

Diaphragm Stimulation During Daily LV Lead Impedance Measurements

SUMMARY

This article describes the most common reason for pacemaker stimulation of the diaphragm, and provides non-invasive methods for its mitigation during Daily Left Ventricular (LV) Lead Impedance measurements.

If a high-amplitude pacing pulse stimulates the diaphragm directly or via the right or left phrenic nerve, the pulse can trigger an involuntary contraction of the diaphragm (hiccup reflex), which can be bothersome for some patients. The most common reason for diaphragm stimulation in CRT patients occurs when pacing is delivered by a left ventricular (LV) pacing lead positioned adjacent to the left phrenic nerve, which passes directly over the heart's left ventricle.

In some device families, diaphragm stimulation is more likely to happen during daily Lead Impedance measurement tests because the temporary pacing amplitude used during the test may be significantly higher than the permanent amplitude at which the device normally provides pacing. Refer to [Table 1](#) for information on how daily Lead Impedance measurements are conducted for Boston Scientific CRT devices.

It is recommended that patients be tested for diaphragm stimulation during the implant procedure by pacing the LV lead through the device at a high amplitude (7.5 V) and adjusting the lead position as necessary. Pacing System Analyzer testing at even higher amplitudes (e.g., 10.0 V) may also be considered to further understand stimulation margins. Note that if tests conducted during the implant procedure (while the patient was supine) did not trigger diaphragm stimulation, it may still occur in some patients when they are in different postures.

Programming mitigations for diaphragm stimulation

If diaphragm stimulation occurs at the same time each day, it may be attributed to daily lead impedance measurement tests. The following programming options may be considered to mitigate diaphragm stimulation resulting from Daily Measurements:

- **Reprogram the LV pace vector.** This may alter the pacing energy pathway such that diaphragm stimulation can be minimized or eliminated. Refer to [Table 2](#) for LV pace vector information.
- **Program the LV Daily Lead Impedance test to Off.** If diaphragm stimulation occurs only during Daily Measurements, the feature can be programmed to Off. Refer to [Table 3](#) for programming information.

If diaphragm stimulation occurs during normal LV pacing, the physician may consider non-invasive programming options such as selecting a new LV pace vector or reducing the LV pacing amplitude, if clinically appropriate.

CRT: Cardiac Resynchronization Therapy

CRM PRODUCTS REFERENCED*

COGNIS™, CONTAK RENEWAL® 3 and 4, CONTAK RENEWAL 3 AVT®, CONTAK RENEWAL 3 RF and 4 RF, CONTAK RENEWAL TR and TR 2, and LIVIAN™

*Products referenced herein may not be approved in all geographies. For comprehensive information on device operation, reference the appropriate product labeling.

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Table 1. Daily LV Lead Impedance Measurements

Devices	How Daily Measurements are conducted
CONTAK RENEWAL® TR & TR 2	Daily pacing lead impedance measurements tests are conducted for each chamber in which pacing is enabled. During a pace lead impedance test, all chambers (RA/RV/LV) of the device temporarily function at a high output, until all chambers have been tested. If the chamber under test does not require a paced beat within 255 cycles, the measurement begins with a triggered pace on the 256 th cycle. If pacing is enabled in all three chambers, the tests occur in series—RA, RV, followed by LV. <i>Depending on the pacing needs of the patient in the RA and RV during the daily measurement, an increase in LV amplitude may last for several minutes and can result in extended diaphragm stimulation in some patients.</i>
CONTAK RENEWAL3 AVT® CONTAK RENEWAL 3 & 3 RF CONTAK RENEWAL 4 & 4 RF LIVIAN™	Daily pacing lead impedance measurements tests are conducted for each chamber in which pacing is enabled. In these devices, the LV chamber is tested independently from the RA and RV chambers. If, during LV testing, the LV chamber does not require a paced beat within 255 cycles, the measurement begins with a triggered pace on the 256 th cycle. When a triggered pace is delivered in the LV, the LV amplitude may be increased for up to three cardiac cycles. <i>Since the daily LV lead impedance test is independent of RA and RV testing, there can only be a maximum of three cardiac cycles with high amplitude pacing in the LV chamber; therefore the duration of diaphragm stimulation, if it were to occur, is greatly reduced.</i>
COGNIS™	This device utilizes a sub-pacing threshold signal (independent of a pacing pulse) to conduct lead impedance tests. This sub-pacing threshold signal is less likely than other devices (which use high-output pacing pulses) to cause diaphragm stimulation during lead impedance tests.

Table 2. LV Pace Vector Programming

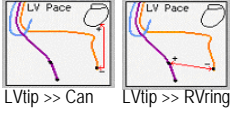
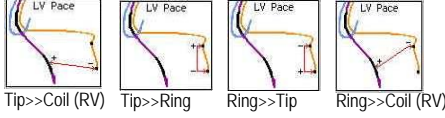
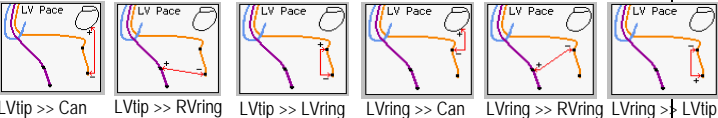
Devices	Lead configuration	LV Pace Vector programming	Programming limitations
CONTAK RENEWAL TR & TR 2	Unipolar LV lead with a Bipolar RV lead configuration	Programming steps: 1. From the System Summary screen, select HF/Brady Parameters > Lead Configuration. Verify that the LV Electrode Configuration is programmed to Single . 2. Select a different Left Ventricular Pace vector. 3. Press the PROGRAM key on the programmer. LV Pace Vector options:  LVtip >> Can LVtip >> RVring	The vector configuration is not programmable when a unipolar RV lead is implanted (i.e., in contrast to a bipolar RV lead programmed to Unipolar)
CONTAK RENEWAL TR & TR 2 CONTAK RENEWAL 3 AVT CONTAK RENEWAL 3 & 3 RF CONTAK RENEWAL 4 & 4 RF	Bipolar LV lead with a Bipolar RV lead configuration	Programming steps: 1. From the System Summary screen, select HF/Brady Parameters > Lead Configuration. Verify that the LV Electrode Configuration is programmed to Dual . 2. Select a different Left Ventricular Pace vector. 3. Press the PROGRAM key on the programmer. CRT defibrillator LV Pace Vector options:  Tip>>Coil (RV) Tip>>Ring Ring>>Tip Ring>>Coil (RV) CRT pacemaker LV Pace Vector options:  LVtip >> Can LVtip >> RVring LVtip >> LVring LVring >> Can LVring >> RVring LVring >> LVtip	For CRT defibrillators, the vector configuration is not programmable when the LV Electrode Configuration is programmed to Single .

Table 3. Programming the LV Daily Measurement Feature to Off

Devices	Programming steps
CONTAK RENEWAL TR & TR 2 CONTAK RENEWAL 3 AVT CONTAK RENEWAL 3 & 3 RF CONTAK RENEWAL 4 & 4 RF LIVIAN	1. From the System Summary screen, select Setup > Daily Measurement. 2. Change the Left Ventricular Pace Impedance test from On to Off. 3. Press the PROGRAM key on the programmer.