

Tech Corner

Window of Atrial Rate Acceleration Detection (WARAD)

NOTE: PLEASE NOTE THAT THE FOLLOWING INFORMATION IS A GENERAL DESCRIPTION OF THE FUNCTION. DETAILS AND PARTICULAR CASES ARE NOT DESCRIBED IN THE ARTICLE. FOR ADDITIONAL EXPLANATION PLEASE CONTACT YOUR SALES REPRESENTATIVE.

Table of Contents

Availability	4
Indication	4
Definition	4
Objectives	4
Discriminate pathological atrial arrhythmia from sinus tachycardia	4
Prevent Pacemaker Mediated Tachycardia (PMT)	4
Description of operation	5
WARAD duration	5
Sinus rhythm and WARAD	5
PAC and WARAD	5
WARAD and SafeR(R) mode (AAI/DDD mode)	6
Isolated PAC	7
Suspected atrial arrhythmia phase	8
WARAD and DDD(R) mode	8
Isolated PAC	9
Suspected atrial arrhythmia phase	10
Ventricular rate management during the suspicion phase	12
AV Delays	13
Programmable parameters	15
Studies and results	15

Window of Atrial Rate Acceleration Detection (WARAD)

The WARAD (Window of Atrial Rate Acceleration Detection) is designed to monitor the atrial activity in order to discriminate pathological atrial waves (Atrial Fibrillation, Atrial Flutter, Atrial Tachycardias) from sinus P waves. This atrial discriminator uses atrial prematurity to trigger mode switching.

Please refer to the Fallback Mode Switch Tech Corner article for more details on the Fallback Mode Switch algorithm.

AVAILABILITY

The WARAD function is available in all dual chamber MicroPort Pacemakers, ICDs, CRT-D and CRT-P models.

INDICATION

The WARAD is indicated for all adult patients, in particular those with atrial arrhythmias.

DEFINITION

The WARAD is a dynamic atrial refractory period that is automatically triggered after every atrial event. The duration is automatically calculated by the device and not programmable.

OBJECTIVES

Discriminate pathological atrial arrhythmia from sinus tachycardia

MicroPort has based the detection criterion on atrial prematurity:

- If the atrial acceleration is progressive, it is classified as a sinus tachycardia.
- If the atrial acceleration is sudden, it is classified as an atrial arrhythmia.

Thanks to the WARAD, the device monitors atrial event prematurity beat by beat, and is able to label each atrial cycle as “normal” or “premature” (PAC = Premature Atrial Contraction).

Prevent Pacemaker Mediated Tachycardia (PMT)

The WARAD prevents the onset of Pacemaker Mediated Tachycardia (PMT) in the event of retrograde conduction. If a retrograde P wave falls within the WARAD, the pacemaker does not start an AV delay, thus preventing induction of PMT (see the section “WARAD and DDD(R) mode”, page 8).¹

¹ Maillard L, Razani M, for the Chorus II Multicenter Study. Prevention of ELTS with an innovative fallback algorithm. PACE. 1995;18 (pt 2) Abstract 437:1213

DESCRIPTION OF OPERATION

The device analyzes cycle by cycle to monitor the acceleration of the atrial rhythm. The WARAD is triggered on every atrial event:

- Paced event (marker: Ap)
- Sensed event outside protection periods (marker: As)
- Sensed event inside protection periods (WARAD and Atrial Refractory Period)² (marker: Ar)

WARAD duration

As long as the atrial rhythm is paced or is a normal sinus rhythm, the WARAD duration is:

- **When the rhythm beats more than or is equal to 80 bpm:** The WARAD duration is 75 % of the previous As-As interval if the atrial event is a sinus P wave (or 75% of the average of the last 8 “normal”³ atrial intervals if the atrial event is a paced atrium).
- **When the rhythm beats less than 80 bpm:** The WARAD duration is 62.5 % of the previous As-As interval if the atrial event is a sinus P wave (or 62.5 % of the average of the last 8 “normal”³ atrial intervals if the atrial event is a paced atrium).

Sinus rhythm and WARAD

The sinus activity is considered as “normal” as long as the atrial events occur outside the WARAD (and the cycles do not contain asynchronous ventricular events).

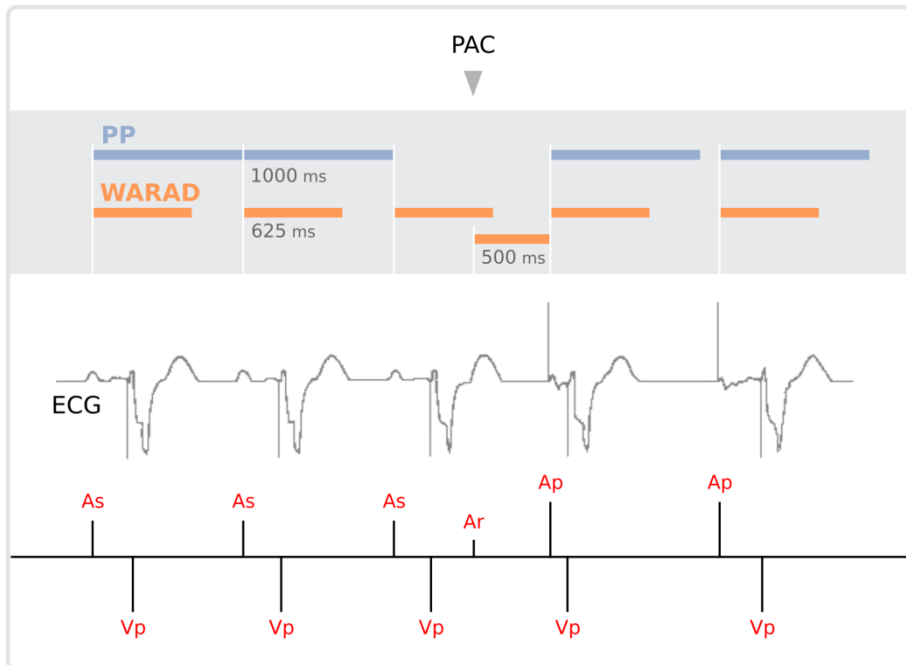
PAC and WARAD

An atrial event is considered as a Premature Atrial Contraction (PAC) if it is detected within the WARAD.

² Except in SYMPHONY, RHAPSODY pacemakers, nor in OVATIO defibrillators programmed in DDD mode

³ Intervals without PAC nor asynchronous ventricular event

Example: Sinus rhythm: 60 bpm, REPLY DR, DDD mode



The WARAD is triggered on every atrial event (As, Ap, Ar).

The WARAD duration depends on the atrial paced or sinus rhythm (here 62.5% of the previous As-As interval).

An atrial event is considered as a PAC (Premature Atrial Contraction) if it is detected within the WARAD.

WARAD and SafeR(R) mode (AAI/DDD mode)

SafeR mode⁴ provides AAI pacing while continuously monitoring AV conduction (ADI mode).

In SafeR mode (ADI mode) the WARAD is triggered on every atrial event and when sensing the first PAC in the cycle, the device starts:

- a new WARAD of 500 ms max from the PAC
- a new atrial escape interval at basic or sensor rate (or the intermediate escape interval if the "Pause Suppression" parameter from the AF prevention algorithms is programmed⁵).

⁴ For more information on this mode, see the article on "SafeR pacing mode".

⁵ This function is not available in the US.

Notes:

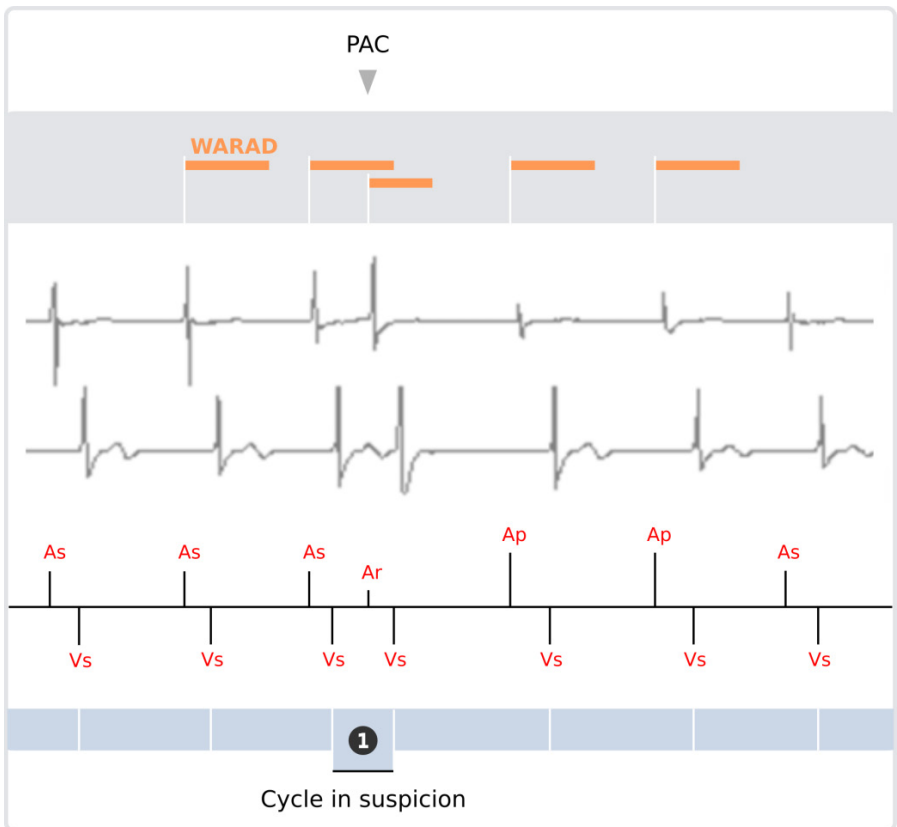
- The device switches to DDD mode upon occurrence of AV block (for the functioning of the WARAD and DDD mode, see the section “WARAD and DDD(R) mode”, page 8).
- In SafeR mode, the Fallback Mode Switch is required and forced ON.

Isolated PAC

After sensing a PAC:

- If the ventricular cycle ends with an atrial pacing, the PAC is considered as an isolated PAC and the device does not enter in suspicion phase.
- If the ventricular cycle does not end with an atrial pacing, the device enters in suspicion phase of atrial arrhythmia (see example below).

Example: Isolated PAC conducted to the ventricle (Sinus rhythm: 60 bpm, REPLY DR, SafeR mode)

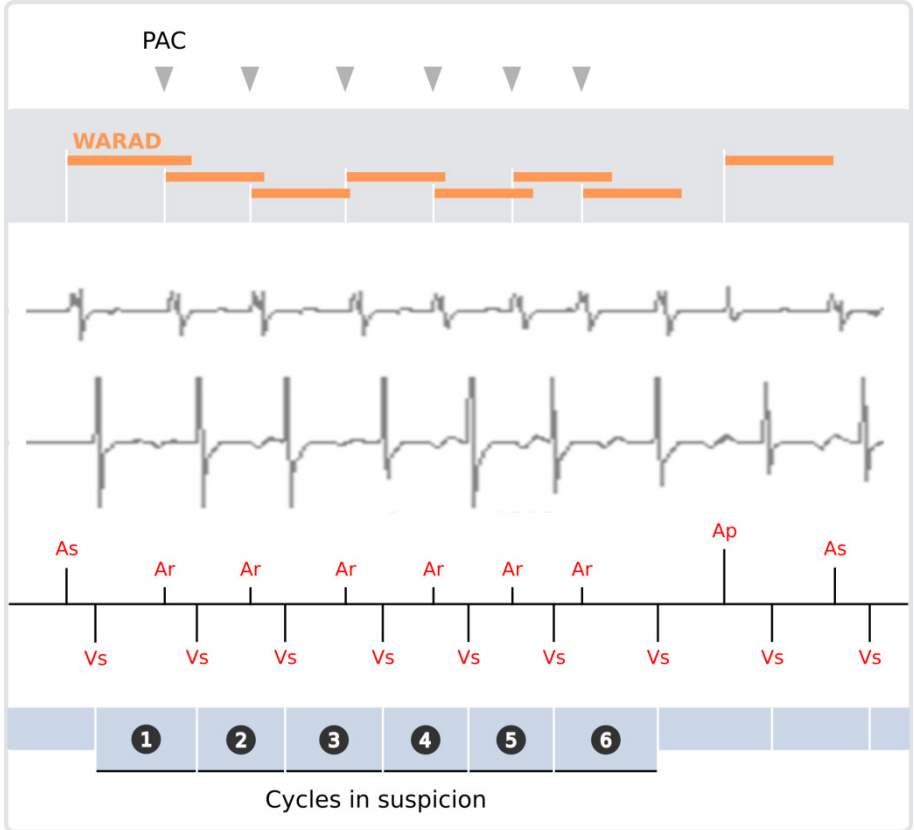


After sensing the PAC, the ventricular cycle does not end with atrial pacing so it is considered as a cycle in suspicion of atrial arrhythmia. All other cycles are not in suspicion since they do not contain any PAC.

Suspected atrial arrhythmia phase

Once the device has entered in suspicion phase, each following ventricular cycle containing a PAC (or PACs) is identified as a cycle in suspicion of atrial arrhythmia.

Example: Short atrial run conducted to the ventricle (REPLY DR, SafeR mode)



All ventricular cycles containing a PAC are considered as cycles in suspicion of atrial arrhythmia.

The cycles in suspicion are logged and statistically analyzed (see more information in the articles “Fallback Mode Switch” and “SafeR pacing mode”).

WARAD and DDD(R) mode

In DDD mode, the WARAD is triggered on every atrial event. When sensing the first PAC in the cycle, the device does not initiate an AV delay, and starts:

- a new WARAD of 500 ms max from the PAC⁶
- a new atrial escape interval of 500 ms

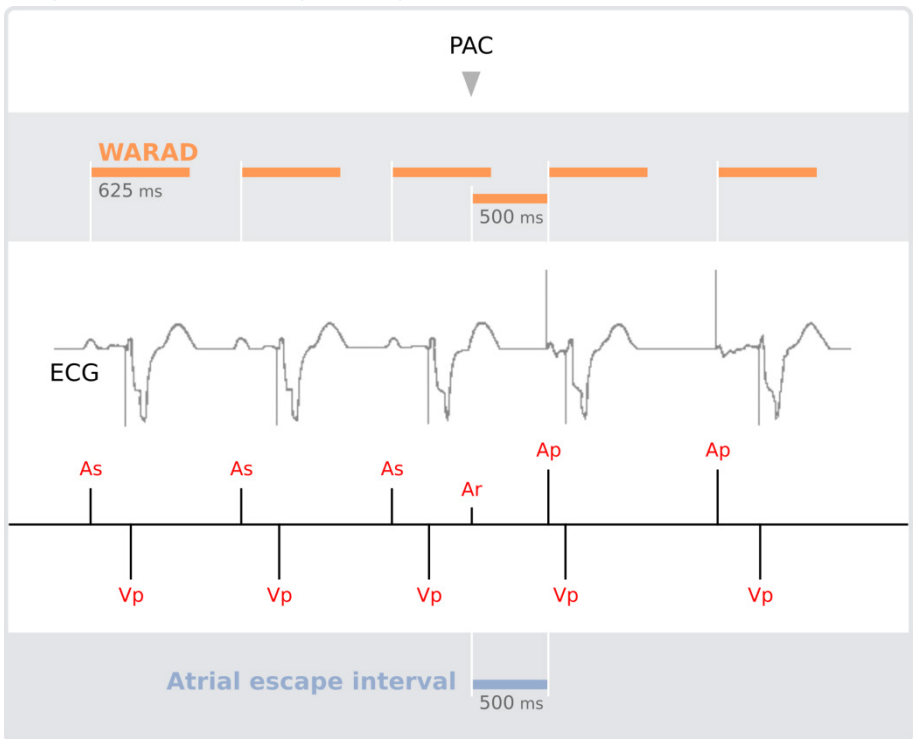
By starting the 500 ms escape interval, the device avoids atrial pacing until 500 ms from the PAC which may reduce atrial arrhythmia, and will maintain an N:1 AV association.

Note: This behaviour is available even if Fallback Mode Switch is OFF.

Isolated PAC

After sensing a PAC, if the ventricular cycle ends with an atrial pacing, the PAC is considered as an isolated PAC.

Example: Isolated PAC (Sinus rhythm: 60 bpm, REPLY DR, DDD mode)



When sensing an isolated PAC, the device does not initiate an AV delay, and starts a new WARAD (500 ms max) and an atrial escape interval (AEI) of 500 ms (or intermediate escape interval if Pause suppression is programmed⁷).

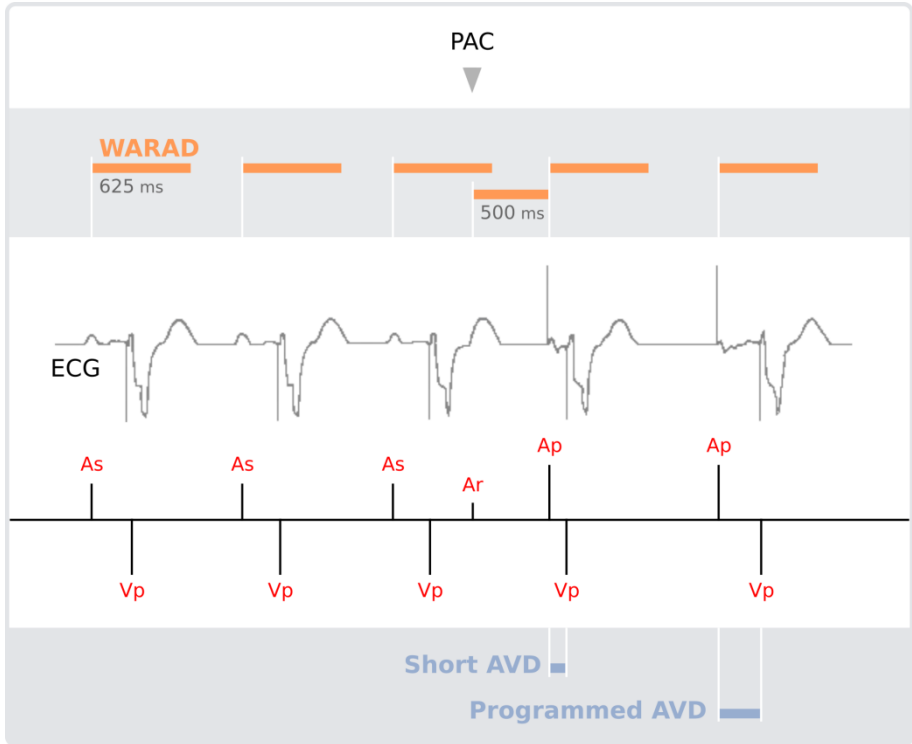
⁶ except in SYMPHONY, RHAPSODY pacemakers and OVATIO defibrillators

⁷ This function is not available in the US.

On the atrial pacing following the PAC, the device triggers a short AV delay in order to optimize the atrial detection. The short AV delay is equal to 110 ms or to the exercise AV delay if programmed shorter. See the section “AV Delays” on page 13, for more details.

Note: This scenario can occur only if the PAC is not conducted to the ventricle. If the PAC is conducted to the ventricle, the ventricular cycle ends without atrial pacing.

Example: Isolated PAC (Sinus rhythm: 60 bpm, REPLY DR, DDD mode)

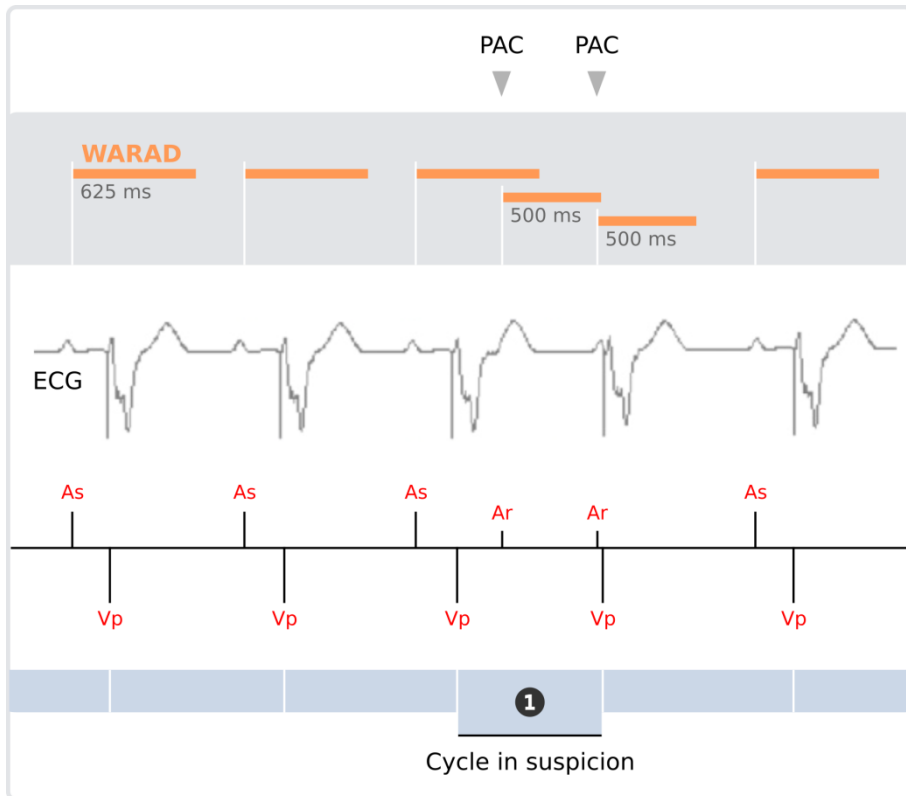


On the Ap, the device triggers a short AV delay = Min [Exercise AV Delay ; 110 ms]

Suspected atrial arrhythmia phase

As soon as a PAC is detected in the ventricular cycle and the cycle does not end with an atrial pacing, the device considers this cycle as a cycle in suspicion and enters in suspicion phase of atrial arrhythmia.

Example: Two consecutive PACs (Sinus rhythm: 60 bpm, REPLY DR, DDD mode)

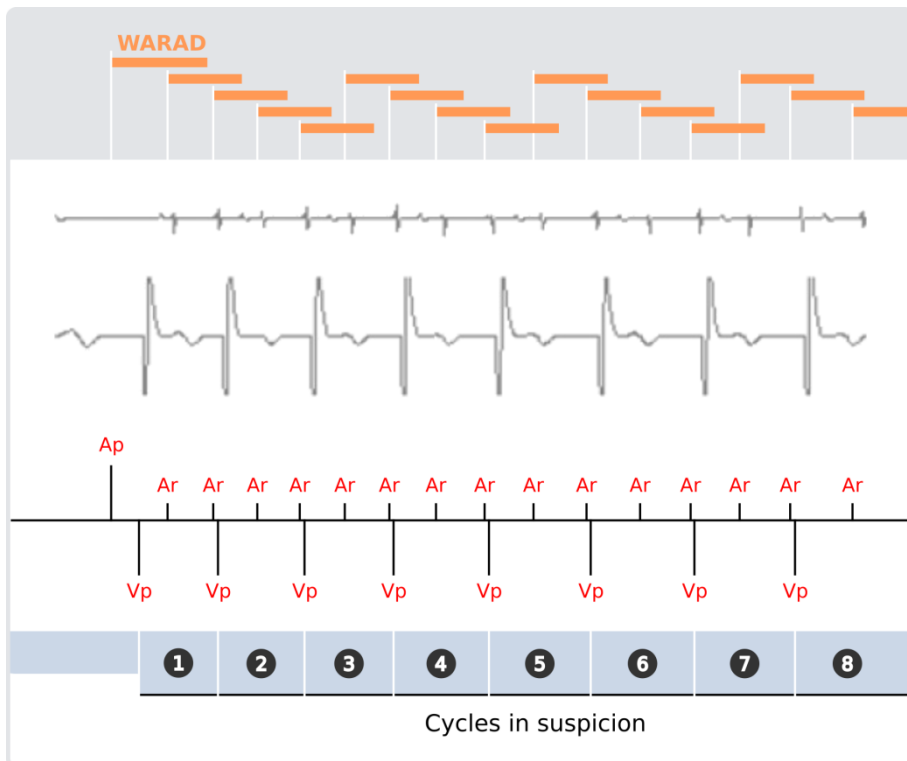


Each atrial event sensed within the WARAD (PAC) starts a new WARAD of 500 ms. The ventricular cycle containing the two PACs is considered as a cycle of suspicion of atrial arrhythmia.

Note: In this example, ventricular pacing occurs after a very short AV delay triggered on the second PAC in order to extend the atrial sensing window on the next cycle. See the section “Ventricular rate management during the suspicion phase” on page 12 in this article.

As long as a PAC is detected in the following ventricular cycles, the device remains in suspicion phase of atrial arrhythmia.

Example: Onset of an atrial arrhythmia (REPLY DR, DDD mode)



Ar markers trigger a WARAD. All ventricular cycles are considered as cycles in suspicion of atrial arrhythmia since they contain PACs (Ar)

Ventricular rate management during the suspicion phase

During the suspicion phase of the atrial arrhythmia, the maximum ventricular pacing rate is limited to 120 bpm⁸ thanks to the following functioning:

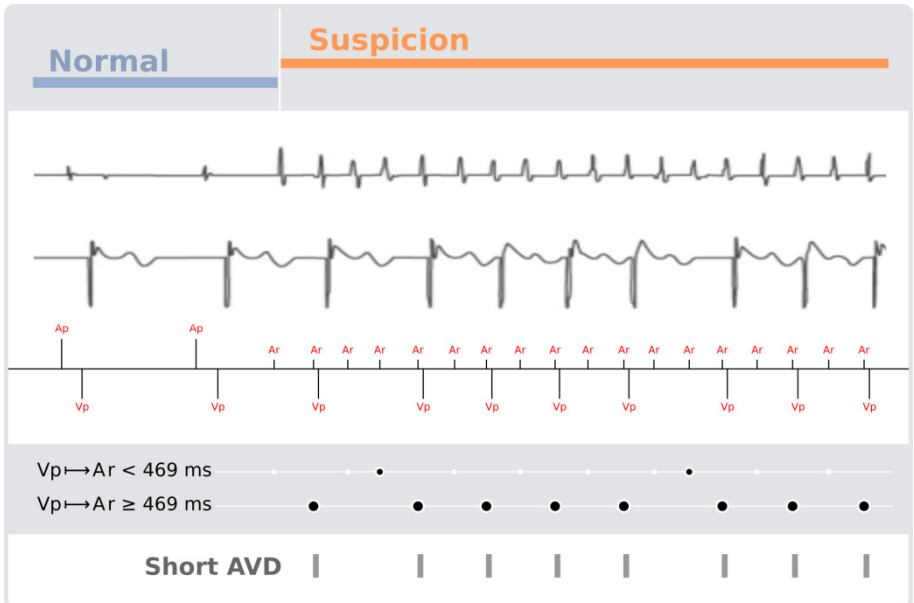
The device measures the V-PAC interval when detecting the **second** PAC in the cycle:

- If V-PAC interval is < 469 ms, the device does not trigger any AV delay and waits for the next PAC.
- If V-PAC interval is \geq 469 ms, the device triggers a very short AV delay (31 ms) and paces the ventricle.

⁸ If the programmed max pacing rate is lower than 120 bpm, the device will apply the programmed max rate during the suspicion phase of the atrial arrhythmia

Thus, during the suspicion phase of atrial arrhythmia, the maximum ventricular pacing interval is at least 500 ms (469 ms + 31 ms), i.e. the ventricular pacing rate is limited to 120 bpm.⁶

Example: Onset of an atrial arrhythmia (REPLY DR)



When the V-PAC interval is $>$ or equal to 469 ms, the device triggers a 31 ms AV delay. The max ventricular pacing rate is then limited to 120 bpm (500 ms)

AV Delays

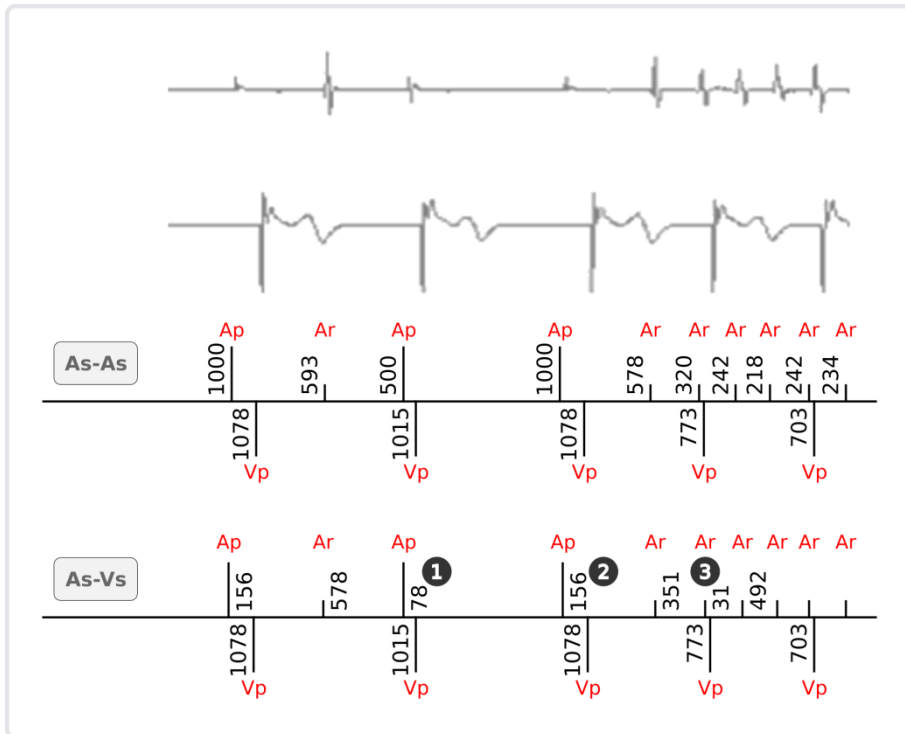
In order to optimize the atrial sensing on the cycle following a PAC (i.e. atrial event detected within the WARAD), the AV delay is:

- 110 ms (or the exercise AV delay, if programmed shorter) after the paced atrial event (Ap)
- 31 ms after the sensed atrial event (Ar) when the 469 ms interval has been reached

If no PAC is present in the previous ventricular cycle, the AV delay is the programmed AV delay.

Note: On PAC detection and during the suspicion phase, the atrial sensing is automatically set to 0.4 mV if the atrial Autosensing is programmed to "AUTO" (in MicroPort Pacemakers and CRT-P models only).

Example: REPLY DR, MicroPort programmer, AIDA⁹ screen.



Event	Description
1	A PAC is sensed in the previous ventricular cycle: AV delay is Min [110 ms ; exercise AV delay] after the paced atrial event (in this example, the programmed Exercise AV delay is 80 ms)
2	Since no PAC is present in the previous ventricular cycle, the AV delay is the programmed AV delay + AVD paced/sensed offset
3	PAC is sensed in the ventricular cycle: AV delay = 31 ms after the sensed atrial event

⁹ Automatic Interpretation for Diagnosis Assistance

PROGRAMMABLE PARAMETERS

The WARAD is a non programmable window. It is continuously and permanently working on all dual-chamber and CRT MicroPort devices, when the following pacing modes are programmed:

- SafeR(R) (see the section “WARAD and SafeR pacing mode” on page 6)
- DDD(R)
- Dplus(R)
- VDD(R)¹⁰

Notes:

1. In SafeR(R), the Fallback Mode Switch is required and forced ON.
2. In DDD(R) and VDD(R),⁹ the WARAD is active even if the Fallback Mode Switch is programmed OFF.

STUDIES AND RESULTS

1. Maillard L, Razani M, for the Chorus II Multicenter Study. Prevention of ELTS with an innovative fallback algorithm. PACE. 1995;18 (pt 2) Abstract 437:1213.
2. Geroux L, Limousin M, Cazeau S. Clinical performances of a new mode switch function based on a statistical analysis of the atrial rhythm. Herzschr Electrophys. 1999; 10 (suppl 1):15-21.
3. Bonnet JL, Brusseau E, Limousin M, Cazeau S. Mode switch despite undersensing of atrial fibrillation in DDD pacing. PACE. 1996;19(pt 2):1724-1728.

Refer to user's manual furnished with the device for complete instructions for use (www.microportmanuals.com).

¹⁰ This mode is not available in the US