

DEVICE THERAPY

INNOVATIVE TECHNIQUES

Observations on Optimal Programming of Closed Loop Cardiac Pacemakers in Patients with Refractory Neurocardiogenic Syncope

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ABSTRACT. *There have been few reports on the use of closed loop cardiac pacing in patients suffering from refractory neurocardiogenic syncope. The optimal pacing algorithm using closed loop cardiac pacing has not been well studied. We herein present our single center experience on the specific pacing algorithm, which has been successful in almost 84% of patients.*

KEYWORDS. *closed loop, pacemaker, neurocardiogenic, syncope.*

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Introduction

Recurrent refractory neurocardiogenic syncope (NCS) can be a debilitating problem that often proves difficult to manage. Whereas standard cardiac pacing in patients with refractory NCS has yielded mixed results, recent reports have suggested that pacemakers that incorporate closed loop cardiac pacing (CLS) algorithms can be quite effective in decreasing the frequency and severity of syncopal events.^{1–3} CLS employs a sensing system that measures myocardial contractility, thereby providing a potential way of detecting the onset of NCS at much earlier point in time than that provided by standard pacing systems.^{1–3} Earlier detection would then allow for pacing to be employed at an earlier point in the syncopal process, potentially enhancing its ability to either prevent (or significantly modify) the syncopal event.³ The programming algorithm for these patients has not been very well standardized. In this paper we present a suggested algorithm for programming CLS pacemakers

based on our experience in the management of refractory neurocardiogenic syncope over the last 4 years in almost 117 patients: with Evia DR-T 359529 in 30 patients and Cylos DR-T 349799 in 87 patients.

The CLS system manufactured by Biotronik (Lake Oswego, OR) uses inotropy-based sensors. The earlier model was the Cylos DR-T device and the latest CLS pacer available in the United States market is the Evia DR-T (which employs the same sensor technology). There is no difference in the CLS pacing algorithm between Cylos DR-T and the newer Evia DR-T.

Physiological basis of CLS pacing

CLS pacing offers a form of rate adaptive pacing using right ventricular (RV) impedance. **Figure 1** illustrates the RV impedance (Z_2) as being constantly measured at the interface of the RV lead and the myocardium. When the RV is full of blood there is a smaller fraction of myocardium that interfaces with the lead tip, and hence the impedance (Z_2) is low. In contrast, when there is less blood in the ventricular cavity the proportion of myocardium at the interface increases resulting in a higher impedance (Z_2) (**Figure 2**). The high impedance triggers the CLS algorithm and starts pacing the heart at a preset CLS intervention rate. The advantage of this beat-to-beat assessment of the RV impedance allows for early detection of inotropic changes that have been observed in NCS patients before an episode.

Dr Grubb has received speaking honorium from Biotronik and also has served as a consultant for Medtronic. Acknowledgement: We would like to thank Dr Volker Lang, Senior Director Software Development, Biotronik for his help with the design of the figures and illustrations.

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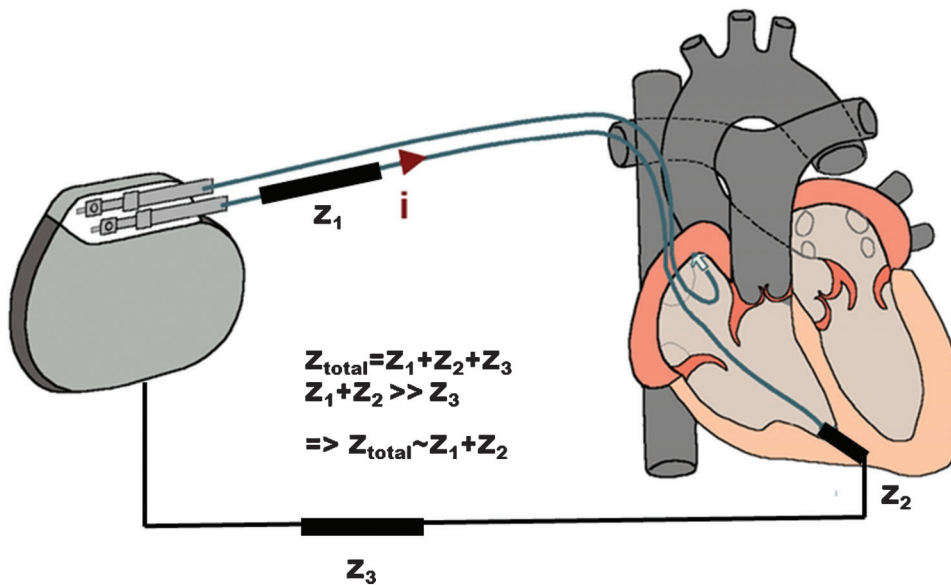


Figure 1: Illustration demonstrating the impedance at the lead tip myocardial interface (Z_2) assessed by the closed loop (CLS) system.

Programming parameters

- 1) Resting Rate Control (RRC):**
 The CLS "Expert Options" feature allows for the programming of the resting rate control. Under normal circumstances the RRC would limit heart rate migration to base rate plus 20 pulses per minute (ppm) as a default if the patient is not currently moving enough to trigger the accelerometer. For the patient population group with NCS we turn the RRC to the OFF mode. Programming the RRC to Off allows the CLS algorithm to vary the rate response in the

device from base rate to the maximum programmed CLS rate based on the current contraction dynamics that are being measured.

When the device is programmed in this manner the algorithm intervenes much earlier in the neurocardiogenic (vagal) reflex, thereby increasing the patient's cardiac output (CO) much sooner. Earlier intervention has been shown to decrease the number of syncopal events, or alternatively to provide a prodromal warning for patient that was not noted before CLS implantation.³

- 2) Basic rate:** We usually program the base rate to between 60 and 65 ppm (**Figure 3**).

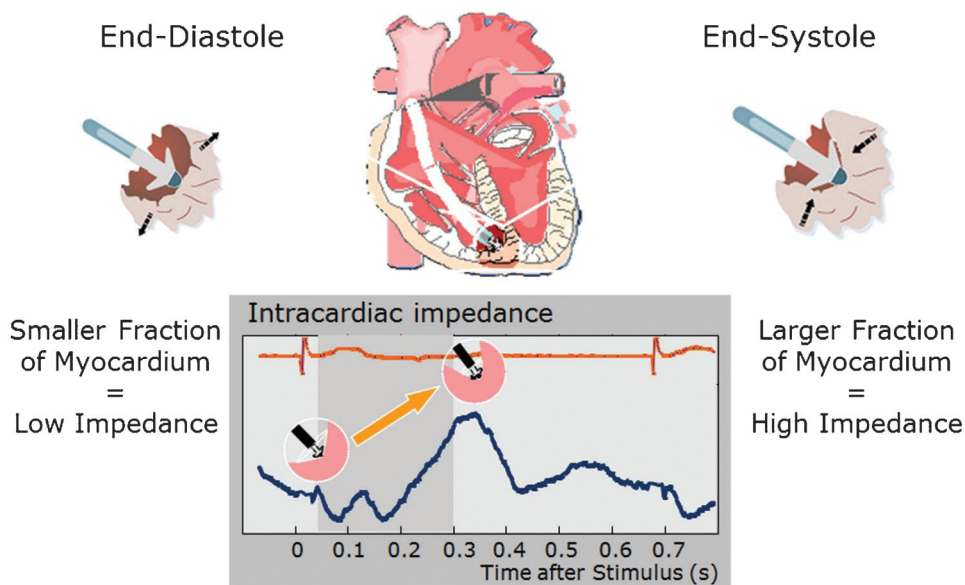


Figure 2: The impedance (Z_2) changes in various phases of cardiac cycle and is high when a small amount of blood in the right ventricle results in a large myocardial fraction at the interface with the lead tip.

Mode	DDD-CLS	Pulse amplitude [V]	3.0	3.0
Basic rate/Night rate [ppm]	60/-----	Pulse width [ms]	0.4	0.4
CLS [ppm]	140	Capture control	ON	ON
Sensor/Rate fading [ppm]	140/-----	Sensitivity [mV]	AUTO	AUTO
Upper rate response [ppm]	160/WKB	Refractory period/Blanking	Standard	
Mode switching [bpm]	180/DDIR	Pacing polarity	BIPL	BIPL
Vp suppression	OFF	Sensing polarity	BIPL	BIPL
Dynamic AV delay [ms]	150/120	Calculated ERI		
Atrial overdrive				

Figure 3: Programming closed loop (CLS) for neurocardiogenic syncope (NCS) based on the University of Toledo experience. The mode is set at DDD-CLS, with the basic rate of 60 bpm and the upper tracking rate is set at 160 bpm. We set the CLS intervention rate at 140 bpm maximum.

- **3) Maximum CLS rate:** We usually program this to between 130 and 140 ppm. This is the maximum rate at which the device can drive the heart rate (Figure 4).
- **4) CLS response:** For neurocardiogenic patients we usually program it to “high” or “very high”. This setting determines the aggressiveness of the CLS response over time.
- **5) Atrioventricular (AV) delay:** We program the AV delay so as to minimize ventricular pacing whenever the patient has intact intrinsic conduction through the use of the AV-hysteresis function in the device. This, of course, is very patient-specific (Figure 5).

Over last 4 years our center has implanted 117 CLS pacemakers in patients with refractory NCS. Over these

years we have used a specific CLS algorithm that we believe has worked very well for our patient population. With the previously stated programming we have been able to achieve an amelioration of symptoms in approximately 84% of patients who had previously suffered from severe refractory forms of NCS.³ Figure 6 demonstrates a typical rate histogram from one of our patients who suffered from refractory neurocardiogenic syncope and received a CLS pacemaker. The results of our experience with CLS pacing have been published previously and since the publication of our data earlier we have used CLS pacing in many more patients with a similar success rate. Further studies will be necessary to better determine the optimal CLS programming required to prevent syncope in patients with recurrent severe

The screenshot shows the pacemaker programming interface. The main screen displays various settings, with 'CLS [ppm]' set to 140, circled in red. A red arrow points from this circle to a pop-up window titled 'CLS'. This window shows 'Expert options' for CLS programming: 'CLS response' is set to 'Very high', 'CLS resting rate control [ppm]' is set to 'OFF', and 'CLS Vp required' is set to 'No'. There are 'OK' and 'Cancel' buttons at the bottom of the pop-up window.

Figure 4: Programming closed loop (CLS) option in patients with neurocardiogenic syncope. We prefer to set the CLS resting control to OFF and the CLS response to “very high”.

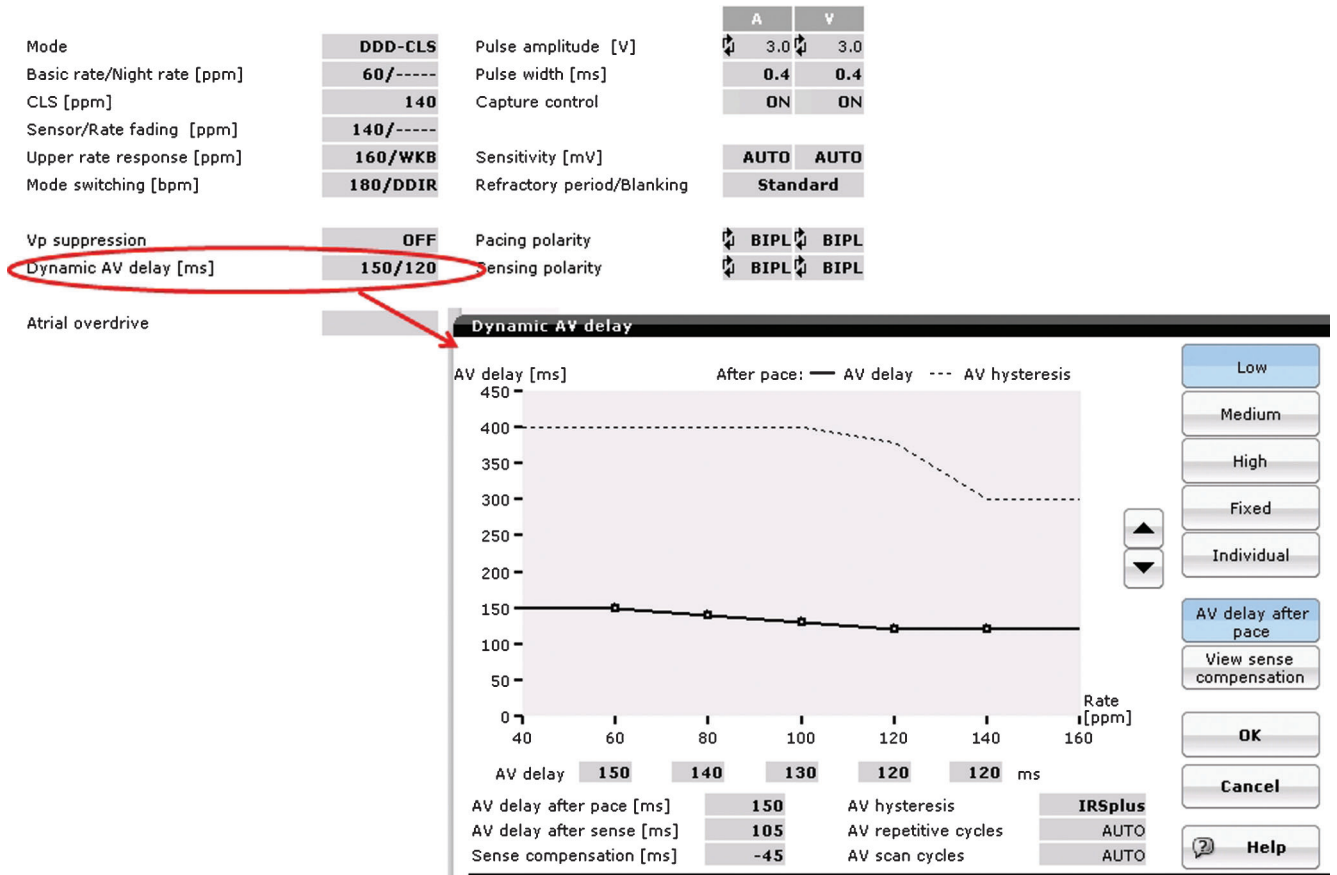


Figure 5: Programming atrioventricular (AV) delay in patients with neurocardiogenic syncope (NCS). We program paced AV delay to 150 at 60 bpm and to 120 at 140 bpm. The AV delay hysteresis is programmed to +280 ms. The resulting maximal AV delay of 400 ms allows for decreased ventricular pacing in patients with NCS who otherwise have a healthy conduction system.



Patient: PSW 1004.U
 Device: CYLOS DR (ICS 3000 SW 1002.U)
 S/N:

Statistics

Date: 07/30/2010
 Time: 17:16

Timing events

Start 11:53 11/09/2009
 Duration 263 days

Event	0	25	50	75	100	%	Count
As - Us	[Bar]					35	11160446
As - Up	[Bar]					5	1615215
Ap - Up	[Bar]					22	6971829
Ap - Us	[Bar]					37	11702845
U - U	[Bar]					1	343311
Sum						100	31793646
As	[Bar]					40	12775875
Ar	[Bar]					1	369960
Ap	[Bar]					59	18688648
Sum						100	31834483
Us	[Bar]					73	23212354
Urs	[Bar]					0	511
Up	[Bar]					27	8600627
Sum						100	31813492

Figure 6: Histogram downloaded from the device demonstrating the amount of pacing the patient receives from the device.

NCS, as well as its potential role in related conditions such as carotid sinus syndrome. Further prospectively designed studies in future may better evaluate the role of this therapy in improving the quality of life in patients with refractory neurocardiogenic symptoms.

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