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SIGNIFICANT QRS DURATION REDUCTION AND MAXIMAL DP/DT ACHIEVED ONLY BY MULTIPOINT™ PACING

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MULTIPOINT™ PACING CASE STUDY

ELECTRICAL CHANGES IN A PATIENT UNDERGOING CARDIAC RESYNCHRONIZATION THERAPY

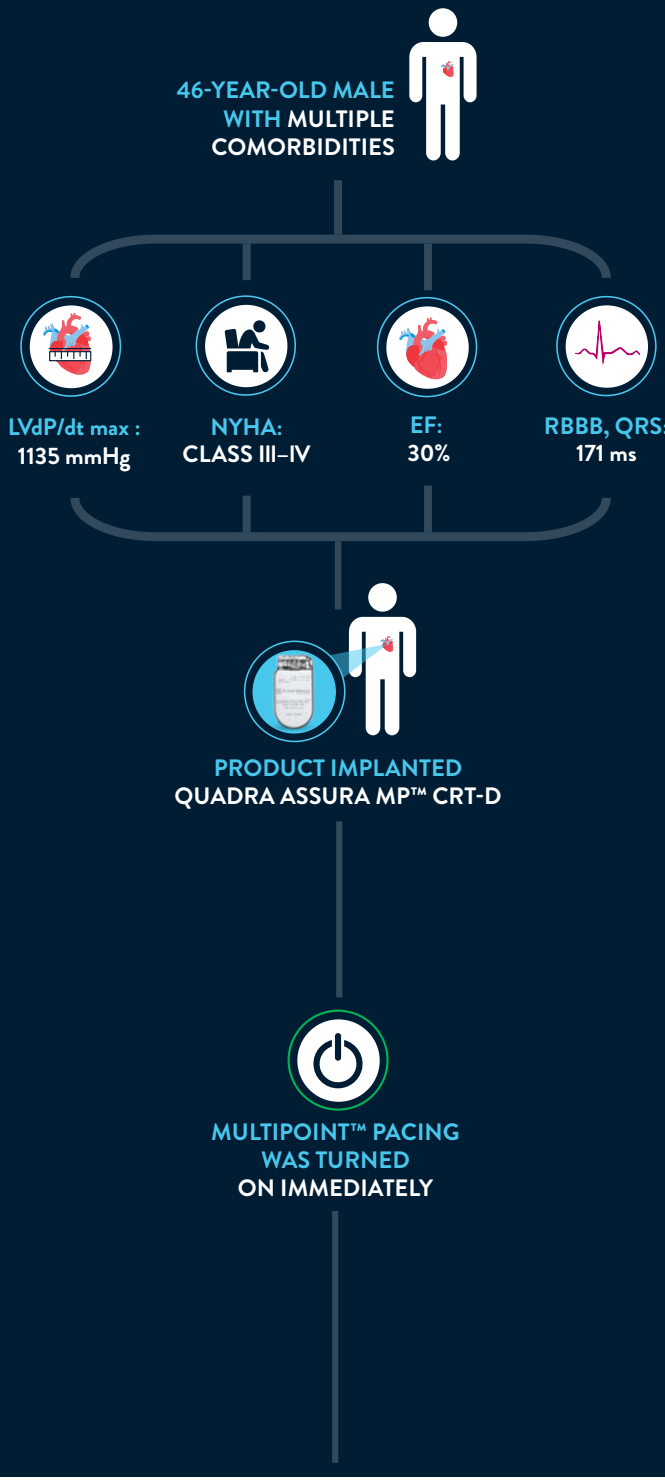

Table 1. Outcome of LV dP/dt_{max} with various pacing configurations

	Baseline	RV pacing	LV pacing (M2-P4)	LV pacing (M3-M2)	BiV pacing (LV: M2-P4)	BiV pacing (LV: M3-M2)	MultiPoint™ pacing technology (LV: M3-M2 + M2-P4)
QRSd	171 ms	215 ms	206 ms	209 ms	143 ms	162 ms	125 ms
LV dP/dt_{max}	1135 mmHg	951 mmHg	1038 mmHg	1046 mmHg	1079 mmHg	1117 mmHg	1139 mmHg

CLINICAL HISTORY

A 46-year-old male with ischemic cardiomyopathy was referred for further management of his advanced heart failure. Past medical history revealed extensive antero-septal ST-segment elevation myocardial infarction (STEMI) in March 2013. He also had hypertension and hyperlipidemia and was an ex-smoker. A coronary angiogram in 2013 showed triple vessel disease with percutaneous coronary intervention (PCI) performed to the left anterior descending (LAD) with a drug-eluting stent (DES). Other findings showed small left circumflex (LCX) vessel, blocked obtuse marginal branch and RCA with chronic total occlusion. The patient required repeated heart failure hospitalizations (NYHA Class III to IV) since May 2014. His ECG at baseline showed sinus rhythm with RBBB pattern [QRS duration (QRSd) 171 ms].

PROCEDURE

The patient underwent cardiac resynchronization therapy defibrillator (CRT-D) implantation for primary prevention. The quadripolar left ventricular (LV) lead was positioned in the distal lateral branch. Before the CRT-D generator was connected to the implanted leads (RA: 1882TC/52, RV: 7121Q/58 and LV: 1458Q/86), we collected ECG morphologies and acute hemodynamic measurements by LV dP/dt_{max} for 1) Baseline (APVS), 2) RV pacing, 3) LV pacing with different feasible bipolar configurations, including conventional biventricular pacing (D1 – M2); the base rate was programmed to DDD 80 bpm, AV interval 120 ms. Specific adaptor connections mimicking device built-in Multipoint™ Pacing algorithms were tested (Figure 1a-c).

Baseline (AAI 90 bpm) was compared with different cardiac resynchronization therapy (CRT) pacing configurations.

Figure 1a. The specific adaptor used in the acute MultiPoint™ pacing testing. **Figure 1b.** Dual connections for testing LV1 and LV2 (purple and green arrows) in the LV port of the PSA in programmer. **Figure 1c.** Positions of MultiPoint pacing testing cable connections onto quadripolar LV lead (purple and green arrows) to pace simultaneously for dual LV sites with two testing cables, similar to the MultiPoint pacing technology.

Figure 1a Figure 1b Figure 1c

BASELINE CHARACTERISTICS

- Baseline ECG showed sinus rhythm with RBBB pattern (QRS duration 171 ms).
- Cardiac MRI showed fixed defect seen in anterior, septal, anterolateral and inferolateral walls.
- Cardiac output by thermodilution during right heart cardiac catheterization was 3.1 L/min and cardiac index was 1.77 L/min/m².
- Echocardiogram: LV showed akinetic apical, anterior (mid and basal) segments, and basal septum with myocardium thinning. Rest of LV appeared hypo-kinetic (LV dd/sd 6.0/5.0 cm; EF 30%).

RESULTS

Implantation included the following acute findings:

- Despite D1 with the most delayed conduction time in RV paced-LV sensed mode, significant phrenic nerve stimulation (PNS) was found in all D1 related vectors.
- M3-M2 stimulation resulted in better LV dP/dt_{max} vectors measurement and more significant QRSd reduction than the M2-P4 stimulation.
- Compared to conventional bipolar LV lead (D1-M2), the quadripolar lead can provide more options in optimization of CRT therapy. The physician could seek further alternative optimal pacing configuration (M3-M2 in this case) for the patient without need of repositioning the lead should PNS occur.

Results with MultiPoint™ Pacing Technology

When comparing with baseline QRSd (171 ms) and other quadripolar configurations in biventricular pacing (215 ms in LV M2-P4 and 162 ms in LV M3-M2), MultiPoint Pacing with M3-M2+M2-P4 configurations resulted in significant reduction in QRSd (128 ms) (Figure 2).

Furthermore, the LV dP/dt_{max} measurement showed MultiPoint Pacing mode (1139 mmHg) a further 6% increase when compared with conventional bipolar configurations (1079 mmHg). The incremental benefits of both electrical and hemodynamic resynchronizations were achieved in this case (Table 1).

Figure 3 showed the following:

- Latest activation was seen at D1 (145 ms) during RV paced-LV sensed mode but PNS was present.
- Other features used to enhance patient care VectSelect Quartet™ programmable LV pulse configuration and QuickOpt™ timing cycle optimization were also applied in this case (Figure 3).
- Activation in M2 (119 ms) and M3 (113 ms) were the next most delayed.
- As QRS duration reduction and increase in LV dP/dt_{max} with M3 to M2 was better than M2 to P4, M3-M2 was selected.
- QuickOpt™ optimization was performed and applied with recommended settings:
  PAV/SAV: 170 ms/120 ms, RV First 10 ms.

Table 1. Outcome of LV dP/dt_{max} with various pacing configurations

	Baseline	RV pacing	LV pacing (M2-P4)	LV pacing (M3-M2)	BiV pacing (LV: M2-P4)	BiV pacing (LV: M3-M2)	MultiPoint™ pacing technology (LV: M3-M2 + M2-P4)
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LV dP/dt_{max}	1135 mmHg	951 mmHg	1038 mmHg	1046 mmHg	1079 mmHg	1117 mmHg	1139 mmHg

Figure 2. ECGs morphologies obtained with different pacing configurations. MultiPoint™ pacing (LV: M3-M2 + M2:P4) showed the most significant QRSd reduction.

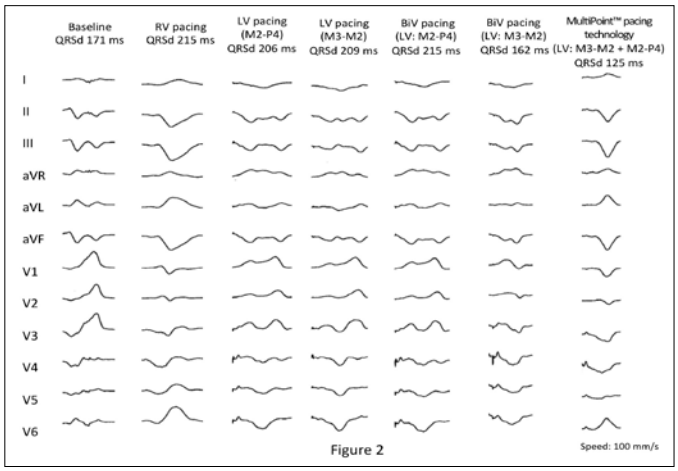
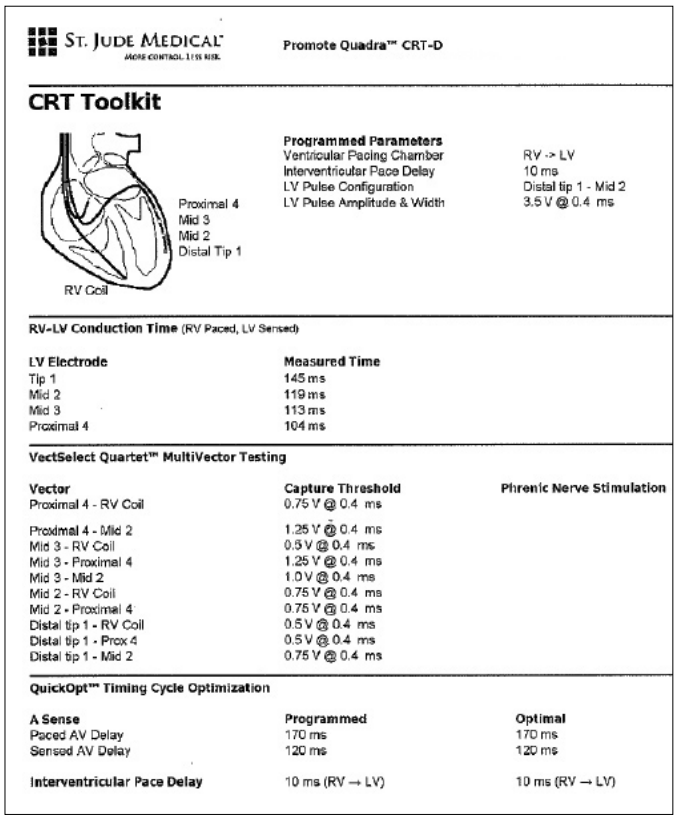


Figure 3.



CONCLUSION

Regarding selecting predictor of CRT-induced positive remodeling, a paradox of QRS duration reduction[1] versus acute hemodynamic measurement[2] exists. Single site left ventricular pacing (LVP) has been shown to be as beneficial as biventricular pacing (BiVP) for LV systolic dysfunction in acute hemodynamic studies[3-5] and in long-term follow-up studies[6,7] despite no reduction in QRS duration with isolated LV pacing (in the absence of fusion with intrinsic rhythm). On the contrary, CRT responders showed significant reduction in QRS duration directly after initiation of CRT and maintained at long-term follow-up. Restoration of electrical synchronization induced by CRT can be reflected by reduction of QRSd.[8] Furthermore, additional hemodynamic benefit can be achieved with fusion beats reflected by significant reduction of QRSd.[9,10] In this case, MultiPoint pacing of LV activation allowed achievement of both narrowest QRS width and the maximum LV dP/dt_{max} measurement when compared with conventional BiVP, resolving the paradox altogether.

The use of a specific adaptor allows the reproduction capability of MultiPoint pacing within the generator. During implantation, acute hemodynamic and ECG analysis can be performed, thus facilitating the implanting physician's decision to implant a CRT-D with the MultiPoint pacing programming option.

LIMITATION

The use of a specific adaptor and connections produced with BiVP and simulated MultiPoint pacing mode in this case were all paced simultaneously without AV and VV optimization for LV dP/dt_{max} and QRSd measurement (i.e., DDD mode). It can be postulated that the actual results in LV dP/dt_{max} and QRSd would be better in a MultiPoint pacing device with QuickOpt™ optimization, RV-LV conduction test and programmability of LV1 and LV2 delay.

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Brief Summary: Please review the Instructions for Use prior to using these devices for a complete listing of indications, contraindications, warnings, precautions, potential adverse events and directions for use.

Quartet™ LV lead
Indications and Usage: The Quartet lead has application as part of an Abbott Biventricular system.
Contraindications: The use of the Quartet lead is contraindicated in patients who:
• Are expected to be hypersensitive to a single dose of 1.0 mg of dexamethasone sodium phosphate.
• Are unable to undergo an emergency thoracotomy procedure.
• Have coronary venous vasculature that is inadequate for lead placement, as indicated by venogram.
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Contraindications: Contraindications for use of the pulse generator system include ventricular tachyarrhythmias resulting from transient or correctable factors such as drug toxicity, electrolyte imbalance, or acute myocardial infarction. Adverse Events: Implantation of the pulse generator system, like that of any other device, involves risks, some possibly life-threatening. These include but are not limited to the following: acute hemorrhage/bleeding, air emboli, arrhythmia acceleration, cardiac or venous perforation, cardiogenic shock, cyst formation, erosion, exacerbation of heart failure, extrusion, fibrotic tissue growth, fluid accumulation, hematoma formation, histotoxic reactions, infection, keloid formation, myocardial irritability, nerve damage, pneumothorax, thromboemboli, venous occlusion. Other possible adverse effects include mortality due to: component failure, device programmer communication failure, lead abrasion, lead dislodgment or poor lead placement, lead fracture, inability to defibrillate, inhibited therapy for a ventricular tachycardia, interruption of function due to electrical or magnetic interference, shunting of energy from defibrillation paddles, system failure due to ionizing radiation. Other possible adverse effects include mortality due to inappropriate delivery of therapy caused by: multiple counting of cardiac events including T waves, P waves, or supplemental pacemaker stimuli. Among the psychological effects of device implantation are imagined pulsing, dependency, fear of inappropriate pulsing, and fear of losing pulse capability. Refer to the User's Manual for detailed indications, contraindications, warnings, precautions and potential adverse events.

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