

## Atrial and Ventricular Rates Below the Programmed Lower Rate Limit

### SUMMARY

Review of rate histograms or electrocardiograms may occasionally reveal atrial or ventricular events below the programmed Lower Rate Limit (LRL). Although these lower-than-expected rates are typically the result of normal device function, clinicians may be interested in evaluating the root cause of the rates. The timing associated with Rate Hysteresis, intrinsic AV conduction, or premature ventricular contractions (PVCs) should be considered.

This article provides tips to help recognize and interpret events observed below the LRL.

ICD: Implantable Cardioverter  
Defibrillator  
CRT-D: Cardiac Resynchronization  
Therapy Defibrillator  
CRT-P: Cardiac Resynchronization  
Therapy Pacemaker

CRM PRODUCTS REFERENCED  
All ICDs, CRT-Ds, CRT-Ps and  
Pacing Systems

### CRM CONTACT INFORMATION

Technical Services – U.S.  
1.800.CARDIAC (227.3422)  
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Technical Services – Europe  
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1.866.484.3268 – U.S. and Canada  
001.651.582.4000 – International

On occasion, clinicians reviewing device diagnostics such as electrograms or rate histograms may observe paced or sensed atrial or ventricular rates below the programmed **Lower Rate Limit (LRL)**. Frequently, these temporary “slow” rates are normal device function resulting from programmed features or standard sensing algorithms.

Atrial and/or ventricular rates below the **LRL** can be the result of oversensing, but can also be attributed to one of the following:

- Rate Hysteresis
- A-V conduction during paced A-V function
- Premature Ventricular Contractions (PVCs)

### Rate Hysteresis

**Rate Hysteresis** is a rate enhancement feature designed to promote longer periods of intrinsic rhythm by temporarily allowing both atrial and ventricular intrinsic and paced rates to fall below the programmed **LRL** (or sensor-indicated rate). If the **Rate Hysteresis** feature is programmed **On**, the programmed **LRL** (or sensor-indicated rate) is lowered by the programmed **Hysteresis Offset** (ranging from 5-80 ppm). This allows a patient’s atrial and ventricular rate to fall below the **LRL** for one or more cardiac cycles when atrial or ventricular intrinsic activity is detected within the programmed **Hysteresis Offset** window.

If the low pacing rates are the result of **Rate Hysteresis** and these low rates are undesirable for a given patient, clinicians may consider reducing the **Hysteresis Offset** to a lower value (to increase the rate) or programming the **Rate Hysteresis** feature **Off**.

### A-V Conduction

**A-V conduction can delay ventricular pacing.** If a patient is paced at or near the **LRL** in both the atrium and the ventricle, and an atrial paced event is intrinsically conducted to the ventricle, it may cause the next V-V interval to be extended beyond the programmed **LRL**.

In the example depicted in Figure 1, the first and second contraction cycles are characterized by a lack of A-V conduction and slow atrial sinus rhythm, resulting in pacing for both chambers (programmed **LRL** of 60 ppm [1000 ms] and **AV Delay** of 250 ms) ① ②. During the third cycle, A-V conduction results in a ventricular intrinsic event that is 70 ms earlier than if the device would have paced at the end of the programmed **AV Delay** ③. To ensure that the next atrial paced interval is not 70 ms faster than the **LRL**, the programmed V-A interval of 750 ms (**LRL** minus **AV Delay**) is extended by 70 ms ④, preserving the A-A interval at 1000 ms. If the next ventricular event is paced rather than conducted, it will occur when the **AV Delay** expires at 250 ms, which adds an extra 70 ms to the V-V interval for this one cycle ⑤. This equates to a ventricular paced rate of approximately 56 ppm.

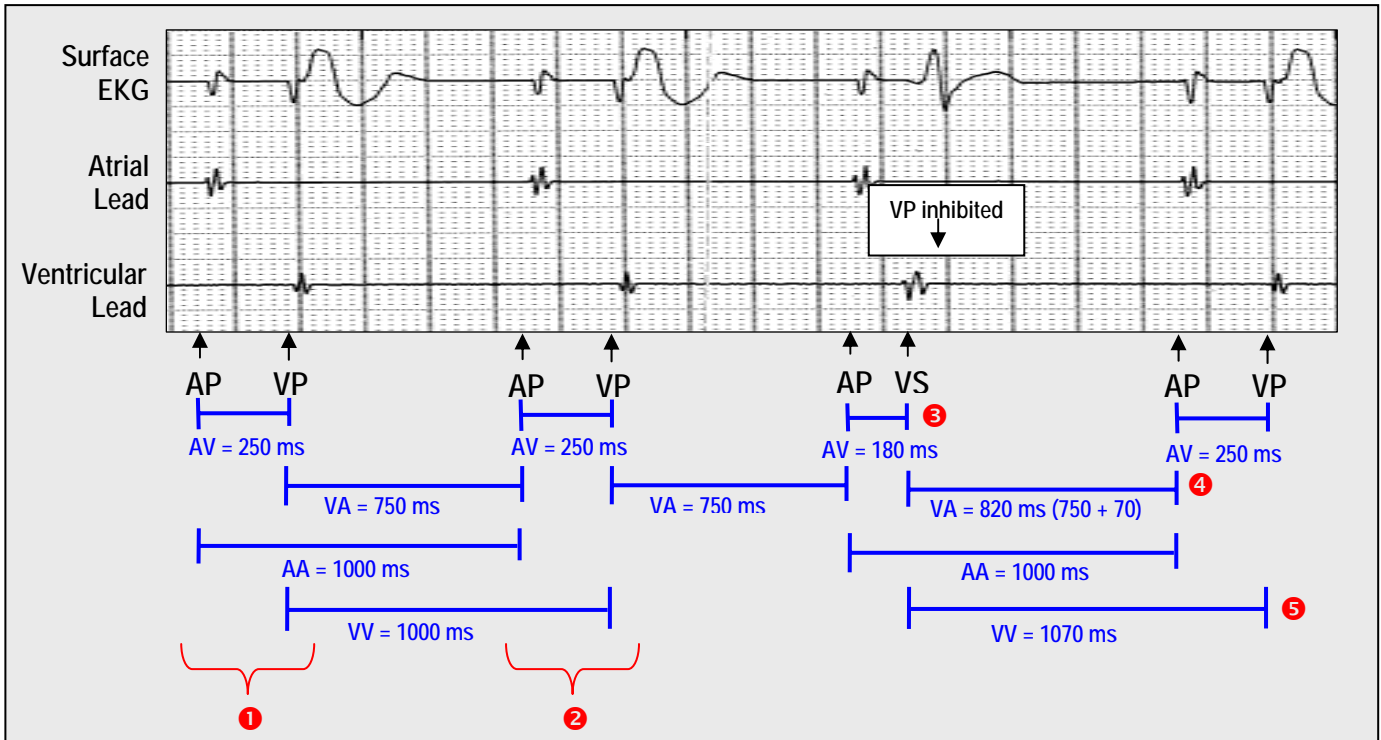


Figure 1. A-V conduction can delay ventricular pacing.

### Premature Ventricular Contraction

A PVC can reset cycle timing and delay atrial pacing. Figure 2 depicts a programmed LRL of 60 ppm (1000 ms) and an AV Delay of 250 ms. Following the second contraction cycle a PVC occurs approximately 680 ms after the previous ventricular paced event ❶. Adding the programmed VA interval of 750 ms (LRL minus AV Delay) ❷ to the PVC places the next paced atrial event a total of 1680 ms from the previous atrial event (250 + 680 + 750) ❸, or 36 ppm, which is significantly slower than the LRL of 60 ppm.

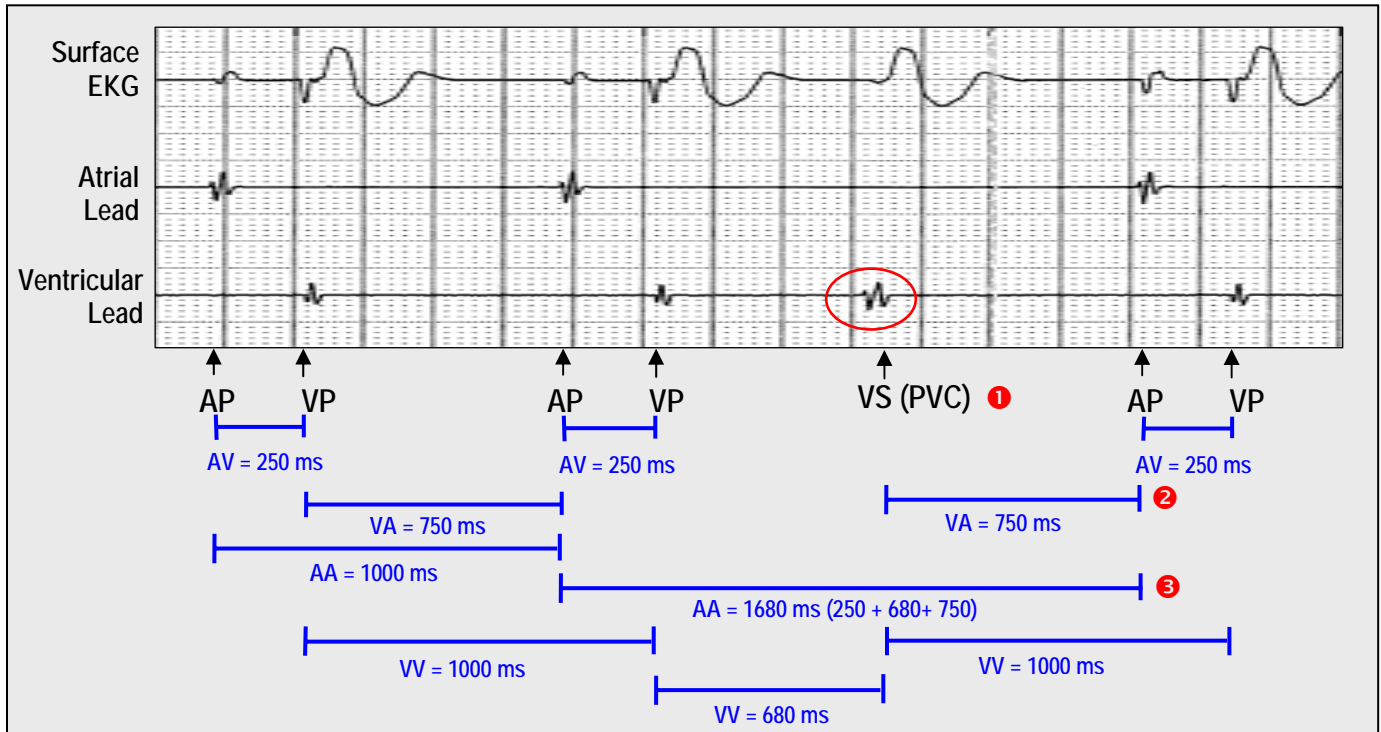


Figure 2. A PVC can delay atrial pacing.