining AV synchrony at higher exercise levels.

In modern pacemakers, rate adaptation of the PAV and SAV intervals starts from a programmed baseline and proceeds in a linear fashion to a programmed minimum value and stop rate.

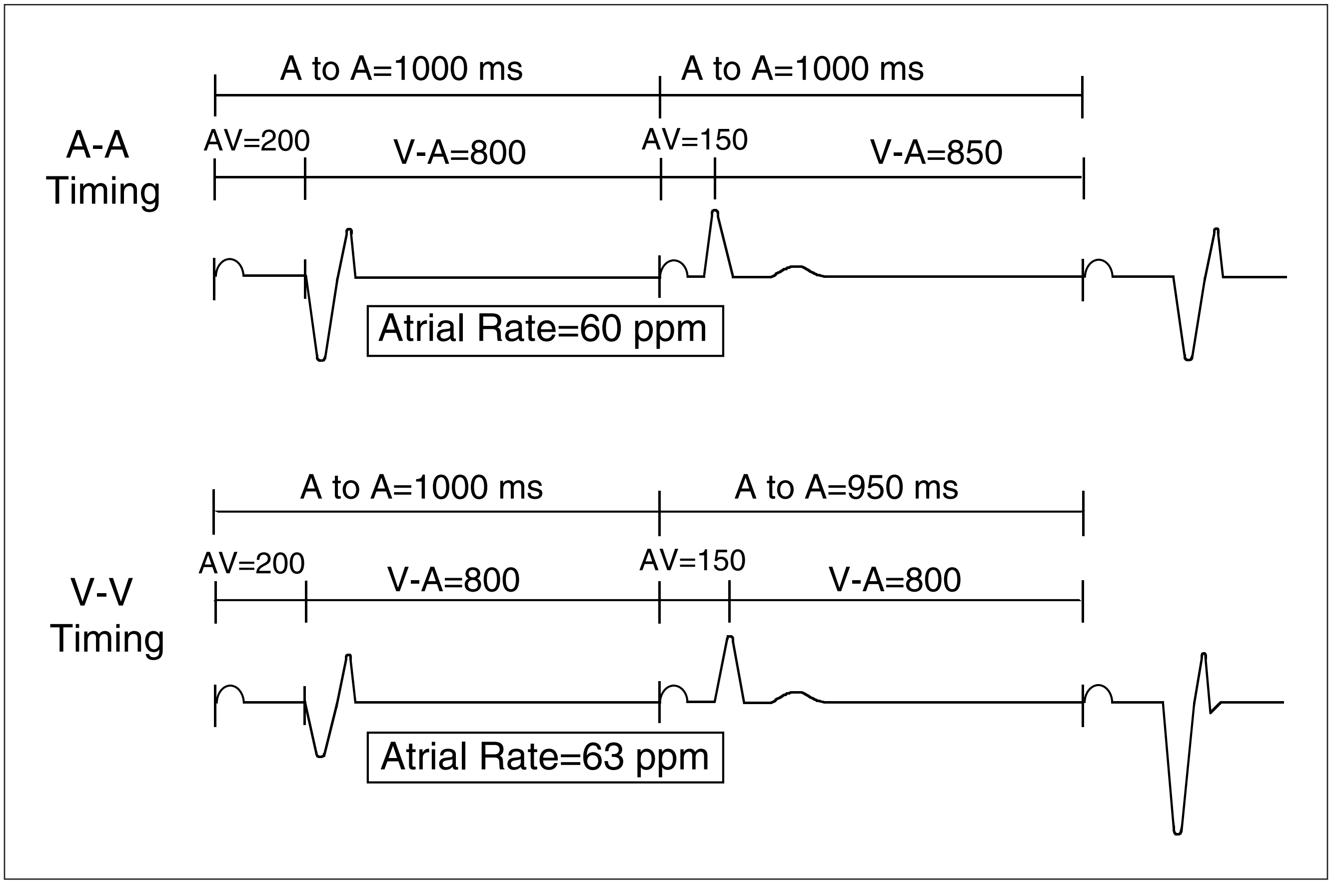
Notes

Question:

A rate-adaptive SAV interval (shortens, lengthens) as the atrial rate increases.

Answer: shortens

A-A and V-V Timing



Pacemakers generally use one of two basic timing schemes, either atrial-based or ventricular-based usually with some modifications.

In atrial-based (A-A) timing, the A-A interval does not shorten in the presence of intrinsic AV conduction, so the atrial pacing rate does not increase. The V-V interval may vary slightly above and slightly below the programmed lower rate in DDD mode.

In ventricular-based (V-V) timing, a conducted ventricular event (VS) resets the VA interval at the moment of sensing. This shortens the entire V-V interval, atrial pacing may therefore be slightly faster than the programmed lower rate in DDD mode.

Notes

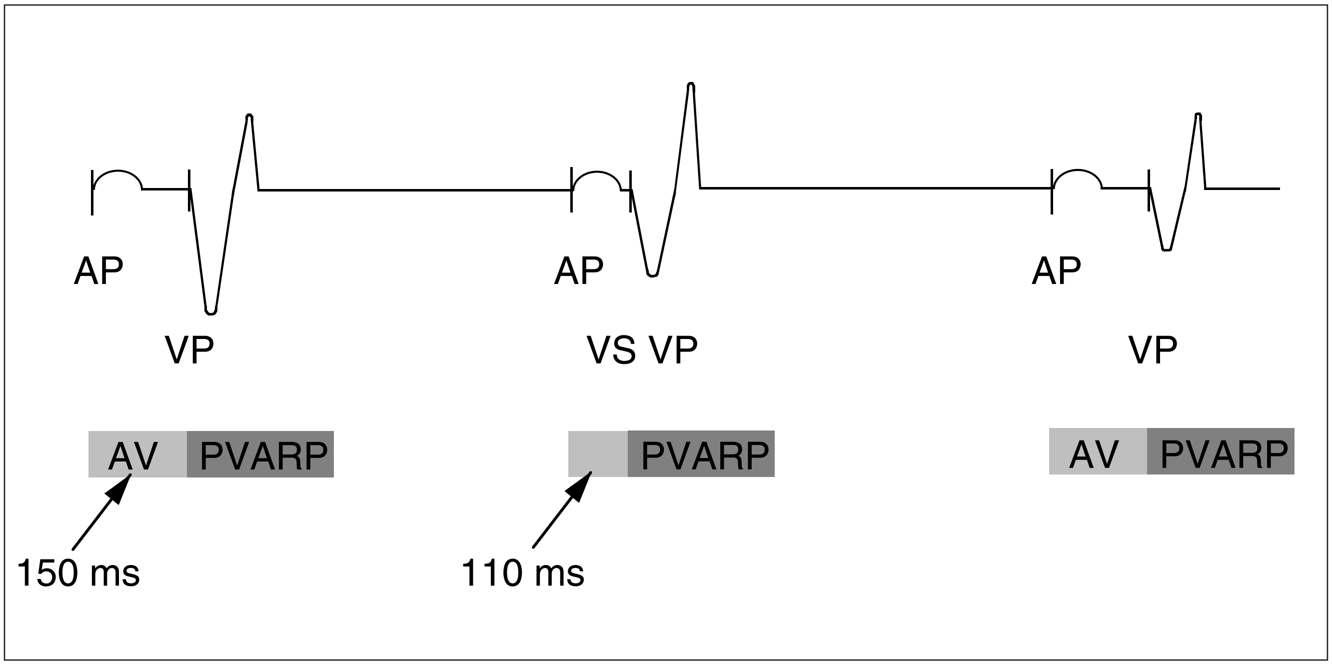
Medtronic dual chamber rate responsive pacing modes generally use modified atrial-based pacing schemes.

Question:

In (A-A, V-V) timing, the A-A interval is not reset or affected by intact conduction.

Answer: A-A

Ventricular Safety Pacing



Ventricular safety pacing is a programmable option that prevents inappropriate inhibition of ventricular pacing in the presence of crosstalk.

When ***ventricular safety pacing (VSP)*** is programmed on, a safety pace window is opened for 110 ms after the delivery of an atrial pace. If activity is sensed during this time (beyond the blanking interval-PAVB), the pacemaker delivers a ventricular pace at the end of the 110 ms interval.

- If the sensed event was an R-wave, the safety pace falls before the vulnerable portion of the heart's refractory (recovery) period.
- If the sensed event was crosstalk, the safety pace triggers ventricular depolarization and the patient is protected from inappropriate inhibition.

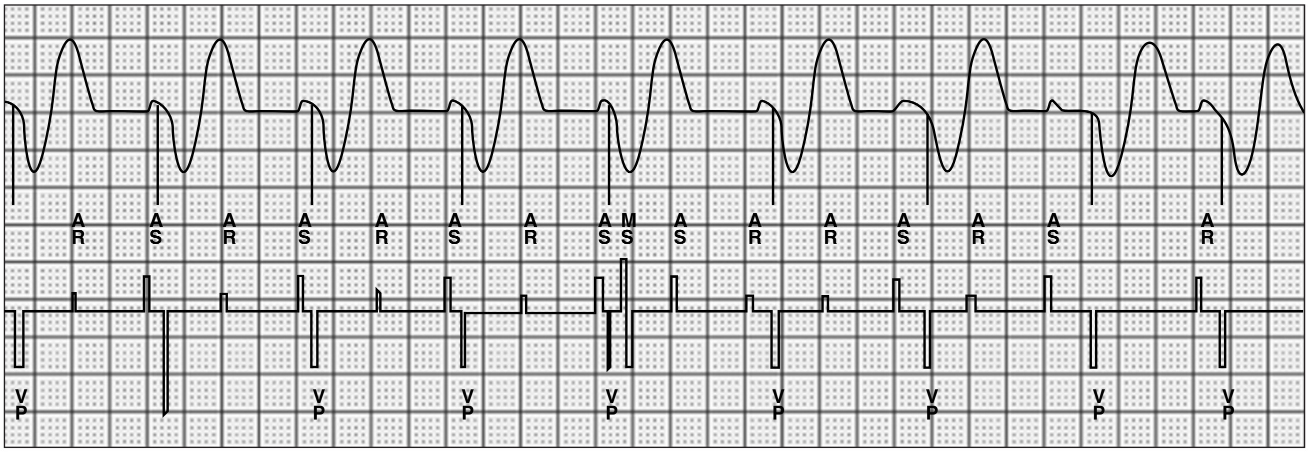
Ventricular safety pacing protects the patient from inappropriate inhibition of the ventricular pace in the presence of crosstalk. Its timing ensures that pacing does not start an arrhythmia. Safety pacing on an ECG is characterized by abbreviated AV intervals (shown).

Notes

Question:
A safety pacing interval has a duration of ______ ms.

Answer: 110

Mode Switching



Mode switching is a programmable option to prevent tracking of rapid atrial arrhythmias or supraventricular tachycardias (SVTs).

> ***Mode switching*** allows the pacemaker to automatically switch from an atrial tracking mode (such as DDD) to a non atrial tracking mode (DDIR) in the presence of supraventricular tachycardias (SVTs).
>
> Mode switches are based on programmed detection requirements. Before a mode switch, ventricular pacing occurs at the upper tracking rate. After a mode switch, ventricular pacing transitions slowly and smoothly to the lower rate. When the tachycardia ends, the programmed atrial tracking mode is restored.

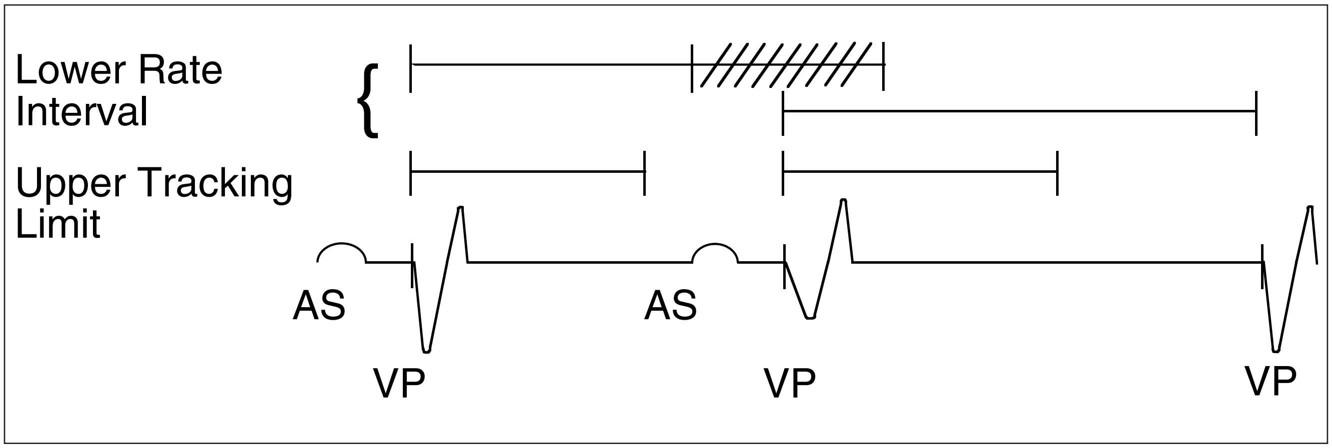
Notes

Question:

____________________ may be used to prevent tracking of supraventricular tachycardias.

Answer: Mode switch

VDD Mode



In VDD mode, ventricular pacing is synchronized to the sensed atrial rate up to the programmed upper tracking rate.

The VDD timing cycle has an SAV interval, but no PAV interval because the atrium is not paced.

- In the presence of a sensed atrial event, the pacemaker starts an SAV interval. If no ventricular activity is sensed during the SAV, the pacemaker delivers a ventricular pace.
- In the absence of a sensed atrial event, the pacemaker waits until the end of the lower rate interval to deliver the ventricular pace.

In VDD mode, an SAV interval always follows a sensed atrial event. If the sensed event is slow (it occurs near the end of the lower rate interval), the ventricular lower rate interval is extended. This allows the ventricular pacing rate to drop below the programmed lower rate and promotes AV synchrony in the presence of slow atrial rates.

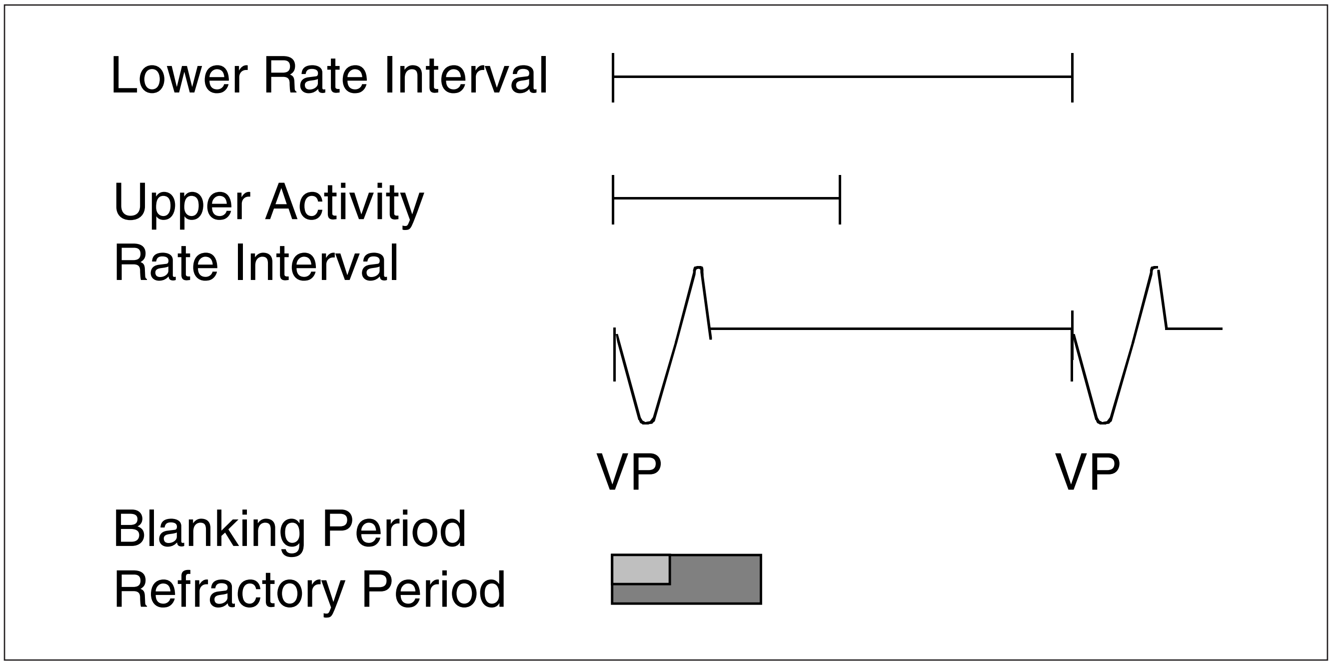
Notes

Question:

The VDD timing cycle does not have a (SAV, PAV) interval.

Answer: PAV

VVI/R Mode



VVIR is like VVI, except that pacing occurs at the sensor-indicated rate.

In the VVIR mode, the pacing rate is dictated by input from the activity sensor. The programmed low rate continues to govern the minimum paced rate as in the VVI mode. The maximum rate the pacemaker is allowed to pace under sensor control is called the ***upper activity rate (UAR)***. The upper activity rate determines the duration of the ***upper activity rate interval (UARI)***.

Example:

60,000 (ms in one minute)

120 ppm (upper activity rate) = 500 ms (upper activity rate interval)

In VVIR mode, the pacemaker operates within the confines of the programmed lower rate and upper activity rate.

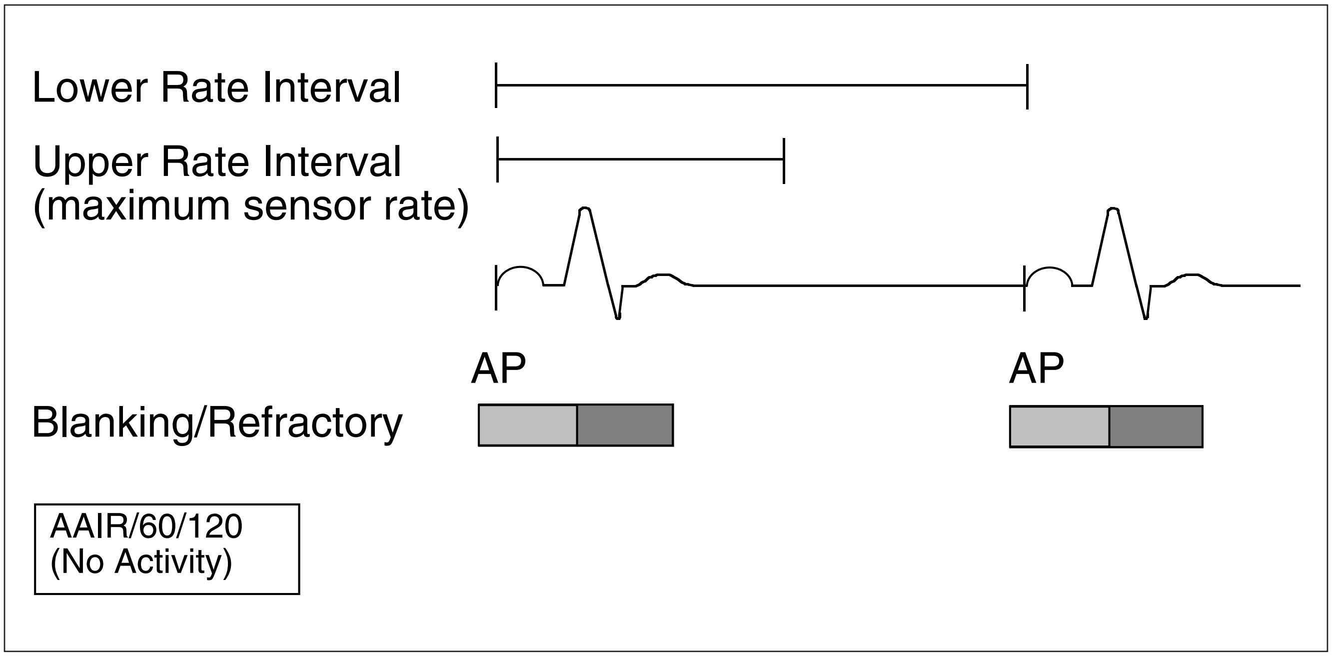
Notes

Question:

In VVIR mode, the pacing rate may increase to the ______________________.

Answer: upper activity rate

AAI/R Mode



AAIR is like AAI except that pacing may occur at the sensor-indicated rate.

AAIR mode provides heart rate variations between the lower rate and upper activity rate in the presence of intact AV conduction. The refractory period in AAIR mode is longer than that in VVIR mode.

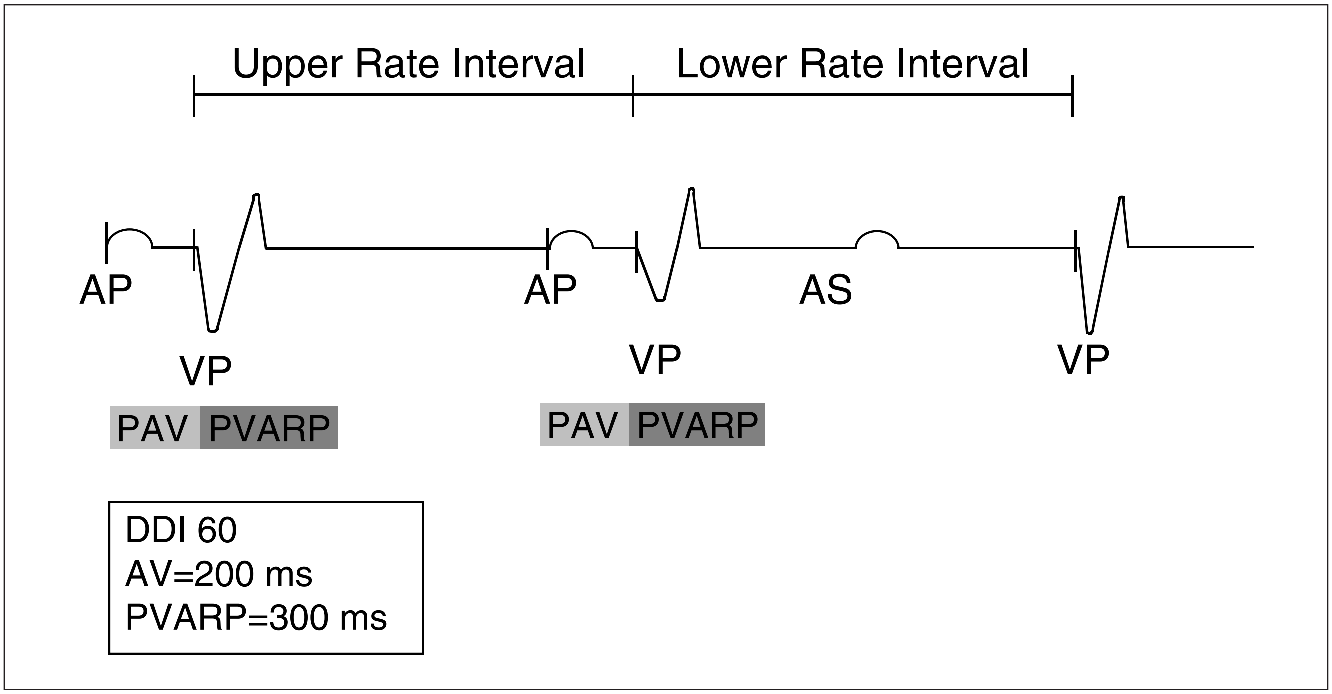
Notes

True or False:

AAIR pacing requires intact AV conduction.

Answer: True

DDI/R Mode



DDI /R modes are nontracking modes that provide AV sequential pacing at either the lower or sensor indicated rate.

In the ***DDI/R*** modes, the pacemaker paces in both chambers and senses in both chambers. A sensed atrial event inhibits the scheduled atrial pace, but does not start an SAV interval. Since the SAV interval does not shorten with the sensed atrial rate, ventricular pacing is never faster than the programmed lower rate in DDI mode and must rely exclusively on the sensor for rate increases in the DDIR mode.

In the DDI/R modes, when the atrial rate is faster than the lower rate or sensor-indicated rate, the patient does not have AV synchrony. Therefore, this mode is not recommended for complete heart block patients.

Notes

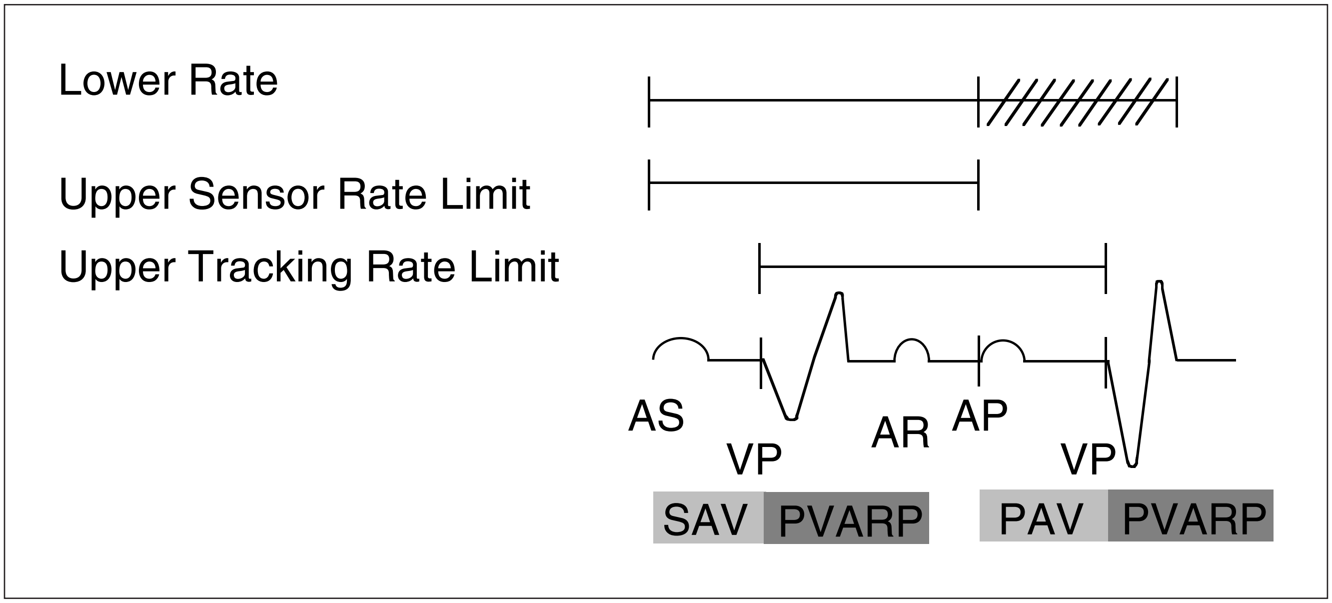
Questions:

The DDI/R timing cycle does not have an (SAV, PAV) interval.

DDI (does, does not) provide AV synchrony when the atrial rate exceeds the lower rate.

Answers: SAV / does not

DDDR Mode



DDDR is like DDD, except that pacing is either sensor-driven or sinus-driven depending on which is faster.

When the sensed atrial rate is faster than the sensor-indicated rate, the pacemaker tracks the atrial rate. When the sensed atrial rate is slower than the sensor-indicated rate, pacing occurs at the sensor-indicated rate. P-wave tracking and sensor-driven pacing occur within the limits of the programmed TARP, lower and upper tracking or activity rates (UTR or UAR).

In DDDR mode, the sensor-indicated rate determines when atrial pacing occurs, so a pacemaker block response during exercise is limited to the sensor-indicated rate rather than to the lower rate.

Notes

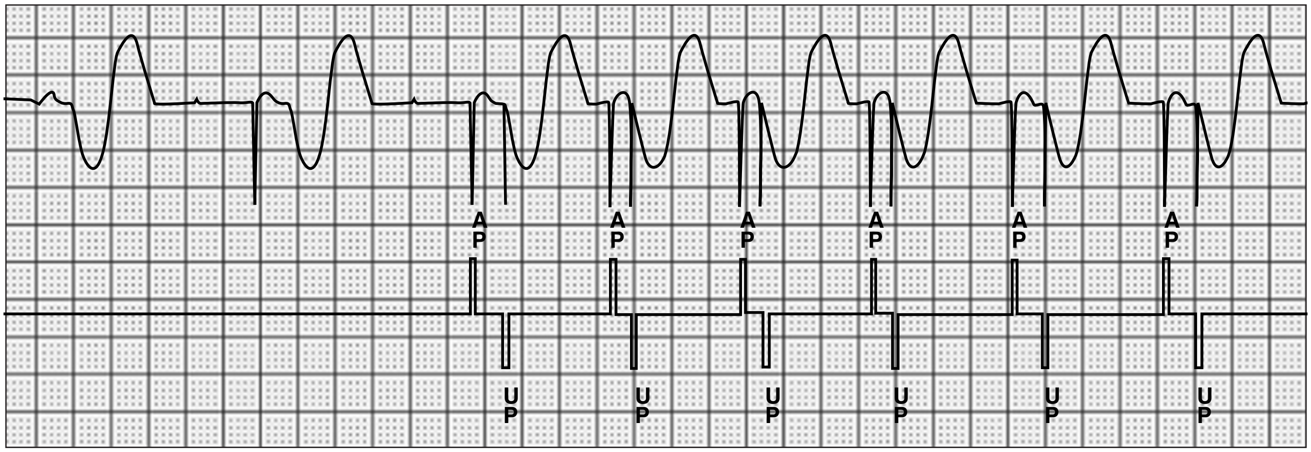
Questions:

Atrial tracking is limited by the ________________.

Sensor-driven pacing is limited by the ________________.

Answers: upper tracking rate / upper activity rate

Asynchronous Pacing



In asynchronous modes, a pacing pulse is delivered at regular, stable intervals.

In AOO and VOO modes, pacing occurs at the programmed lower rate in the designated chamber. In DOO mode, the AV and VA intervals are fixed. A ventricular pace is delivered at the end of the AV interval, and an atrial pace at the end of the VA interval.

Note: Asynchronous pacing is used only during magnet operation, surgery, and in emergencies.

Notes

Question:

____________________ modes provide pacing without sensing.

Answer: asynchronous

Pacing and Timing Abbreviations	
AP	Atrial pace
VP	Ventricular pace
AS	Atrial sense
VS	Ventricular sense
AR	Atrial refractory event
VR	Ventricular refractory event
AEI	Atrial escape interval – longest allowable interval between ventricular and atrial event (also called VA interval)
ARP	Atrial refractory period
AV	Atrioventricular
AV interval	Longest allowable interval between atrial and ventricular event
LR	Lower rate – slowest pacing rate allowed
LR interval	Longest period of time allowed before delivery of a pacing stimulus
MS	Mode switch
PAV	Paced AV interval – longest allowable interval between paced atrial beat and paced or sensed ventricular beat
PMT	Pacemaker-mediated tachycardia
PVAB	Post-ventricular atrial blanking period
PVARP	Post-ventricular atrial refractory period
SAV	Sensed AV interval – longest allowable interval between sensed atrial beat and paced or sensed ventricular beat
TARP	Total atrial refractory period (AV + PVARP)
UAR	Upper activity rate (also called maximum sensor-indicated rate)
UR	Upper rate – fastest pacing rate allowed
UR interval	Shortest allowable interval between paced beats or a sensed and paced beat
UTR	Upper tracking rate – fastest rate the ventricles may be paced in 1:1 synchrony with the sensed atrial rate (also called maximum tracking rate)
VA interval	Time between ventricular and atrial event
VRP	Ventricular refractory period
VSP	Ventricular safety pacing