Why do we need ECHO for CRT device optimization?

Prof.dr.sc. J. Separovic Hanzevacki

Department of Cardiovascular Diseases, University Hospital Centre Zagreb
School of medicine, University of Zagreb
Zagreb, Croatia
Disclosure

Speaker:
Prof. dr. sc. J. Separovic Hanzevacki

I do NOT have any potential conflict of interest related to my presentation
Roles of Echocardiography to Guide Cardiac Resynchronisation Therapy

Patient Selection

LV & RV Lead Positioning

Device Timing Optimization

Long-term benefit from CRT

NO Positive ECHO trial!
How to maximize potential of the resynchronization therapy?

Baseline  LVESV 115ml

CRT – 6 mo.  LVESV 81ml

Good selection, Optimal leads positioning Electromechanical optimization
WHERE IS THE PLACE OF ECHO?

I. MANY STUDIES
   MANY OPTIMIZATION TECHNIQUES
   NO CONSENSUS

   ECHO: AV VTI, MV VTI, LV ESV, EF,
   E-A duration, E-A truncation
   • thoracic electrical impedance
   • CO by rebreathing techniques
   • Blood pressure
   • plethysmography and pulse contour
   • IEGM and ECG
   • QRS morphology, QRS axis;
   • heart sounds and phonocardiography
   • LV (dp/dtmax) and pressure–volume

   ECHO IS CORNESTONE OF CRT OPT.
   BASED ON UNDERLYING PHYSIOLOGICAL CONCEPT OF SYNCHRONIZING

II. DEVICE BASED ALGORITHMS
Adaptive CRT

Eliminate the need for echo-optimization?

- CRT that automatically adapts to patient’s intrinsic conduction
- Optimizes AV and VV delays based on periodic, automatic measurement of cardiac conduction
- Maintain CRT if conduction changes (PRshortens)
- Reduce unnecessary RV pacing for patients with intact conduction
II. Device based algorithms

SonR hemodynamic sensor embedded in the tip of the lead detects cardiac muscle vibrations that reflect heart sound.

Repeated individual optimizations

At rest:  
- 42 AV/VV combinations followed with
- 11 sensed and 11 paced AV delays with the optimal VV delay

During exercise:  
- 5 paced or 5 sensed AV/VV combinations
Where is the place of ECHO?

ECHO is cornerstone of CRT opt. based on underlying physiological concept of synchronizing
Roles of Echocardiography to Guide Cardiac Resynchronization Therapy

Patient Selection

LV & RV Lead Positioning

Device Timing Optimization

Long-term benefit from CRT

NO Positive ECHO trial! PROSPECT trial - Neg.

ECHO based optimization: a very time intensive costly process operator dependent
Median and 95% confidence interval for the primary end point of echocardiographic LVESV change between baseline and the 6-month follow-up.

Ellenbogen K A et al. Circulation 2010;122:2660-2668
SmartAV  Primary Endpoint
Subgroups: Bundle Branch Block, QRS Width, Etiology

Ellenbogen K A et al. Circulation 2010;122:2660-2668
Only in women, ECHO and SmartD significantly reduce LVESV compared to fixed!

Reasons?
- Patient selection!
- Lead position
- Suboptimal device settings

Ellenbogen K A et al. Circulation 2010;122:2660-2668

www.escardio.org/EACVI
Potential Reasons for Suboptimal CRT Response

- Suboptimal AV Timing
- Arrhythmia
- Anemia
- Suboptimal LV Lead Position
- < 90% Biventricular Pacing
- Suboptimal Medical Therapy
- Persistent Mechanical Dyssynchrony
- Underlying narrow QRS
- Compliance Issues
- Primary RV Dysfunction

ECHO
SmartAV
Distribution of AV Delays at 6-months post-implant

Only 15% pts were optimal with fixed settings
Effect of atrioventricular delay on transmitral flow

Schematic diagram showing the effect of atrioventricular delay duration on Doppler echocardiographic recordings of transmitral flow.
AV delay and Transmitral flow „Gold” standard

Too long AV delay

Too short AV delay

Important!
Pattern Heart rate Diastolic disfunction Dinamic AV - exersice

Optimal AV delay?

Iterative method
Mitral inflow velocity time integral (VTI) to optimize the AV interval

AV delay – 120 ms
MV VTI – 12.8 cm

AV delay – 50 ms
MV VTI – 14 cm

Important!
Pattern
Heart rate
Diastolic disfunction
Dinamic AV - exersice

Whole „picture” !
Device based algorithms

Impedance measurements and MR?
Disynchrony

Intra-ventricular

Inter-ventricular

Atrioventricular

Electric ➔ mechanical !!!
Intraventricular mechanical (dys)synchrony after CRT?
Evaluation of Intraventricular mechanical (dys)synchrony after CRT

LV Lead displacement!

Post CRT
Electromechanical dyssynchrony

Post CRT
Electromechanical synchrony
Electric LV activation patterns
Implications for CRT optimization

Contact electro-anatomical activation mapping

Delgado V, Bax J J Circulation 2011;123:640-655
Potential Reasons for Suboptimal CRT Response

- Suboptimal AV Timing
- Arrhythmia
- Anemia
- Suboptimal LV Lead Position
- < 90% Biventricular Pacing
- Suboptimal Medical Therapy
- Persistent Mechanical Dyssynchrony
- Underlying Narrow QRS
- Compliance Issues
- Primary RV Dysfunction
VV interval optimizations by measuring LVOT VTI, MR dp/dt

- LV RV 4ms
- LV RV 16ms
- LV RV 30ms

LV- RVPEP 170-220 = 50 ms
Optimization by measuring LVOT or MV VTI

Caution with „pick-the-highest” analysis
Beat-to-beat variability - generates an artefactual ‘benefit’ of optimization

Noise alone produces increments!
VV interval optimizations by measuring LV mechanical dyssynchrony

Mechanical delay parameters
M mode
Strain imaging
3D
VV interval optimizations by measuring LV mechanical dyssynchrony

Mechanical delay parameters

- **M mode**
- Strain imaging
- 3D

**M mode**
- septal-to-posterior wall motion delay (SPWMD)

**Strain**
- time difference between the peak systolic radial strain of the wall

**3D**
- time interval to reach the minimum systolic volume SDI
ECHO guided optimization-
individualized and tailored optimization of AV and VV timings

Difficulties to predict optimal delay

Variable conduction delays (*intra-atrial, inter-, intra-ventricular*)
Different positions of leads

Variable Electric and mechanical LV activation patterns!
VV delay: LV pre-excitation in patients with better conduction

Shorter PR, narrower QRS

Longer PR, wider QRS
Better RV Function with LV Only Pacing

- LV pacing at an appropriate AV interval prior to the RV sensed impulse provides superior RV hemodynamics compared with BiV pacing (LV hemodynamics similar to BiV)


www.escardio.org/EACVI
Device based algorithms

- Micro-accelerometer
- Acoustic vibrations
- Isovolumic contraction
Post-implantation approach

3 Q: Is there...

I. Electrical synchrony
   • QRS duration
   • IGM A-RVs, As-LVs

II. Atrioventricular synchrony
   • Transmitral flow
   • Tricuspid flow

III. Mechanical synchrony
   • Intraventricular dysynchrony

Interventricular
Algorithm to decide when to optimize AV and VV interval during follow-up

Pre-discharge
AV and VV interval optimization

3 months follow-up
Lack of improvement in NYHA functional class

YES
Repeat AV and VV interval optimization

6 months follow-up
Reduction of LVESV ≤ 15%

YES
Repeat AV and VV interval optimization

12 months follow-up
Clinical responder + LV reverse remodeling

NO
Non-responder: consider status of heart failure and potential alternative therapies

YES
Re-evaluation every 3-6 months:
If clinical or echocardiographic parameters worsen, consider repetition of AV and VV interval optimization

Integrative approach
EP,ECHO,HF - Croatian model UHC „Zagreb”

Patient Selection

LV & RV Lead Positioning

Device Timing Optimization

Follow up + opt.
1. Baseline CRT
2. 6 weeks
3. 3 or 6moth.
4. 1 y.

Results
Reverse remodelling volume “responders”
84% (N=32)

volume “non-responders”
15.9% (N=6)

Long-term benefit from CRT

CRT pts. UHC „Zagreb” 2009/12
– FU 0.5 -2y.
- 41 pts./38 in analysis
- age 60.3y

www.escardio.org/EACVI
9th Croatian Cardiol. Congress,Opatija 2012.
Conclusion

I. “gold standard” of device optimization
   underlying physiological concept of synchronizing

II. Early detection of reasons for suboptimal response
   whole „picture” individualized and tailored approach
   - CRT related (lead position, lead failure, dyssynchrony)
   - other (DD, RV failure, pulmonary hypertension, valvular disease)

III. Guided ‘treatment’ of suboptimal response and non-responder
   Careful! Pattern instead single number
   Noise and beat to beat variability
Dubrovnik 2013.