



MULTIPOINT™ PACING: A COLLECTION OF CASE STUDIES

**Highlighting Electrical and Hemodynamic
Changes in Patients** Undergoing Cardiac
Resynchronization Therapy

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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

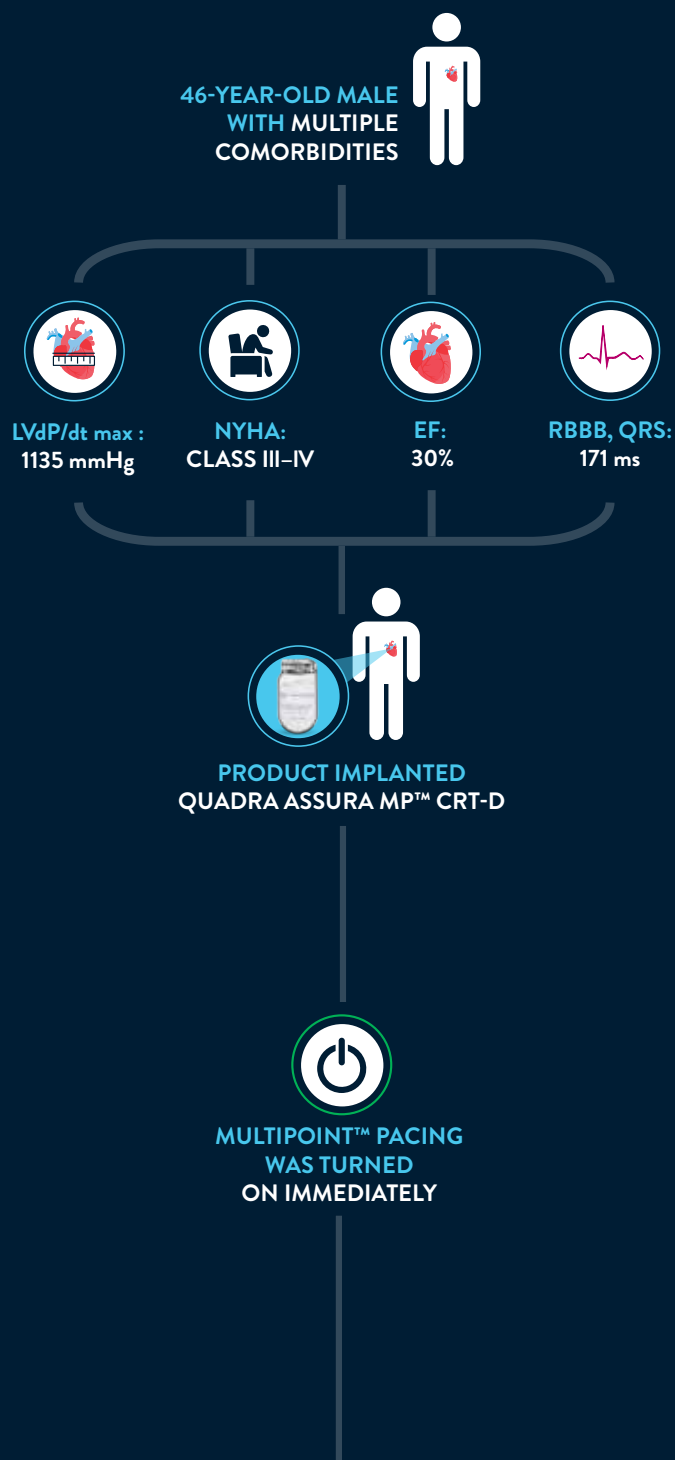


Table 1. Outcome of LV dP/dt_{max} with various pacing configurations

	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

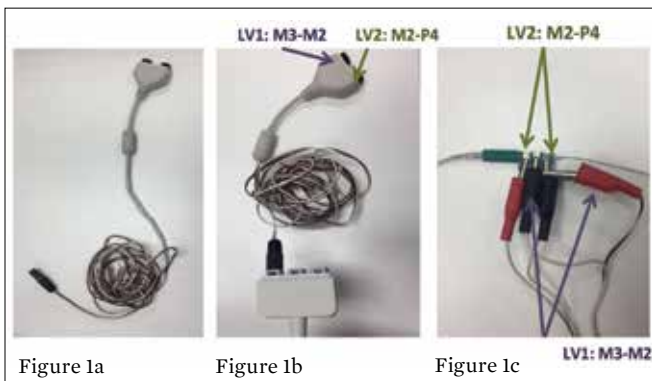
A 46-year-old male with ischemic cardiomyopathy was referred for further management of his advanced heart failure. Past medical history revealed extensive antero-septal ST-segment elevation myocardial infarction (STEMI) in March 2013. He also had hypertension and hyperlipidemia and was an ex-smoker. 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.



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).

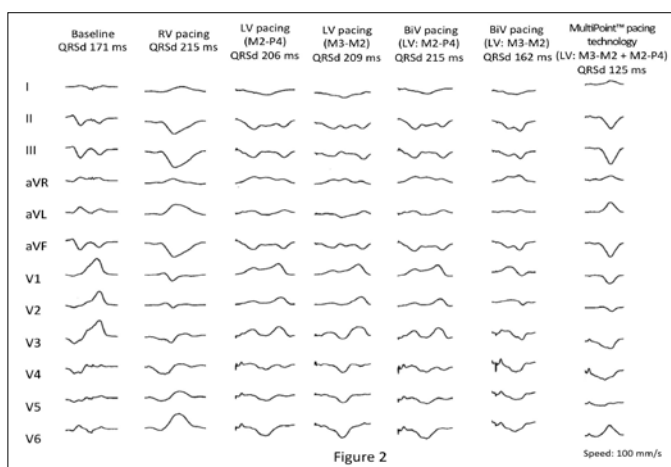
Furthermore, the LV dp/dt_{max} measurement showed MultiPoint Pacing mode (1139 mmHg) a further 6% increase when compared with conventional bipolar configurations (1079 mmHg). The incremental benefits of both electrical and hemodynamic resynchronizations were achieved in this case (Table 1).

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)
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

Figure 2. ECGs morphologies obtained with different pacing configurations. MultiPoint™ pacing (LV: M3-M2 + M2:P4) showed the most significant QRSd reduction.**Figure 3.**

ST. JUDE MEDICAL

ACROSS CONTINUAL 11/15/10/10

Promote Quadra™ CRT-D

CRT Toolkit

Proximal 4
Mid 3
Mid 2
Distal Tip 1

RV Coil

Programmed Parameters
Ventricular Pacing Chamber
Interventricular Pace Delay
LV Pulse Configuration
LV Pulse Amplitude & Width

RV → LV
10 ms
Distal tip 1 - Mid 2
3.5 V @ 0.4 ms

RV-LV Conduction Time (RV Paced, LV Sensed)

LV Electrode

Tip 1
Mid 2
Mid 3
Proximal 4

Measured Time

145 ms
119 ms
113 ms
104 ms

VectSelect Quartet™ MultiVector Testing

Vector

Proximal 4 - RV Coil
Proximal 4 - Mid 2
Mid 3 - RV Coil
Mid 3 - Proximal 4
Mid 3 - Mid 2
Mid 2 - RV Coil
Mid 2 - Proximal 4
Distal tip 1 - RV Coil
Distal tip 1 - Prox 4
Distal tip 1 - Mid 2

Capture Threshold

0.75 V @ 0.4 ms
1.25 V @ 0.4 ms
0.5 V @ 0.4 ms
1.25 V @ 0.4 ms
1.0 V @ 0.4 ms
0.75 V @ 0.4 ms
0.75 V @ 0.4 ms
0.5 V @ 0.4 ms
0.5 V @ 0.4 ms
0.75 V @ 0.4 ms

Phrenic Nerve Stimulation

QuickOpt™ Timing Cycle Optimization

A Sense

Paced AV Delay
Sensed AV Delay

Programmed

170 ms
120 ms

Optimal

170 ms
120 ms

Interventricular Pace Delay

10 ms (RV → LV)

10 ms (RV → LV)

CONCLUSION

Regarding selecting predictor of CRT-induced positive remodeling, a paradox of QRS duration reduction¹ versus acute hemodynamic measurement² 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 studies³⁻⁵ 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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IMPLANT FINDINGS AND OPTIMIZATION CONSIDERATIONS

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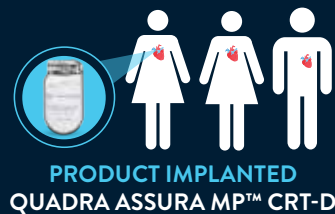
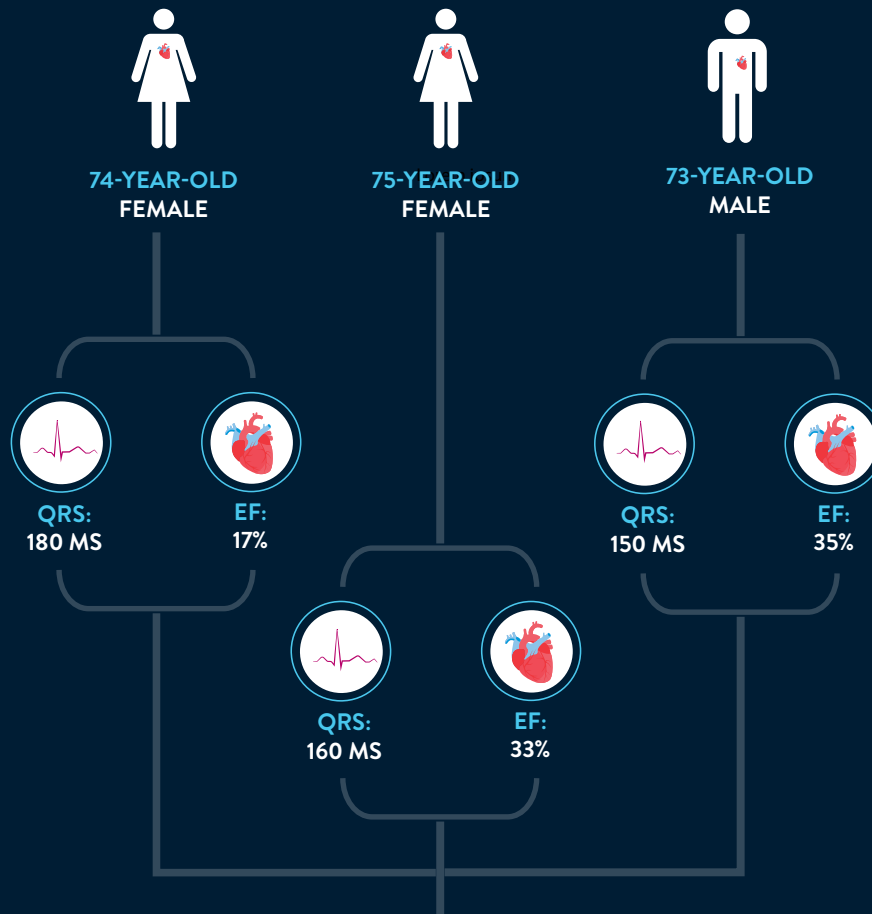
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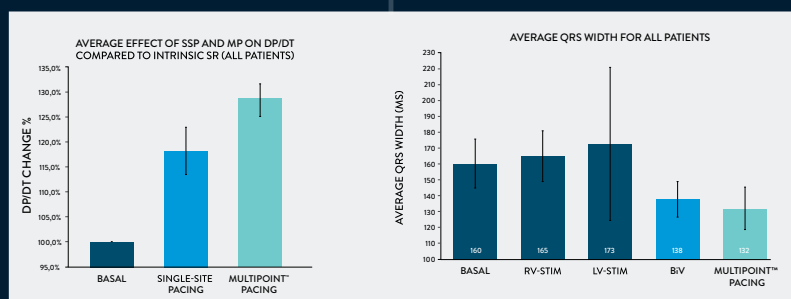
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MULTIPOINT™ PACING CASE STUDY

ELECTRICAL CHANGES IN A PATIENT UNDERGOING CARDIAC RESYNCHRONIZATION THERAPY



MULTIPOINT™ PACING
WAS TURNED
ON IMMEDIATELY



INTRODUCTION

In recent years, cardiac resynchronization therapy (CRT) has seen many changes. One of the most interesting occurred in 2009 with the introduction of the quadripolar technology for left ventricular leads, which reduced the occurrence of common therapy problems such as phrenic nerve stimulation and high thresholds to a historic minimum.¹ Even though quadripolar leads allow a more individualized CRT optimization, response to CRT is inadequate and unpredictable.² A new technology in pacing for quadripolar systems now allows an additional stimulation vector (MultiPoint™ Pacing) added to the standard quadripolar left ventricular single-site pacing. This results in a double LV-stimulation per cardiac cycle. The two stimulation vectors can be chosen from the 10 vectors available in the quadripolar systems. Presented here are three cases of a recent MultiPoint Pacing implantation with an acute hemodynamic assessment of contractility via intracardiac LV dp/dt_{max} measurement.

METHODS

All patients were implanted with a quadripolar CRT-D (Quadra Assura MP™ CRT-D, Abbott) with MultiPoint pacing capability. After the implantation of the CRT-D was finished, a pressure wire (PressureWire™ FFR measurement system, Abbott) was placed in the LV cavity over a standard multipurpose catheter. The dp/dt_{max} was assessed using the PhysioMon™ software (Abbott). The patients did not receive any sedative or analgesic agents and the measurement was performed with emphasis on a quiet and undisturbed environment to limit external influences on the dp/dt_{max} . A baseline unpaced ECG in sinus rhythm (SR) was recorded. To allow comparison between different patients, a protocol was developed to standardize programming and measurements. The AV-time was optimized using an ECG-based method.³ For the conventional BiV stimulation, the VV-delay was programmed to simultaneous. The delay of the two MultiPoint pacing pulses (LV1/LV2/RV) was set to 5 ms between LV1 and LV2 and 15 ms between LV2 and RV. All stimulation vectors (Baseline, BiV and MultiPoint pacing) were tested in a random order protocol.

Each vector was evaluated in the same way. The output was programmed 2 V above the measured threshold. At least 15 sec of a stable rhythm were recorded. Premature ventricular complexes (PVCs) were manually identified and excluded from the analysis. For every configuration, a 12-lead ECG was recorded.

Table 1

	Patient 1	Patient 2	Patient 3
Gender	Female	Female	Male
Age	74	75	73
Etiology	DCM	DCM	CAD
QRS-width (ms)	180	160	150
QRS Morphology	LBBB	LBBB	LBBB
EF (%)	17	33	35
AV-Time (ms)	180	160	170
Atrial rhythm	SR	SR	paroxysmal AF/SR at implant

PATIENT HISTORY

All patients were on stable medication for heart failure. Patient characteristics are stated in Table 1.

IMPLEMENTATION AND LEAD PLACEMENT

Implantation of the device and the leads with standard techniques was successful with good threshold and impedances. The LV lead was implanted in a lateral/posterolateral position (see Figures 1 to 3).

Figure 1: Patient 1 (LAO 45°)

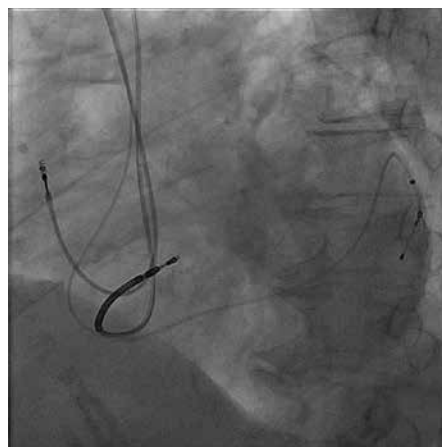
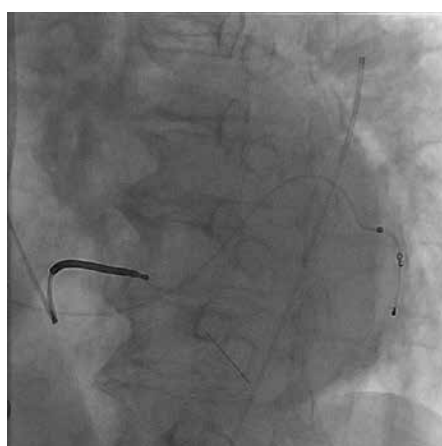


Figure 2: Patient 2 (LAO 40°)



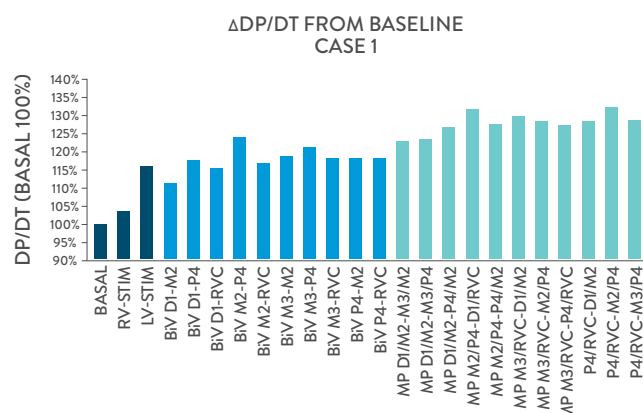
Figure 3: Patient 3 (LAO 41°)



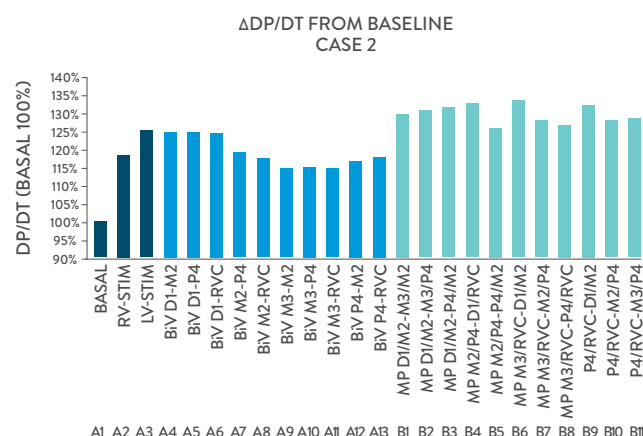
MEASUREMENTS AND MULTIPOINT™ PACING CONFIGURATION

Graphs 1 to 3 show the results that the LV dp/dt_{max} measurements yielded.

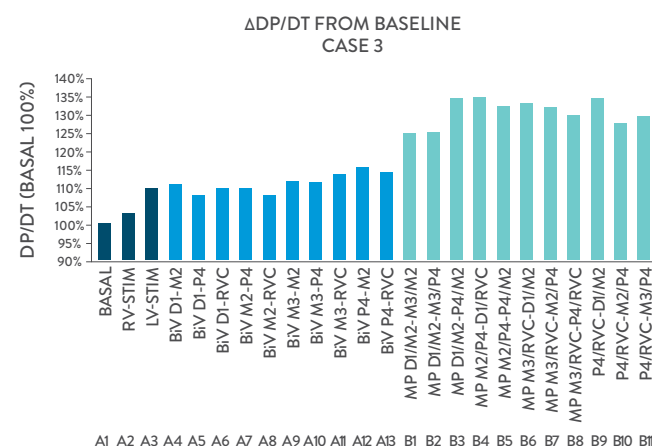
Graph 1



Graph 2

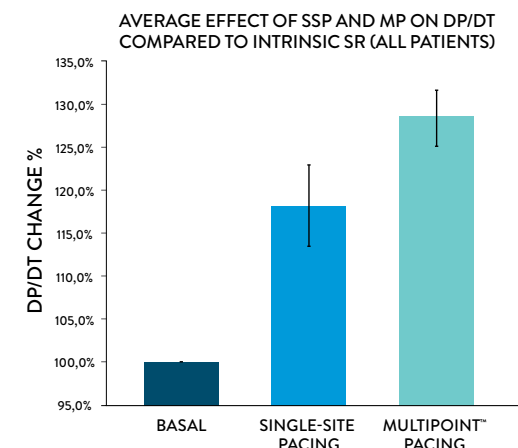


Graph 3

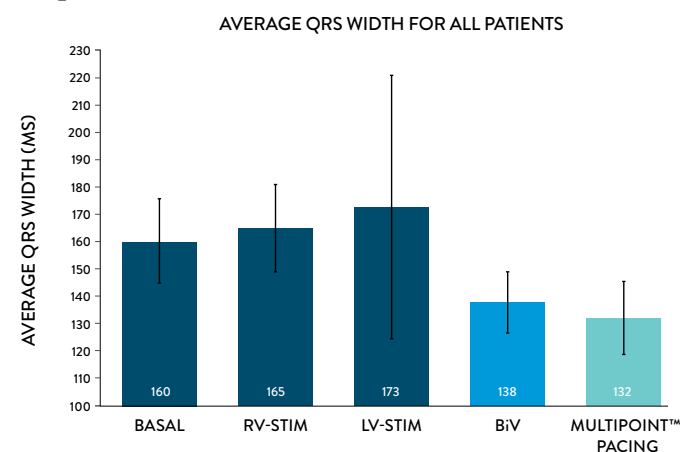


The average effect of BiV vs. MultiPoint pacing stimulation over all patients is summarized in Graph 4.

Graph 4



Graph 5



CONCLUSION

In patients with an indication for CRT, MultiPoint pacing reduces the average QRS width. In comparison with single-site pacing and standard biventricular pacing, MultiPoint pacing may potentially show an additional increase of acute LV dp/dt_{max} measurements. This indicates a positive effect on acute inotropic contraction and may potentially alleviate the rate of non-responders.

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HOW WILL THIS NEW TECHNOLOGY INFLUENCE VELOCITY TIME INTEGRAL?

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MULTIPOINT™ PACING CASE STUDY

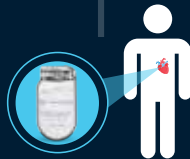
HEMODYNAMIC CHANGES IN A
PATIENT UNDERGOING CARDIAC
RESYNCHRONIZATION THERAPY



74-YEAR-OLD MALE WITH
NYHA CLASS III, LEFT BUNDLE
BRANCH BLOCK (LBBB)



VELOCITY TIME
INTEGRAL: 22 CM



PRODUCT IMPLANTED
QUADRA ASSURA MP™ CRT-D



MULTIPOINT™ PACING
WAS TURNED
ON IMMEDIATELY



VELOCITY TIME INTEGRAL:
38% ACUTE IMPROVEMENT
AS COMPARED TO
TRADITIONAL BIV PACING

* AT 6 MONTHS THE VTI IN TRADITIONAL
IMPROVED TO ALMOST AS MUCH AS
THE MULTIPOINT™ PACING SITE

PATIENT HISTORY

A 74-year-old male presented with NYHA Class III, left bundle branch block (LBBB), EF 28%, QRS width 148 msec, velocity time integral (VTI) at 22 cm.

The aim of this case was to evaluate the influence of MultiPoint™ pacing on VTI with acute echocardiographic testing at baseline, after implant and after 6 months.

PROCEDURE

After CRT implantation and at 6 months of follow-up, an echocardiographic test was performed measuring mean VTI (over three tests) for each configuration tested. The configurations tested were distal biventricular (D1-RVCoil) and four different MultiPoint pacing configurations (see Table 1). After the implant, the device was permanently programmed in BiV pacing mode.

Table 1

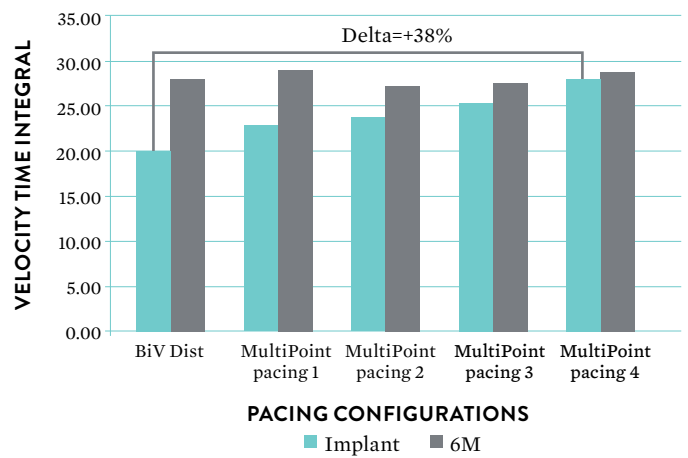
Pacing Configurations	Delays V-V [ms]
BiV: D1-RV Coil	0
MultiPoint pacing: M3-P4; D1-RV Coil	5-5
MultiPoint pacing: M3-P4; D1-RV Coil	20-5
MultiPoint pacing: D1-RV Coil; M3-P4	20-5
MultiPoint pacing: D1-RV Coil; M3-P4	5-5

RESULTS

In acute tests at baseline, VTI with all MultiPoint pacing configurations was always better than in BiV configurations, and the best value was 28 cm (best improvement over the VTI with conventional BiV pacing: Delta = +38%). Only after 6 months in BiV pacing mode, the VTI increased at a value comparable to the acute MultiPoint pacing VTI value, as well. At 6 months, MultiPoint pacing mode was tested again and the VTI was found to be greater than VTI in BiV mode (29 cm, see Figure 1).

BiV pacing increased VTI after 6 months. With MultiPoint pacing, pacing increased VTI immediately after the implant (in acute).

Figure 1. Average of VTI in different pacing configurations



CONCLUSION

Traditional CRT is an established therapy which provides clinical benefit in a majority of patients. However, our case study has shown promising results of the acute impact of MPP on VTI.

In this case, the same improvement in VTI was obtained with acute MultiPoint pacing tests 6 months in advance; also, a better result at 6 months follow-up was shown.

MAXIMUM LV DP/DT_{MAX}
ACHIEVED WITH
MULTIPOINT™ PACING
AS MEASURED BY
NON-INVASIVE MEANS
IN A TERMINAL HEART
FAILURE PATIENT

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MULTIPOINT™ PACING CASE STUDY

HEMODYNAMIC CHANGES IN A
PATIENT UNDERGOING CARDIAC
RESYNCHRONIZATION THERAPY



PATIENT HISTORY

A 56-year-old man with advanced heart failure was initially referred for consideration of heart transplantation. He presented with repeated heart failure hospitalization since the beginning of 2014 and continued to deteriorate despite best-tolerated optimal medical therapy (NYHA Class IV ambulatory).

The patient's detailed medical history revealed multiple co-morbidities, including a history of Crohn's disease and Behçet syndrome with severe aortitis. He has a medical history of Crohn's disease and Behçet syndrome with severe aortitis. He underwent prosthetic aortic valve replacement (AVR) and mitral valvuloplasty in 2006 for severe aortic and mitral regurgitation. Due to recurrent infective endocarditis, he required lifelong clindamycin treatment. Other significant co-morbidities included renal cell carcinoma with left nephrectomy performed in 2005. MRI of the brain showed multiple old infarcts.

Taking into account the above medical history, he was considered neither a suitable candidate for heart transplant nor an implantable left ventricular assist device (LVAD) recipient. After much detailed discussions, cardiac resynchronization therapy (CRT) was offered as a last resort for him and a special effort was made to ensure the best possible CRT programming and optimization for this desperate patient.

PROCEDURE

The patient's baseline characteristics included the following:

1. ECG: Sinus rhythm with LBBB pattern (QRS duration 225 ms)
2. Echocardiography: Markedly dilated left ventricle (LV) with globally impaired contraction (LVdd/sd was 9.0/8.7 cm, ejection fraction 8%), moderate mitral regurgitation, AV prosthesis functioning with no paravalvular leakage seen

The patient underwent successful CRT-D implantation (Quadra Assura MP™ CRT-D, Abbott) with LV quadripolar lead (Quartet™ Quadripolar LV Lead 1458Q/86, Abbott) positioned in coronary sinus lateral branch in January 2015 (Figures 1a and 1b).

Acute direct invasive hemodynamic measurements of LV dp/dt_{max} could not be performed during the procedure due to the presence of mechanical aortic valve prosthesis. Instead, both acute data during implantation and subsequent chronic hemodynamic data were collected by using Nexfin™ hemodynamic monitoring system (Edwards Lifesciences) (Figure 2). The result of the dp/dt_{max} by Nexfin system measured during implantation is shown in Table 1.

Figure 1a. Retrograde coronary sinus venogram (LAO view) delineating CS branches. The metallic aortic valve prosthesis and mitral valvuloplasty ring could be clearly visualized.

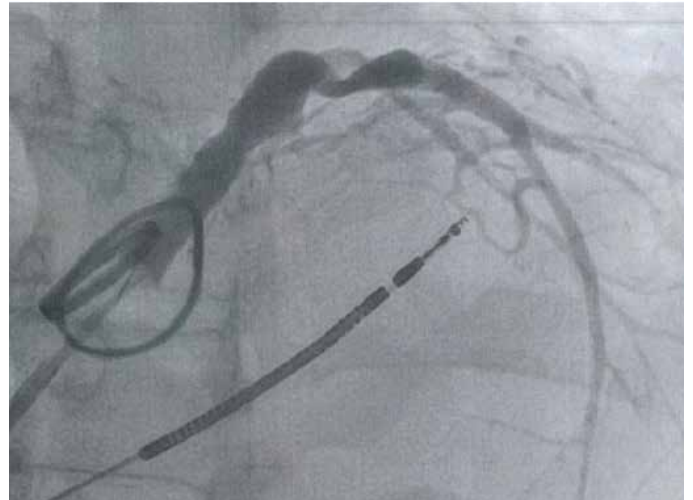
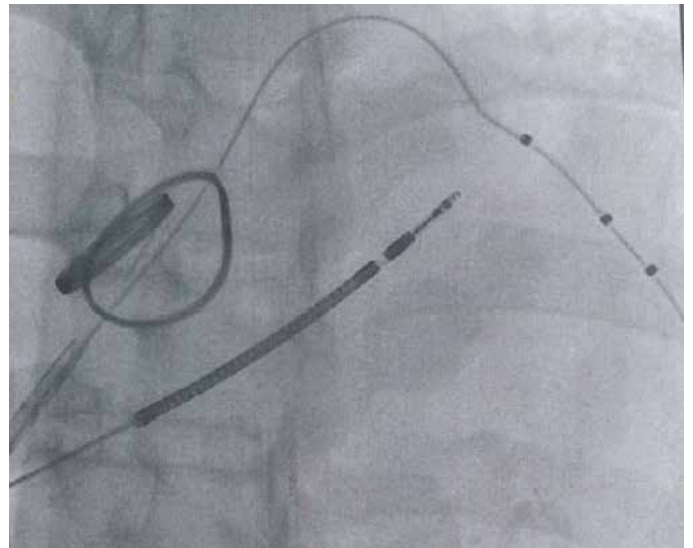


Figure 1b. Position of LV Quadripolar lead in CS posterolateral branch



Other additional features utilized for further optimization of device programming (all from Abbott) are shown in Figure 3:

1. QuickOpt™ timing cycle optimization
2. VectSelect™ programmable LV pulse configuration
3. RV-LV conduction time measurement
4. DeFT Response™ technology

In view of markedly dilated LV, MultiPoint™ Pacing (Abbott) was not turned on until one month follow-up when the final position of the LV lead was fixed and stabilized. We repeated the echocardiogram at one month post-conventional biventricular pacing, three and six months after MultiPoint™ Pacing was programmed at best selected configurations as guided by dp/dt_{max} .



A simple, noninvasive approach to monitoring key hemodynamic parameters.

- Stroke Volume (SV)
- Stroke Volume Variation (SVV)
- Cardiac Output (CO)
- Systemic Vascular Resistance (SVR)
- Continuous Blood Pressure (cBP)

Cross-section of cuff application.

To accurately mirror arterial line output, real-time finger pressure measurement is performed 1000 times per second utilizing the volume clamp method.

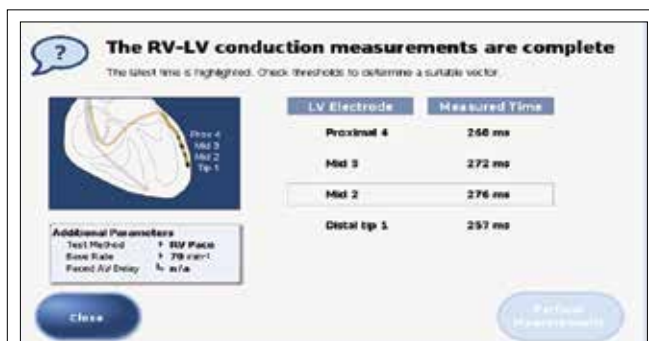
Table 1. Results of LV dp/dt_{max} measurement by Nexfin™ system during implant

Types of measurement	Mode of Pacing	dp/dt_{max} Measurement
Baseline	ApVs	856
RV pacing only	ApRVp	891
LV pacing only LV pacing D1 to M2	ApLVp	1107
Bi-V pacing with nominal setting LV: D1 to M2 PAV: 140 ms/SAV: 90 ms/Simultaneously	ApBiVp	1133
Bi-V pacing with QuickOpt™ optimization LV: D1 to M2 PAV 140 ms/SAV 90 ms/ LV first 65 ms	ApBiVp	1126

Table 2. Measurement of dp/dt_{max} by Nexfin™ system one-month follow-up

Mode of pacing			dp/dt measurement (mmHg)
MultiPoint™ Pacing	LV1: M2-P4 LV2: M3-M2	LV1 - LV2 Delay: 5 ms LV2 - RV Delay: 30 ms	1120
		LV1 - LV2 Delay: 10 ms LV2 - RV Delay: 25 ms	1124
		LV1 - LV2 Delay: 15 ms LV2 - RV Delay: 20 ms	1161
		LV1 - LV2 Delay: 20 ms LV2 - RV Delay: 15 ms	1209
		LV1 - LV2 Delay: 25 ms LV2 - RV Delay: 10 ms	1262
		LV1 - LV2 Delay: 30 ms LV2 - RV Delay: 5 ms	1273

Figure 3. Measurement of RV-LV conduction and QuickOpt™ optimization for recommendations of MultiPoint™ Pacing setting



Measurement of RV-LV conduction delay try to find out the longest conduction time and shortest conduction time.

	Programmed	Optimal
Paced AV Delay:	120 ms	140 ms
Sensed AV Delay:	90 ms	90 ms
	Programmed	Optimal
Interventricular Pace Delay:	65 ms (LV → RV)	65 ms (LV → RV)

QuickOpt™ optimization measurement

RESULTS

The patient was discharged home with CRT pacing under conventional biventricular pacing configuration, namely PAV 140 ms/SAV 90 ms with LV first 65 ms by QuickOpt™ optimization, and quadripolar LV lead vector of D1-P4 since this configuration had the lowest capture threshold without phrenic nerve stimulation. His ECGs at baseline and post CRT implantation were showed in Figures 4a and 4b.

Figure 4a. ECG at baseline with LBBB pattern (QRS duration: 225 ms)



Figure 4b. ECG at post-CRT-D implantation

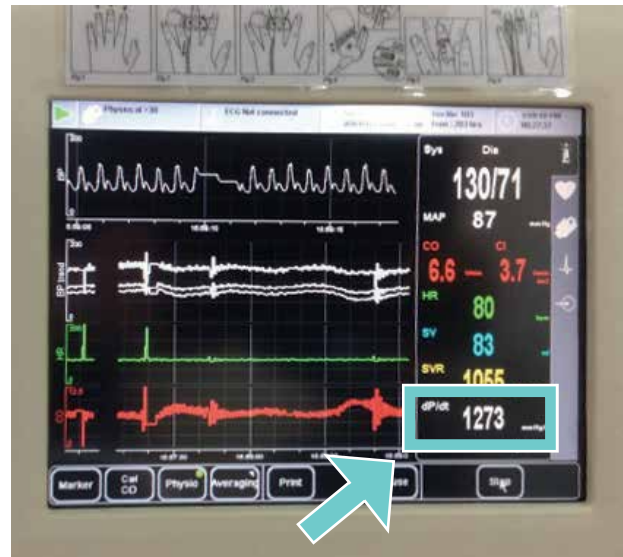


The patient returned at one month post-implantation and was reassessed with an echocardiogram (LVdd/Sd 9.3/8.6cm, EF 15%) and underwent repeat cardiac resynchronization therapy optimization using Nexfin™ continuous hemodynamic monitoring system as guidance (Figures 5a and 5b). Due to non-invasiveness of Nexfin™ system, we devised a more detailed study by testing various combinations of MultiPoint™ Pacing programming in order to identify the best cardiac output with maximum dp/dt_{max} . In this case, the best MultiPoint™ Pacing configuration was LV1(M2-P4) to LV2(M3-M2): 30 ms and LV2(M3-M2) to RV 5 ms as shown in Table 2. His latest echocardiogram performed six months post-implant showed significant remodeling effects (LVdd/sd 8.3/7.4 cm, EF 24%). A comparison of his chest X-rays before CRT-D implantation and at six months was shown in Figures 6a and 6b showing evidence of significant reduction in cardiomegaly. Clinically, the patient has significant improvement in exercise tolerance (NYHA Class II) during subsequent follow-ups.

Figure 5a. Patient undergoing detailed study with various MultiPoint™ Pacing programming combinations.



Figure 5b. Best dp/dt_{max} 1273 mmHg (arrow) indicated with best optimal MultiPoint™ Pacing setting



DISCUSSION

Cardiac resynchronization therapy has been shown to improve exercise capacity and quality of life and to reduce heart failure hospitalizations and mortality in patients with NYHA Class III and IV heart failure.^{1,2} In randomized studies, the number of NYHA Class IV heart failure patients enrolled has been very low. Many NYHA Class IV patients are still considered unsuitable for survival studies and have been systematically excluded from clinical trials because of the expectation of a much shortened lifespan. The COMPANION trial's sub-analysis of NYHA Class IV patients demonstrated that CRT-P and CRT-D improve only the combined endpoint of time to all-cause mortality and hospitalizations in ambulatory NYHA Class IV patients but could not show a benefit on survival.³⁻⁵

In reality, the line between NYHA classes is not distinct and determination of disease severity in heart failure requires a wide range of clinical, biochemical and functional parameters. As a result, universally accepted and definable measures are still lacking. Furthermore, many of these patients are ambulatory but require repeated hospitalizations with resource-consuming treatments, and neither heart transplant nor implantation of assist devices are appropriate treatment for them. The patient reported here illustrated the actual reality case in which carefully titrated MultiPoint™ Pacing therapy allowed significant reverse remodeling in an otherwise desperate patient with end-stage heart failure, which we encountered other than those patients included and reported in large randomized clinical survival studies.

Invasive acute hemodynamic response by measuring dp/dt_{max} to guide LV lead implantation predicts chronic remodeling in patients undergoing CRT.⁶ This was contraindicated in this patient with mechanical aortic valve prosthesis and thus we resorted to use an alternative non-invasive hemodynamic monitor Nexfin™ system as a guide to clinical decisions for guiding MultiPoint Pacing therapy for this patient. In fact, due to its non-invasive nature, future refinement of MultiPoint Pacing programming during short- and long-term follow-ups becomes an added bonus.

The measurement of cardiac output (CO) has been traditionally limited to critically ill patients in the intensive care unit. However, with an increasing number of heart failure patients undergoing device therapy such as CRT, goal-directed therapy of maximizing CO and dp/dt_{max} values in acute setting and long-term management guided by non-invasive manner is desirable. The recently introduced Nexfin™ monitoring system is a completely non-invasive system requiring only the use of pneumatic finger cuff, without the insertion of any intravascular lines. It consists of a model-based method that provides beat-to-beat measurement of CO by analysis of the non-invasive finger arterial blood pressure trace, which is measured continuously by the use of an inflatable finger cuff. Stroke volume is determined by dividing the pulsatile systolic area of each beat by impedance, which is estimated by the device based on patient characteristics.

Numerous studies have been published validating this technique for monitoring blood pressures when compared to invasive monitoring.^{7,8} Although this was associated with some conflicting results as to its potential usefulness with recent studies, it showed promising results in regards to its ability to trend when compared to pulmonary artery catheter values,^{7,9} transthoracic echocardiography and esophageal Doppler.¹⁰ Furthermore, we propose that CO and dp/dt_{max} data obtained by a less invasive technique, even if slightly less accurate, may be preferable if it can be obtained more rapidly and conveniently, and allows tracking and titrating the short-term and long-term effects of MultiPoint™ Pacing in patients with advanced heart failure implanted with CRT.

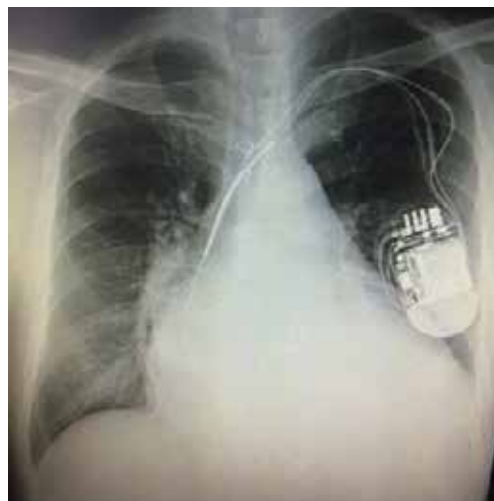
CONCLUSION

In addition to a novel and innovative approach at the optimization of therapy using the Nexfin system, this case study reflects a significant clinical improvement with MultiPoint Pacing in the conversion of a hemodynamically unstable NYHA class IV heart failure with multiple comorbidities, who was previously rejected for advanced heart failure treatments.

Figure 6a. X-ray pre-implant



Figure 6b. Six-month post-implant with MultiPoint™ Pacing therapy



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CAN MULTIPOINT™ PACING IMPROVE AN ECHO-OPTIMIZED PATIENT?

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MULTIPOINT™ PACING CASE STUDY

HEMODYNAMIC CHANGES IN A
PATIENT UNDERGOING CARDIAC
RESYNCHRONIZATION THERAPY



54-YEAR-OLD MALE WITH
BIFASCICULAR BLOCK



EF: 27%



PRODUCT IMPLANTED
QUADRA ASSURA MP™ CRT-D
AV DELAY WAS OPTIMIZED
VTI = 28.21 CM



MULTIPOINT™ PACING
WAS TURNED ON
VTI = 30.10 CM



EF: 32%

CLINICAL HISTORY

- 54-year-old male
- February 2014: Complaints of dyspnea
- March 2014: ECG showed bifascicular block
- April 2014: Echocardiogram showed a dilated left ventricular ejection fraction (LVEF) 46%
- June 2014: MRI showed LVEF 27%
- July 2014: Coronary angiogram (CAG) with normal coronary arteries

PROCEDURE

November 2014: Implant of an Abbott Quadra Assura™ CRT-D with MultiPoint™ Pacing technology. The implant procedure was uncomplicated. A nice posterolateral vein was found and a Quartet™ lead was placed.

Measurements and Device Parameters

- Optimal VV timing with echo achieved best results when pacing LV 20 msec before RV.
- Initial velocity time integral (VTI) was 26.6 cm (Figure 1); after the echo optimization, VTI increased to 28.2 cm (Figure 2).
- Device was further optimized with MultiPoint™ Pacing based on the site of latest LV activation (RV pace to LV sense).
 - Electrode 1:201 msec delay
 - Electrode 2:209 msec delay
 - Electrode 3:217 msec, which has the latest activation point
 - Electrode 4:201 msec delay but with high threshold
- VTI was measured at different MultiPoint™ Pacing settings, with the largest measurement (30.1 cm) corresponding to MPP using electrodes 3 and 2 (LV1-LV2) with LV1-LV2 and LV2-RV delays of 10 msec (Figure 3).
- Output settings were right atrium 2.0 V and both RV and LV 1.5 V by 0.5 msec.

Figure 1. VTI initial 26.63 cm

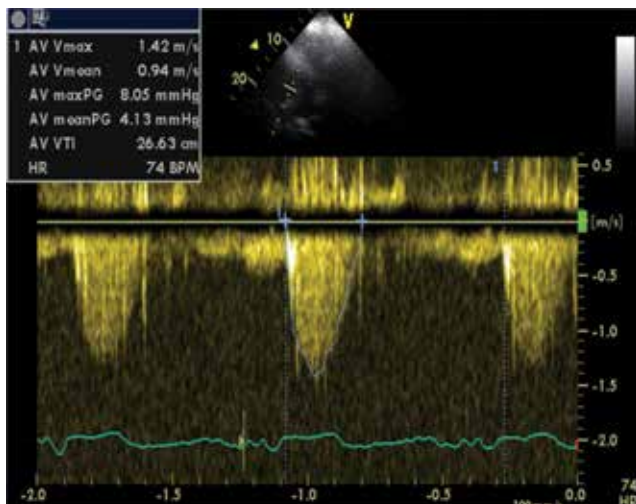


Figure 2. VTI optimal 28.21 cm

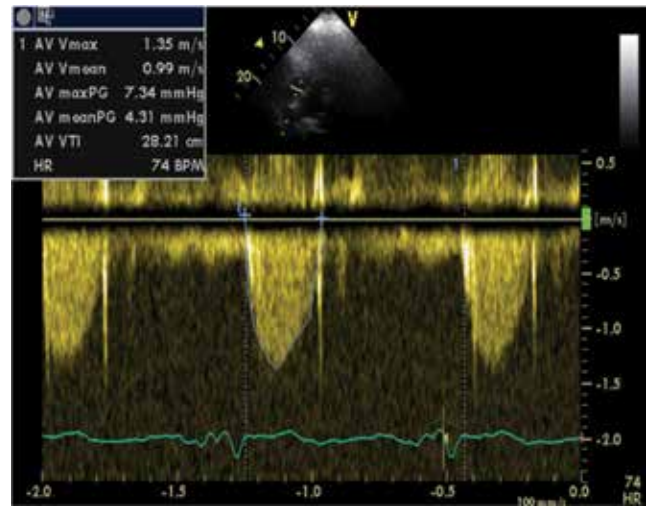
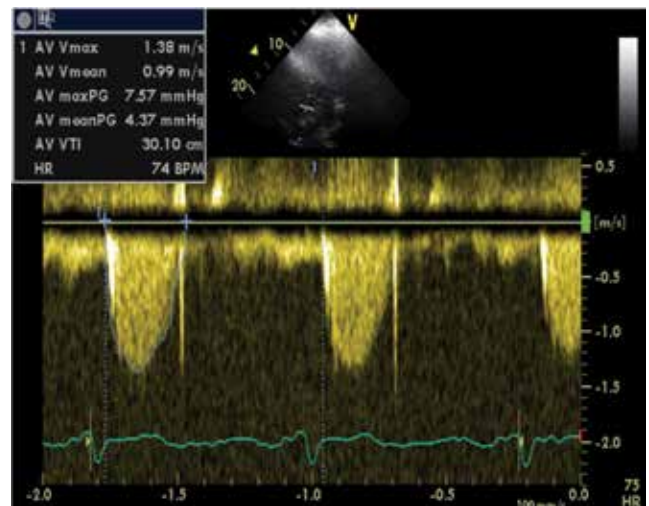


Figure 3. VTI optimal with MultiPoint™ pacing 30.10 cm



CONCLUSION

- AV timing of 200 msec was optimal; this was the first series of measurements before starting the VV timing.
- LV 20 msec before RV was the optimal echo optimization.
- MultiPoint™ Pacing was optimized when using LV1-LV2 (Electrode 3 - Electrode 2) and LV2-RV both with 10 msec delays.
- Ejection fraction improvement was from 26% to 32%.
- When the optimization was done, lead measurements and sensing were stabilized.
- Echo optimizations performed by experienced physicians and technicians is standard protocol in this hospital, but MultiPoint Pacing provided a better patient outcome in this specific case study.

AN OPTICARE-QLV CASE STUDY: PRESSURE-VOLUME LOOPS TO OPTIMIZE CRT WITH A QUADRIPOlar (QUARTET LEAD) LEFT VENTRICULAR LEAD

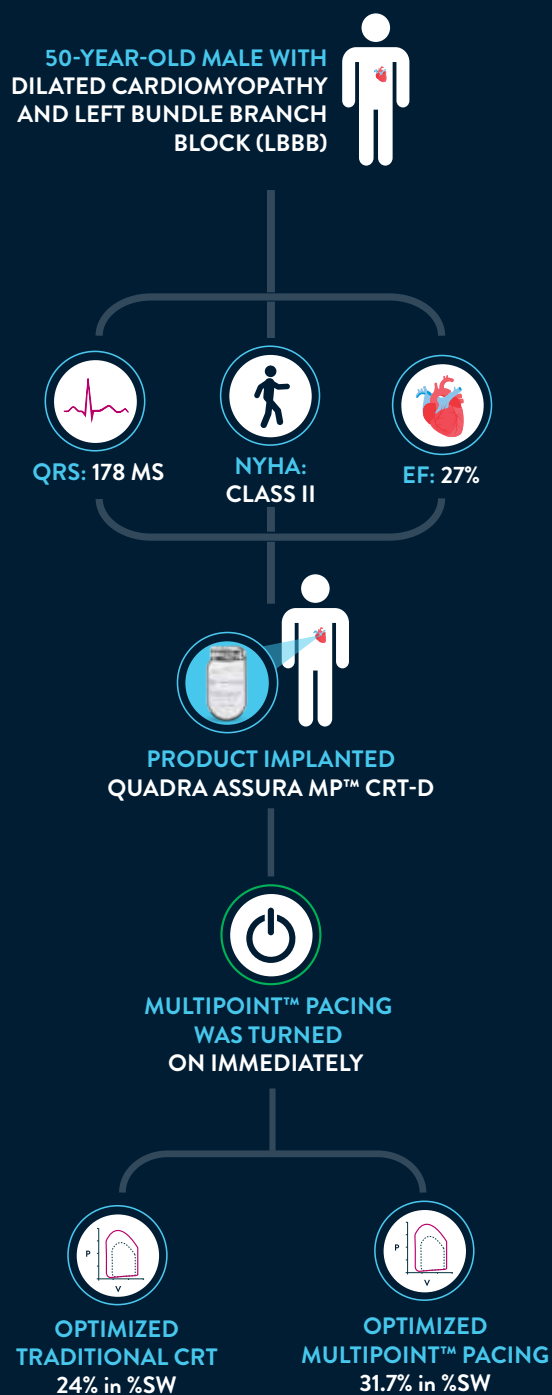
W.M. van Everdingen, M.D.

A.T. Tuinenburg, M.D.

M. Meine, M.D.

MULTIPOINT™ PACING CASE STUDY

HEMODYNAMIC CHANGES IN A
PATIENT UNDERGOING CARDIAC
RESYNCHRONIZATION THERAPY



INTRODUCTION

This is a case report of a 50-year-old male with dilated cardiomyopathy and left bundle branch block (LBBB) who underwent cardiac resynchronization therapy (CRT) implantation. The patient participated in a study conducted in the UMC Utrecht (the Netherlands) optimizing CRT settings with pressure-volume loop measurements; the OPTICARE-QLV study.

This patient suffers from heart failure, NYHA functional Class II with a LV ejection fraction of 27% on MRI. A dilated cardiomyopathy was diagnosed, as MRI showed no signs of delayed enhancement. Comorbidity was paroxysmal atrial fibrillation. ECG: QRS-width of 178 ms with a LBBB according to Strauss criteria (Figure 1).

Figure 1. Baseline ECG recording, showing an LBBB.

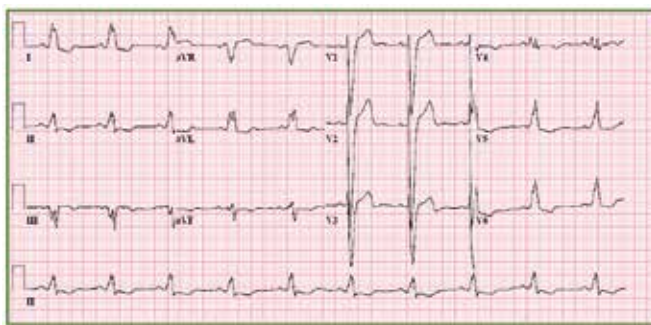


Figure 2A. An RAO 0 recording during CRT implantation. The abbreviations (D1, M2, M3 and P4) represent the four quadripolar electrodes of the Quartet™ lead.

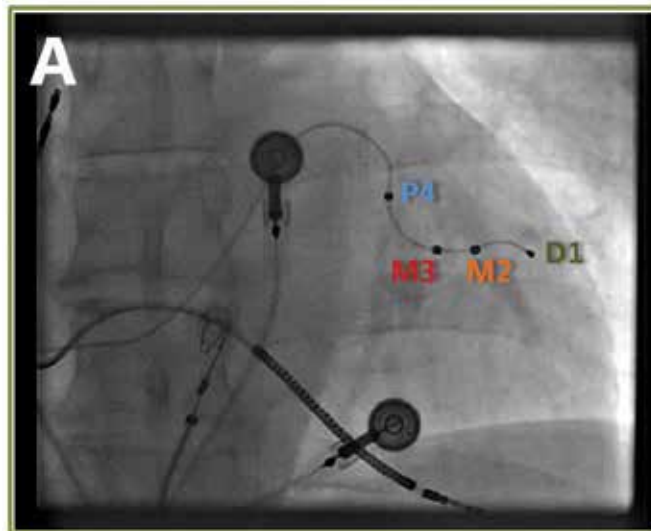
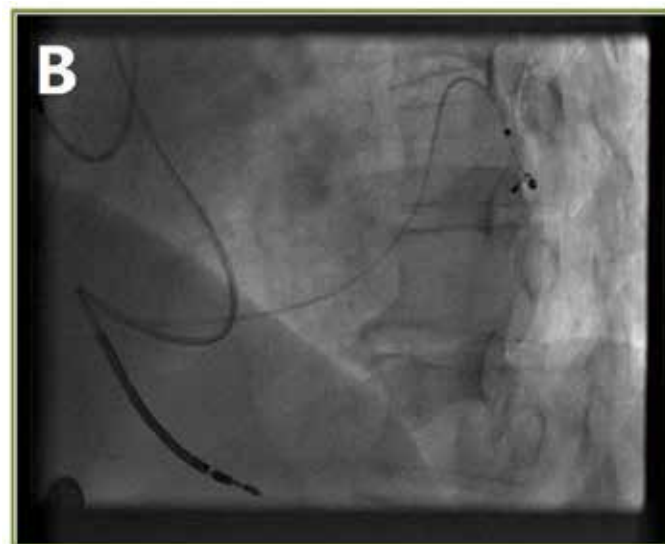


Figure 2B. Represents the LAO 40° recording.



METHODS

A CRT-D device (Quadra Assura MP™, Abbott) was successfully implanted with a Quartet™ quadripolar LV lead. First, the electrical delays between onset of QRS-complex and local LV-depolarization were measured (QLV) of each quadripolar electrode. Next, a pressure volume loop catheter (CD Leycom™, Zoetermeer, the Netherlands) was inserted via the femoral artery and placed in the LV cavity.

Pacing settings were optimized for all four quadripolar electrodes, using the RV-coil as anode. Four atrioventricular delays (AVD) were implemented, using 80, 60, 40 and 20% of the intrinsic atrial paced to RV-sensed delay. All settings were programmed using an interventricular delay (VVD) of -40 ms (LV first). DDD pacing was performed 5 to 10 beats above intrinsic rhythm. PV-loops (Figure 3) were recorded for 60 beats for each pacing setting and compared to preceding and subsequent baseline recording of 30 beats each (AAI pacing). The resulting parameter, increase in stroke work compared to baseline (%SW) was recorded and calculated by offline analysis for each setting and electrode.

The results of %SW were plotted against the used AV-delay, and a second order polynomial curve was fitted to the data. The maximal increase of the fitted line was used as the theoretical maximal benefit of the quadripolar configuration.

Finally MultiPoint™ Pacing was implemented, using the electrodes D1 and P4 of the quadripolar lead. Three settings were compared: simultaneous MultiPoint™ Pacing with D1 and P4 (D1-RVcoil and P4-RVcoil with a minimal inter left ventricular delay (ILVD) of 5 ms and a VVD of -35 ms), D1 and P4 with an ILVD of 35 ms and VVD of -5 ms, and finally the electrode sequence was switched, pacing P4 first and D1 second with the same delays. All configurations were tested with the four previous mentioned AVD's.

Figure 3A. PV-loops of optimal biventricular pacing with D1-RVcoil with a AVD of 110 ms and VVD of -40 ms (green loop).

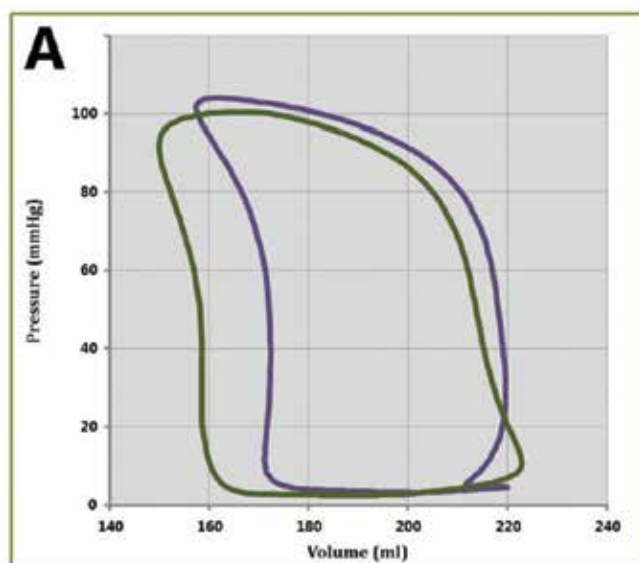
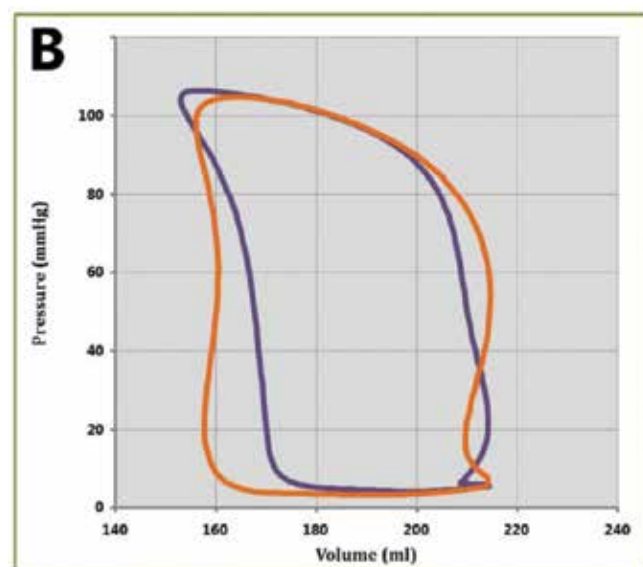


Figure 3B. Displays the PV-loop of the optimal MultiPoint™ Pacing setting in orange (P4D1, AVD 170 ms, VVD -5 ms and ILVD 35 ms.) The purple loops are the average of two neighboring baseline recordings.



RESULTS

The optimal pacing configuration using a quadripolar lead (D1-RVcoil, AVD 140 ms and VVD -40 ms) gave an acute increase of 24.0% in %SW (Figure 4A) compared to baseline. The electrode configuration with the least optimal response was P4-RVcoil, with an increase of 9.0%. MultiPoint™ Pacing gave a maximal benefit in %SW of 31.7% on D1 and P4 with an inter left ventricular delay of 35 ms (AVD 145 ms, VVD -5 ms, ILVD 35 ms (Figure 4B). There was no correlation between %SW and QLV (QLV results, D1: 153 ms, M2: 164 ms, M3: 162 ms, P4: 153 ms).

Figure 4A. Displays results of D1 (green), M2 (orange), M3 (red) and P4 (blue) using RV-coil as anode. D1-RVcoil has the maximal increase in %SW (24.0%).

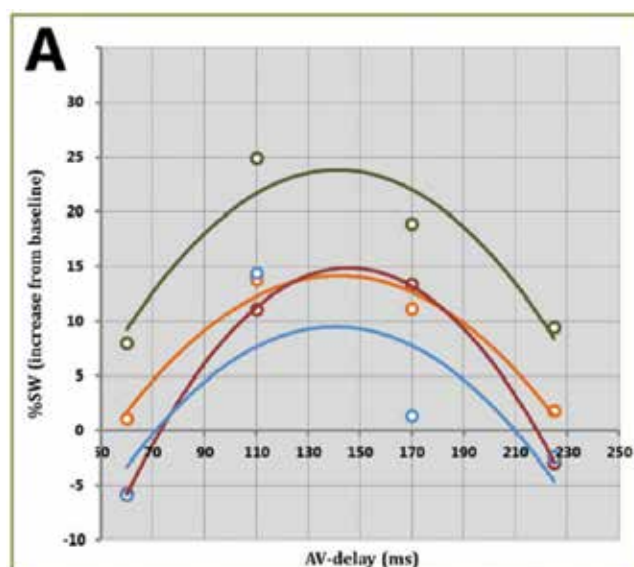
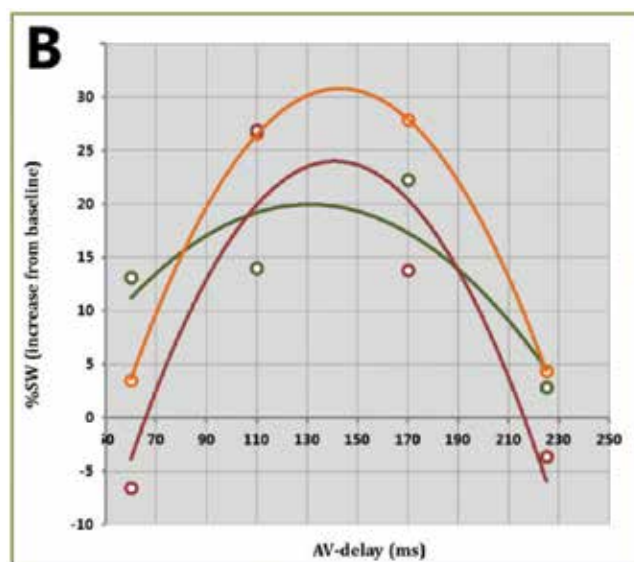


Figure 4B. Displays MultiPoint™ Pacing, with D1 and P4 simultaneous (green), D1 and P4 with an ILVD of 35 ms (orange) and P4 and D1 with an ILVD of 35 ms (red). P4D1, ILVD 35 ms gave the maximal increase of %SW (31.6%). Dots represent measured %SW per electrode and AV-delay, the colored lines represent the fitted curves.



CONCLUSION

This case report shows the acute hemodynamic benefit of optimizing CRT with a quadripolar LV lead, using multiple AV-delays and pressure-volume loops. It further advocates the potential benefit of MultiPoint™ Pacing. More cases are needed to confirm these results, and will follow in the OPTICARE-QLV study.

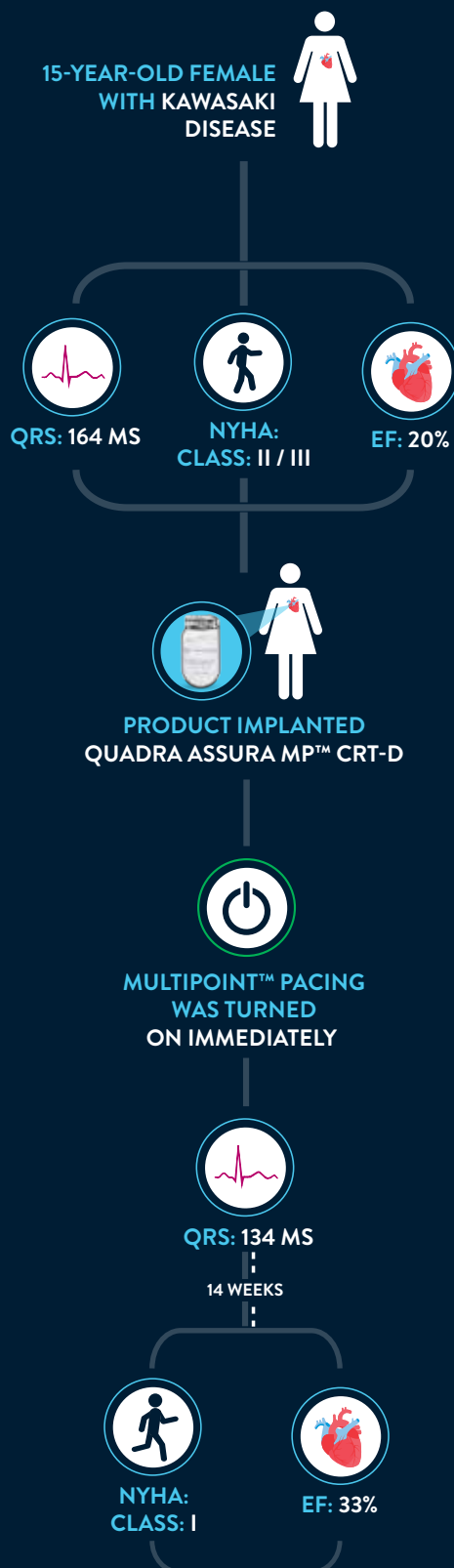
MULTIPOINT™ PACING CARDIAC RESYNCHRONIZATION THERAPY IMPROVES HEMODYNAMIC OUTCOMES

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MULTIPOINT™ PACING CASE STUDY

HEMODYNAMIC CHANGES IN A
PATIENT UNDERGOING CARDIAC
RESYNCHRONIZATION THERAPY



INTRODUCTION

Recent studies have shown that MultiPoint™ Pacing can improve the hemodynamic response to cardiac resynchronization therapy (CRT).¹ Data has also shown that the improvement was seen in both ischemic and nonischemic patients.¹⁻⁴ This new technology advancement has strengthened the confidence of a young ischemic cardiomyopathy patient, her family and her pediatric physician, who had been hesitant about device therapy but is now committed to CRT implant.

PATIENT HISTORY

- 15-year-old female
- NYHA Class II/III
- Kawasaki disease diagnosed in 2001 when patient was 1 year old
- Myocardial infarction due to LAD and RCA occlusion in 2011 that progressed to dilated cardiomyopathy
- CABG surgery in 2002 (LITA to mid LAD)
- Since 2010, the deterioration of LV function, QRS widening and dyspnea were more significant (Table 1)

Table 1

Time	QRS duration (ms)	LVEDD (mm)	LVESD (mm)	LVEF (%)	NYHA class
2010-Aug	106	55	40	52	I
2011-Jul	118	62	48	43	I
2012-Sep	138	68	51	47	I
2013-Jul	146	69	61	26	I-II
2014-Aug	158	72	60	33	II-III
2015-Jan	164	75	64	20	II-III

IMPLANTATION AND MULTIPPOINT™ PACING PROGRAMMING

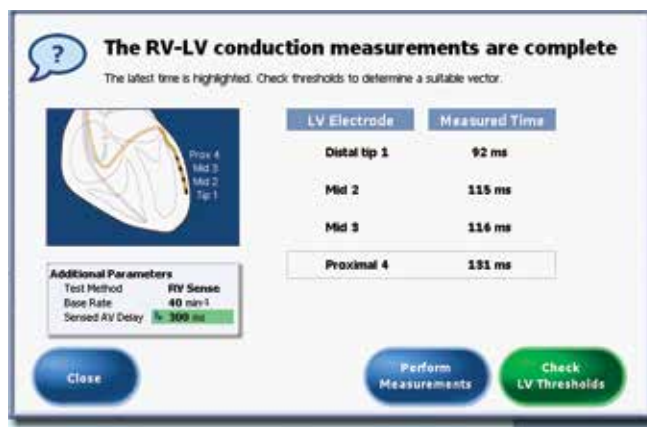
The patient was implanted with an Abbott Quadra Assura MP™ CRT-D and Quartet™ LV lead 1458Q. The Quartet lead facilitated a fast and smooth implantation of about 1.5 hours, which helped to lessen the nervousness of the pediatric patient.

ECG was evaluated for all 10 vectors under biventricular pacing. Then, RV-LV conduction test was performed to determine the earliest and latest conduction test.

RV-LV conduction test (RV sensed) (Figure 1)

- Earliest activation: D1 (92 ms)
- Latest activation: P4 (131 ms)

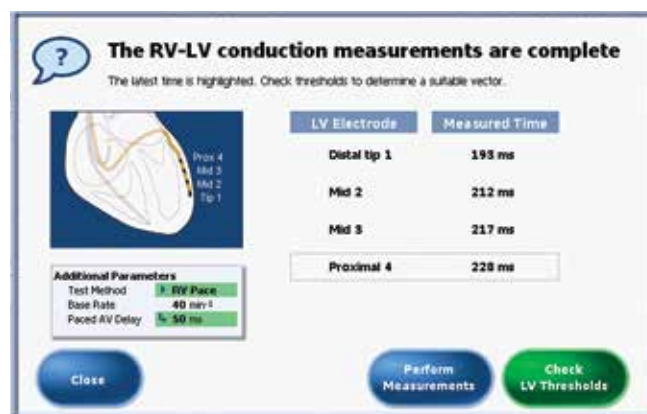
Figure 1



RV-LV conduction test (RV paced) (Figure 2)

- Earliest activation: D1 (193 ms)
- Latest activation: P4 (228 ms)

Figure 2



MultiPoint™ Pacing was programmed ON based on the RV-LV conduction test results in Figures 1 and 2 using P4 (latest activation site) as LV1 and D1 (earliest activation site) as LV2, and then to RV (Figure 3). The positions of the P4, D1 and RV pacing sites are as shown in the venograms (Figure 4).

Figure 3. Programed pulse configurations and delays for MultiPoint™ pacing

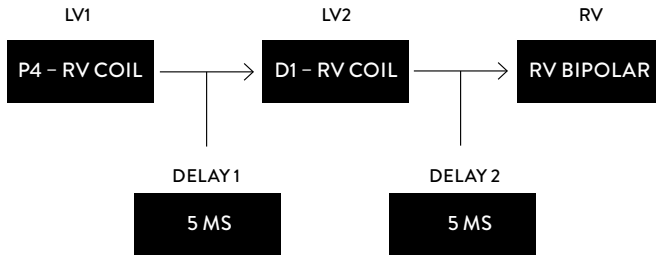
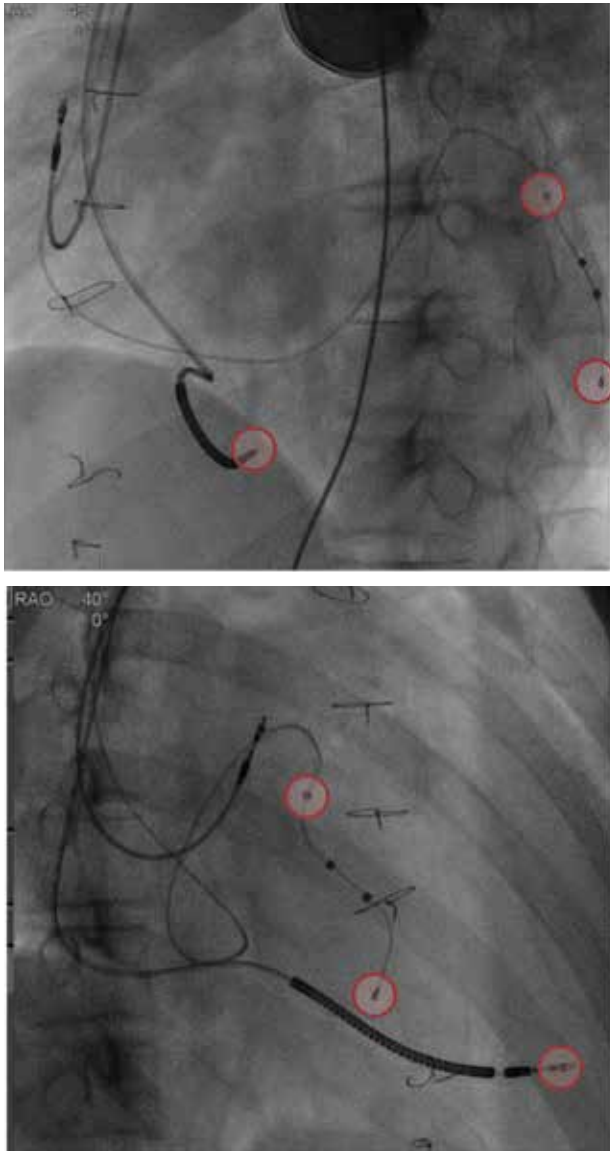


Figure 4. CRT-D: MultiPoint™ pacing with P4, D1 and RV



HEMODYNAMIC IMPROVEMENT WITH MULTIPOINT™ PACING

During the implant, the QRS duration under various pacing configurations was measured. A narrowing of the QRS complex was observed progressively from intrinsic baseline to conventional CRT (D1-M2), and then MultiPoint™ Pacing. The shortest QRS duration was achieved with MultiPoint Pacing at 134 ms (Figure 5).

Figure 5a. Change in QRS duration. 2010-Aug: QRSD 106 ms (top) and 2015-Jan: QRSD 164 ms (bottom)

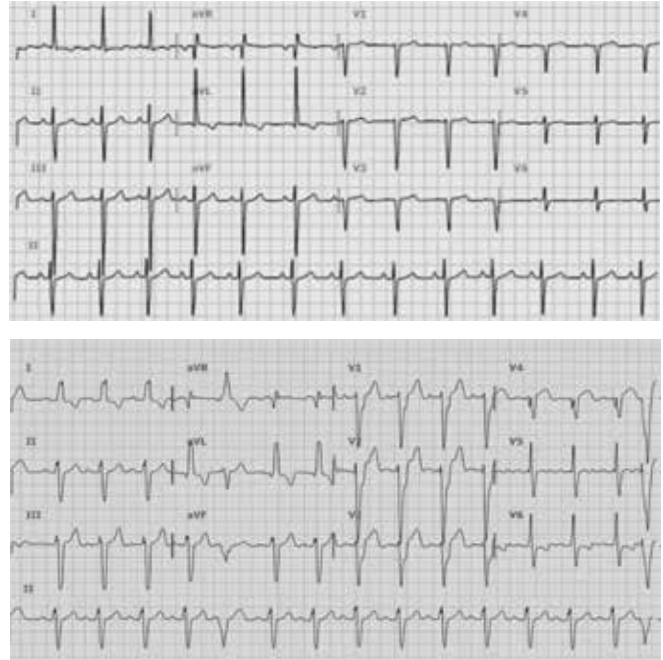


Figure 5b. Change in QRS duration. Conventional CRT: QRSD 145 ms (top) and MultiPoint Pacing CRT: QRSD 134 ms (bottom)

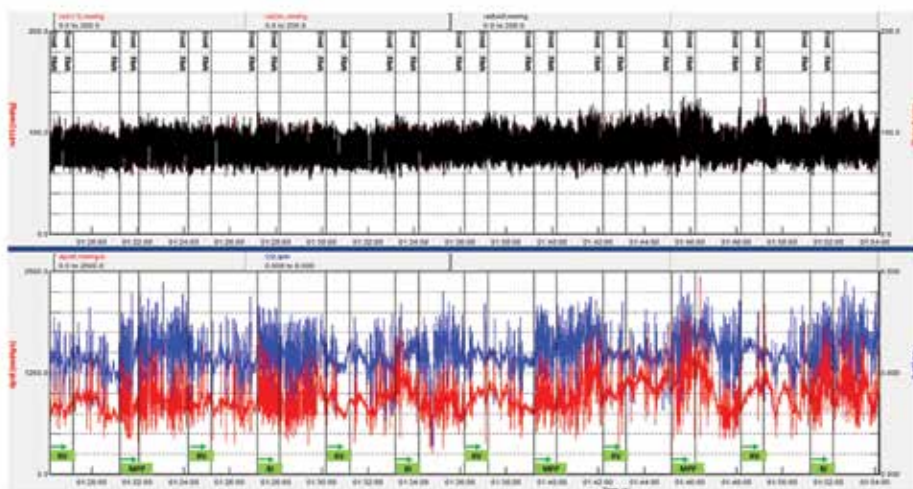


On the next day after implant, acute dp/dt_{\max} measurement was performed. The best dp/dt_{\max} was acquired under MultiPoint™ Pacing with a 39.4% increment from the baseline (Table 2 and Figure 6).

Table 2. Acute hemodynamic changes

Pacing types		dp/dt (mmHg/s)	C.O. (l/m)
Intrinsic		710	2.69
3 min.	Conventional BiV pacing	980	3.65
	MultiPoint™ pacing	990	3.81

Figure 6



Two weeks after implantation, the NT-proBNP test was done. There was a significant reduction of the NT-proBNP level from 4,299 before implantation to 2,168 after two weeks of MultiPoint Pacing. The reading was reduced to 1,854 after six weeks of MultiPoint Pacing, and further reduced to 1,231 after 14 weeks. The continued reduction in NT-proBNP levels following implant with MultiPoint Pacing programming indicated that the patient's heart failure condition was continuously improving (Figure 7).

Figure 7. Change in NT-proBNP

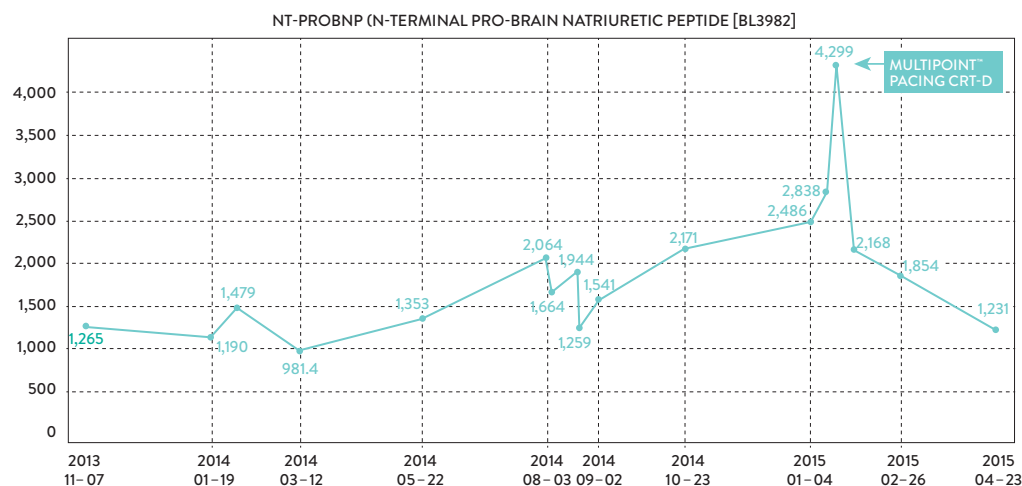


Table 3 and Table 4 summarize the acute and 3-month hemodynamic improvement of the patient.

Table 3. Acute hemodynamic change

Test	Time to Perform	Intrinsic Baseline	Conventional CRT	MultiPoint™ Pacing
QRS Duration (ms)	Implant day	164	145	134
dP/dt _{max} (mmHg/s)	2nd day	710	979	990
Cardiac Output (L/m)	2nd day	2.69	3.65	3.81

Table 4. Summary of the hemodynamic improvement of the patient

Test	Baseline	2 weeks	6 weeks	14 weeks
NT-proBNP	4,299	2,168	1,854	1,231
LV EF (%)	20%	25%	30%	33%
NYHA Class	II/III	II	I/II	I

CONCLUSION

MultiPoint™ Pacing demonstrated a better performance compared to conventional biventricular pacing regarding acute electrical reverse remodeling and hemodynamic changes for this patient with ischemic cardiomyopathy caused by Kawasaki disease. This patient's condition was improved with an early activation of MultiPoint Pacing therapy.

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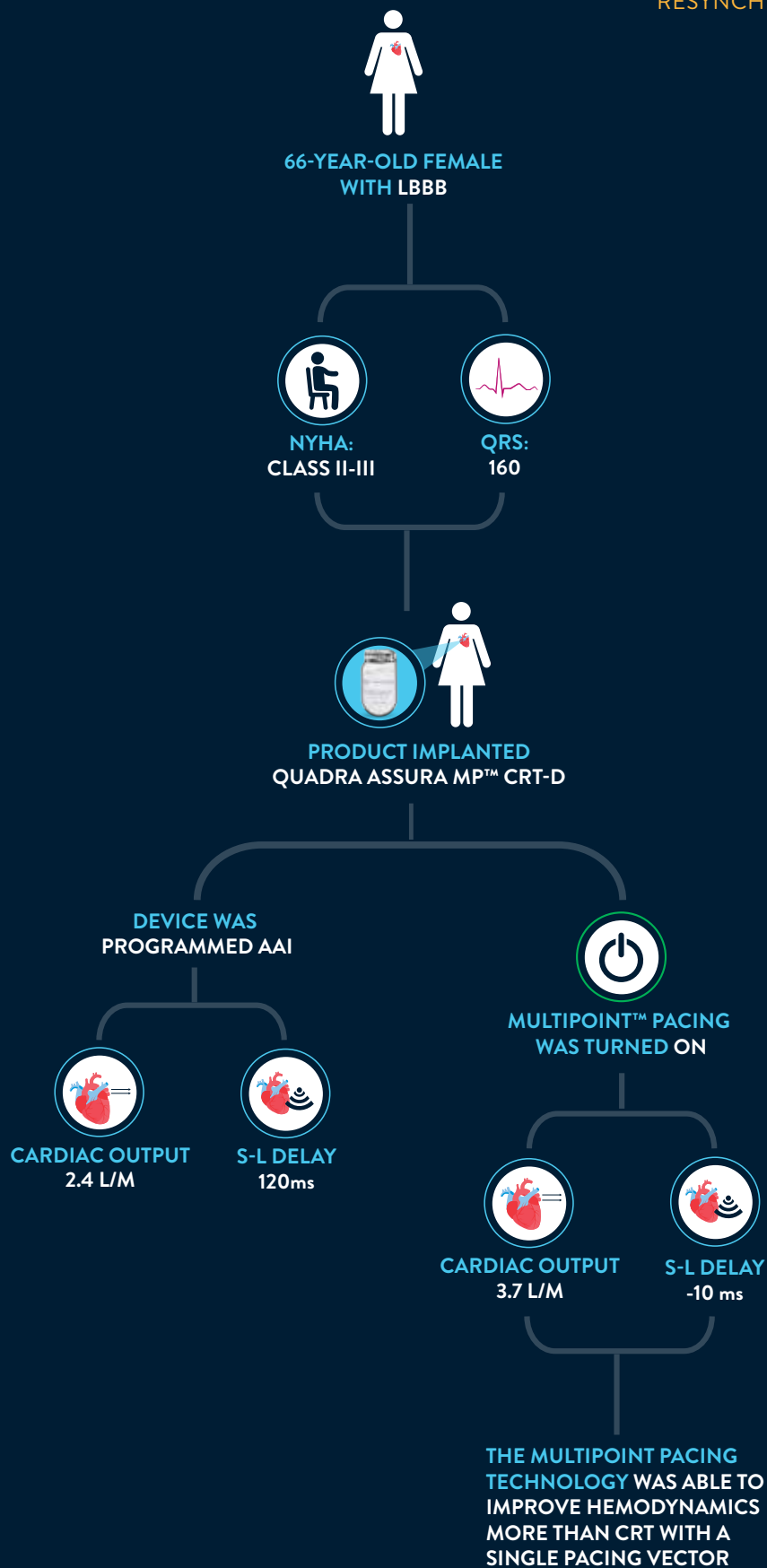
LV DYSSYNCHRONY AND HEMODYNAMIC IMPROVEMENT WITH MULTIPOINT™ PACING AFTER THREE MONTHS. AN ANATOMICAL APPROACH

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MULTIPOINT™ PACING CASE STUDY

HEMODYNAMIC CHANGES IN A
PATIENT UNDERGOING CARDIAC
RESYNCHRONIZATION THERAPY



CLINICAL HISTORY

- 66-year-old female
- Dilated cardiomyopathy
- Left ventricular ejection fraction (LVEF) 30%
- Left bundle branch block (LBBB) with QRS width of 160 ms
- NYHA functional class II to III

PROCEDURE

Dyssynchrony evaluation protocol

Three months after device implantation, transthoracic echocardiography was performed in a blind fashion to calculate haemodynamic parameters (LVEF and cardiac output). Radial dyssynchrony by speckle-tracking strain was defined as the time-to-peak difference between the septal and lateral wall segmental peak strains (S-L delay, Figure 1). Standard deviation of times to peak radial strain in the six basal segments was also measured as a global dyssynchrony parameter.

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

Vectors Configuration

- Distal vector: D1-RV coil
- Proximal vector: P4-RV coil
- MultiPoint™ Pacing technology anatomical-guided vector: D1-RVcoil → P4-RVcoil, to capture a broader area.
- MultiPoint Pacing technology electrical-guided vector: M3-RVcoil → P4-RVcoil, by using the electrodes with a greater delay between RV sensing.

Table 1. Programmed settings before and after MultiPoint Pacing

Pacing Configuration	Timing	Cardiac Output (l/m)	S-L Delay (ms)	RS-SD6 (ms)
AAI		2.4	120	82
P4-RV coil	Simult	2.6	110	81
D1-RV coil	Simult	2.7	95	64
D1-RV coil → P4-RV coil	5-5 (LV-LV-RV)	3.7	-10	12
M3-RV coil → P4-RV coil	5-5 (LV-LV-RV)	3.2	60	43

Figure 1. Example of S-P calculation in baseline situation; S-L delay is indicated by white arrow and measured (124 ms).

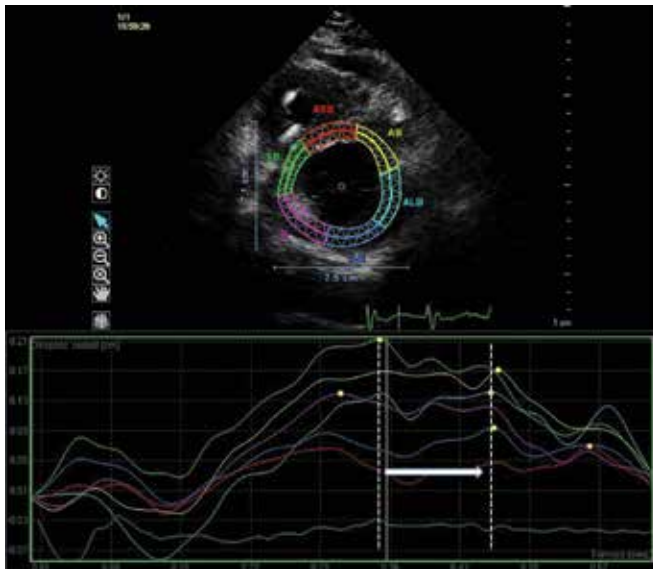
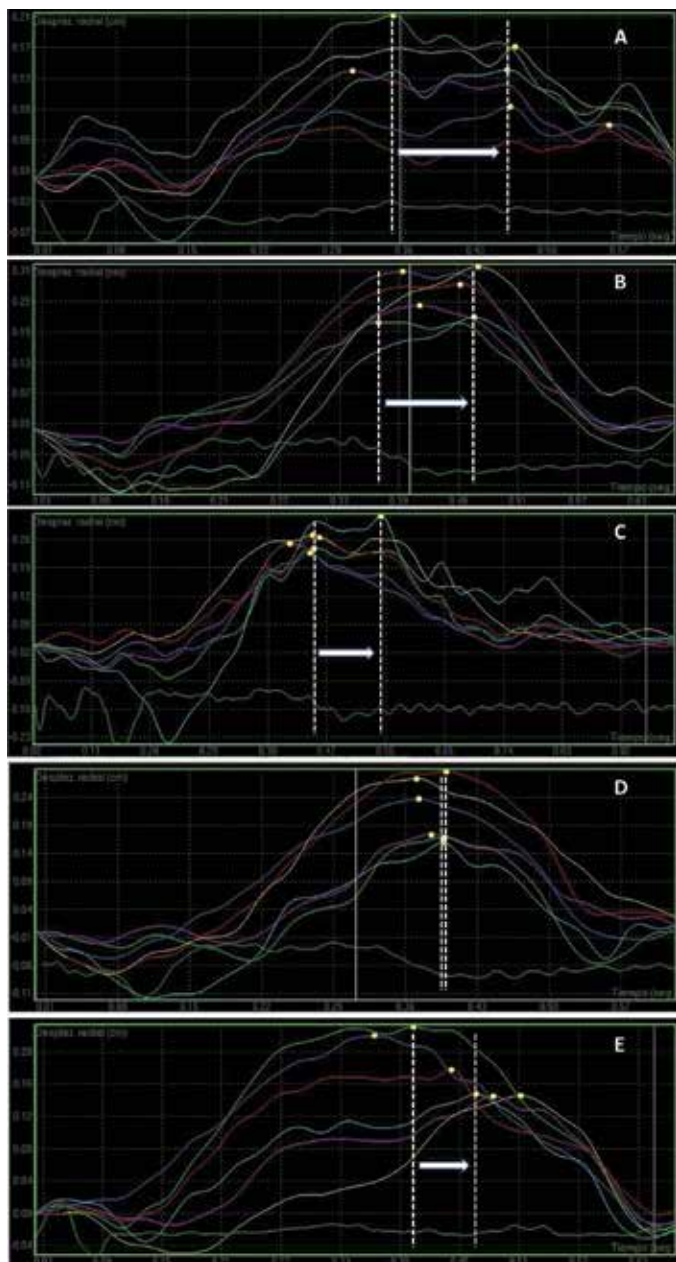


Figure 2. LV dyssynchrony analysis from basal short-axis views in the patient. In baseline conditions, the patient exhibited significant LV dyssynchrony (QRS width 160 ms). Furthermore, there was a delayed mechanical activation of the lateral wall compared with the septum (S-L delay 124 ms) (B and C). With conventional biventricular pacing configuration, a decrease in the value of LV dyssynchrony was shown (S-L delay 110 and 95 ms) (D and E). With MultiPoint™ pacing technology configuration, a higher decrease in LV dyssynchrony was shown. The highest LV dyssynchrony reduction was seen when anatomical approach (D) was employed (S-L delay 10 ms).



RESULTS

- The MultiPoint Pacing technology was able to improve haemodynamics more than CRT with a single pacing vector (see Table 1).
- The MultiPoint Pacing technology provided a higher correction of dyssynchrony than conventional CRT (see Figure 2).
- Anatomical approach showed better results (see Table 1).

OPTIMIZATION OF CARDIAC PACING OUTCOMES BY USE OF MULTIPOINT™ PACING CARDIAC RESYNCHRONIZATION THERAPY (CRT) COMPARED WITH CONVENTIONAL CRT

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MULTIPOINT™ PACING CASE STUDY

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INTRODUCTION

While the 2009 introduction of quadripolar lead technology led to improved acute hemodynamic response to CRT,^{1,2} non- or low-responder rates still remain a challenge. By providing an additional left ventricular (LV) stimulation vector, MultiPoint™ Pacing can improve resynchronization and hemodynamic outcomes.³⁻⁵ While the patient in this case had a good clinical response to conventional LV single-site CRT in terms of QRS interval reduction and increased ejection fraction, a switch to MultiPoint™ Pacing improved these outcomes further.

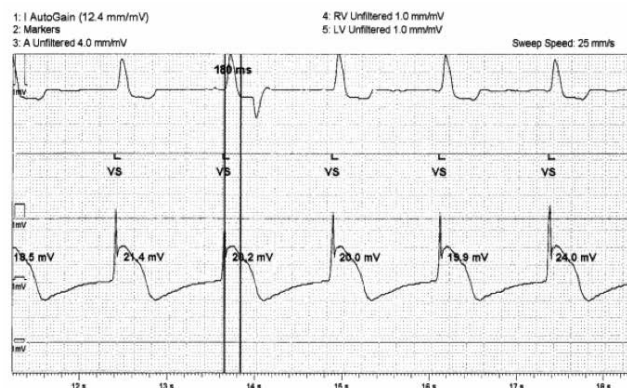
PATIENT HISTORY

- 85-year-old female
- History of coronary artery disease (CAD)
- QRS duration = 180 ms
- Left bundle branch block (LBBB)
- Baseline ejection fraction (EF) = 36%
- Heart rate (HR) range 38-89 bpm on Holter monitoring

The patient had moderate LV systolic dysfunction with regional variation in contraction probably not entirely attributable to LBBB, but consistent with CAD.

Baseline ECG

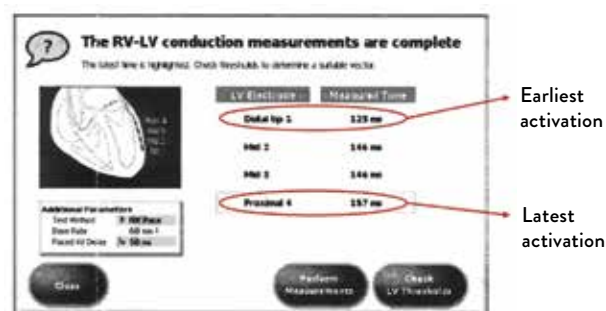
Sinus rhythm, no stimulation QRS = 180 ms, 25 mm/s



Response to conventional LV single-site pacing

Pacing site	QRS duration (ms)
Right ventricle (RV) paced	168
D1 LV pacing only	180
P4 LV pacing only	191
Simultaneous biventricular pacing at P4	144

Response to conventional LV single site pacing



MULTIPOINT™ PACING THERAPY

The patient was implanted with a Quadra Assura MP™ CRT-D and Quartet™ LV lead (Abbott).

PROGRAMMING

The anatomical method, i.e. selection of the two farthest poles with no phrenic nerve stimulation (PNS) and satisfactory thresholds, was used in this patient.

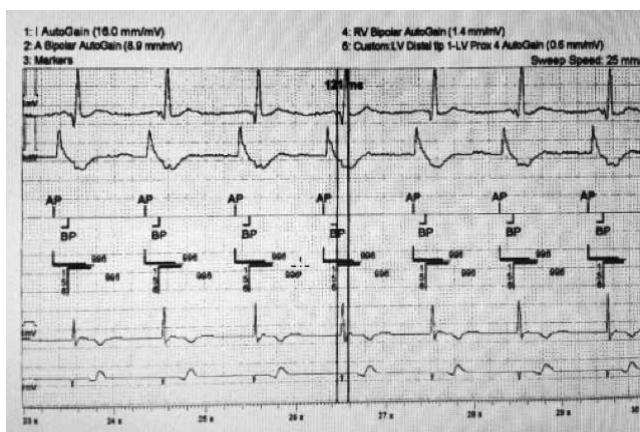
Two methods were used to determine LV1 and LV2:

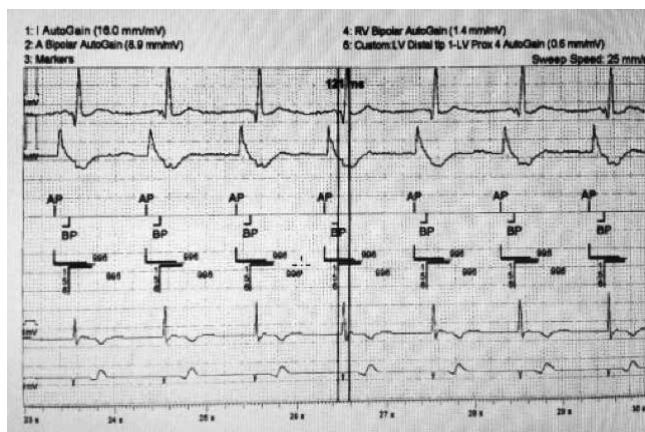
1. Latest activation = LV1, and earliest activation = LV2
2. Earliest activation = LV1, and latest activation = LV2

MultiPoint™ Pacing programming (anatomical method)

	LV1	LV2	LV1 - LV2	LV1 - LV2	QRS
Prog. 1	P4 to RVC (latest)	D1 to RVC (earliest)	5ms	25ms	121ms
Prog. 2	D1 to RVC (earliest)	P4 to RVC (latest)	5ms	25ms	109ms

Program 1: QRS = 121 ms



Program 2: QRS = 109 ms
**IMPROVED HEMODYNAMIC OUTCOMES
WITH MULTIPPOINT™ PACING THERAPY**

Each MultiPoint™ Pacing configuration (vectors and timing) provided improved electrical synchronization (assessed by QRS width) versus RV only, LV only and simultaneous RV–LV stimulation.

In this case, programming using the shortest delay between LV1 and LV2 (5ms) produced incremental benefit for the patient compared with traditional CRT.

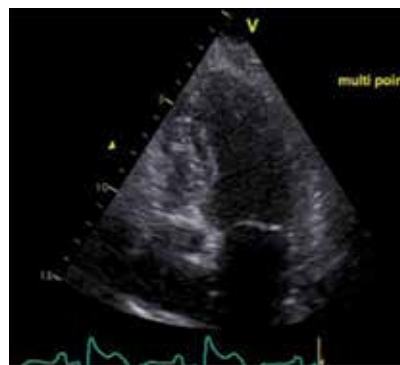
**VENTRICULAR REMODELING FOLLOWING
IMPLANTATION**

The patient returned for echo optimization of CRT at 3 months following implantation and activation of MultiPoint™ Pacing. At this visit her intrinsic (unpaced) EF was found to have increased from pre-implantation baseline value (36%) to 39%, suggesting that some remodeling may have already taken place.

	Ejection fraction (%)	Percentage increase (%) compared with baseline
Baseline	36	
Intrinsic (unpaced) at 3 months	39	8
Traditional CRT	49	36
MultiPoint™ pacing	62	72

ECHO IMAGING

Baseline echo: QRS = 180 ms; EF = 36%



CRT echo: QRS = 140 ms; EF = 49%



MultiPoint™ Pacing CRT echo: QRS = 109 ms; EF = 62%

**CONCLUSION**

Developments in MultiPoint™ Pacing programming have provided multiple options, not currently available with traditional CRT, which potentially may improve patient outcomes. This case study demonstrates that MultiPoint™ Pacing may potentially offer a significantly improved acute hemodynamic response to CRT, compared with traditional single-site LV pacing.

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IMPROVING THE HEMODYNAMIC RESPONSE TO CARDIAC RESYNCHRONIZATION THERAPY WHILE ELIMINATING PHRENIC NERVE STIMULATION IN A PATIENT WITH NON-ISCHEMIC CARDIOMYOPATHY

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MULTIPOINT™ PACING CASE STUDY
HEMODYNAMIC CHANGES IN A
PATIENT UNDERGOING CARDIAC
RESYNCHRONIZATION THERAPY



SUPPORTING EVIDENCE

Approximately 30% of patients do not respond to traditional cardiac resynchronization therapy (CRT).¹ Abbott CRT devices featuring quadripolar pacing and MultiPoint™ Pacing have been designed for efficient CRT optimization. Physicians can implant the left ventricular lead in the most stable position without making trade-offs in electrical performance and make non-invasive lead revisions to meet the changing needs of patients with heart failure. A growing body of clinical evidence shows that MultiPoint™ Pacing can enhance the response to CRT for heart failure patients whose devices are appropriately programmed.²⁻⁴ This case reports on the application of MultiPoint™ Pacing to improve the hemodynamic response to CRT in a patient with non-ischemic cardiomyopathy.

PATIENT HISTORY

- 69-year-old female
- Non-ischemic cardiomyopathy
- Dual chamber pacemaker implanted previously due to intermittent heart block in February 2016; right ventricular (RV) pacing > 50%
- Patient experienced worsening symptoms of heart failure in September 2016:
 - Left ventricular ejection fraction (LVEF): 30%
 - New York Heart Association Class III heart failure

CASE EXPERIENCE

Implantation

- Quadra Assura MP™ CRT-D device with a Quartet™ LV lead (Abbott) was implanted after explanation of a dual-chamber pacemaker.
- The previously implanted right atrial pace/sense lead demonstrated adequate diagnostics and was retained.
- The right ventricular pace/sense lead was extracted and replaced with a Durata™ defibrillation lead (Abbott).

RESPONSE TO CRT: INITIAL PROGRAMMING AND OPTIMIZATION WITH MULTIPPOINT™ PACING

Baseline

The CRT-D device was initially programmed to standard biventricular pacing utilizing the M3-RV coil vector with a threshold of 1.5V @ 0.4 ms in order to establish a baseline response. Other parameters are shown in Table 1.

Table 1. Baseline CRT Parameters

Parameter	Value
Mode	DDR: 60/120 ppm
Paced AV delay	150 ms
Sensed AV delay	100 ms
V-V timing via QuickOpt™ timing cycle optimization	LV → RV 35 ms

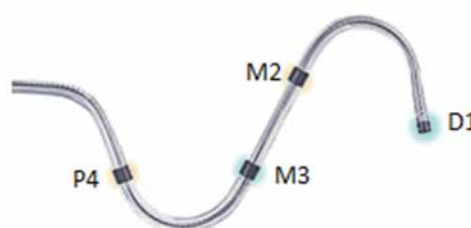
3-MONTH FOLLOW-UP **MULTIPPOINT™ PACING PROGRAMMED ON**

- The patient's LVEF improved to 40% on echocardiography prior to her 3-month follow-up with no heart failure symptoms at a clinic visit in December 2016.
- MultiPoint™ Pacing was programmed ON at this point in an effort to gain further improvements. The vectors shown in Table 2 and Figure 2 were chosen due to low thresholds and to provide a 30 mm separation between the cathodes. The interventricular delay between LV1 and LV2 was set at 5 ms and V-V timing was shortened to 30 ms as recommended with QuickOpt™ timing cycle optimization.
- The patient experienced intermittent phrenic nerve stimulation one week later. This was resolved with revised programming: the LV2 vector was changed from D1-RV coil to D1-P4 with a threshold of 1.5@ 0.4 ms; there was no phrenic stimulation at maximum output.

Table 2. Biventricular CRT Vectors at 3-Month Follow-up

LV Pulse	Pacing Vector	Threshold
LV1	M3-RV coil	1.5 V @ 0.4 ms
LV2	D1-RV coil	1.0 V @ 0.4 ms

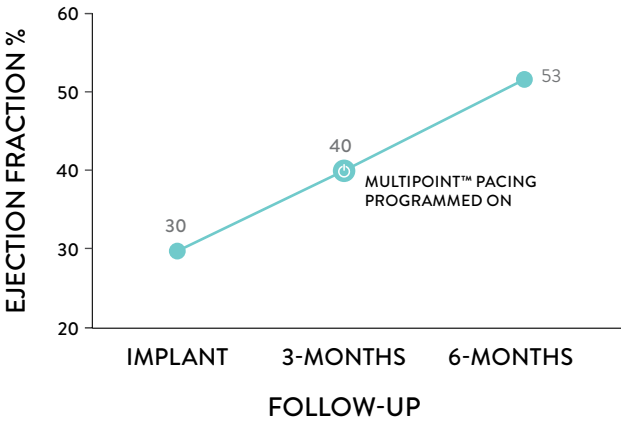
Figure 1. MultiPoint™ pacing vectors programmed ON at 3-month follow-up.



6-MONTH FOLLOW-UP

- The patient’s LVEF improved further to 53% at 6-month follow-up, Table 3.
- The patient had no heart failure related hospital admissions at 6-month follow-up.

Table 3. Left Ventricular Ejection Fraction with and without MultiPoint™ Pacing



CONCLUSIONS

MultiPoint™ Pacing provided the flexibility needed to potentially optimize biventricular pacing and manage phrenic nerve stimulation non-invasively. The patient’s improved response to CRT was enhanced as demonstrated by incremental improvements in LVEF after MultiPoint™ Pacing was initialized.

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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.

MultiPoint™ Pacing and SyncAV™ CRT Technology

Indications: Abbott ICDs and CRT-Ds are intended to provide ventricular antitachycardia pacing and ventricular defibrillation for automated treatment of life-threatening ventricular arrhythmias. AF Suppression™ pacing is indicated for suppression of paroxysmal or persistent atrial fibrillation in patients with the above ICD indication and sinus node dysfunction. In patients indicated for an ICD, CRT-Ds are also intended: to provide a reduction of the symptoms of moderate to severe heart failure (NYHA Functional Class III or IV) in those patients who remain symptomatic despite stable, optimal medical therapy (as defined in the clinical trials section included in the Merlin™ PCS on-screen help) and have a left ventricular ejection fraction less than or equal to 35% and a prolonged QRS duration to maintain synchrony of the left and right ventricles in patients who have undergone an AV nodal ablation for chronic (permanent) atrial fibrillation and have NYHA Class II or III heart failure.

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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