

# Tech Corner

## Right Atrial Autothreshold (RAAT) in dual chamber and CRT-D devices: ALIZEA, BOREA, CELEA, ULYS, EDIS and GALI

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 AVAILABILITY IN YOUR COUNTRY AND ADDITIONAL EXPLANATION PLEASE CONTACT YOUR SALES REPRESENTATIVE.

NOT AVAILABLE FOR DISTRIBUTION OR SALE IN THE USA.

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# THE RIGHT ATRIAL AUTO THRESHOLD (RAAT)

The Right Atrial Autothreshold function (RAAT) allows the automatic adjustment of the atrial pacing amplitude, according to the result of the threshold test performed every day.

The aim of RAAT is to maintain automatically and periodically the atrial capture and to adapt the atrial pulse pacing amplitude in order to ensure safety and to save energy.

The test is performed daily, at night to maximize the chances of having a slow and stable rhythm.

To perform RAAT, the device launches the following tests every night at 2:00 am (programmable):

- P-TEST is performed when the patient has SPONTANEOUS sinus rhythm: the atrial pacing threshold is tested by increasing the atrial pacing voltage and checking if a sinus P wave occurs after the atrial spike.
- AR-TEST is performed when the patient has PACED atrial rhythm and AV conduction: the atrial pacing threshold is tested by decreasing the atrial pacing voltage and checking a spontaneous R wave occurs after the atrial spike.

## AVAILABILITY

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The Right Atrial Autothreshold algorithm is available in the following dual chamber and CRT-D devices:

- ALIZEA DR<sup>1</sup>
- BOREA DR<sup>1</sup>
- CELEA DR<sup>1</sup>
- ULYS DR<sup>2</sup>
- EDIS DR<sup>2</sup>
- GALI CRT-D, GALI SonR CRT-D, GALI 4LV CRT-D, GALI 4LV SonR CRT-D<sup>2</sup>

RAAT is available when one of the following pacing mode is programmed: DDD(R), DDD/DDIR, SafeR(R), SafeR/DDIR, Dplus(R)<sup>3</sup>, or Dplus/DDIR<sup>3</sup>.

*Note: RAAT function is also available in the previous MicroPort CRM pacemaker range (ENO TEO OTO and KORA 250) with a few differences in the functioning.*

<sup>1</sup> Not available for distribution or sale in the USA

<sup>2</sup> Available in Europe

<sup>3</sup> Only available in the Pacemaker range

## INDICATIONS

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RAAT can be programmed for all patients whose atrial pacing threshold is within normal limits ( $< 4 \text{ V}$ ).

The test is not performed for patients with AF at the time of the test. In the event of fast and unstable rhythm, the test is not launched and is considered as not successful.

RAAT is also indicated for patients equipped with Remote Monitoring system: as impedance and detection, RAAT gives information on the atrial capture to evaluate if the atrial lead is working properly.

## DESCRIPTION OF THE FUNCTIONING

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The right atrial autothreshold is launched every night at 2:00 am (as-shipped, programmable).

RAAT is made of 5 phases; the aim and operation of each phase is described here after.

### 1 Starting phase:

*Check of the conditions to launch the RAAT*

### 2 Selection phase

*P-test or AR-test?*

- *In case of stable atrial rhythm: P-test (increase of the atrial pacing voltage)*
- *In case of stable atrio-ventricular conduction: AR-test (decrease atrial pacing voltage)*

For P-test or AR-test:

### 3 Calibration phase

*Assessing of the starting amplitude*

### 4 Search phase and confirmation of the threshold

### 5 Amplitude adjustment

*Automatic reprogramming of the atrial pacing amplitude*

## 1. Starting phase

### Aim

Designed to insure the accurate and safe functioning of the test, the device checks the required conditions are met before starting the RAAT. The spontaneous or paced atrial rhythm must be **at rest**.

### Operation

Since the spontaneous or paced atrial rhythm must be **at rest**, the device checks the following conditions at 2:00 am. If one or several of these conditions are not fulfilled, the device tries to start the test on every following cycle until midnight. If after midnight the test cannot be launched, RAAT is aborted. RAAT is launched on the next day.

## Conditions to start

The main conditions are:

- The rhythm rate is less than (<) 80 bpm (with as-ship parameters)
- No atrial arrhythmia is ongoing
- No ventricular arrhythmia is detected (ICD/CRT-D devices only)
- No post-shock mode is ongoing (ICD/CRT-D devices only)
- No other algorithms are running
- No other test is ongoing

## 2. Selection phase: P-test or AR-test?

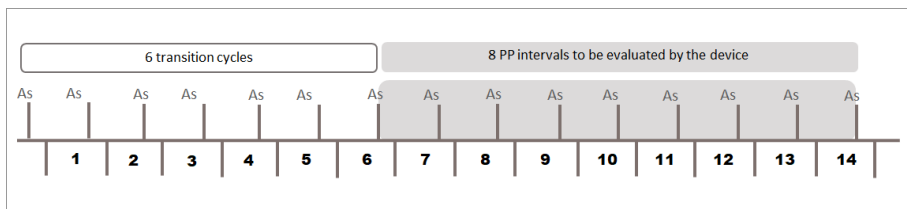
### Aim

In order to select the appropriate test, the device performs the selection phase which consists in 14 cycles for the first test (P-test) and if the first test fails, 10 additional cycles for the second test (AR-test).

### Operation

#### Conditions to launch the P-test

- The device decreases the pacing rate to 50 bpm (or the basic rate if programmed lower) for 14 cycles in order to promote the sinus P-waves.
- The first 6 cycles (spontaneous or paced) are not taken into account. The device checks the stability of the 8 following atrial intervals.



#### **The P-test is launched if the device detects:**

1. At least 6 As-As intervals out of the last 8 cycles (i.e. the patient is in sinus rhythm), and
2. The stability of the As-As intervals:  $\max [\text{As-As}] - \min [\text{As-As}]$  difference is less than 71 ms.

At this stage, the device also calculates the As-As averaged duration to determine the As-As stability window that will be used during the P-test.

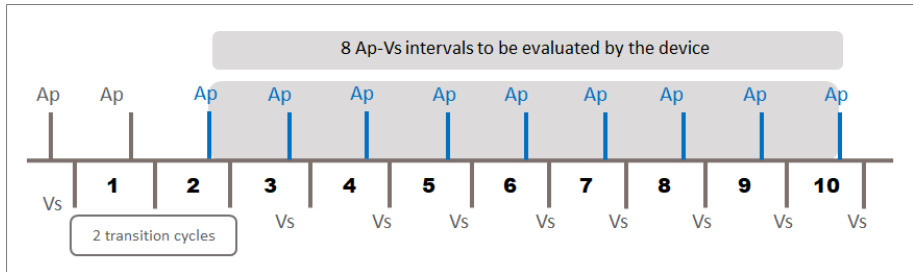
The As-As stability window is calculated as follows:  $\text{average} [\text{As-As}] \pm 55 \text{ ms}$ .

If these conditions are met, the P-test is performed. Otherwise, the P-test is abandoned (the patient

has no stable sinus rhythm) and the device starts checking for AR-test conditions.

### Conditions to launch the AR-test

If the conditions are not met to initiate the P test, the device checks the conditions to initiate the AR-test. After 2 transition cycles, in the event of the atrium is paced or As-As intervals are unstable, RAAT increases the atrial pacing rate to overdrive the unstable atrial rhythm and extends the AV delay to promote the spontaneous AV conduction. Then it assesses the stability of Ap-Vs intervals on the next 8 cycles.



### The AR-test is launched if the device detects:

1. At least 7 Ap-Vs intervals out of the 8 cycles, **and**
2. The stability of the Ap-Vs intervals:  $\max [\text{Ap-Vs}] - \min [\text{Ap-Vs}]$  difference is less than 63 ms.

At this stage, the device also calculates the Ap-Vs average duration to determine the Ap-Vs stability window that will be used during the AR-test.

The Ap-Vs stability window is calculated as follows:  $\text{average} [\text{Ap-Vs}] \pm 47 \text{ ms}$ .

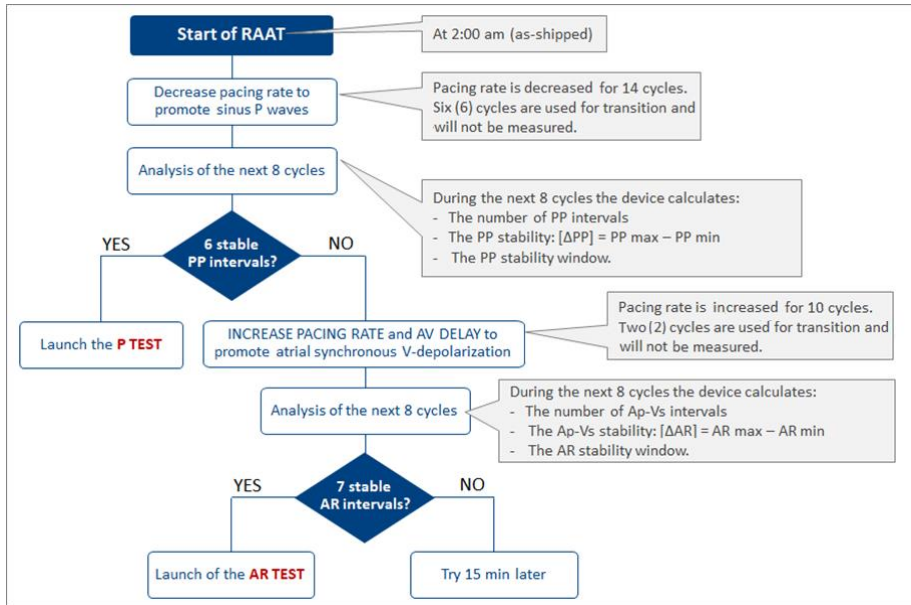
If these conditions are not met, the device looks again for the starting conditions after 15 minutes. It can make up to 5 retries (i.e. 6 attempts in total).

### Note:

The device needs the 7 Ap-Vs (AR) intervals to calculate the Ap-Vs stability, therefore:

- If one or more spontaneous atrial contraction (As) is detected within the 7 intervals, the AR-test is not launched.
- The device allows a maximum of one ventricular pacing (Vp) during this phase.

## Selection phase overview



### Notes:

1. When programmed in Dplus<sup>3</sup>, the pacemaker is temporarily forced the DDD mode to perform the RAAT. If the device is programmed in SafeR, it remains in SafeR during the RAAT.
2. Once the selection phase has started, if no P-test nor AR-test can be performed, the device retries 15 min later from Starting phase. It can make up to 5 retries (i.e. 6 attempts in total).

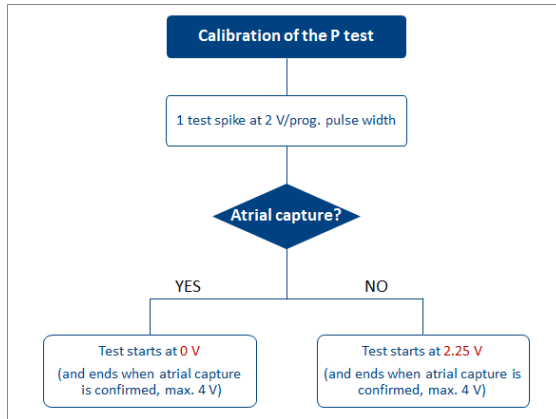
## 3. P-test

### Calibration phase

The calibration phase is made to define the pacing amplitude the test should start, with a capture verification of 1 test spike at 2V.

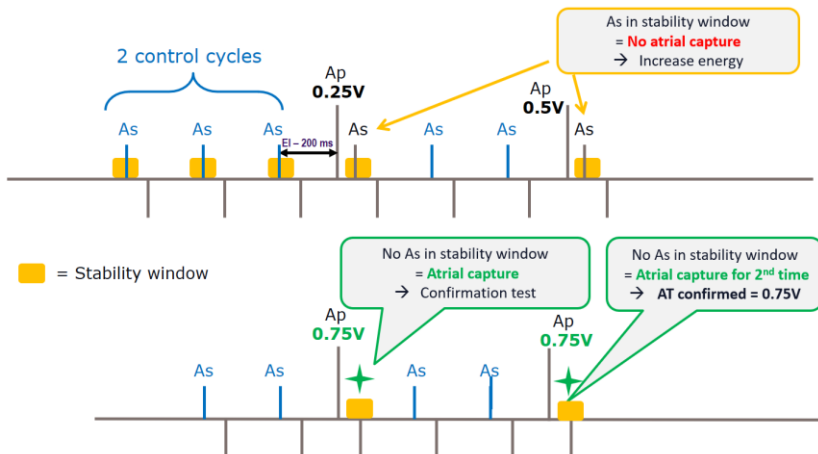
To do so, the device paces with 1 test spike at 2V with programmed pulse width:

- **If there is atrial capture** (i.e. no P wave is detected in the As-As stability window): the device starts the test with a first spike at 0 V with programmed pulse width, and increases the atrial amplitude until the atrial capture is confirmed (max. 4 V).
- **If there is no atrial capture** (i.e. a P wave is detected in the As-As stability window): the device starts the test at 2.25 V with programmed pulse width, and increases the atrial amplitude until the atrial capture is confirmed (max 4 V).



## Threshold search phase

### P-test: increase of the atrial voltage



### For each energy test:

The device starts with 2 control cycles at test rate. The P waves of the 2 control cycles have to be within the As-As stability window (calculated during the selection phase).



To test each energy step, it applies the earlier atrial test spike 200 ms earlier than the average interval measured selection phase. As long as the atrial spike<sup>4</sup> does not capture (P-wave is detected within the stability window), the device **increases** the energy by steps of 0.25 V (between 0 and 2.5 V) and 0.5 V (between 2.5 and 4 V).

Notes:

1. *During the P-test, when performed in DDD, once the atrial spike has captured, a ventricular spike is delivered at the end of the As-As stability window if no R wave is detected to ensure ventricular contraction.*
2. *The stability window lasts 110 ms, it starts 55 ms before the time the P-wave is expected (i.e. the calculated As-As average – 55 ms)*

### **Confirmation**

When the atrial test spike captures, the device repeats the test spike to confirm the atrial capture.

Notes:

1. *The P-test fails if:*
  - *There is capture at 0 V (first test spike)*
  - *There is no capture at the max amplitude (4 V)*
2. *When the P-test fails, the device launches the AR-test if the conditions are met.*

## **4. AR- test**

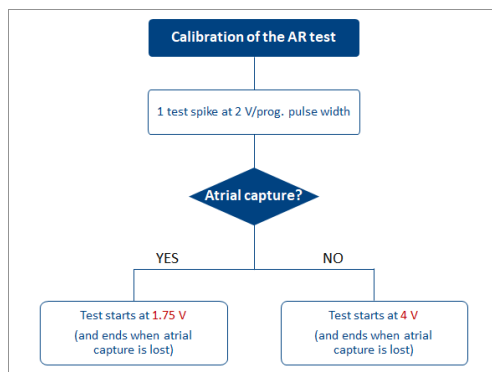
### **Calibration phase**

The calibration phase is made to define the pacing amplitude the test should start, with a capture verification of 1 test spike at 2V.

To do so, the device paces with 1 test spike at 2V/ with programmed pulse width:

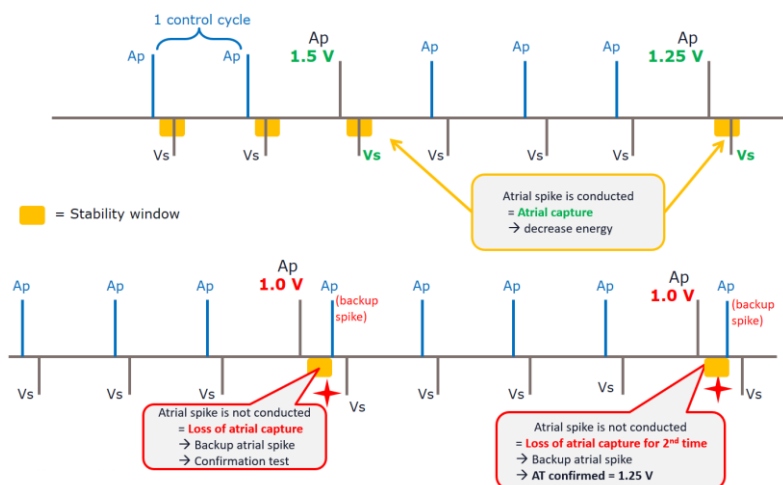
- **If there is atrial capture** (i.e. R wave is detected in the Ap-Vs stability window): the device starts the test at 1.75 V with programmed pulse width, and decreases the atrial amplitude until loss of atrial capture.
- **If there is no atrial capture** (i.e. no R wave is detected in the Ap-Vs stability window): the device starts the test at 4 V with programmed pulse width, and decreases the atrial amplitude until loss of atrial capture.

<sup>4</sup> *The atrial refractory period after the atrial spike is the standard refractory period, but the algorithm is “allowed” to check the atrial signal during the stability window.*



## Threshold search phase

AR-test: decrease atrial voltage



For each energy test:

The device starts with 1 control cycle (5 V/1 ms) with an increased atrial pacing rate to overdrive the rhythm. The R wave of the control cycles have to be within the ventricular stability window (calculated during the selection phase).

Then it applies 1 test spike to test each energy step. As long as the atrial test spike captures (R wave is detected within the ventricular stability window), the device **decreases** the energy by steps of 0.5 V (between 4 and 2.5 V) and 0.25 V (between 2.5 and 0.25 V).

Notes:

1. *During the AR-test, when performed in DDD, the device starts a 94 ms AV delay after the backup spike and pace the ventricle if necessary.*
2. *The ventricular stability window lasts 94 ms, it starts 47 ms before the time the R-wave is expected (i.e. the calculated Ap-Vs average – 47 ms).*

### **Confirmation**

When the atrial test spike does not capture, the device applies an atrial backup spike (same energy as the control spikes) and repeats the test spike to confirm the atrial capture.

Notes:

1. *The AR-test fails if there is no capture at the max amplitude (4 V).*
2. *If the AR-test fails, then the device retries RAAT 15 min later from the starting phase. It can make up to 5 retries (i.e. 6 attempts in total).*

## **5. Amplitude adjustment phase**

### **Aim**

The amplitude adjustment aims to adjust and reprogram the atrial pacing amplitude by applying the amplitude safety margin (threshold x 2 by default, programmable) or the programmed **Atrial Min amplitude** if higher.

### **Operation**

If RAAT has been programmed to AUTO and the P-test or AR-test has successfully ended, the atrial amplitude is automatically reprogrammed to the measured atrial threshold multiplied by 2 (as-shipped value, programmable parameter: “**Amplitude Safety Margin**”). The atrial amplitude is equal or higher than the programmed **Atrial Min amplitude** if higher: see the section Programming.

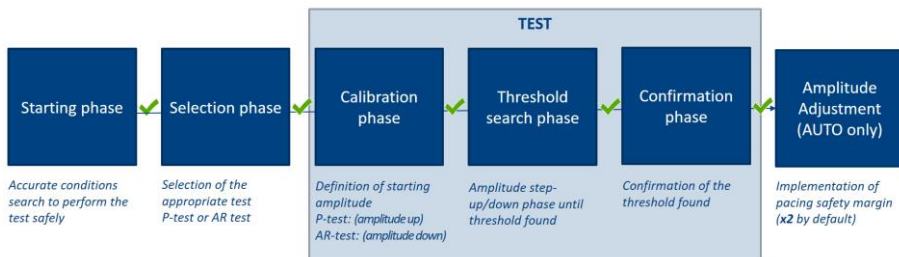
*Note: The Atrial Max amplitude that can be automatically programmed by the device is fixed at 5 V.*

### **Particular cases**

- If the measured threshold is > 4 V, the atrial amplitude is automatically reprogrammed to 5 V.
- If RAAT cannot be measured, the device takes the same value as the previous test.
- If RAAT cannot be measured during more than 7 consecutive days, the atrial amplitude is reprogrammed to the programmed Safety atrial amplitude (as-shipped: 3.5 V, see the section Programmable parameters).

## SUMMARY OF RIGHT ATRIAL AUTOTHRESHOLD

Here after a summary of a successful RAAT functioning.



*Summary of RAAT process: description and aim for each phase.*

## PROGRAMMING

The RAAT parameters are available in Pacing/Sensing tab/section.

It is programmable and can be set on: Auto, Monitoring or Off.

### 1. AUTO

If the RAAT is programmed to Auto, the device will automatically perform an atrial threshold test every night at 2:00 am (as-shipped) and reprogram the atrial output amplitude at the measured atrial threshold x 2 (as-shipped) or the programmed Minimum atrial amplitude if higher.

**Pacing/Sensing** **Brady** **Remote** **Auto** **Tested**

**Basic Parameters**

Mode: **DDD**

Basic Rate: **60 min-1**

Max Rate: **130 min-1**

Hysteresis: **0 %**

AVD Rest/Exer: **140 ms** **80 ms**

AVD Paced/Sensed Offset: **65 ms**

Accel. / AVD short: **0 %**

**Preprogrammed Settings**

Name: **Brady**

First Interrog.: **04/Sep/2020 02:08**

**Pacing/Sensing**

	A	V
Sensitivity	1.0 mV	2.5 mV
Sensing Polarity	Unipolar	Unipolar
Autosensing	Monitor	Monitor
Amplitude	5.0 V	5.0 V
Width	0.50 ms	0.50 ms
Paced Polarity	Unipolar	Unipolar
<b>Autothreshold</b>	<b>Auto</b>	Off
Amplitude Safety Margin	x2.0	
Min Amplitude	1.5 V	
Safety Amplitude	3.5 V	
Max Amplitude	5.0 V	
Max Rate	110 min-1	
Start Time	02:00	
Lead Polarity Switch	Off	Off

*Pacing/Sensing Brady programmer screen with available RAAT parameters when RAAT is programmed to "AUTO".*

When **AUTO** is programmed, 5 programmable and 1 non-programmable parameters are displayed:

1. **Amplitude safety margin:**  $x1.5 - x2$  (default) –  $x2.5 - x3$ . The atrial threshold measured is multiplied by the programmed Amplitude safety margin. The result is the programmed atrial output until the next RAAT is performed.
2. **Min Amplitude:**  $1 - 1.5$  (default) –  $2 - 2.5 - 3 - 3.5$  (V). It is the minimum pacing amplitude that can be automatically applied by the device.
3. **Safety Amplitude:**  $2 - 2.5 - 3 - 3.5$  (default) –  $4 - 4.5 - 5$  (V). It is the atrial pacing amplitude programmed if RAAT cannot be performed for 7 consecutive days.
4. **Max Amplitude:** the Maximum pacing amplitude that can be applied by the device is 5 V (not programmable).
5. **Max Rate:**  $100 - 110$  (default) –  $120$ . It is the maximum atrial rate that can be used to perform the atrial threshold test.
6. **Start time:** Time of the start of RAAT.

## 2. MONITORING

If the RAAT is programmed to **Monitoring**, the atrial threshold test will be performed like in **AUTO**, but the amplitude will not change from the value programmed manually. The information will be stored in AIDA.

When **MONITORING** is programmed, two parameters are used:

1. **Max Rate:**  $100 - 110$  (default) –  $120$ . It's the maximum atrial rate that can be used to perform the atrial threshold test.
2. **Start time:** Time of the start of RAAT.

*Note: The “RA Amplitude Safety Margin”, “RA Min Amplitude”, “RA Safety Amplitude”, “RA Max Amplitude” parameters are still displayed but not applied. They are only used for the calculation of the “suggested RA amplitude” within the RA Autothreshold curve available in AIDA memories (see section Right atrial Autothreshold in AIDA).*

## PROGRAMMING CONSTRAINTS

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The RAAT is available when **DDD(R)**, **DDD/DDIR**, **SafeR(R)**, **SafeR/DDIR**, **Dplus(R)**<sup>5</sup> or **Dplus/DDIR**<sup>5</sup> pacing mode is programmed.

The RAAT is NOT available when:

- The atrial pacing amplitude is  $>$  or equal to 6 V (in pacemakers) or  $> 5$  V (in ICDs/CRT-Ds).

<sup>5</sup> *Dplus is only available in the Pacemaker range*

When RAAT is programmed on Auto or Monitoring:

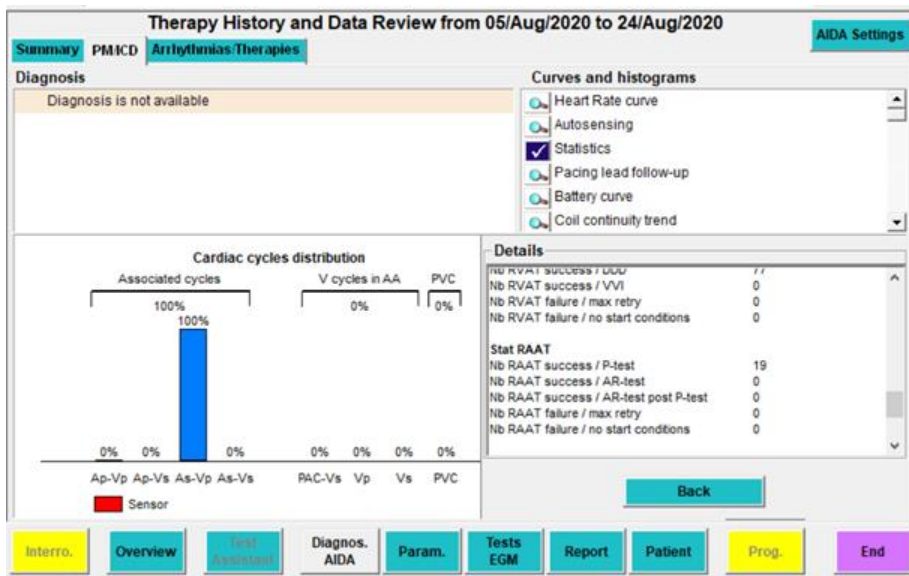
- Atrial pulse width maximum value is 0.5 ms,
- SafeR parameter “AVB I switch” is forced to “Rest+Exercise”,
- “Atrial Min Amplitude” is always lower than the “Atrial Safety Amplitude”,
- Basic Rate maximum value: 70 min<sup>-1</sup> when RAAT Max rate is equal to 100 min<sup>-1</sup>, and
- Basic Rate maximum value: 80 min<sup>-1</sup> when RAAT Max rate is equal to 110 or 120 min<sup>-1</sup>.

## RIGHT ATRIAL AUTOTHRESHOLD IN AIDA

All programmer screens with data on RAAT are available when RAAT is programmed to “AUTO” or “MONITORING”.

## 1. Detailed statistics

In AIDA, **PM** or **PM/ICD** tab, select **Statistics**, and **Details**:



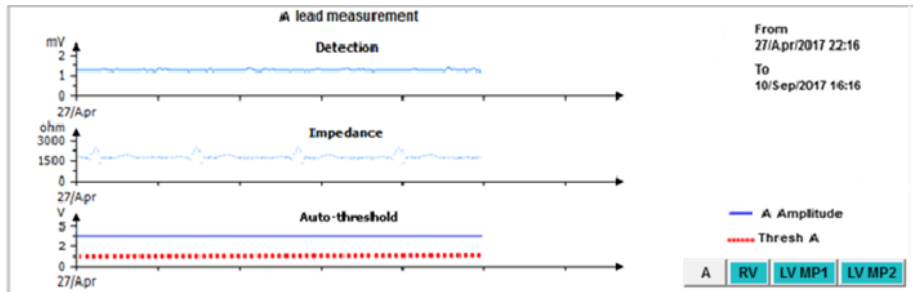
Programmer screen with RAAT statistics when Details Statistics are selected.

Available statistics are:

- Number of successful RAAT (P-test)
- Number of successful RAAT (AR-test)
- Number of successful RAAT (AR-test post P-test)
- Number of RAAT failures due to maximum number of retries reached
- Number of RAAT failures due to starting conditions not met

## 2. 6-Month curve

A 6-month curve is displayed in AIDA > **PM** or **PM/ICD** tab, **Autothreshold curve**, to show the trend of the daily threshold over 6 months, as well as the programmed output based on that threshold.

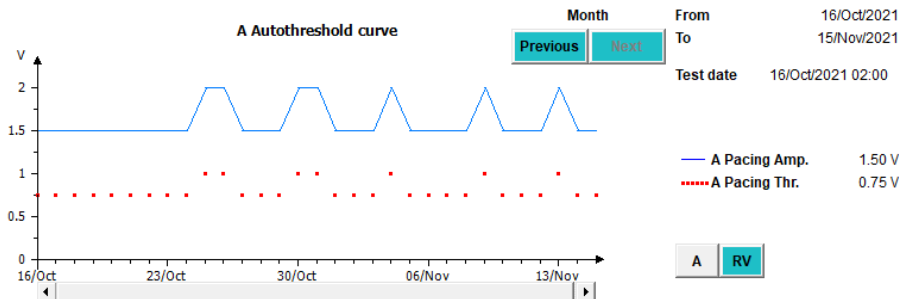


Programmer screen with RA lead measurement trends when Pacing lead follow-up with A lead is selected.

## 3. Per month curve

A monthly curve can be also displayed in AIDA > **PM** or **PM/ICD** tab > **Autothreshold curve**.

By clicking on the curve, the corresponding threshold value of the day is displayed on the right side.



Programmer screen with RA Autothreshold Curve when Autothreshold curve with A lead is selected and RAAT was programmed to "AUTO".

## 4. Diagnosis

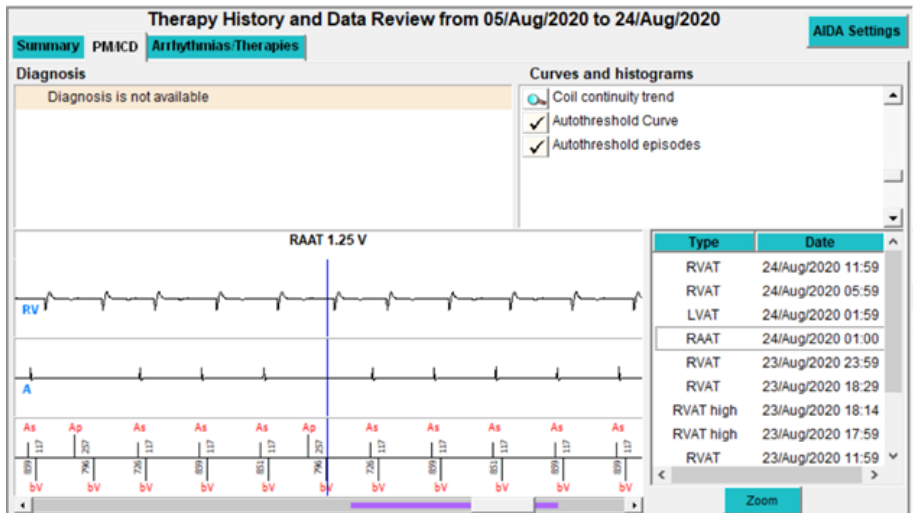
RAAT automatic interpretations are available when the follow-up period with RAAT programmed to "AUTO" or "MONITORING", is above 1 month.

Hereafter, the list of automatic RAAT diagnosis available:

1. Low successfulness of RAAT
2. Overestimation of RAAT
3. Too low "RA Safety Amplitude"
4. Too high "RA Min Amplitude"

## 5. Stored episodes

In AIDA, **PM** tab or **PM/ICD** tab, **Autothreshold episodes**, the RAAT episodes are stored with intracardiac EGM and synchronised marker chains.



Programmer screen with RAAT episodes when Autothreshold episodes is selected.

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

*Note : all programmer screenshots were captured from SmartView 3.06*